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Investment Analysis System

Object-Oriented Specification and Design

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# Introduction

This report is to accompany the Investment Analysis System. It will consist of all the materials that were produced throughout the project during the various stages. For instance, use case diagrams which were created during the initial requirement elicitation stage will be included, along with analysis of said diagrams. This project was centred around the financial world; specifically, investments through the purchase of bonds. Due to this, research has been undertaken to obtain a clearer understanding of what is being requested, as well as what is expected from the final system. References of sources will be included at the end; all references stated have either directly or indirectly aided in the understanding of this system. The roles that each team member had have been described towards the end of this report, contributions made by each member have too been stated.

# Background Study

“*Investing is the act of committing* [*money*](http://www.investopedia.com/terms/m/money.asp) *or* [*capital*](http://www.investopedia.com/terms/c/capital.asp) *to an endeavour (a business, project,* [*real estate*](http://www.investopedia.com/terms/r/realestate.asp)*, etc.) with the expectation of obtaining an additional income or* [*profit*](http://www.investopedia.com/terms/p/profit.asp)*. Investing also can include the amount of time you put into the study of a prospective company, especially since time is money.*” (Investopedia, n.d.).

‘Investing’ as the very well written definition above states, is essentially a way for people to make profit. It could be on a small personal level where an individual invests for self-gain, or might be on a larger scale where a business invests for the betterment of the company. In terms of finance, investments are usually made by giving money to an organisation (i.e. a bank) who then with the money they receive, invest at a significantly larger scale. Depending on how much money individuals have invested, they then receive a portion of any turnaround the organisation makes.

There are various ways to invest, a simple but effective one is to loan money to those who need it and then add some interest. In fact, there are services available who make this process a lot easier by helping connect people together and managing the whole procedure. An example of such a service provider is “LendingClub”, they not only have investment options for institutions, but regular individuals too.

The investment method that this project and system is concerned with are bonds. A bond is an investment whereby the investor loans money to a company (usually governmental or corporate), who then borrows the money for an agreed amount of time while paying the investor a variable or fixed interest rate at a frequency, before paying the initial investment back.

Bonds have properties which define how profitable they truly are. Bonds typically last for a couple of years, the duration is known as their ‘term’. They each have a coupon which is the percentage (fixed or variable) of the original investment that will be paid back at an agreed frequency, e.g. a 10% coupon which is paid once a year.

When a term ends, the final coupon is paid, and the initial investment is returned. When deciding to purchase a bond, the inflation rate and consequently the value of the currency when the term ends needs to be considered. £100 today will not be worth the same in two years, this is as gradual inflation would decrease the value of a pound.

The Macaulay duration of a bond “measures the present value weighted average maturity for a bond. It describes how sensitive a bond’s price is to changes in interest rates.” (Investopedia, 2015)

A good Macaulay duration can help reinforce the decision to invest in a bond. The longer the term of a bond, the greater the risk the investor is taking due to the volatile value of money. Especially since all inflation rates are estimations and in reality, anything could happen.

Simply put, the Macaulay duration is the average number of years after the purchase date of a bond at which point the sum of the present value of the cash flows received would equal the amount paid for the bond. Therefore, a quicker maturing bond is a safer bet, as there will be a shorter time frame in which the value of money could possibly decrease.

The internal rate of return (IRR) is a percentage which states the rate at which the value of the bond equals the price paid, without taking factors such as discounted payments or inflation into account. An IRR can be calculated for most investments and is not necessarily restricted to bonds. All that is needed to calculate the IRR is the price paid and the cash flows.

Example, if we pay £80 for a bond and get back the cash flows of: £10, £10, £10, £110; the IRR would be equal to 17.339%. This is as when using this rate: 10/(1 + 0.17339)1 = 8.52, 10/(1 + 0.17339)2 = 7.26, 10/(1 + 0.17339)3 = 6.19, and 110/(1 + 0.17339)4 = 58.03, the sum of the results is £80 which is the amount we paid. If the IRR is being calculated by hand it is done through trial and error, fortunately software offering this functionality is available (e.g. Microsoft Excel). If the inflation rate in reality is higher than the calculated IRR, then the bond is not a good deal for investors, if it is lower than the IRR, it is a good deal for investors.

# Requirements

From analysis of the project brief, several key requirements have been identified. Firstly, the system should allow new bonds to be defined with the attributes: name, term, coupon, frequency of payments, purchase date, and price. The system should have the ability to add bonds to an investor’s portfolio too.

In terms of computations, there are four calculations that the system is required to perform. The system should be able to compute the sum of all payments from a bond.

* If a bond pays out the following: £20, £20, £20, £120. The system should display the sum as £180.

The payments would be calculated from the coupon, here the investor has invested £100 where the coupon is paid annually at a 20% rate.

The system ought to be able to do this whilst taking an inflation rate into account too (as a separate feature).

* For the same bond with a 2% inflation rate, the payments would be: £19.61, £19.22, £18.85, £110.86. The sum that would be expected from the system here is £168.54.

Another computation that the system needs to perform is calculating the Macaulay duration of a bond.

* The system should be able to calculate that the above bond has a Macaulay duration of 3.31 years.
  + £19.61 \* 1 = £19.61, £19.22 \* 2 = £38.44, £18.85 \* 3 = £56.55, £110.86 \* 4 = £443.44, total = £558.04
  + 558.04/168.54 = 3.31 years.

The final computation that the system should offer, is being able to calculate the internal rate of return from knowledge of the payments and amount paid for the bond.

* Using the example bond’s payments and assuming the bond price was £160, it should be possible to request that the internal rate of return is computed. The expected response in this case would be 3.619% since:
  + 20/(1 + 0.03619)1 = 19.30, 20/(1 + 0.03619)2 =18.63, 20/(1 + 0.03619)3 = 17.98, and

120/(1 + 0.03619)4 = 104.09, the sum of the results being £160 (the price).

## Ambiguity:

There are some ambiguities that are apparent with the assignment brief. The first ambiguity noticed was that the brief states: the system enables new bonds to be defined. However, it does not mention which type of users define them, nor does it state which type of users will be using the system. If the system is used by investors solely, then who defines the new bonds? Surely, if an investor had the opportunity to define bonds himself, he would define it to maximise his profits. This is not realistic as organisations selling bonds would essentially be giving out free money.

Another ambiguity is the amount that investors invest into each bond. The brief states that the investment is “100” yet doesn’t say whether that is to mean £100, or means 100% of another value.

It is also unclear whether the name of bonds can be used to uniquely identify them as it has not been stated.

Furthermore, the brief tells us that investors can purchase bonds, but it does not mention whether an investor may purchase the same bond more than once.

Although we are told the properties of the bonds (e.g. coupon, price, name), the data types of these attributes have not been expressed.

The number of investors using the system is ambiguous too, the brief does not give any indication that more than one investor might be using the system. This is as it has not mentioned that the system should have the functionality to create portfolios. If the system should be able to create additional portfolios, would some sort of authentication be required to prevent users from accessing another investor’s portfolio?

Finally, the brief never mentions that there are different types of bonds in the real world. Therefore, is the system to stick to the type of bond described in the brief, or should it include other types such as “Gilts” (government bonds).

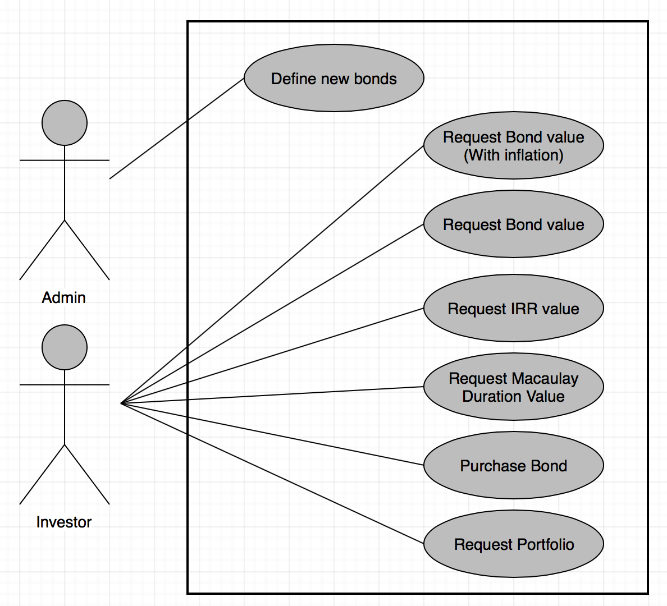
## Assumptions:

The first assumption that has been made is that an admin would have the authorisation to define new bonds, whereas an investor would only be able to view and purchase pre-defined bonds. It is assumed that the authentication system will be disjoint with the investment analysis system. Due to this, our system will make all operations available and assume that the current user has already been authorised (i.e. logged in). The amount that investors will invest into each bond is assumed to be £100, as it seems like this is what was meant when the brief said “investment = 100”. Moreover, it has been assumed that an investor may purchase the same bond more than once. This is because there seems to be no harm in allowing an investor this opportunity. Especially since there was no mention of there being a limited quantity of each bond. The data types of the attributes will be what is deemed to be most appropriate. For instance, the name of a bond will be a String, and the term of a bond will be an integer.

Next, there will be only be a single type of bond, and it will be the way bonds have been described within the brief.

Lastly, it will be assumed that the name of a bond isn’t necessarily unique, thus bonds will now have an additional attribute known as “ID” which will allow bonds to be unique identified.

# Use Case Diagrams



Use Case steps

# Class Diagrams

Classes, Attributes, Visibility, Associations.

# Architecture Diagram

Lorem ipsum.

# Operation Definitions

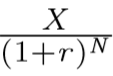
Below, the four main operations that the functional core offers have been defined. These are the operations that calculate valuable information for investors such as calculating the bond value, the Macaulay duration, and computing the Internal Rate of Return.

## Calculate All Pay-outs

This operation calculates the sum of the payments that would be received from a bond. This computation requires the bond’s coupon and the amount invested (fixed at £100). Essentially, this function works out the amount that the bond annually pays from knowledge of the coupon. Then it sums up the payments by multiplying the amount paid by the term. As the investment is returned at the end of the term, the £100 is then added to the sum of the payments and the result is returned.

## Calculate Bond Value

Calculating the bond value has the same algorithm as the operation above, the difference is that in order to obtain an educated estimate of the bond value, an inflation rate is taken into account. Therefore, each payment is re-evaluated using the inflation rate and the year that this payment would have been made. The formulae for this is:

Where *X* is the payment, *r* is the inflation rate, and *N* is the year of the term of when this payment would be made. For instance, if a payment was £10 and was to be paid 3 years into the term; the value would be £8.64 assuming the inflation rate was 5%, and would be £9.42 if the inflation rate was 2%.

## Calculate Macaulay Duration

To calculate the Macaulay Duration of a bond, the discounted payments are required. There are three calculations that need to be processed to output the Macaulay Duration. Firstly, the bond value needs to be obtained (previous operation). Then, the sum of the discounted payments multiplied by their corresponding year is needed. Finally, the latter is divided by the first giving us the Macaulay Duration.

## Calculate IRR

The IRR was the most computationally expensive operation within the functional core (relative to the other operations). The reason being is that as mentioned in the background study, the IRR cannot be directly calculated from knowledge of the bond price and the payments. Yet, it can be derived when some trial and error is involved. The algorithm for this operation was simply to start off with a blind guess of what the IRR could be, then the bond value is calculated using this IRR to see if it matches the price of the bond. Depending on how far off the result was from the actual bond price, the IRR is then adjusted to get a more accurate result. This is then repeated until it satisfies the pre-defined margin of error.

# Pseudocode for operations

## Calculate All Pay-outs

## Calculate Bond Value

## Calculate Macaulay Duration

## Calculate IRR

# Pseudocode for Use cases

## Calculate All Pay-outs

## Calculate Bond Value

## Calculate Macaulay Duration

## Calculate IRR

# Code Listing

Lorem ipsum.

# Test Cases

Lorem ipsum.

# Team Member Roles/Contributions

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# Meetings Register

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| ***Name*** | ***Date*** | | | | | | |
| 17/10/17 | 24/10/17 | 31/10/17 | 07/11/17 | 14/11/17 | 21/11/17 | 28/11/17 |
| Mert | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |  |
| Aflal | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |  |
| Anton | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |  |
| Damyan | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |  |
| Yuji | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |  |

# Conclusion

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# Bibliography

Investing Answers, n.d. *Macaulay Duration.* [Online]   
Available at: http://www.investinganswers.com/financial-dictionary/bonds/macaulay-duration-5079  
[Accessed 25 October 2017].

Investopedia, 2015. *What does the Macaulay duration indicate about a bond?.* [Online]   
Available at: http://www.investopedia.com/ask/answers/050115/what-does-macaulay-duration-indicate-about-bond.asp  
[Accessed 25 October 2017].

Investopedia, n.d. *Bond.* [Online]   
Available at: http://www.investopedia.com/terms/b/bond.asp  
[Accessed 25 October 2017].

Investopedia, n.d. *Investing.* [Online]   
Available at: http://www.investopedia.com/terms/i/investing.asp#ixzz4wXU620Nc  
[Accessed 25 October 2017].

LendingClub, n.d. *About Us.* [Online]   
Available at: https://www.lendingclub.com/company/about-us  
[Accessed 25 October 2017].

Rose, J., 2016. *7 Smart ways to invest $1000.* [Online]   
Available at: https://www.forbes.com/sites/jrose/2016/03/15/how-to-invest-1000-dollars/#466e5e23c48a  
[Accessed 25 October 2017].

Tarver, E., 2015. *What impact does inflation have on the time value of money?.* [Online]   
Available at: http://www.investopedia.com/ask/answers/042415/what-impact-does-inflation-have-time-value-money.asp  
[Accessed 25 October 2017].