

AN ONLINE WEB STREAMING SERVICE FOR BITCOIN EXCHANGES

Final Report



THE UNIVERSITY OF
SYDNEY

Information Technology Capstone Project

COMP5703

Group Members

Jiaqing Li (470166910)

Karim Santallo (470155497)

Sreejith Warriar (470217050)

Yangkai Hong (470231528)

ABSTRACT

The motivation behind this proposal is to fill an information gap within the financial sector in terms of cryptocurrency. Since Bitcoin was first introduced in 2009, cryptocurrency has become increasingly popular, leading to a surge in new cryptocurrencies and investment opportunities. In order to invest, a culmination of financial data and market analysis is needed in order to make informed decisions, much like stocks and bonds.

Unfortunately, the quality and quantity of available visualisations of financial market data for cryptocurrency exchanges differs depending on the cryptocurrency exchange used. Third party platforms compatible with multiple cryptocurrency exchanges are available but limited when it comes to the comparison of basic financial market data between exchanges, such as price and volume. This causes information to be in multiple places and leaves some conversion and analysis up to the user.

The project proposed is aimed at creating a Web Application allowing the comparison of cryptocurrencies market data (price and volume) for the BTC/USD pair from two different exchanges by using different visualisation techniques such as candlestick and market depth charts.

In order to accomplish the objective, the project uses a hybrid agile methodology for the software development process based on incremental development. As cryptocurrency is fast paced and constantly changing, this methodology allows the scope to quickly adapt and seize opportunities that may arise during the project, but also allows the team to stay flexible and add as many features as possible given the limited time frame available.

TABLE OF CONTENTS

Abstract	i
Table of Contents	ii
1. INTRODUCTION.....	1
2. RELATED LITERATURE REVIEW	1
3. PROJECT PROBLEMS	2
3.1 Project Aims & Objectives	2
3.2 Project Problems	3
3.3 Project Scope	3
4. METHODOLOGIES.....	3
4.1 Management Approach.....	3
4.2 Development Methods	4
4.3 Data Collection	5
4.4 Data Analysis	5
4.5 Deployment.....	5
4.6 Testing.....	6
4.7 Quality Assurance.....	6
5. RESOURCES	7
5.1 Hardware & Software	7
5.2 Materials	8
5.3 Roles & Responsibilities.....	9
6. TIMELINE	10
6.1 Milestones	10
6.2 Sprints	11
6.3 Gantt Chart.....	12
7. RESULTS	17
7.1 Project Outcomes: The Application.....	17
7.2 Interpretations: Answers to Project Problems.....	30
8. DISCUSSION	31
8.1 Results and Significance	31
8.2 Closing Gaps within the Field.....	31
8.3 Implications.....	32
9. LIMITATIONS AND FUTURE WORKS.....	34
9.1 Limitations	34
9.2 Future Works	35
10. REFERENCES.....	37

1. INTRODUCTION

The cryptocurrency market has increased by 1,204% in 2017 alone, with a total market cap of \$230.9 billion (Bovaird, 2017). Buying and selling cryptocurrencies has become an extremely popular activity. One way to acquire or dispose of cryptocurrencies is by using a cryptocurrency exchange. Cryptocurrency exchanges facilitate buying and selling cryptocurrencies in a similar fashion that regular stock exchanges do.

Also, the quality and quantity of available visualisations of financial market data for cryptocurrency exchanges differs depending on the cryptocurrency exchange used. Third party platforms compatible with multiple cryptocurrency exchanges are available but limited when it comes to the comparison of basic financial market data between exchanges, such as price and volume.

Filling this information gap by creating an application allowing the centralisation of this information historically or in real-time would allow for a better understanding and overview of the crypto market. This application would be able to fulfil educational purposes or allow for more informed decisions when trading cryptocurrencies.

2. RELATED LITERATURE REVIEW

Cryptocurrency is a digital currency that uses blockchain technology in order to authenticate and record transactions. Since Bitcoin was first introduced in 2009, cryptocurrency has become increasingly popular, introducing a great number of cryptocurrencies to the market such as Ethereum, Ripple, and Dash (Furlonger, Valdes, & Kandaswamy, 2017).

Much like stocks and bonds, cryptocurrency is traded on exchanges and requires a culmination of financial data and market analysis in order to make informed decisions. Online platforms, like Coinigy, are providing some basic visualisation charts for traders/users to acquire real-time or historical transaction data (e.g. price, volume, liquidity, etc.) among different cryptocurrencies from different exchanges (“Coinigy - Professional Bitcoin & Cryptocurrency Trading Platform”, 2018). For example, a simple line chart can be used to display the prices for a given period of time or a candlestick chart, offering the high and low of the buy and sell orders in specified intervals, to acquire more information about price over time (“CoinDesk - Understanding Bitcoin Price Charts: A Primer”, 2014). In addition, platforms like

CryptoCompare.com provide a visual dashboard for traders to compare cryptocurrency with actual currency like the US Dollar (“CryptoCompare - Live Cryptocurrency Prices, Trades, Volumes, Forums, Wallets, Mining Equipment and Reviews”, 2018).

There are limitations, especially in visualisation, when it comes to mainstream trading platforms. In order to design and provide efficient and effective visualisation solutions for users, two general principles should be followed:

1. Choose the right data
2. Choose the right visualisation

Firstly, time-based transaction data often has multi-dimensional attributes (Xie et al., 2014). A three-level model: the goal, the questions, and the measures, is defined for the designer to understand the data (Janes, Sillitti, & Succi, 2013). Secondly, aesthetics like colour coding, layout, and chart type should be selected carefully to avoid conveying information in a confusing manner or creating cognitive overload.

Research indicated that dashboards misuse and overuse colours lead to longer decision-making time for the decision makers who use such dashboards (Palash Bera. 2016). Such effect can potentially result in financial losses for cryptocurrency investors who highly rely on trading platforms with bad design of dashboards.

In conclusion, for the visualisation of information to be useful, it has to contain/display data related/according to the business goals. The development of such visualisation requires comprehensive understanding as well.

3. PROJECT PROBLEMS

3.1 Project Aims & Objectives

To develop a web application:

- Utilising visualisation techniques, such as charts, to easily display and compare cryptocurrency market data including, but not limited to transactional volume and price between different cryptocurrency exchanges for the BTC/USD trading pair.
- Modular and flexible to easily allow the addition of extra cryptocurrency pairs or exchanges.

- Providing a pleasing user experience with ease of use, and a clean, organised layout.

3.2 Project Problems

- Quality and quantity of available visualisations of financial market data of cryptocurrency exchanges differs and is specific to the cryptocurrency exchange used.
- Third-party platforms are available but focused on trading and limited to the comparison of basic financial market data between exchanges such as price and volume.
- Users would like to compare market data of multiple exchanges on a single platform instead of having to use multiple websites at the same time.

3.3 Project Scope

- The team will develop a web application using visualisation techniques to display and/or compare real-time or historical financial market data including, but not limited to price data of two cryptocurrency exchanges for the BTC/USD trading pair.
- The scope of this project only includes the development of the said application.
- The deployment of the application on the client's infrastructure is out of scope.
- Any analysis of the data or visualisations provided by the application such as pattern discovery or trend analysis is out of scope.

4. METHODOLOGIES

4.1 Management Approach

The project is conducted by a professional team with diverse expertise in Bitcoin, web application development, and data analytics. The team has implemented a comprehensive set of project management methodology, processes, and procedures. For example: the project tasks are assigned and monitored through an online project management tool; a secure environment has been set up for team coding, knowledge management, and communication; and a weekly meeting is scheduled as a quality assurance mechanism to ensure the project is on track towards success. More details on project supporting resources can be found in the Resources section (Section 5) of this proposal.

4.2 Development Methods

Based on the background of the project and the client requirements, the product requires a flexible and iterative development approach in order to achieve all its the aims and objectives. Therefore, the project will follow a hybrid System Delivery Life Cycle (SDLC) methodology in terms of both the agile and waterfall model (Figure 1).

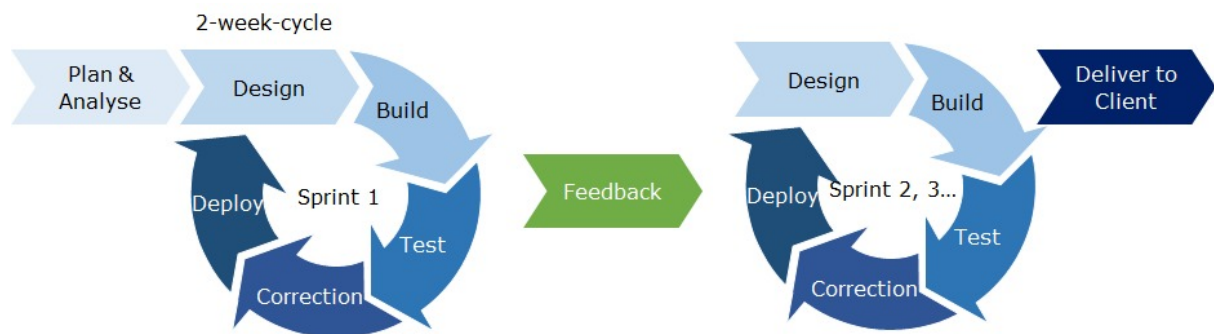


Figure 1 - Created by COMP5703 CP22 Group 5

The initial phase of the project is the planning and analysing phase, which mainly focuses on defining the project scope and product features, as well as determining technology stacks. The second phase is a set of spiral cycles (or sprints). Each sprint lasts for approximately 2 weeks and contains following stages: design, build, test, correction, and deploy. There will also be a short feedback phase at the end of each sprint in order to review whether it meets the project goals and client requirements. The final phase will be delivering the final product to client after conducting an end-of-lifecycle testing and comprehensive quality assurance checks. Such methodology will provide the following benefits:

1. Early and Predictable Schedule
 - Fixed schedule (2 weeks for each Sprint)
 - Earlier release and test
2. Flexibility for Changes
 - Easier decision making on priority
 - Constantly refine and re-prioritise
3. Quality Improvement
 - Manageable units/modules

- Test and reviews during each iteration

4.3 Data Collection

The application collects financial market data from cryptocurrency exchanges using their APIs and stores the data in the application's database. Data from third-party providers such as coinmarketcap.com and blockchain.com is also collected and used in the dashboard of the application. Effective testing and examinations will be conducted by the project team and the data specialist will ensure data integrity and quality.

4.4 Data Analysis

Not applicable for this project. Any data analysis is out of scope as mentioned in the project scope statement.

4.5 Deployment

The client is required to have a GitHub account and will be granted access to the application's GitHub repository.

The final release of the web application will be provided as a zip file, downloadable from the release page on the application's GitHub repository. Subsequent updates will be added to the release page and downloadable in the same manner.

The application is a regular Nodejs-MongoDB application. The client is responsible for deploying and configuring it on their own infrastructure.

Bugs shall be reported by email or using the "Report Issue" function on the application's GitHub repository. A new release containing the bug fix will then be created and made available on the GitHub release page of the application. The client is responsible for downloading this release and re-deploying it on their infrastructure.

4.6 Testing

The testing process and methodology of this project will follow the “whole team” strategy of agile, in which each member of the team will be involved in the testing phase to ensure the product’s high quality. Therefore, the testing mechanism of this project can be mainly divided into the following parts:

1. Test-Immediately After Approach in every sprint.
2. End of Lifecycle Testing before delivery to the client.

During the first part, as a small team, the role of coder and tester will be merged so that a cross-test method will be applied to review and fix the defects efficiently and effectively.

For the second part, before the product is ready to go-live and deliver to client, an independent test will be conducted by the whole team. A comprehensive checklist with related supporting tools will be designed and applied during this part for quality assurance and client acceptance.

#	Module/Page	Test Point	Details	Tester	Status	Note
1	General	configuration	1. Website URL availability 2. Heroku environment setting and monitor 3. Check config.js	Karim Santallo	Completed	
2		implement guidance	1. Readme File	Karim Santallo	Completed	
3		content	1. All text free from spelling errors 2. Placeholder text removed 3. All pages have content 4. Footer includes copyright statement	Karim Santallo	Completed	
4		security	1. Sensitive data is encrypted or protected (password, user profile...)	Karim Santallo	Completed	
5	User Login/Register	local login	1. input correct username(email) and password 2. provide wrong message if any error happened	Jiaqing Li	Completed	
6		social login	login with legitimate Google or GitHub account	Jiaqing Li	Completed	
7		sign-up	1. input full name, email address, password, confirm password 2. ensure valid data is entered 3. provide wrong message if any error happened	Jiaqing Li	Completed	
8		forgot password (Local login only)	1. input registered email address 2. check password request email 3. Redirect to reset page with legitimate url 4. input password, confirm password in reset page 5. check password successfully updated email 6. check password reset url is no longer valid if it is not being used within 1 hours or has been used already 7. provide wrong message if any error happened	Jiaqing Li	Issues	Need to update the reset url address from localhost into heroku
9		User Menu	1. Display user avatar and name correctly in upper right corner 2. Profile and Logout button successfully redirect to target page	Jiaqing Li	Completed	
10		Profile Display	1. Display user avatar, full name, registered email, joined date, user type 2. For local login user only, display buttons of changing password and name 3. Both button can redirect to actual pages respectively	Jiaqing Li	Completed	
11		Change name (Local login only)	1. input new user name 2. provide wrong message if any error happened 3. "Back" hyperlink can redirect back to profile display page	Jiaqing Li	Completed	
12	User Profile	Change password (Local login only)	1. input current password, new password, confirm new password 2. provide wrong message if any error happened 3. "Back" hyperlink can redirect back to profile display page	Jiaqing Li	Completed	

Figure 2 - Final Checklist (Created by COMP5703 CP22 Group 5)

4.7 Quality Assurance

Quality assurance is the responsibility of a quality assurance subgroup within the team. These members will conduct a set of procedures to ensure the web application meets the project goals and requirements as well as guarantee the general quality of the delivered software.

5. RESOURCES

A detailed list of the resources needed to develop the web application is provided below.

5.1 Hardware & Software

1) Hardware

The product is a web application that is accessible through an internet browser, preferably Google Chrome. The application would need to be running on a server that can handle large data. Therefore, the server should have 1.6GHz CPU with 4 Gb RAM. It should have least 10 Gb of free space for the data.

2) Front-End

React: The web application uses the React library to build the user interfaces for the web application. The framework JSX, which combines both HTML and JavaScript, makes it easier to develop the application. It also improves the performance of the application and makes it easier to perform unit testing and integration testing.

React Stockcharts: The application uses a library called React Stockcharts for all its charting needs. This includes candlestick charts, market depth charts and, the line charts. The team decided not to use the original planned library (d3.js) as it was found that React Stockcharts better suits the needs of this project.

Ant Design: The application uses the Ant Design React UI library. This enables faster and easier development of React component while maintaining high quality standards.

3) Back-End

NodeJS: The back-end of the web application is created using NodeJS v8. NodeJS runs on the traditional JavaScript engine and is able to operate extremely fast. NodeJS works mainly on a non-blocking I/O model. This makes the framework ideal for real time web applications that utilise large amounts of data. It also works with other web technologies and utilises less memory compared to other server engines.

ExpressJS: The application uses the ExpressJS framework for the server side. ExpressJS makes development in NodeJS easy and efficient. The framework makes use of middleware to respond to various HTTP requests and makes it easier to connect with the MongoDB database.

MongoDB: MongoDB is a NoSQL database. It does not use complex joins and makes the structure of the document and object clear. MongoDB also uses Document Oriented Storage whereby data of the application can be stored in JSON format. It is more scalable and can handle large data efficiently, thereby providing superior performance to the application.

5.2 Materials

1) Project Management Tools

Slack: Slack is the main tool used for communication and knowledge sharing between team members. Slack improves collaboration between team members by using various channels to organise conversations according to predefined topics. Team members can share files, conversations, and documents within slack channels and add additional comments under these files. Additionally, Slack provides integration with various other applications and makes it a single platform for all the project's needs.

TeamGantt: TeamGantt is a project planning tool that uses a Gantt chart to track the progress of the project. The team uses TeamGantt to plan and manage the project effectively. Each member can view and update their own progress for their assigned tasks.

GitHub: GitHub is version control system used to store code and improve collaboration between team members. Each team member would have his own repository where he can work and update his code and share it with other team members.

SharePoint: All the reports and documentation will be stored in Microsoft SharePoint as a backup. SharePoint allows team members to collaborate on the documentation and make live changes to the documentation.

2) Other Tools

WebSocket APIs: The web application uses WebSocket to collect real-time data from exchanges using their WebSocket APIs. Using the WebSocket API for the collection of this data, instead of the Rest API, allows to have the most recent data. It also prevents issues, such as hitting a rate limit (example: sending too many requests per second), when collecting such data.

Rest APIs: The application connects to exchanges using their Rest API as it is the only way to collect historical data.

Socket IO: The back-end APIs use socket.io in order to feed real-time updates to the front-end of the application without refreshing the page or querying periodically the back-end of the application. Additional features of socket.io are also used such as: auto-reconnection and, channels and namespaces for data segregation.

5.3 Roles & Responsibilities

Karim Santallo

Team Lead, Web Developer, Quality Assurance

- Keeps the team on track to deliver a quality product on time.
- Responsible for the implementation and management of the agile methodology.
- Maintains the product backlogs and planning of sprints.
- Schedules, organises and facilitates team meetings.
- Front-End/Back-End functions design, implementation, and testing.
- Quality assurance of software and report deliverables.

Jiaqing Li

Web developer, Data specialist, Quality Assurance

- Assist Team Lead with management duties and responsibilities.
- Front-End/Back-End functions design, implementation, and testing.
- Quality assurance of software and report deliverables.

Sreejith Warriar

Web Developer

- Focuses on back-end functions design, implementation, and testing.
- Assist with front-end development when necessary.

Yangkai Hong

Web Developer

- Focuses on front-end functions design, implementation, and testing.
- Assist with back-end development when necessary.

6. TIMELINE

As discussed in Section 4, the project follows an “agile” methodology based on incremental development. Each iteration, called a “sprint” here, aims at delivering a product that will be refined with each new iteration based on feedback from the client.

This project will consist of four sprints. Each sprint has a two-week duration.

A list and description of the milestones, sprints, and Gantt chart have been provided below.

6.1 Milestones

Milestone	Description	Planned Date
Project Start-Up Session Completed – Initial Product Backlog Created	The team has been formed and understands the objectives of the project. High-level design decisions have been completed. Initial set of features to start development iterations have been created.	29/08/2018
Project Proposal Submission and Approval	The project proposal submitted has been approved.	Week 5 (27/10/2018 – 02/11/2018)
Start of Development Iterations	See Section 6.2 for more details.	29/08/2018
Progress Report	Progress report on obstacles encountered, deviation to the planned timeline, etc.	05/10/2018

End of Development Iterations	See Section 6.2 for more details.	22/10/2018
Web Application Demonstration to Clients	Presentation of the final release of the web application.	Week 13 (22/10/2018 - 26/10/2018)
Final Release to Clients Submitted	The files for the final release of the web application have been transferred to the clients. Project can be closed.	26/10/2018
Final Report	Final Report for the project.	16/11/2018

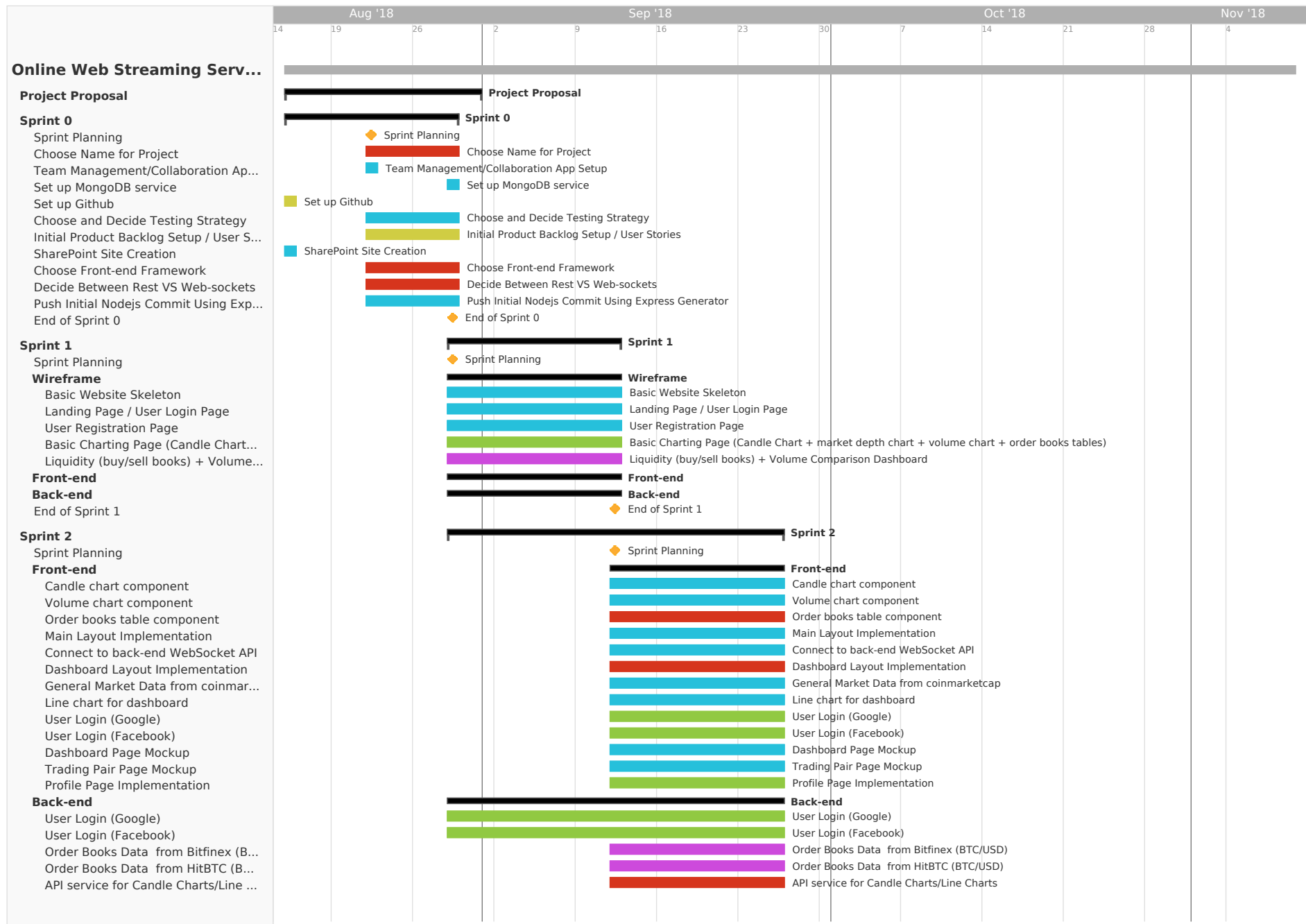
6.2 Sprints

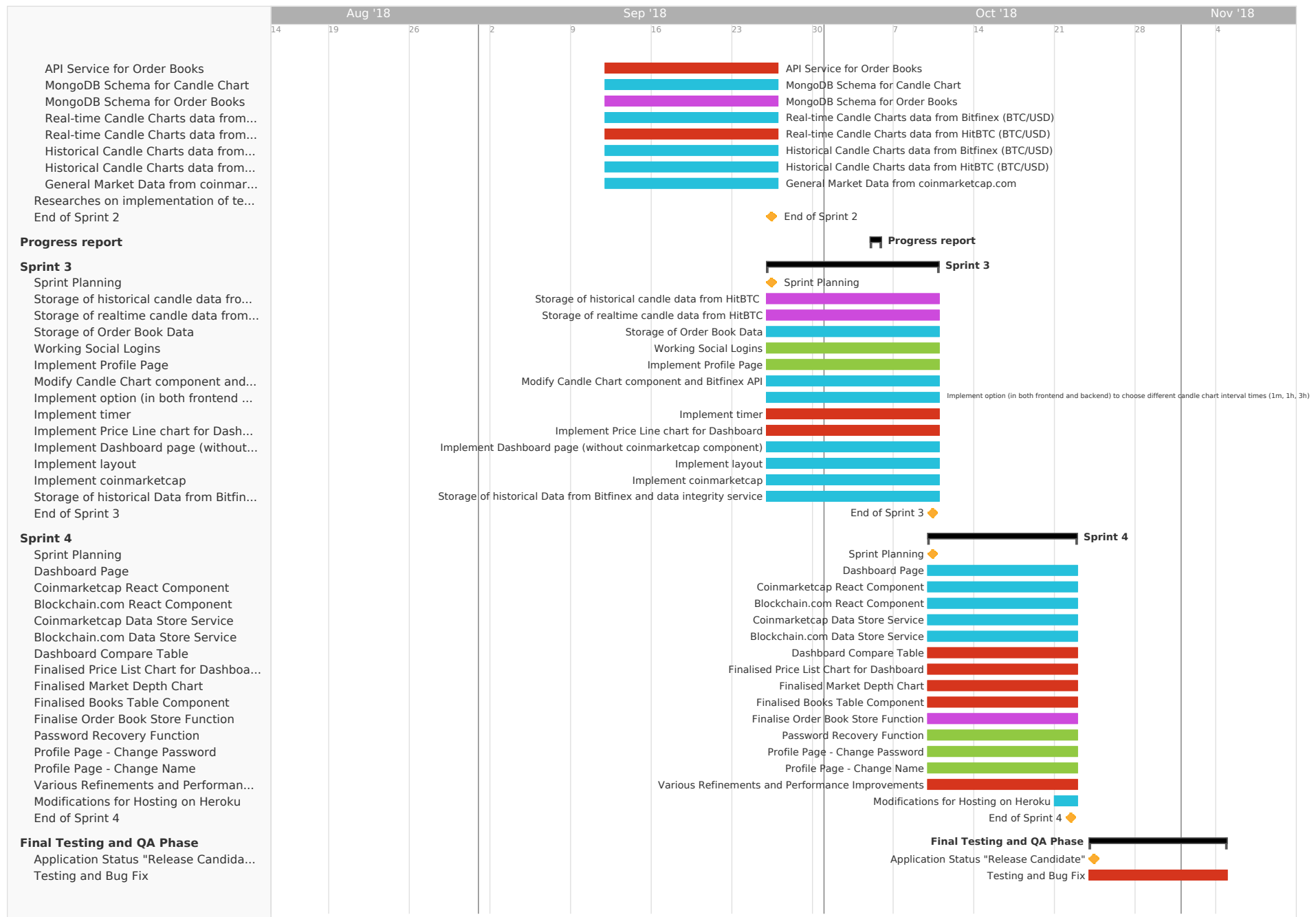
Iteration	Description	Start Date	End Date
Sprint 1	Website skeleton creation and implementation. Required functionalities implementation.	29/08/2018	12/09/2018
Sprint 2	Required functionalities implementation. Front-end interface enhancements.	12/09/2018	26/09/2018
Sprint 3	Required functionalities implementation. Optional features implementation.	26/09/2018	10/10/2018
Sprint 4	Web application finalisation.	10/10/2018	22/10/2018

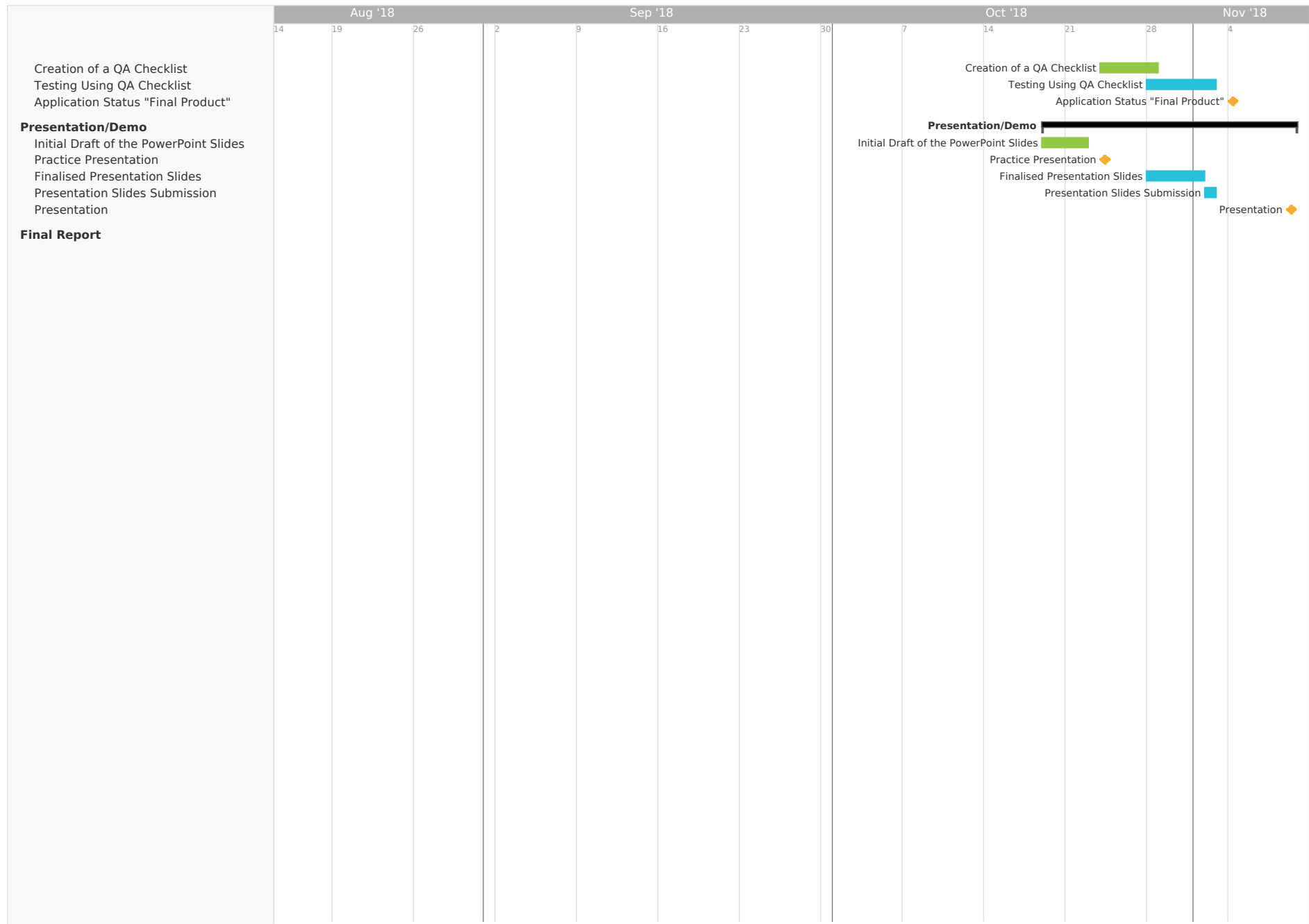
6.3 Gantt Chart

A Gantt chart, exported from our management tool TeamGantt, is provided below. This Gantt chart provides a detailed timeline of the different tasks that were accomplished in order to complete this project.

Sprint 0 in the chart includes the start-up sessions mentioned in the milestones table.







7. RESULTS

The purpose of this section is to identify and discuss the results of the project in terms of project outcomes and to interpret those results in order to answer the project problems (i.e. how the product solves these problems). A detailed list of features will accompany screenshots in order to explain the results, while a second subsection will address answering project problems.

7.1 Project Outcomes: The Application

The main deliverable of this project is a web application that allows the comparison of cryptocurrency market data for the BTC/USD pair from two different exchanges by using different visualisation techniques such as candlestick and market depth charts. In order to identify and discuss the results of this project (the project outcomes), a description of each page of the application (the landing page, dashboard, profile page, exchange page, and other miscellaneous results) will be provided along with screenshots and, followed by a discussion of features for that page.

Landing Page

The landing page is the first point of contact with the application for non-authenticated users. It allows users to login, register and reset their password.

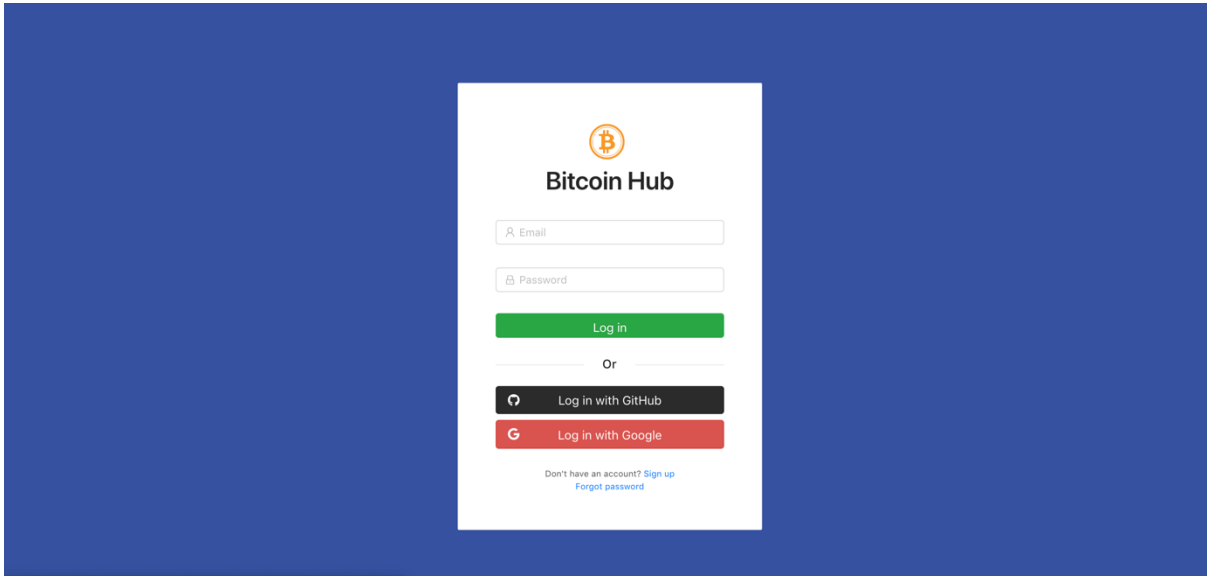


Figure 3: Landing Page of the Application

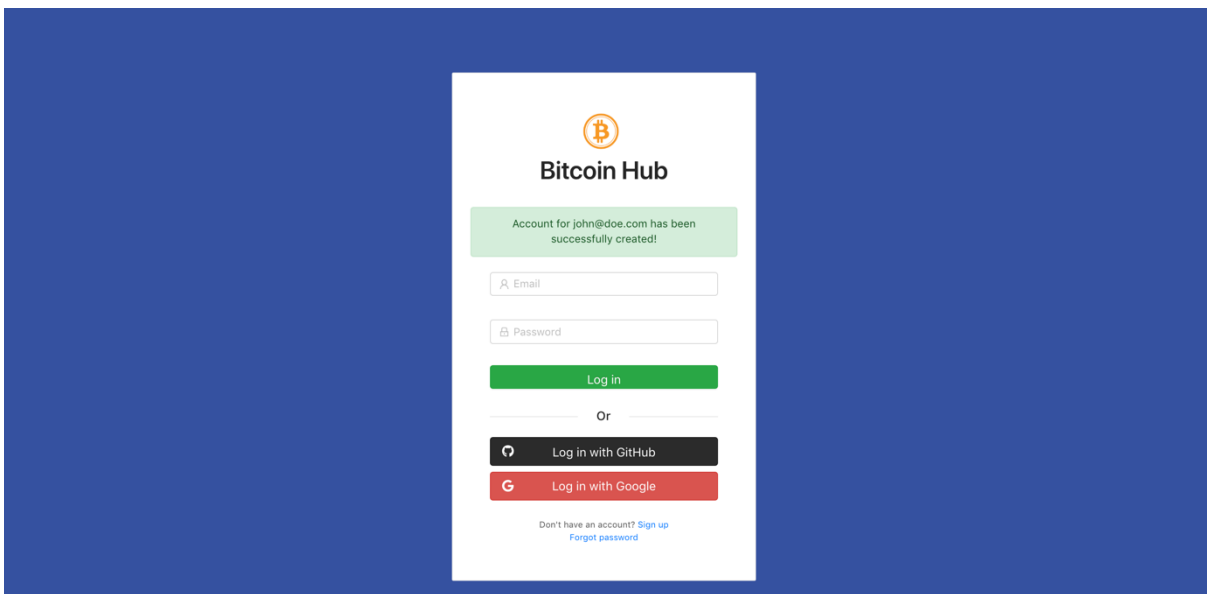


Figure 4: Login Screen Showing a Successful Registration Message

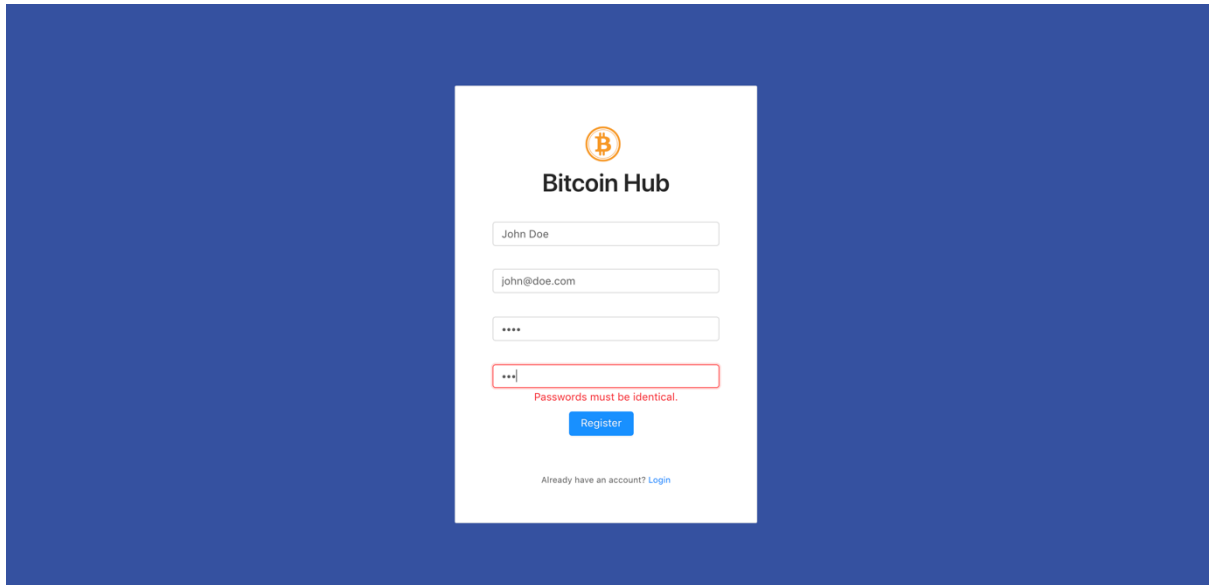
The image shows a registration form for 'Bitcoin Hub' centered on a dark blue background. The form is white and contains a Bitcoin logo at the top. Below the logo, the text 'Bitcoin Hub' is displayed. The form includes four input fields: a name field with 'John Doe', an email field with 'john@doe.com', a password field with four asterisks, and a second password field with three asterisks. A red border highlights the second password field, and a red error message 'Passwords must be identical.' is displayed below it. A blue 'Register' button is positioned below the error message. At the bottom of the form, there is a link 'Already have an account? Login'.

Figure 5: Registration Page Showing Input Checks

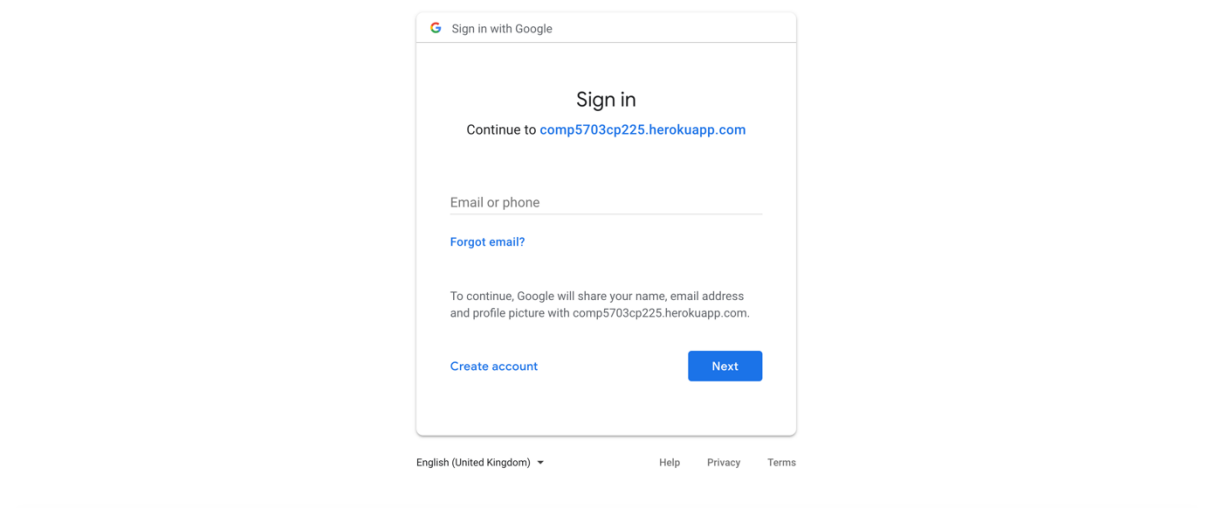
The image shows a Google sign-in page. At the top, there is a 'Sign in with Google' header. Below this, the text 'Sign in' is displayed, followed by 'Continue to comp5703cp225.herokuapp.com'. There is an input field for 'Email or phone'. Below the input field, there is a link 'Forgot email?'. A paragraph of text states: 'To continue, Google will share your name, email address and profile picture with comp5703cp225.herokuapp.com.' Below this text, there are two buttons: 'Create account' and 'Next'. At the bottom of the page, there is a language selector 'English (United Kingdom)' and links for 'Help', 'Privacy', and 'Terms'.

Figure 6: Login into the Application Using a Google Account

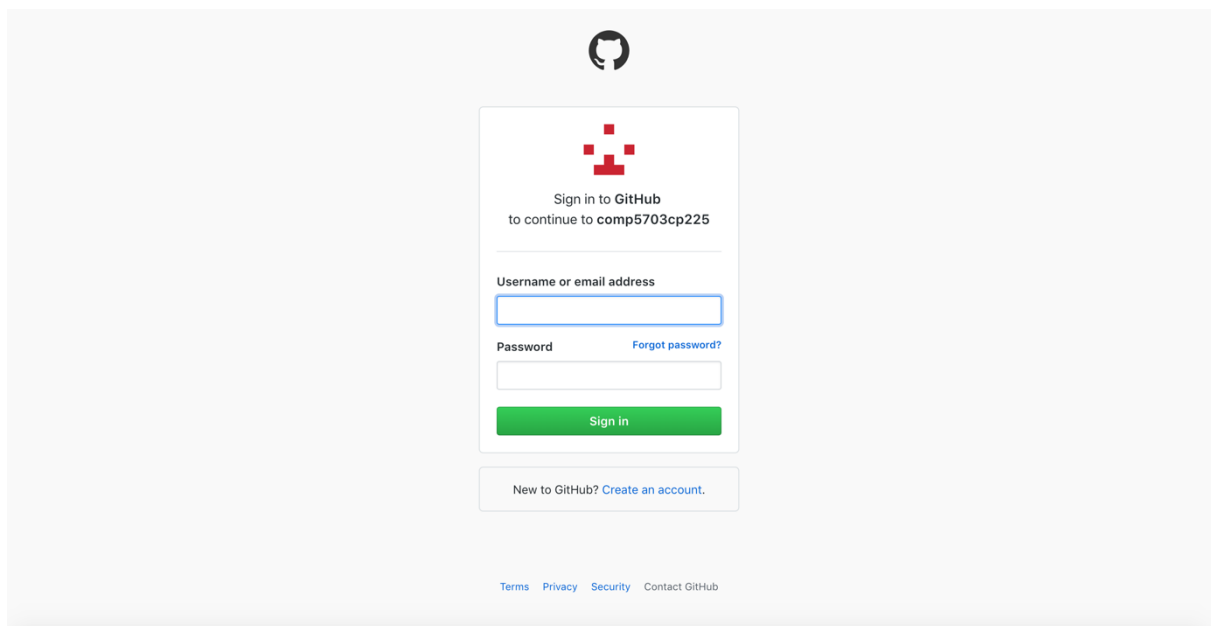


Figure 7: Login into the Application Using a GitHub Account

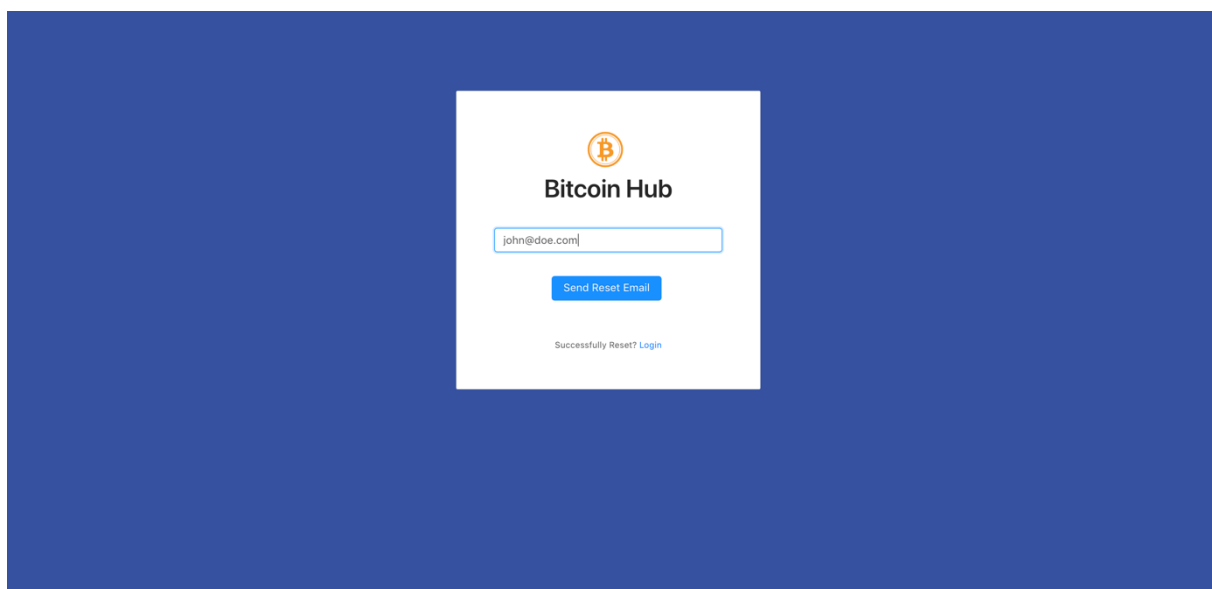


Figure 8: Reset Password Request using the Email Address Screen

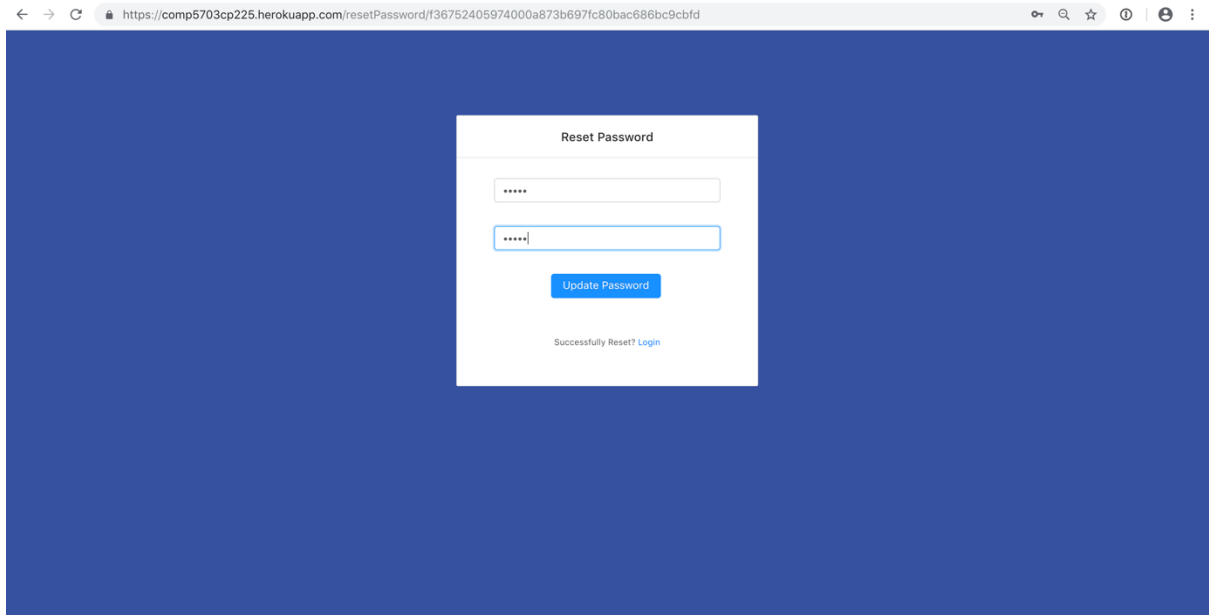


Figure 9: Reset Password Screen after Clicking the Link in the Reset Password Email

Features:

- Login using an account previously created in the application (Figure 3).
- Register an account in the application (Figure 5).
- Login using a GitHub or Google account (Figure 6 and Figure 7).
- Login and registration with feedback messages and input checks (Figure 4 and Figure 5).
- Reset the password of an account using its email address (Figure 8 and Figure 9).

Profile Page

The profile page allows authenticated users to display information about their account. Accounts that have been registered in the application (non-social accounts), can also change the name and password registered for their account.

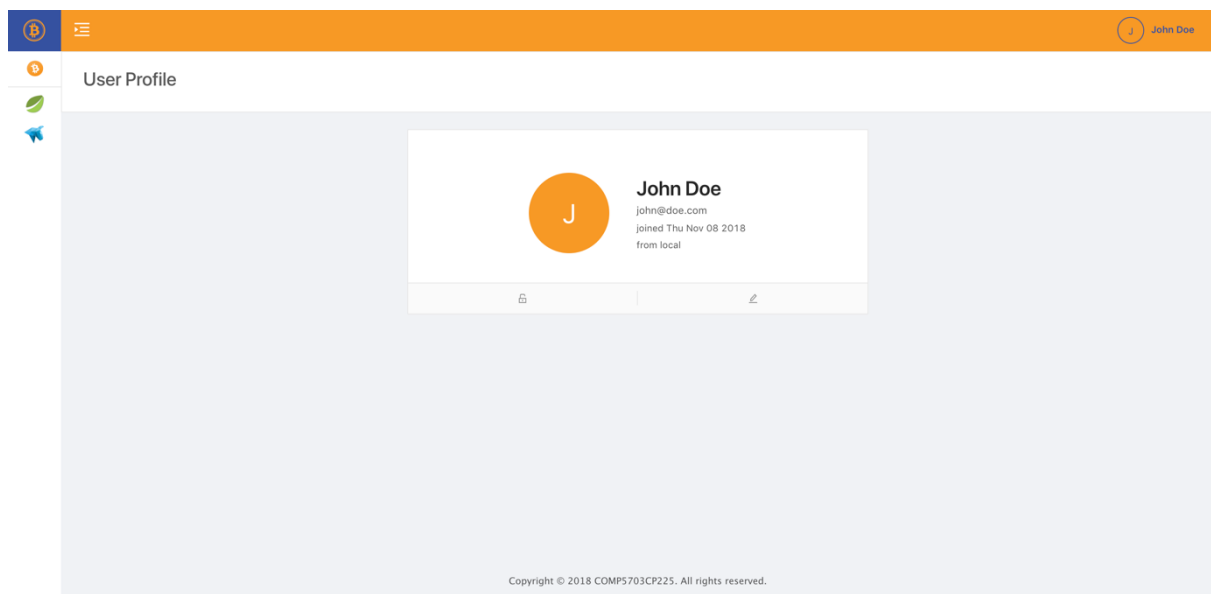


Figure 10: Profile Page

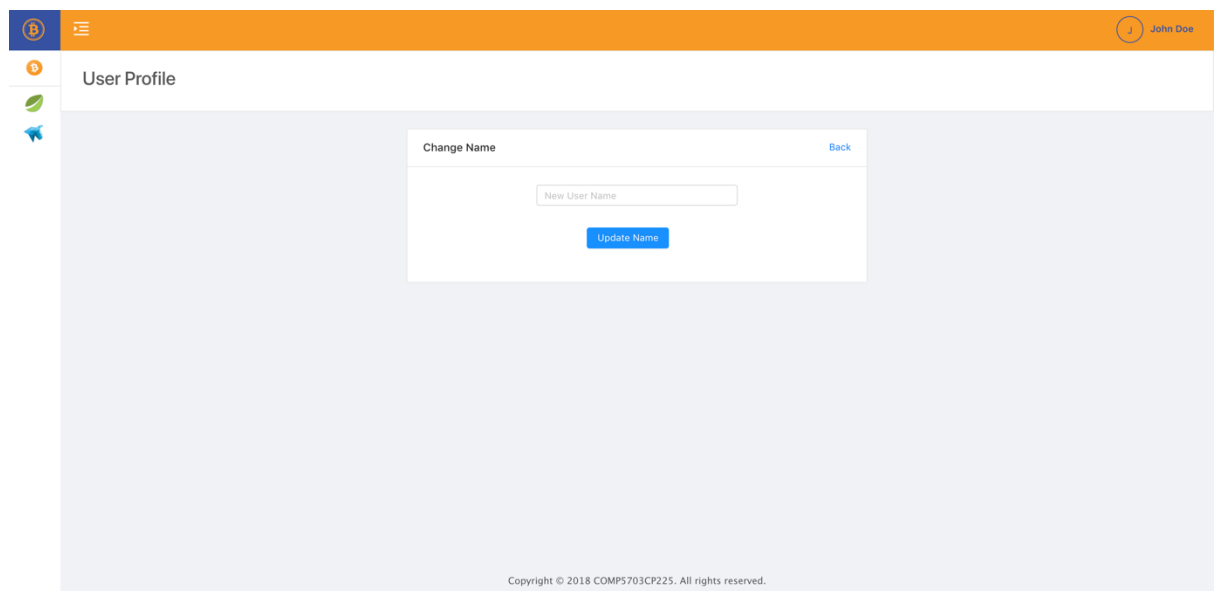


Figure 11: Change Name Screen

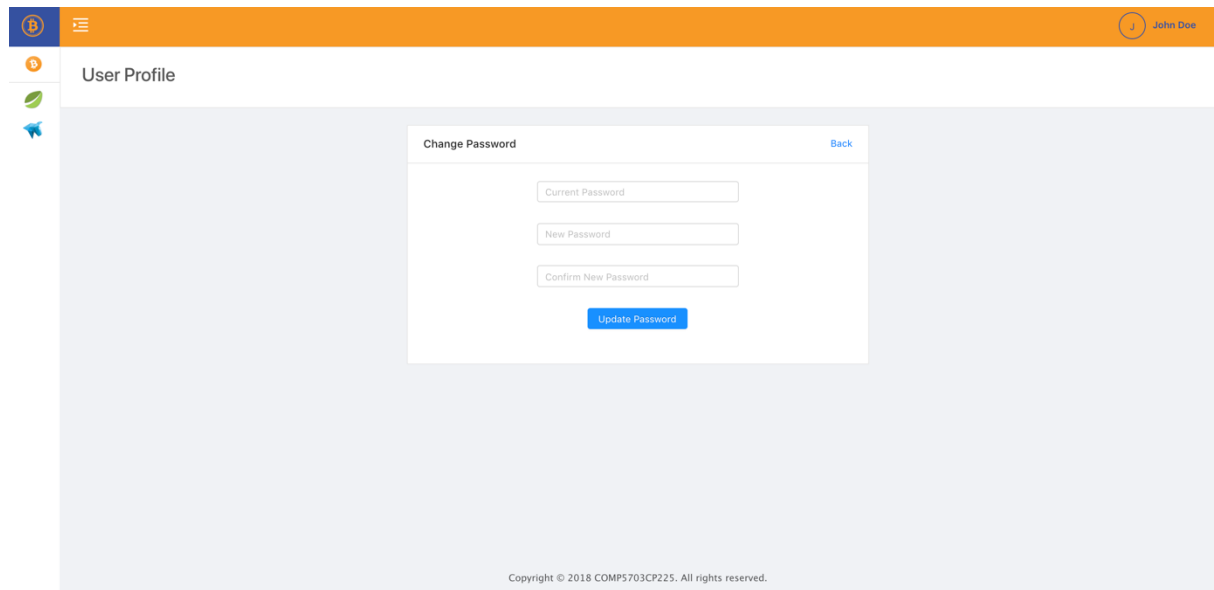


Figure 12: Change Password Screen

Features:

- Display information about the current account such as name, email address, and registration date (Figure 10).
- Change the name registered with the account (Figure 11).
- Change the password of the account (Figure 12).

Dashboard

The bitcoin dashboard provides an overview of the state of bitcoin. It was designed to allow users to have a more complete picture of bitcoin by combining both market and blockchain data. In order to do that, this page aggregates data from different providers including coinmarketcap.com, blockchain.com and the exchanges supported by the application.

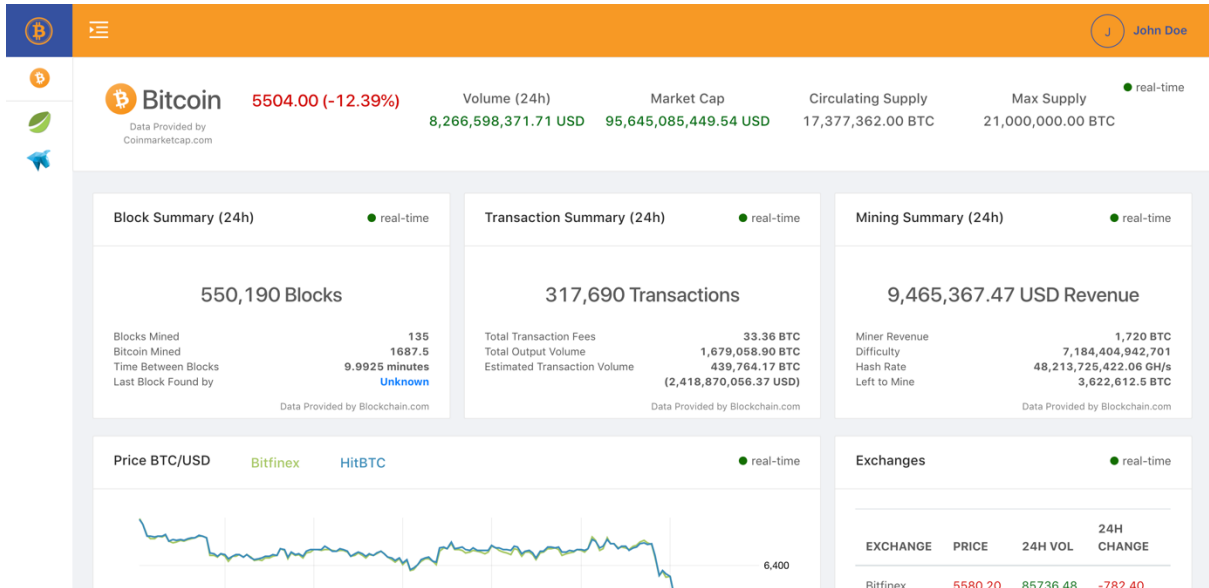


Figure 13: Dashboard Page for Bitcoin

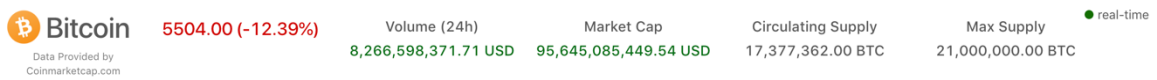


Figure 14: Bitcoin Market Information

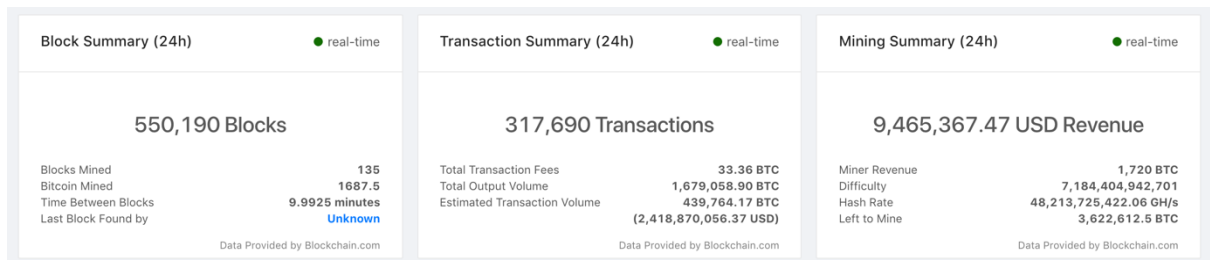


Figure 15: Blockchain Information Tiles

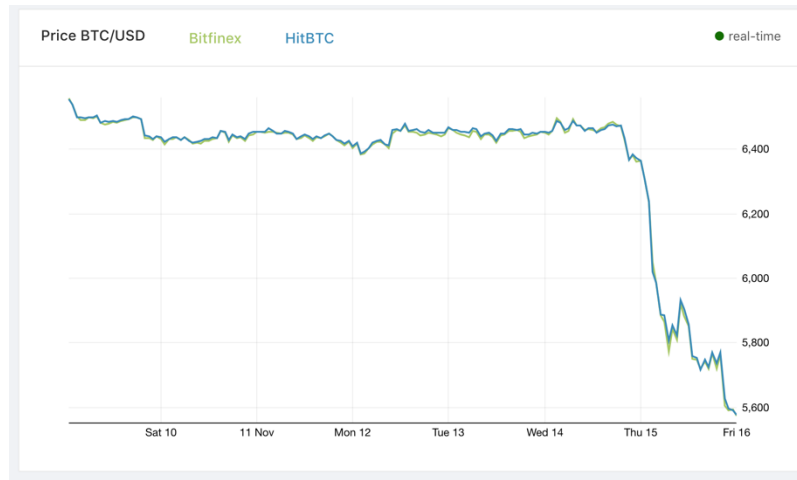


Figure 16: Price Line Chart

EXCHANGE	PRICE	24H VOL	24H CHANGE
Bitfinex	5580.00 USD	85740.49 BTC	-782.60 (12.30%)
HitBTC	5584.02 USD	25617.97 BTC	-789.73 (14.14%)

Figure 17: Comparison Table between the Exchanges

Features:

- Real-time market information about bitcoin (ex: market cap, 24h volume across hundreds of exchanges and markets) (Figure 14).
- Real-time information about the bitcoin blockchain (ex: average discovery time for blocks, number and volume of transactions within 24h, etc) (Figure 15).
- A real-time line chart displaying the price of bitcoin on the supported exchanges over seven day to quickly identify trends (Figure 16).

- A real-time exchange comparison table to quickly compare the price, daily volume and price change difference and percentage of the BTC/USD market across the supported exchanges (Figure 17).

Exchange Page

The exchange page allows users to have detailed information about the state of the BTC/USD market for the supported exchanges.

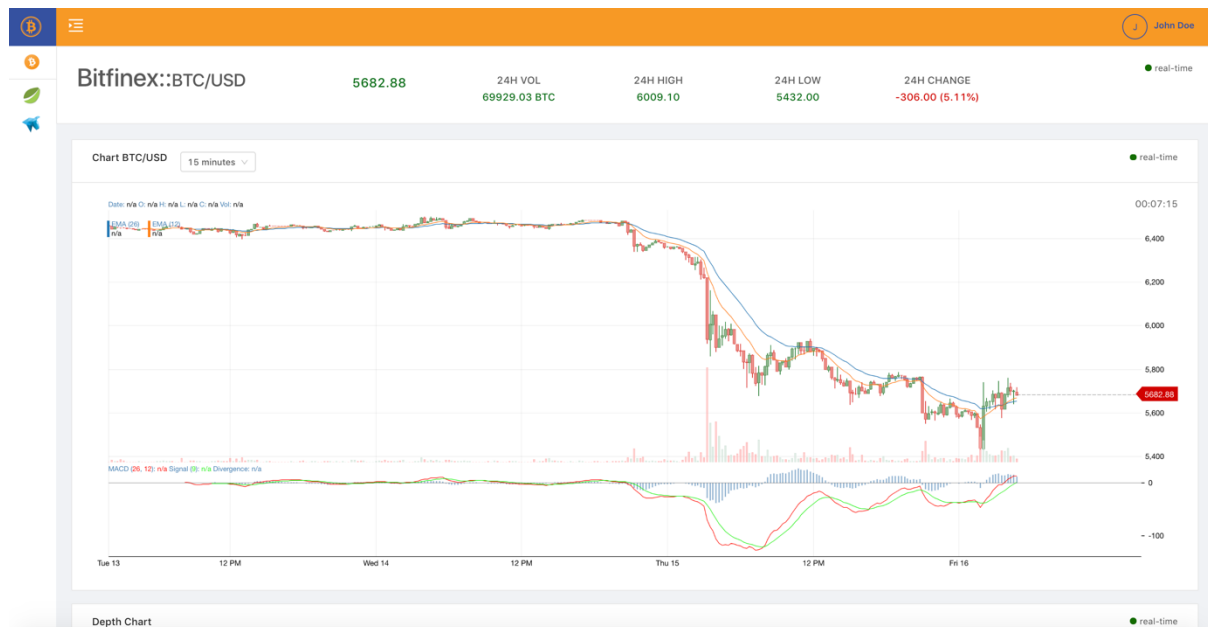


Figure 18: Exchange Page

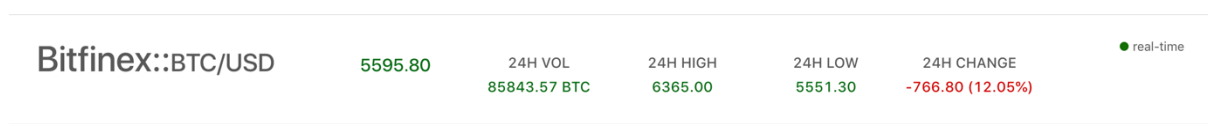


Figure 19: Bitfinex Basic Real-time Market Info Data



Figure 20: Candlestick and Volume Chart with MACD and Moving Averages Indicators

00:13:48

Figure 21: Timer Indicating How Much Time Left in the Interval

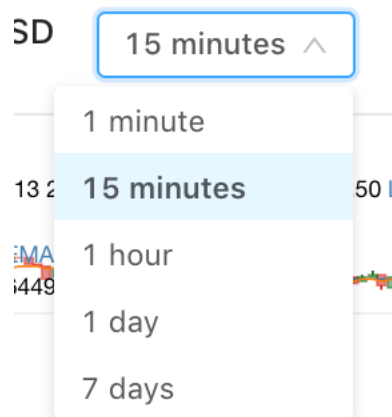


Figure 22: Dropdown Box to Switch Between Candlestick Chart Intervals

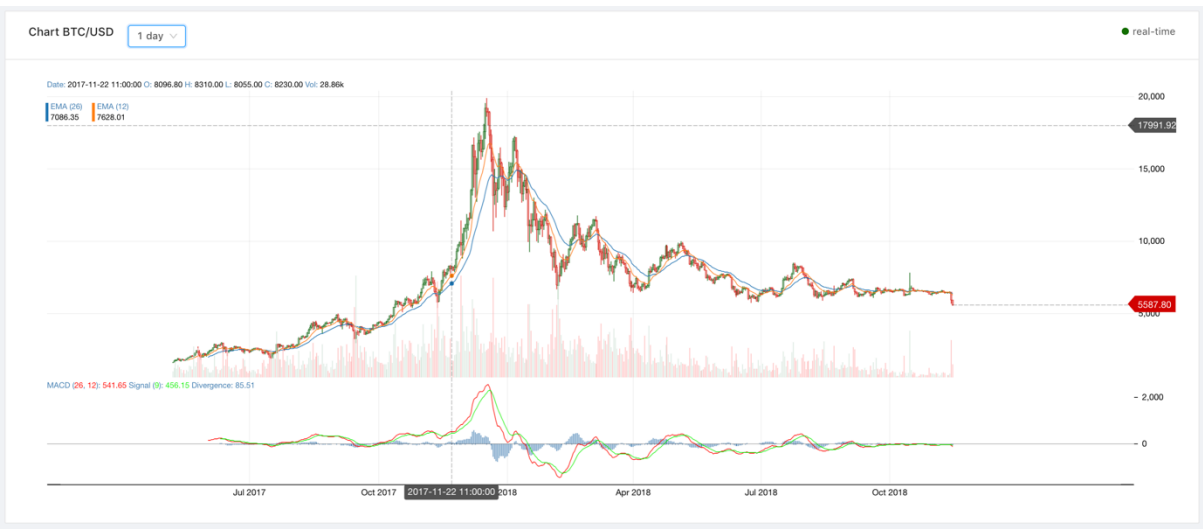


Figure 23: Candlestick Chart Displaying Data from January 2017

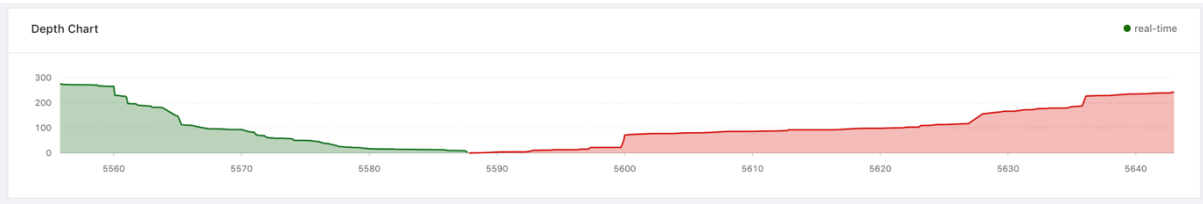


Figure 24: Market Depth Chart

Books

Sum	Amount	Bid (USD)	Ask (USD)	Amount	Sum
5.20	5.20	5587.50	5589.30	1.55	1.55
8.20	3.00	5585.80	5589.80	1.10	2.65
8.30	0.10	5585.50	5590.00	3.22	5.87
9.25	0.95	5584.90	5590.50	0.72	6.59
9.75	0.50	5583.60	5591.50	0.30	6.89
10.30	0.55	5583.40	5592.50	0.30	7.19
10.60	0.30	5582.50	5592.80	3.00	10.19
11.55	0.95	5582.40	5593.50	0.20	10.39
11.64	0.09	5582.20	5593.80	5.73	16.12
14.64	3.00	5582.10	5593.90	1.43	17.55

294.64 BTC 267.27 BTC

Figure 25: Order Book Tables

Features (For both Bitfinex and HitBTC):

- Basic market data for the exchange selected (current price, volume in 24h, lowest price in 24h, etc.) (Figure 19).
- The application is retrieving, processing, and storing in a database, real-time and historical financial data (price and volume) for the BTC/USD market. This includes both basic market data and data necessary to draw candle stick charts (Figure 19 and Figure 20).
- Candlestick chart with different financial indicators (MACD, moving averages) combined with a volume chart (Figure 20).
- A timer is provided indicating how much time is left in the interval before a new candle is drawn (Figure 21).
- The candlestick chart supports zooming and panning.
- A dropdown box is provided for users to switch between different intervals for the candlestick chart (Figure 22).
- Data is available from January 2017 and can be displayed for all intervals by zooming out or panning left to right (Figure 23). Necessary data is automatically downloaded.
- A real-time market depth chart provides a quick graphical overview of the state of the order books (Figure 24).
- Real-time order book tables for the specific market and exchange (Figure 25).

Others

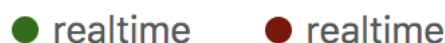


Figure 27: Real-time Indicator – connected (left) disconnected (right)

- The application is developed using the latest technologies (Node.js, MongoDB, React, WebSocket).
- The application has functions and safeguards to ensure the integrity and completeness of the data retrieved from the exchanges.
- The application has “real-time indicators” to inform users of the real-time status (or not) of the data (Figure 27).
- The different components are colour coded to allow users to know if prices are up or down with a quick glance.

- The interface has been created with React to allow reduced loading times between pages for a better user experience.
- The layout and colour scheme of the user interface have been chosen to be appealing to users.
- The application can be easily split into Front-end, Back-end and Workers to allow horizontal and vertical scaling.
- The application is modular and flexible to easily add new exchanges and markets.

7.2 Interpretations: Answers to Project Problems

The problems addressed in Section 3.2 will be listed within this section and answered in terms of how our product solves that problem. More detail of the implications of these solutions are provided in the following section, Section 8, the discussion section.

- Problem: Quality and quantity of available visualisations of financial market data of cryptocurrency exchanges differs and is specific to the cryptocurrency exchange used.
 - Answer: The application provides, through a unified platform, the same high-quality visualisations of financials market data for all the exchanges supported by the application (currently Bitfinex and HitBTC).
- Problem: Third-party platforms are available but focused on trading and limited to the comparison of basic financial market data between exchanges such as price and volume.
 - Answer: The application provides more information than just basic financial market. Blockchain information including block, transaction, and mining summary information is available on the dashboard as well as global market information on Bitcoin including its market cap, transactional volume across multiple exchanges and market, and its circulating supply.
- Problem: Users would like to compare market data of multiple exchanges on a single platform instead of having to use multiple websites at the same time.
 - Answer: The application allows users to display exchange market data for both Bitfinex and HitBTC within the same interface. Additionally, components such as the price line chart (Figure 15) and comparison table (Figure 16) on the dashboard allows users to quickly be able to compare values between the two exchanges.

8. DISCUSSION

8.1 Results and Significance

The web application, successfully completed, allows users to easily explore and interact with different components involved in Bitcoin trading activities all within one convenient place without a complex start-up learning curve. Registration for an account is quick and intuitive with the use of an email address or social media account (GitHub and Google). The application provides visualisations for market data and makes use of candlestick charts, market depth charts, order book tables, and a dashboard. The application currently supports two cryptocurrency exchanges, HitBTC and Bitfinex. Users can view market information (price, volume, order books, etc.) specific to each exchange within the same application. Blockchain information is also integrated into the application by using a third-party data provider, Blockchain.com. Block, transaction, and mining summary information are available on the dashboard. Another data provider, Coinmarketcap.com, is used to get global market information on bitcoin including its market cap, transactional volume across multiple exchanges and market, and its circulating supply.

Safeguards have been built in during implementation of the application in order to ensure integrity and completeness of the exchange data provided. The application presents information in an aesthetically pleasing and practical way. Additionally, the information is updated and displayed in real-time without the need to refresh the page. Finally, the application has been developed to be modular and flexible in order to easily add new exchanges and markets, and also be scalable horizontally and vertically.

8.2 Closing Gaps within the Field

Pulling data from multiple places and integrating it together in one place closes two gaps within the field: (1) it creates an all-in-one type resource that allows research to be more efficient and not require a user to have to hunt for all of the information in different places, (2) the application has the potential to aid in better decision making by providing more context of cryptocurrency information than the existing resources individually.

When looking for market information on Bitcoin, depending on the information a user needs, they would have to visit an exchange to view buy and sell orders, a site for the blockchain information, a site for volume and market cap information, an explorer for more detailed transaction information, and popular forums to see what is being said or forecasted. This application aggregates information from three of these five sources, allowing for a more efficient resource. The way the information is organised also provides for a pleasant user experience and aesthetically pleasing layout.

Having access to isolated pieces of data does not have the same value as data together with context. For example, a user could look at an increase of the number of transactions and volume in 24 hours and assume that Bitcoin is gaining popularity based off this information. However, looking at the line chart displayed on the same page, the price of bitcoin is dropping greatly and quickly. The increased of transaction and volume was most likely due to people panicking and transferring their bitcoins to exchanges in an attempt to sell them as quickly as possible before losing too much value. Another benefit of having information from difference sources in one place is that it is easier to compare and see strange anomalies or problems. A user could possibly see that pricing is inflated on one exchange (which usually happens when deposits are in maintenance) by comparing it to the price of other exchanges on the application.

8.3 Implications

The range of features and information that Bitcoin Hub provides, implies that it could be used by a variety of users. Below are two implications of the application:

1) A business intelligence tool for investors and traders.

Currently, mainstream cryptocurrency exchanges or trading platforms are designed very differently with a complicated dashboard and hidden information displayed over multiple pages. Users have to use multiple websites at the same time to compare different market data and spend a lot of effort to learn how to find useful information across multiple platforms. Also, if users don't know about the information or where to find it then they might not see it at all. These problems may lead to longer decision-making time for the decision makers who use such platforms and less accurate decisions from only seeing a portion of the information.

However, cryptocurrency investors that use our web application can easily escape these problems. For example: the clean, organised layout of our dashboard and charts can help them identify useful patterns and trends without creating any cognitive overload. Secondly, users only need to open one page for comparing real-time indicators from multiple exchanges. Lastly, users can gain a better experience through the fast data loading time. For these reasons, our web application as business intelligence tool, can support users to make better trading decisions in a convenient way, in shorter time.

2) A tool for trading beginners and scholars.

Most of the mainstream cryptocurrency exchanges or trading platforms are not user friendly enough for the beginners who are interested in learning about cryptocurrency due to their complex design. With a simple design that is easy to use, our application could be used as an educational tool to help understand how trading works on cryptocurrency exchanges, as well as understand the differences and similarities between cryptocurrency and traditional stock exchanges. For scholars, additional projects could also make use of this tool by connecting directly to its database and exporting the historical exchange market data collected. This data could then be used to try to identify patterns and trends to help create price prediction models for further studies.

In summary, core competence of our web application has been achieved by the following features:

1. A clean, organised layout that is intuitive and easy to use.
2. Real-time data display and comparison of key trading indicators across different exchanges.
3. Accurate and complete trading data with fast loading times.
4. A development infrastructure with modular design and the latest technologies for flexibility and scalability.

In real business use cases, such advantages could allow us to provide unique value to different users and compete within the field.

9. LIMITATIONS AND FUTURE WORKS

9.1 Limitations

Although the group completed all of the objectives they set out to complete, there were a few limitations that helped shape these initial objectives: the size of the team, a technical learning curve, time limitations of when the project needed to be complete, and available APIs.

When considering these objectives:

- The size of the team, four persons, was heavily considered when deciding on roles for team members in order to complete the project on time and well executed. This led the group to pick realistic, yet still challenging objectives, and required the team to stay flexible in their roles, jumping in when needed and adapting to changes within their skillsets.
- A learning curve was considered since the group members were attempting to implement and provide a product that required skills not possessed by the team. Ample time was put into the timeline of the project in order to adapt to this limitation.
- The group had to recognise that time was limited and picked a set of objectives that would allow for the creation of a quality product while fulfilling the requirements of the project.
- The product was limited to just two exchanges, HitBTC and Bitfinex, for one market, Bitcoin/USD. Because of time constraints and other limitations above, the group thought that the most realistic option was to choose popular exchanges within the field with good and well documented APIs.

Additionally, there was a limitation during the development of the application that prevented the implementation of the original social authentication methods chosen (Facebook and Twitter). These had extra requirements that could not be met (creation of a privacy policy, strict usage of the https protocol, etc). Google and GitHub were chosen as replacement as they did not have such restrictions.

9.2 Future Works

Below are realistic and possible future works that would make this web application even better, and exceed the original goals set forth in this project.

- A project that was offered as an option for the capstone unit proposed to utilise machine learning in order to predict the price of Bitcoin. A future work of this application could be to integrate this project with ours in order for the application to take a more active role in decision making and trading by offering predictions for the price of Bitcoin.
- Currently a user has to actively check our application for information. A future work for the application could be to implement a notification system for users to set and customise. For example: if a user wants to be notified that the price of Bitcoin is below a certain amount, they could set that up with a notifications function for the application to notify them via email, text, or on-screen message.
- The dashboard is currently set up to have an intuitive flow that is aesthetically pleasing and doesn't overwhelm the user. However, not everyone has the same aesthetic preferences nor the same needs regarding information they want. Allowing users to customise the dashboard by being able to place information they want to see and where they want to see it within the page would greatly enhance and guarantee a proper user experience for everyone.
- The candlestick charts could have more financial indicators in order to provide more information for better analysis. Our current candlestick chart displays MACD and Exponential Moving Averages (for 12- and 26-days periods). A future work could be to add other indicators such as Bollinger Bands, RSI, etc.
- The application only supports two exchanges: HitBTC and Bitfinex. A future work for this project could be to add more exchanges, providing more information for users to compare and contrast against.
- The application only includes the BTC/USD market. A future work for this project could be to add other cryptocurrency markets. This would allow for users to utilise the application for other markets instead of just the most popular one, Bitcoin.
- The application's financial indicators are currently calculated on the client side. These calculations take a lot of processing power and excessively reduce the battery life of users accessing the application with a laptop or smartphone. If a user has a low-end computer, it

could possibly slow down the loading of the charts which would not be ideal. A future work for this application could be to have the calculations done on the server side. Taking the responsibility away from the client and moving it to the back-end helps provide a more consistent experience across all types of users.

- Although users can view the buy and sell orders books of supported exchanges, there is no way for the users to actually place orders themselves. A future work could be to implement a link between the exchange and the application to allow for users to buy and sell directly from it.
- Currently there is no way to export charts from the application. A future work would be to implement this function, allowing users to export charts as images instead of having to take screenshots.
- There is currently no way to export data collected by the application (candlestick chart data points, books order, etc.) directly through the application. The data can only be extracted by connecting directly to the database of the application using an external tool. A future work could be to implement a function to allow any data stored in the application to be exported according to user's needs (type of data, time range of the data, and format of the data). This would allow users to easily be able to use that data outside its original application (ex: in TensorFlow for machine learning studies).

10. REFERENCES

- Bovaird, C. (2017). Why The Crypto Market Has Appreciated More Than 1,200% This Year. Retrieved from <https://www.forbes.com/sites/cbovaird/2017/11/17/why-the-crypto-market-has-appreciated-more-than-1200-this-year/#61adfa9e6eed>
- CoinDesk - Understanding Bitcoin Price Charts: A Primer. (2014). Retrieved 30 August 2018, from <https://www.coindesk.com/information/understanding-bitcoin-price-charts/>
- Coinigy - Professional Bitcoin & Cryptocurrency Trading Platform. (2018). Coinigy.com. Retrieved 30 August 2018, from <https://www.coinigy.com/features/>
- CryptoCompare - Live cryptocurrency prices, trades, volumes, forums, wallets, mining equipment and reviews. (2018). Retrieved 30 August 2018, from <https://www.cryptocompare.com/>
- Furlonger, D., Valdes, R., & Kandaswamy, R. (2017). *Hype Cycle for Blockchain Business, 2017* (ID: G00332628). Retrieved from Gartner database.
- Janes, A., Sillitti, A., and Succi, G. (2013). *Effective Dashboard Design*. Cutter IT Journal. 26. 17-24.
- Palash Bera. 2016. *How colors in business dashboards affect users' decision making*. Commun. ACM 59, 4 (March 2016), 50-57. DOI: <https://doi.org/10.1145/2818993>
- Xie, C., Chen, W., Huang, X., Hu, Y., Barlow, S., and Yang, J. *VAET: A visual analytics approach for e-transactions time-series*. IEEE Transactions on Visualisation and Computer Graphics, 20(12):1743–1752, 2014.