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CS3307: Object Oriented Analysis and Design
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# System Enhancement Project: SimpleBank

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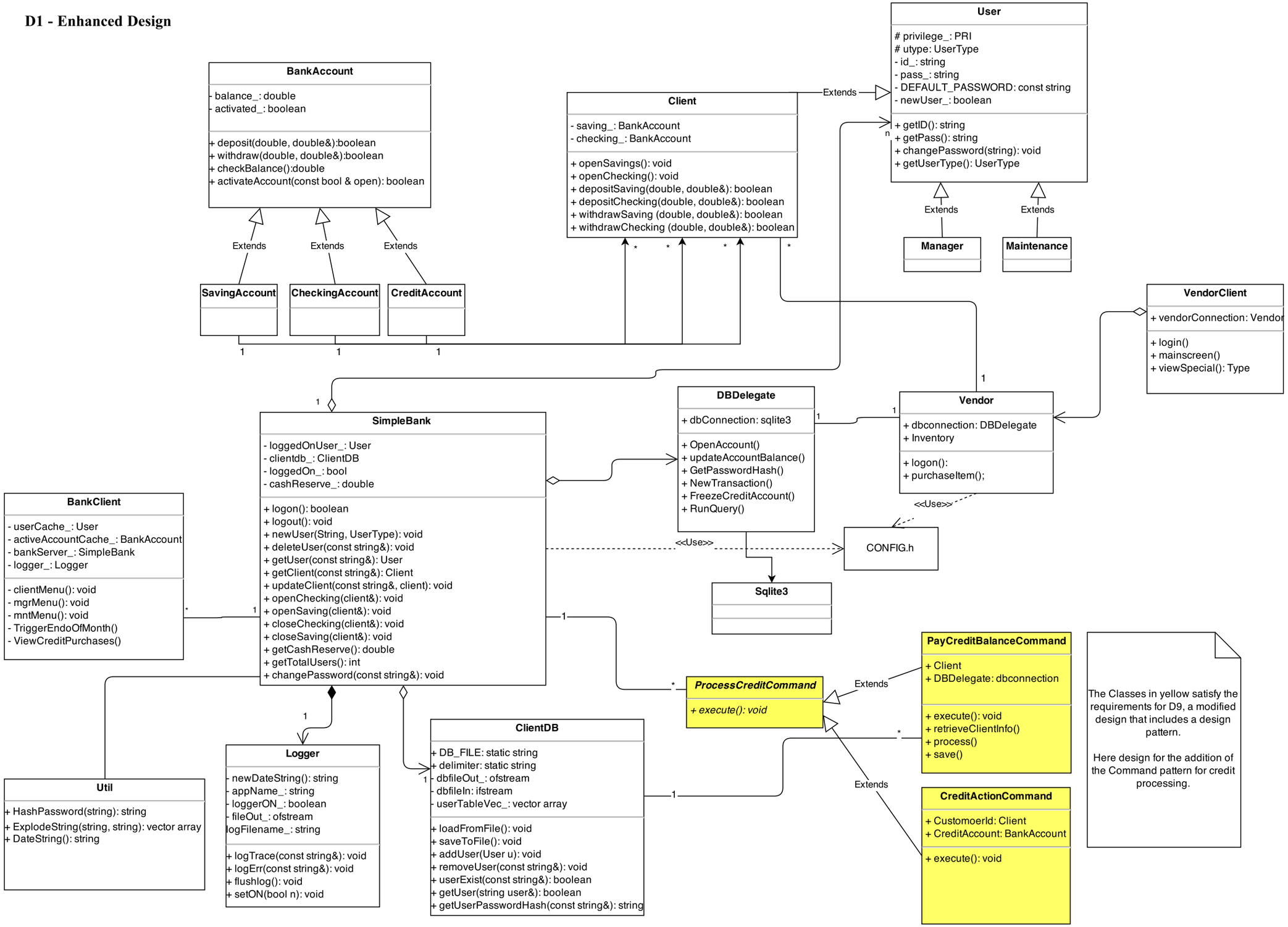
## D1 - Enhanced Design



## D1 Enhanced design

Please see the attached UML diagram above.

## D2 C++ source code

- All source code is located in `SimpleBank/src`
- To build on a Unix based system, type `make` in the same directory
- Run bank system with ./SimpleBank.exe
- Run vendor system with ./vendor.exe
- `make clean` to remove trace files and objects files
- `make reset` to reset database files

Default Manager account:
Username: 3307
Password: pass

## D3 Explanation of correspondence between code and design

Our bank system's old data persistence interface could no longer accommodate the new vendor system, and so an additional one, DBDelegate, is added. The old interface implemented by ClientDB was limited in that it parsed a csv (comma-seprated filed) as plain text. Each row on the file directly related to a user along with its account balances. To incorporate additional information from the vendor system, that simple model does not work. For example, adding a transaction record of a purchase would be difficult to encode for each user in the same file and would have a lot of coding overhead. A relational database would be necessary.

DBDelegate aims to delegate the old ClientDB requests to a new database interface. Instead of using file parsing, we use the self-embedded C++ relational database library sqlite. We chose sqlite for its expressive power for simple sql queries such as create tables, select, and update. It is self-embedding in a sense that we don't need to have a separate server database process, and is built into the application. DBDelegate creates three main tables: users, accounts, and transactions. users hold all use info such as user id, user password hash and some user options. accounts hold all the bank account information, such as account ids, balances, and owner ids. Finally, transactions hold every purchase a user approves at the vendor. DBDelegate provides an interface to both the bank system and the vendor system. In effect, our systems use a shared database, the bank can see vendor's purchase log, and the vendor can see user's credit information.

The new vendor system is implemented in the following set of classes: Vendor, VendorClient, and v_main. The vendor system is a separate executable instance and is instantiated by

v_main. VendorClient, like BankClient, is a front-end client module that accesses the Vendor module. More specifically, in our case, VendorClient is a console client. We've again considered separation of concerns in this design. If in the future we were to implement a new vendor client in a different medium, such as a web client (e.g. web checkout), we can simply adapt the Vendor interface into that new client. This design aims for low coupling between the server and client code, while having high cohesion within each module itself.

Vendor has a very simple interface. It has a static vector containing a list of available inventory for purchase. Realistically, this would be modeled inside vendor's own database, but for simplicity, it is a static vector of roughly 30 items. Then vendor has a reference to the DBDelegate interface. The interface provides simple methods to get and store information to the shared database, such as authenticating users, checking user credit validity, or recording purchases. And finally, VendorClient implements a simple method that randomly generates a "special" item for sale by randomly selecting an item from its inventory for a random price.

Inside the bank system, we've extended the BankAccount hierarchy and have added the class CreditAccount as a derived class. A credit account shares many properties with the BankAccount, such as balances, withdraw (make payments), and deposit (making purchases). Again, due to design issues from assignment 1, there would be a lot of code restructuring to integrate the credit and vendor system to the old system. As a workaround to satisfy the requirements, we've sought to user functional techniques instead of object oriented ones. For example, to update a user's account balance, instead of calling User.CreditAcccount.Depsoit, we call the method:

```
void UpdateAccountBalanceDel(int uid, int atype, double newBalance);
```

inside DBDelegate. In a sense, we're calling more functions and passing object properties instead of calling methods on objects.

Another relationship among the new vendor code and the old bank system code is the amount of code reuse in the vendor system. Many methods and types can be used again in the vendor, some include: console client code, checking user input, displaying menu, logging module, database module, user type module, and the utilities module. Knowing the reusability of so many components in the bank system, future enchantment would include better organization of these modules, and have separate public header interfaces for them.

The last aspect from our new design is the new CONFIG.h file. This header file contains predefined system constants and configurations. It serves two purposes: one, users can define common settings such as default usernames and passwords; and two, we've added constants across the system to eliminate magic numbers. This is very useful if we need to change commonly used constants in the future in just one place instead of at all the locations.

# D4 Operational Evidence

Scenario 1: Purchase made at the vendor (valid credit card). Bank notified of transaction.

This scenario involves the following steps:

1. A customer with a valid credit card logs into the vendor
2. The customer approves the random item for purchase
3. A transaction record is saved in the database, and the bank is therefore notified

trace.txt

```
Sat Nov 29 23:43:02 2014|VENDOR|     Authenticating user...
Sat Nov 29 23:43:04 2014|VENDOR|     Attempting to login as joey
Sat Nov 29 23:43:04 2014|VENDOR|     Login failed.
Sat Nov 29 23:43:04 2014|VENDOR|     Login failed for user joeyAttempt: 0
Sat Nov 29 23:43:04 2014|VENDOR|     Successfully logged in as joey
Sat Nov 29 23:43:07 2014|VENDOR|     Attempting to login as joey
Sat Nov 29 23:43:07 2014|VENDOR|     Successfully logged in as joey
Sat Nov 29 23:43:07 2014|VENDOR|     Credit card approved for user
Sat Nov 29 23:43:08 2014|VENDOR|     Starting console vendor client
Sat Nov 29 23:43:09 2014|VENDOR|     Displaying special item
Sat Nov 29 23:43:09 2014|VENDOR|     Purchase for CHICKEN approved: Notifying bank system
database.
Sat Nov 29 23:43:10 2014|VENDOR|     Logging out vendor
```

Terminal Console

```
[Welcome to G8'S GROCER self checkout!]
YOUR EVERYDAY FOODS | CHECKOUT
Sat Nov 29 23:43:00 2014
<Please select an option to continue>
----------menu----------
1   Login
2   Quit
>1

User ID: joey
PIN:password
Incorrect username or password.

User ID: joey
PIN:pass

[Welcome joey]
Sat Nov 29 23:43:07 2014
You have a valid credit card from SimpleBank!

1   Buy today's special!
2   Logout
>1
[Special Item for sale!]
Item Name:  CHICKEN
```

```
Price:      $92

Continue with purchase? [y\n]
>y
[Welcome joey]
Sat Nov 29 23:43:09 2014

You have a valid credit card from SimpleBank!

1    Buy today's special!
2    Logout
>2
```

Database: transactions table

| tid | customer_id | amount | description | date | hidden |
|---|---|---|---|---|---|
| … | | | | | |
| 3 | 3 | 92.000000 | CHICKEN | Sat Nov 29 23:43:09 2014 | 0 |

Here, transaction 3 has the cutomer_id (the user) that made the above purchase. The bank is able to look at this table.

Scenario 2: Purchase made at the vendor (frozen credit card). Customer notified.

This scenario involves the following steps:

1. Customer with a frozen credit card makes attempts to login to the vendor
2. The customer's credit card is rejected and is notified

Database: accounts table

| aid | owner_id | balance | type | activated |
|---|---|---|---|---|
| 1 | 3 | 0 | 1 | 1 |
| 2 | 3 | 196.0 | 2 | 0 |

The user's credit account (type 2) is currently frozen (i.e. not activated in the db).

trace.txt

```
Sun Nov 30 01:26:54 2014|VENDOR|     Starting console vendor client
Sun Nov 30 01:26:36 2014|VENDOR|     Authenticating user...
Sun Nov 30 01:26:37 2014|VENDOR|     Attempting to login as joey
Sun Nov 30 01:26:37 2014|VENDOR|     Successfully logged in as joey
Sun Nov 30 01:26:37 2014|VENDOR|     Your Credit Card is not valid or is frozen!
Please contact your bank for assistance.
```

Terminal Console

```
[Welcome to G8'S GROCER self checkout!]
YOUR EVERYDAY FOODS | CHECKOUT
Sun Nov 30 01:26:34 2014
<Please select an option to continue>
```

```
----------menu----------
1    Login
2    Quit
>1

User ID: joey
PIN:pass
[Welcome joey]
Sun Nov 30 01:26:37 2014
Your Credit Card is not valid or is frozen!
Please contact your bank for assistance.
```

Scenario 3: Customer views current month's purchases at ATM

This scenario involves the following steps:

1. Customer logs in to the vendor system
2. Customer approves multiple purchases
3. Customer logs into the bank system
4. Customer views purchases made at the vendor

trace.txt

```
Sun Nov 30 01:35:24 2014|VENDOR|  Authenticating user...
Sun Nov 30 01:35:26 2014|VENDOR|  Attempting to login as joey
Sun Nov 30 01:35:26 2014|VENDOR|  Successfully logged in as joey
Sun Nov 30 01:35:26 2014|VENDOR|  Credit card approved for user
Sun Nov 30 01:35:46 2014|VENDOR|  Starting console vendor client
Sun Nov 30 01:35:29 2014|VENDOR|  Purchase for TURKEY approved: Notifying bank system database.
Sun Nov 30 01:35:30 2014|VENDOR|  Purchase for TOMATO SAUCE approved: Notifying bank system database.
Sun Nov 30 01:35:32 2014|VENDOR|  Purchase for BEEF approved: Notifying bank system database.
Sun Nov 30 01:35:33 2014|VENDOR|  Purchase for PEANUTS approved: Notifying bank system database.
Sun Nov 30 01:35:35 2014|VENDOR|  Purchase for CHICKEN BROTH approved: Notifying bank system database.
Sun Nov 30 01:35:37 2014|VENDOR|  Purchase for SAUSAGE approved: Notifying bank system database.
Sun Nov 30 01:35:38 2014|VENDOR|  Purchase for POPCORN approved: Notifying bank system database.
Sun Nov 30 01:35:39 2014|VENDOR|  Purchase for CHILI approved: Notifying bank system database.
Sun Nov 30 01:35:41 2014|VENDOR|  Purchase for CHICKEN approved: Notifying bank system database.
Sun Nov 30 01:35:43 2014|VENDOR|  Purchase for RAISONS approved: Notifying bank system database.
Sun Nov 30 01:35:44 2014|VENDOR|  Purchase for TEA approved: Notifying bank system database.
Sun Nov 30 01:35:50 2014|SB_Console Client|  Starting Console Client
Sun Nov 30 01:35:55 2014|SB_Console Client|  Attempting to login as joey
Sun Nov 30 01:35:55 2014|SB_Console Client|  Succesfully logged in as joey
Sun Nov 30 01:35:59 2014|SB_Console Client|  Viewing credit purchase history and report
Sun Nov 30 01:39:13 2014|SB_Console Client|  Logging out user: joey
```

Terminal Console

```
Welcome joey!
Your role: Client
Sun Nov 30 01:35:55 2014

Delegate db id: 3
----------menu----------
1    Access Savings Account
2    Access Checking Account
```

```
3    Transfer funds to\from account
4    Change Password
5    View Credit Report
6    Logout
>5

[Monthly Credit Purchase History]
-------------------------------------------------------
Date                          Item                Price
Sat Nov 29 23:37:17 2014      SAUSAGE             $100.00
Sat Nov 29 23:41:45 2014      JUICE               $4.00
Sat Nov 29 23:43:09 2014      CHICKEN             $92.00
Sun Nov 30 01:35:29 2014      TURKEY              $65.00
Sun Nov 30 01:35:30 2014      TOMATO SAUCE        $86.00
Sun Nov 30 01:35:32 2014      BEEF                $93.00
Sun Nov 30 01:35:33 2014      PEANUTS             $7.00
Sun Nov 30 01:35:35 2014      CHICKEN BROTH       $21.00
Sun Nov 30 01:35:37 2014      SAUSAGE             $28.00
Sun Nov 30 01:35:38 2014      POPCORN             $35.00
Sun Nov 30 01:35:39 2014      CHILI               $49.00
Sun Nov 30 01:35:41 2014      CHICKEN             $56.00
Sun Nov 30 01:35:43 2014      RAISONS             $70.00
Sun Nov 30 01:35:44 2014      TEA                 $77.00
-------------------------------------------------------
Total:                                            $783.00

[CREDIT SUMMARY]
-------------------------------------------------------
Checking Balance              $1034.00
Unpaid Credit Balance         $587.00
Credit to Checking ratio      %56


Enter a key to continue...d
```

Scenario 4: End-of-Month trigger by a manager

This scenario involves the following steps:

1. A customer (joey) has enough checking balance to pay his credit purchases
2. A customer (bobbie) does not have enough checking balance to pay his credit purchases
3. Transaction history for those who successfully pay in full will be hidden
4. Both customers have the default setting of paying in full
5. A manager logs in to the bank system to trigger the end of month

trace.txt

```
Sun Nov 30 02:04:27 2014|SB_Console Client|        Starting Console Client
Sun Nov 30 02:04:30 2014|SB_Console Client|        Attempting to login as 3307
Sun Nov 30 02:04:30 2014|SB_Console Client|        Succesfully logged in as 3307
Sun Nov 30 02:04:33 2014|SB_Console Client|        [Processing End of Month Credit Payments...]
Sun Nov 30 02:04:42 2014|SB_Console Client|        Logging out user: 3307
Sun Nov 30 02:04:33 2014|BANK SERVER|  Triggering end of month event credit processing
Sun Nov 30 02:04:33 2014|BANK SERVER|  Processing user: joey, credit balance: 204.000000
Sun Nov 30 02:04:33 2014|BANK SERVER|  Processing user: bobbie, credit balance: 139.000000
Sun Nov 30 02:04:38 2014|BANK SERVER|  Failed to process user: bobbie due to insufficient checking funds
```

FailedCreditPayments.txt

```
Sun Nov 30 02:04:38 2014|SYS|      User: 4 bobbie failed to pay credit balance of $139.000000
Sun Nov 30 02:04:38 2014|SYS|      Freezing credit account for: bobbie
```

# D5 Design inspection with analysis and findings

We have conducted analysis on group 9's code. The following is our findings.

**Structural correspondence between Design and Code:**
Are all the classes and interrelationships programmed in the application explicitly represented in the class diagram of the system?
Yes No Partly (Can be improved)
Comment on your analysis: The class diagram appropriately represents the implemented system.
Comment on your findings: The class diagram appropriately represents the implemented system.

**Functionality:**
Do all the programmed classes perform their intended operations as per the requirements?
Yes No Partly (Can be improved)
Comment on your analysis: All the functions tested (mentioned in the findings below) accurately perform in accordance with the requirements.
Comment on your findings: The following functions were tested and accurately performed their purpose:

- Customer Functions
  - o Withdraw
  - o Deposit
  - o Transfer
- Maintenance Person Functions
  - o Trace function (associated 'Wraps.cpp')
- Manager Functions
  - o Totals
  - o Create user
  - o Close account
  - o Edit
  - o Account view

**Cohesion:**
Do the methods encapsulated in each programmed class, together perform a single, well defined, task of the class? (High-Cohesion: the functionalities embedded in a class, accessed through its methods, have much in common, e.g., access common data)
Yes No Partly (Can be increased)

Comment on your analysis:
The function of the customer class is the manipulation of account values. The functions of the customer class could be more properly implemented based on this purpose using just one

'MANIPULATION' method. There is no need for separate values for withdrawals, deposits, and transfers – these are all ultimately doing the same thing! One manipulation function is all that is needed (dealing with negative numbers for withdrawal, positive numbers for deposit, and a combination for both.
In the manager class, gathering values from the accounts is done completely separately in the total function and account view functions. This could be made more cohesive by gathering data in the same way (i.e. with the same function). The total function could just do the identical method that the account function does but repeated and totalled.

Comment on your findings:

- Customer Functions
    - o Withdraw – deals with a unique 'withdrawAmount' variable
    - o Deposit – unique 'depositAmount' variable
    - o Transfer – unique 'transferAmount' variable
- Maintenance Person Functions
    - o Trace function (associated 'Wraps.cpp')
- Manager Functions
    - o Totals – Gathering values completely independent from gathering value in account view
    - o Create user
    - o Close account
    - o Edito Account view

**Coupling**:
Do the programmed classes have excessive inter-dependency? (High Coupling: In this case a class shares a common variable with another, or relies on, or controls the execution of, another class.)
Yes No Partly (Can be reduced)

Comment on your analysis: There is very low coupling HOWEVER this is made a significantly easy accomplishment by the very low separation of concerns. The manager class is coupled more than it needs to be as the variables and functions are all named/designed to refer directly to accounts and users. This manager function could be much more reusable if it was implemented as a 'controlling class' that would work on any other [attribute bearing] class (such as a user or an account).

Comment on your findings: There are no shared variables or inter-control.

**Separation of concerns:**
Is the scoped problem decomposed into separate concerns where each concern is encapsulated in a construct such as a class with well-defined interface and cohesive functions with minimal of connections with other concerns?

Yes No Partly (Can be improved)

Comment on your analysis: Because a banking system can have 1) different types of accounts (savings/checking...) and 2) different types of users (consumer/small business/large business...) it is important to separate each of these concerns into separate, loosely coupled classes. Additionally, the accounts (checking and savings) are not only un-capsulated, but are also only represented by a single value. These accounts should clearly be represented by a separate class to allow for proper scalability both in terms of adding more attributes to the accounts and in terms of eventually adding other types of accounts.

Comment on your findings: The accounts and users are defined together in one class! This is not a proper separation of concerns and results in a program that is not scalable.

**Do the classes contain proper access specifications (e.g.: public and private methods)?** Yes No Partly (Can be improved)

Comment on your analysis: A more effective encapsulation and separation of concerns could be implemented by declaring certain functions as private and isolating them to their respective class.
The real issue here is that the functions are not separated enough to allow for the proper balance between private and public functions. As mentioned earlier, manipulating the amount in an account can be done by one [private!] function (for deposit, withdraw, and transfer).
Comment on your findings: It appears that NO classes are privatized.

**Reusability:**
Are the programmed classes reusable in other applications or situations?Yes, most of the classes No, none of the classes Partly, some of the classes Don't know

Comment on your analysis: Both the user and account functionality are completely not reusable. They are coupled into the same class and this therefore hinders both their ability to be reused in another system as a user and account class respectively. The manager class could be made more reusable (as mentioned above) if it were designed as a more generic 'controlling class'.
Comment on your findings: The functions in the user class and the implementation of the account system are coupled into the same class.

**Simplicity:**
Are the functionalities carried out by the classes easily identifiable and understandable? Yes No Partly (Can be improved)

Comment on your analysis: The naming and organization of the classes, functions, and variables properly reflected their functionalities. There was no confusion here.

Comment on your findings: No discrepancies between the setup and the functionalities.
Do the complicated portions of the code have /*comments*/ for ease of understanding? Yes No Partly (Can be improved)

Comment on your analysis: The amount of comments was definitely sufficient to understand the code.Comment on your findings: Comments on top of all functions and variable declarations. Also comments on top of various other complicated processes.

**Maintainability**:
Does the application provide scope for easy enhancement or updates? (i.e., enhancement in the code does not require too many changes in the original code (see, for example, requirements of the "enhancement" project))
Yes No Partly (Can be improved) Don't know

Comment on your analysis: As mentioned in the section of 'separation of concerns', this program is not particularly well separated. This means that changes to one aspect of the program might have affects on others. For example, the User and Account functions are completely coupled into the same class. Thus, changing something in the User functionality would most definitely have an effect on the account functionality. This would make updates significantly more tedious than if the program was more modular.

Comment on your findings: Refer to findings for separation of concerns.

**Efficiency:**
Does the design introduce inefficiency in code (e.g., causes too many nested loops or delays in concurrent processing)?
Yes No Partly (Can be improved) Don't know

Comment on your analysis: If the accounts were separated into their own class, then the 'total' function in the manager class could loop through account objects to get the total. Right now it loops through all the users and checks both checking AND savings accounts. Some of these users might have no money in either accounts, or money in just one of their accounts. This makes looping through all users and both accounts for each inefficient. Other than that, the system appears efficient.

Comment on your findings: The 'total' function in the manager class loops through all users.

**Depth of inheritance:**
Do the inheritance relationships between the ancestor/descendent classes go too deep in the hierarchy? (The deeper a class in the hierarchy, the greater the number of methods it will probably inherit from its ancestors, making it harder to predict its behaviour).

Yes No Partly (Can be improved) Comment on your analysis: User hierarchy is only a 1 level hierarchy.

Comment on your findings: Only hierarchy exists is with users.
Children:

Does a parent class have too many children classes? (This could possible suggest an abstraction problem.)
Yes No Partly (Can be improved)

Comment on your analysis: There is appropriate hierarchical structure (no excessive children).
Comment on your findings: There is a user class that has 3 children (customer, manager, maintenance).

## D6 CCCC Software Metrics Report

Reports generated by cccc are located in CCCC-R1 and CCCC-R2 folders for R1 and R2, respectively.

## D7 Spreadsheet of historical OO measures

The consolidated spreadsheet for R1 and R2 is in the file "D7 – Historical OO Metrics.xls". Below is an overview of it.

## D8 Quality trend across releases R1 and R2

The class BankClient shows risks in the WMC1[1] metric across both R1 and R2 of our system. CCCC[2] reports a WMC1 of 33 in both R1 and R2; this number indicates that there are 33 methods in this class. This threshold, indicated as yellow in CCCC, suggests that BankClient's WMC levels are below the danger line, but still have a cause of concern. Its implications suggest that the class requires a lot of effort to develop; it's complex; and is hard to reuse or maintain. Looking closely at the code again, we see that BankClient is indeed very application specific, and not easy to understand at first glance. BankClient's original intention is to handle console inputs and outputs from the user; then feed user inputs to the bank system logic component, SimpleBank class. BankClient's complexity easily piles up with all the different menus and input possibilities. In the future, we may choose to divide up this class into classes such as CustomerClientMenu, or ManagerClientMenu, to separate different types of client code in order to lower WMC.

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[1] WMC1 – Weight Methods per Class: nominal weight of 1 for each function
[2] C and C++ Code Counter, software

D7 Historyical records of OO Meaures

| | | WMC1 | DIT | NOC | CBO |
|---|---|---|---|---|---|
| R1 | BandAccount | 7 | 0 | 0 | 1 |
| | BankClient | 33 | 0 | 0 | 2 |
| | CheckingAccount | 3 | 0 | 0 | 0 |
| | Client | 13 | 0 | 0 | 3 |
| | ClientDB | 24 | 0 | 0 | 5 |
| | DataEntry | 0 | 0 | 0 | 1 |
| | Logger | 8 | 0 | 0 | 1 |
| | Maintenance | 2 | 0 | 0 | 1 |
| | Manager | 2 | 0 | 0 | 1 |
| | SavingAccount | 2 | 0 | 0 | 0 |
| | SimpleBank | 16 | 0 | 0 | 3 |
| | User | 10 | 0 | 0 | 3 |
| | UserType | 0 | 0 | 0 | 3 |
| | Utils | 3 | 0 | 0 | 1 |
| | anonymous | 1 | 0 | 0 | 0 |
| | | WMC1 | DIT | NOC | CBO |
| R2 | AccountType | 0 | 0 | 0 | 1 |
| | BankAccount | 7 | 0 | 0 | 1 |
| | BankClient | 33 | 0 | 0 | 2 |
| | CheckingAccount | 2 | 0 | 0 | 0 |
| | Client | 13 | 0 | 0 | 3 |
| | ClientDB | 24 | 0 | 0 | 5 |
| | CreditAccount | 3 | 0 | 0 | 0 |
| | DBDelegate | 30 | 0 | 0 | 5 |
| | DataEntry | 0 | 0 | 0 | 1 |
| | Logger | 8 | 0 | 0 | 1 |
| | Maintenance | 2 | 0 | 0 | 1 |
| | Manager | 2 | 0 | 0 | 1 |
| | SavingAccount | 2 | 0 | 0 | 0 |
| | SimpleBank | 25 | 0 | 0 | 4 |
| | User | 9 | 0 | 0 | 3 |
| | UserType | 0 | 0 | 0 | 4 |
| | Utils | 11 | 0 | 0 | 1 |
| | Vendor | 8 | 0 | 0 | 1 |
| | VendorClient | 9 | 0 | 0 | 1 |
| | anonymous | 1 | 0 | 0 | 0 |

The DIT[3] trend across both R1 and R2 have been consistent, the metrics report mostly 0. This trend is caused by the fact that most of our classes are concrete C++ classes and do not pose high level of inheritance. This has implications in very few reused methods across classes, and also low levels of polymorphism. None of the classes show levels of danger or concern.

The NOC[4] trend across both R1 and R2 is also consistent, the metric reports mostly 0. This is again, due to very low levels of inheritance used across the code base. The only inheritance that's lightly used was the User class, having three derived classes: Client, Manager and Maintenance, and the BankAccount class, having three derived classes: CheckingAccount, SavingAccount, and CreditAccount. In both cases, the NOC should be 3 for the base class. Regardless, CCCC reports no levels of danger or concern for all the classes.

Looking at both the DIT and NOC metrics, it is evident that there are very little levels of polymorphism in our code due to the lack of inheritance. One shortcoming of this is the inability to easily extend our classes ones given more enhancement opportunities. Finally, the CBO[5] trends show no signs of danger or concern across both releases; this indicates appropriate design of encapsulation among the classes.

## D9 Modified design including design pattern

The design for our pattern, the command pattern, is included in our D1's UML diagram. The relevant classes involved are highlighted in yellow; namely they are the abstract class ProcessCreditCommand, and the concrete classes PayCreditBalanceCommand and CreditActionCommand.

An ancillary pattern in support of the command pattern is described below.

## D10 Explanation of design pattern

Design pattern: Command Pattern, Factory method pattern

When processing the end-of-month credit purchases by the banking system, there are many combinations of calculations and actions to take depending on the configurations and account statuses of customers. For example, some credit customers have settings to pay in full or pay the minimum 10% for their credit balance. Some customers of the bank do not have credit

[3] DIT - Depth of inheritance tree
[4] NOC – Number of Children
[5] Coupling between objects

accounts activated at all (i.e. when they don't have a checking account yet). There are also customers that have paid the previous month's balances, and thus for this month, we need to disregard the already paid purchases from the vendor. With so many cases of calculation for each customer in the bank system, it can be tedious to check and verify every situation manually in the bank server. To mediate this complex processing issue, we sought to implement the command pattern (with requirements of a factory method pattern) to abstract away each high level processing. First a factory class method (described below) will construct a pointer to the interface of ProcessCreditCommand, where it only has the execute command. The bank server, when processing each user, is not concerned with all it's gritty details of each user, and just calls the execute method. Depending on the specific client in question, each instance of PayCreditBalanceCommand is initialized to reflect that user's configurations, such as payment options, balances and his/her purchase history. This organization ensures the accuracy of processing for each user. And in the event of further enhancements and extensions, or policy changes, we can modify the command class to accommodate processing of all users.

Factory Method Pattern: The factory method design pattern is a creational pattern that can be used in the banking system application to facilitate the creation of ProcessCreditCommand concrete classes. As opposed to most design patterns opting to use new classes, with the Factory method only a new operation is required. In a modified version of the design and banking patterns we can use the factory method pattern by using a template method to create instances of a class.

A bank-processing unit would make use of the template class and be the factory in the situation of generating relevant user info in preparation for processing. The account manager template class would be responsible for creating the exact class of PayCreditBalanceCommand. The vendor system act like a source of data and have control over creating and managing specific client transactions. The account manager class would contain an interface for creating objects while subclasses like the vendor system would control what is instantiated at the time (i.e. new accounts, transactions etc). The interplay with this creational pattern in creating specific commands for processing, it abstracts away the details of each implementation that would otherwise differ for each customer. Overall, this pattern separates a layer of concern between what the bank server should know in processing each user's credit information and payments.