**INDUSTRIAL TRAINING REPORT**

**TRAINING ORGANIZATION : LONDON STOCK EXCHANGE**

**GROUP TECHNOLOGY**

**PERIOD OF TRAINING : FROM 05/04/2021 TO 04/10/2021**

**FIELD OF SPECIALIZATION : COMPUTER ENGINEERING**

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**E/15/280**

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**ABBREVIATIONS**

BER Bit error rate

CNN Convolution neural network

DNN Deep neural network

FC Camera frame

FD Display frame

IoU Intersection over union

LED Light emitting diode

LSTM Long-term short-term memory

LARC Living Analytics Research Center

ML Machine learning

MOS Mean opinion score

RC Camera frame rate

RD Display frame tare

RGB Red green blue

SCC Screen to camera communication

SIS School of Information Systems

SMU Singapore Management University

VLC Visible light communication

Chapter 1

INTRODUCTION

**1. 1. TRAINING SESSION**

The training establishment that I underwent training with respect to the TR400 Industrial Training module was London Stock Exchange Group Technology (LSEG Technology), also Called as Millenium IT Software (Private) Limited in Sri Lanka, which is situated in 01 Millennium Drive, Malabe. My training period commenced on 05th April 2021 and terminated on 04th October 2021, extending throughout a duration of 26 weeks.

**1.2. INTRODUCTION TO THE TRAINING ORGANIZATION**

**1.2.1 London Stock Exchange Group**

London Stock Exchange Group (LSEG) is a leading global financial markets infrastructure and data provider headquartered in the City of London, England and operates in 70 countries across. London Stock Exchange was founded in Sweeting's Alley in London in 1801. In 2007, it merged with Milan Stock Exchange Borsa Italiana, creating London Stock Exchange Group and currently it employs around 25,000 people globally, more than half located in Asia Pacific. It is a public company leading the global financial markets infrastructure and data provider, trusted to deliver excellence by customers, partners and markets around the world.

The company purpose is to drive financial stability, empowering economies and enabling customers to create sustainable growth.

Figure 1.1 below, illustrates the logo of the London Stock Exchange Group.

Figure 1.1: LSEG logo

**1.2.1 Millenium IT Software (Private) Limited**

In early 90’s Sri Lanka was having a rudimentary stock trading system and due to the lack of technology the authorities could not expand and attract foreign investors. In 1996, MilleniumIT founded by Tony Weerasinghe and they provided a software-based solution to Sri Lankan trading System at Colombo Stock Exchange (CSE).

In 2009 London Stock Exchange Group acquired MilleniumIT with a contract for a new enhanced, fast  
trading platform for equities. This acquisition was a big milestone in MIT history because after that the  
company entered the international market with a considerable number of orders from all around the  
world. Now the company is rebranded as LSEG Technology, the technical support provider for the  
mother company LSEG. It delivers six different capital market technical products & services.

* Millennium Exchange
* Millennium Surveillance
* Millennium SOR
* Millennium Market Data
* Millennium PostTrade
* Millennium LiveOps

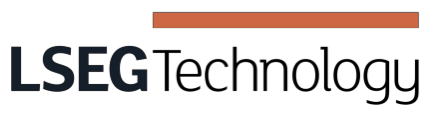
 Figure 1.2 below illustrates the logo of LSEG Technology and Figure 1.3 depicts a magnificent view of the LSEG technology in Malabe.

Figure 1.2: Logo LSEG Technology

Figure 1.3 LSEG Technology, Malabe

**1.2.2 Company Vision**

“MillenniumIT is the partner of choice for organizations needing real-time, high performance, agile & resilient capital market technology. We set the global standard for multi asset, pre to post-trade STP solutions for financial markets.”

**1.2.2 LSEG Technology Divisions**

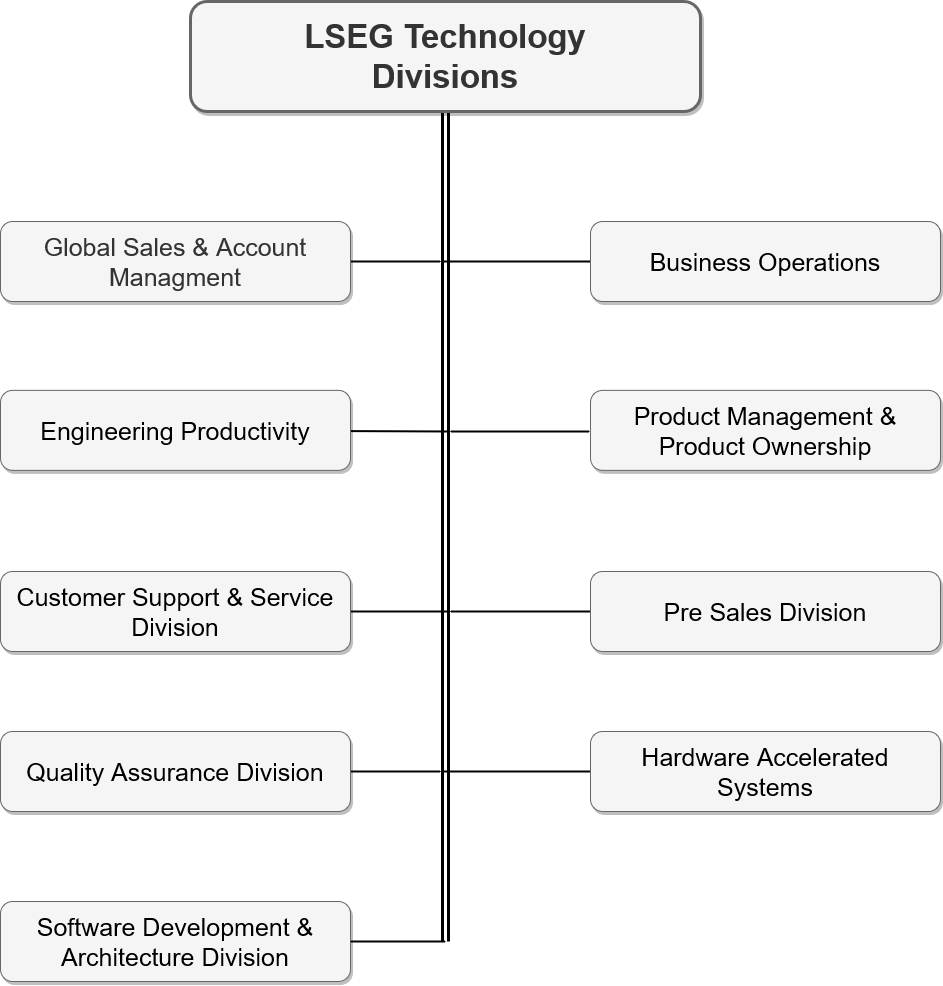
**** Figure 1.4 below depicts different division of LSEG Technology. There are around 9 divisions collaboratively work to achieve their goals.

Figure 1.4 LSEG Technology Divisions

**1.2.3 LSEG Technology Management Structure**

**** Since 2009, the group has made several other acquisitions increasing the size and scope of the LSE group. Figure 1.4 shows the ExCo members of LSEG after several acquisitions.

Figure 1.4 Executive Committee (ExCo) members of LSEG

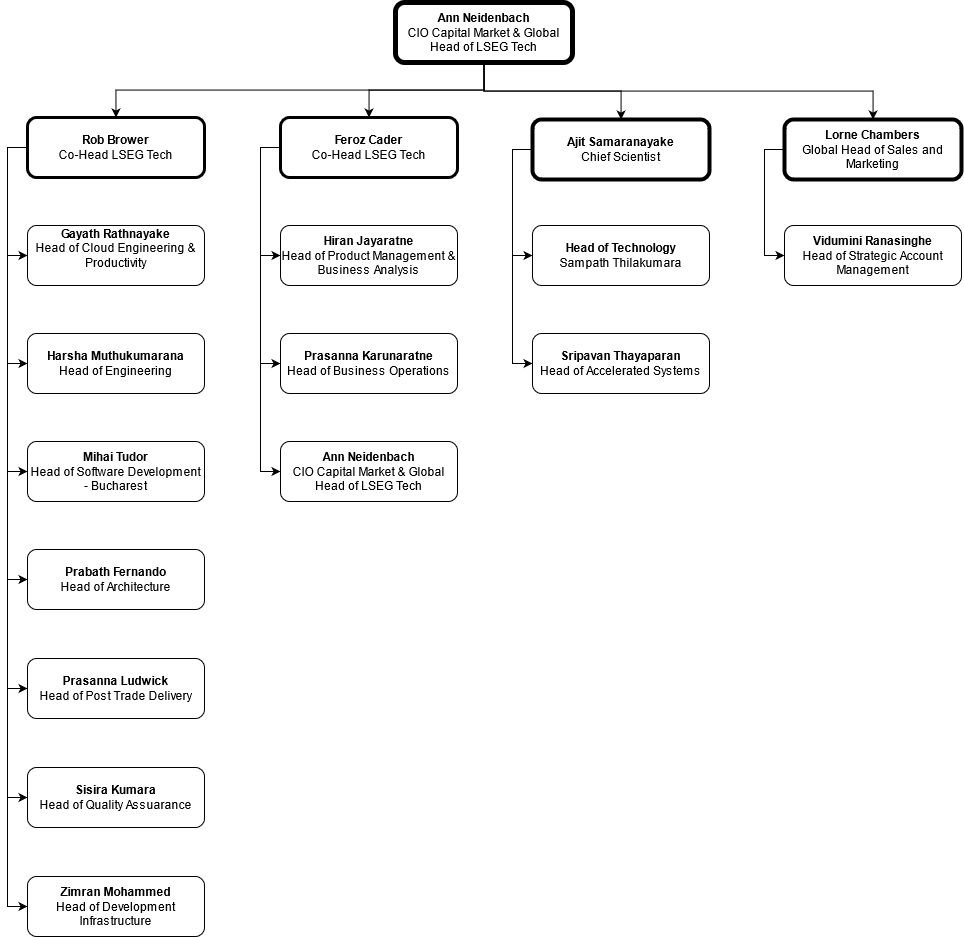
**** LSEG Technology in Sri Lanka, guided by ExCo members and Figure 1.5 illustrates the leadership structure expanded according to different divisions.

Figure 1.5 Leadership structure of LSEG Technology in Sri Lanka

**1.3. SUMMARY OF TRAINING EXPOSURE**

SMU requires interns to work on a research project. I started working on a project called **“DeepLight”** which aims to develop a VLC (visible light communication) technology with SCC (screen to camera communication).

The training period was spent on learning about existing VLC, SCC techniques, understanding the working principles and theory behind those implementations, assessing the shortcomings of those systems and developing the new SCC technique. To the latter part of the training, I worked on evaluating and benchmarking the system. Finally, I put my time to write a research paper (along with the rest of the group) on our project.

Chapter 2

OVERVIEW, BACKGROUND AND RELATED WORK

## **2.1. INTRODUCTION**

## **2.2. OVERVIEW OF DEEPLIGHT**

## **2.3. KEY CONTRIBUTIONS**

## **2.4. BACKGROUND OF SCREEN CAMERA COMMUNICATION**

## **2.5. RELATED WORK**

Chapter 3

INTRODUCTION TO THE GROSS EXPOSURE CALCULATION

## **3.1. INTRODUCTION**

This chapter describes financial terms I have come across during the internship and the Gross Exposure calculation that I accelerated as the internship project.

## **3.2. GROSS EXPOSURE CALCULATION**

In the stock trading system, the gross exposure calculation is a time-sensitive real-time calculation that should be sensible for microsecond scale delays. Since my project is related to the financial market, one of the major challenges was learning those financial terms to understand the project. To learn these terms, I got help from my mentor and resources from the internet. Table 3.1 describes financial terms I have come across during this project.

Table 3.1: Financial Terms

|  |  |
| --- | --- |
| Financial Term | Explanation |
| Instrument | An implement with which to store or transfer value or financial obligations |
| Currency | Medium of exchange for goods and services |
| Quantity | Number of shares one wishes to buy or sell |
| Market Price | The market price of a stock is the price that it sells for on the open market at a given point in time |
| Position | A single stock that a trader owns in his portfolio |
| Position Update | Adding/removing a position from a trader’s portfolio |
| Market Data Update | Price change in a single instrument-currency pair |
| Gross Exposure | Gross exposure measures an investment fund's total exposure to financial markets |

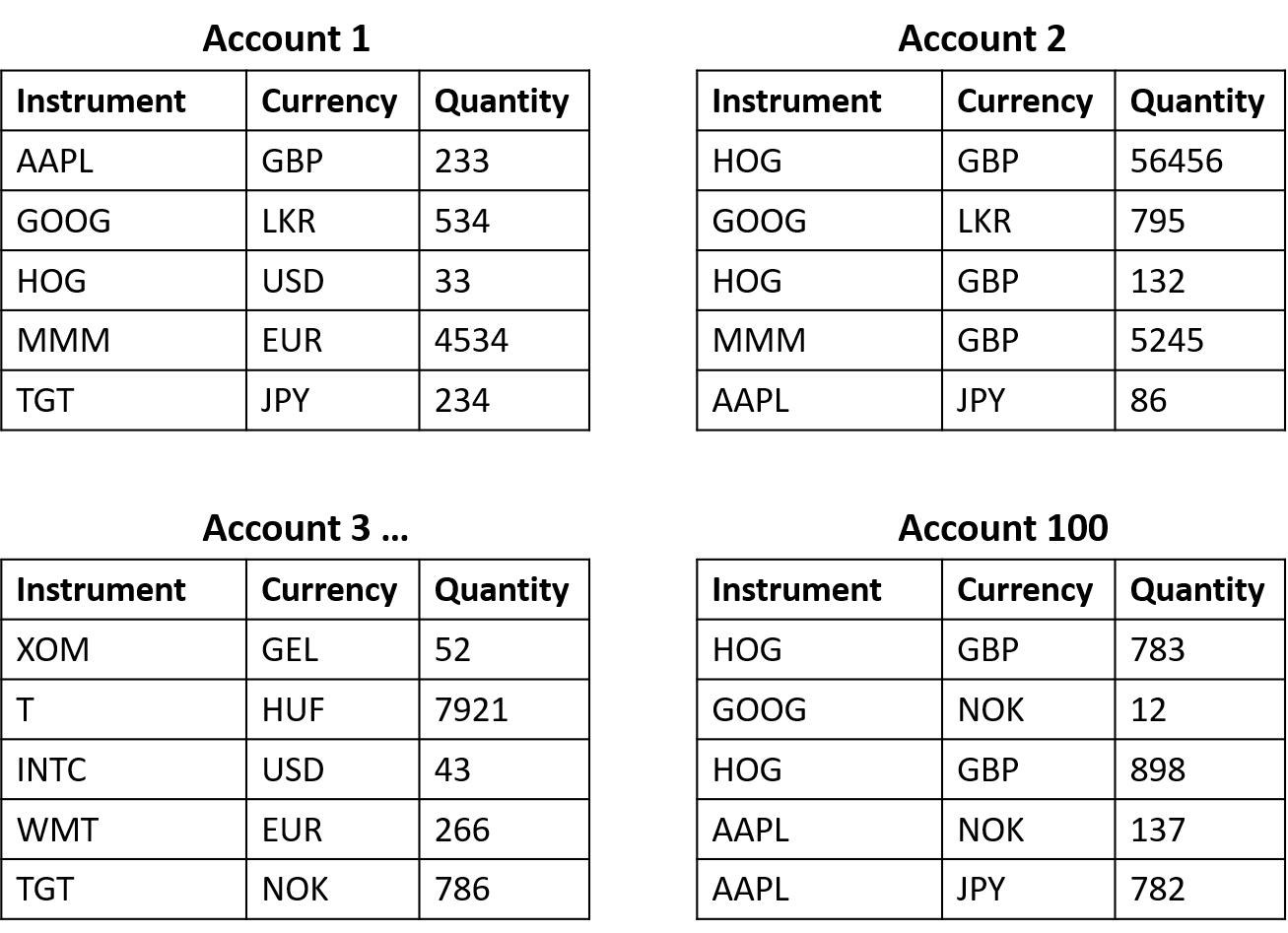
 There are several accounts (portfolios) for each of the users. When my mentor explained the gross exposure calculation to me, he told me to consider these accounts as different stock-broker firms. Therefore, for the sake of understanding, I am referring to them as different stock-broker accounts. In each of the accounts, there are several positions. Simply, we can think of a position as a tuple that includes an instrument, currency, and quantity. Figure 3.1 illustrates a sample system with a set of accounts.

Figure 3.1: Account Details

As you showed in Figure 3.1, we can use instrument-currency pair as a unique entry in an account. Some of the essential statistical data are,

* There can be 20,000 maximum number of positions per account.
* The total number of currencies is 15.
* The total number of instruments is 1000.

Position distribution in accounts is purely random. Each instrument-currency pair has a price at a given time. Table 3.2 illustrates a sample price list at a particular time.

Table 3.2: Sample Price List

|  |  |
| --- | --- |
| Insturment-Currency pair (IC) | Price |
| AAPL-GBP | 432.34 |
| TGT-JPY | 89.55 |
| AAPL-USD | 4589.00 |
| MMM-EUR | 38.93 |
| HOG-USD | 7865.95 |
| GOOG-LKR | 624.00 |

To calculate the account level gross exposure, we need to take the multiplication of quantity and price of every position and sum them up in each account.

An example calculation using sample data of Account 1 in Figure 3.1 and Table 3.2 is shown below.

**3.3 Experience Gained**

Chapter 04

DESIGN AND IMPLEMENTATION – GROSS EXPOSURE CALCULATION

## **4.1. INTRODUCTION**

The GPU team needed to investigate the performance of gross exposure calculation using a GPU-FPGA heterogeneous computing system. They assigned the projct to me as a research project. As I started working on my project, first, my mentor asked me to create a timeline. Therefore, I created a timeline including the following milestones.

* A quick literature survey to find existing solutions/approaches to the current problem.
* A design that should include my approach to the problem.
* Implementation of the project.
* Find bottlenecks and Optimize the run-time.

In this section, I intend to describe my work during each of these milestones.

Since I got experience in OpenCL programming from my final year university project, my line manager and the rest of the team members suggested me to use OpenCL in a GPU-FPGA heterogeneous environment to accelerate the gross exposure calculation.

**4.2. Literature Survey**

**4.2 Design Decisions**

**4.2.1 Choosing Accelerators**

**4.2.2 Choosing Programming Framework/Languages**

**4.3 Design**

**4.3.1 Class Diagram**

**4.3.2 Sequence Diagram**

**4.3.3 Kernel Design**

**4.4 Implementaion**

**4.5 Difficulties**

**4.6 Optmizations**

Chapter 5

RESULTS AND DISCUSSION

5.1. INTRODUCTION

5.2. EVALUATION

CONCLUSION