alamAPI: Development of Stock Market Price Trend Forecasting System Using Dynamic Mode Decomposition, Long Short-Term Memory, and Auto Regression Integrated Arnaud Legoux Moving Average

A Special Problem
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Contents

List of Figures

Chapter 1

Introduction

1.1 Background and Rationale

The stock market is a type of market that allows companies to raise capital by issuing shares of stock to investors. These shares represent a share of ownership in the company and entitle the holder to a share of the company's profits and voting rights. The stock market also provides a platform for investors to buy and sell these shares, allowing for the efficient trading of company ownership. By allowing companies to raise capital and investors to buy and sell shares, the stock market plays a crucial role in the growth and development of the economy (Chen, 2022; The Economic Times, n.d.).

Contrary to popular belief, the stock market is not a form of gambling. It involves a significant amount of analytical thinking and risk management, and the returns are based on the supply and demand for a given stock, rather than on false promises or assurances. In other words, the stock market is a legitimate platform for investing and generating returns, rather than a scam or gamble (Schwab-Pomerantz, 2021; Adams, 2022; Summers, 2022).

1.1.1 The Philippine Stock Exchange (PSE)

The Philippine Stock Exchange (PSE), Inc. is the official stock exchange market in the Philippines. It is a non-stock company that was incorporated in 1992 and manages and operates the stock market in the country. Registered individuals can participate in market exchanges on the PSE. (The Philippine Stock Exchange, Inc., n.d.-a).

Moreover, the main index of the Philippine Stock Exchange (PSE) is the Philippine Stock Exchange Index (PSEI). The PSEI is a market capitalization-weighted price index that is based on the 30 largest and most actively traded companies on the PSE. These companies are pre-determined based on strict criteria, such as liquidity and market capitalization. The PSEI is often used as a benchmark for the performance of the overall stock market in the Philippines. (Bangko Sentral ng Pilipinas, n.d.) The companies that make up the PSEI are often referred to as blue-chip companies, as they are typically large, well-established companies with a history of strong financial performance. As of October 2022, there are 286 companies listed on the PSE, providing a diverse range of investment opportunities for investors. (Fayed, 2022; The Philippine Stock Exchange, Inc., n.d.-b).

1.1.2 Economic Relevance and Benefits of Stock Market Investment

It is commonly accepted that the stock market plays a crucial role in economic growth, as it allocates and provides capital to businesses, which in turn drives economic activity and growth. This is evident from the fact that stock market performance is often correlated with a country's Gross Domestic Product (GDP) (Trade Brains, 2022; Hall, 2022; Bae & Kang, 2017) Additionally, historical trends in stock prices can provide insight into broader economic movements (Campbell, 2021).

Moreover, a study by Balaba (2017) found that the stock market has a positive effect on the economy of the Philippines. The data from the study showed that as the stock market grew, the country's unemployment rate declined. This is

because the stock market's performance leads to job creation, which in turn drives economic growth. This relationship has been evident in the Philippines for the past 10 years.

1.1.3 Benefits of Investing for the Individual

The Philippine Stock Exchange allows individuals in the Philippines to trade shares of listed companies. Investing in the stock market can provide several benefits for an individual, such as:

(a) Protecting the value of an individual's money from inflation: Inflation in the Philippines was at 6.9% as of September 2022 (Trading Economics, n.d.), while savings account deposit interest rates are only between 1-3% annually (Bureau of the Treasury Bangko Sentral ng Pilipinas, n.d.). This means that savings in deposit banks may not keep pace with inflation, potentially reducing the purchasing power of an individual's money (Royal Bank of Canada Direct Investing Inc., n.d.; EdwardJones, n.d.).

(b) Providing opportunities for capital growth: Investing in the stock market can provide individuals with the p otential for significant capital growth, without the need for direct involvement in business operations. This can be beneficial for individuals such as students or working professionals, who can grow their capital while focusing on their studies or careers (U.S. Securities and Exchange Commission, n.d.).

1.1.4 Utilization of Machine Learning in Stock Market Trading

In recent years, there has been a growing interest in applying machine learning techniques to predict the movement of the stock market, both in the short and long term. This has led to numerous studies and practical applications exploring the use of machine learning in stock market prediction. These efforts aim to improve the accuracy of predictions and help investors make informed decisions.

(Kumbure, Lohrmann, Luukka, & Porras, 2022; Strader, Rozycki, Root, & Huang, 2020; Soni, Tewari, & Krishnan, 2022; Rea, 2020; Guo, 2022). Wherein, one of the common techniques used in machine learning for stock market prediction is Long Short-Term Memory (LSTM). A study by Budiharto (2021) found that LSTM was effective in predicting the Indonesian stock market by 95% using short-term data. This indicates that LSTM can be a valuable tool for making short-term stock market predictions.

Recently, the use of Dynamic Mode Decomposition (DMD) for predicting stock market price trends has gained momentum in the financial and scientific communities. DMD is a mathematical method that can be used to identify patterns and trends in complex data sets, such as stock market data. By applying DMD to stock market data, it is possible to make more accurate predictions about future stock price movements. This can help investors make informed decisions about their investments and potentially generate better returns. In connection to this, a study by Lu and Tartakovsky (2020) found that DMD can be a faster predictor than Proper Orthogonal Decomposition (POD), but it is less accurate.

Furthermore, other studies have shown that DMD can be effectively applied to the Turkish and Indian stock markets to predict market price trends (Savaş, 2017; Kuttichira, Gopalakrishnan, Menon, & Soman, 2017). These studies indicate that DMD is easy to implement and can be a useful tool for making stock market predictions.

Aside from LSTM and DMD, another model is also being used in stock market predictions, which is the Auto Regression Integrated Moving Average (ARIMA). In a study conducted by Ayodele Ariyo Adebiyi (2014), ARIMA model shows satisfactory results for predicting stock prices on the short-term period. Moreover, in this special problem the author will also explore the feasibility of using Arnaud Legoux Moving Average (ALMA) in combination with ARIMA. This will be done since compared to the traditional Moving Average (MA), ALMA produces a more reliable signal (Sarkar, 2019).

1.2 Statement of the Problem

The Philippines' economic growth is expected to decline in the coming years due to the global pandemic, high inflation, and low employment rates. (Alegado, Lopez, & Calonzo, 2022; Canto & Romano, 2022; Reuters, 2022).

Currently, the lack of free and publicly available stock market predictive systems or tools creates a gap in the information available to the public compared to large private individuals or institutions. These large institutions have the resources to spend a significant amount of money on stock market research, giving them a significant advantage in the investing market. This lack of access to the same information puts the public at a disadvantage (Kim, 2022).

Furthermore, the lack of publicly available stock market prediction tools can lead to unwise investment decisions by individuals, particularly first-time investors, resulting in significant losses and discouragement from investing in the stock market. This is a significant problem, as the number of local investors in the Philippine Stock Market is already quite low, comprising only around 1% of the total population and there also has been a massive decline in foreign investment in the Philippines in recent years (Business World, 2022), leading to a corresponding decline in investment volume. As suggested by the study of Balaba (2017), this is expected to have a negative multiplier effect on the country's economic development in the future.

Hence, the development of a publicly available, easy-to-use, and accurate stock market price trend prediction system could help to reduce the information gap and level the playing field for individual investors. By providing the public with fast and reliable information, this system could help to increase transparency and fairness in the stock market, leading to more informed and confident investing decisions and ultimately a more stable and prosperous market. Additionally, such a system could help to increase the participation of individual investors in the market, leading to a more diverse and stable market overall. (Department, 2022; Commission on Population and Development, 2021).

Despite the clear and functional benefits of investing in the stock market, many

Filipinos remain hesitant to do so for the following reasons:

(a) The complexities associated with learning the fundamentals of effective stock investing.

(b) The time-consuming nature of technical and fundamental analysis, particularly for students and working individuals with limited time.

(c) The higher financial risk due to the volatility of the stock market, as well as the potential for emotional decision-making to compromise investments

These factors contribute to a lack of confidence and understanding among potential investors, making it difficult for them to take advantage of the opportunities offered by the stock market.

As such the development of the proposed system, shall help to address the following:

(a) The lack of free and publicly available stock market prediction systems or tools.

(b) The time and resources required to study complex traditional market analysis tools, such as fundamental and technical analysis.

(c) The potential for inaccurate market decisions leading to significant investment losses.

(d) The hesitancy of the Filipino public to begin investing in the Philippine stock market.

1.3 Significance of the Study

The significance of this special problem lies in its potential to develop a system that will greatly benefit the stock market, individual investors, and the overall economy. The system's contributions to data-driven investing, financial protection

and management, and economic development will provide a valuable resource for investors and help to promote financial stability and growth. Additionally, the development of publicly accessible data-driven investing tools will enable more Filipinos to participate in the market and take control of their own financial future. Overall, this study has the potential to make a meaningful impact on the stock market and the economy in the Philippines.

Specifically, this study is significant for the following reasons:

(a) The development of the alamAPI will provide the following benefits to the Filipino people:

1. Access to simplified yet accurate information – The proposed system will provide Filipino investors with fast, accurate, and relevant information necessary for effective decision making in the stock market. Using advanced machine learning classifiers, the system will provide users with the two most important pieces of information: which stocks to buy, and which stocks to sell. This simplified investing model will help investors to make informed decisions and navigate the stock market with confidence.

2. Provide an application interface to facilitate data-driven and wise market decisions – The proposed system will provide users with an intuitive and user-friendly application interface to facilitate data-driven investment decisions, particularly during times when the market is unpredictable or experiencing a downturn. Whereas traditional market analysis tools may not be sufficient to navigate these challenging conditions, the system's advanced machine learning algorithms will provide investors with the insights and guidance they need to make informed and wise decisions. This will help to promote confidence and stability in the market, even during times of uncertainty.

3. A platform for accessible stock market investment – The proposed system will provide all investors, regardless of their investment knowledge, educational attainment, and societal status, with a platform for participating in the stock market. By offering a simplified yet accurate model for investment decision making, the system will empower users to make informed decisions and invest with confidence. This will help to democratize access to the stock market and promote financial inclusion for all Filipinos.

(b) The development of the alamAPI, specifically the Stock Market Price Trend Forecasting System (SMPTF Sys), will provide the following benefits to the future developers or researchers:

1. Extension of functionality to other financial markets – The proposed system can be easily adapted or expanded to address related problems in other financial markets, such as investing in government bonds or personal finance management. This flexibility and versatility will make the system a valuable tool for a wide range of investment and financial management scenarios.

2. Testing of new trading algorithms and machine learning models – The system provides a platform for introducing and testing new data-driven trading algorithms and machine learning models. This will allow researchers and developers to continually improve the system and keep it at the forefront of data-driven investing technology.

3. Development of a graphical user interface – To further improve the public accessibility of the system, a user-friendly graphical user interface can be developed as a web or mobile application. This will make the system easy to use and intuitive for all users, regardless of their technical expertise.

(c) The development of the alamAPI will help to stimulate economic recovery and development in the country by increasing the number of local investors. As discussed in previous sections, the benefits of the system will encourage more people to invest in the stock market, leading to a multiplier effect that will benefit the economy in several ways. For example, the increased participation in the market will lead to the creation of jobs and a lowering of unemployment rates. Additionally, the influx of capital into the market will drive fast developments and innovations in various industries, and the increased consumer spending that results from successful investing will stimulate economic growth. Overall, the development of the alamAPI will have a positive and far-reaching impact on the economy of the Philippines.

1.4 Objectives

The main objective of this special problem is to develop a system that will make investing easier, more publicly available, data-driven, and more approachable to the public by minimizing both the time required for stock price trend analysis, and potential financial risk by using a predictive model. Specifically, it aims to do following:

(a) Develop a RESTful API, which will be referred to as alamAPI, using the combination of Python libraries and MongoDB for the backend services and database, respectively.

Whereas this backend service will be using Python's FastAPI that will enable different user to connect to the database and collect the information provided by the Stock Market Price Trend Forecasting Model.

Specifically, this will be done by doing the following:

1. Develop a Data Collector Module (DCM), which will get the historical data every day for the past 200 days every after market close from Mondays to Fridays. The data collected will be eventually processed by the Pre-Database Processor (PDB) with the help of the Preprocessor Utilities Module (PUD). Wherein, DCM, PDB, and PUD will be part of the Preprocessor Module (PPD) of alamAPI.

2. Develop a database that will store the results provided by the PPD, and other essential data about the stock market that is needed to be provided in the backend service.

3. Develop the necessary API endpoints that will provide recommendation on which stocks to buy or sell. Additionally, it provides the general information about these stocks.

(b) Develop the following Stock Market Price Trend Forecasting Machine Learning Models:

1. Model A (DMD-LSTM) – Utilize the dynamic modes in DMD as a parameter to the LSTM model.

2. Model B (ARIALMA) – Modify ARIMA by using the optimized parameters for ALMA instead of the traditional MAs.

(c) Finally, develop a mobile-based test application to showcase the main functionalities of the developed RESTful API.

1.5 Scope and Limitations

This study is limited only within the companies listed in the Philippine Stock Exchange, including the PSE Index itself. Wherein, only 20 selected high volume trade stocks from the year 2021 to 2022 which are has following stock symbols: (1) MEG, (2) JGS, (3) BDO, (4) FGEN, (5) ICT, (6) ALI, (7) SMC, (8) TEL, (9) GLO, (10) BLOOM, (11) RLC, (12) MER, (13) AC, (14) PGOLD, (15) LTG, (16) MPI, (17) AP, (18) RRHI, (19) URC, and (20) PSE Index will be included in the system, instead of the total 286 listed under the Philippine Stock Exchange, this is because the data directly from the Philippine Stock Exchange Inc., is not free, and the free data provided by a third-party only allows for 20 requests per day. Also, using data scraping tools may prove to be illegal, as it is considered as data theft because data provided in those websites are for public viewing purposes only and are also paid by the companies hosting them.

Chapter 2

Review of Related Works and Literature

One of the challenges facing investors in the Philippine Stock Market is the limited availability of resources and tools for making market decisions. In contrast, other countries have begun implementing machine learning techniques for stock market prediction and analysis, which allows for more accurate decision-making and reduces the risk of poor investment outcomes. As a result, these countries are likely to experience better returns on their investments.
In this literature review, the following general topics are reviewed, discussed, and synthesized: (a) Integration of Machine Learning based Trading Algorithms; and (b) Utilization of Dynamic Mode Decomposition on the Financial markets.

2.1 Integration of Machine Learning based Trading Algorithms

Stock market analysis is crucial for effective risk management. This involves using various methods, such as technical and fundamental analysis, to make informed decisions for investors and traders. In recent years, the growth of computing power and resources has led to the increasing use of machine learning techniques for stock market prediction and analysis. These advances help companies better

predict upcoming market trends and make more informed decisions.

The integration of machine learning algorithms in the stock market is growing, as investors and traders increasingly rely on fast and accurate market information to reduce potential risks and make better decisions. These algorithms allow for more efficient analysis of market data, leading to more informed decisions and improved investment outcomes (Obthong, Tantisantiwong, Jeamwatthanachai, & Wills, 2020).

2.1.1 Comparison of Machine Learning Models in Stock Market Predictions

To have a better grasp in the accuracy of the different models used in algorithmic trading it is essential that different models are compared against each other.

Combination of Computational Efficient Functional Link Artificial Neural Network (CEFLANN) and Traditional Technical Analysis

This hybrid model combines a classification-based model: CEFLANN and the traditional technical analysis to create a stock trading framework Dash and Dash (2016), which the results show a profit of 24.29%.

Deep Long Short-Term Neural Network (LSTM) with Embedded Layer

In one of the models developed by Pang, Zhou, Wang, Lin, and Chang (2020), it shows that by adding an embedded layer to the LSTM it yields to a stock market price prediction accuracy of 57.2%. However, its accuracy dips to 52.4% when the model is applied to individual stocks.

LSTM with Automatic Encoder

As part of the second model developed by Pang et al. (2020), this model shows a slightly inaccurate stock market prediction, by only having a measured accuracy of 56.9%. However, compared to the first model developed by the group this is 0.1% more effective for individual stocks.

Optimal Deep Learning (ODL)

In the study conducted by sManish Agrawal, Khan, and Shukla (2019) they have created a stock price prediction model using an Optimal Deep Learning (ODL) which combine the concepts of Correlation-Tensor and an Optimal LSTM algorithm. Whereas their results show a mean and highest accuracy of the model as 59.24% and 65.64%.

NMC-BERT-LSTM-DQN-X Algorithm

More recently, a team have applied a combination of three models for forecasting the market trends. Namely, (1) Non-stationary Markov Chain (NMC), (2) Bidirectional Encoder Representations from Transformers (BERT), (3) Long Short-Term Memory (LSTM). Wherein their model shows an accuracy of 61.77%. Furthermore, the team also mentioned that the model produces 29.25% annual return on investment, with a maximum losses rating of -8.29% (Liu, Yan, Guo, & Guo, 2022).

2.2 Utilization of Dynamic Mode Decomposition (DMD) on the Financial Markets

Dynamic Mode Decomposition (DMD) as an emerging data-driven technique which allows spatial-temporal pattern recognition from a complex set of data and was first introduced in the field of fluid mechanics by (SCHMID, 2010).

2.2.1 Chronological Utilization of DMD in the Financial Markets

In (2015) Mann and Kutz proved that DMD can be used as data-driven analytics on the financial market data. Wherein, DMD allows a predictive assessment of the market dynamics, which helps in the capitalization of stock market strategies and decisions to be applied.

Utilization of DMD for Determining the Cyclic Behavior in the Stock Market (2016)

By utilizing the reproducible Koopman modes it made it possible to have extracted four cyclic variations (also reproducible modes) in the stock market, which were previously unknown and have persisted since the 1870s' global economic crisis (Hua, Roy, McCauley, & Gunaratne, 2016; Williamson, 2015).

Utilization of DMD as part of an Algorithmic Trading Strategies for the Turkish Stock Market (2015 and 2017)

The study of Mann and Kutz (2015) in the utilization of DMD for financial stock market prediction has become the foundation of the study by Savaș (2017) on the algorithmic trading strategies with Dynamic Mode Decomposition for the Turkish Stock Market. Wherein, based on their results they found out that the timing of DMD analysis was not significantly accurate, as such they have used a simple moving average with genetic algorithm to improve the market timing of DMD, which prevents 80% of the false trade signals.

Furthermore, this also shows that DMD is an effective alpha model that is easy to implement and use for any algorithmic trading strategy, and the addition of technical analysis tools can further improve its capabilities, especially on the predictive temporal side of the data.

Utilization of DMD-based Trading Strategy in the Chinese Stock Market (2016)

In the study by Cui and Long (2016), they have found that DMD was able to capture the dynamic patterns of the Chinese Stock Market, especially in a sideway trending market.

Their study also shows that the predictive ability of DMD can effectively model the behavior of the Chinese Stock Market, even if there are no clear trends that can be observed.

Utilization of Adaptive Elastic DMD to Improve Momentum Strategies (2021)

A study by Uchiyama and Nakagawa (2021), using Adaptive Elastic Dynamic Mode Decomposition (AEDMD) shows that they were able to estimate the market trend, and were able to demonstrate that the approach is better than existing momentum strategy which are only based on simple past trends.

2.3 Synthesis

Fast and accurate market information is an essential tool for stock market participants. In recent years, the development of machine learning models for the financial markets, such as stocks, has proven to be increasingly effective in predicting future stock prices and trends. The use of Dynamic Mode Decomposition (DMD) in the stock market has also been shown to be effective in predicting stock price trends. The simplicity and elegance of the Koopman Decomposition Operator make it an ideal basis for the development of a Stock Market Price Trend Forecasting System (SMPTF System).

These studies are crucial for the development of the alamAPI to provide investors with fast and accurate information about which stocks are likely to go up or down, allowing them to make more informed decisions about buying or selling

those stocks.

In addition to the potential benefits for investors and traders, the implementation of machine learning techniques in the stock market can also help improve market efficiency and reduce the risk of market manipulation. By providing a more accurate and comprehensive view of market trends, these techniques can help ensure that prices reflect the true value of stocks and other assets, leading to more stable and fair market conditions.

Chapter 3

Materials and Methods

This chapter will discuss the materials and methods that will be used for the development of the proposed system: alamAPI. Specifically, the following will be discussed in this chapter:

(a) Development Tools and Software Requirements

(b) System Diagrams

(c) Hardware Requirements

(d) Methodology

(e) Gantt Chart

3.1 Development Tools and Software Requirements

The development of the alamAPI will use the following development tools and software requirements:

3.1.1 Development Tools

(a) Visual Studio (VS) Code – This is a highly functional code editor, which will be used as the main development interface for the project.

(b) MongoDB Compass – This is a graphical user interface used for the development and management of different MongoDB databases.

(c) GitHub – This will serve as the code repository and version control system (using git) for the project.

3.1.2 Software Requirements

(a) Python (version 3.11.x) – this will serve as the main programming language for the development of the different components of alamAPI, more specifically the following libraries will be used:

- For the development of the API and Database ODM
  - FastAPI (version 0.85.0) – This is a library primarily used for building modern, fast, and high-performing web framework APIs (Tiangolo, n.d.). This will be utilized in the development of the project because of its (1) ease of utilization; (2) fast implementation; (3) high-performance; (4) built-in robust API documentation; and (5) high scalability.
  - mongoengine (version 0.24.2) – This is a library developed as an Object-Document Mapper, which lets Python connect and work with MongoDB (MongoEngine, n.d.) This will be used in the alamAPI to connect the API endpoints to the MongoDB database.
  - json (pre-installed) – This is a python library that can transform Python dictionary into json object, and vice versa. This will be used in the development of alamAPI for parsing and conversion of the data from the API and to the MongoDB database through an ODM.
  - datetime (pre-installed) – This python library is used for creating a datatime object, which as the name suggests is an object that

contains the date and time information. This will be used in the development to keep track with all the processes that is happening in the system through a date and time logs.

- os (pre-installed) – This is a python library that enables the user to do operations in the operating system such as creating directories, files, accessing operating system information, etc. This will be used to access the operating system's environment variables, and to help in other OS-based functions.

- For the pre-processor (data collector)
  - requests (version 2.28.1) – This library allows the user to create web requests to an external or internal servers. This will be used to connect and collect the current EOD market data from the third-party market historical data provider: EODHD.
    EODHD – A third-party market fundamental and historical data APIs provider (EODHD, n.d.).

- For the pre-processor (machine learning processor):
  Note that these libraries will also be used in the development of the machine learning model.
  - pickle (pre- installed) – This allows an object to be saved and reloaded as a variable in Python, as such this will be used to save the machine learning developed and be utilized to process the new and updated data provided by the data collector.
  - joblib (pre-installed) – xxx
  - numpy - xxx
  - pandas - xxx
  - sklearn - xxx
  - tensorflow - xxx
  - matplotlib - xxx
  - seaborn - xxx

(b) MongoDB – This will be used as the non-relational (document-based) database, that will hold the stock information, stocks to buy, and stocks to sell.

(c) Jupyter Notebook – This will be used during the training and testing of the machine learning model that will be developed as part of the alamAPI.

(d) CRON – A Linux-based scheduler. This will be used in the system to set a schedule for the historical data collection and processing for each market end-of-day (EOD) every 5 PM from Mondays to Fridays. Moreover, the scheduler is part of the pre-processor module of the system.

(e) Docker – This is a very useful tool to creating containers, whereas a container contains a code and all its dependencies in one standard unit of software, which can be run in different machines regardless of its difference from the development machine used (Docker, n.d.). As such this will be used to create containers for each of the component of alamAPI, to enable it to run in different deployment machines.

(f) Docker-compose – In order to run multiple containers at once, docker-compose will be used. This will be further discussed in the Container Diagram section of this chapter.

(g) Dart and Flutter - xxx

(h) Git - xxx

3.2 System Diagrams

3.3 Hardware Requirements

3.4 Methodology

3.5 Gantt Chart

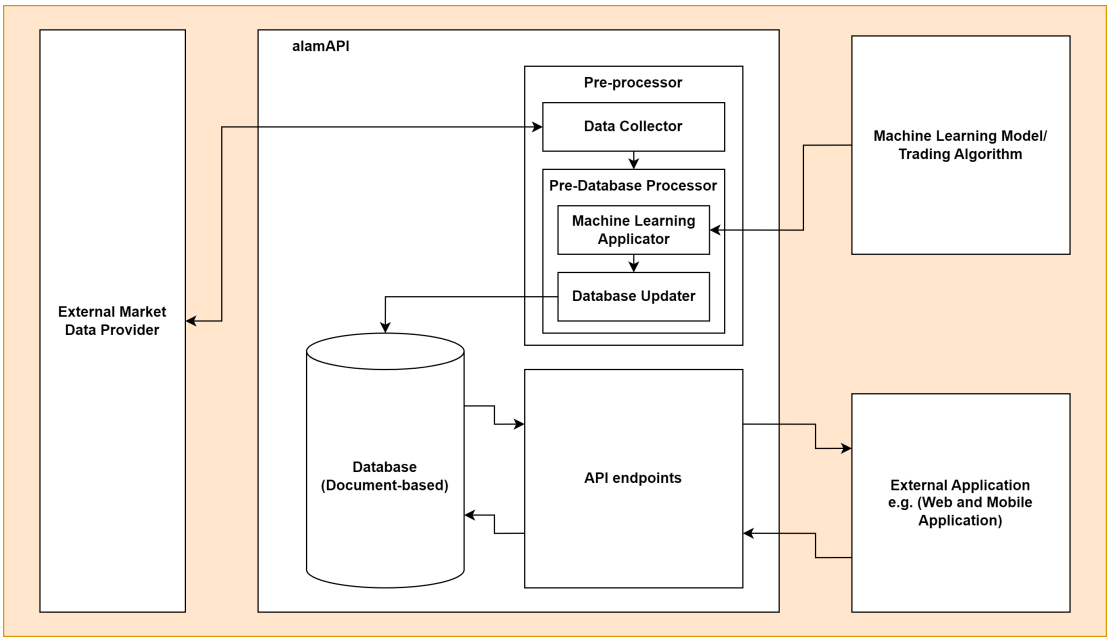

Figure 3.1: Top-Level Overview of the alamAPI and Interactions with External Applications/Systems

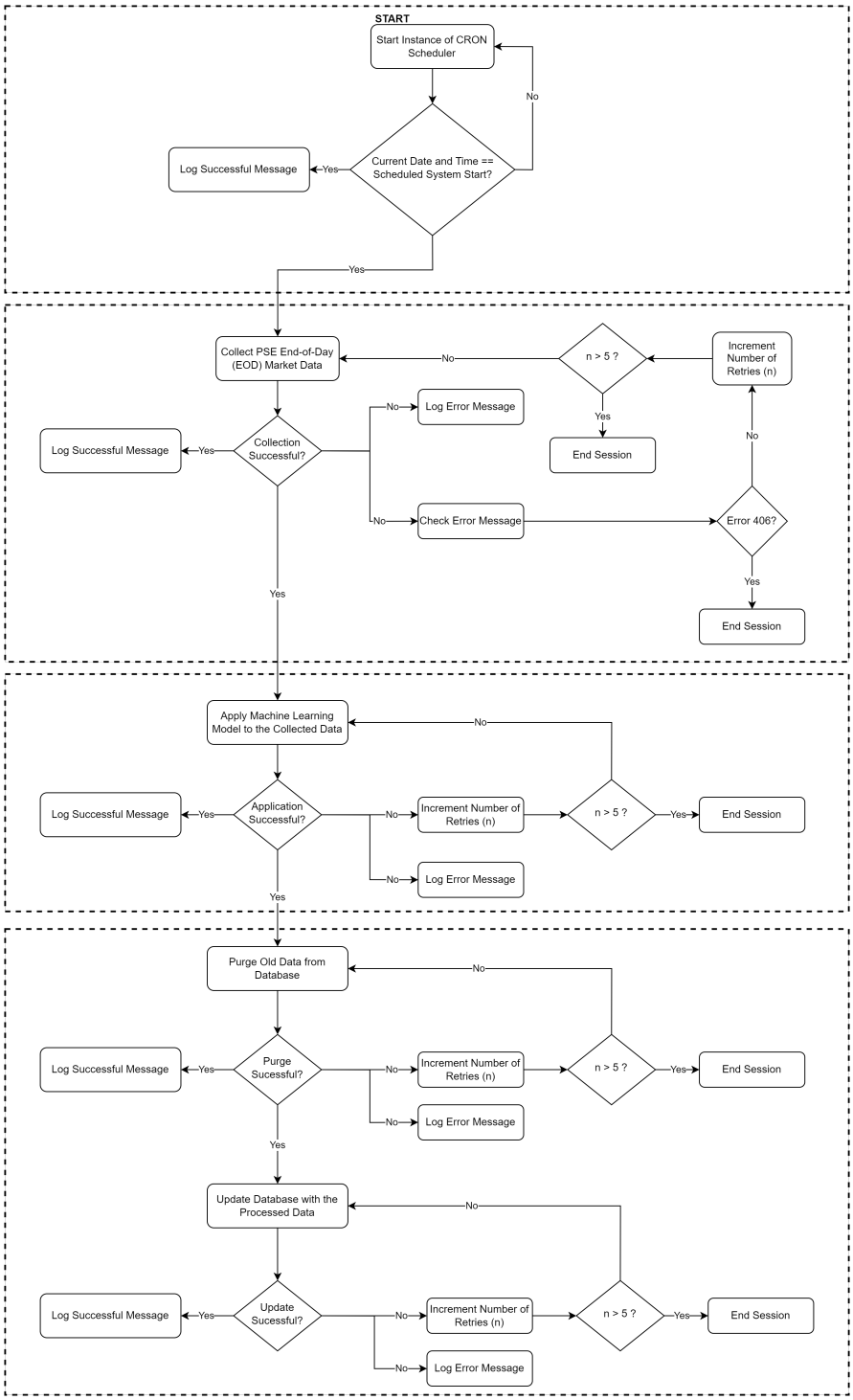

Figure 3.2: Full Overview of the Process Flow Diagram for the alamAPI

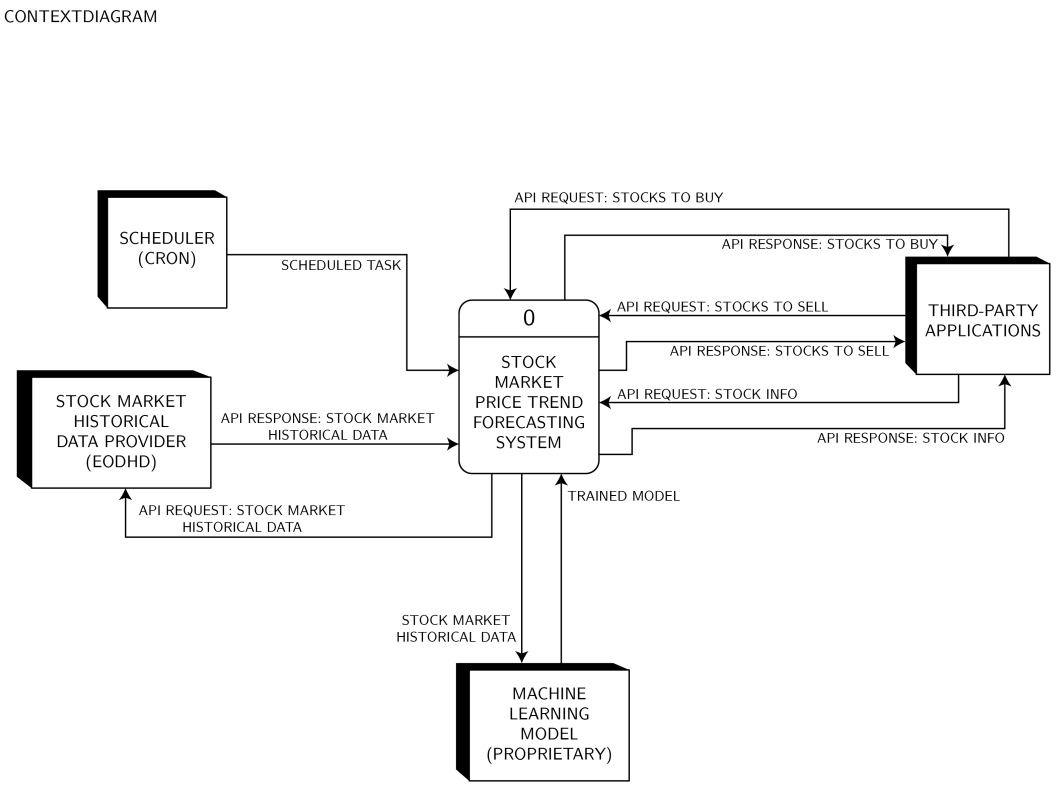

Figure 3.3: Data-Flow Diagram for the alamAPI

DIAGRAM 0 DFD FOR STOCK MARKET PRICE TREND FORECASTING SYSTEM

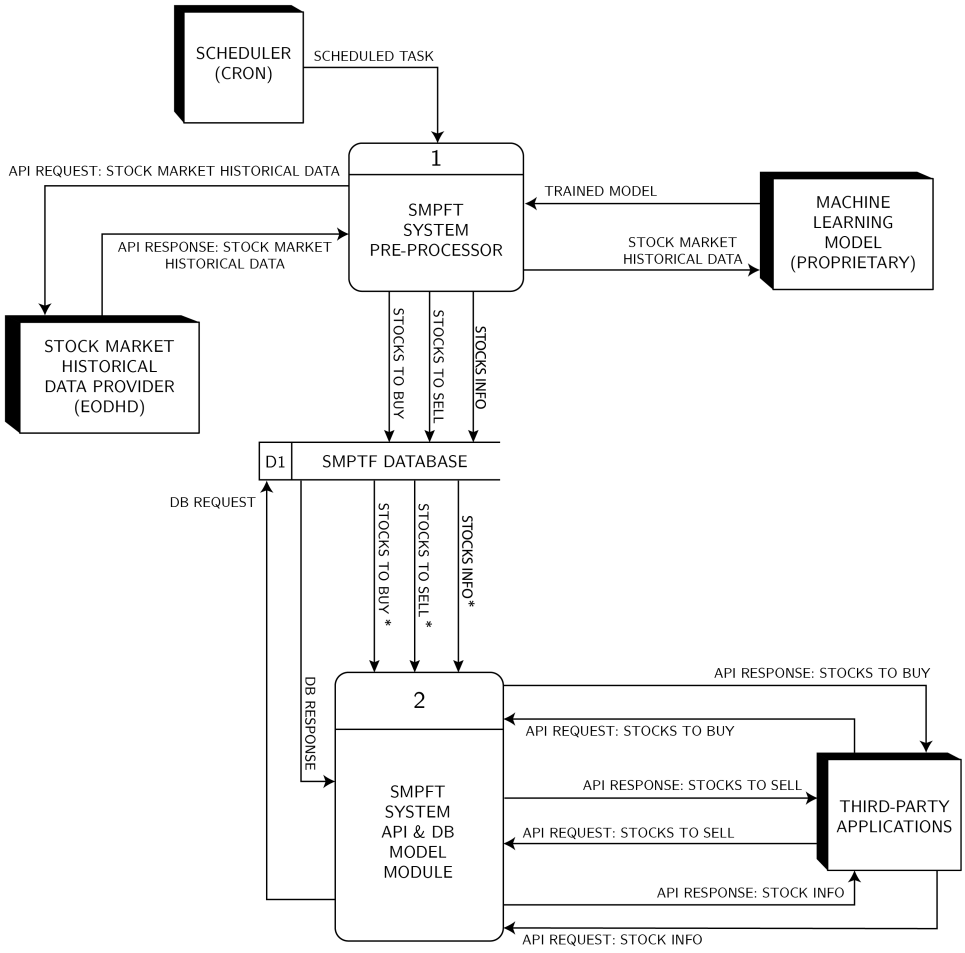

Figure 3.4: DFD 0: Data-Flow Diagram for the alamAPI

DIAGRAM 1 DFD FOR STOCK MARKET PRICE TREND FORECASTING SYSTEM (SMPTF) PREPROCESSOR

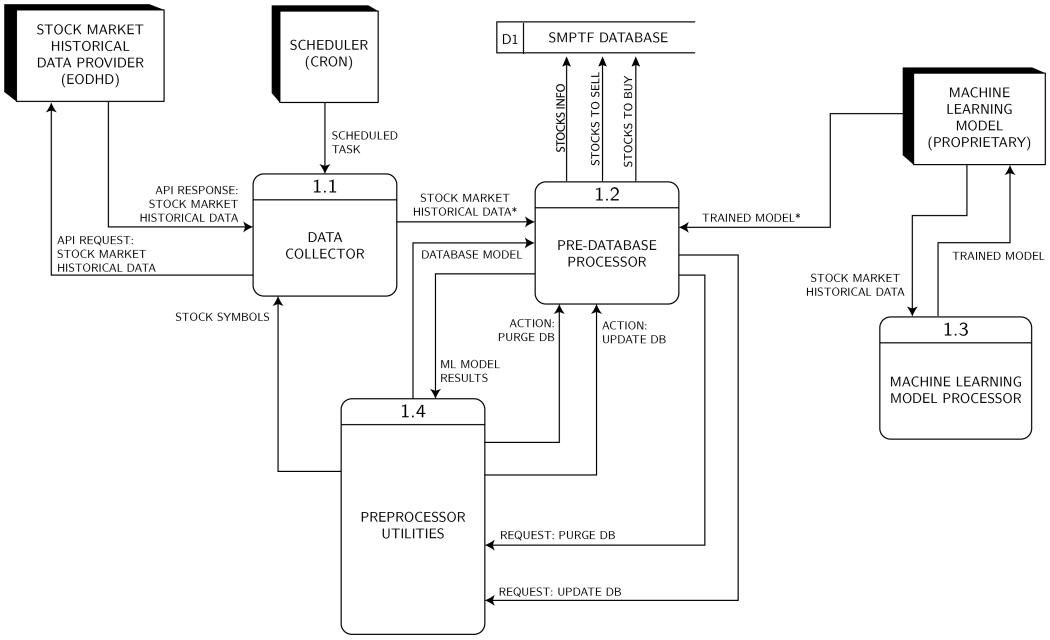

Figure 3.5: DFD 1: Data-Flow Diagram for the alamAPI

DIAGRAM 2 DFD FOR STOCK MARKET PRICE TREND FORECASTING SYSTEM (SMPTF) API & DB MODULE

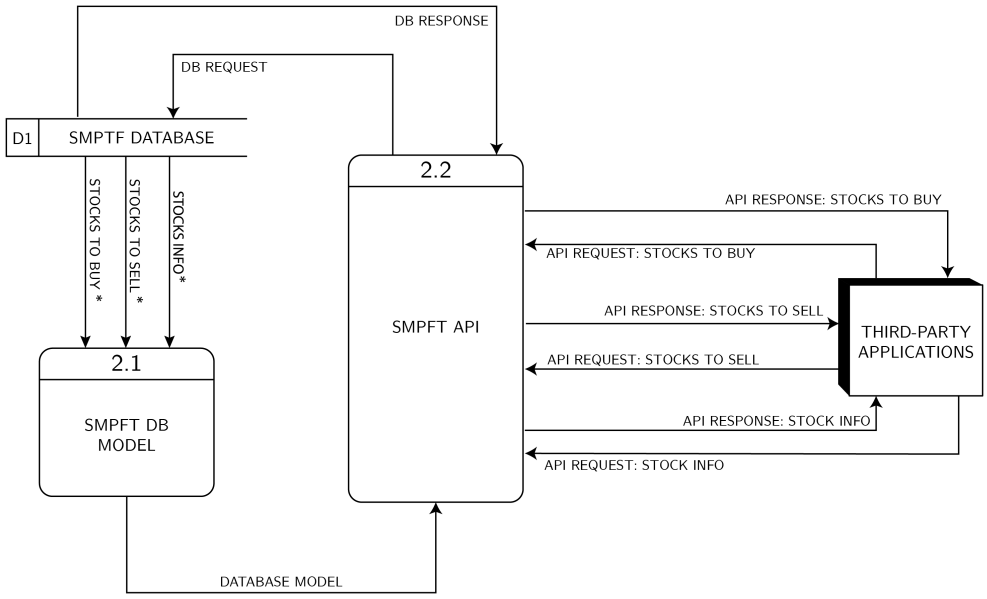

Figure 3.6: DFD 1.2: Data-Flow Diagram for the alamAPI

DIAGRAM 1.2 DFD FOR STOCK MARKET PRICE TREND FORECASTING SYSTEM (SMPTF) PREPROCESSOR

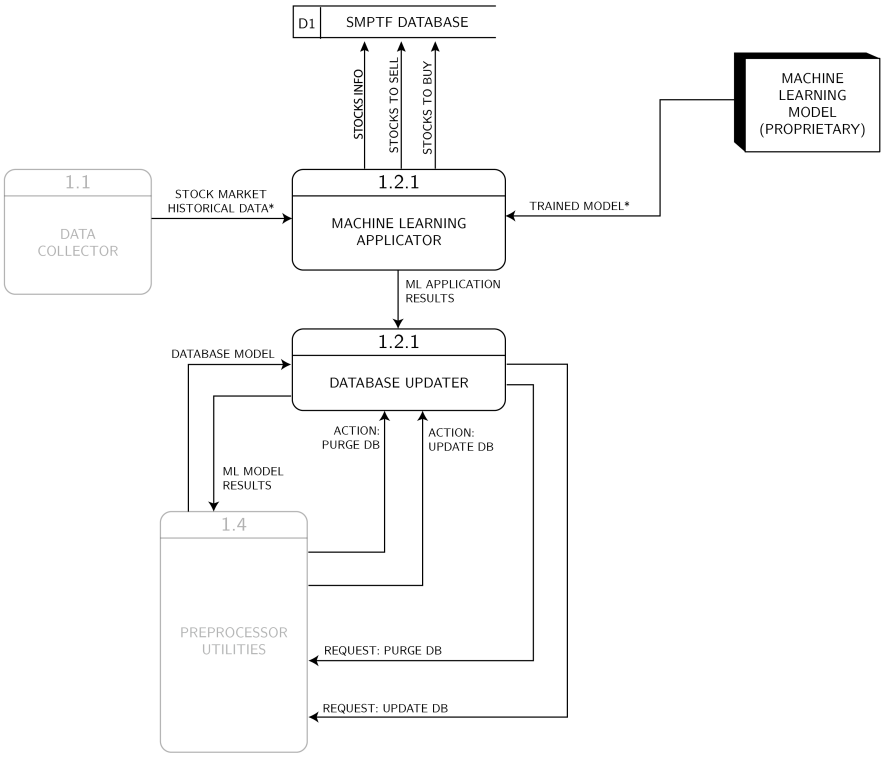

Figure 3.7: DFD 2: Data-Flow Diagram for the alamAPI

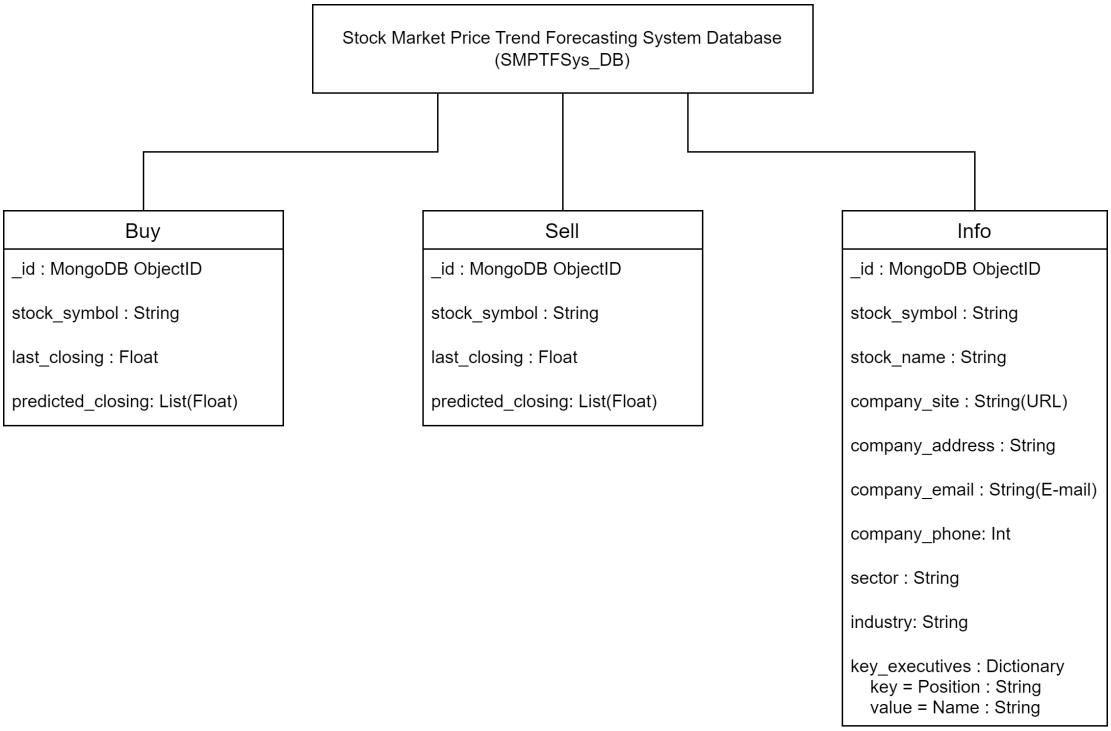

Figure 3.8: Object-Data-Model for the alamAPI

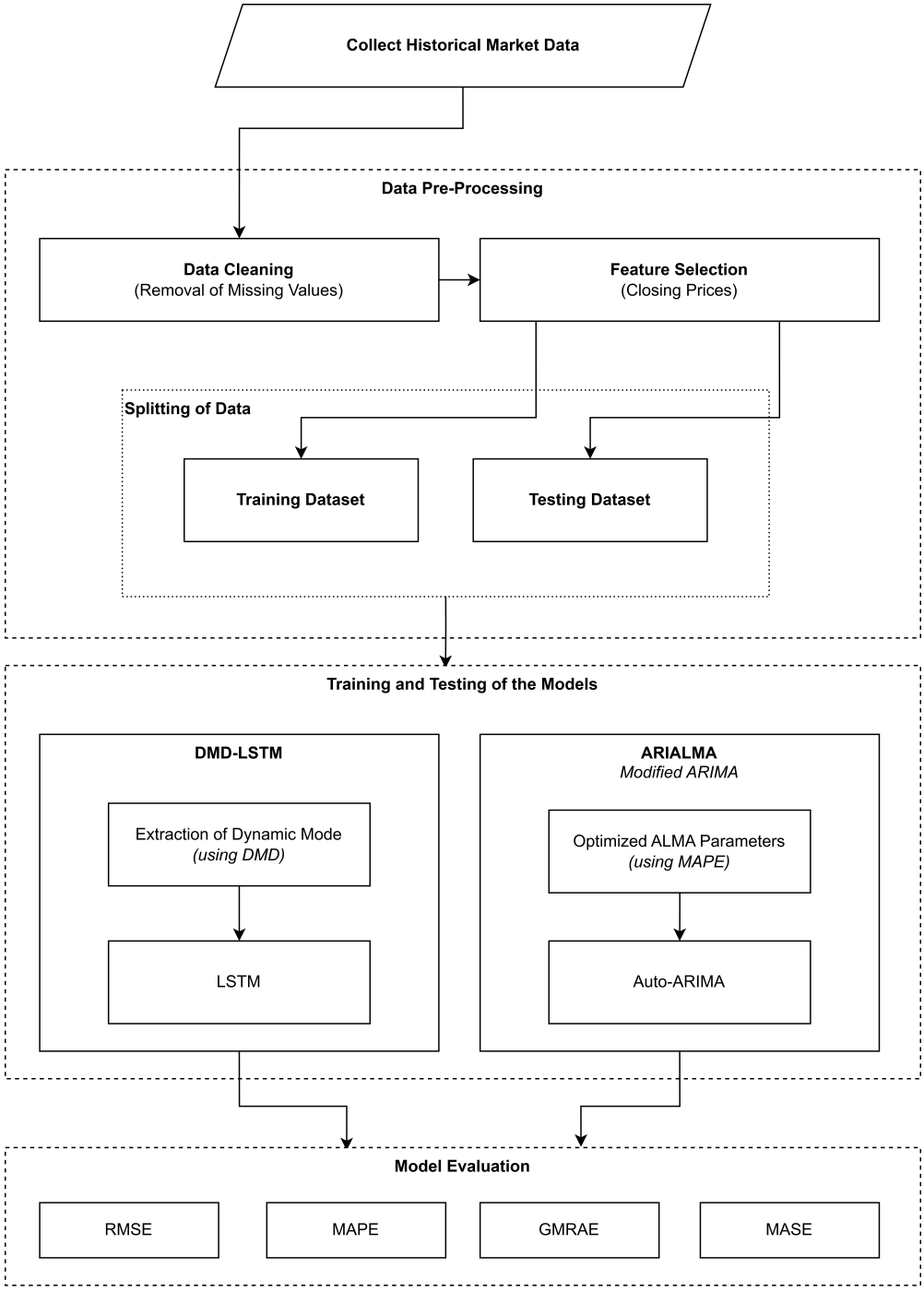

Figure 3.9: Machine Learning Model for the alamAPI

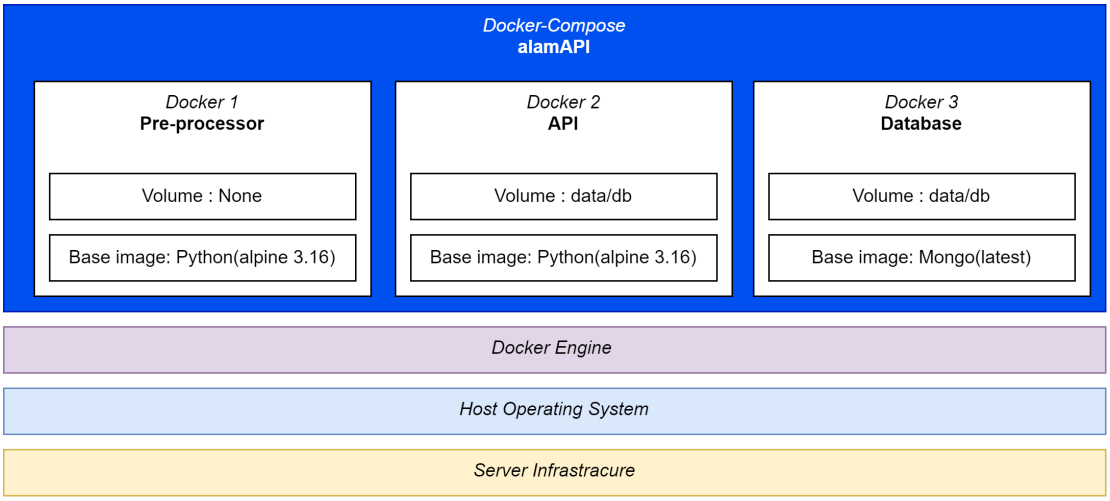

Figure 3.10: Docker-Compose Layer Diagram for the alamAPI

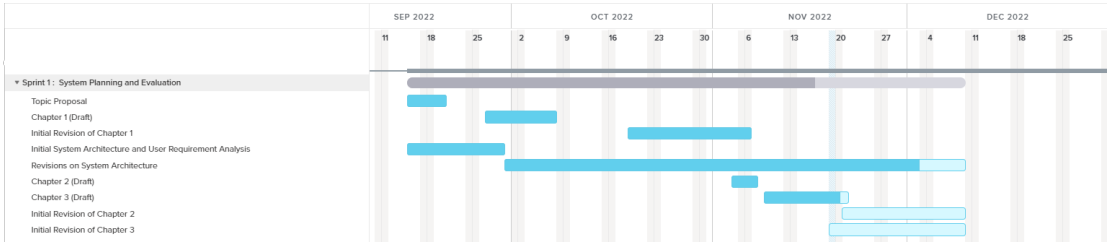

Figure 3.11: Gantt Chart for Sprint 1

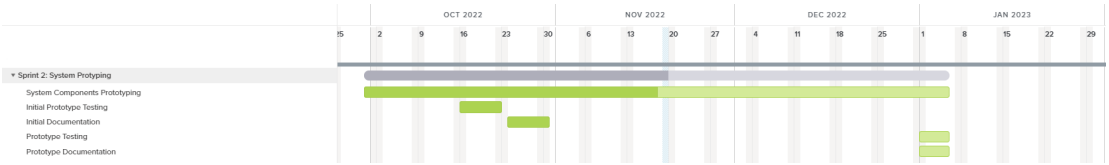

Figure 3.12: Gantt Chart for Sprint 2

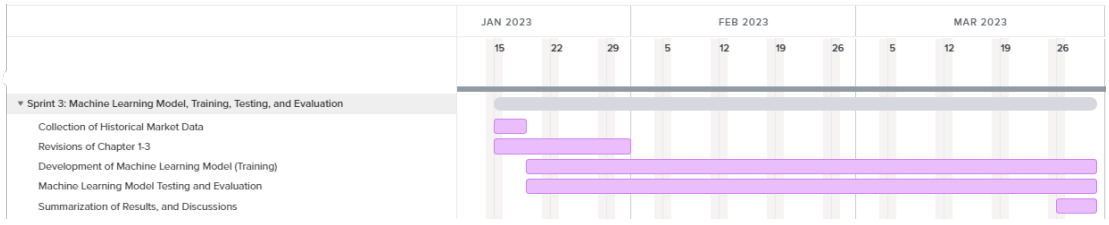

Figure 3.13: Gantt Chart for Sprint 3

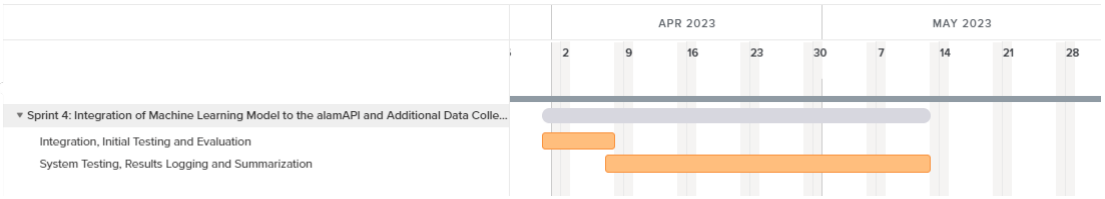

Figure 3.14: Gantt Chart for Sprint 4

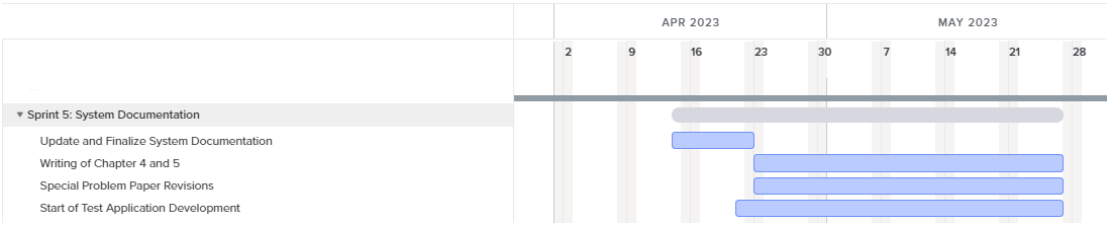

Figure 3.15: Gantt Chart for Sprint 5

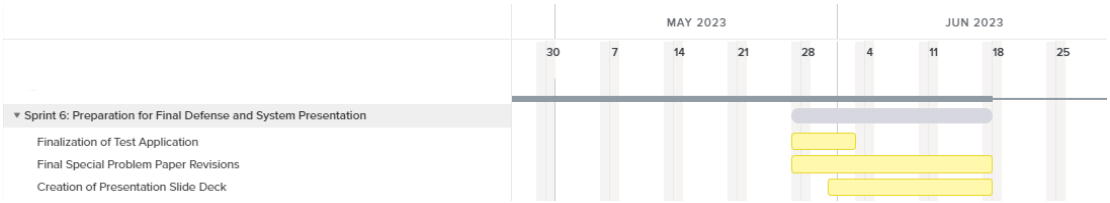

Figure 3.16: Gantt Chart for Sprint 6

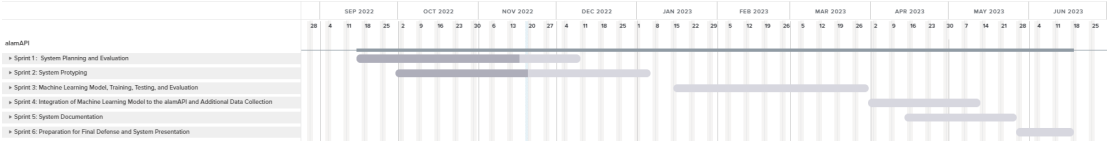

Figure 3.17: Full Gantt Chart

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