EQUITY/DEBENTURE PORTFOLIO AND INVESTMENT MANAGEMENT SYSTEM

A dissertation submitted for the Degree of Master of Information Technology

D. G. N. Jayakody
University of Colombo School of Computing
2019

UCSC

EQUITY/DEBENTURE PORTFOLIO AND INVESTMENT MANAGEMENT SYSTEM

D. G. N. JAYAKODY
2019

DECLARATION

The thesis is my original work and has not been submitted previously for a degree at this or any other university/institute.

To the best of my knowledge it does not contain any material published or written by another person, except as acknowledged in the text.

Student Name: D. G. N. Jayakody

Registration Number: 2015/MIT/020

Index Number: 15550202

_____

Signature: Date:

This is to certify that this thesis is based on the work of

Mr. /Ms. D. G. N. Jayakody

Under my supervision. The thesis has been prepared according to the format stipulated and is of acceptable standard.

Certified by:

Supervisor Name:

_____

Signature: Date:

ABSTRACT

NDB Securities is a well reputed financial company in Sri Lanka which is a subsidiary of NDB bank. Mainly, The Company focuses on a securities exchange (stockbroker) and other investment needs of the customers to provide the best service to them. Hence, the investment field is highly competitive and challenging, and it is necessary to deliver value-added services to preserve their existing customers as well as attract new customers. Further, efficient process and procedures need to establish by stratifying above services. To achieve the requirement, the company has expanded with introducing many solutions and services to clients.

Implementing this project will help the individual investor to track their investment and analyses the portfolio for the current market trend. In addition to that, this will enable the right investments decisions to gain the maximum profit form the investment; thus, it will lead to an inflow of foreign and local funds to the Sri Lankan economy.

To achieve the above objectives, the NDB Securities IT department has decided to introduce the several systems to overcome the manual process and procedures with the improvement of efficiently and accurately. This project will lower the operational cost of the company with easy and secure access to its data.

This projected software solution is a web-based system that delivers a better graphical user environment to the end user. The dashboard is cooperative and summarizes with necessary details to provide quick investment decisions and other tasks more easily with the help of summary turnover, gain/loss, and portfolio holdings.

The system developed as a web-based system that involves the core as PHP (Hypertext Pre-processor) which is an HTML-embedded web scripting language. MySQL that is an open source database system has been used for store and retrieve the data. The Rapid Application Development Model is used for system development lifecycle, which is most suitable for developing this kind of systems. After beta testing completed, the portfolio management software will be commencing the live operation on NDB Securities.

ACKNOWLEDGMENT

Firstly, I would like to express my thankfulness to the supervisor, Dr. M.D.J.S. Goonetillake, for the direction, motivation, and useful advice gave to me during the development of this system.

Furthermore, I would like to thank the CEO and other colleagues of NDB Securities, especially including IT Department staff members who assisted me during the progression of this project from requirement gathering to system evaluation process.

Finally, I must express my sincere thankfulness to my wife, parents, and friends for providing me with constant support and non-stop motivation throughout the project development as well as writing the dissertation. This accomplishment would not have been possible without them. Thank you.

TABLE OF CONTENTS

x

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

AJAX – Asynchronous JavaScript and XML

ASPI – All-Share Index Price

ATS – Automated Trading System

CDS – Central Depositary System

CEO – Chief Executive Officer

CSE – Colombo Stock Exchange

HTML – Hyper Text Markup Language

PHP - Hypertext Preprocessor

SDLC - Software Development Life Cycle

SEC – Securities Exchange Commission

1 Introduction

NDB Securities is one of the Equity and Debenture asset management, advisory and broker for over 20 years. NDB Securities registered security broker in the Colombo stock market, and it is back by the National Development Bank and its group of companies.

A portfolio is a group of financial assets such as shares, stocks (securities), bonds, debt instruments, mutual funds, cash equivalents. Portfolio management is the art and science of creation judgments about investment combination and policy, matching investments to objectives, asset allocation for individuals and institutions, and balancing risk against performance.

The key to active portfolio management is the long-term mix of assets. Asset allocation is base on the accepting that different types of assets do not move in concert, and some are more volatile than others.

1.1 Purpose

Equity Portfolio management has the following problems that have been searching for answers through the last decades,

- How to be having a strong portfolio which tries to make investment activity more rewarding and less risky?

- Taking decisions about investment mix, policy, and matching investments to objectives?

- Asset allocation for individuals and institution and balancing risk against performance?

- What are differences between the integrated, strategic, tactical, and insured approaches to asset allocation?

- How can futures and options be useful in managing an equity portfolio?

If the broker/adviser, management, or user point of view of the portfolio balances, purchasing history, profit earning through security will be beneficial to the decision making the for portfolio management.

1.2 Motivation

Portfolio management involves making decisions about investment combination and policy, matching investments to objectives, asset allocation for individuals and institutions, and balancing risk against performance.

The management is executed by a specific investment goal and investment profile and takes into consideration the level of risk, diversification, a period of investment and maturity that the investor seeks.

- Currently, the Investment adviser is providing information about the client's portfolio details over the phone.

- An investment advisor or client needs to calculate buying power manually using calculation software like Microsoft office excel. Figure 1.1 shows a sample buying calculation mechanism.

- Investment history needs to manually maintain in the written format or Microsoft Excel or word processor systems.

- The client has to maintain the payment history details through their system.

- The client has no information about risk measurements in security instruments and their CDS account.

Buying Power Calculation										
Total Portfolio		LKR 13,259,450.00					Accont Status		Pending Ordes	
Buying Power	50%	LKR 1,846,725.00								
Instruments Details	Security Exporse	Last Traded Price	Average Price	Quantity	Porfolio Valuation	Total Gain/Loss	Acconut Balance	Payments	Buy	Sell
JKH.N0000	100%	LKR 148.50	LKR 168.33	12,000	LKR 1,782,000.00	-LKR 237,960.00		LKR 160,000.00	LKR 50,000.00	LKR 15,000.00
SAMP.N0000	100%	LKR 141.20	LKR 153.65	40,000	LKR 5,648,000.00	-LKR 498,000.00		LKR 850,000.00	LKR 28,000.00	
AFSL.N0000	10%	LKR 20.00	LKR 34.68	2,000	LKR 40,000.00	-LKR 29,360.00		LKR 175,000.00		
NDB.N0000	100%	LKR 93.50	LKR 91.45	60,000	LKR 5,610,000.00	LKR 123,000.00	-LKR 6,890,000.00	LKR 1,000,000.00		
TESS.N0000	40%	LKR 1.10	LKR 2.15	8,500	LKR 9,350.00	-LKR 8,925.00				
DIAL.N0000	100%	LKR 10.50	LKR 12.63	15,000	LKR 157,500.00	-LKR 31,950.00				
SIRA.N0000	60%	LKR 2.00	LKR 2.00	6,300	LKR 12,600.00	LKR 0.00				

FIGURE 1.1 – BUYING POWER CALCULATION USING MICROSOFT EXCEL

1.3 Objectives

- Having better investment advice to the customer to purchase the securities based on their **historical performance**.

- The system provides detailed portfolio analytics products for the back office, enabling portfolio **risk measurement**, attribution, and reporting.

- Users can easily log in from anywhere to the **web-based system** rather than the old internal windows based application system.

- Makes it easy to keep track of many investment portfolios and monitor the markets to manage the investments effectively.

- Get the Clear idea of the **portfolio distribution** and spread. Instead of looking at individual investments, Users can overlook and understand their portfolio as a whole.

- Get the information about **performance evaluation** of investment advisor and his client base.

- Evaluate the daily, monthly, quarterly, and yearly results on the portfolio's **financial gains and losses** to gain professional level insight into the investment.

1.4 Scope

The portfolio management system consists of the following five modules

- ➢ User Management Module

- ➢ Instrument Management Module

- ➢ Portfolio Management Module

- ➢ Risk and Compliance Module

- ➢ System Administration Module

1.4.1 User Management Module

This module provides a way to let BackOffice staff approve clients, advisors, and other users easily as well as grant them particular roles. Users can perform specific functions as per the permissions and modules assigned, and the user groups that they belong to.

- ▪ Insert, edit and delete the clients' application details and portfolio information's

- ▪ System users including back office staff and investment advisors

- ▪ User password reset, unlock and modify for all users

- ▪ User registration, transfer

- ▪ The user Activity report and session report

1.4.2   Instrument (stock) Management Module

A stock trader pursuing value-focused investing is forever on the lookout for under-priced stocks. The idea is to buy these stocks and then make an income as the market recognizes the value of the undervalued company, and the stock price rises. To achieve such target trader and client need to have an idea about the security instruments state and future trends of the instrument. In this module stock performance and clients buying patterns can be identified by the stock trader.

- Equity securities add, remove and modify

- Debt securities add, remove, modify and maturity data field modify

- Sector-wise, Instrument wise report generation

- Instrument performance chart and graph generation to dashboard

1.4.3   Portfolio Management Module

The main focus of this module is portfolio performance evaluation. This module considers the practical issues surrounding forming and managing a portfolio. This module provides the over role idea about the client's portfolio status, with this information module shows the high-risk securities that client portfolio contain.

- Client Portfolio details enquire, add, remove or transfer

- Portfolio history backdated reports

- Client wise or portfolio wise brokerage calculation and get the top clients for a particular period

- Trade execution report for client wise per day or a specific period

1.4.4   Risk and Compliance Module

Businesses today function in sophisticated and highly active global environments. Managing change across risk, marketing, and regulatory environments, and keeping the organization aligned with these changes is one of the biggest challenges. Risk and compliance module consist of the security classification using instrument exposer level adjustment. This module is more helpful for BackOffice staff rather than clients.

- Security exposer(instrument weightage) level adjustment

- Client buying power calculation, adjustment and checking for virtual buying power

- Debtor's client list Report

- Negotiated transaction brokerage calculation and broker fee setup

- Negotiated transaction report

1.4.5 System Administration Module

Main Server settings and the system update process will be handling from this module. Data synchronize with the other systems will be managed through this module.

- Email server Settings configuration

- Brokerage settings configuration

- User change log management

- Error trade details investigate

- CSE /SEC text file verification and upload

1.5 Structure of the thesis

Portfolio management system thesis will be consists of the following chapters and structure.

- Introduction

From this chapter gives the purpose to develop this project and its main modules to be implemented in the system.

- Background

Background chapter will focus on the problem domain spread and enterprise-grade similar system that simulates some of the function from the main modules and services.

- Analysis and Design

This chapter includes the system development methods, functional and non-functional requirement of the system and system design methodology, database design, and visual representation of system diagrams.

- Implementation

Implementation section focuses on hardware and software requirement of the new system. Development tools, base scripting language, network setup, and user interface features described on this stage.

- Evaluation and Testing

This chapter will cover the user testing on the system and system feature evolution with the help of end-user feedback.

- Conclusion and Future Work

Finally, the last chapter focus on a summary of the system, problems, and limitation arises when developing system and future improvement to this system.

1.6 Chapter Summary

In this chapter focus on the initial problem as, absence of a portfolio management system for NDB Securities (Pvt) LTD will significantly reduce their customer attraction and ability to give them more professional support via systematically. The proposed solution will consist scope of five different modules with different services form each module.

2 Background

Beginning day of security instrument trading and exchanging goes around the 12th century. When the new world is expanding their domain, connecting, and then human initiated to trade among each other with the start of stock markets.

2.1 History of Colombo Stock Exchange

The Colombo Stock Exchange (CSE) is the leading stock exchange in Sri Lanka. It is one of the exchanges in South Asia, providing a fully automated trading platform. The headquarters of the CSE has been located at the World Trade Center (Colombo) Towers in Colombo since 1995, and it also has branches across the country in Kandy, Jaffna, Negombo, Matara, Kurunegala, Anuradhapura, and Ratnapura. [1]

Share trading in Sri Lanka was initiated in 1896 under Share Brokers Association (SBA). In 1904 SBA was renamed as Colombo Brokers' Association. They started auctioning shares in open land. Later a competitor evolved, Stock Brokers Association and in 1985 Colombo Brokers & Stock Brokers merged and formed Colombo Securities Exchange. [1]

The establishment of a formal stock exchange took place in 1985 with the incorporation of the Colombo Stock Exchange (CSE), which took over the Stock Market from the Colombo Share Brokers Association. It currently has a membership of 15 institutions, all of which are licensed to operate as stockbrokers. [1]

In 1990, the business was renamed as Colombo Stock Exchange. CSE introduced that automated central Depository System and clearing. In 1995 CSE headquarters was opened at WTC, Colombo. [1]

2.2 Current status

The Colombo Stock Exchange (CSE) has 295 companies representing 20 business sectors as at 14th July 2017, with a Market Capitalization of LKR. 3,068.3 Bn.

Public Businesses incorporated under the Companies Act No.7 of 2007 or any other statutory establishment, incorporated or established under the rules of Sri Lanka or established under the regulations of any other state (subject to Exchange Regulator approval) are eligible to seek a register on the Colombo Stock Exchange to increase Debt or Equity. Companies desiring to be admitted to the authorized list of the Exchange and to secure a listing of their instrument securities will be required to fulfill with the relevant

provisions of the above act and the Securities & Exchange Commission Act No.36 of 1987 (as amended) and the Listing Rules of the Exchange.

There are presently dual indices in the CSE;

❖ The All Share Price Index (ASPI)

❖ The S&P Sri Lanka 20 Index (S&P SL20)

Figure 2.1 shows that the actual ASPI for the period 2009 to 2019.

FIGURE 2.1 - CSE – ALL SHARE INDEX PRICE GRAPH FROM 2009 TO 2019

The CSE operates two main systems

• The Central Depository System

• Automatic Trading System

The CSE commenced the process of automating the Exchange in 1991 with the installation of the Central Depository System (CDS) and an electronic clearing and settlement system for share transactions. This automation process was completed with the commissioning of the Automated Trading Systems (ATS) in 1997. The technology introduced by the Exchange significantly enhanced the competitiveness of the CSE and provided a more efficient and transparent market.

2.2.1 Automated Trading System (ATS) of the CSE

The order driven trading platform assures a transparent market and executes trades on price and time priority.

The Trading System commences trading with a pre-open session followed by an auction process for price discovery and proceeds to regular trading. The market is closed with the calculation of the average closing price for each security, taking into consideration the last hour's trading from the previous trade.

All orders are visible to the trader through the Blotter window, which provides detailed information about executions and also displays partial executions. Orders can be active up to 5 market days and can be canceled or modified during trading hours.

The technology introduced by the Exchange has significantly enhanced the competitiveness of the CSE and has provided a more efficient and transparent market. The CSE is currently in the process of introducing a debt securities trading system for trading of fixed income securities. [2]

The transaction day at the CSE will be divided into the following periods:

- Pre-open phase

During pre-open, the system accepts orders; however, no trade executions is happening in this phase. Orders can be amended and canceled through pre-open. Though, no executions take place during this stage.

- Open-Auction phase

During open-auction, the system momentarily closes the order window and starts matching orders. It begins the opening price and decides the orders to be executed according to the rules for the open-auction period.

- Regular trading interval

During the regular transaction, new orders are continually matched to current orders in the order book according to Rule 5. If an order cannot be performed, it is stored in the order book.

- Close phase

When the market closes, trading in all instruments for that market comes to an end. A message to this result is sent to all trading members. No further orders are accepted, but the user is permitted to perform the activities like inquiries.

Preference stocks, non-voting shares, warrants, units of closed-end funds, and debt securities instruments do not update the market indices.

- Trading session

The securities market is open from Monday through Friday except on days declared as holidays by the Exchange.

Pre-open:- 9.00am to 9.30am

Open-auction: 9.30am

Regular trading: 9.30am to 2.30pm

Close: 2.30pm

Figure 2.2 shows that CSE trading system overview.

2.3 Stock Explanation

The stock (also capital stock) of a corporation is constituted of the equity stock of its owners. A single share of the stock represents fractional ownership of the corporation in proportion to the total number of shares. In liquidation, the stock represents the residual assets of the company that would be due to stockholders after discharge of all senior claims such as secured and unsecured debt. Stockholders' equity cannot withdraw from the company in a way that is intended to be detrimental to the company's creditors. [3]

A stock is a slight part of a company. It is a small piece of ownership to a company. If any person has one stock from a company, that person has a small claim to its assets and earnings in the future. Whether it says that shares or equity, it all means the same. [4]

2.4 Stock Market

A stock market, equity market or share market is the aggregation of buyers and sellers (a loose network of economic transactions, not a physical facility or discrete entity) of stocks (also called shares), which represent ownership claims on businesses; these may include securities listed on a public stock exchange as well as those only traded privately. Examples of the latter include shares of private companies which has been selling to investors through equity crowdfunding platforms. [5]

2.5 Portfolio Management

The portfolio is a collection of security or value-added resources that can be exchanged or used to increase the importance of the property. In simple meaning stock market portfolio can be a collection of equity and debenture securities instruments. Portfolio management is an art of balancing the risk of individual security instrument with the rest of other shares in the portfolio.

2.6 Commercial Products in Similar capacity

Portfolio management's commercial products are commonly focused and developed for stock exchanges that have a high volume of trading statistics. Industry leading, international top rated few portfolio management systems will be explained in this section.

2.6.1 Ledgex

Ledgex PM is a comprehensive portfolio management system for investment managers with exposure to all alternative investments. Ledgex Portfolio Manager natively supports the unique way multi-manager investment managers handle daily trading activity, positions, and pricing methodologies. The platform allows asset allocators to easily manage complex portfolio structures and look through these portfolios for exposure, performance, and allocation weights. [6]

Ledgex PM also streamlines the communication between the front, middle and back office activities related to managing manager activities and closing portfolios. The platform delivers robust and configurable reporting and decision support tools, including automated communications of manager activity with an appropriate hand-off to operations and accounting to close and reconcile the portfolio with administrators. [6]

Portfolio Management Features

➢ Performance and attribution reporting

➢ Portfolio exposure analysis

➢ Portfolio construction: What-if analysis, modeling

➢ Portfolio look through: Reporting, pricing propagation, and automated allocation updates

➢ Portfolio analytics and benchmarking

➢ Handle complex portfolio structures

➢ Manage private equity investments

➢ Easily price securities and track managers

➢ Security master file: Liquid investment vehicles

➢ Risk management

➢ Portfolio cash management

2.6.2 StockMarketEye

StockMarketEye is a powerful yet easy-to-use application for tracking investments and following the changes in the stocks. It is simple, elegant, and intuitive interface saves time when doing market and stock analysis, while its investor-friendly tools give the information that needs to make informed investment decisions. [7]

StockMarketEye is consists of the following features and options:

❖ Manage Portfolios

➢ Creating and Deleting a Portfolio

➢ Portfolio Properties

➢ Getting Current Quotes for Portfolio

❖ Managing Cash Balance

➢ Buying and Selling

❖ Tracking Bonds and Other Non-Quoted Securities

- ❖ Entering Dividends, Capital Gains and Return of Capital

- ❖ Entering a Stock Split

- ❖ Importing Data from a Brokerage

- ❖ Measuring Investment Performance

- ➢ Individual Investment Performance Metrics

- ➢ Comparing Performance to a Benchmark

- ❖ Reports

- ➢ The Transactions Report

- ➢ The Summary Report

- ➢ The Gain/Loss Report

2.6.3   EquityStat

EquityStat is a powerful yet easy to use investment portfolio application. Investors developed it for investors. The adage "necessity is the mother of invention" was the driving force behind the founding of EquityStat. The portfolio management tools with brokerage firms were too cumbersome, lacked useful features, and were geared toward buying and selling stocks at the brokerage. [8]

EquityStat wanted a way to track and manage all of the investments in one application from the cloud. As many investors know, assets have been scattering around many brokerages, mutual funds, and retirement plans. EquityStat objective was to create an application where investors could manage all of their investments in a single location. Also, to be able to access investments from any computer or device is the primary goal. [8]

EquityStat Features

- ❖ Portfolio Features

    - ➢ Manage all of the financial investments.

    - ➢ Instantly see the value of the portfolio based on current investment prices.

    - ➢ Create multiple portfolios (e.g., Stocks, Mutual Funds).

    - ➢ Track the performance of investments.

    - ➢ Track investment's gain, quarterly return, year-to-date return, and annualized return.

- Individual client's dividend information and benefits have been tracking for the specific investment portfolio.

- View all transactions for an investment.

❖ Portfolio Analysis

- Summary performance graphs and performance metrics.

- Analyze account portfolio holdings graphically.

- Performance charts for best and lowest investments are for the day, year, and quarter.

- Analyze dividends graphically.

❖ Display

- Sort clients investments by name, value, return and gain.

- Sort clients transactions are by date, transaction type, and amount.

2.6.4 Fund Manager

Fund Manager is a full-featured investment portfolio management application. Fund Manager Tracks stocks, mutual funds, and other investments. Analyze and compare investments and portfolios with a wide variety of easy to use graphs and reports. Graphs will plot value, cost, gain, or allocation for any investment or portfolio. Charts will also plot share price, price plus distributions, moving averages, and technical analysis for investments. Overlay indices, increased investments, and portfolios for comparing performance. Line plots, pie charts, and stacked graph formats are all available. Over a dozen reports are available for viewing information on investments and portfolios. [9]

Features

❖ Track stocks, funds, options, bonds.

❖ Powerful graphing

❖ Extensive reports

❖ Capital gain calculations

❖ FIFO, AVG, or Specific Lot

❖ Wash sale support

❖ Export to tax software

- ❖ Yield calculations (GIPS/AIMR compliant)

- ❖ Technical analysis

- ❖ Retrieve prices from the internet

- ❖ Retrieve transactions from broker/fund

- ❖ Trailing stop loss alerts

- ❖ Import from Quicken, Money, or text

- ❖ Bond calculations/income schedule

- ❖ Multi-currency support

- ❖ Broker/dealer interfaces

- ❖ Client management, fee calculations

2.7 Comparison

The following table 2.1 will show a summary of the above portfolio management system.

Feature	Led gex	StockMarket Eye	Equity Stat	Fund Manager
Portfolio Add/View/Manage	√	√	√	√
Client Management	√			√
Risk Management	√			
Cash Management	√	√		
Transaction Management			√	√
Report present via graphs	√		√	√
Buying power/Yield calculations				√

Export portfolio and other reports	√	√	√	√
Instrument Management	√	√		

TABLE 2.1 – COMPARISON OF SIMILAR SYSTEMS

2.8 Chapter Summary

This chapter has the background history and current operation of stock trading rules and necessary regulations imposed by CSE and SEC in Sri Lanka. Furthermore, this will briefly discuss the stocks and stock market behaviors and characterizations. Finally, compare the industry-leading similar solutions and their strengths and weakness.

3 Analysis and Design

System analysis and design are the essential phases in the system development life-cycle.

In this section focus on identifying what kind of process and procedures having on existing practice and what are the most suitable design method implements the cater to the defined requirements.

3.1 Analysis

Software Development Life cycle (SDLC) is the collection of various steps which followed for the systematic development, design, and maintenance of the software projects and ensure that all the user requirement is fulfilled with least amount of resource consumption. These methodologies help to deliver a quality product on time and as per the client requirement. This SDLC model is suitable for specific kind of projects that cannot deploy on one single model for all the software projects. Because every project had different requirements, that is the reason to always collect user requirement before selecting any SDLC model for the project. Hence that the traditional models such as Waterfall, Spiral, Incremental, and RAD are not able to fulfill the client's satisfaction levels. Therefore move ahead towards hybrid SDLC model development such as the agile process is itself a software development process. An agile process is an iterative approach in which customer satisfaction is at the highest priority as the customer has direct involvement in evaluating the software.[9]

3.1.1 Feasibility Study

1. The idea's methodological feasibility (Can we build it?)

2. The financial feasibility (Will it provide business value?)

3. The managerial possibility (If we build it, will it be used?)

3.1.2 Fact gathering techniques

Fact gathering is the most critical and baseline of the software development life cycle, analysis stage. Above technique will helps in finding out bottlenecks and evolving solutions for overcoming the weaknesses of the system to achieve the organizational goals. In this project, information was collected using the following techniques.

1. Study the existing business processes

2. Gather operational data

3. Understand the information flow

4. User interaction with simple quires (Discussions, Questionnaires, Interviews)

Study the current business process enable the input for main system requirements and the securities trading system tasks and back office, client and advisor operational procedures and functionalities. Usage of functional data analysis helps to find what kind of information and what levels of information available to end users. Information flow gives important identification about the data representation methods and techniques.

User Infarction is used to gather the information about different user aspects and views for the system and usability features that the user requires from the new system. In this phase, information gathering has concluded with the face to face user interviews from investment advisors, back office staff, management staff, and clients.

3.2 Functional Requirements

Functional requirements identification and the document is a leading part of the software development life cycle (SDLC) system analysis phase. Technical requirements describe the desired end function of a system operating within normal parameters, to assure the design is adequate to make the desired product and the end product reaches its potential of the model to meet user expectations.

3.2.1 User Management Module

- Users need to login to the system by entering the system URL in a web browser and access the system using username and password.

- The system needs to provide the user registration form to enter and edit the new or existing user data.

- The system needs to provide the user with different system access roles and permission levels.

- Registered user password change/ reset facility need to provide by the new system.

- System user logout facility or system exit facility need to provide by the system.

- An authorized user can generate a system user activity report (audit log) and session report.

3.2.2 Client Management Module

- Users need to add/view/edit a stock market listed company details to the system.

- Users need to add and modify a stock market sector details to the system.

- Users need to add/view/edit client information through the new system.

- System user needs able to get the client modification report

3.2.3 Instrument (stock) Management Module

- Colombo stock exchange-listed instrument codes creation, alteration, and deactivation feature need to be available on the system.

- Authorized users can generate Instrument performance reports.

- System users need to enable the sector report, client report, and performance report generations.

3.2.4 Portfolio Management Module

- The system needs to be able to include/transfer the portfolio details through CSE data files

- An authorized privileged user needs to enable the inquiry / maintain the customer portfolio details

- An authorized privileged user needs to allow the inquiry/ maintain the customer profit gain and lost details from the new system

- Users need to generate the reports for the portfolio valuation, brokerage details and gain and loss reports

3.2.5 Compliance and Risk Management Module

- Authorized users need to be able to view and change the security expose for the selected security instrument or all security instruments.

- Users need to be setups and calculate clients buying power adjustment through the new system

- System users are required to facilitating with negotiated brokerage calculation for the over 100 million rupees transactions.

- Users need to be able to generate the debtors/ negotiated trade reports from the new system

3.2.6 System Administration Module

- System advisor codes introduce, modify and disable options need available on the system

- Need to configure the email server settings or adjust the settings for an authorized user

- The new system can be able to handle CSE text data upload process and procedure without any errors

3.3 Non-Functional Requirements

Non-Functional requirements define what is required to deliver the desired function or behavior from a system to a user's standards. Non-Functional requirements can be performance factors, reliability, availability, scalability, accessibility, data integrity, logging, control, and backup.

- **Performance** - Performance is a vague concept; many different kinds of products can have been considering. Transaction rates, efficiency, resource usage, throughput, response time are some of the performance counters to test the system. Main components for the performance is response time and throughput. Response time, which is the time between the end of the request and the beginning of the response. Throughput, which is the number of applications served during a specified period. Poor performance leads to negative user experience. It also jeopardizes system safety when it is overloaded.

- **Reliability** - Reliability defines how likely it is for the software to work without failure for a given period. Reliability drops because of bugs in the code, hardware failures, or glitches with other system components. Measure software reliability; the user can count the percentage of operations that are completed correctly or track the average period the system runs before failing.

- **Availability** - Availability is gauged by the period that the system's functionality and facilities are accessible for use with all processes. So, planned maintenance periods directly influence this parameter. Moreover, it is essential to define how the impact of maintenance can minimize. When documenting the availability requirements, the team has to determine the most demanding components of the system that need to be accessible at all time. User should also prepare user notifications in case the system or one of its parts becomes unavailable.

- **Scalability** - Scalability requirements describe how the system must grow without negative influence on its performance. Scalability means serving more users, processing more data, and doing more transactions. Scalability has both hardware and software implications. For instance, a user can increase scalability by adding memory, servers, or disk space. On the other hand, the user can compress data, use optimizing algorithms.

- **Security** - Safety processes and procedures need to be implanted in the system to guarantee that the data records present in the system are protected, and no illegal person can access them.

- The application needs to have proper user login and password complexity to prevent the malicious user gain access to the system.

- **Data Integrity** - Data Integrity refers to the accuracy and consistency of data, facts, and statistics over a product's lifecycle. Data Integrity ensures recoverability, searchability, and traceability of any original records.

- **Backup** - A folder backup is a replica of a folder that is stored in a discrete location from the original. Backing up is the creation of duplicates of data which may be used to restore the original afterward a data damage event.

3.4 System Design

The design phase of the SDLC uses the requirements that were gathered during analysis to create a blueprint for the future system. A successful design builds on what was learned in earlier phases and led to a smooth implementation by creating a clear, accurate plan of what

needs to complete. This chapter describes the initial transition from analysis to design and presents three ways to accomplish the design for the new system. [10]

The purpose of the analysis phase is to figure out what the business needs. The purpose of the design phase is to decide how to build it. System design is the determination of the overall system architecture—consisting of a set of physical processing components, hardware, software, people, and the communication among them—that will satisfy the system's essential requirements. [11] Figure 3.1 shows that overview of the software development lifecycle.
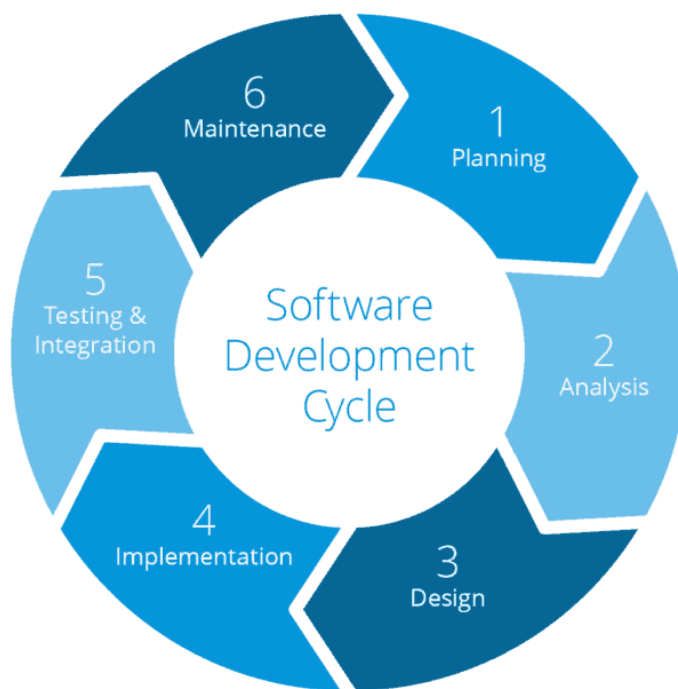
FIGURE 3.1 - SOFTWARE DEVELOPMENT LIFE CYCLE (SDLC)

3.4.1 Methodology

One of the most critical decisions when developing software is selecting an appropriate software development methodology. Selecting the proper method can increase the probability of project success. It is crucial that an organization perform the research on all the techniques they may choose before starting the development process and make a decision regarding what procedure to select. Sometime should be allocated for research and decision making as well as for training and implementation.

Rapid application development (RAD) focuses on the active development and delivery of a project at low cost and with high quality. RAD works to minimize overall project risk by deconstructing the development into smaller sections during which prototypes need to

create and refine. RAD supports change during the development process - the change could introduce at any time in the cycle.

The foundation of RAD is to satisfy customer business requirements in a short amount of time. For this reason, RAD is the most suitable development methodology RAD. The RAD method concentrates on the user, and therefore, the user has a high level of input into the system. RAD can support rapid changes to the structure based on changing requirements or user demand. RAD can provide significant savings in time, cost, and resources. [12] Figure 3.2 shows that RAD development phases.
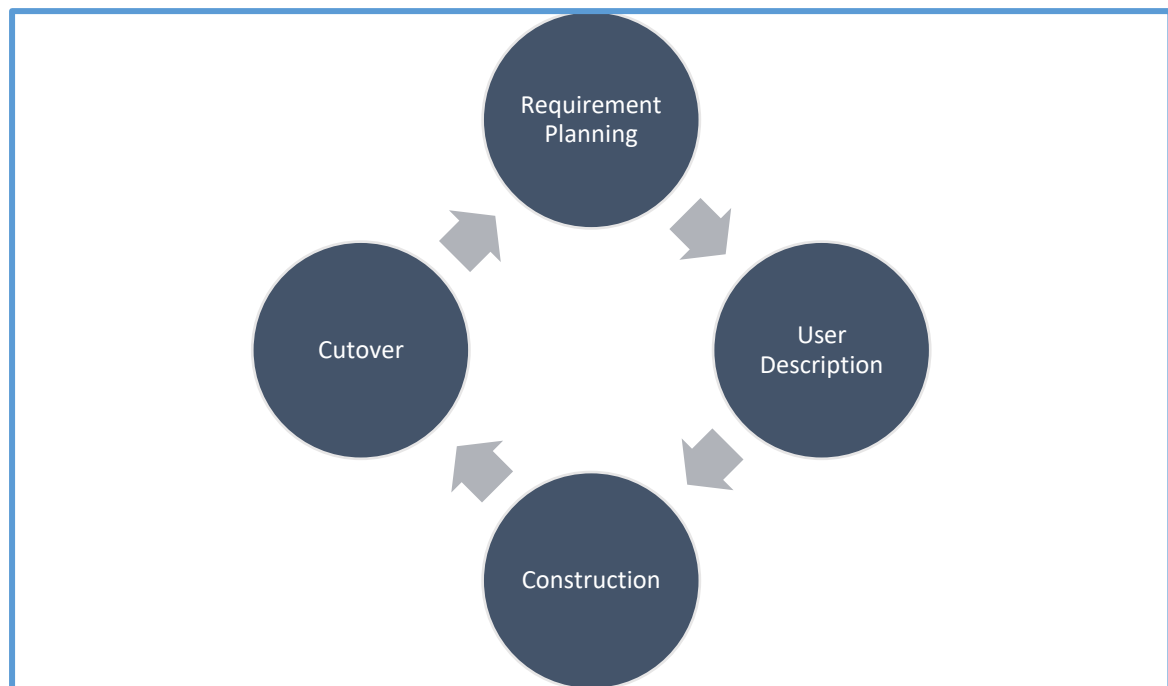
FIGURE 3.2 – RAPID APPLICATION DEVELOPMENT PHASES

Phases of RAD

▪ Requirement Planning Phase

Combines the elements of the system planning and systems analysis phases are one of the systems development life cycle (SDLC). Users, Stakeholders, and staff members discuss the business needs, project scope constraints, and system requirements.

▪ User Description Phase(Analysis & Design)

During this phase, users interact with system analysts, develop models and prototypes that represent all system process, inputs and outputs

▪ Construction Phase (Implementation & Testing)

Users continue to participate and still suggest changes or improvements. This phase consists of programming and application development, coding, unit testing, and system testing.

- Cutover Phase (Evaluation)

Resembles the final tasks in the SDLC is an implementation phase, including data conversion, testing, the swop to the new system, and user training.

3.4.2 Use case diagram

Use case diagram used to represent the functionality of the system interacting with the end user and their relationship. Following figure 3.3 shows the use case diagram of the system.
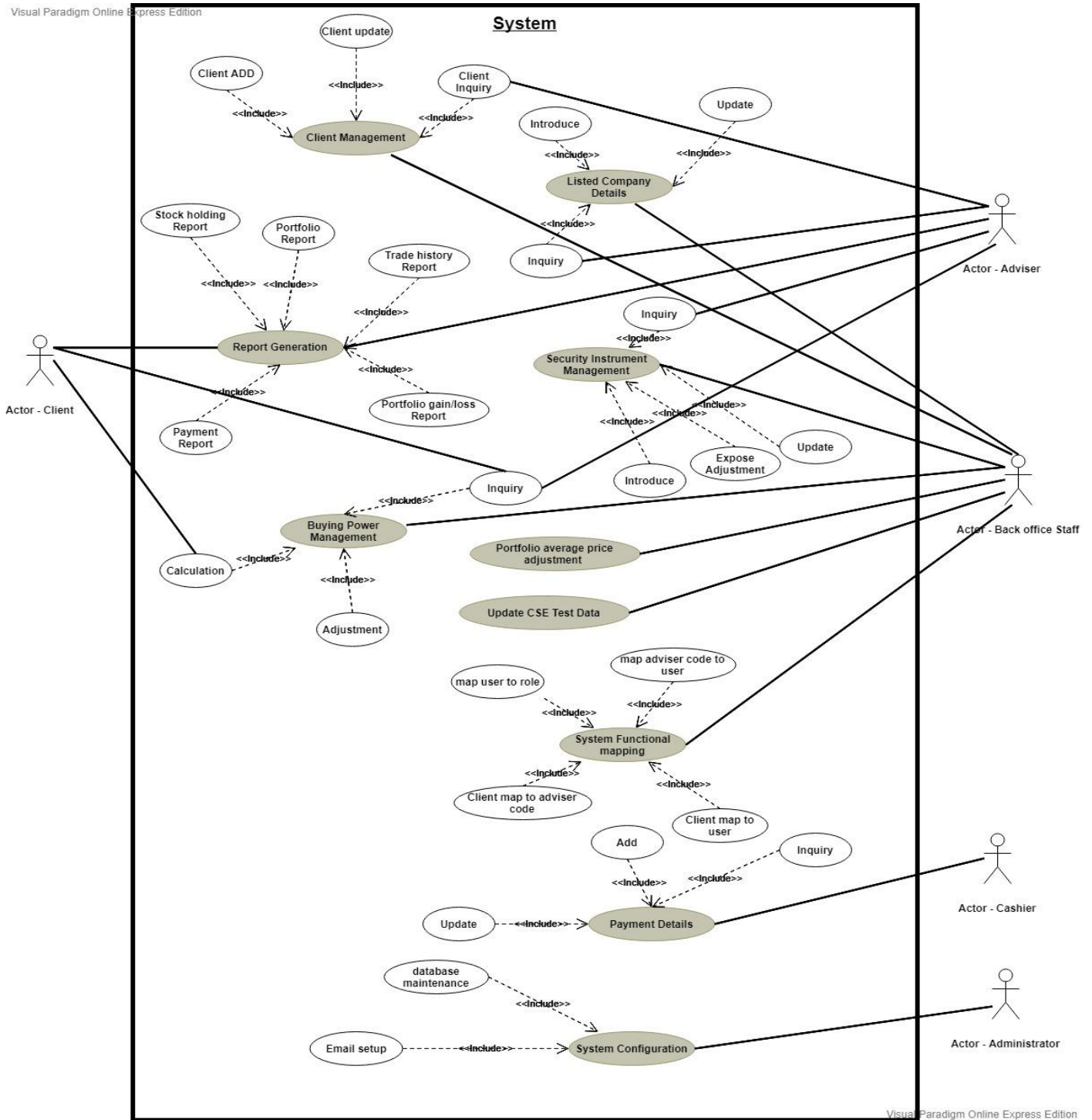
FIGURE 3.3 – SYSTEM USE CASE DIAGRAM

3.4.3 ER diagram

An Entity relationship diagram represents the high-level architecture of the system with a real-world entity and their relationship with the cardinality ratio. Following figure 3.4 shows the ER diagram of the system.

25
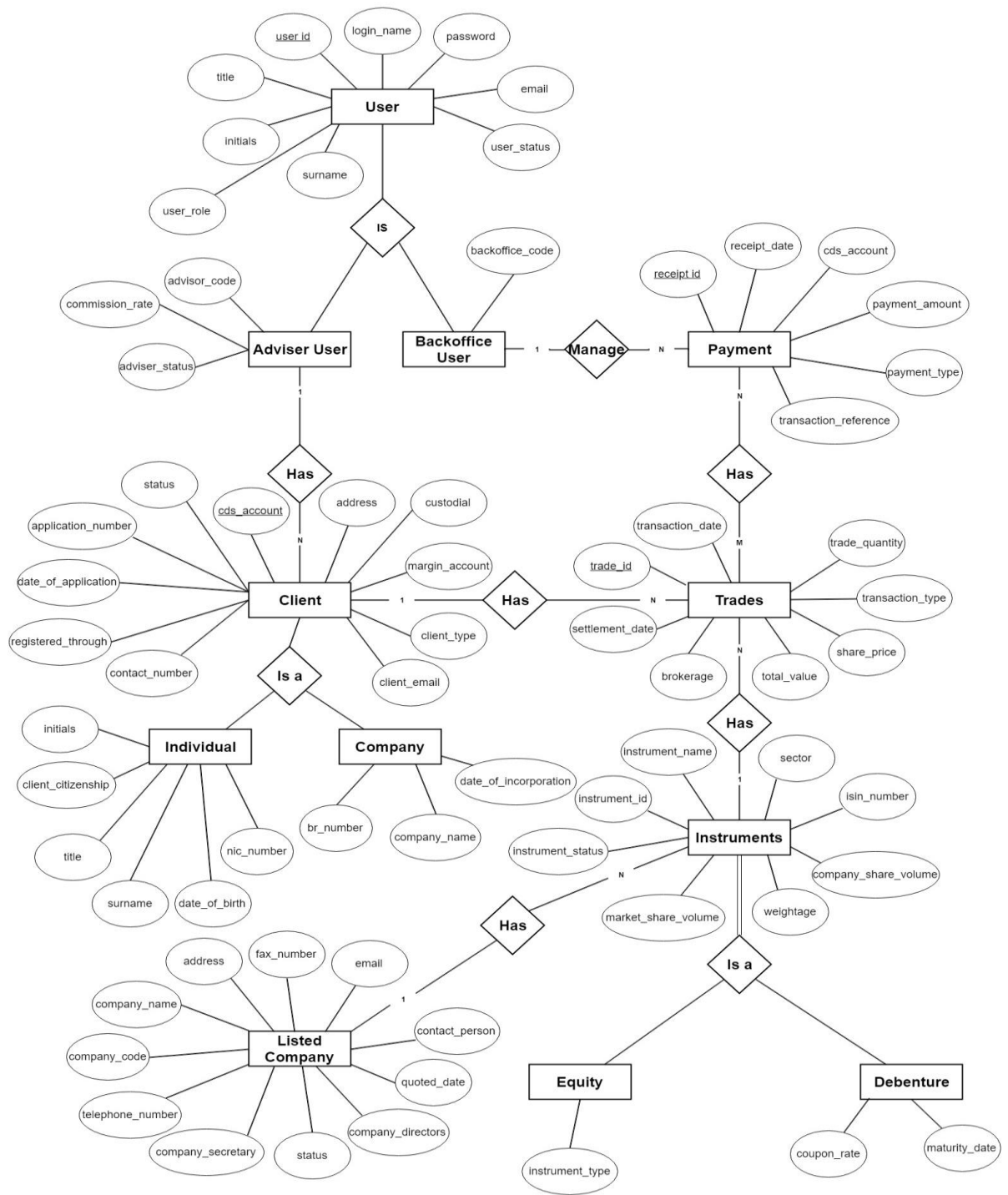
FIGURE 3.4 – SYSTEM ENTITY RELATIONSHIP DIAGRAM

3.5 Database Design

The organization of data in a proper data model is essential to information systems reliability, speed, and accuracy. The database design should be optimized to save the data and retrieve data within a small amount of time. Since stock market changes can happen in a limited amount of time database, need to design precisely. Following figure 3.5 shows that database design of the system.
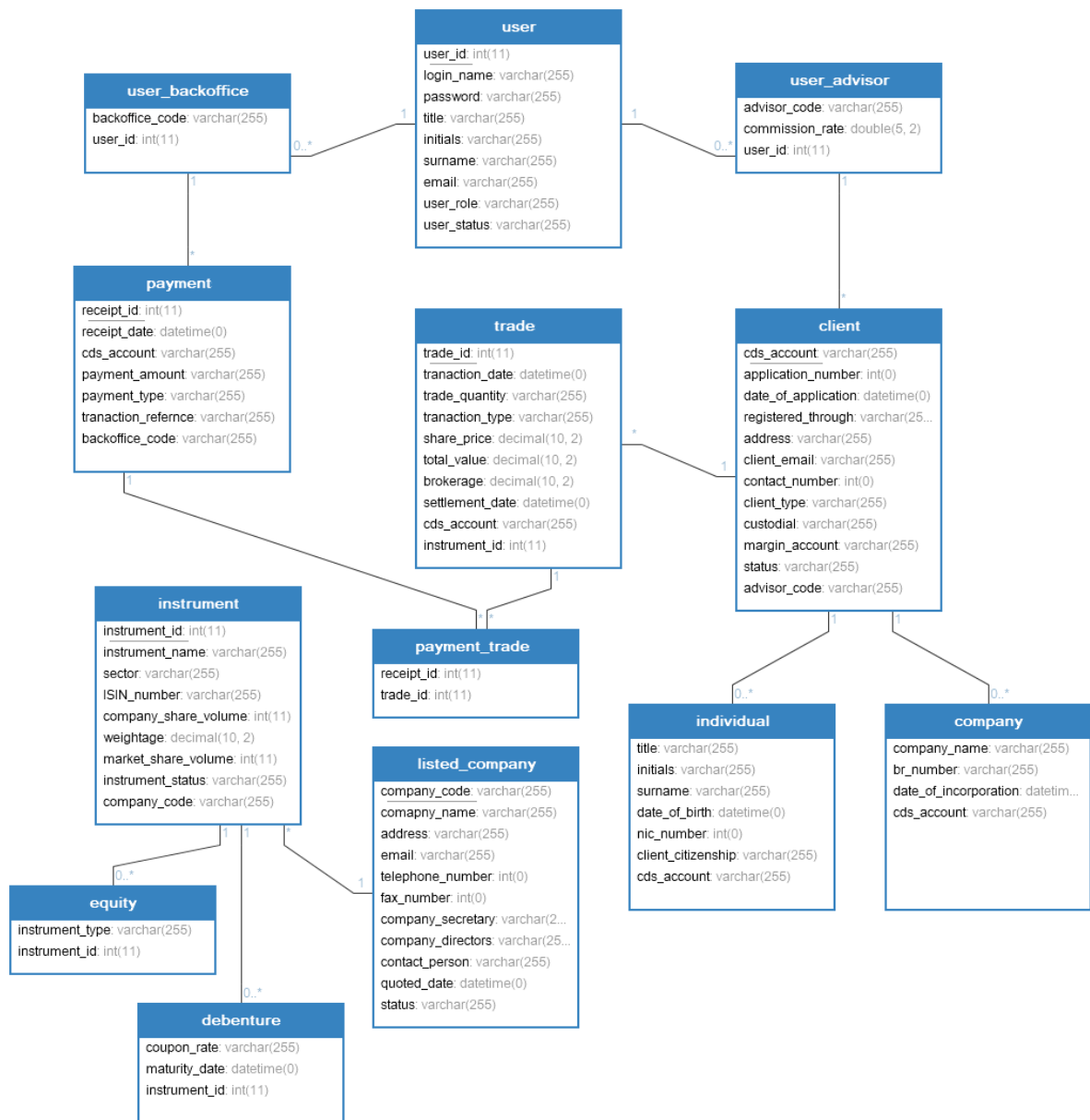
FIGURE 3.5 – DATABASE DESIGN OVERVIEW

3.6 Interface Design

The interface design focus is on developing a graphical interface. UI requires to give services and outputs in a standard, flexible approach for end users. Following figure 3.6 will be shown that basic dashboard design using a drawing tool.

27
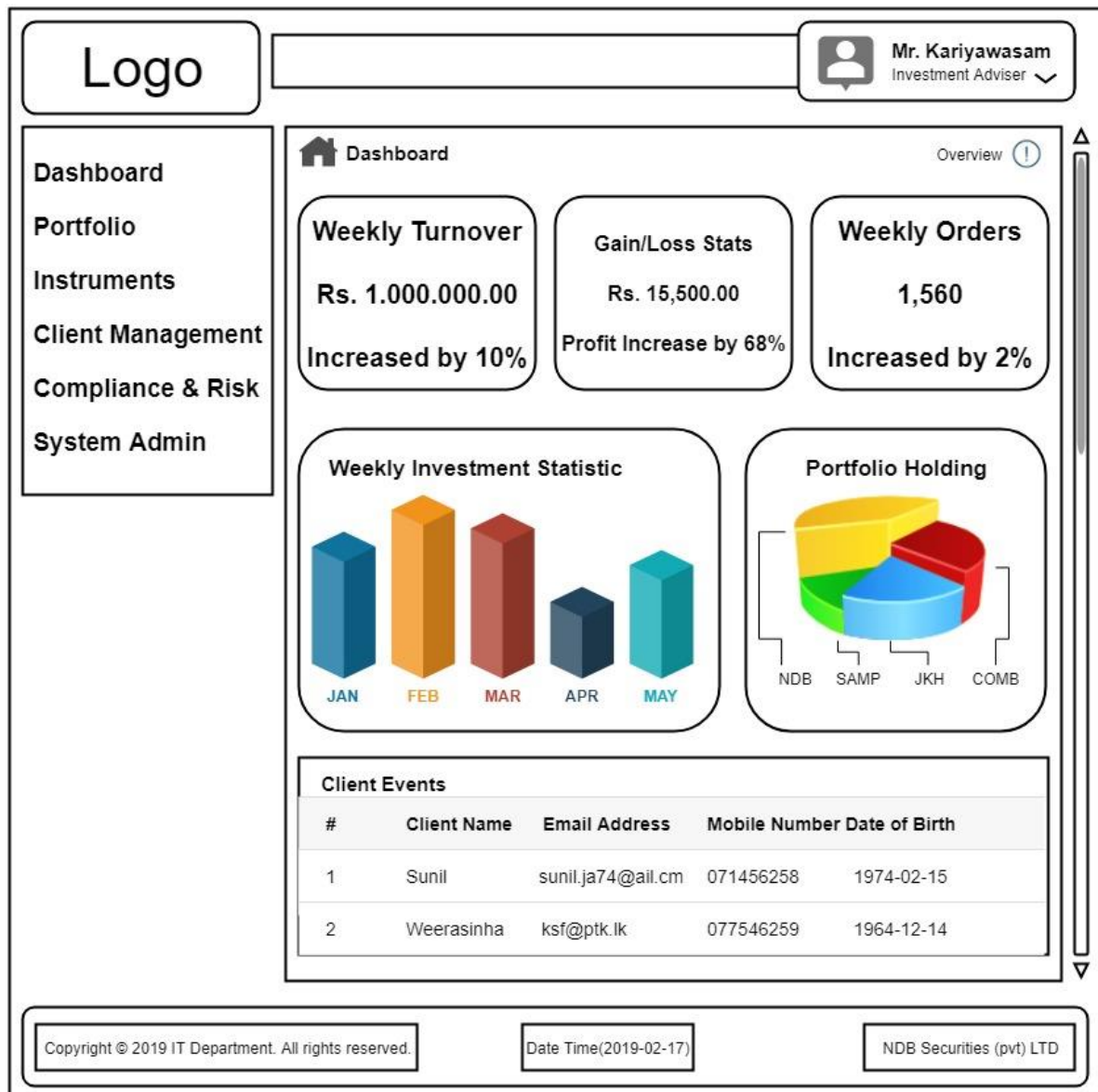
FIGURE 3.6 – DASHBOARD INTERFACE DESIGN

3.7 Chapter Summary

This chapter discussed the system analyst methodologies and which method is most suitable for implementing the system. In addition to that system, functional requirement and non-functional requirements analyzed and discussed. System design section describes the high level of system diagrams such entity relationship, use case, and database diagrams.

4   Implementation

System implementation consecration on how the system has constructed in a way that system functionality and requirements will be on operational and meets the quality standards.

4.1   Hardware and Software Requirement

Hardware and software scope for the implementing system will have been identifying in this section. Suitable performance hardware devices and stable, secure software solution will be the right combination for system accuracy and speed.

4.1.1   Hardware Requirement

Implementing specific hardware resource will be better for performance, but without high availability or clustering with load balancing will lead to the availability of the system. The System will be consisting of two identical hardware servers.

- Processor – Intel Xeon Processor E4210

- RAM Memory – 4 GB DDR4

- Hard Disk Memory – 140 GB SSD RAID 1

- Network Interface – Dual 1Gbps interface

4.1.2   Software Requirement

This project implemented based on apache server that consists of open source popular web platforms PHP, and MySQL.

Operating System – Windows Server 2016

Web Server – Apache 2.4.35

Backend – PHP 7.2.10

Database – MySQL 5.7.23

Browser – Google Chrome 70.0 above or Firefox 60.0 above

4.1.3 Human Resource Requirement

To properly update the CSE text file, administration staff needs to add update process as their daily routine. CSE text file update process consists of morning process and evening process with data integrity and settlement balance check process.

4.2 Development Tools

System progress has been accomplishing by using WAMP server. WAMP is a widespread, cross-platform application to develop a website or web solutions which consist of Apache web server, MySQL open source database system, and PHP web scripting language. In addition to the above server, notepad++ used as text editing software as well as PHP, HTML coding, and developing software. Following development tools used to create documentation and other required drawings.

- Diagram Editor – www.draw.io online designer

- Document – Microsoft word

- Database - phpMyAdmin

4.3 Scripting Language

Development of the required system has been accomplishing by using PHP as a scripting language on server-side processing and JavaScript as a client-side scripting language.

PHP: Hypertext Pre-processor is a general-purpose programming language originally designed for web development. Rasmus Lerdorf created it in 1994. [13] PHP is a server scripting language that processes the end user's PHP page and sends the output as an HTML to the web browser.

JavaScript-based is an ECMAScripting language that is the most used technology in the World Wide Web. JavaScript in this project will be used to end users scripting language to secure and enhance user experience with the system. AJAX web technology is used to send data to a web server and get process data and pages to the system. Live search function, page load into the main body has been configured through AJAX technology.

4.4 Current Network Setup

Currently, system development has been accompanying in a test server environment with limited access to internal and external users. The system will be live in a production server with standard security controls and monitoring techniques. Production and the testing environment have a difference as the limited access from the internal network and external network. As per figure 4.1 shows the testing environment, and figure 4.2 shows the planned production network environment.
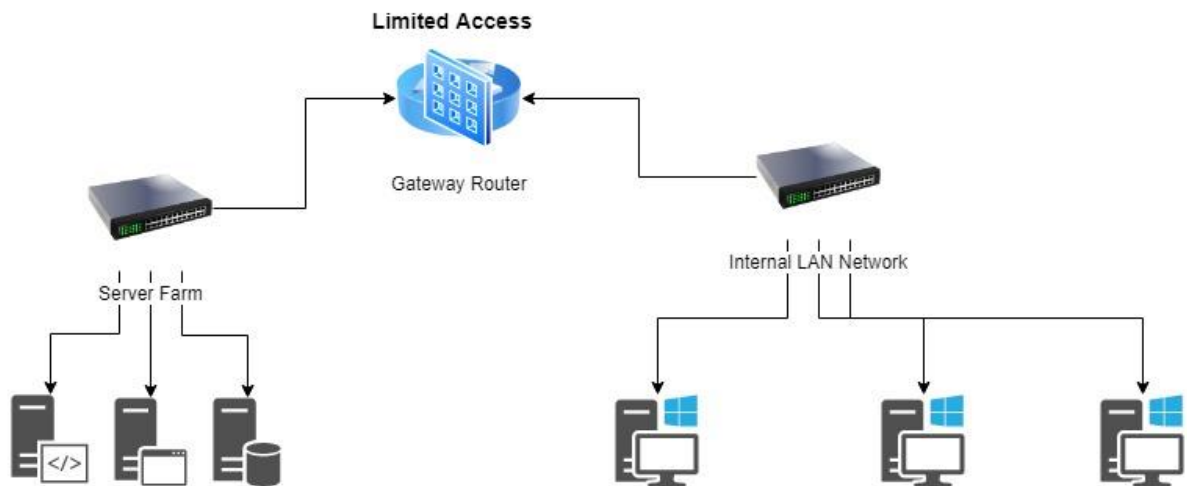
FIGURE 4.1 – NETWORK SETUP [TESTING]
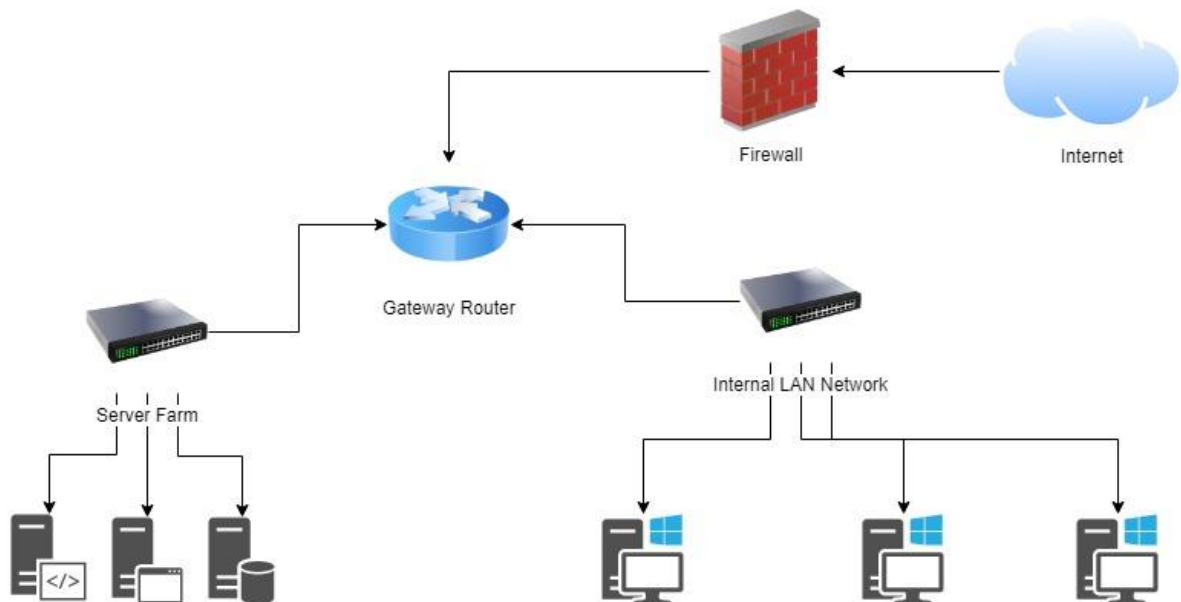
FIGURE 4.2 – NETWORK SETUP [PRODUCTION]

4.5　User Interface

The user interface is that the end user and system interaction media or metered, that can be PC monitor, keyboard, and mouse. This section explains the various user interfaces to the system and how the user can access the system, and it is functionally through an interface.

4.5.1　User Login Interface

The system initially loads into the login page and providing correct username and password combination will be authorized to access the system. Otherwise, the system will generate the error message that the user input need to recheck and re-enter. Following figure 4.3 shows below is a login page of the system.
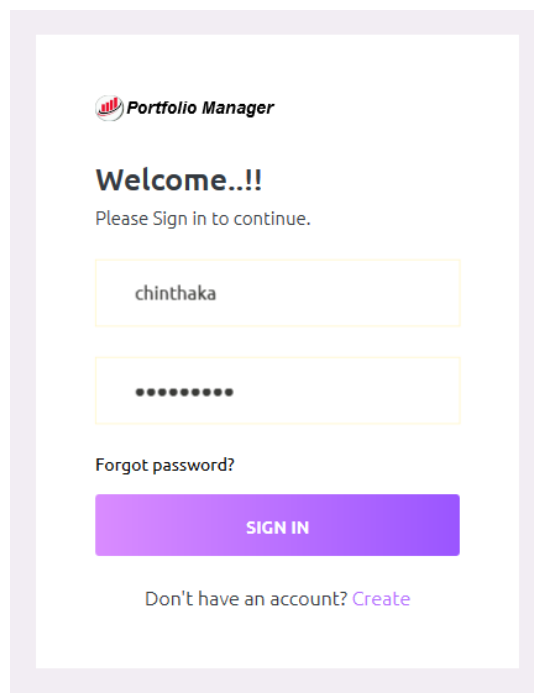
FIGURE 4.3 – LOGIN INTERFACE

4.5.2　Dashboard

Successful user login will redirect to a system dashboard to getting the summary details on the system. The dashboard includes the weekly turnover, gain/loss statistics, and weekly order details as main information outlets. Weekly investment statistics and portfolio holding display as graphs. Bottom information display option has the client events such as client birthday and next meeting schedules. Following figure 4.4 shows that dashboard of the system.
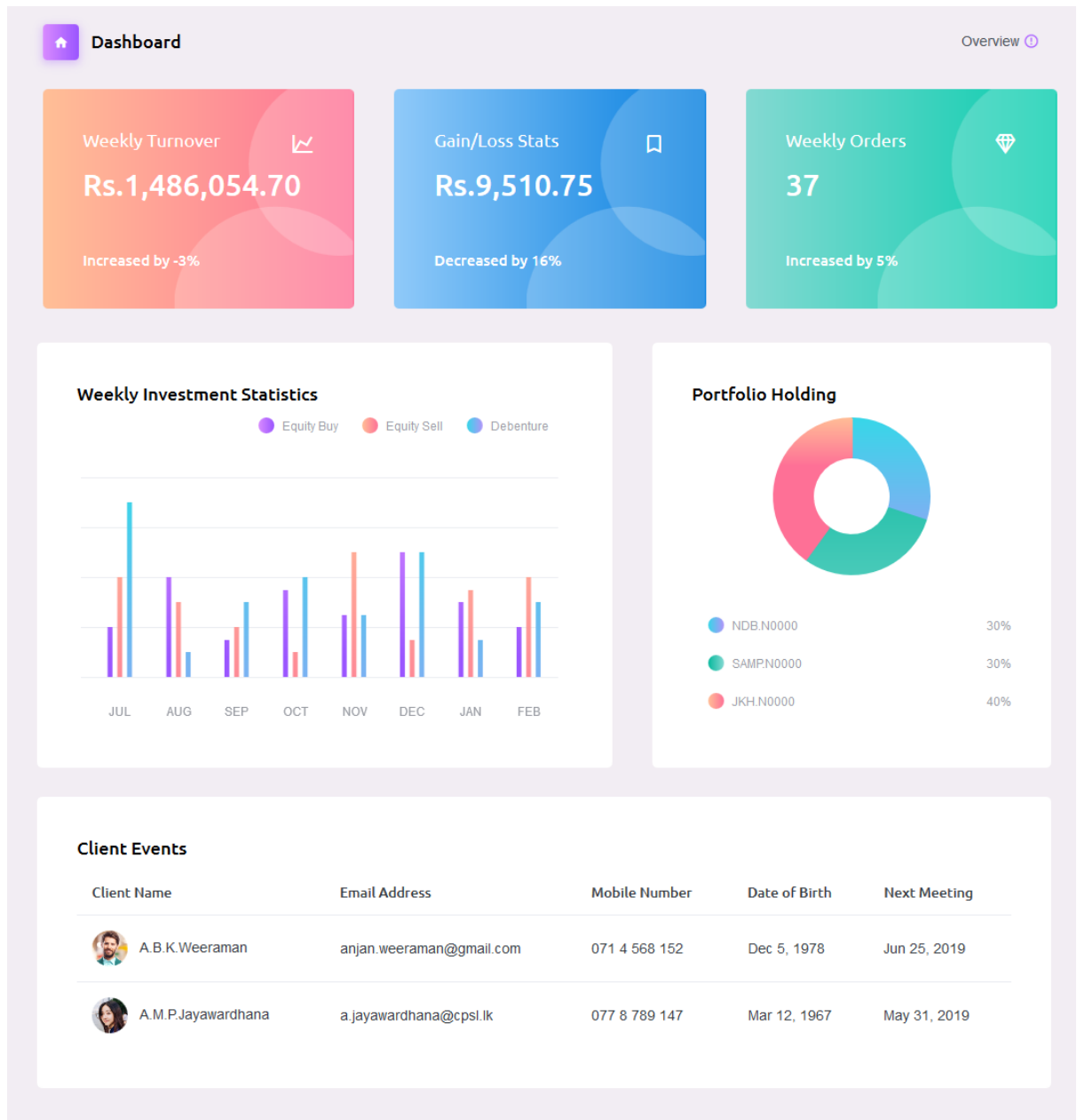
FIGURE 4.4 – DASHBOARD INTERFACE

4.5.3 Navigation Panel

The following figure shows the system navigation to different interfaces and system functionalities. This navigation panel loads the PHP pages via AJAX/JQuery web technology to the main body element. Figure 4.5 shows that the system navigation panel.
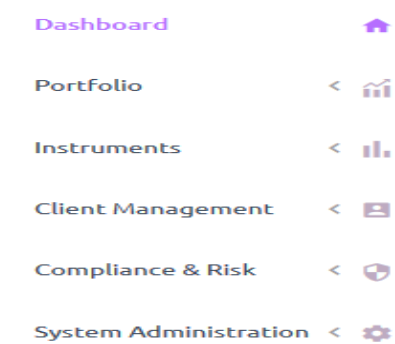
4.5.4 New Client Introduce Interface

New clients and client applications will be processed through this system interface. Authorized system advisor can add new users after completion of mandatory fields and filled that have a specific input pattern. On successful data input, the system will give a success message to the user, and if the event of an unsuccessful attempt, it will provide an error message.

FIGURE 4.6 – NEW CLIENT ADD INTERFACE

4.5.5 New Instrument Introduce Interface

This interface will facilitate the user to add new security instrument to the system, and the following figure shows it is the interface. An authorized user can add a new security instrument by searching the listed company that belongs to the instrument. If the listed company does not found that the company which belongs to the instrument, the user need to introduce the newly listed company and then after that add a new instrument.

FIGURE 4.7 – NEW INSTRUMENT INTRODUCE INTERFACE

4.5.6 New Listed Company Introduce Interface

Listed company introduction interface represent in the following figure. After system authorized user login, the user can add newly listed company by completing the all required fields and inputs. The successful adding to the system will pop-up an information message saying that details have been updating into the database, and an unsuccessful message will show an error message.

FIGURE 4.8 – NEW LISTED COMPANY INTRODUCTION INTERFACE

4.5.7 New Payment Receipt Entering Interface

From this interface, backoffice staff can enter the client payment receipts details. The following figure shows the new receipt entering interface that has a search function to locate the client CDS account details. Figure 4.9 shows that payment receipt entering the interface.

FIGURE 4.9 – PAYMENT INTERFACE

4.5.8 Client Amendment Interface

Client amendment interface will initially give a client CDS account search input and while entering it will provide search suggestions. User can select the idea to filter the client amendment interface. This interface will provide clients every detail with restricted to edit specific input fields. Figure 4.10 shows the system client amendment interface.

FIGURE 4.10 – CLIENT AMENDMENT INTERFACE

4.5.9 Client Transfer Interface

Following figures shows that client transfer interface that has a live search option in client account input field. Whenever NDBS client leaves from client database, all other client associated portfolio and payment details will be disabled. In addition to that this interface gets the information about the client's new broker details and justification to leave the current system. Client transfer interface will help to improve the business process to retain the existing client database. Figure 4.11 shows the system client transfer interface.

FIGURE 4.11 – CLIENT TRANSFER INTERFACE

4.5.10 Instrument Status View Interface

An authorized user can view the details about the current instrument by entering the instrument code or a name of the instrument on the input field. Following figure describe the interface and output for the specific instrument code. Figure 4.12 shows the systems instrument status interface.
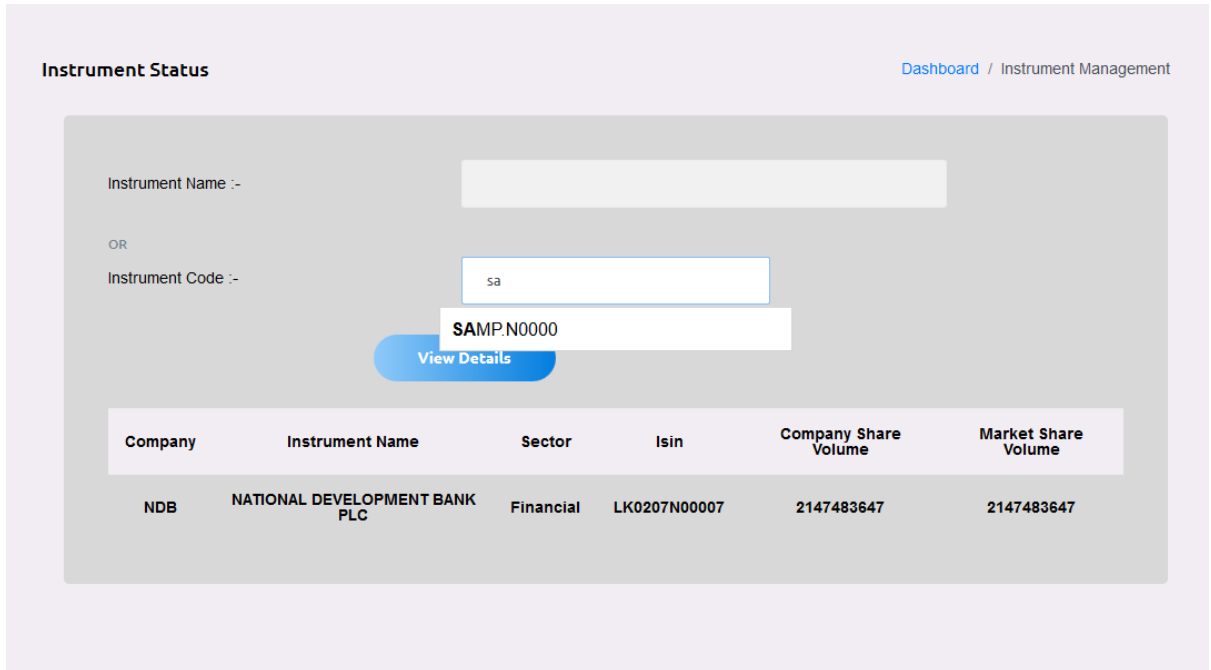
FIGURE 4.12 – INSTRUMENT STATUS VIEW INTERFACE

4.5.11 Instrument Details Update Interface

Instrument details update capability has been enabling through this interface. User can search for the instrument code from the input field, or they can type the complete instrument code detail to get the current information. When displaying current instrument details, update details form will appear on the page. Figure 4.13 shows that the system instrument update interface.

FIGURE 4.13 – INSTRUMENT UPDATE INTERFACE

4.5.12 Listed Company Status View Interface

Listed company screen will be used to check before the new instrument introduce to the system. The new instrument needs to have a listed company before adding them. As per the figure showing on below authorized user can search the listed company details by entering company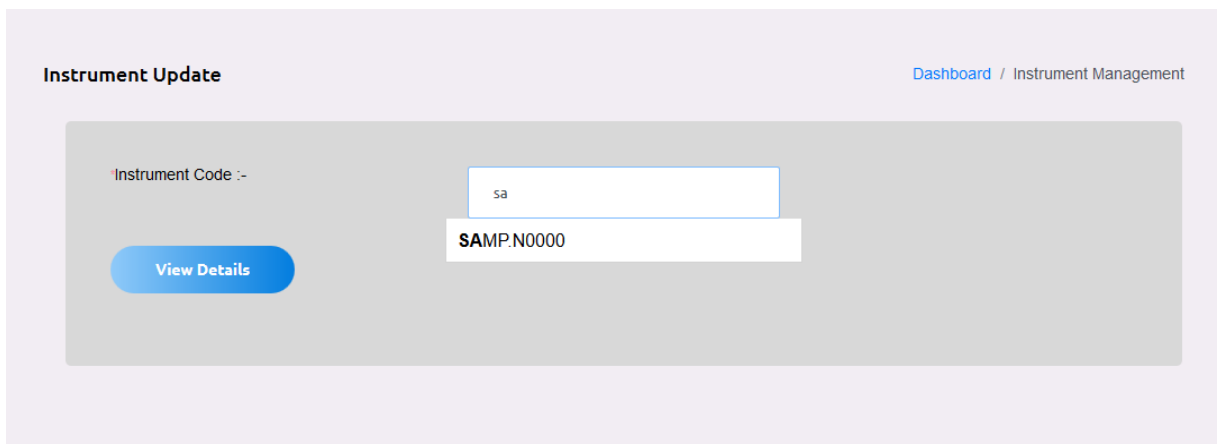 code. Listed Company status will display all the information about the listed company. Figure 4.14 shows that the system listed company status interface.

FIGURE 4.14 – LISTED COMPANY STATUS VIEW INTERFACE

4.5.13 Portfolio Valuation View Interface

The following figure represents the portfolio valuation details interface summary report for a specific client account number. This interface will give the listed user's security instrument and its holding quantity details along with the average price for the share list. Figure 4.15 shows that portfolio valuation view interface.
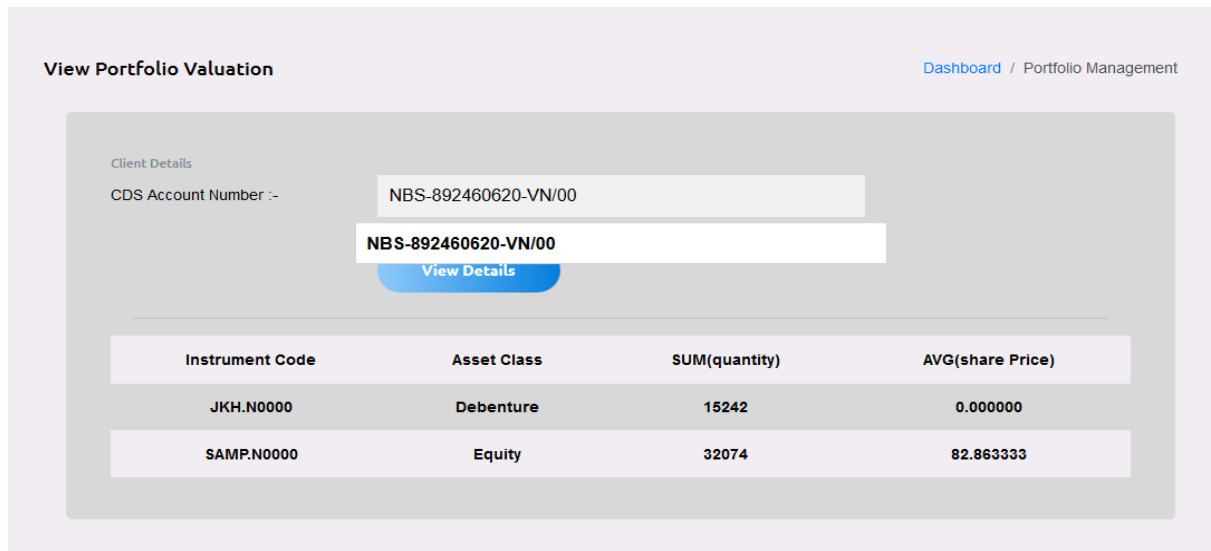
FIGURE 4.15 – PORTFOLIO VALUATION INTERFACE

4.5.14 Portfolio Transfer Interface

When the user transfers to another stock market broker, they will shift their existing portfolio to the new broker's account. The same requirement needs to fulfill when a new account or same broker house client (ex:-father will transfer his current portfolio to his son as a gift) portfolio transfer occurring from the client's end. Figure 4.16 shows the system portfolio transfer interface.
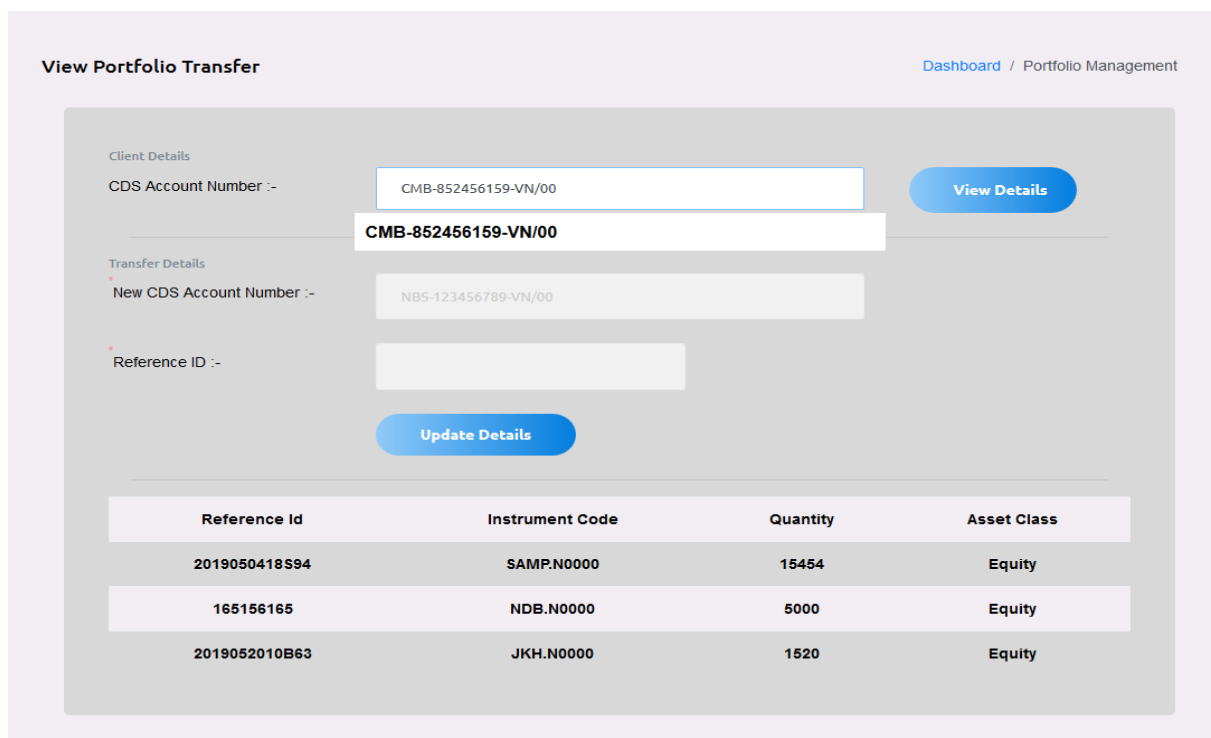
FIGURE 4.16 – PORTFOLIO TRANSFER INTERFACE

4.6   System User Interface Implementation

The user interface is the application that will directly be communicated and create a connection between the core system and end user. User interface design much helps the target audience to operate the system through simple tasks efficiently or click. In user interface design, color theories are being used to give a better experience for system users.
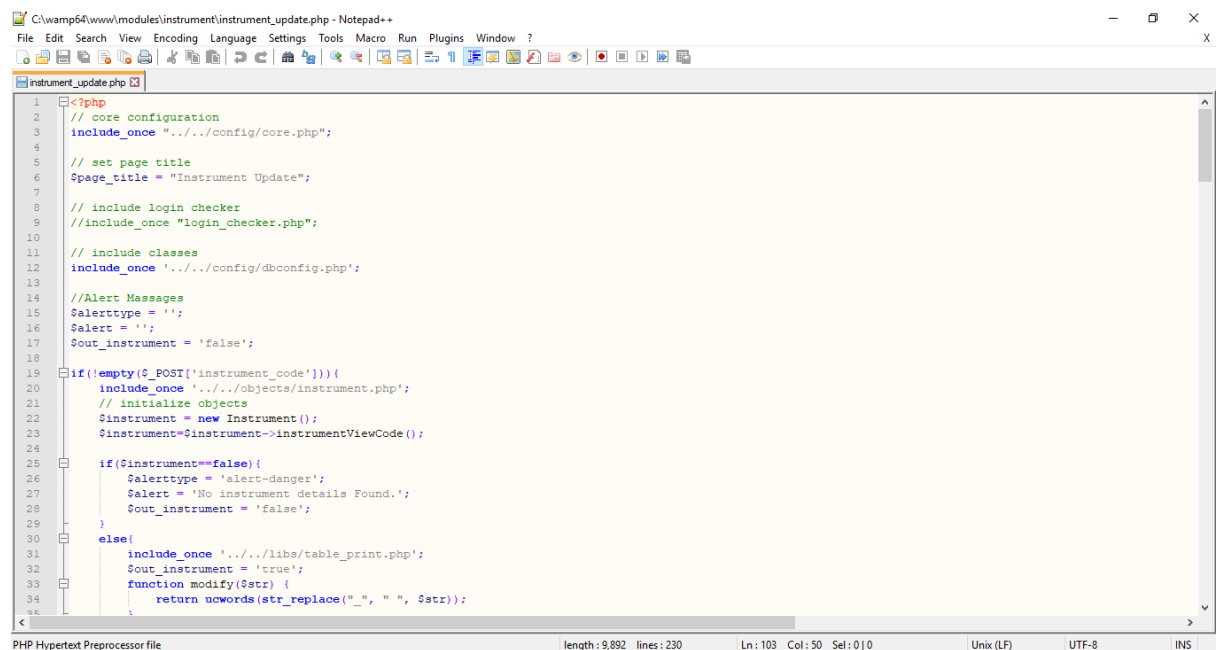
Introduction of twitter bootstrap has been changing the web development standards and methodologies by a certain extent. Bootstrap is open-source, responsive, CSS web framework that has the ability of loading web pages in a matter of second.

Bootstrap Dash offer good quality twitter bootstrap based HTML, PHP, and JavaScript enabled bundle web templates and solution. "Purple Admin" is a Bootstrap Dash best quality web design template that will be most suitable for developing a portfolio management system.

System mock-up interfaces have been creating through industry-leading material design enabled interface designing tool www.draw.io online web service.

4.7   Coding

In system, cording notepad is using for basic text editing, and notepad++ has been using for advance text edition, other script language edition and log file reader. The following figure shows that code editing on instrument update php page. Figure 4.17 shows that the notepad++ system cording screenshot.

43

FIGURE 4.17 – NOTEPAD++ ADVANCED TEST EDITOR

4.7.1 Data Validation

Data validation is the most curtail segmentation in the system. Data validation could apply to individual input files, filters, and then it validates the data before sending to the server. Validation could implement on the client side or server side, which more suitable regarding the operation of the s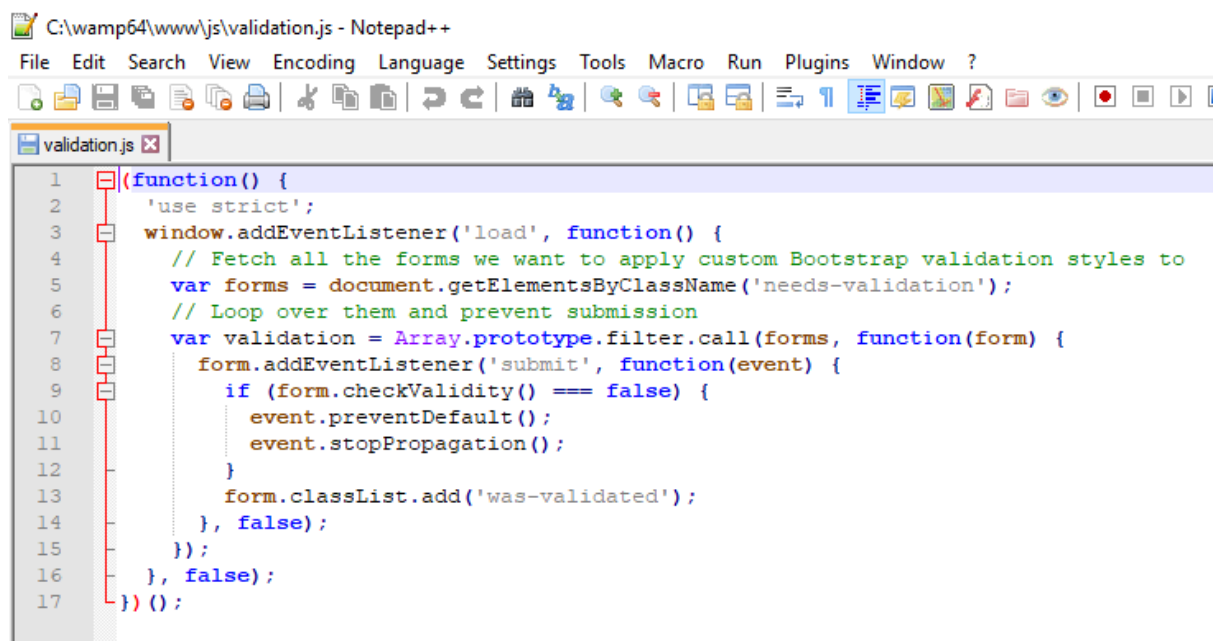ystem. HTML input fields have the inbuilt data validation mechanism that can be applied directly to get the input pattern. As per example if input field mark as email input, the user should provide correctly formatted email details to the data or otherwise the information input will be rejected.

Adding data validation to submission form will check on the end users mandatory input fields are not empty when submitting button click on the form. Below figure shows that validation function that used to check for a form that has class name "needs-validation" and loops its input elements and give a not-validated output if the input field is empty. Figure 4.18 shows the notepad++ system validation cording screenshot.
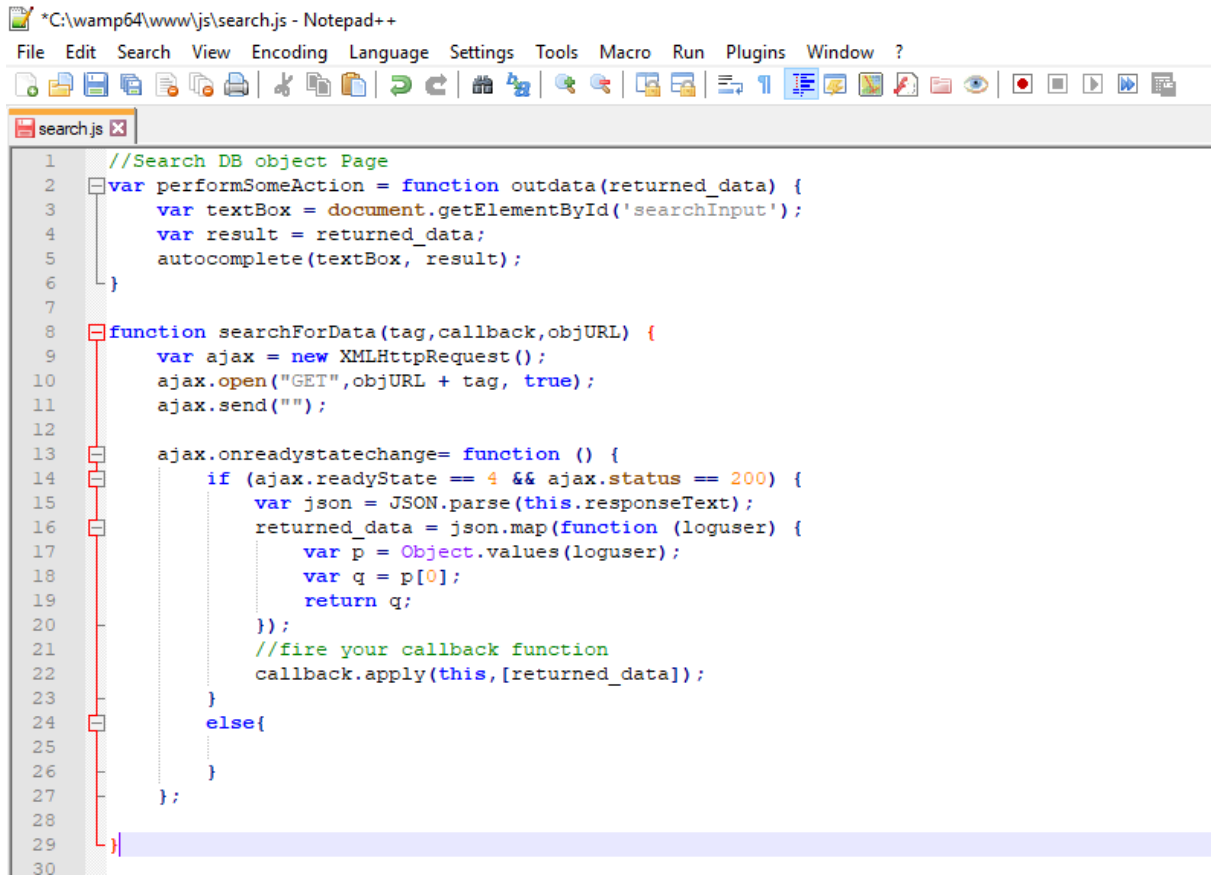

```javascript
(function() {
    'use strict';
    window.addEventListener('load', function() {
        // Fetch all the forms we want to apply custom Bootstrap validation styles to
        var forms = document.getElementsByClassName('needs-validation');
        // Loop over them and prevent submission
        var validation = Array.prototype.filter.call(forms, function(form) {
            form.addEventListener('submit', function(event) {
                if (form.checkValidity() === false) {
                    event.preventDefault();
                    event.stopPropagation();
                }
                form.classList.add('was-validated');
            }, false);
        });
    }, false);
})();
```

FIGURE 4.18 – JAVASCRIPT VALIDATION CODE

4.7.2 Reusing Existing Codes and Libraries

In system development reusing the standard modules and code libraries good practice, since the developer does not needs to develop the desired functions and classes. When using the developer of the publically available module need concern about the security and how easy

to integrate the shared module into the system. Following figures 4.18 shows that JavaScript autocompletes search function that has been customized and applied in search fields of the system. Figure 4.19 is showing that PHP library to print table for data array using the recursive, iterative function. Figure 4.19 shows the notepad++ system search function screenshot.

FIGURE 4.19 – SEARCH FUNCTION

Figure 4.20 shows the notepad++ system PHP table output class screenshot.

FIGURE 4.20 – PHP TABLE PRINT LIBRARY CLASS

4.8 Chapter Summary

In this chapter, concentration about hardware and software requirements in the development and production environment for a new implementation. User interface features, end-user reflexion, and functionality have been discussing through separate interface screens. Finally, the system user interface is an implementation strategy; cording aspects such as data validation and module reusability has been considered.

5 Evaluation and Testing

Evaluation is that the making of assessment, judgment, or identification about the capability and boundary of developed system or software. Evaluation is expected to carry on whenever a new element introduces to the environment. Whether to check that new implementation comply with the specified requirement is handled by system evaluation. Programming testing is characterized as an action to check whether the actual outcomes match the typical results and to guarantee that the product framework is without any deformity.

As per the summarization, evaluation and testing are used to verify that validation and verification. Software system validation is that checking of "are we building the right product?" and verification is "are we building the product right?".

5.1 User Evaluation

In software development end users will have different viewpoints of the systems to complete their requirements from system. This feature is handled by categorizing the users into groups or user roles in such a way that each group has different functions and interfaces map to their system.

In this project standard system user is divided into two groups as backoffice and advisor category. Backoffice user category has different subcategories based on department and managerial level.

User evaluation questionnaire and forms distributed among the sample population that covers all the categories in the company to get the wide-spread idea of system evaluation. Following table 5.1 shows that sample questionnaire google form and figure 5.1 shows sample feedback results.

Name	Chinthaka	Sahan	Gayan	Gehan
Department	Sales	Accounts	Operations	IT
Select Your Role	Advisor	Backoffice	Backoffice	Administrator
How satisfied were you with the System?	5	5	5	5
[Dashboard]	4	4	4	4

[Color Scheme]	4	4	4	4
[System Navigation]	4	3	4	3
[Login Interface]	4	4	4	4
[Easy of Learning]	3	4	4	3
[Response Time]	4	3	3	4
[Searching Facility]	4	4	4	4
[Productivity Improvement]	4	3	4	4
[Browser Compatibility]	3	3	3	3
[Reading Characters]	3	3	4	4
[Error Massages helpful?]	4	3	4	3
Additional feedback on System Improvement?				

TABLE 5.1 – USER EVALUATION RESULTS IN SAMPLE FORM

Legend	
1	Very good
2	Good
3	Satisfactory
4	Weak
5	Failure

5.2 Evaluation Summary

User evaluation feedback result gives the overall system acceptance from the sample population in the company. Feedback forms are deployed through google forms online analysis tools that have great features of natural building, a form with authentication from Google's email account.

Based on the user feedback system has been introduced, new interfaces, function, and UI feature to match the end users expectation. Following figure 5.3 graph shows overall system feedback and figure 5.2 for component feedback summary.

How satisfied were you with the following features?
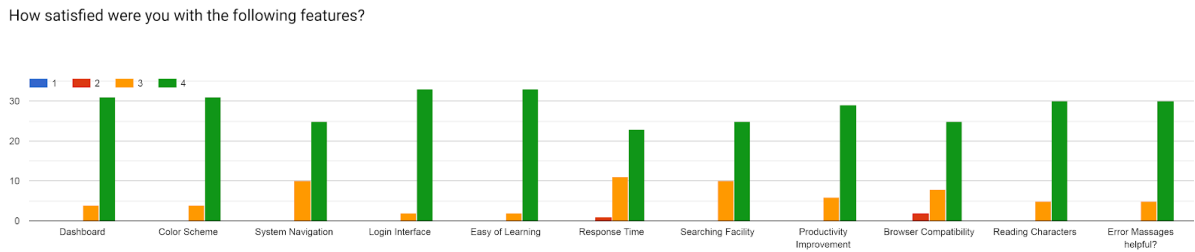
FIGURE 5.2 – SYSTEM FEATURES FEEDBACK SUMMARY

How satisfied were you with the System?

35 responses
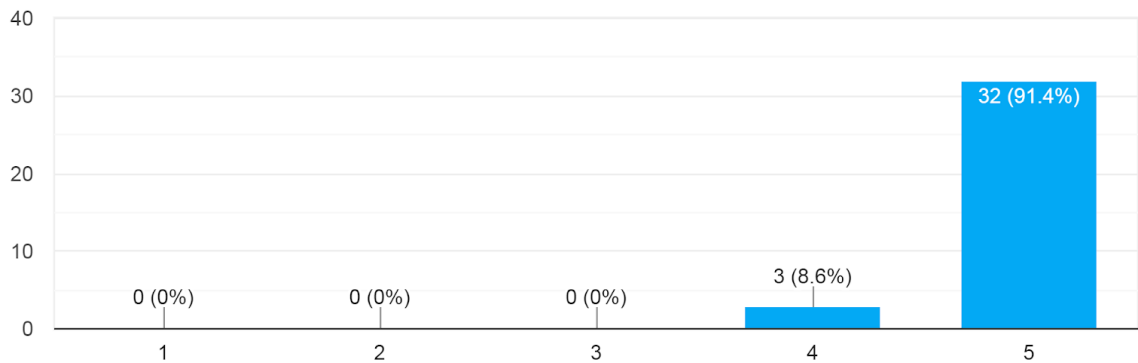
FIGURE 5.3 – OVERALL SYSTEM FEEDBACK

Feedback of the overall system, indicating that more than 90% of the user population is delighted with the system. Few users gave good selection as per they are experiencing in discontent in response time and browser compatibility. Given the resulting outcome is that the system user evaluation is very successful at the period of evaluation time.

5.3 System Testing Methodologies

System testing is used to identify the newly implemented system code error and logic errors that will lead to malfunction the expected outcome to end users. Overcome the coding and

logical fallacies; software development lifecycle has the module testing option. After module development has been completing, it will go through a standalone test, and intergrade analysis will be complete when the module connects to the main system.

5.3.1 Black Box Testing

Black box testing is the technique that will check on whether the requirement of customer or end user has been an encounter with giving scope. The critical concentration in black box testing is on the functional testing of the system as an in one piece — most of the web application test using black box testing method to ensure to end user system expectation.

5.3.2 White Box Testing

White box testing techniques study the inner structures the used data structures, core design, program structure, and the operation of the software rather than the objective of the functionality as in black box testing. It is likewise so-called glass box testing or clear box testing. [14]

5.4 System Testing Types

In software engineering, system development is a methodology that software testing has the pre-determined in order to complete the assessment scenario. Initially testing start on unit testing and next check for the integration testing. After all, the software product modules are combining lead to system testing. Finally, the acceptance test will be completed by end users.

5.4.1 Unit Testing

Unit testing is performing whenever the simple low-level module that has been finalizing the developing phase. Purpose of this validation is that the module will output the expected result and solution when all the modules are intergraded together as per the whole system. Unit is the smallest part and testable component in the software. A single unit has few inputs that can have been mimicking during the testing. Usually, unit testing completed in system development (cording).

Portfolio Management System Main system units testing result sample shows in table 5.2

	System Unit	Test Result
01	Login Module	Pass
02	User Module	Pass
03	Client Module	Pass
04	Transaction Module	Pass
05	Payment Module	Pass
06	Instrument Module	Pass
07	Listed Company Module	Pass

TABLE 5.2 MAIN SYSTEM UNITS TESTING RESULT

5.4.2 Integration Testing

Integration is that the testing whenever the two or more modules are interconnected to each other and form a group to function as one system. Purpose of this testing is to minimize the errors between modules that eventually lead to system malfunction. Typically system developing within module dependency (cohesion) need to be high, and inter-module dependency (coupling) need to be low value.

5.4.3 System Testing

System testing is where all the modules integrated into one whole system and check its functionality end-user expected results. Reason for this test is that to check, whether all the system requirements have been completed and fulfill by a newly implemented system. System testing takes, as its feedback, all of the combined modules that have accepted on integration testing.

5.4.4 Acceptance Testing

Acceptance testing is that the proper measurement concerning user requests, requirements, and business processes accompanied to decide whether or not a system fulfills the

acceptance standards and to enable the end user or other approved entity to conclude whether or not to accept the system.

5.5 Test Plan and Test Cases

Test plan and test cases are essential tasks in the quality assurance of a software development system. A test plan is a text script that will execute the proper testing elements with defined scope and activities. Test case creation is the most critical and time-consuming task for a quality assurance engineer. Standard test case document consists of a simple test and its expected output from the system.

Following tables 5.3 shows that sample test cases of Portfolio management system

Test Case 1 - Login to the System				
Test Number	Test Data	Purpose	Result Obtained	Result
101	Enter Valid Username and Password and click login button	Login to the system	Login to the system	OK
102	Enter Valid Username and Incorrect Password and click login button	Error message display	Error message display	OK
103	Enter invalid Username and valid Password and click login button	Error message display	Error message display	OK
104	Enter invalid Username and Password and click login button	Error message display	Error message display	OK
105	Enter empty space as Username and Password and click login button	Error message display	Error message display	OK
106	Click logout Button	Redirected to the login Window	Redirected to the login Window	OK

TABLE 5.3 – SAMPLE TEST CASE

5.6 Chapter Summary

In this chapter initially focus on the user evaluation of the implemented system. User evaluation is completed by providing testing system access to sample population and fill-out google response from the end user. Secondly, concentration on system testing

methodologies such as black box testing and white box testing approaches. Finally, this chapter discussed the test plan and test cases of the implemented system.

6 Conclusion

NDB Securities is a well establish stockbroker who is back by the National Development Bank. Sri Lankan stock market handle by Colombo Stock Exchange who is a member of the world federation of exchange. CSE is the only stock exchange in Sri Lanka which is governed by the Securities and Exchange Commission. NDB Securities is a member of the Colombo Stock Exchange.

This project describes the development of a software system that is implementing as a web-based solution. The functionality of the application includes the ability to manage the individual or company user's portfolio, trading history, and payment information as well as get some advantage to make a sound investment decision.

6.1 Critical evaluation of the System

NDB Securities internal trading system connects to the CSE Automated Trading System to process and execute client's trading. NDB Securitas has around 60,000 of the client base, and each client has allocated to an advisor. Whenever a client tries to buy shares, he needs to have virtual buying power to execute the transaction. Calculating buying power is a manual process that ether client or advisor needs to calculate with the existing account balance. In order to overcome this kind of problems, NDBS has decided to develop a new Portfolio Management system.

With the analysis of the client, user, and management requirements, the system has a design with several modules. User Management, Investment Management, Portfolio Management, Risk Management, Compliance Management, and System Administration are the main modules in the system. System design and implement on popular open source web platform Apache, PHP, and MySQL. User evaluations are carrying on the participation of NDB Securities sample population. User feedback and response archive the more than expected level and company management has approved the new system.

6.2 Problems Encountered

When requirement gathering most of the problems encountered. Since the end user is a different viewpoint capturing is the hardest part of the project. Following minor problems is an encounter on other system development lifecycle.

- Finding and analysis of local product

- Professional drawing tools are more expensive than projected

- Get the management approval to set up a test environment

- Restrict the access to the test environment (access enable for sample population)

6.3 Future Enhancements

The system has been developing according to current user requirement and specification and business process. Sri Lankan economy has been changing over time. With this effect can change future business plans and procedures. The current system has been built to adapt the future changes. Following is the list that can be intergraded to the system and improve the business process.

- Integrate the current system with CSE trading system

- Integrate with NDB online payment system

- Improve the report generation

7 REFERENCES

[1] "Wikipedia," [Online]. Available: https://en.wikipedia.org/wiki/Colombo_Stock_Exchange. [Accessed 06 February 2019].

[2] "CSE - ATS Rules," April 2019. [Online]. Available: https://cdn.cse.lk/pdf/ATS_Rules_Amended_2019_APR_20.pdf. [Accessed 09 April 2019].

[3] "Wikipedia," [Online]. Available: https://en.wikipedia.org/wiki/Stock. [Accessed 18 January 2019].

[4] "Investopedia," [Online]. Available: www.investopedia.com/terms/s/stockmarket.asp. [Accessed 12 February 2019].

[5] "Wikipedia," [Online]. Available: https://en.wikipedia.org/wiki/Stock_market. [Accessed 22 January 2019].

[6] "Ledgex Portfolio Management," [Online]. Available: https://ledgex.com/features/portfolio-management/. [Accessed 20 November 2018].

[7] "StockMarketEye," [Online]. Available: https://www.stockmarketeye.com/users-guide/introduction-to-stockmarketeye.html. [Accessed 07 December 2019].

[8] "EquityStat," [Online]. Available: https://www.equitystat.com/portmgr/pages/featurelist.aspx. [Accessed 13 December 2018].

[9] "Fund Manager," [Online]. Available: https://www.fundmanagersoftware.com/versions.html. [Accessed 25 November 2018].

[10] Sahil Barjtya, Ankur Sharma and Usha Rani, "A detailed study of Software Development Life Cycle (SDLC) Models," *International Journal Of Engineering And Computer Science,* 2017.

[11] A. DENNIS, B. HALEY WIXOM and R. M. ROTH , "System Analysis and Design," 03 April 2011. [Online]. Available: http://www.saigontech.edu.vn/faculty/huynq/SAD/Systems_Analysis_Design_UML_5th%20ed.pdf.

[12] A. Farrell, "ATHABASCA UNIVERSITY," October 2007. [Online]. Available: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.614.9644&rep=rep1&type=pdf. [Accessed 16 January 2019].

[13] "Wikipedia," [Online]. Available: https://en.wikipedia.org/wiki/PHP. [Accessed 8 April 2019].

[14] "Geeks for Geeks," [Online]. Available: https://www.geeksforgeeks.org/software-engineering-white-box-testing/. [Accessed 15 May 2019].

Appendices

Appendix A – System Documentation

This appendix documentation consists of hardware and software requirements of the system environment. Following tables A.1 shows that recommended hardware requirements.

Hardware	Recommended Requirement
Processor	Intel Xeon Processor E4210
Memory	4 GB DDR4
Hard Disk	140 GB SSD RAID 1
Display	17 Inch 1366 x 768 resolution Monitor
Network Connectivity	2 Mbps Lease Line Internet Connection
Power	UPS Redundant Power
Printer	Standard LaserJet Printer

TABLE A.0.1 – HARDWARE REQUIREMENT

Following the table, A.2 shows that recommended software requirements.

Software	Recommended Requirement
Operating System	Windows Server 2016
Web Server	Apache 2.4 / PHP 7.2
Database Server	MySQL 5.7
Web Browser	Google Chrome 70.0 above or Firefox 60.0 above
Email Server	Postfix Mail Server or Microsoft Exchange Server

TABLE A.0.2 – SOFTWARE REQUIREMENT

Appendix B – Test Cases

Test Case 1 - Login to the System				
Test Number	**Test Data**	**Purpose**	**Result Obtained**	**Result**
101	Enter Valid Username and Password and click login button	Login to the system	Login to the system	OK
102	Enter Valid Username and Incorrect Password and click login button	Error message display	Error message display	OK
103	Enter invalid Username and valid Password and click login button	Error message display	Error message display	OK
104	Enter invalid Username and Password and click login button	Error message display	Error message display	OK
105	Enter empty space as Username and Password and click login button	Error message display	Error message display	OK
106	Click logout Button	Redirected to the login Window	Redirected to the login Window	OK

TABLE B.0.3 – TEST CASE 01

Test Case 2 - User account management				
Test Number	**Test Data**	**Purpose**	**Result Obtained**	**Result**
201	Click User management	Load the Page	Load the Page	OK
202	Enter new user details and submit without filling required fields	Error message display	Error message display	OK
203	Enter new user details and submit with filling required fields	Success message display	Success message display	OK
204	Click on user summary	Load Page	Load Page	OK
205	Click on update user	Load Page	Load Page	OK
206	Enter updated details and submit with filling required fields	Success message display	Success message display	OK
207	Enter updated details and submit without filling required fields	Error message display	Error message display	OK

TABLE B.0.4 - – TEST CASE 02

Test Case 3 - Client account management				
Test Number	Test Data	Purpose	Result Obtained	Result
301	Click client management	Load the Page	Load the Page	OK
302	Enter new client details and submit without filling required fields	Error message display	Error message display	OK
303	Enter new client details and submit with filling required fields	Success message display	Success message display	OK
304	Click on client summary	Load Page	Load Page	OK
305	Click on update client	Load Page	Load Page	OK
306	Enter updated details and submit with filling required fields	Success message display	Success message display	OK
307	Enter updated details and submit without filling required fields	Error message display	Error message display	OK

TABLE B.0.5 – TEST CASE 03

Test Case 4 - Instrument management				
Test Number	Test Data	Purpose	Result Obtained	Result
401	Click instrument management	Load the Page	Load the Page	OK
402	Enter new instrument details and submit without filling required fields	Error message display	Error message display	OK
403	Enter new instrument details and submit with filling required fields	Success message display	Success message display	OK
404	Click on instrument summary	Load Page	Load Page	OK
405	Click on update instrument	Load Page	Load Page	OK
406	Enter updated details and submit with filling required fields	Success message display	Success message display	OK
407	Enter updated details and submit without filling required fields	Error message display	Error message display	OK

TABLE B.0.6 – TEST CASE 04

Test Case 5 - payment management				
Test Number	**Test Data**	**Purpose**	**Result Obtained**	**Result**
601	Click payment management	Load the Page	Load the Page	OK
602	Enter new payment details and submit without filling required fields	Error message display	Error message display	OK
603	Enter new payment details and submit with filling required fields	Success message display	Success message display	OK
604	Click on payment summary	Load Page	Load Page	OK
605	Click on update payment	Load Page	Load Page	OK
606	Enter updated details and submit with filling required fields	Success message display	Success message display	OK
607	Enter updated details and submit without filling required fields	Error message display	Error message display	OK

TABLE B.7 – TEST CASE 05