
Sri Lanka Institute of Information Technology

# Laboratory Information Management System

Project Proposal

Information Technology Project – IT2080

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# 1. Background

Medi Line is a small privately owned and operated medical laboratory in Athurugiriya. It was established in 2016. The laboratory focuses on providing routine clinical laboratory services which includes haematology, clinical chemistry, and biochemistry to the local community.

Haematology is the scientific study of blood including its composition, function, and diseases. Clinical chemistry uses chemical processes to measure levels of chemical components in body fluids and tissues, blood and urine being the most common specimens. It plays a crucial role in the diagnosis and management of a wide range of diseases, such as liver and kidney disease, diabetes, and certain cancers. Clinical biochemistry refers to the application of chemical and biochemical methods to the study of diseases. It includes a wide range of tests and techniques used to diagnose and monitor various medical conditions. [1]

The medical laboratory at Medi Line is staffed by trained phlebotomists, who are medical professionals responsible for collecting blood samples from patients, and medical laboratory scientists and technicians who does the diagnostic testing of blood and body fluids. There is also a receptionist who interacts with the patients during the billing process.

In addition to performing in-house tests, Medi Line also outsources some tests to other laboratories. A courier from the outsourced laboratory will collect the samples from Medi Line and transport them for testing, then return the test results to the laboratory.

The laboratory is equipped with a range of instruments and machines, including syringes, microscopes, ECG machines, and haematology analysers. These tools are critical for accurately analysing samples and providing patients with accurate and timely test results.

Medi Line is dedicated to staying current and using the latest tools and techniques into their practices. This helps ensure that patients receive the highest quality care possible.

# 2. Problem and Motivation

At present Medi Line relies on a physical file-based system to manage their information and workflows. Although this approach seems more convenient for them, it has many drawbacks having a significant impact on efficiency and accuracy of their operations. Some of the draw backs include data redundancy, data inconsistency, limited data sharing and poor enforcement of standards.

## 2.1. Problems

- Re-registering patients

When a patient comes to the premise with a prescription, the first thing they do is register the patient. And patients (mostly the elderly) seem to give them different information every time they come for a test. Pulling patient records and updating information can be a real hassle. Therefore, they re-register the patient on their demographics and contact information. This leads to data duplication.

- Difficulty in tracking samples

With physical files, it can be difficult to access information quickly and easily about the status of a sample. This can lead to delays in processing and testing, as staff must manually search through files to find the necessary information. This will lead to lost or mislabelled samples resulting in delays in patient diagnosis and treatments.

- Archiving

All records of tests are to be archived, so that even if a previous patient of theirs requests for a test report that was done years ago, it should be available. This will be a tedious task to search for previous records.

- High laboratory turnaround time

Laboratory Turnaround Time (TAT) is a measure of the time it takes from receiving a sample to producing test results. Using a physical file system can negatively impact this as the staff has to share files between them which can lead to reduced productivity.

- No inventory management

Having no inventory management can lead to increased costs. Lack of inventory control can result in waste due to overstocking, stock shortages, or expired materials, which can be costly. Without accurate inventory records, it can be difficult for the lab to plan for future needs, leading to additional costs and decreased efficiency.

- No statistical data

Generating statistical data can be challenging for a medical laboratory without proper systems and processes in place. It will take more time and inaccuracy. Without access to statistical data they wont be able to make informed decisions.

## 2.2. Motivation

The laboratory can make significant improvements by addressing the above problems mentioned.

- Improved efficiency

By finding ways to better track samples and keeping an organized inventory, laboratories can work more efficiently and process samples more quickly. This means that results can be available sooner and with less delay.

- Enhanced productivity

By implementing archiving systems, laboratories can store and retrieve samples more easily, which saves time and effort required to find and handle specific samples. This allows researchers and technicians to focus on other important tasks and ultimately increases productivity in the lab.

- Better data management

By implementing statistical analysis tools, laboratories can gain a better understanding of their data, enabling them to make more informed decisions based on evidence. This, in turn, helps laboratories to optimize their processes and improve their overall performance.

- Compliance with regulations

Regulatory agencies, such as the FDA or EPA, often require laboratories to accurately track and archive samples. By addressing difficulties in these areas, laboratories can meet regulatory requirements and avoid penalties or fines.

# 3. Aim and Objectives

## 3.1. Aims

- By registering the patient on their first visit to the laboratory, LIMS creates a unique identifier for that patient, which is used to track all test results associated with that patient. It tracks samples from the time they are collected to the time they are analyzed.

- We are using standardized sample collection to reduce errors and simplify sample tracking. This includes consistent labeling.

- Barcoding is used to label and track samples, making it easier to identify and track them in LIMS. It can reduce errors and improve accuracy.

- In order to overcome the archiving problem, LIMS categorizes data according to different criteria, such as patient name, date of the test, test type, and test results. This helps organize the data and makes it easier to search for specific records. Also set up access control for archived data, so that authorized users can access it. This ensures that patient data is protected. Also authorized users can conduct maintenance on the archived data, including data backup.

  This makes it easier to search and retrieve previous test records from the LIMS. also reduce the time and effort required to access historical data, ensuring that patients receive the information they need in a timely manner.

- Automate many processes including sample registration, data entry, test result reporting, etc. By going automatic, the laboratory can reduce manual errors, eliminate paper-based systems, and accelerate testing.

- Dashboards are used to provide a visual representation of laboratory operation and performance. This helps to identify the areas that need more attention.

- Inventory management is used to monitor the stock levels of supplies. This can include the quantity on hand, the quantity used, and the quantity ordered. The manager can ensure that supplies are ordered before stock levels fall below 10 or 20. This can help to prevent stockouts and ensure that testing can be done uninterruptedly. By using an inventory LIMS can track supplier information including contact details,

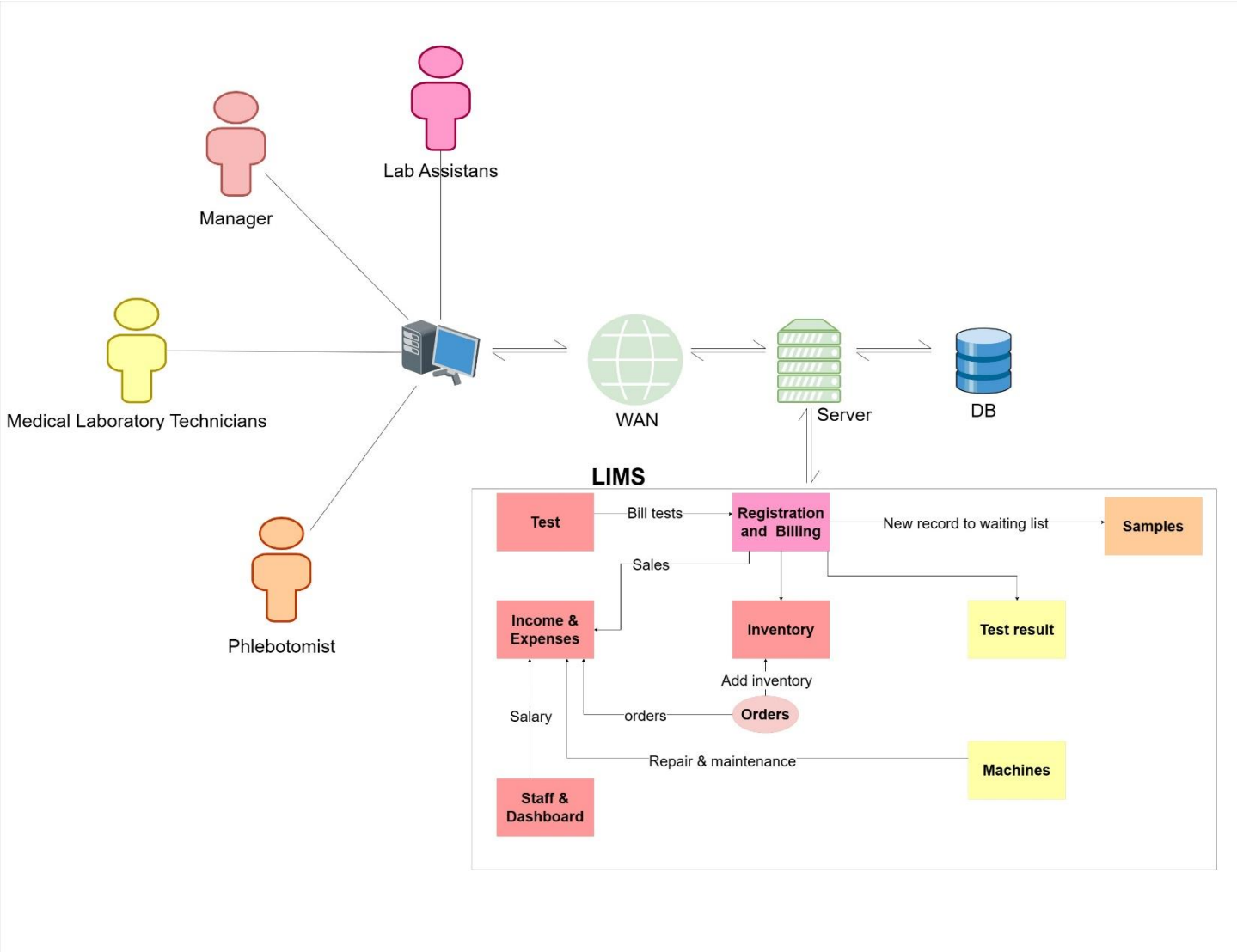
and pricing information. This can help to ensure that the laboratory is getting the best value for its purchases. Managing inventory efficiently, reducing the risk of stockouts and overstocking, while also ensuring that testing can be completed on time and at the right cost.

- Reports can provide insights and recommendations based on the data that has been collected and analyzed. These insights can help decision-makers better understand the problem and develop appropriate solutions. The recommendations can also help guide future data collection efforts to address any gaps in statistical data.

## 3.2. Objectives

Mediline's information system is manual. We are creating a solution to replace paper-based and outdated systems, as well as spreadsheets, which are usually time-consuming, incorrect, insecure, inconsistent, and lack an audit trail. The main objective is to reduce their manual work. Automate and make tasks easy by managing laboratory data, streamlining workflows, and enhancing data quality. A LIMS may help improve laboratory operations' quality and efficiency, support doctors in better decisions, and improve patient care and safety.

# 4. System Overview




- Actors and their functions are colour matched in the above diagram.

LIMS includes 7 functions:

1. Sample and Test Results
2. Registration and Billing
3. Income and Expenses
4. Dashboard, Login and Staff
5. Inventory
6. Machines
7. Test Data

## 4.1. Sample and Test results

Effective management of samples and tests is critical for accurate and timely diagnoses and can significantly improve patient outcomes. In a laboratory setting, the process typically comprises three distinct phases, each of which is crucial to ensuring high-quality results: pre-analytical, analytical, and post-analytical. [2]

During the pre-analytical phase, the focus is on proper handling and tracking of samples. When a patient is billed, their information is entered into a waiting list that keeps track of which tests need to be performed that day. A sample record is created from the waiting list, and the sample is marked as pending. When a phlebotomist (a trained professional who performs sample collection) collects the sample from the patient, they mark it as collected in the LIMS system, which records the time of collection and moves the sample to the accessed section. The phlebotomist then prints unique barcodes to label the sample for tracking throughout the lab. If the phlebotomist needs to recollect the sample, they can move it back to the pending stage by clicking on "redraw." Additionally, the phlebotomist can dismiss the sample for reasons such as hemolysis, insufficient quantity, or if the test is canceled.

In the analytical phase, the sample is investigated by the medical laboratory technician (MLT). This is the stage where the actual analysis of the sample takes place, and it is crucial that the technician follows the proper procedures to ensure accurate results.

Finally, in the post-analytical phase, the MLT enters the test results and has the option to edit them before submitting. The test record is then removed from the waiting list and moved to the archives. The patient can be notified via email that their test report is ready, and there is also the option to print or save the report as a PDF.

## Non-functional requirements:

- Performance – the system should be able to handle large number of samples, data entry and retrieval faster.
- Data integrity – the system should identify prevent entry of wrong data.
- Security – the system should have security measures to protect sensitive data.

## Technical requirements:

- Database – the system should have a one centralized database that can handle large amounts of data entry and retrieval and real time updates.
- Export files – the system should be able to export file such as test reports in a pdf format.
- The staff will require printers and barcode readers for labeling and tracking samples.
- Sending emails to patients.

## 4.2. Patient registration and billing

The patient registration and transaction management is essential for any laboratory regardless of organizational size, financial backing or any other factors. Inefficient and manual record-keeping processes can lead to errors, confusion, and delays in delivering services. The lack of a centralized system can also make it difficult to keep track of patient billing, history, and service delivery. Storing an ever expanding cluster of patient data effectively can be challenging and tedious if not done properly.

To address the above problem, we propose to facilitate the automation of day-to-day laboratory operations. Said system will enable patients to register, view their previous medical reports, calculate their bills , and view their transaction history. Additionally, the system will also provide a platform for lab personnel to approve the service requests made by the patients, add them to a pending list and mark them as "completed" when the task is performed.

First of all the lab assistant who also doubles as the receptionist, will search for the NIC of the patient when they request a service. If the patient is not registered in the system, the receptionist will proceed with the registration process. For this personal information like name, NIC, email address will be asked and entered to the system. If for some reason the patient is unable to provide NIC, then a legal identification number assigned to the patient such as passport number , driving license number etc can be used instead. If the patient is already registered with the system, then the registration process will be skipped and the lab assistant will be directed to the patient's profile page.

For the billing process, the lab assistant will inquire the patient on which services that they need from the laboratory. A list of services offered by the laboratory will be displayed and are expected to be chosen according to patient’s requirements. If the patient requests a service that is not offered by the laboratory, the receptionist will add that as an “to be outsourced” test. After this process, the patient’s requirements will be added to a bill. Once the bill is calculated, it will be sent to the patient's email and it can also be printed as a receipt. The transaction details will be also saved in a database that contains the patient’s profile information . Meanwhile, the requested services will be added to a list known as "yet to be completed test", and the lab personnel will mark them as "completed" when the service is performed successfully. Any reports generated by said tests will be stored in a database.

## Non-functional requirements

The non-functional requirements of the proposed system include scalability, reliability, and security.

- Scalability - The system should be scalable to accommodate future growth since the patient's datasets are always expanding with each and every transaction.
- Reliability - This ensures that the system is always available and accessible when needed.
- Security - the system should be secure since it contains sensitive data such as patients' personal information and transaction details.
- User friendliness - The system should also be user-friendly, with an intuitive interface that is easy to use and navigate.
- Low response time - Since the data is stored in servers, the data retrieval and upload time should be decreased.

## Technical requirements

- Database – The system should have a centralized database that can handle large amounts of data entry and retrieval and real time updates.
- Printers - The system should have printing capability since the bills and reports should be printed.
- Email API - In order to send a softcopy of the reports and bills to the patient, an automated emailing system should be implemented

## 4.3. Income and expenses

The income and expenses management are very important for any laboratory. Because most of the decisions regarding the future of the laboratory depend on the financial report. This function provides the net revenue of the laboratory and user can get the idea about whether laboratory is working well.

The income is the money laboratory takes in. laboratory get it from the patients who get the service from the laboratory. To enter income system has billing function and from the income function user can get the total income according to given date or year. In this option system validate the value and date with entered data type and Date.

The expenses are the money laboratory spends on. In this system expenses divide two parts. First one is daily expenses. It describes the day-to-day expenses laboratory has. Such as water bill, electricity bill etc. The user must manually enter these expenses for the system. For that user must select the add expenses option. Then the system displays the add expenses form. So that user must enter expenses name with amount and the date expenses done. In this option system validate date and amount with entered data type and Date.

The second one is orders. It describes the money spends by the laboratory for orders. Inventory orders is one of the examples for that. These expenses in inventory management function and user can get total expenses according to the date or year. In this option also system validate the value and date with entered data type and Date.

Generate the financial report is the one of the options of income and expense's function. For this user must choose the generate report option and the time duration. Time duration validate the system with the date and finally generate financial report with income and expenses details. Whether the user wants to get previous report, system provides search option and user can get it with entering the month or year required. System validates the date in here also. If the user wants to print the report system has print option and user can get the pdf type report.

### Non-functional requirements

- Reliability -This ensures that system and the data always available always it needed.
- Security – system should secure the sensitive data in the system.
- User-friendliness – System should always be user friendly with an interactive interface.

### Technical requirements

- Database – The system should have one centralized database to handle the large amount of data.
- Export files – The system should be able to export files when financial report need in pdf type.
- Printers – system should have the printing capabilities to print the financial reports when it requires.

## 4.4. Dashboard, Login and Staff management

### 4.4.1. Login to the system

System Login is responsible for holding the accessibility and authentication of users to the system. System login provides two particular functions as Admin Login and Staff Login. Admin Login is for the administrator of the system and the Staff Login is for the rest of the staff members in the laboratory.

System Admin can create accounts in the system for staff members and the function is responsible for adding the account details to the database. Only Admin has the facility to delete profiles. Staff members and Admin may login to the system and update profiles and the function has the capability to retrieve , delete and update data in the database when such actions are performed. Furthermore sub-functions such as password management, setting user privileges , ability to searching for specific system logs and generating reports on system usage are included in the function

### 4.4.2. Dashboard

A dashboard is provided with summarized information that is important to the users. A quick way to access an overview of the laboratory matrices in the system. This shows some significant
data on the system such as orders by month , number of tests received on the day , number of tests ran on the day etc. . Dashboard is updated in real time so every time the tab is clicked the data will be refreshed.

### 4.4.3. Staff management

This function is responsible for recording attendance as the user logins to the system. This task will be performed once per day for a single user. At the end of the month the system will calculate the total presented days on the month and it will calculate the salary of the user. Function can generate reports on performance of the staff members considering the attendance

### Non-Functional Requirements

- Usability – Login function will be simple so its easy for user to use
- Performance – System will have quick response time so user can login to the system without a delay.
- Security – password secure policies and procedures will be used to prevent unauthorized access.
- Scalability – As the growth of user base the system will be able to keep up with better performance and secure policies.

## Technical Requirements

- Database -the system should be able to handle many records and retrieve them faster.
- CAPCHA and two-factor authentication will be used prevent unauthorized access.
- The attendance will be automatically recorded as the user logins

## 4.5. Inventory Management

Inventory management System is used for keeping track of chemical and test-kit in the lab, remove test-kits and track how much has been used. Inventory Management system is very important to the efficiency of laboratory operation. Also, a report is created about all the inventory management process that takes place in the laboratory over a month.

Here, the quantity of Test-kit and chemical is calculated live and when their quantity is minimum, the manager is notified through notifications. Then the manager is checked if he has current stock. If there is stock, it will be added to the system and if there is no current stock, the manager will order stock in the required quantity.

When a patient registers for a test and selects the test from the drop-down menu, the number of test kits related to that test is displayed, and after the patient registers for the required test, it is subtracted from the inventory of test kits and chemicals related to the test. Always keeping inventory in the lab without inconveniencing the patients. The report created monthly is very helpful to avoid the problems caused by the test-kit, because it is created monthly, so we can understand how much inventory we need in the future

### Non-functional requirement

- Accessibility - Only manager can do inventory management.
- Usability – User-friendly, easy to navigate, easy to use and perform tasks efficiently.
- Reliability – No crashes or data loss.
- Integrity – The system does not allow outdated inventory to be entered into the system.

### Technical Requirements

- Database – The system should be able to handles and retrieve them efficiently, adding and subtracting inventory according to the test that happens every time.
- Staff need printers to print reports.

## 4.6. Machine Information Management

Machine information management system is designed to collect, store, manage, and analyse machines. Machine information management can help improve laboratory operations' efficiency and accuracy.

This is a system for managing machine information that gathers and stores machine-specific information. The information about the machine includes its model, manufacturer, brand, serial number, date of purchase, and place of manufacture. The database is updated whenever a new device is bought by adding new machine records.

All of the machines that belong to that specific machine type that are available are shown once a staff member searches for a machine type. Assume, for instance, that there are three microscopes in the lab and a staff member is trying to find the oldest one, but all three are on exhibit. The user can then choose a certain microscope and get all of its specifications.

This is used to track and monitor machine quality control parameters to ensure that machines are functioning properly and generating accurate results. The medical laboratory technician (MLT) is the one who is responsible for quality control. The owner provides a test sample and a report for that sample, and MLT uses its available machines to test that sample. Once both report data sets have been added to the system. The system evaluates the similarities and displays an equality percentage. MLT certifies that the machine may be utilized based on the computed percentage. The server is updated with the date that quality control is completed and the sample report data is added to the system. The sample report data can be used to check repeatedly if MLT is unhappy with the outcome or wants more test result percentages to verify the machine's quality. MLT must perform quality control once more after a particular time. Then MLT should replace the previously added details with details from a sample test report.

With the scheduling of preventative maintenance and the identification of problems, before they result in downtime or other issues, this machine information management assists in managing the maintenance and servicing of machines. MLT updates the record on that system with all of those details as well. The database also keeps track of when maintenance and quality control were performed. The system creates a report with the technician's name, maintenance information, payments, and the scheduled date for subsequent maintenance. A column in the database keeps track of the upcoming maintenance and quality control days. Hence, staff members should update the database to add new details as soon as machine details are added.

Employees can look up information about machines, including all problems, fixes, replacement parts, and maintenance histories.

The record should be deleted of the machine's details once it is malfunctioning.

## Non-functional requirements

- Accessibility – The machine information management is accessible to medical laboratory technicians and the owner of the laboratory.
- Usability – easy to use, user-friendly, easy to navigate, perform tasks efficiently.
- Reliability - downtime, crashes, or data loss are very low
- User-friendliness - interface is attractive, simple and easy to use.
- Integrity – system identifies and prevents the entry of wrong data.

## Technical Requirements

- Database -the system should be able to handle many records and retrieve them faster.
- Export report - possible to export the reports that the system generates.
- Printers – printers are used to print reports.

## 4.7. Test Data Management

There are different kinds of tests being performed on a daily basis in a medical lab. These tests can be divided into two main categories as inhouse tests and outsourced tests. Inhouse tests are tests where the samples are both collected and tested in the lab while outsourced tests are the tests where the samples are collected and transferred to another lab to perform the test. The information recorded on these tests effects the rest of the workflow. Hence it is important that the information about the tests being conducted by the laboratory is managed properly.

This function aims to make the process of creating, retrieving, updating and deleting different kinds of tests being performed by the lab more efficient and usable. The primary user intended for this is the manager of the laboratory.

The user will be shown a list of all currently available tests when the user first enters the function. In addition to the test name important information such as the test ID, short name for the test and the price will be shown for each test. Also, a special tag will be displayed for the outsourced tests. In addition, a search bar will be available to retrieve a specific test that the user wants.

An option will be given to add new tests using which a user can create a test by providing necessary information such as test ID, test name, short name, price, remarks to be printed in the report related to a new test. Users can also add test subcategories that will be checked in a particular test. A single test can have many subcategories and these subcategories have their own attributes such as unit of measurement (UOM), references range and category heading.

Once a test is selected from currently available tests, if the subcategories of a particular test or the test itself has to be updated an option will be provided to accomplish that using this function. The relevant values will be filled upon viewing and user can update the information required and save the changes.

If any of the tests being conducted by the laboratory is discontinued, an option will be provided to delete that test after selecting it from the list of tests.

Additionally, reports can be generated on a specific test that contains all information about the test including the sub categories of that test. Also, the user will be given an option to generate a report on all available tests which will contain only the necessary information such as test ID, test name, short name and price. An option will be given to manage the courier details of outsourced samples of a particular day.

## Non-functional requirements:

- Time to complete user requirement – since the user is entering and managing a lot of data, the time to complete the task should be made low as possible.
- Usability – since this is the first time a computerized system is used for the client; it should be simple and user friendly as possible.
- Access control and Security – since the information on test data can affect the rest of the business flow, who can manage this information should be selected carefully and made sure cannot be accessed by any other.

## Technical requirements:

- Database – data entered using this function will be used by other functions thus making a centralized database such as mongo DB a necessity.
- Front-end – a web browser that can run JavaScript is needed since the web app is developed using MERN stack.
- Export reports – the ability to export the reports generated by the system should be present.

# 5. Literature Review

| Title | Advantages | Disadvantages | Author | Year |
|---|---|---|---|---|
| The Ideal Laboratory Information System [3] | - Suggests the use of data mining to improve the quality of the services provided.<br>- Suggests different levels of result certification in the system before the results are released. | - No machine management function is available.<br>- An expert system might become too complex. | 1. Jorge L. Sepulveda<br>2. Donald S. Young | 2013 |
| Laboratory Information Management Systems [4] | - Suggests a pre-login sample type for samples expected to be received for testing. | - To implement the suggestion all samples dealt with for the day should be known prior.<br>- The client does not deal with samples from outside the lab. | 1.Christine Paszko<br>2. Elizabeth Turner | 2018 |
| Laboratory Information Management Systems (lims) [5] | - Suggests a function to record the possession of samples from the point of collection until it is received at the lab.<br>- Suggests data archiving and warehousing to keep a record history of 5 or more years. | -A function to record possession of samples from the time of collection might result in too much time spent to enter data and might be unnecessary. | 1. Kyle Boyar<br>2. Andrew Pham<br>3. Shannon Swantek<br>4. Gary Ward<br>5. Gary Herman | 1970 |
| Matrix Gemini LIMS [6] | - The system has lot of functionalities that cover the requirements of a laboratory information system.<br>- Provides documentation for staff training. | - The system is complex because it has lot of functionalities.<br>- Does not have a function to manage machines. | - | 2021 |
| Thermo Fisher LIMS [7] | - Provides workflow capabilities that can map to the laboratory process.<br>- Provides the option to deploy the system on the cloud. | - The business cost can be high when using this system.<br>- Not specifically designed for clinical laboratories. | - | 2021 |

## 5.1. Summary

Although the literature about Laboratory Information Management Systems (LIMS) provides some very insightful functions and existing systems already implement innovative functions there are reasons why these systems cannot be implemented as it is without implementing a new system. The reasons are highlighted below,

1. The Ideal Laboratory Information System:
    - Since a computerized system is implemented for the first time for the client the system cannot be complex thus making an expert system not the best choice.
2. Laboratory Information Management Systems:
    - In addition to not knowing the samples handled in a particular day prior to that day, the client also does not interact with samples originated outside the lab.
3. Laboratory Information Management Systems (lims):
    - Since the client is a small lab operating on 5-6 employees a function to record the possession of samples from the point of collection until is received at the lab will be too time consuming for an added layer of security. The fact that the lab collects their own blood samples and do not interact with outside samples solidifies the inefficiency of the function.
4. Matrix Gemini LIMS:
    - As mentioned above since the client is a company that is computerizing their system for the very first-time usability is of the utmost importance.
    - The system does not have a function to manage machine records which was specifically requested by the customer.
5. Thermo Fisher LIMS:
    - The LIMS is not specifically created for the client and in addition to that, the system is not created only for clinical laboratories, thus making the system provided a very general LIMS.

Due to the above reasons the existing systems cannot be implemented directly since that will not meet user's requirements completely. Hence a new system should be developed that covers user requirements while maintaining the usability of the system as much as possible to ensure the client can adapt quickly.

# 6. Methodology

Our team plans on using a variety of methods, tools, and technologies to develop an efficient laboratory information management system web application. For this agile system development method will be used, which is well-suited for software development projects with rapidly changing requirements.

## 6.1. Requirements Engineering Methods:

To collect and analyze requirements, we are planning on interviews, surveys, and focus groups. And also, through observations and document analysis we can get a better understanding of how the regular business routine is being done currently. We will also use use-case modeling to document the functional requirements of the system. Diagrams.net provides access to all the necessary tools to design the use-case model efficiently. For that reason, Diagrams.net is chosen among alternatives such as Gleek.io and lucidchart. In addition, we will converse with individual stakeholders to ensure that their requirements are addressed and make any necessary changes in a timely manner.

## 6.2. Design Methods:

For designing the system, we will use Figma, a collaborative design tool that allows our team to create interactive and responsive user interfaces. We will create design prototypes and share them with the client to get their feedback. As alternative options, Adobe XD or Axure RP can be used instead. However, since Figma has a very user friendly nature, all the while providing essential tools for UI designing, we decided to select Figma as the number one option.

Also, for designing essential documents such as project proposals, charters Microsoft Office software package will be used. LibreOffice packages can be used alternatively. However, since Microsoft Office packages offer excellent design tools and all the members are well experienced with the said software package, it was chosen over the LibreOffice.

## 6.3. Development Tools and Technologies:

To develop the system, we will use MERN stack, a popular open-source technology stack that includes MongoDB, Express, React, and Node.js. MongoDB will be used for database management, Express for back-end development, React for front-end development, and Node.js for server-side development. The MERN stack is supported by a huge community. And our development team is well versed with MERN stack. So, it was chosen over other

alternatives such as MEAN and MEVN. Also Github will be used for version control and collaboration since it centralizes the software system in a single development environment that can be accessed by all the members. And Github is backed by its popularity and functionality. Alternatively, local Git or BitBucket can be used.

## 6.4. Testing Methods:

We will use both manual and automated testing methods to ensure that the system is functioning as expected. We will conduct unit tests, integration tests, and system tests to identify and fix any bugs in the system. For this purpose we are planning to use JUnit since it is open source. TestingWhiz or TestComplete tools can be used as alternatives.

## 6.5. Integration Methods:

To ensure that the different parts of the system work together seamlessly, we will conduct integration testing. We will also use continuous integration and continuous deployment (CI/CD) tools to streamline the integration process and quickly deploy new changes.

## 6.6. Project Plan:

To manage the project, we will use ClickUp, a project management tool. ClickUp offers a variety of tools fro project management. And also it has an user friendly interface. Therefore, ClickUp is selected as the project management tool for our LIMS application. As alternatives, Basecamp or trello can be used if any unforeseen circumstances were to occur with ClickUp. Furthermore, we will create a Gantt chart to track our progress and to ensure that the project is completed on time. We will also create a work breakdown structure (WBS) in a tabular format to break down the project into smaller, manageable tasks.

In conclusion, we believe that our methodology is well-suited for developing an efficient laboratory information management system web application that meets the client's requirements. We will use a combination of methods, tools, and technologies to ensure that the project is completed successfully and on time.

# 7. Gantt Chart

PROJECT **Laboratory Information Management System for Medi Line**

| Gantt Chart | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Week | | | 01 | | | | | | | 02 | | | | | | | 03 | | | | | | | 04 | | | | | | |
| | | | M | T | W | T | F | S | S | M | T | W | T | F | S | S | M | T | W | T | F | S | S | M | T | W | T | F | S | S |
| Requirement analysis | 06/2 | 10/2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Planning | 13/2 | 24/2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Page UI design | 20/2 | 03/3 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Database Design | 27/2 | 17/3 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Coding the structure | 06/3 | 24/3 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Development | 06/3 | 07/4 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Testing | 10/4 | 21/4 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Launching the webapp | 24/4 | 28/4 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

| Gantt Chart | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
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| Week | | | 05 | | | | | | | 06 | | | | | | | 07 | | | | | | | 08 | | | | | | |
| | | | M | T | W | T | F | S | S | M | T | W | T | F | S | S | M | T | W | T | F | S | S | M | T | W | T | F | S | S |
| Requirement analysis | 06/2 | 10/2 | | | | | | | | | | | | | | | | | | | | | | MID EXAM | | | | | | |
| Planning | 13/2 | 24/2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Page UI design | 20/2 | 03/3 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Database Design | 27/2 | 17/3 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Coding the structure | 06/3 | 24/3 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Development | 06/3 | 07/4 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Testing | 10/4 | 21/4 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Launching the webapp | 24/4 | 28/4 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

| Gantt Chart | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
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| Week | | | 09 | | | | | | | 10 | | | | | | | 11 | | | | | | | 12 | | | | | | |
| | | | M | T | W | T | F | S | S | M | T | W | T | F | S | S | M | T | W | T | F | S | S | M | T | W | T | F | S | S |
| Requirement analysis | 06/2 | 10/2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Planning | 13/2 | 24/2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Page UI design | 20/2 | 03/3 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Database Design | 27/2 | 17/3 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Coding the structure | 06/3 | 24/3 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Development | 06/3 | 07/4 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Testing | 10/4 | 21/4 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Launching the webapp | 24/4 | 28/4 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

# 8. **Work breakdown structure**

| Name | Function | Description |
|---|---|---|
| Gunawardana.U.G.C.D | Sample and test results | • UI designing<br>• Create new samples<br>• View samples<br>• Delete samples<br>• Print barcode labels<br>• Add results<br>• Edit results<br>• View results<br>• Print test reports<br>• Send emails |
| Gunathilaka.L. P. N | Patient registration and Billing | • UI designing<br>• Create profiles/Register patients<br>• Edit profiles<br>• View patients' profiles<br>• Delete profiles<br>• Search profiles<br>• Create bills<br>• Edit bills<br>• View transaction history and bills<br>• Delete bills<br>• Search bills<br>• Print bills<br>• Send emails<br>• Add requested services to relevant queues |
| Surendra.D.M.B.G.D. | Income and Expenses | • UI designing<br>• Add expenses.<br>• Add income.<br>• Edit expenses.<br>• Delete expenses.<br>• Calculate net revenue.<br>• Generate financial report.<br>• Search previous financial reports.<br>• Print financial report. |

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| Wijerathne.B.N.B | Profile management, Dashboard, Staff management | • UI designing<br>• Create profiles<br>• Edit profiles<br>• Delete profiles<br>• Send verification email<br>• View laboratory matrices<br>• Calculate matrices<br>• Generate reports on specific matrices<br>• Record attendance<br>• Calculate attendance at month end<br>• Calculate salary<br>• Generate reports on staff performences |
| Gunasekara.G.G.K.T.A.V | Inventory | • UI designing<br>• Add new inventory to system<br>• View inventory levels<br>• Edit inventory<br>• Delete inventory<br>• Add new orders<br>• View, edit and delete.<br>• Search for specific inventory<br>• Generate reports<br>• Low inventory notification |
| Perera.M.A.S.S | | • UI Design<br>• Add machine records.<br>• Search machine details.<br>• Retrieve machine history.<br>• Update maintenance dates.<br>• Add sample test report details and generated report details.<br>• Quality Control |

| | | |
|---|---|---|
| | | • Delete machine details.<br>• Generate a report of machine quality and machine maintenance report |
| Senadheera.S.A.A.D | Test Data | • UI Design<br>• Add new tests<br>• Add subcategories for a test<br>• Update tests<br>• Update required test sub categories<br>• Delete discontinued tests<br>• Search for specific tests using search bar<br>• Generate reports on specific tests<br>• Generate reports on available tests<br>• Manage courier details. |

# 9. Evaluation Method

Our LIMS could be evaluated by focusing on the following areas:

## 9.1. Functionality:

The system could be evaluated by testing the features of the system.

## 9.2. User Interface:

A LIMS with a good user interface can improve user adoption and satisfaction, leading to increased productivity and accuracy. This can be done by gathering feedback from the users.

## 9.3. Performance:

A LIMS needs to be able to handle large amounts of data and requests in a timely manner. This can be evaluated by testing the speed and responsiveness, and identifying areas where it could be optimized.

## 9.4. Security:

A LIMS must maintain the confidentiality, integrity, and availability of sensitive data. This can be done by using security testing such as penetration testing.

## 9.5. Scalability:

As the amount of data and users grow, the system needs to be able to scale up to handle the increased demand. This can be evaluated by entering large data sets into the system.

# 10. References


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