601.220 Intermediate Programming

Inheritance

Inheritance

Classes we use are often related to each other

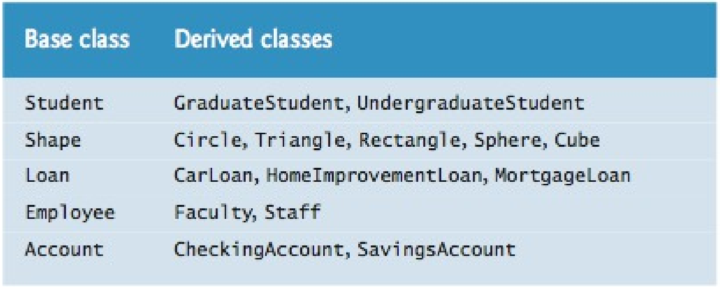
`class Account {...};`, `class CheckingAccount {...};`

- **is-a** relationship; a checking account is a kind of an account
- this is inheritance

`class GradeList {...};`, `std::vector<double>;`

- **has-a** relationship; a grade list **has** a vector of grades as part of it
- this is composition or aggregation

Inheritance examples



Base class	Derived classes
Student	GraduateStudent, UndergraduateStudent
Shape	Circle, Triangle, Rectangle, Sphere, Cube
Loan	CarLoan, HomeImprovementLoan, MortgageLoan
Employee	Faculty, Staff
Account	CheckingAccount, SavingsAccount

Fig. 12.1 | Inheritance examples.

These are all **is-a** relationships.

Inheritance hierarchy

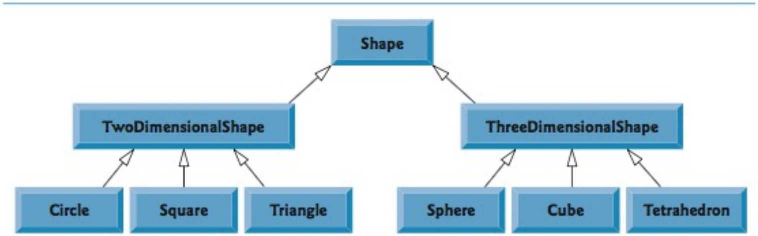


Fig. 12.3 | Inheritance hierarchy for Shapes.

Multiple levels of **is-a** relationships.

Inheritance declaration and terminology

```
class BaseClass {
    // Base class definitions
};
class DerivedClass : public BaseClass {
    // Derived class definitions
}
```

- **Derived class** inherits from **base class**
- Java-like vocab: **subclass** inherits from **superclass**
  (We'll typically say **derived** and **base**)
- This is **public inheritance** – by far the most common kind
  - access of members in the base class is passed down and preserved
- `protected` & `private` inheritance also possible, but rarely used
  - if you forget to explicitly say `public`, the default is private and that can get you into trouble

Inheritance access

- `protected` is an access modifier we haven't used yet
- `protected` fields & functions can only be accessed:
  - from member functions of their class
  - from member functions defined in derived classes
- Base-class members marked `public` or `protected` can be accessed from member functions defined in the derived class
- Base-class members marked `private` **cannot** be accessed from member functions defined in the derived class
  - They're still there, and base class member functions can still use them, but derived class member functions can't use them (without `public` or `protected` accessor or mutator functions)

C++ classes: inherit what?

- Derived class inherits most members of base class, whether `public`, `protected` or `private`
    - can only access `public` and `protected` members directly
- Does not inherit
    - constructors
    - assignment operator if explicitly defined
- Derived class cannot delete things it inherited; cannot pick and choose what to inherit
- But derived class can **override** inherited member functions
    - `override` = substitute an own implementation for base class's

C++ classes: An Account base class

```cpp
// account.h
class Account {
public:
    Account() : balance(0.0) { }
    Account(double initial) : balance(initial) { }

    void credit(double amt)    { balance += amt; }
    void debit(double amt)     { balance -= amt; }
    double get_balance() const { return balance; }
private:
    double balance;
};
```

Default constructor sets `balance` to `0`; non-default constructor sets according to arguments

`balance` is `private`, modified via `credit(amt)`/`debit(amt)`

C++ classes: An Account base class usage

```cpp
// account_main1.cpp
#include "account.h"
#include <iostream>

int main() {
    Account acct(1000.0);
    acct.credit(1000.0);
    acct.debit(100.0);
    std::cout << "Balance is: " << acct.get_balance() << std::endl;
    return 0;
}
```

```
$ g++ -o account_main1 account_main1.cpp -std=c++11 -pedantic -Wall -Wextra

$ ./account_main1

Balance is: 1900
```

C++ classes: Inheritance example - Checking Account

```cpp
// checking_account.h
class CheckingAccount : public Account {
public:
    CheckingAccount(double initial, double atm) :
    Account(initial), total_fees(0.0), atm_fee(atm) { }

    void cash_withdrawal(double amt) {
        total_fees += atm_fee;
        debit(amt + atm_fee);
        }

    double get_total_fees() const { return total_fees; }

private:
    double total_fees;
    double atm_fee;
};
```

C++ classes: Inheritance - classing base class constructor

- Derived classes don't inherit constructors, but (usually) need to call their base class constructor to initialize inherited data members
  - We do this with the base class name in C++ (no super() like in Java)
  - The base class constructor call must be the first thing in the derived class constructor
  - If the base class constructor call is missing, then a default constructor for the base class will be called automatically; error if one doesn't exist!

```
CheckingAccount(double initial, double atm) :
    Account(initial), total_fees(0.0), atm_fee(atm) { }
```

C++ classes: Inheritance example - Savings Account

```
// savings_account.h

class SavingsAccount : public Account {
public:
    SavingsAccount(double initial, double rate) :
    Account(initial), annual_rate(rate) { }

    // Not implemented here; usual compound interest calc
    double total_after_years(int years) const;

private:
    double annual_rate;
};
```

C++ classes: Inheritance usage

```cpp
// account_main2.cpp
#include <iostream>
#include "account.h"
#include "savings_account.h"
#include "checking_account.h"

int main() {
    Account acct(1000.0);
    acct.credit(1000.0);
    acct.debit(100.0);
    std::cout << "Account balance is: $" << acct.get_balance() << std::endl;

    CheckingAccount checking(1000.0, 2.00);
    checking.credit(1000.0);
    checking.cash_withdrawal(100.0); // incurs ATM fee
    std::cout << "Checking balance is: $" << checking.get_balance() << std::endl;
    std::cout << "Checking total fees is: $" << checking.get_total_fees() << std::endl;

    SavingsAccount saving(1000.0, 0.05);
    saving.credit(1000.0);
    std::cout << "Savings balance is: $" << saving.get_balance() << std::endl;
    return 0;
}
```

```
$ g++ -o account_main2 account_main2.cpp -std=c++11 -pedantic -Wall -Wextra
```

```
$ ./account_main2
```

```
Account balance is: $1900
Checking balance is: $1898
Checking total fees is: $2
Savings balance is: $2000
```

C++ classes: Inheritance & destructors

- When a derived class object is created, its inherited (base) parts must be initialized before any newly defined parts by executing a base constructor (default or explicit call to one)
- When the lifetime of a derived class object is about to end, two destructors are called: the one defined for the derived object and then the one defined for the base class
  - Either destructor may be explicitly defined, or just the provided default
  - A chain call happens for multi-levels inheritances
- Note that constructors and destructors are executed in opposite orders!