

# Thalia Project Report

Team Charlie

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## Acknowledgement

TO DO: Thank stackoverflow and everyone else here.

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# 1 Introduction

## 1.1 Project Overview

The aim of this project was to create a portfolio backtesting software, which enables creating custom portfolios and measuring their performance with different backtesting functions. The user can pick from a variety of assets, some of which are Equities, Fixed Income, Currencies, Commodities, and Cryptocurrencies. Risk metrics and performance are then visualized for the given asset allocation.

## 1.2 Motivation/Rationale

Since retail investing is a growing market, our target audience consists of individual investors, who instead of seeking the full package that comes with financial advising, would like to take over the wheel and assess the viability of their investment strategies themselves. As retail investors are non-professionals and invest comparatively small amounts, with financial advice services being non affordable for those individual clients, our goal was to create a product that would not only be more affordable for small retail investors, but would also include a variety of international assets, which most existing backtesting software fails to provide.

## 1.3 Project management strategy

The creators of Thalia are:

- Martti Aukia
- Arthur-Louis Heath
- Albert Boehm
- Marcell Veiner
- George Stoian
- Daniel Joffe
- Weronika Kakavou

The team held regular meetings, both with the project guide, Dr Nigel Beacham, and the Dr Ernesto Compatangelo. During the analysis stage meetings took place weekly and were aimed to discuss ideas and requirements. Whereas later, during the implementation stage the team held meeting at least once per week, some of which were aimed to discuss the design for the tool with the inclusion of some coding sessions.

As in the past, our workflow was centered around the GitHub platform and the tools it provides. Furthermore, we continued to follow the Egalitarian Team structure, as this worked very well during the first term of the course. In our Technical Report [1] we also discussed the use of effort-oriented metrics, i.e. story points, which were assigned to tickets based on the time needed and the functionality of the task. However, the following term we concluded that in many occasions these metrics failed to successfully measure the size of a task, as they were artificially assigned. Based on this observation, we decided not to make use of them for the rest of the development.

As we were fortunate enough to gain an additional member this term, some of our initial effort was focused on introducing her to the project and team dynamics. Given our access to a large team, it was common to see coding tickets assigned to pairs and groups rather than individuals. We believe this not only resulted in writing better-quality code, but in faster team communication when making design decisions.

## 1.4 Budget

As previously discussed, we did not have any budget restrictions other than time. All of us agreed to allocating a minimum of 10 hours per week to development efforts and discussed personal expectations well in advance.

## 2 Background and Competitors

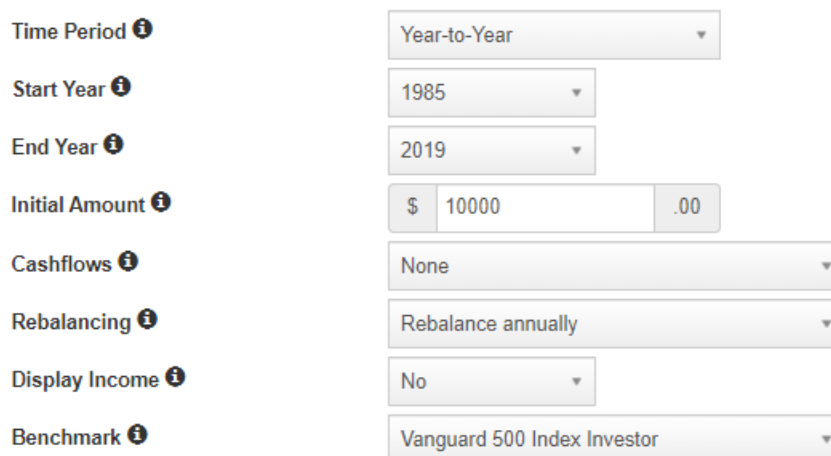
As a result of our initial competitor analysis, we may group the competing software into two categories. For a comprehensive list of available backtesters please see [2]. The first consists of various third-party trading software, such as Fidelity, MetaTrader and NinjaTrader that offer backtesting features as well. Although it may be beneficial to consider some trading features provided by the members of this group, these would only be part of a future development process, and not in the scope of this course.

The second category consists of pieces of software that do not offer trading as a service, and solely focus on backtesting. Thus, for now, we shall only consider the feature set provided by the second category. In the following paragraphs we will consider some of the design decisions made by competing software, together with the brief analysis and conclusion on each feature.

### 2.1 Portfolio Visualizer

Our main competitor of the second category is an online backtesting tool named Portfolio Visualizer[3]. During the inception phase of development we heavily relied on this website for writing the requirement analysis. Let us now briefly dissect what it has to offer.

Upon opening the website we are greeted with a brief description of the domain, together with the following input form:



The screenshot shows the input form for Portfolio Visualizer. It includes the following fields and their current values:

Field	Value
Time Period ⓘ	Year-to-Year
Start Year ⓘ	1985
End Year ⓘ	2019
Initial Amount ⓘ	\$ 10000 .00
Cashflows ⓘ	None
Rebalancing ⓘ	Rebalance annually
Display Income ⓘ	No
Benchmark ⓘ	Vanguard 500 Index Investor

Figure 1: Portfolio Visualizer - Input

As we can already see, the key elements of portfolio analysis are provided. Considering the functionality of our prototype as a baseline (that is testing an allocation of assets with a fixed initial investment on a fixed time period), we see that in addition users are able to do the following set of features:

- Set the endpoints of the investment period, up to months.
- Set the initial investment.
- Specify a regular cashflow and its frequency.
- Select a rebalancing strategy.
- Select a benchmark strategy for comparison.
- Compare multiple strategies at the same time.
- Adjust to inflation.
- Select from a set of lazy portfolios.

- Calculate additional metrics.
- Export the results to PDF, Excel, or save link.

At first it may seem as if Portfolio Visualizer meets all the requirements needed for a financial backtester, and indeed our main criticism is regarding the UI, responsiveness and user experience, and is a result of the initial user testing.

The UI design is simplistic and has a non-commercial, bare-bones look, and although this was appreciated while testing the system, it certainly does not improve the user experience. The input, mostly using dropdown menus is straightforward to use, except for the selection of Assets, which we will discuss briefly at the end of this section.

Moreover, users will want to fine-tune their investment strategies, by changing their allocations frequently. The only means to do this using Portfolio Visualizer is to scroll to the top, change the input and send it again. Our goal is to design a more responsive and dynamic system, to ease this procedure.

The website also has user accounts, these accounts however offer little to no extra features, which further decreases the overall user experience. Finally, as a last remark, which holds for most of the backtesting tools we have tried, the website is heavily US biased, and so the selection of asset classes is limited. Furthermore, we have no means of changing the currency, which would also be an important feature.

## 2.2 Other Competing Software

The rest of the alternatives are of a significantly lower quality. In the remaining parts of this section we will briefly consider a few design decisions made by these websites.

### Tree-like Asset Selection

One of the tricky design decision in building the system, is the following:

What is the most intuitive way for selecting a portfolio item?

Where a portfolio item could be: an equity, ETF index, a commodity, bond or stock. Within these classes we have more options to choose from. Many backtesters opted for a search bar, which is a sensible approach, but poor in practice. Many portfolio items are named similarly, and for a new user it is a barrier, as they might not know what is available.

One of the better option is what ETFReplay [4] has implemented, which is a tree-like selection form, shown below.



Figure 2: ETFReplay - Tree-like Structure

We feel this was the most intuitive to use, and will thus pursue a similar approach. Our only criticism was that it opens in a new window, which we would like to avoid.

## Tiles

It may be worth briefly discussing an example of a backtester with a good layout design. We found the simplistic and tiled design of Backtest Curvo [5] a good choice as it gives the website an overall modern and fresh look, whereas most backtesters looked old and out of date. Our goal is to achieve a layout similar to this. For a further analysis on design decisions, please see section 4 of this report.

## Simple Logic

In our whitepaper, we briefly discussed implementing a simple scripting language allowing users to simulate dynamic trading strategies. As mentioned, this would not be in the scope of the course, but for inspiration we can have a look at the approach of Stockbacktest [6].

**Signals (Need at least one buy or short signal)**  
 Buy When:

Signal 1:	Upper Bollinger Band (days devs) ▼	Crosses Below ▼	Percentage % ▼	AND ▼
	20 2	none	70	
Signal 2:	Close Price ▼	Is At Least % Above (%) ▼	Percentage % ▼	
	none	15	10	

Figure 3: Stockbacktest - Simple Logic

Although not intuitive at all, given its presentation, it shows this feature is also possible. We believe that after nailing down how exactly the user would create the rules, this would be a straightforward task, as the calculations involved are not more complicated than in the static case. As mentioned above, this is something we would like to implement in the future.

## 2.3 Summary

As we initially tested the competing software during the inception phase of development, we were left with three key observations. These were the following:

- Transparency: Many of the testers we have found did not look transparent or trustworthy, which is something we should avoid.
- Learning Curve: After getting to know our target audience we concluded that most seem willing to learn how to use a complex system if it is worth it.
- Design of the UI: It was easy to tell which backtesters are still getting updated, by looking at their design. We should aim at looking fresh. In addition, some backtesters offered so many features that every corner of their UI was packed with information, this is something we should also avoid doing.

Having analysed the competing software, we are now better suited to determine the requirements of our system.



### 3 Requirements

Earlier in the inception phase of the development, we classified our requirements using the established FURPS+ model [7]. Let us briefly revisit our main functional and non-functional requirements. The items outlined below focus on some of the key requirements we have so far identified as features necessary for providing a compelling product for paying customers.

#### 3.1 Functional Requirements

Portfolio Configuration	
Allocate fixed amount/proportions of the portfolio to given assets	Choose how much each asset contributes to the portfolio's total value using either percentages or raw monetary amounts
Find assets quickly by category or name	When adding an asset the user can search a category for assets or search for a specific asset by its name
Share portfolio	Portfolios can be shared between people using a URL
Edit portfolio	Change asset allocation and their distributions in a portfolio

<b>Portfolio analysis</b>	
Compare portfolios	Use multiple portfolios in a single analysis to see differences in their performance
Use a selection of lazy portfolios	Select an existing common portfolio to compare against, such as common index funds (e.g. Vanguard 500 Index Investor or SPY)
Plot portfolio as a time-series	View portfolio performance as a line graph for a quick overview
Specify a time frame for the analysis	Select start and end dates for portfolio analysis
Choose rebalancing strategy	Optionally choose a strategy for buying and selling assets to meet your strategy e.g. buying and selling stocks each year to ensure the value of portfolio stays at 60% stocks and 40% bonds (i.e. maintain the initial allocation)
Change the distribution of assets in a portfolio using a slider	A slider for each asset to quickly increase or decrease its proportion of the total value
Edit portfolio analysis	Change parameters for portfolio's analysis after running it (e.g. date range or rebalancing strategy)

<b>View results</b>	
See key numerical figures	Show important numerical metrics for a portfolio's performance such as Initial Balance, Standard Deviation, Worst Year, Sharpe Ratio, and Sortino Ratio
See both real and nominal values	See portfolio's value as both adjusted and not adjusted for inflation
A breakdown of portfolio value at specific points of time	See what the value of the portfolio is at some point in time (e.g. January 3rd 1997)
Export result of analysis	Exports results to PDF for sharing and offline reading

User accounts	
Combine portfolios	Combine two portfolios' assets into one single portfolio
Save portfolio analysis for later	Save portfolio analysis parameters to the account so you can rerun it with a single click
Delete saved portfolio analysis	Remove a stored portfolio analysis from your account
Manage portfolio analyses	Edit saved portfolio analysis with different assets, distributions or other parameters
Sign-up, log in and log out	Basic authentication

Assets	
Choose assets from European market	Data for European assets were found to be lacking in competing products
Choose assets from Equities, Fixed Income, Currencies, Commodities, and Cryptocurrencies	Coverage of some of the largest asset classes

## 3.2 Non-functional Requirements

### 1. Usability:

- The product must be easily usable for users who already have some financial investment experience.
- The basic backtesting interface needs to look familiar to people already experienced with it.
- The product must have detailed instructions on how to use its advertised functions.
- All major functions must be visible from the initial landing page.
- Must work in both desktop and mobile browsers.
- The results page should scale with mobile.

### 2. Reliability:

- The product must have a greater than 99% uptime.
- All our assets need to have up to date daily data where the asset is still publicly tradeable.
- All assets supported by the system must provide all publicly available historical data.

### 3. Performance:

- The website should load within 3 seconds on mobile [2].
- Large portfolios must be supported - up to 300 different assets.

### 4. Implementation:

- The system needs to work on a cloud hosting provider.

#### 5. Interfacing:

- The Data Gathering Module must never use APIs stated to-be-deprecated within a month.
- The Data Gathering Module must not exceed its contractual usage limits.

#### 6. Operations:

- An administrator on-call will be necessary for unexpected issues.

#### 7. Packaging:

- The product needs to work inside a Linux container (e.g. Docker).
- All dependencies need to be installable with a single command.

#### 8. Legal:

- All user testing must be done with ethical approval from the University.
- UI must display a clear legal disclaimer about the service not providing financial advice.
- All third-party code should allow for commercial use without requiring source disclosure (e.g. no GPL-3).
- User data handling should comply with GDPR.

In the literature, the FURPS+ model has been criticised to disregard developer consideration [8], such as not taking into account portability and maintainability.

TODO

Furthermore it has been pointed out, that our requirements fail to capture ...

TODO

### 3.3 Use Cases

TODO

### 3.4 Feasibility Analysis

TODO

## 4 Design

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## 5 Coding and Integration

After a brief overview of the project and the project plan, this section will focus on the main technologies used in the project and the rationale behind choosing them. Moving on, we will discuss how these components were integrated and eventually deployed.

### 5.1 Overview

One of the first decision we have made this term was to completely recreate our prototype of Thalia. Firstly, this radical move was the consequence of a new implementation decision (for more detail see 5.4.1). Secondly, as prototypes are meant to be disposable and are designed only to answer key questions about the system [9], the proof of concept served its purpose, giving us a chance to refine the structure and the quality of the code.

Despite of the risks posed by using an Software Version Control (SVC) Host such as GitHub, we have decided to continue using it as our software development platform. The reasoning behind this builds on the argument developed in our Technical Report [10], which highlights that our, that our Data Processing Module is a completely separate component in our system which none of the other components is able to access. Additionally, we are storing API keys as environment variables in a file that is not tracked by our SVC system, which minimizes the probability of us exposing sensitive data.

TODO talk about API keys and security measures

We have also decided to develop the application with python as our main choice of programming language. Even though this choice seemed obvious from the beginning, we did consider its main benefits, these would be the following:

- Python is a high level programming language allowing us to better focus on the application.
- A standard choice for prototyping.
- Provides superb third party libraries and frameworks for free.
- Easy to integrate if we were to choose other languages at some point in our development.
- The whole team was already familiar with the language, saving us the precious time needed to learn another programming language.
- Our application does not require an unreasonable amount of computation, so there is no need for a more efficient programming language such as C. 5.4.3 [11].

We will discuss other technologies used in more detail after the discussion on project planning.

### 5.2 Planning

Early in the inception phase of development we have decided that our goal was not to have fixed responsibilities in our team, allowing everybody to work on each component of the system. This decision has also eased the code review process, as we had no status differences to distort the error-correcting mechanism [12]. Furthermore, since no team member was the sole developer of a system component, this allowed us to direct comments at the code and not the author [13]. For these reasons we have decided to follow the Egalitarian Team structure, and make use of the flexibility offered by it.

Our workflow was centered around the tools provided by GitHub. We used a ticketing system to divide and distribute tasks among team members. These tickets were sometimes given by the team on the weekly meetings, but occasionally they were chosen by the member proposing the feature or change. Our goal with this approach was to divide larger jobs into smaller tasks.

A typical ticket in our project was an encapsulation of a user story, as it consisted of a title, a one liner, value, acceptance criteria, and sub tasks. In the first half of development we also used effort-oriented metrics, called story points to measure the amount of work but we decided to abandon this aspect. An example of a ticket can be seen on Figure4.

mara42 commented on Nov 17 2019 • edited
+ 😊 ...

As a user, I want to see the results of a backtest, so I can use the tool.

**Value**

- Working product

**Acceptance criteria**

- Does pressing submit on the portfolio page return results of the backtest?
- Do the results contain a table of key metrics?
- Do the results contain a graph?

SP:?

Subtasks:

- ☒ Send user input to backend
- ☒ Send backtest data back to frontend
- ☒ Create graph
- ☒ Create table

Figure 4: Ticket Example

TODO update git stats

Throughout the whole project we had a total of 110 tickets, and 71 pull requests. The following graph also shows the number of contributions to master, excluding merge commits.

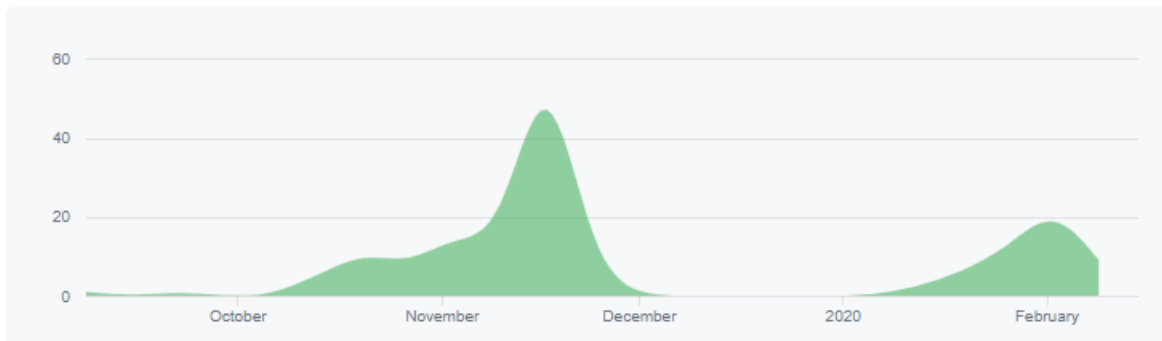


Figure 5: Contributions to the Master branch

Nevertheless, this was not always achievable especially in the beginning of the development when more crucial components of the systems were developed. In these cases, we assigned the ticket to a pair, or group of people. This approach achieved the following:

- Improved the overall code quality and fastened production [14].
- Minimised review time on the long run.
- Distributed the knowledge of large system components amongst a few people instead of one.
- Eased introducing the new team member to the project.

In addition, we also had a scrum board as an overview for the ongoing tickets. Although in the Scrum community there are ongoing discussions about the benefits of a physical scrum board over an online one

[15], given no actual workplace this was not possible to achieve. This allowed us to see which tickets needed to be reviewed and which were ready to be merged. The tickets/cards were distributed into columns, such as To do, In progress, Review in progress, Review complete and Finished. A truncated picture of this scrum board can be seen on figure Figure6.

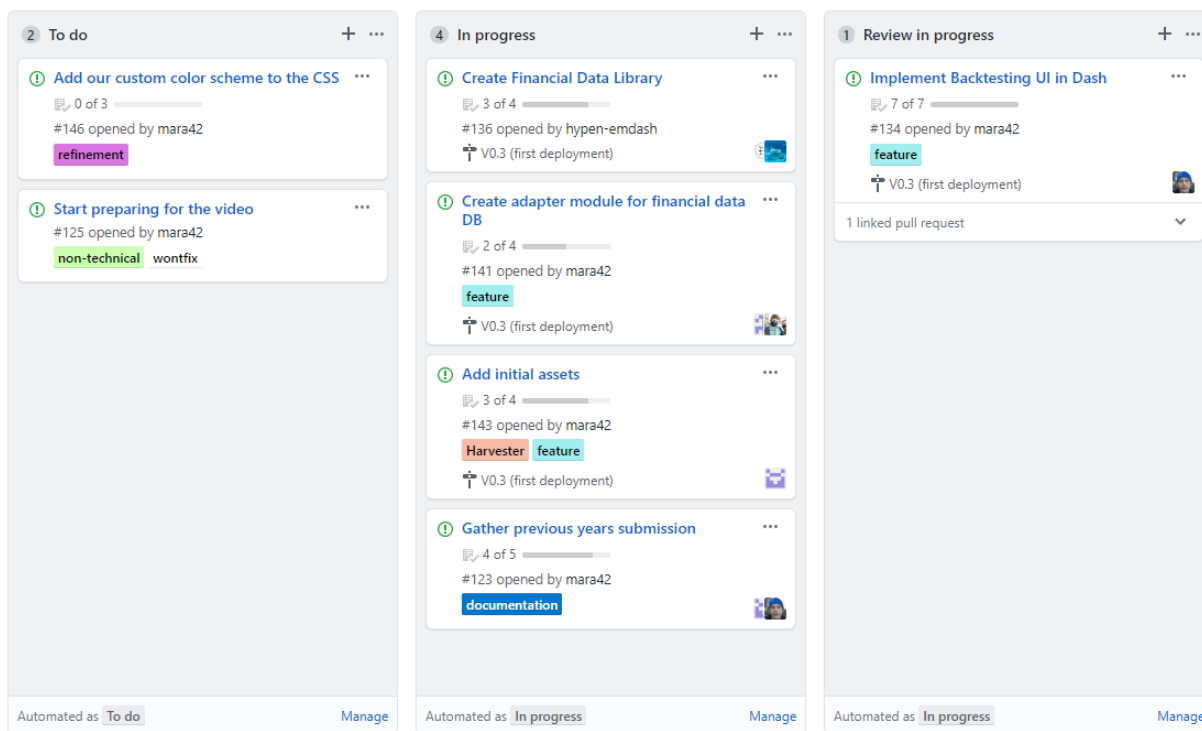


Figure 6: Scrum board - truncated

The workflow then largely depended on the task at hand and the person working on it. It was up to them if they met for pair-programming, or chose to work individually. In the beginning we all agreed on the developing environment and coding standards (for a detailed analysis see the later section 5.5). Since this report was a relevant portion of the workload, we decided to treat it as code. The report was written in  $\text{\LaTeX}$ , first creating the overall structure of the document with a `main.tex` compiling the sections together. This let us to work on different sections separately just like features in our software.

Regardless of the nature of the ticket, the week, or in case of some larger tasks, two weeks, ended by the creator indicating that the changes were ready to be integrated. This was done by publishing the changes and creating a new pull request, pushing the changes onto the master branch. To ensure code quality, we set up a continuous integration (CI) environment (more on that in 5.5). After all checks have passed, the changes were successfully integrated into the code base.

### 5.3 Schedule

As mentioned in our Technical Report, we introduced some milestones or releases for our product based on incremental sets of features. This was done to help us stay on track with development. The roadmap based on this schedule can be seen on Figure7.



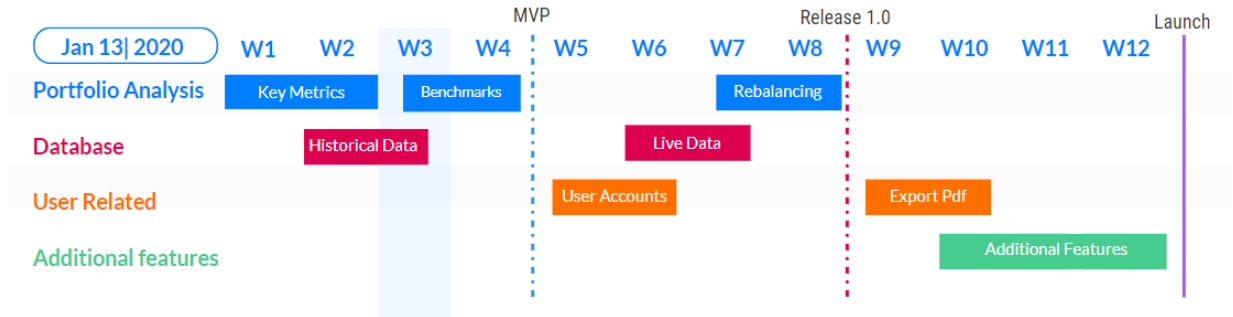


Figure 7: Technical Report: Roadmap - revisited

TODO retrospective on schedule

## 5.4 Key Implementation Decisions

Let us now discuss the main technologies used in our project, these can be categorised as follows:

### 5.4.1 Web Framework

Choosing the right web framework was more controversial than originally planned. The two major options for Python are Django and Flask. Although we decided to use Django for our MVP in the first semester, we had to spend a significant portion of the time available learning the framework, so we had to decide whether we were going to stick with it or learn Flask. In the end, we opted to go with Flask for the following reasons:

- Django has one architecture that all projects must share, and we have designed the architecture for our project ourselves. While neither architecture is wrong, the two are not compatible. Flask, on the other hand, is structure-agnostic, so we can lay out the code as we see fit.
- Flask comes with the bare minimum for web-development, which means that we don't need to manage the complexity of any feature we're not using. Django has a more complete feature-set from the beginning. This would be desirable in a large web application, but introduces significant overhead in our case, where the website has only a handful of pages.
- Django all but insists on using its ORM for all database interaction, while we plan to have a more manual approach.
- Our concerns were also confirmed by more experienced web-developers, suggesting simpler alternatives.

As stated this decision has contributed to the opportunity to recreate the basis of our application, and to apply what we have learnt from our prototype.

### 5.4.2 GUI

### 5.4.3 Business Logic

### 5.4.4 Database & Finda

### 5.4.5 Harvester

## 5.5 Integration

Writing well documented and good quality code is one thing, but making sure it all works together as a whole is a completely different story. In the first term, many hours have been wasted on trying to integrate different components of the system which did not want to fit together. Even then we had some DevOps tools in place [16], but considering that we had to produce significantly less code and more documentation last term, this was not a priority.

Starting afresh the coming term, we have decided to set up the development environment again. Upon opening the setup.py file, we see a list of required libraries, and the following two lines of code:

```
1 """A setuptools based setup module."""
2 from os import path
3
4 from setuptools import find_packages, setup
5
6 here = path.abspath(path.dirname(__file__))
7
8 install_requires = [
9     "flask",
10    "flask-login >= 0.5",
11    "flask-migrate",
12    "flask-wtf",
13    "pandas",
14    "dash",
15 ]
16
17
18 tests_require = ["pytest", "coverage"]
19
20 extras_require = {"dev": ["black", "flake8", "pre-commit"], "test": tests_require}
21
22 setup(
23     name="Thalia",
24     version="0.2.0",
25     packages=find_packages(),
26     install_requires=install_requires,
27     extras_require=extras_require,
28 )
```

Listing 1: setup.py - Development environment

One of the first decisions we had to make, is to decide on a standards coding style. This is exactly what flake8 is for, which we can see amongst the extras in the code snippet above. The original documentation of flake8 defines it as ” [...] is a command-line utility for enforcing style consistency across Python projects. By default it includes lint checks provided by the PyFlakes project, PEP-0008 inspired style checks provided by the PyCodeStyle project, and McCabe complexity checking provided by the McCabe project” [17]. However, as many other developers we also decided to redefine the maximum line-length from 79 to 88 as we found this convention a hindrance.

Another tool used for enforcing uniform style was the black auto-formatter for Python [18], which formatted the code for us upon every save if enabled, and also when committing code. This has been achieved by the use of githooks [19], which are programs that are triggered upon certain git actions. For this we needed the pre-commit package for setting up these actions and writing the configuration file. This ensured that both flake8 and black have been run before publishing changes.

### 5.5.1 Continuous Integration

Many studies have investigated the positive effects of developing in a continuous integration (CI) environment [20], [21]. Regardless of the exact implementation, its obvious benefit is that it provides security and uniformity for projects. We already made some steps to achieve a uniform style, but had no means to know whether the code published has been also passed its tests. Note in this section we will only discuss testing as a part of CI and not the testing strategy, for that see the section 6.

Another important part of the DevOps toolchain is the use of containers, which is what Docker helps to achieve [22]. Docker helps developers focus on writing code rather than worrying about the system the application will be running on, and also helps to reveal dependency and library issues. As Docker is open source, there are many free to use docker images available online [?]. When choosing the CI environment, Docker support was one of the main requirements.

The most promising candidate for this was CircleCI [23], which is a cloud-based system with first-class Docker support and a free trial. After connecting our GitHub repository to CircleCI, and setting up a

configuration, CircleCI now does the following on every pull-request:

1. Sets up a clean container or virtual machine for the code.
2. Checks previously cached requirements.
3. Installs the requirements from requirements.txt
4. Caches the requirements for faster performance.
5. Clones the branch needed to be merged.
6. Runs flake8 one last time and saves results.
7. Runs tests and saves results.
8. Deploys the master branch to Heroku, see 5.6

The outcome of these steps is visible on CircleCI, but more importantly also on GitHub, and it refuses to merge if failing test (or no tests) have been found.

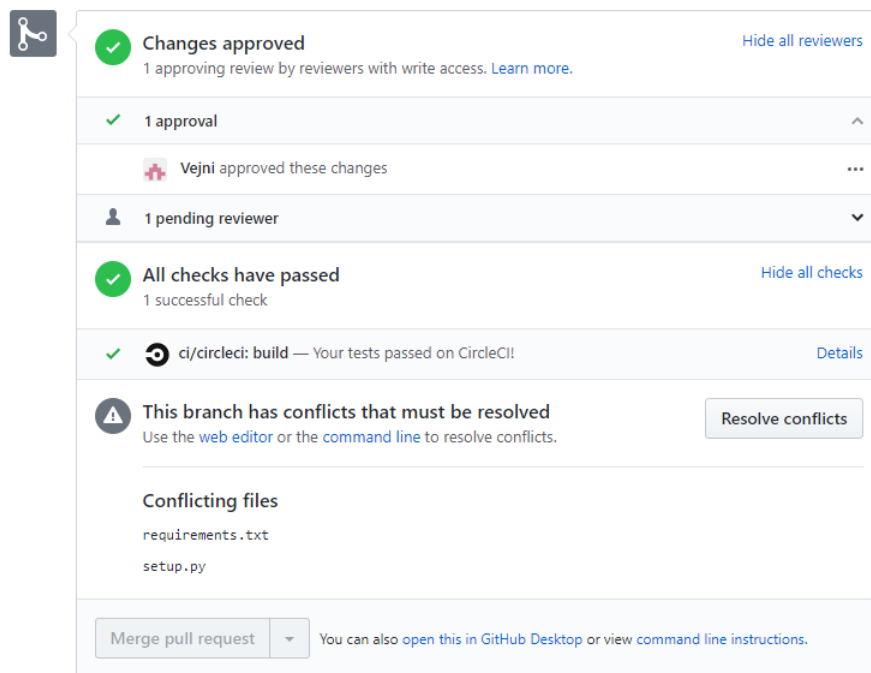


Figure 8: CircleCI on GitHub

With the help of these steps and CircleCI we managed to ensure that the code written is uniform and of good quality. It significantly reduced the time needed for integrating and code reviewing. The last step was now to deploy the system.

## 5.6 Deployment

## 6 Testing and Evaluation

Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Ut enim ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex ea commodo consequat. Duis aute irure dolor in reprehenderit in voluptate velit esse cillum dolore eu fugiat nulla pariatur. Excepteur sint occaecat cupidatat non proident, sunt in culpa qui officia deserunt mollit anim id est laborum.

## 7 Conclusions and further work

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## 8 Appendices

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## 8.1 Appendix A - User Manual

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## 8.2 Appendix B - Maintenance Manual

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## 8.3 Appendix C - Glossary

- **Portfolio** - A portfolio is a grouping of financial assets such as stocks, bonds, commodities, currencies and cash equivalents, as well as their fund counterparts, including mutual, exchange-traded and closed funds. An investor's portfolio is the group of assets they have currently invested in. [<https://www.investopedia.com/terms/p/portfolio.asp>]
- **Asset** - Generally an asset that gets its value from being owned; can be traded on financial markets. Stocks, bonds, commodities, (crypto-)currencies are all types of financial assets. [<https://www.investopedia.com/terms/a/asset.asp>]
- **Asset Class** - An asset class is a grouping of investments that exhibit similar characteristics and are subject to the same laws and regulations. Asset classes are made up of instruments which often behave similarly to one another in the marketplace. [<https://www.investopedia.com/terms/a/assetclasses.asp>]
- **Backtesting** - Backtesting is the general method for seeing how well a strategy or model would have done ex-post. Backtesting assesses the viability of a trading strategy by discovering how it would play out using historical data. [<https://www.investopedia.com/terms/b/backtesting.asp>]
- **Standard Strategy / Lazy Portfolios** - A lazy portfolio is a collection of investments that require very little maintenance. [<https://www.thebalance.com/how-to-build-the-best-lazy-portfolio-2466533>]
- **Rebalancing** - Rebalancing is the process of realigning the weightings of a portfolio of assets. Rebalancing involves periodically buying or selling assets in a portfolio to maintain an original or desired level of asset allocation or risk. [<https://www.investopedia.com/terms/r/rebalancing.asp>]
- **Key metrics** - Performance measures of a portfolio that are of high interest to the majority of investors.
- **Standard Deviation** - The standard deviation is a statistic that measures the dispersion of a dataset relative to its mean. [<https://www.investopedia.com/terms/s/standarddeviation.asp>]
- **Worst Year** - The worst performance over any given 365 day period starting from January 1st of some year.
- **Sharpe Ratio** - The Sharpe ratio was developed by Nobel laureate William F. Sharpe and is used to help investors understand the return of an investment compared to its risk. [<https://www.investopedia.com/terms/s/sharperatio.asp>]
- **Sortino Ratio** - The Sortino ratio is a variation of the Sharpe ratio that differentiates harmful volatility from total overall volatility by using the asset's standard deviation of negative portfolio returns, called downside deviation, instead of the total standard deviation of portfolio returns. [<https://www.investopedia.com/terms/s/sortinoratio.asp>]
- **Inflation** - Inflation is a quantitative measure of the rate at which the average price level of a basket of selected goods and services in an economy increases over a period of time. [<https://www.investopedia.com/terms/i/inflation.asp>]
- **Nominal Values** - A value that is unadjusted for inflation.
- **Real Values** - A value that is adjusted for inflation.
- **Equity** - Equity is typically referred to as shareholder equity (also known as shareholders' equity) which represents the amount of money that would be returned to a company's shareholders if all of the assets were liquidated and all of the company's debt was paid off.

- Fixed Income - Fixed income is a type of investment security that pays investors fixed interest payments until its maturity date.  
[<https://www.investopedia.com/terms/f/fixedincome.asp>]
- Commodity - A commodity is a basic good used in commerce that is interchangeable with other commodities of the same type. Commodities are most often used as inputs in the production of other goods or services. The quality of a given commodity may differ slightly, but it is essentially uniform across producers.  
[<https://www.investopedia.com/terms/c/commodity.asp>]
- FOREX / FX - Forex (FX) is the marketplace where various national currencies are traded. The forex market is the largest, most liquid market in the world, with trillions of dollars changing hands every day.  
[<https://www.investopedia.com/terms/f/forex.asp>]
- Overfitting - Overfitting is a modeling error that occurs when a function is too closely fit for a limited set of data points.  
[<https://www.investopedia.com/terms/o/overfitting.asp>]
- Leverage - Leverage results from using borrowed capital as a funding source when investing to expand the firm's asset base and generate returns on risk capital.  
[<https://www.investopedia.com/terms/l/leverage.asp>]
- Technical Analysis - Technical analysis is a trading discipline employed to evaluate investments and identify trading opportunities by analyzing statistical trends gathered from trading activity, such as price movement and volume.  
[<https://www.investopedia.com/terms/t/technicalanalysis.asp>]

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