

Product Lifecycle Management System for Telecommunication Industry

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Product Lifecycle Management System for Telecommunication Industry

**A dissertation submitted for the Degree of Master
of Information Technology**

**D. A. M. Abeysekara
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Declaration

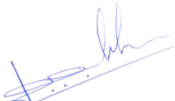
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This is to certify that this thesis is based on the work of Mr. D.A.M Abeysekara under my supervision. The thesis has been prepared according to the format stipulated and is of an acceptable standard.

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Abstract

This thesis is aimed to present the project work carried out to explore the possibility of developing a product lifecycle management system that will help product managers in the lifecycle management of the product. This software development was focused on the telecommunication industry. But the knowledge gained through the development can be applied to any service sector industry. There are softwares called “product lifecycle management systems” in the market but mainly focused on the product development process of the manufacturing industry. Many tools available for service sector industries are analytical tools that can analyse the market behaviour mathematically. But such tools do not have inbuilt knowledge to analyse the market dynamics based on marketing, product, and business perspective. Therefore, product managers have to use analytical tools to analyse the market dynamics in the mathematical domain and map them to the marketing domain to interpret the results. This mapping is depending on the skills of the product manager. The key objective of this project is to demonstrate the advantage of building this domain mapping capability into the software tool to ease the work of the product managers. The solution was designed using software design tools after carefully analysing the user requirement. The web-based solution was developed according to the design using the “CodeIgniter” framework with MySQL database. Developed software includes dashboard, data input portals, decision support system, and report generating capability. The system was tested during the development period using the “IntelliJ IDEA” testing environment and evaluated by the users. The challenging part of the project was the development of the algorithm for the decision support system which requires significant knowledge on product management and sufficient datasets to evaluate and validate the same. The accuracy of the outcome of the system depends on this algorithm. In this project, the basic level algorithm was developed to demonstrate the function, but there’s more space to improve further with the assistance of domain experts. Further, the scope of the project was narrowed down by excluding the system integration part from the project. This area also can be considered for further improvement. Finally, the knowledge gained through this project can be used to develop a more sophisticated product lifecycle management system for any service industry.

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List of abbreviations

ACPM	Average customer base growth per month
ADPM	Average disconnection per month
ARPU	Average revenue per user
ASPM	Average sales per month
BOM	Bill of Material
BSS	Business Support System
CA	Actual customer base
CAR	Customer base achievement rate
CMSR	Churn mitigation success rate
CRM	Customer Relationship Management
CT	Target customer base
DA	Actual disconnections
DCM	Data Capturing Module
DSS	Decision Support System
DT	Forecasted disconnections
DVM	Data Visualization Module
EYOYC	Estimated year on year customer base growth
EYOYR	Estimated year on year revenue growth
EYOYS	Estimated year on year sales growth
ISV	Independent Software Vendor
KPI	Key Performance Indicators
LS	Life span
MS	Market share of the product
OSS	Operation Support System
PLM	Product life cycle management
RA	Actual Revenue
RAR	Revenue achievement rate
RM	Reporting Module
RS	Revenue share of the product

RT	Target revenue
SA	Actual sales
SPL	Stage of product lifecycle
SSR	Sales success rate
ST	Target sales
UIB	User Interface Blocks
Y2DC	Year to date customer base
Y2DD	Year to date disconnection
Y2DR	Year to date Revenue
Y2DS	Year to date sales
YOYC	Year on year customer base growth
YOYD	Year on year churn mitigation
YOYR	Year on year revenue growth
YOYS	Year on year sales progress

1 Introduction

Product lifecycle is the whole process of product design and development, introduction to the market, driving the market, and withdrawing from the market. This is divided into two main parts; product development and product lifecycle management. Usually, product in lifecycle management is known as product lifecycle management, which excludes the product design and development stages. In short, it's the period of the product from its' introduction to the market till its' withdrawal from the market. Introduction to market and withdrawal of the market are two instances or benchmarks of the product lifecycle. Therefore, driving the market is the key process that needs to be engaged during the product lifecycle. During this process, the product passes deferent stages of the product lifecycle: product introduction, growth, maturity, and declining. Product performance of the different stages is different and needs to be evaluated based on different Key Performance Indicators (KPI).

1.1 Motivation

During the product lifecycle, product managers need to manage 4Ps; product, price, place, and promotions to drive the market. Therefore, they need to decide product strategies, pricing strategies, promotion strategies based on market dynamics; market demand, competitor movements, economic situation, etc...Many KPIs and factors need to be considered by the product managers in their decision-making. These factors include product attractiveness, market competitiveness, possible product cannibalization, product profitability, revenue achievement, sales achievement, and customer base achievement but are not limited to them. Therefore, the decision-making of the product managers is more complex due to the multiple aspects that need to be considered in decision-making.

1.2 Statement of the problem

To understand the market dynamics and the performance of the product, certain information has to be readily available with product managers. In the current scenario, past and current raw data are available on standard systems like Customer Relationship Management (CRM), Enterprise Resource Planning (ERP) systems, Billing Support System (BSS), etc... and need to generate reports for analysis using generic analytical tools. Outcomes of those analyses are

interpreted by the product managers based on their knowledge and experience. Therefore, most of the time decisions of two product managers on the same result can be deferent and inconsistent. Therefore, there is a requirement for the system, which can analyse and interpret the product performance to take more accurate and consistent decisions.

According to the literature survey done on Product Lifecycle Management Systems (PLMS), many PLMS are available in the market which offers many features such as project management, cost management, knowledge management, procurement management, quality management, Bill of Material (BOM) management, change management, reporting and analysis, supply chain management and many more features. These applications are available as open-source as well as proprietary applications. Some solutions are available from leading tech solution providers like SIEMENS and Autodesk. However, all these offers are focused on product development and production process which is the initial part of the product life cycle. All these leading applications are to manage the production lifecycle which is the cycle from raw material to finished good. None of the applications has a component to manage the product lifecycle which has a fairly long period than a production lifecycle. Therefore, there is a vacuum for the application which is capable to capture the product performance over a while and analyse the performance under different market conditions based on the stage of the product lifecycle to interpret the product status and suggest the move forward to the product managers.

1.3 Aims, and Objectives

The objective of this project was to develop a software application to use in the telecommunication industry which can analyse the market dynamics of the product and interpret them in the marketing domain to enable the product managers on making accurate and consistent decisions. It will ease the decision-making process of product managers to make the decisions on product enhancement, price revision, product marketing promotions, product offers and product sales promotions, etc....

1.4 Scope

The scope of the project is to develop a product lifecycle management system. It was narrowed down by limiting the implementation to the telecommunication industry. It excludes monitoring and managing of the product development process the system integrations. The scope of the project includes requirement analysis, design, and development of the system.

PLM system was developed with four main components: Data Capturing Module (DCM), Data Visualization Module (DVM), Decision Support Module (DSM), and Reporting Module (RM). DCM is capable to capture Product details such as product name, market strategy, initiation fee, monthly rental, etc... and market performance data of the product such as sales, revenue, customer churn, etc...DVM is a dashboard that gives a snapshot of the product performance through graphical representation of the product performance. Messages coming from DSM also pop up through the dashboard to make quick decisions on the product. DSM is the algorithm that analyzes the available data and interprets the outcome in the marketing domain. The development of necessary algorithms for these product lifecycle management decisions is also a part of this project.

A combination of the waterfall software development methodology and the agile software development methodology was used in this software development. As the development is a new concept, requirement gathering, and design were done before starting the development. During the development process, it was handled according to the agile software development process. In this project use case analysis, use case diagrams, and use case narratives were used to analyse the user requirement for the development. Check the product attractiveness, product competitiveness, product profitability, announcing product promotions, checking the effectiveness of the campaign, deciding on the promotional budget, introducing new price plans, introducing new product features, and generating sales and revenue reports were considered as key use cases for the development. All use cases were divided into two main categories: data analysis and decision making. These two areas were addressed in developing DSM in the PLMS. The reporting module provides the capability to export the analysis report and data in a suitable format for users to use in different requirements. As a whole, the PLM system will help the product managers in decision making on marketing mix; product, price, place, and promotion by analysing the data and outputting them through data visualization. Logics and algorithms will be developed in Decision Support System (DSS) to help the

decision-making of the product manager according to the stage of the product lifecycle and the performance of the product. It will help the product manager by providing hints on decision-making. As the application is designed to use a central database by multiple users, the system was developed as a client-server web-based system that can be accessed from anywhere through the web browser. It was developed based on the "CodeIgniter" MVC framework. PHP and "JS" were used for development and My SQL database was used as a database. Libraries like "Google chart library" and "JSPDF library" were also used during the development. There was testing and validation after the development of each module. Selenium Webdriver was used to test the user interfaces (UI) and the "TestNG" unit testing framework was used during the testing.

1.5 Structure of the thesis

In chapter 2, the outcome of the literature survey carried to find and review the similar systems, and details of the problem analysis were presented. In the literature survey, the eight most popular PLMS were reviewed based on their features. It includes the leading PLMS system like Autodesk Fusion PLMS and SIEMENS Teamcenter PLMS also. Use cases, use case diagrams, and use case narratives were used as problem analysis tools and details are presented in the same chapter. In chapter 3, present the detail of the design including user interface design, the formulation of the logic for the DSM, and database design. "FluidUI" online UI design tool was used to design UI for the PLMS. Database design was done using EER diagrams also included in Chapter 3. Chapter 4 present the details of the implementation. Chapter 5 presents the details of the testing and evaluation that were done using the testing tools and user feedback. Details of the test cases for deferent user interfaces build using "selenium web driver" and "testNG" as unit test framework and results of the testing are presented in this chapter. The conclusion of the project including achievement, gaps, and the areas that need to the improved in the future is presented in Chapter 6.

2 Background

2.1 Introduction

In this chapter, requirement analysis and results of the literature survey were presented. Use cases, use case diagrams, and use case narratives were used as tools to understand the requirement. Finally, functional, and non-functional requirements were tabulated for the development. In the project literature survey, eight similar systems were studied and found similar features which are more useful in product development and production lifecycle management. However, none of the systems focused on product in lifecycle management and do not have product performance interpretation tools.

2.2 Requirement Analysis

2.2.1 Use cases

Following use cases were identified for the development of the product lifecycle management system. In this analysis, a use case relevant to the product in-lifecycle was considered. None of the use cases relevant to the product development stage was included.

1. Introduce new product
2. Introduce product offers
3. Introduce new features
4. Set the annual targets for the product
5. Monitor product performance
6. Check the product attractiveness
7. Check the product competitiveness
8. Check the product profitability
9. Announce sales campaign
10. Announce product promotional campaign
11. Check the campaign effectiveness
12. Announce product withdrawal
13. Generate reports
14. Add new users to the platform

2.2.2 Use case diagram

Use-case diagram for product lifecycle management system is illustrated in **Figure 2-1 - Use case diagram (PLMS)**

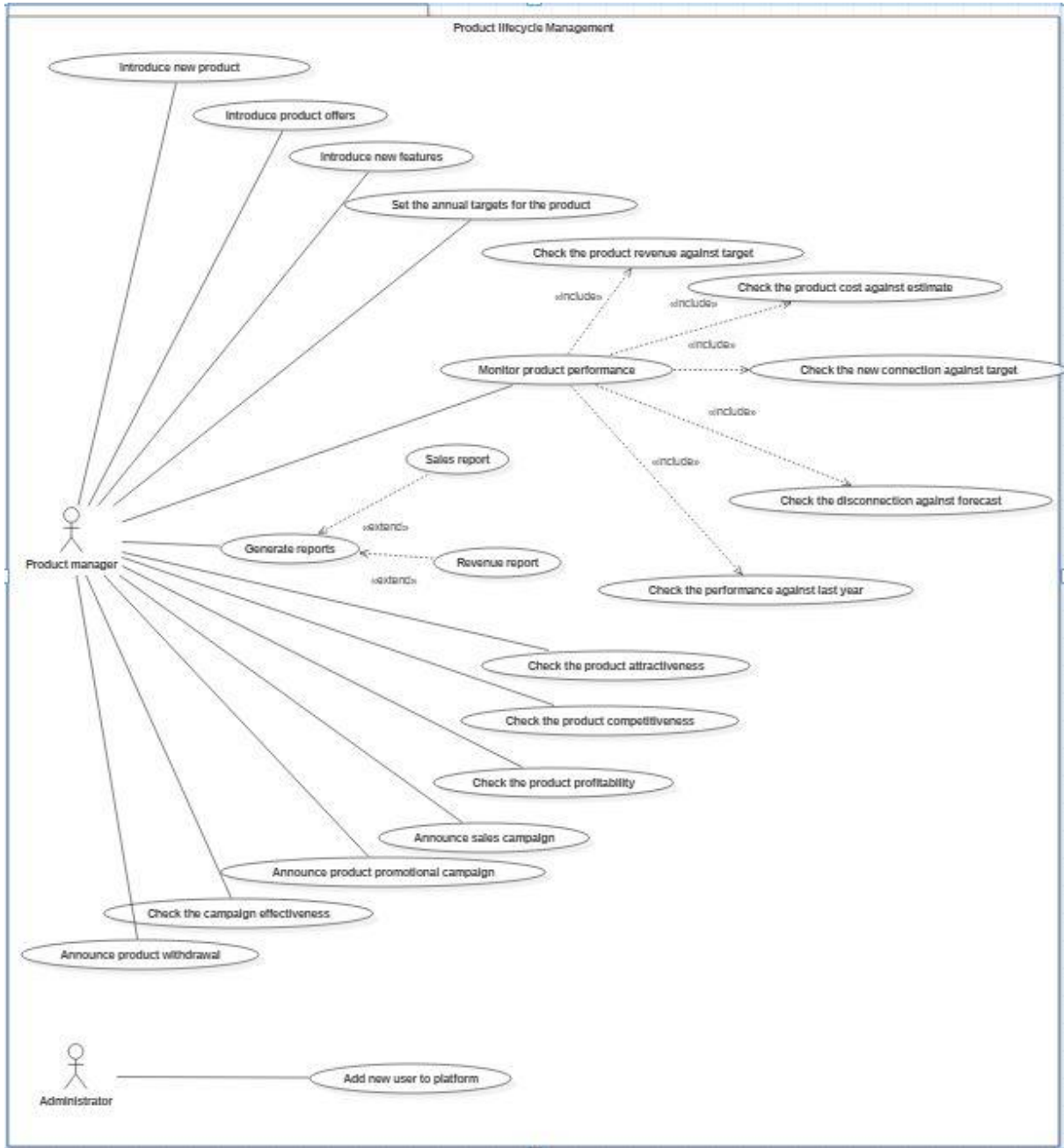


Figure 2-1 - Use case diagram (PLMS)

2.2.3 Use-case narrative

To understand the use case behaviors and the interactions, use-case narratives were developed and presented in this section. Use-case narratives were developed for 14 use-cases and presented in a tabular format from table 2-1~14.

Use-Case Name:	Introduce new product	Use-case type – The business requirement
Use-Case ID:	PLM-001	
Priority:	Medium	
Source:	When the product is in a declining stage	
Primary business Actor:	Product Manager	
Other Participating Actor:	null	
Other Interested Stakeholders:	Customer	
Description	This use case describes the requirement of introducing a new product	

Table 2-1- Use-case narrative - Introduce a new product

Use-Case Name:	Introduce product offers	Use-case type – The business requirement
Use-Case ID:	PLM-002	
Priority:	High	
Source:	When product performance is below the target	
Primary business Actor:	Product Manager	
Other Participating Actor:	null	
Other Interested Stakeholders:	Sales team/ Customer	
Description	This use case describes the additional service/goods provided along with the standard product	

Table 2-2 - Use-case narrative - Introduce product offers

Use-Case Name:	Introduce new features	Use-case type – The business requirement
Use-Case ID:	PLM-003	
Priority:	Medium	
Source:	When the product is in a declining stage	
Primary business Actor:	Product Manager	
Other Participating Actor:	null	
Other Interested Stakeholders:	Customer	
Description	This use case describes the requirement of introducing new features to the existing product	

Table 2-3 - Use-case narrative - Introduce new features

Use-Case Name:	Set the annual targets for the product	Use-case type – The business requirement
Use-Case ID:	PLM-004	
Priority:	High	
Source:	Before ABP year commence	
Primary business Actor:	Product Manager	
Other Participating Actor:	null	
Other Interested Stakeholders:	Board of directors, Top management	
Description	This use case describes the requirement of setting targets for each product every year	

Table 2-4 - Use-case narrative - Set the annual targets for the product

Use-Case Name:	Monitor product performance	Use-case type – The business requirement
Use-Case ID:	PLM-005	
Priority:	High	
Source:	Monthly product progress review	
Primary business Actor:	Product Manager	
Other Participating Actor:	null	
Other Interested Stakeholders:	Sales team	
Description	This use case describes the requirement of monitoring the product performance	

Table 2-5 - Use-case narrative - Monitor product performance

Use-Case Name:	Check the product attractiveness	Use-case type – The business requirement
Use-Case ID:	PLM-006	
Priority:	high	
Source:	When the periodic check is required	
Primary business Actor:	Product Manager	
Other Participating Actor:	Nil	
Other Interested Stakeholders:	Competitors	
Description	This use case describes the requirement of checking the product attractiveness. The success of sales achievements against the target is the reflection of the product attractiveness of the product.	

Table 2-6- Use-case narrative - Check the product attractiveness

Use-Case Name:	Check the product competitiveness	Use-case type – The business requirement
Use-Case ID:	PLM-007	
Priority:	High	
Source:	When the periodic check is required	
Primary business Actor:	Product Manager	
Other Participating Actor:	null	
Other Interested Stakeholders:	Competitors	
Description	This use case describes the requirement of checking product competitiveness. Disconnection rate is the reflection of the measurement.	

Table 2-7 - Use-case narrative - Check the product competitiveness

Use-Case Name:	Check the product profitability	Use-case type – The business requirement
Use-Case ID:	PLM-008	
Priority:	high	
Source:	When the periodic check is required	
Primary business Actor:	Product Manager	
Other Participating Actor:	Nil	
Other Interested Stakeholders:	Higher management	
Description	This use case describes the requirement of checking product profitability. IRR and NPV are the measurements of profitability.	

Table 2-8 - Use-case narrative - Check the product profitability

Use-Case Name:	Announce sales campaign	Use-case type – The business requirement
Use-Case ID:	PLM-009	
Priority:	High	
Source:	When sales targets are not achieved	
Primary business Actor:	Product Manager	
Other Participating Actor:	null	
Other Interested Stakeholders:	Sales team	
Description	This use case describes the requirement of announcing a sales campaign	

Table 2-9 - Use-case narrative - Announce sales campaign

Use-Case Name:	Announce product promotional campaign	Use-case type – The business requirement
Use-Case ID:	PLM-010	
Priority:	High	
Source:	When the product attractiveness is low and sales targets are not achieved	
Primary business Actor:	Product Manager	
Other Participating Actor:	null	
Other Interested Stakeholders:	Customer, sales team	
Description	This use case describes the requirement of announcing a product promotion campaign	

Table 2-10 - Use-case narrative - Announce product promotional campaign

Use-Case Name:	Check the effectiveness of the campaign	Use-case type – The business requirement
Use-Case ID:	PLM-011	
Priority:	Medium	
Source:	When the campaign is over	
Primary business Actor:	Product Manager	
Other Participating Actor:	Nil	
Other Interested Stakeholders:	Sales team	
Description	This use case describes the requirement to Check the effectiveness of the campaign. In this use case revenue of the surplus sales during the campaign is evaluated against the cost incurred with the sales campaign.	

Table 2-11 - Use-case narrative - Check the effectiveness of the campaign

Use-Case Name:	Announce product withdrawal	Use-case type – The business requirement
Use-Case ID:	PLM-012	
Priority:	High	
Source:	When the product starts loss-making at the end of the declining stage	
Primary business Actor:	Product Manager	
Other Participating Actor:	null	
Other Interested Stakeholders:	Top management, customer	
Description	This use case describes the requirement of withdrawing the product from the market	

Table 2-12 - Use-case narrative - Announce product withdrawal

Use-Case Name:	Generate reports	Use-case type – The business requirement
Use-Case ID:	PLM-013	
Priority:	high	
Source:	Every month	
Primary business Actor:	Product Manager	
Other Participating Actor:	Nil	
Other Interested Stakeholders:	Sales team	
Description	This use case describes the requirement of generating reports monthly and annually	

Table 2-13 - Use-case narrative - Generate reports

Use-Case Name:	Add new users to the platform	Use-case type – The business requirement
Use-Case ID:	PLM-014	
Priority:	high	
Source:	When a request is raised	
Primary business Actor:	Administrator	
Other Participating Actor:	Nil	
Other Interested Stakeholders:	Sales team	
Description	This use case describes the requirement of adding new users to the platform on their request	

Table 2-14 - Use-case narrative - Add new user to the platform

2.2.4 Functional requirement of the system

Functional requirements for PLMS were identified and tabulated in Table 2-15 - Functional requirement of the system

Requirement	Description
F01	Users shall be able to login into the system using username and password
F02	Users shall be able to sign up for the system
F03	The administrator shall be able to authenticate the new users
F04	User shall be able to update the monthly progress of the product
F05	User shall be able to update the annual target
F06	User shall be able to configure a new product
F07	Users shall be able to create a new campaign
F08	Users shall be able to view the product performance through the dashboard
F09	The system shall be able to generate hints for product management decision

Table 2-15 - Functional requirement of the system

2.2.5 Non-functional requirement of the system

Nun functional requirements for the PLMS were identified and tabulated in Table 2-16 - Non-functional requirement of the system.

Requirement	Description
NF01	The system shall be able to validate the data input through the input panel based on the predefined criteria
NF02	Multiple users shall be able to access the system simultaneously
NF03	The system shall be able to access through different browsers
NF04	The system shall be able to allow only authorized people to log in using username and password
NF05	The system shall be able to pop up alerts on error or exception conditions.

Table 2-16 - Non-functional requirement of the system

2.3 Review of Similar Systems and Technologies

The eight most popular Product Lifecycle Management Software (PLMS) available in the market were studied in the literature survey to understand the features of the existing PLM systems. All these systems have been developed to support the production lifecycle, which is the process, converting the raw material into a finished good. Most of this software has features like Bill of Material (BOM) management, change management, reporting, and analysis, quality management, supply chain management, product data management, etc..., which are specially designed for production line management. It is difficult to find the software systems, which have been designed for the product in lifecycle management. Product in lifecycle management is how to manage the product in the market, from the product introduction to the market to withdrawal from the market.

Detail of the studied eight PLM systems is presented in this chapter.

2.3.1 Autodesk Fusion PLM

Autodesk Fusion PLM is a software introduced by leading software company "AUTODESK". It helps uses to accelerate the product development process by information collaboration and workflow management tools. This software is available as a cloud-based system, which is accessible anywhere, anytime. It is available as a subscription model. Licenses are available which are suitable for small businesses as well as large enterprises.

By examining the key features of the software, helps to understand the usability of the software. Autodesk Fusion PLM following key features.

1. New product development project template includes task assignment to different business-unit with governing gate process.
2. Portal to manage Bill of Materials in a centralized shared environment to access any time anywhere.
3. Customizable workflow provides easy monitoring and change management.
4. Customizable workflows facilitate better coordination of multiple stockholders across the organization.
5. Collaboration tools are extensible to third-party suppliers and service providers.

All these features are related to the manufacturing process. Therefore, Autodesk Fusion PLM is focused on product Lifecycle management of the manufacturing industry. This product is specifically designed for industries like industrial machinery and product, consumer electronic and high-tech products, automotive and component suppliers. (Anon., 2021)

2.3.2 PTC Windchill

PTC Windchill is product lifecycle management software with a pack of development tools suitable for small-scale businesses to large conglomerates. It has many more features than Autodesk Fusion PLM including data visualization and analysis, which is the key component of this project. The list of features of the software is as follows.

1. Project integration management
2. Quality management
3. Cost management
4. Procurement management
5. Change management
6. BOM and Detail design generation tools
7. Visualization tools for easy monitoring
8. Knowledge management tools
9. Analytical tools for analysis
10. Product management tools

XPLM is part of PTC's Partner Advantage Program since 2017 to build official future ECAD integrations to PTC Windchill which is illustrated in Figure 2-2 - PTC Windchill integration options (XPLM, 2021).

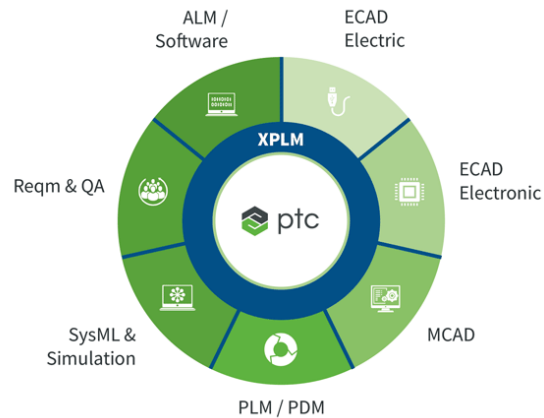


Figure 2-2 - PTC Windchill integration options (XPLM, 2021)

Licenses are available as a subscription which are suitable for small businesses as well as large enterprises.

2.3.3 SIEMENS Teamcenter PLM

SIEMENS Teamcenter PLM has been designed to handle more complex development processes with multi-party collaboration across the globe. Compared to other PLM systems, the SIEMENS system has fewer features listed. Those features are,

1. 3D design analysis tool to analyses 3D design from a different 3D design platform
2. Analytical tool to analyse the performance matrix to optimize performance and productivity.
3. Collaboration tool integrated with Microsoft SharePoint
4. Search engine facility to place the orders to complete the design

Licenses are available as a subscription which is suitable for small businesses as well as large enterprises.

2.3.4 Bamboo Rose

Bamboo Rose is a community-based virtual marketplace to collaborate to design new products for diverse markets across the globe. Product lifecycle management is a part and parcel of the collaboration platform. It does not limit to the product lifecycle management, but also provides,

1. Shopping cart solution for business customers
2. cross border supply chain management

Bamboo Rose PLM is a full-fledged solution to generate proprietary labels and brands through the collaboration of diversified designers and manufacturers in different countries by minimizing the time to market. Whatever the option selected by the product owner, Bamboo Rose can support any sophisticated design and fabrication process most simply. (Bamboorose, 2021)

In product lifecycle management, the software focuses on the first part of the PLM; product development. Licenses are available as subscriptions, which are suitable for small businesses as well as large enterprises.

2.3.5 DASSAULT ENOVIA

DASSAULT ENOVIA enables a wide spread of stockholders from the different strategic business units of the organization to contribute with their specialized areas for the development of an innovative product in a short development cycle. Software more focuses on the product development phase of the product lifecycle management. The platform supports the following features.

1. Accurate and up-to-date ENOVIA BoM management facilitates more accurate cost estimates for production.
2. Configuration management module enables the production with dynamic parameters.
3. The design management module facilitates access to the subject area expert remotely
4. ENOVIA IP classification enables companies to accelerate product development and shorten time to market through the reuse of design components
5. ENOVIA product planning and program management enables the project portfolio management, project monitoring, and project governance process

Licenses are available as subscriptions, which are suitable for small businesses as well as large enterprises.

2.3.6 ARAS PLM

ARAS PLM is an open-source integrated software platform, which delivers many PLM features. ARAS PLM consists of the following features.

1. Flexibility in integration and platform migration
2. More flexibility on process change
3. Bi-directional data synchronization to ensure updated information
4. Performance-oriented management

XPLM and Aras have had a certified Independent Software Vendor (ISV) partnership and are therefore capable of delivering integrated open-source solutions for multiple engineering disciplines. (XPLM, 2021) Integration options are illustrated in **Figure 2-3 - ARAS PLM integration options** (XPLM, 2021).

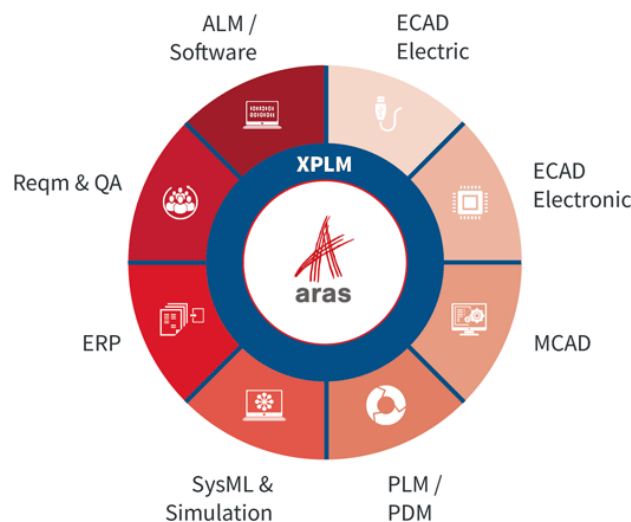


Figure 2-3 - ARAS PLM integration options (XPLM, 2021)

ARAS systems are used by the world's leading manufacturing organizations such as GM, Yanmar, Carestream, Microsoft, Airbus, etc... Licenses are available as subscriptions that are suitable for small businesses as well as large enterprises.

2.3.7 ARENA PLM

ARENA PLM very limited capabilities which are very common for many PLM systems available commercially. These features include,

1. Collaboration tools
2. Bill of material (BoM) management
3. Project change management
4. Document management tool

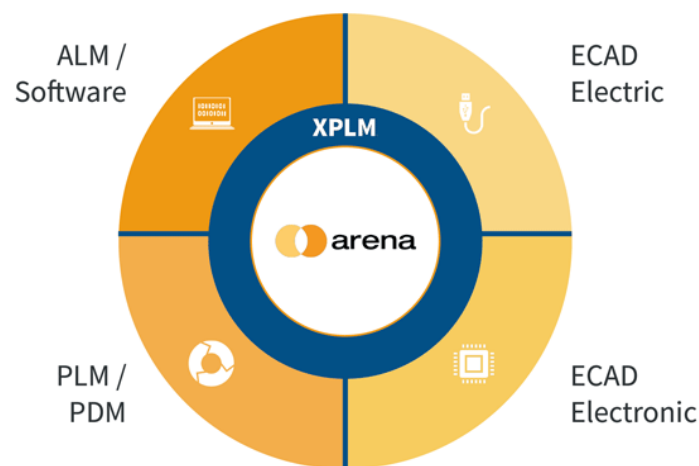


Figure 2-4 - ARENA PLM integration (ARENA, 2021)

ARENA PLM can be easily integrated with many other applications to provide full fledged operational experience as illustrated in Figure 2-4 - ARENA PLM integration (ARENA, 2021).

2.3.8 SAP PLM

SAP PLM software has a full range of automation tools to support product development and product lifecycle management. It covers areas from product ideas to the final delivery of services to the customer.

1. Supplier relationship management software for procurement and supply chain management.
2. Multiple credential levels for the access of different software tools for the uses from diversified working areas and different SBUs of the organization.

3. Improve decision making through information collaboration, monitoring, and analytical tools which provide better visibility and insights.
4. Improve monitoring and control of the whole product development process
5. XPLM open technology framework which ensures up-to-date enterprise-level information for forecasting, planning, manufacturing, and sales.

Licenses are available as subscriptions that are suitable for small businesses as well as large enterprises.

Key features of the top eight PLM systems were summarized for the comparison to understand the gap of the existing system and tabulated in Table 2-17 - Feature comparison of the existing PLM system.

	Autodesk Fusion	PTC Windchill	SIEMENS Teamcenter	Bamboo Rose	DASSAULT ENOVIA	ARAS	ARENA	SAP	Proposed PLM system
Project integration management	✓	✓	✓	✓	✓	✓	✓	✓	×
Quality management	×	✓	×	×	×	×	×	×	×
Cost management	×	✓	×	×	✓	×	×	×	×
Procurement management	×	✓	×	✓	×	×	×	✓	×
Change management	✓	✓	×	×	×	✓	✓	×	×
Bill of Materials management	✓	✓	×	×	✓	×	✓	×	×
Visualization tools for easy monitoring	✓	✓	×	×	✓	×	×	✓	✓
Knowledge management tools	×	✓	×	×	×	×	×	×	×
Analytical tools for analysis	×	✓	✓	×	×	×	×	✓	✓
Product management tools	×	✓	×	×	×	×	×	×	×
Document management	×	×	×	×	×	×	✓	×	×
Task assignment	✓	×	×	×	✓	×	×	×	×
Interpretation tool	×	×	×	×	×	×	×	×	✓

Table 2-17 - Feature comparison of the existing PLM system

According to the system analysis and similar system review, the proposed solution is not a known system to develop. There are certain areas, that must be designed properly before starting the development. Therefore, the combination of the waterfall and agile development process was selected to carry out the development.

3 Design Architecture

This chapter presents the high-level design of the PLMS. It includes the details of the software components of the system, database design, and the user interface (UI) design. Basic mathematical models required for the implementation of the data visualization portal and the decision support system are also annexed separately.

3.1 High-level software architecture

3.1.1 Data input module

The data input module facilitates the user to update the annual targets, product cost, product performance, and details of the product performance. Separate web forms are available to update the details of each area.

3.1.2 Data visualization module

Data visualization portal is the dashboard of the system which facilitates visualizing the product performance in a single window. It includes the KPI of the product and various graphs which will help for a quick understanding of the product performance. It also helps to percent the outcome of the decision support system.

3.1.3 Decision support system module

The decision support system (DSS) helps to analyse the available data and interpret those outcomes in the marketing domain to provide a useful guide for product managers on decision making. DSS uses various mathematical formulas and logic to analyse and interpret the data. These mathematical models are available in appendix A separately.

3.1.4 Administrator module

The administrator module is for the administrative functions of the system. This is useful for user creation and authentication.

3.1.5 Reporting Module

The reporting module is used to extract the raw data of the product which is used in the dashboard. It will help to export the data in CSV and PDF format. The overall architecture is illustrated in Figure 3-1 – PLMS high-level software architecture.

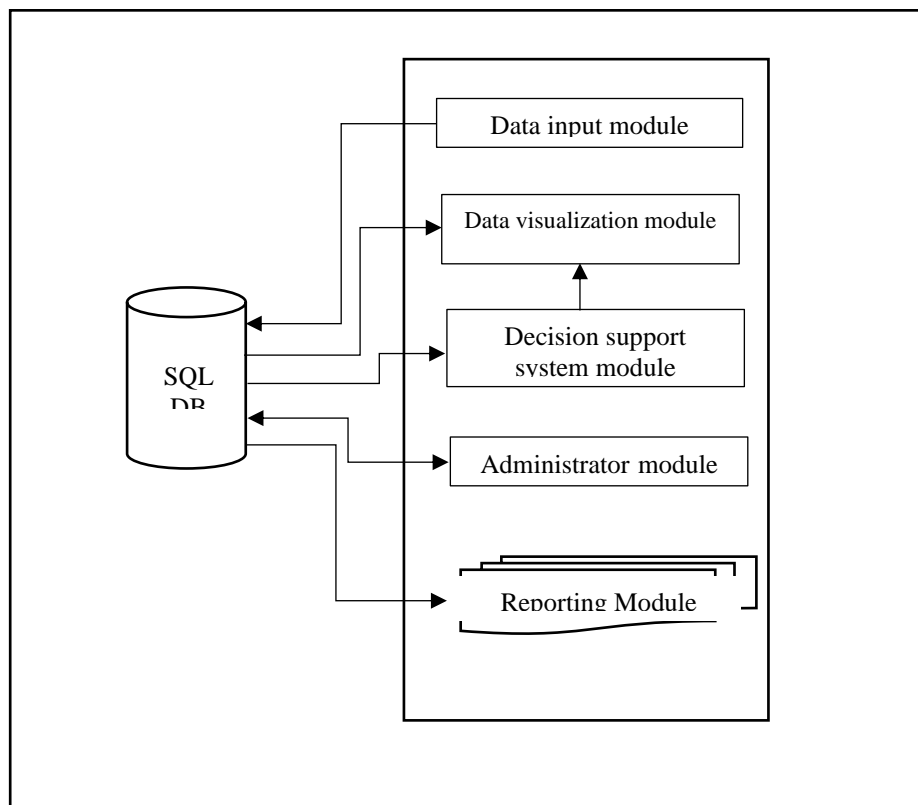


Figure 3-1 – PLMS high-level software architecture

The class diagram is used to model the solution. “StarUML” modeling software was used for this purpose. The class diagram which illustrates the system structure is shown in Figure 3-2- Class diagram of PLMS.

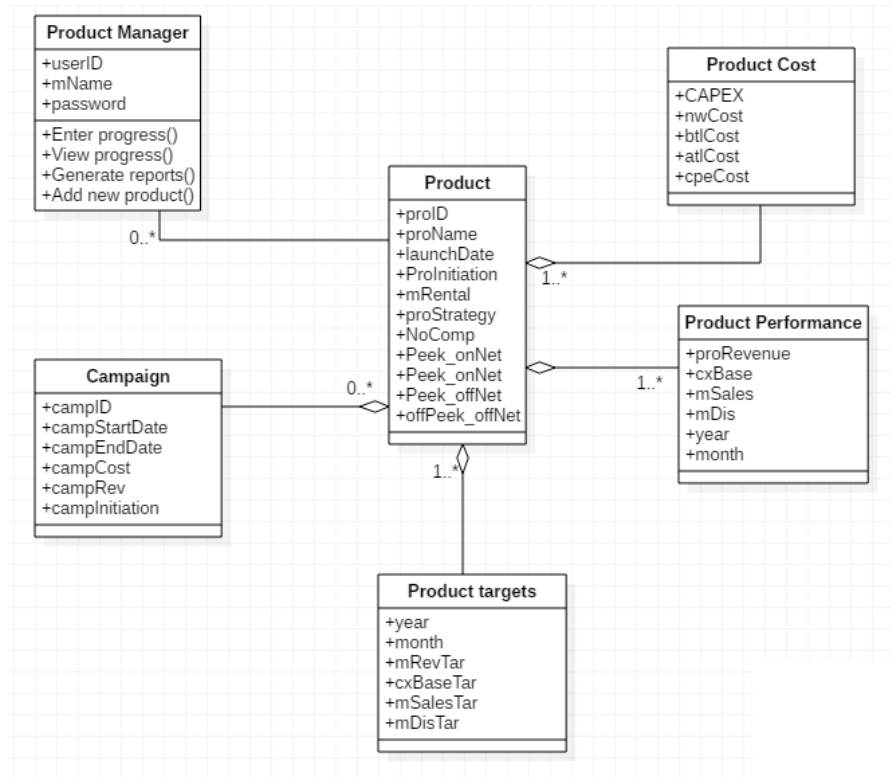


Figure 3-2- Class diagram of PLMS

3.2 Detailed design

During the design stage functionalities of each module were identified. The visualization module is the key implementation of the system which is integrated with all other modules. Figure 3-3 - Components of the dashboards illustrate the key components of the dashboard implementation which facilitate access to the inputs and output of the other modules such as the data input module, decision support system, and the reporting module. Details of the interface design will be further discussed in section 3.4



Figure 3-3 - Components of the dashboards

The activity diagram for the dynamic view of the dashboard is illustrated in Figure 3-4 - Activity diagram for visualization module where activities 1,2,3 and 4 represent the following functions.

- Activity 1 - Load summary KPI and report with a graph for the current year
- Activity 2 - Load summary KPI and report with a graph for the selected year
- Activity 3 - Load product performance KPI and report with a graph for the current year
- Activity 4 - Load product performance KPI and report with a graph for the selected year

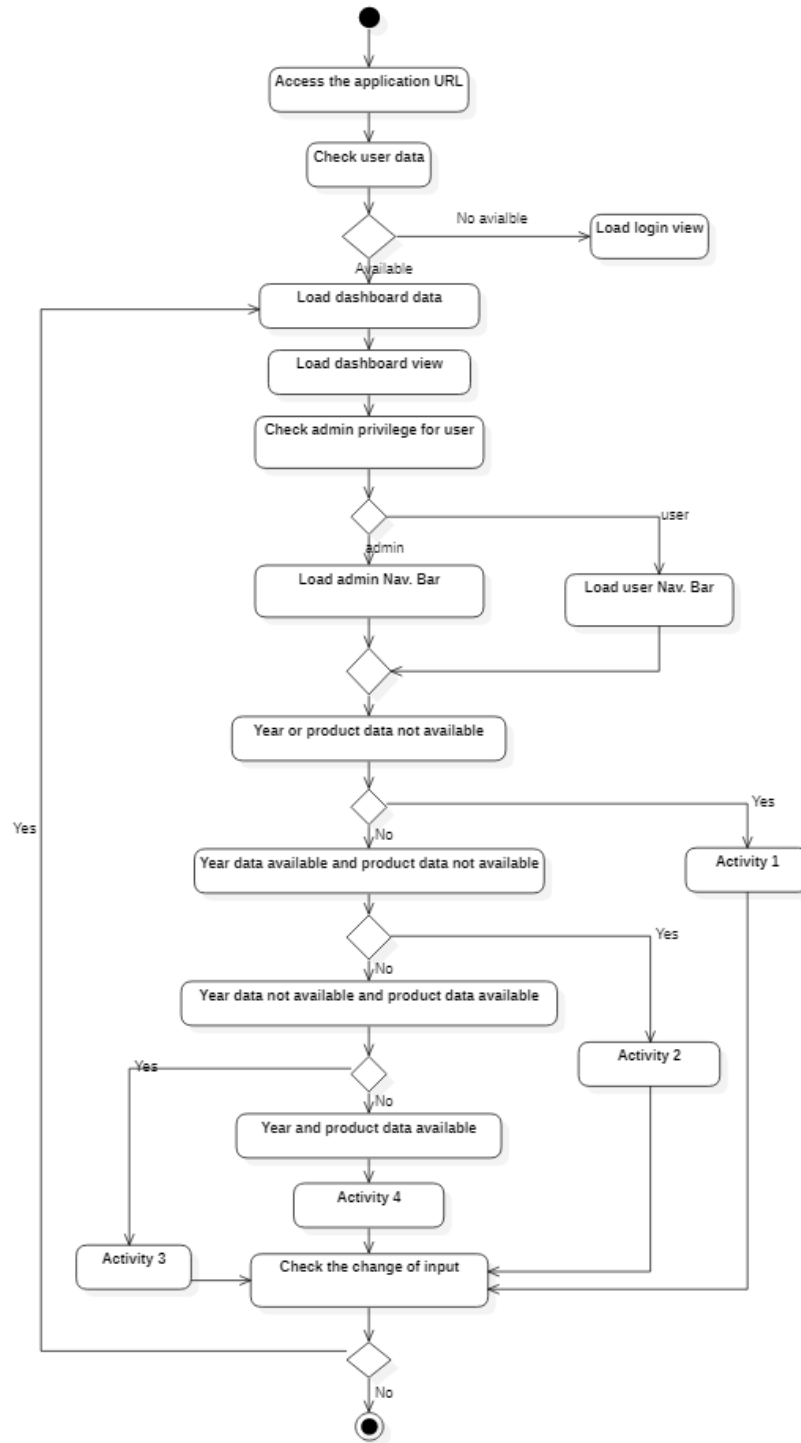


Figure 3-4 - Activity diagram for visualization module

All the users access the PLMS system through a web browser directed to the login page for authentication purposes and the function of the user authentication is illustrated in Figure 3-5 - Activity diagram for user authentication.

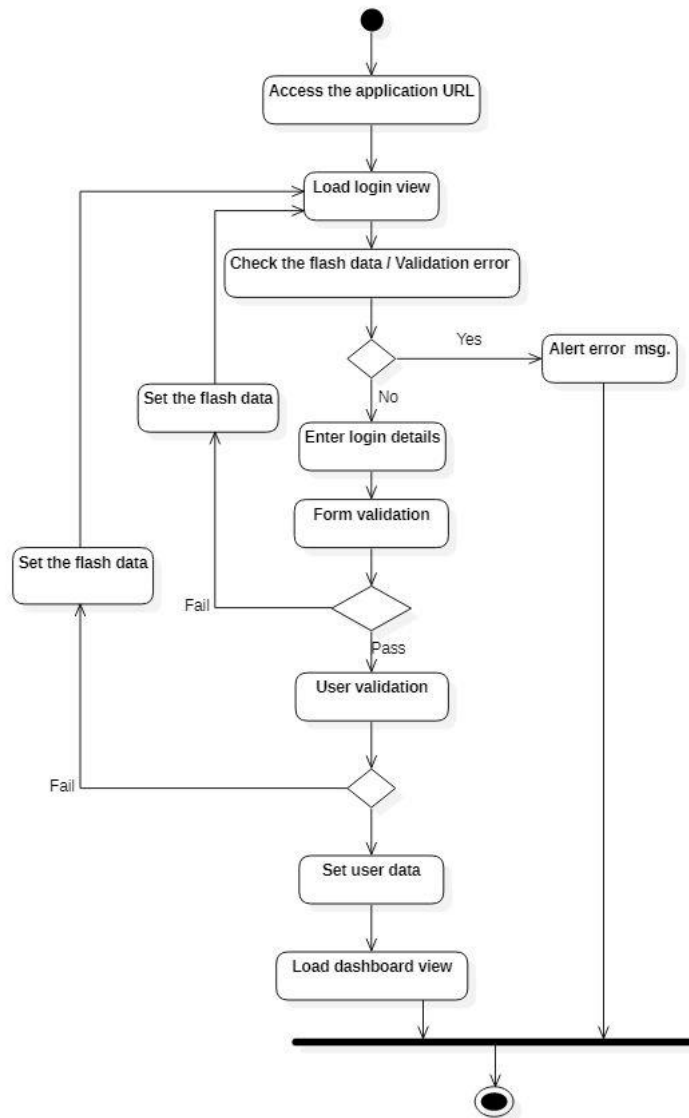


Figure 3-5 - Activity diagram for user authentication

Users with administrator privileges are allowed to register new users on the system. The new user registration process is illustrated in Figure 3-6 - Activity diagram for new user registration.

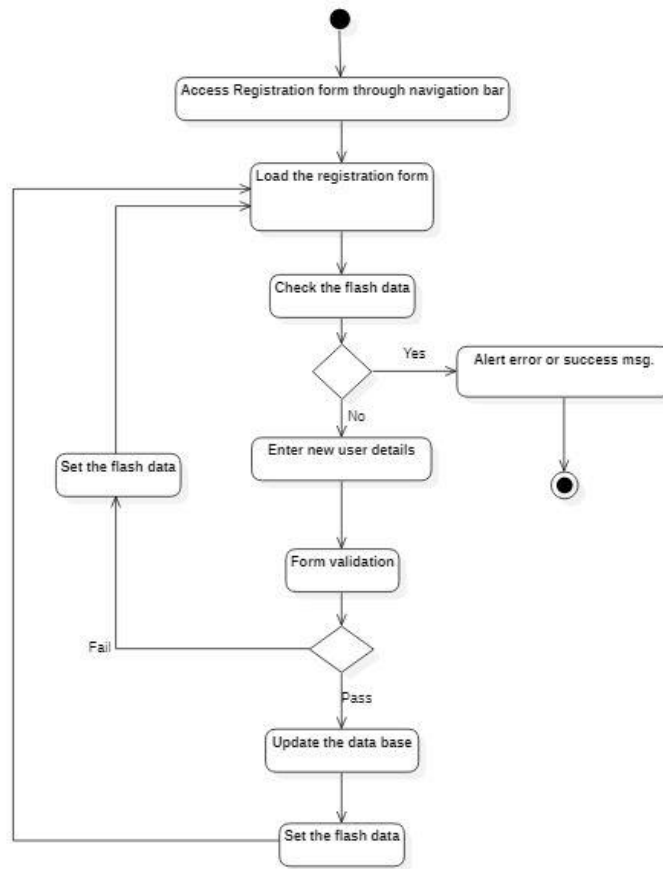


Figure 3-6 - Activity diagram for new user registration

The data input module consists of five main forms with data validation to ensure the availability of accurate data for accurate decision-making. Two forms are available to configure product and campaign data. The other three forms are available to update the ABP targets, product performance, and product cost data.

Product configuration form is the first interface provided to users to configure any new product planned to be managed using PLMS. The product configuration process has been designed to avoid duplicate entry of the same product to the system multiple times. Figure 3-7 - Activity diagram for the product configuration process, illustrate the detailed process of product configuration.

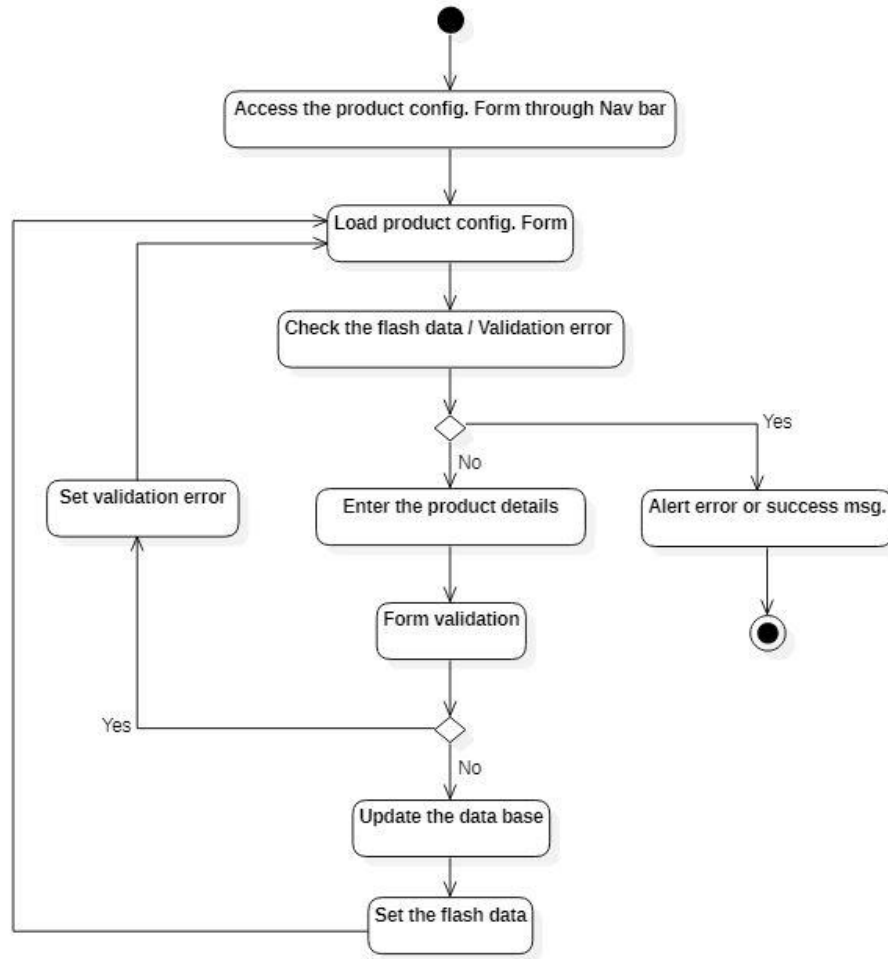


Figure 3-7 - Activity diagram for the product configuration process

The campaign registration process is also similar to the product registration process and annexed for reference in Appendix –B

Product target data is mandatory information that needs to be updated in the system before entering the product progress data. The target update process is illustrated in Figure 3-8 - Activity diagram for product target update.

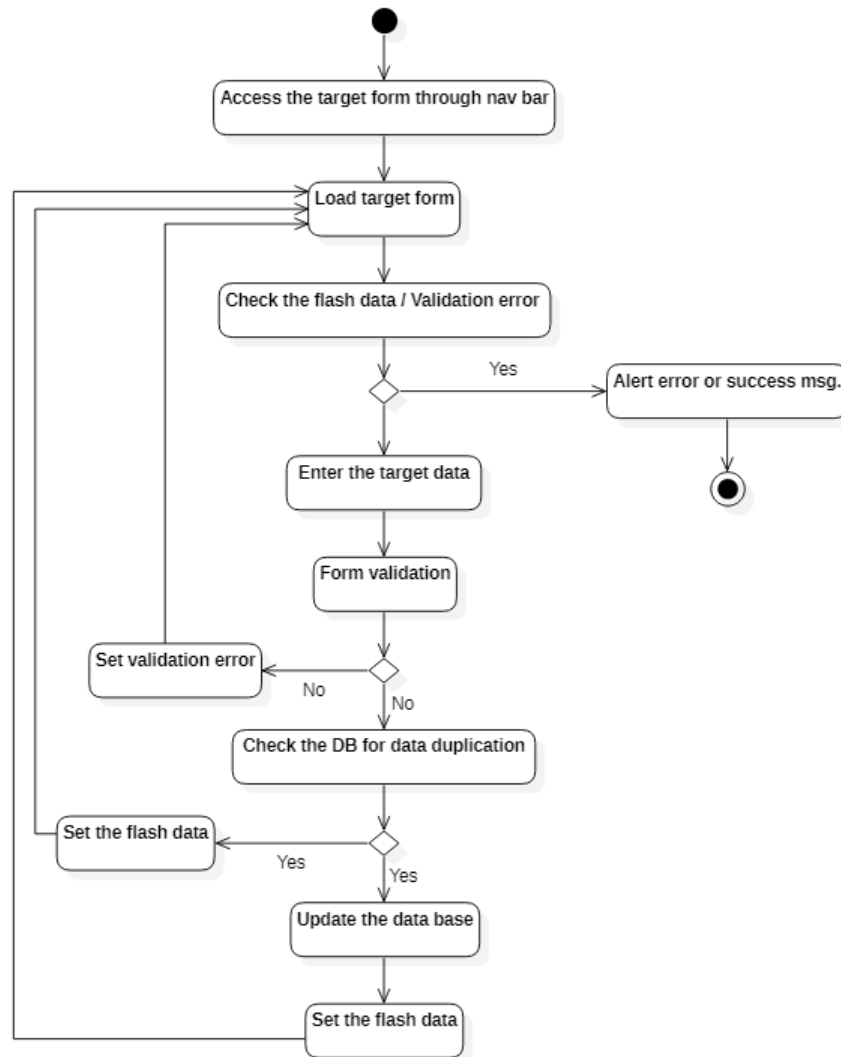


Figure 3-8 -Activity diagram for product target update

The scope of this project has excluded the system integration to capture the data from other systems such as CRM, BSS, OSS, etc.... Therefore, product performance data required for product analysis has to be updated monthly. A progress update form has been provided for this purpose. Following business rules has been applied to the progress update interface to assure the availability of quality data to the system.

1. Monthly progress cannot be updated before the end of the moth
2. Monthly progress for the particular year cannot be updated without updating annual targets.
3. Monthly progress data will not be allowed to update if the previous month data is absent

The product progress update process is illustrated in Figure 3-9 -Activity diagram for a product progress update.

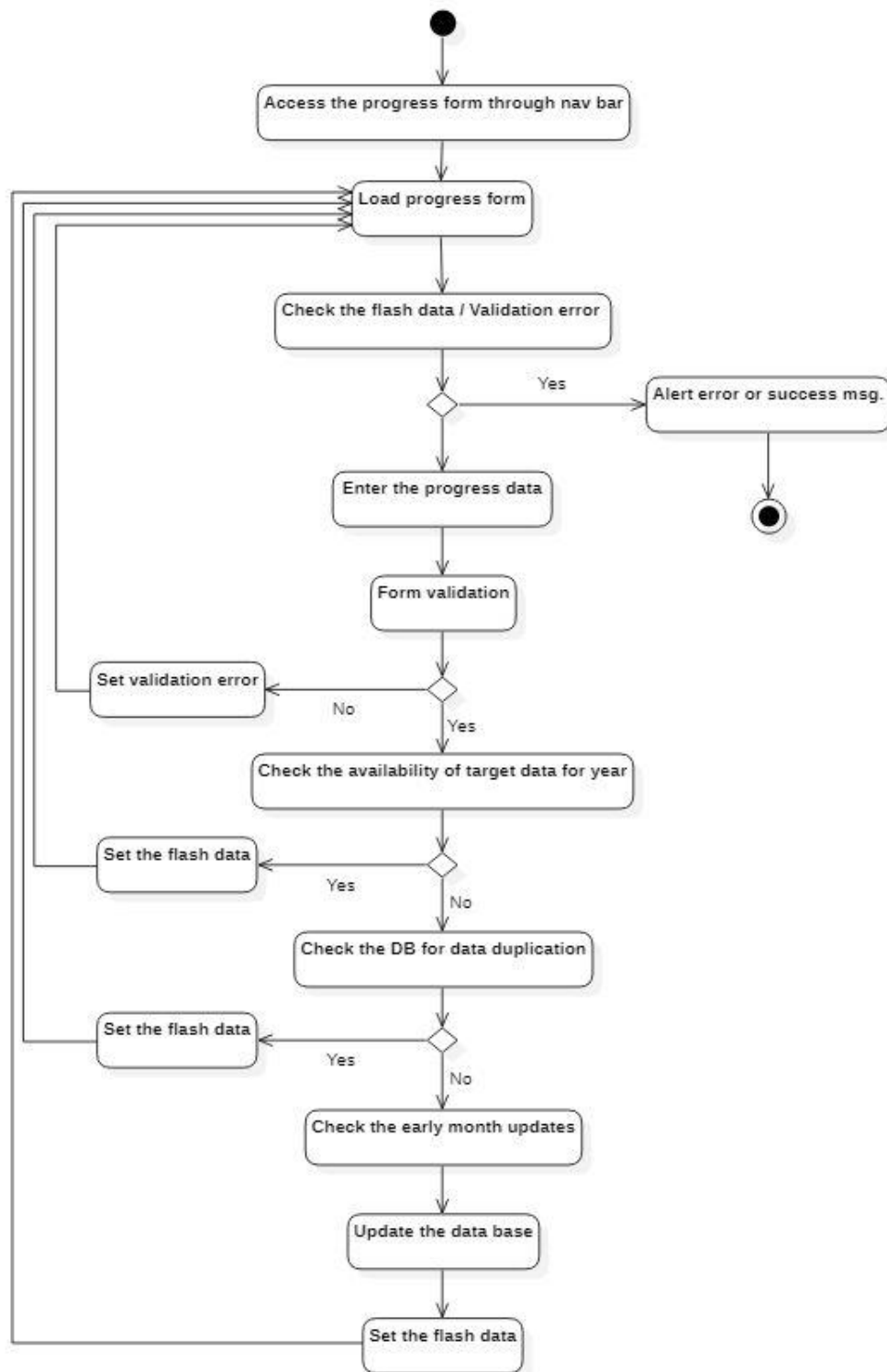


Figure 3-9 -Activity diagram for a product progress update

Illustration of the product cost update process also has been annexed in Appendix – B for reference.

3.3 Database design

Six relations were identified in database design and therefore, six tables will be created on the database accordingly. The relevant EER diagram is illustrated in **Figure 3-10 - EER diagrams of the PLMS**.

Product Manager (userID, mName, Password, administrator)

Product (proID, proManager, proName, mRental, ProInitiation, launchDate, proStrategy, Peek_onNet, offPeek_onNet, Peek_offNet, offPeek_offNet, NoComp)

Product Performance (proID, year, month, proRevenue, cxBase, mSales, mDis)

Product cost (proID, CAPEX, nwCost, cpeCost, btlCost, atlCost)

Campaign (proID, campID, proManager, campInitiation, campStartDate, campEndDate, campCost)

Product targets (proID, year, month, mRevTar, cxBaseTar, mSalesTar, mDisTar)

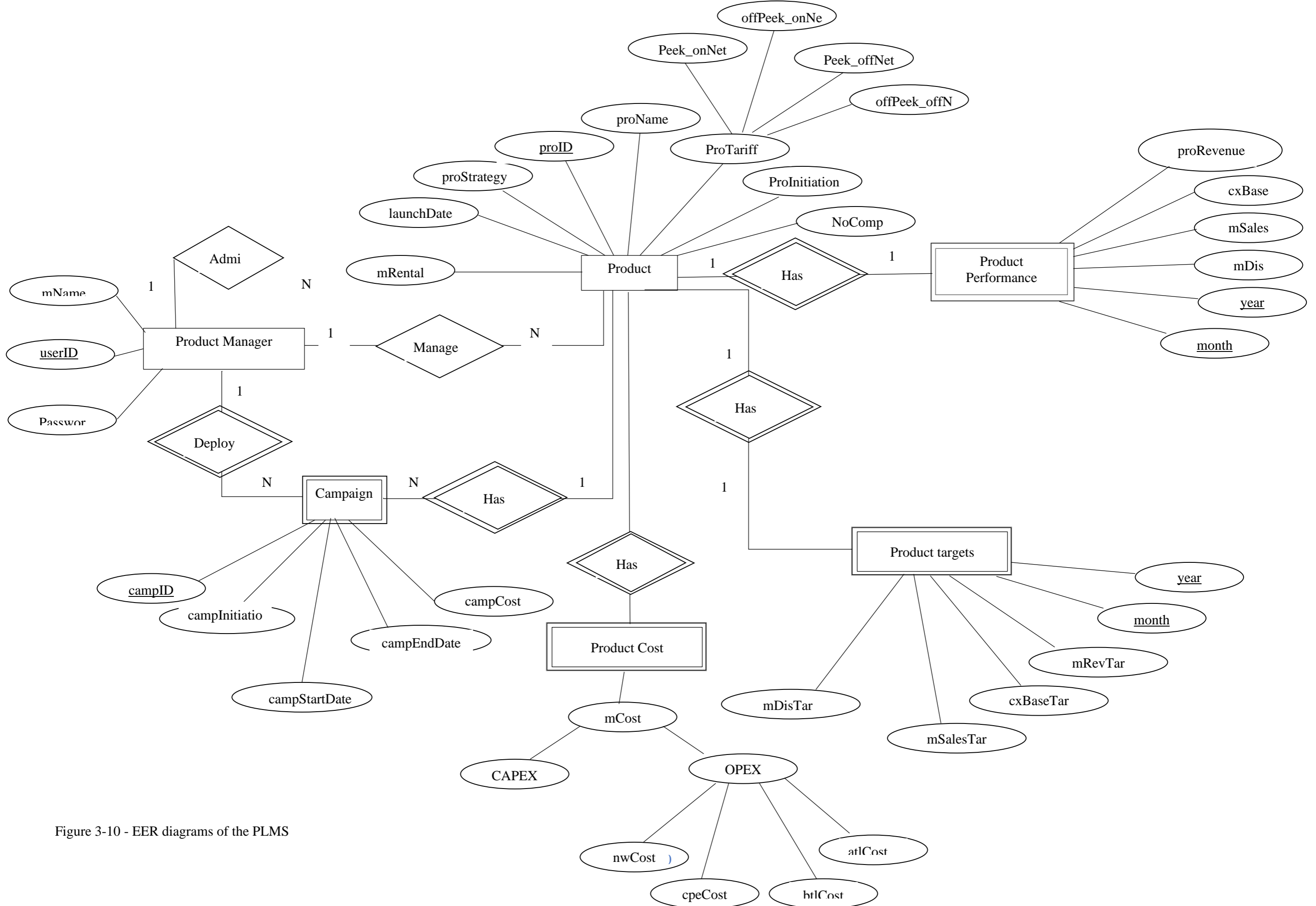


Figure 3-10 - EER diagrams of the PLMS

The actual implementation of the tables is illustrated in Figure 3-11 - Table implementation of the database.

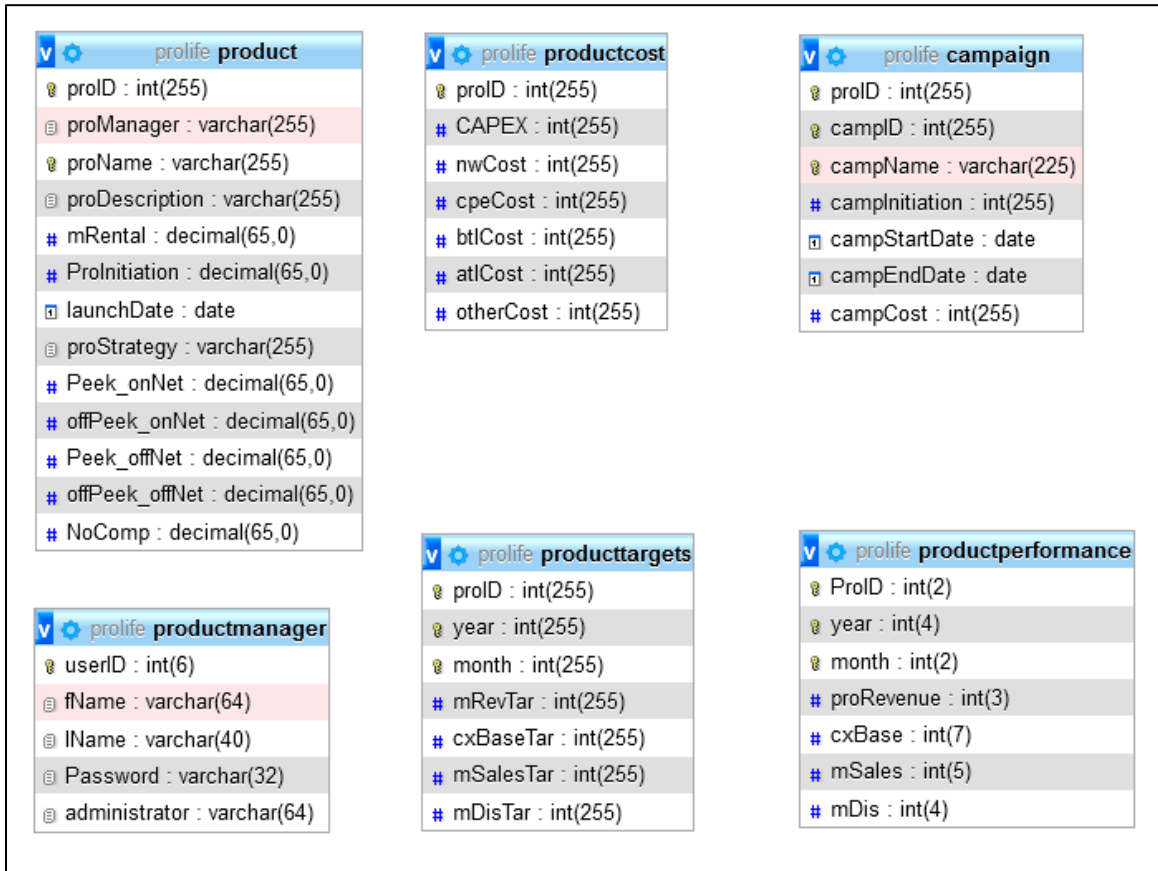


Figure 3-11 - Table implementation of the database

3.4 User Interface design

User interface block (UIB) design for PLMS is illustrated below Figure 3-12 - UIB for system login and Figure 3-13 - UIB for system input portals.

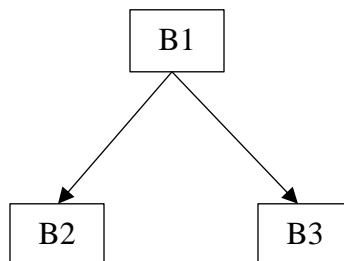


Figure 3-12 - UIB for system login

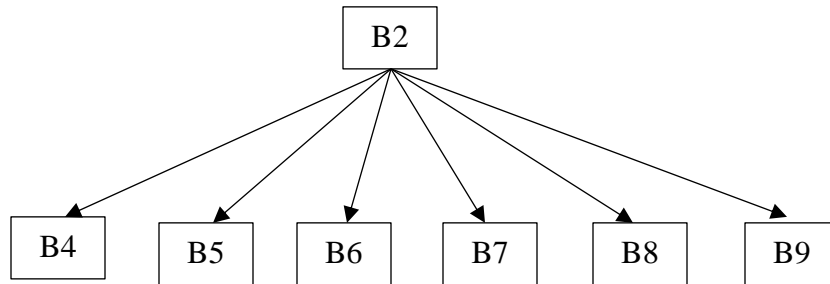


Figure 3-13 - UIB for system input portals

- B1 – Login page
- B2 – Dashboard page
- B3 – User registration
- B4 - Product configuration page
- B5 – Monthly progress update page
- B6 – Annual target update page
- B7 – Product cost update page
- B8 – campaign update module
- B9 – System info page

“FluidUI” online UI design software was used to design the UI of the PLMS. The basic design of the UIs is illustrated in figure 3-14 3-15 and 3-16. In user interface design, a navigation bar was implemented on the left-hand side while keeping sufficient space for the data visualization in the dashboard implementation. The same layout was used for all forms without any change.

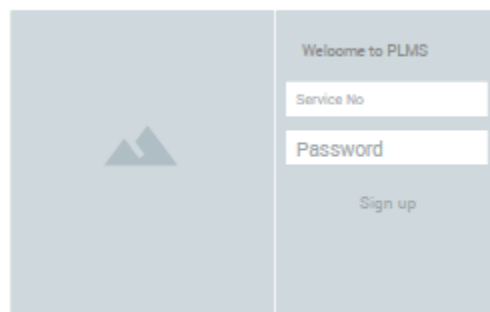


Figure 3-14- UI design for the Login page (UIB 1&3)

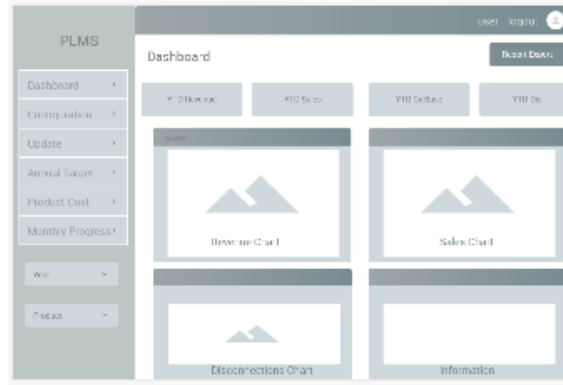


Figure 3-15(UIB 3) - UI design for the Dashboard page

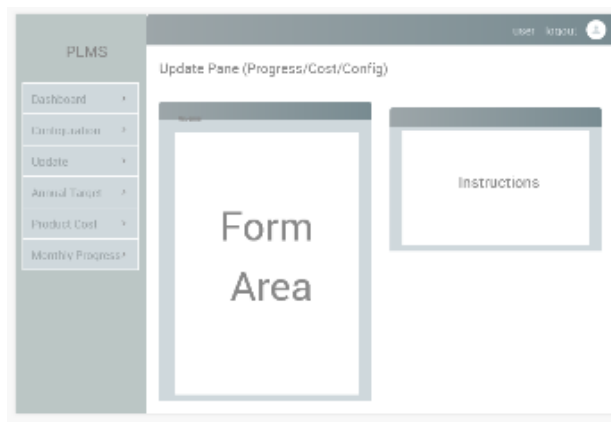


Figure 3-16- UI design for input portals (UIB 4,5,6,7 & 8)

Based on the initial prototype design, the most suitable open source “SB Admin” dashboard template was selected for the implementation which is illustrated in Figure 3-3 - Components of the dashboards.

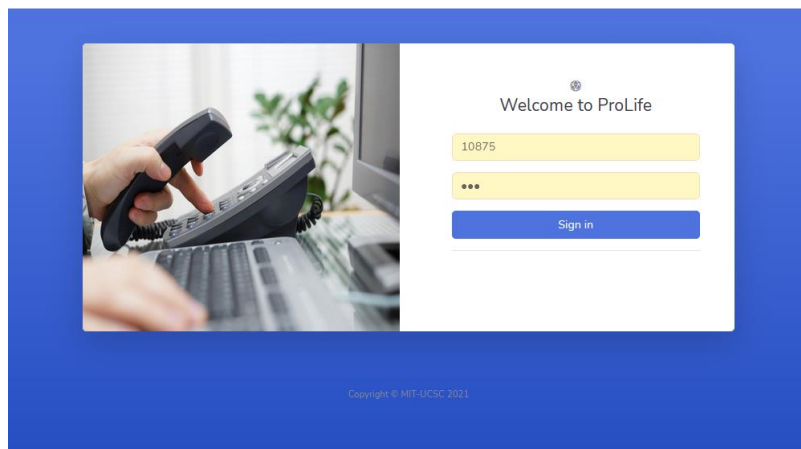


Figure 3-17 - Login page for the system

All the system users who access the PLMS through URL is directed to the login page illustrated in Figure 3-17 - Login page for the system for authentication purpose. Once the user is authenticated, the user will be directed to the dynamic interface illustrated in Figure 3-3 - Components of the dashboards.



Figure 3-18 - Collapsible menu implementation

As illustrated in Figure 3-18 - Collapsible menu implementation, navigation bar to access other pages were implemented as a collapsible menu under three main categories; namely configuration, updates, and portal admin. Only users with administrator privilege can access the user registration menu as illustrated in Figure 3-17.

As mentioned earlier graphs, KPIs, reports, and alerts are dynamically changed on the dashboard based on the user selection. The initial dashboard is loaded with aggregated KPI and graphs which display the overall performance of the products. This page provides a quick overview of products including which products contribute more to the company revenues, which products have more sales, which products have more customer churn, and which products have achieved the targets.

Dynamic change of the dashboard is illustrated in Figure 3-19 - Dynamic behavior of the dashboard.



Figure 3-19 - Dynamic behavior of the dashboard

The output of the DSS is also easily accessible through the dashboard. Alerts from DSS are displayed in the interface under three categories and illustrated in Figure 3-20 - Alerts from the Decision Support System.

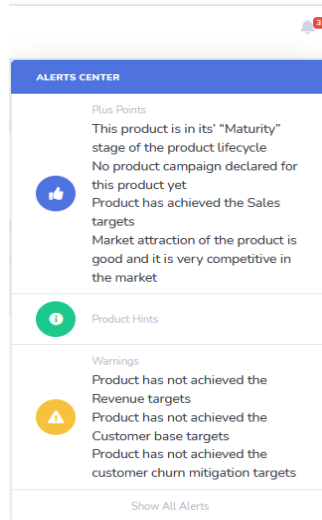


Figure 3-20 - Alerts from the Decision Support System

Report generated from reporting module also accessible through the dashboard and illustrated in Figure 3-21 - Management reports generated from the reporting module.

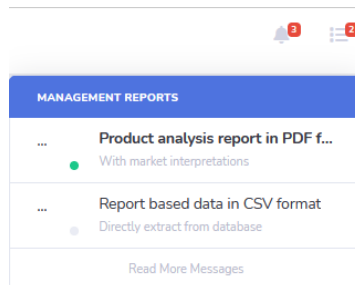


Figure 3-21 - Management reports generated from the reporting module

All interfaces of the data input module have been annexed as Appendix – C. All data input forms have been designed and implemented with data validation. Extra precaution has been taken in the Progress update form, target enters foam and cost update form to avoid accidental data overwrite. Separate links have been provided to existing data verification and overwrite as illustrated in Figure 3-22 - Separate links provided for existing data verification and overwrite.

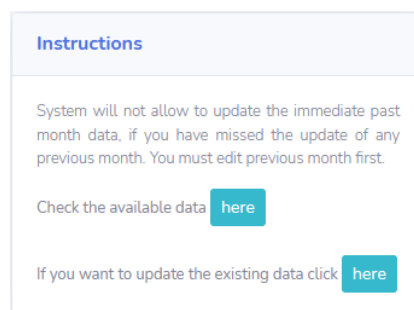


Figure 3-22 - Separate links provided for existing data verification and overwrite

4 Implementation Details (Methodology)

4.1 Overview

Implementation of the project consists of four main areas: Data Capturing Module (DCM), Data Visualization Module (DVM), Decision Support Module (DSM), and Reporting Module (RM). Mainly DCM consists of a few data capturing forms and needs to implement a data validation process to ensure the quality and accurate data input to the system. DVM is the implementation of the dynamic dashboard which processes and visualizes the data available in the database and output of the DSM. DSM consists of mathematical calculations and logic for decision-making. Finally, RM helps to present and convert the processed data in downloadable file format.

4.1.1 Implementation environment

WAMP server with the following configuration was used to host the application.

Apache Version	2.4.46
Port defined for Apache	80
PHP Version	7.3.21
MySQL Version	MySQL Version
Port defined for MySQL	3306

Following browsers were used for testing purposes during the development

1. Mozilla Firefox 93.0 (64 -bit)
2. Google Chrome 95.0.4638.69 (Official Build) (64-bit)
3. Internet Explorer 11

4.1.2 Resources and the technologies

This system was developed based on the “*CodeIgniter*” framework. The bootstrap framework was used to develop the UI for the system. PHP and JS languages were used for the implementation. Google graphs library was used to display the product performance in graphical representation.

“JSPDF” library was used to generate the report using the system. MySQL was used as a database for this implementation and six tables were created to capture the data input from the data input interfaces.

4.2 Coding

4.2.1 File structure

This development was based on “CodeIgniter” frame work. Therefore, the file structure of this project also followed the same file structure. Under the view folder, ten PHP view files were created. In addition to that, six PHP code parts that were reused in view files were saved in the “codeblocks” subfolder. Implementation is illustrated in Figure 4-1 - PHP view files structure.

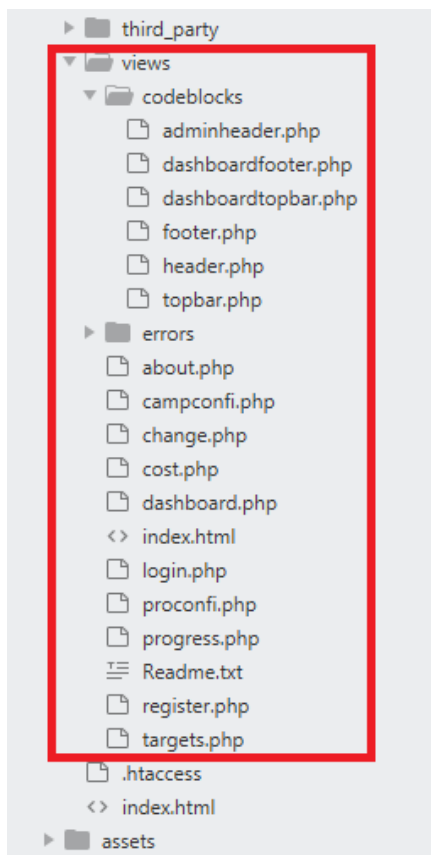


Figure 4-1 - PHP view files structure

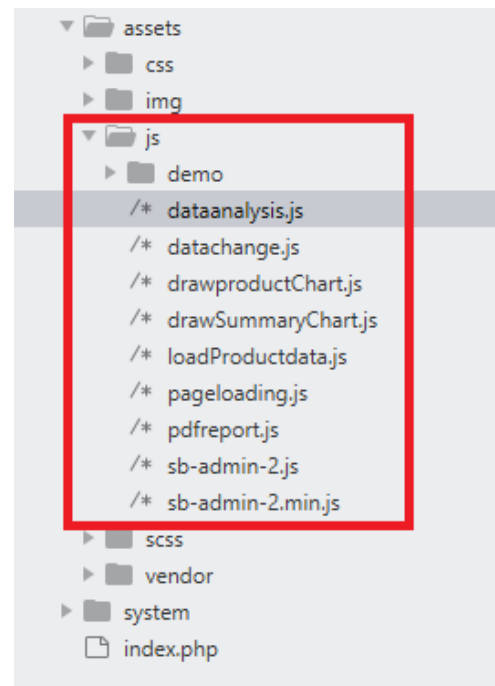


Figure 4-2 - Java script used in the dashboard view

Few java scripts were used to implement dynamic dashboard view and all customized js files were saved in the “js” subfolder in the “assets” folder. The file structure for java scripts was illustrated in Figure 4-2 - Java script used in the dashboard view.

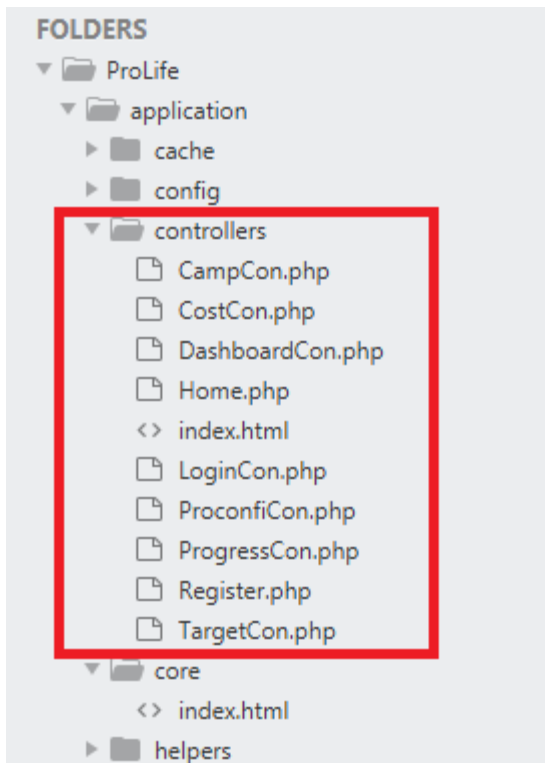


Figure 4-3 - Controllers of the system

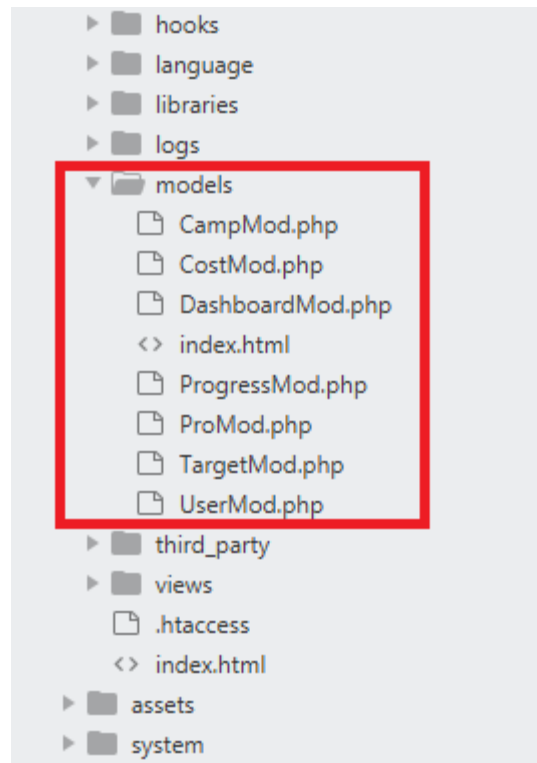


Figure 4-4 - Models of the system

Nine controllers and seven models were used for the implementation and file structures are illustrated in Figure 4-3 - Controllers of the system and Figure 4-4 - Models of the system respectively.

```

<!--Load custom scripts to draw summary charts -->
<script type="text/javascript" src="<?php echo base_url ('assets/js/drawSummaryChart.js'); ?>"></script>

<!--Load custom scripts to draw product charts -->
<script type="text/javascript" src="<?php echo base_url ('assets/js/drawProductChart.js'); ?>"></script>

<!--Load custom scripts for data analysis (DSS) -->
<script type="text/javascript" src="<?php echo base_url ('assets/js/dataanalysis.js'); ?>"></script>

<!--Load custom scripts to generate reports -->
<script type="text/javascript" src="<?php echo base_url ('assets/js/pdfreport.js'); ?>"></script>

<!--Load custom scripts for page initial loading-->
<script type="text/javascript" src="<?php echo base_url ('assets/js/pageloading.js'); ?>"></script>

<!--Load custom scripts for page changes-->
<script type="text/javascript" src="<?php echo base_url ('assets/js/datachange.js'); ?>"></script>

```

Figure 4-5 - Use of javascript file in the dashboard view

All the JavaScript files are called in the dashboard view file and the use of JS files is illustrated in Figure 4-5 - Use of javascript file in the dashboard view.

4.2.2 Data validation

Data validation played a major role in the implementation of DCM. In this implementation, a combination of the following validation methods was used for data validation.

1. HTML 5 built in form validation
2. “CodeIgniter” standard form validation
3. “CodeIgniter” customized form validation

The use of HTML 5 built-in form validation is illustrated in Figure 4-6 - HTML 5 built-in form validation code and Figure 4-7 - Error message generated by HTML 5 built-in form validation.

```
<label for="proInitiation">Product Initiation fee</label>
<input type="number" name="proInitiation" class="
form-control" id="proInitiation" placeholder="Product
Initiation fee">
```

Figure 4-6 - HTML 5 built-in form validation code

The image shows a web form with a label 'Product Initiation fee' in blue text. Below the label is a text input field with a light blue border and a small dropdown arrow on the right. The input field contains the text 'sdfaf'. Below the input field is a red error message box with rounded corners and a white background, containing the text 'Please enter a number.' in black. The error message box is positioned to the left of the input field.

Figure 4-7 - Error message generated by HTML 5 built-in form validation

CodeIgniter standard form validation is the main tool used in the implementation and the sample code set used in campaign form is illustrated in Figure 4-8 -CodeIgniter standard form validation code.

```
$this->form_validation->set_rules('campInitiation', 'Campaign Initiation', '
required|greater_than_equal_to[0]');
```

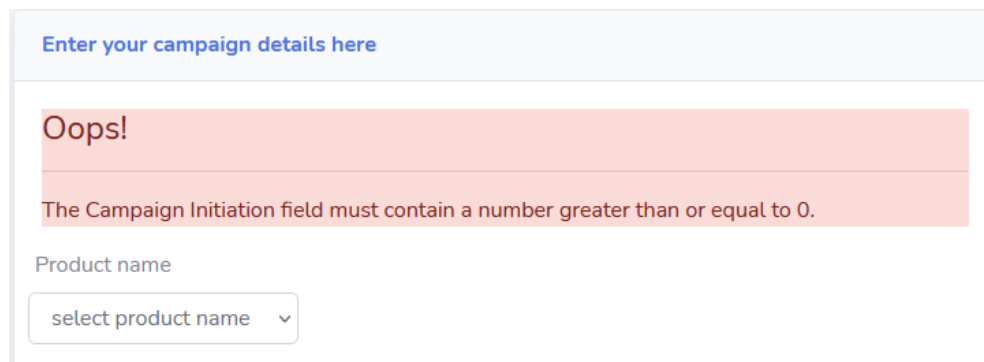
Figure 4-8 -CodeIgniter standard form validation code

In CodeIgniter form validation, it is possible to display the error and success messages according to any format preferred. Code set illustrated in Figure 4-9 -PHP code set used in view file to display the error message was used in all forms commonly to display the form validation error messages.

```
if (validation_errors())
{
    ?>
    <div class="alert-danger" role="alert">
    <h4 class="alert-heading">Oops!</h4>
    <hr>
    <?php echo validation_errors(); ?>
    </div>
    <?php
```

Figure 4-9 -PHP code set used in view file to display the error message

Sample error message created by this code set is illustrated in Figure 4-10 - Formatted error message using Bootstrap alerts.



The screenshot shows a form titled "Enter your campaign details here". A red alert box is displayed, containing the text "Oops!" and "The Campaign Initiation field must contain a number greater than or equal to 0." Below the alert, there is a "Product name" label and a dropdown menu with the text "select product name" and a downward arrow.

Figure 4-10 - Formatted error message using Bootstrap alerts

CodeIgniter customized form validation is used to implement advance form validations. The callback function is used to call customized function for form validation and sample code illustrated in Figure 4-11 - Use of CodeIgniter callback function for form validation.

```
$this->form_validation->set_rules('campStartDate', 'Campaign Start Date', 'required|callback_check_campaign_startdate');
```

Figure 4-11 - Use of CodeIgniter callback function for form validation

The code set of the function used with a callback function to validate the campaign start date in the campaign configuration form is illustrated in Figure 4-12- Customized function written for advance form validation.

```
public function check_campaign_startdate($sdate){
    $todayDate = date('Y-m-d'); // select date in Y-m-d format

    if($todayDate>$sdate){
        $this->form_validation->set_message('check_campaign_startdate', 'The {field} field can not
            be past date');
        return FALSE;
    }
    else{
        return TRUE;
    }
}
```

Figure 4-12- Customized function written for advance form validation

4.2.3 Dynamic page implementation

Many JavaScripts were used in the implementation of the dashboard of the DVM. At the time of user authentication and directing to the dashboard, it is necessary to direct the user to the dashboard with the correct navigation bar based on their user privilege. The code implementation illustrated in Figure 4-13 -Load different headers based on the user privilege.

```
<?php if($this->session->userdata('admin')== 'admin'){
    include 'codeblocks/adminheader.php';
}
else{
    include 'codeblocks/header.php';
}
?>
```

Figure 4-13 -Load different headers based on the user privilege

As illustrated in Figure 3-4 - Activity diagram for visualization module, it is necessary to load summary graphs and aggregated KPIs in initial page loading. After changing the year and product field to other values, it is necessary to load product performance graphs and KPIs. To implement this design two java scripts; “pageloding.js” and “datachange.js” were used. Code set used in two files are illustrated in Figure 4-14 - Code set used in “pageloding.js” and Figure 4-15 -Code set used in “datachange.js”

```
$( window ).on( "load", function() {
  console.log( "window loaded" );
  var year = new Date().getFullYear();

  document.getElementById("chart1_heading").innerHTML = "Product Revenue contribution - " + year ;
  document.getElementById("chart2_heading").innerHTML = "Sale contribution for each product - " + year ;
  document.getElementById("chart3_heading").innerHTML = "Product wise customer churn impact - " + year ;
  document.getElementById("chart4_heading").innerHTML = "Revenue target achievement of each product - " + year ;
  load_summary_data(year);
  load_aggregated_KPI(year);
});
```

Figure 4-14 - Code set used in “pageloding.js”

```
$(document).ready(function(){
  $('form-control').change(function(){
    var year = $("#year").val();
    var product = $("#product").val();

    if(($("#year").val()!='' && $("#product").val()!=''))
    {
      var d = new Date();
      var year = d.getFullYear();
      document.getElementById("chart1_heading").innerHTML = "Product Revenue "+ year;
      document.getElementById("chart2_heading").innerHTML = "Sale performance "+ year;
      document.getElementById("chart3_heading").innerHTML = "Customer base "+ year;
      document.getElementById("chart4_heading").innerHTML = "Churn rate "+ year;
      load_instructions(year,product);
      load_productwise_data(year,product, 'Month Wise Data For');
    }

    if(($("#year").val() && $("#product").val())!= '') ==
    if($("#year").val()!='' && $("#product").val() == '') ==
  });
});
```

Figure 4-15 -Code set used in “datachange.js”

Once the page is loaded to the client-side browser, it is necessary to change the page content according to the changes that happen in the client browser. To do this it is necessary to send the changes to the server-side and fetch the data accordingly. To do this AJAX function was used and data is exchanged between server and client in JSON format.

Code set used in “loadproductdata.js” to fetch the product data to draw the graphs are illustrated in Figure 4-16 - Use of AJAX function to fetch the product data from server-side.

```
function load_productwise_data(year,product)
{
    var temp_title = 'temp title' + ' ' + year;
    $.ajax("DashboardCon/fetchProductData",{
        method:"POST",
        data:{year:year,product:product},
        dataType:"JSON",
        success:function(data)
        {
            console.log("success");
            drawProRevChart(data, temp_title);
            drawProSalesChart(data, temp_title);
            drawProChurnChart(data, temp_title);
            drawCxBaseChart(data, temp_title);
        },
        error: function(xhr,ajaxOptions, errorThrown) {
            alert("Data is not availabel. please check")
            console.log("error");
        }
    })
}
```

Figure 4-16 - Use of AJAX function to fetch the product data from server-side

Implementation of the DSM is the key area of the implementation where all the mathematical calculations and logic are executed. Java scrip “dataanalysis.js” was used for this purpose and calculation of KPI is the basis for all decisions. Figure 4-17 - Code set for the calculation of product KPIs and Figure 4-18 -Segment of the code set used DSM output based on KPIs illustrate the methodology used to calculate KPIs and way of the use of KPIs for DSM output.

```

var YOYR = (((cumProRevenue-cumProRevenue_yearbefore)/cumProRevenue_yearbefore)*100).toFixed(2);
var YOYS = (((cumSales-cumSales_yearbefore)/cumSales_yearbefore)*100).toFixed(2);
var YOYD = (((cumDis-cumDis_yearbefore)/cumDis_yearbefore)*100).toFixed(2);
var YOYC = (((cxBase-cxBase_yearbefore)/cxBase_yearbefore)*100).toFixed(2);
var YOYR3 = ((cumProRevenue-cumProRevenue_3yearbefore)/(cumProRevenue_3yearbefore*3))*100;
var YOYS3 = ((cumSales-cumSales_3yearbefore)/(cumSales_3yearbefore*3))*100;
var YOYD3 = ((cumDis-cumDis_3yearbefore)/(cumDis_3yearbefore*3))*100;
var YOYC3 = ((cxBase-cxBase_3yearbefore)/(cxBase_3yearbefore*3))*100;
var RAR = ((cumProRevenue/cumRevenueTar)*100).toFixed(2);
var SAR = ((cumSales/cumSalesTar)*100).toFixed(2);
var CAR = ((cxBase/cxBaseTar)*100).toFixed(2);
var CMAR = ((cumDisTar/cumDis)*100).toFixed(2);
var RS = (cumProRevenue/AggregatedCumRev);
var MS = (RS>=0.2)?"high":"low";
var ARPM = ((cumProRevenue+cumProRevenue_lastyeartailing)/12).toFixed(2);
var ASPM = ((cumSales+cumSales_lastyeartailing)/12).toFixed(2);
var ADPM = ((cumDis+cumDis_lastyeartailing)/12).toFixed(2);
var ACBGPM = ((cumProRevenue+cumProRevenue_lastyeartailing)/12).toFixed(2);
var ARPU = ((cumProRevenue+cumProRevenue_lastyeartailing)*1000000/(y2dcxbase*12)).toFixed(2);

```

Figure 4-17 - Code set for the calculation of product KPIs

```

if(SAR>100 && CMAR>0){
  m23.innerHTML = "";
  m24.innerHTML = "";
  m20.innerHTML = "Market attraction of the product is good and it is very competitive in the market";
}
else if (SAR>100 && CMAR<=0){
  m20.innerHTML = "Market attraction of the product is good but not competitive in the market";
  m24.innerHTML = "Cheek the quality aspect of the sales ";
}
else if (SAR<=100 && CMAR>0){
  m24.innerHTML = "";
  m20.innerHTML = "Product have poor market attraction but very competitive in the market";
}
else{
  m20.innerHTML = "";
  m21.innerHTML = "";
  m22.innerHTML = "";
  m24.innerHTML = "";
  m23.innerHTML = "Product nether attractive nor competitive in the market.";
  m24.innerHTML = "Need immediate product revamp";
}

```

Figure 4-18 -Segment of the code set used DSM output based on KPIs

Finally, the system needs to present the output from the system in report format. For this purpose, the “JSPDF” library was used and content to the report was organized in the report layout using the X and Y coordinates. Figure 4-19 - Code segment used to create report layout in “pdfreport.js” illustrates how the X and Y coordinate is used to place the heading and report date in the report layout.

```
doc.setLineWidth(0.5);
doc.line(80, 45, 120, 45);
doc.setFontSize(10);
doc.setFontType("bold");
doc.text(80, 50, 'Product Analysis Report');
doc.line(80, 55, 120, 55);

// *****generate product name and report date *****

var today = new Date();
var dd = String(today.getDate()).padStart(2, '0');
var mm = String(today.getMonth() + 1).padStart(2, '0'); //January is 0!
var yyyy = today.getFullYear();
var product = $('#product :selected').text();

if (product=="select product ID"){
    product = "Overall Performance"
}

today = mm + '/' + dd + '/' + yyyy;
doc.setFontType("normal");
doc.text( 20, 65, 'Report on' );
doc.text( 20, 70, 'Report generated on' );
doc.text( 50, 65, product );
doc.text( 50, 70, today );
```

Figure 4-19 - Code segment used to create report layout in “pdfreport.js”

5.1 Reporting Module

The system was developed to generate reports on the dashboard output in PDF format and extract the raw data in CSV format. PDF.js library was used to generate a PDF report of the dashboard of PLMS. Snapshots of the reports are illustrated in Error! Reference source not found. and Figure 4-21 – Snapshot of the CSV report generated from the system respectively. A full PDF report is annexed as Appendix – G for reference.

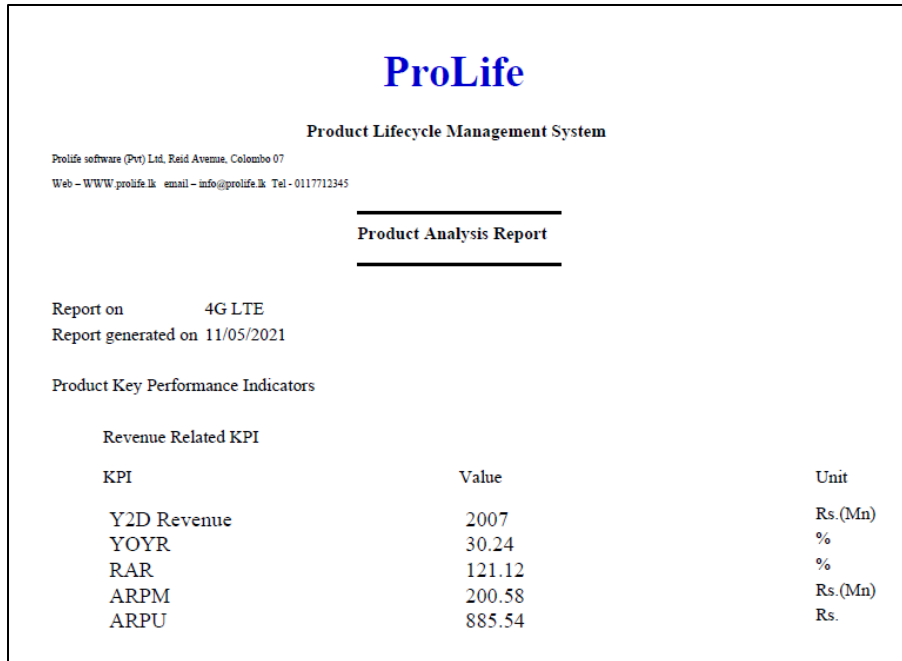


Figure 4-20 – Analysis report in PDF format

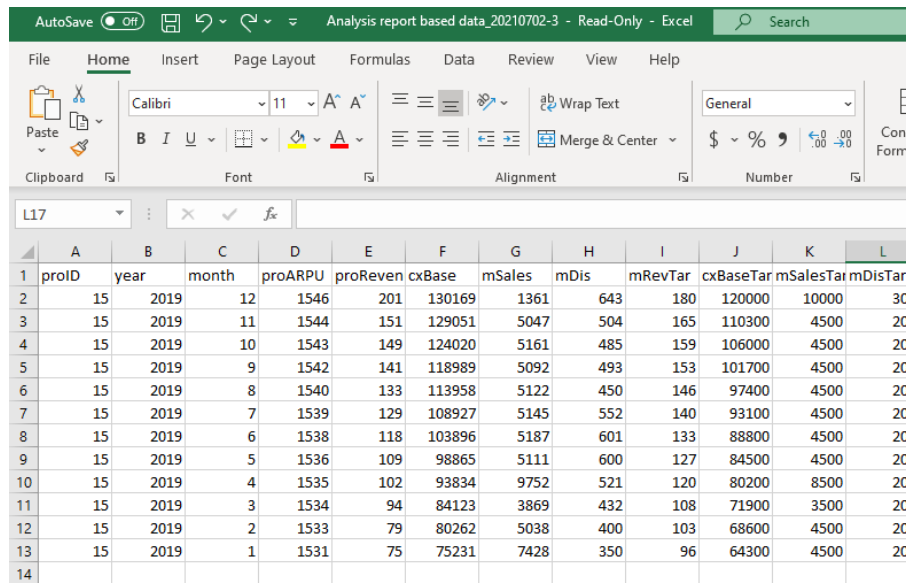


Figure 4-21 – Snapshot of the CSV report generated from the system

6 Testing and Evaluation

6.1 Related Testing Types

6.2 UI testing

This PLMS has nine basic user interfaces to input and output the information relevant to product lifecycle management. The key intention of the UI testing was to make sure all design interfaces are working properly and responded as expected.

For this purpose, the Maven project was created on the “IntelliJ IDEA” environment, and the “selenium web driver” was used as a web framework to execute cross-browser testing. This testing was done for all ten interfaces successfully.

6.3 Unit testing

In this project “testNG” unit test framework was used as a framework for unit testing. Twenty-three test cases were written using Java language to test the different validations and responses applicable on different interfaces. Test case coded to test the successful creation of new user is illustrated in Figure 6-1 - Test case developed to run on IntelliJ IDEA to test successful registration of user.

```

@BeforeMethod
public void setUp() {
    System.setProperty("webdriver.chrome.driver", "D:\\Personal\\MIT\\Semister 3\\chromedriver.exe");

    driver = new ChromeDriver();
    driver.get("http://localhost/prolife");
    driver.manage().window().maximize();
}

@Test
public void testRegisterSuccess() {
    driver.findElement(By.id("uerID")).sendKeys(...charSequences: "10875");
    driver.findElement(By.id("passWord")).sendKeys(...charSequences: "123");
    driver.findElement(By.id("submit")).click();
    driver.findElement(By.xpath("//*[id=\"accordionSidebar\"]/li[4]")).click();
    driver.findElement(By.xpath("//*[id=\"collapsePages\"]/div/a[2]")).click();
    driver.findElement(By.id("FirstName")).sendKeys(...charSequences: "Thilini");
    driver.findElement(By.id("LastName")).sendKeys(...charSequences: "Munasinghe");
    driver.findElement(By.id("uerID")).sendKeys(...charSequences: "10555");
    driver.findElement(By.id("RegPassword")).sendKeys(...charSequences: "Plms@UCSC#123");
    driver.findElement(By.id("RepeatRegPassword")).sendKeys(...charSequences: "Plms@UCSC#123");
    driver.findElement(By.id("admin")).sendKeys(...charSequences: "admin");
    driver.findElement(By.className("btn-primary")).click();
    //Thread.sleep(3000);
    String successMessage = driver.findElement(By.xpath("//*[id=\"content\"]/div/div[2]/div[2]/div/div/h4")).getText();
    Assert.assertEquals(successMessage, expected: "User registered successfully", message: "user creation successful");
}

```

Figure 6-1 - Test case developed to run on IntelliJ IDEA to test successful registration of user

6.4 Test Cases

Mainly test cases were identified to check the behaviour of the interfaces on different inputs of each UIs. Those test cases were built on the “IntelliJ IDEA” testing environment and executed to identify any gaps in the implementation. The followings are the test cases executed during the testing.

1. Login page success test
2. Login page failed test
3. Create an account with duplicate user
4. Create an account with a password mismatch
5. Create an account with missing information
6. Product configuration with product name duplication
7. Product configuration with missing field
8. Product configuration with negative values
9. Product configuration with invalid launched date
10. Campaign configuration with campaign name duplication
11. Campaign configuration with missing field
12. Campaign configuration with negative values
13. Successful product configuration
14. Annual target update in the wrong period
15. Annual target update with negative values
16. Annual target successful update
17. Product cost update with negative values
18. Product cost update with missing field
19. Successful Product cost update
20. Monthly progress update in the wrong period
21. Monthly progress update with negative values
22. Monthly progress update with missing field
23. Successful monthly progress update

Test cases and test result for the new user registration interface is summarized in Table 6-1 - Test cases and test result of the user registration process for easy reference.

Test case No		02	
Test Case Name		User creation	
Test environment/Preconditions		User logged in to the system with administrator privilege	
Step	Action	Expected result	Test result (Pass/Fail)
1	Access the registration page through the navigation bar (Portal admin>Register)	Users will be directed to the registration form	Pass
2	Create an account with duplicate user	Display error message “The Service Number field must contain a unique value”	Pass
3	Create an account with a password mismatch	Display error message “The Second Password field does not match the Password field”	Pass
4	Create an account with missing information (Last Name)	Display error message “The Last Name field is required”	Pass
5	Create account successfully	Display message “User registered successfully”	Pass

Table 6-1 - Test cases and test result of the user registration process

All the test cases for each processor were summarized into tables and presented in Appendix E for reference.

6.5 Results of the Testing

After running the test case developed using “IntelliJ IDEA” an environment report of the result was generated. A snapshot of the test results is illustrated in Figure 6-2– Snapshot of the test result generated on IntelliJ IDEA. Complete test results are annexed as Appendix - F

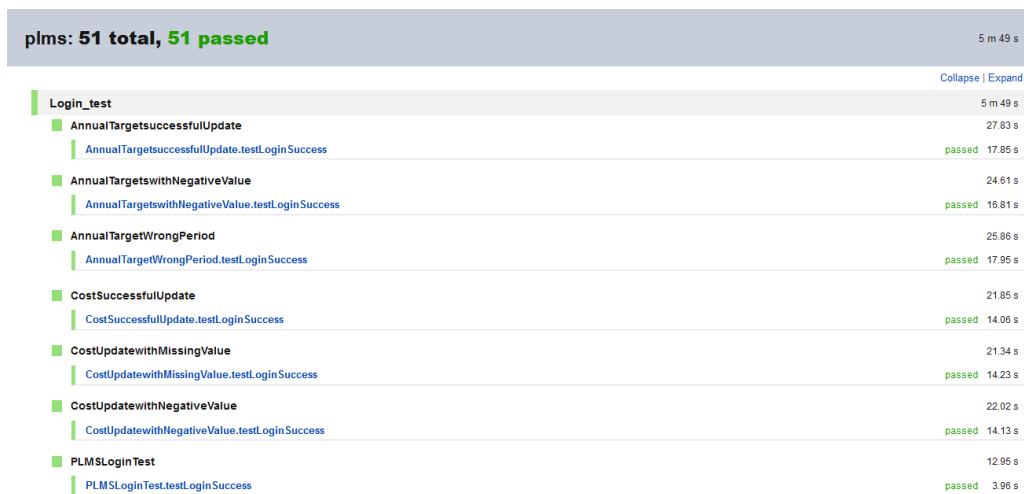


Figure 6-2– Snapshot of the test result generated on IntelliJ IDEA

6.6 System evaluation

Even though an automated process is used for interface testing, it is difficult to use the automated testing method to evaluate the accuracy of the DSM of the system. Therefore, the output of the DSM was evaluated for three products in three years manually. For this process designer and the evaluator is the same, evaluation is done based on the knowledge used for the design. It is not verified by the third party for accuracy. DSM output evaluation is also annexed in Appendix E.

6.7 User Evaluation

User evaluation was done by giving the developed system to six product managers for evaluation. All the dimensions of the evaluation were briefed before evaluation. Having limited data set, availability of the limited evaluators, and lack of understanding about evaluation dimensions of the users were some of the limitations had during the evaluation. The result of the user experience plotted on the radar plot is illustrated in Figure 6-3 - Results of the user experience. Used questioner and summary results are annexed as Appendix H.

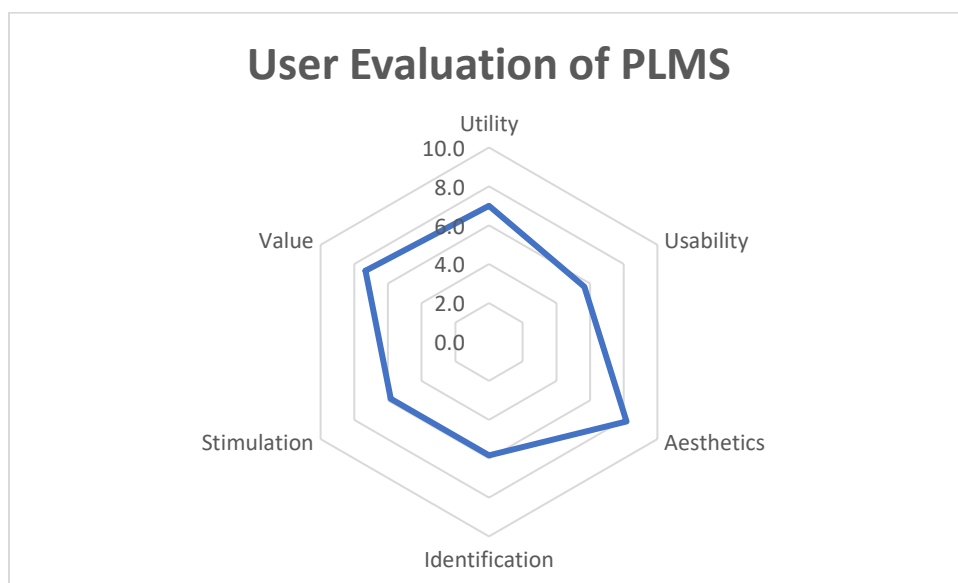


Figure 6-3 -Results of the user experience

7 Conclusion

The objective of this project was to develop PLMS for the telecommunication industry. During the project, requirement analysis was done for product lifecycle management done by product managers and identified the requirement. Accordingly, PLMS were developed with four main functionalities: data capturing, visualizing, reporting and decision supporting. DVM which consists of the dashboard is the main development of the project which helps to visualize the product performance and the output of the DSM. The dashboard includes messages from DSM, Key Performance Indicators (KPI) of the product, and graphs of the targets against achievements on revenue, sales, and forecasted customer churn. Features to download the analysis report in PDF and export the base data in CVS are also provided through the dashboard.

7.1 Challengers

The most challenging part of the development was the design and development of the algorithm for DSM. The algorithm for this project was based on product performance data, annual target, and product campaign performance. Competitor dynamics were not considered in developing the algorithm. To develop a more sophisticated algorithm, the engagement of a cross-functional team including marketing professionals and financial professionals is required. The development of such an accurate algorithm is sufficient scope for the separate project. Validation of such an algorithm is also a challenging task as “2” data sets are required to validate the algorithm with “n” decision variables. Therefore, it is necessary to have a real user with a large data source to develop and validate such an accurate algorithm. However, by selecting data set with three products in three different product lifecycle areas (Growth, Maturity, and Declining) it was able to validate the key outcome of the DSM.

7.2 Potential future work

As mentioned in the scope of the project, there were a few exceptions to the scope of the project. Monitoring and managing the product development process and integration with other systems to

capture the data were excluded from the scope of the project. Therefore, many areas will help to improve the development as a comprehensive solution for product lifecycle management of the service sector. In this PLMS, data is fed to the system through data forms, and it can be improved by providing a facility to backup and upload the data file to the system. System integration of PLMS with other systems also can be considered for improvement which was excluded in the scope of this project. The algorithm of the DSM is a definite area of improvement that needs to be considered for further development. Finally, this PLMS can be improved to use in any service industry vertical.

References

AltexSoft, n.d. *Product Management: Main Stages and Product Manager Role*. [Online]
Available at: <https://www.altexsoft.com/blog/business/product-management-main-stages-and-product-manager-role/>
[Accessed 1 2021].

Anon., 2021. <https://www.autodeskfusionlifecycle.com/en/>. [Online]
[Accessed 20 January 2021].

ARENA, 2021. https://www.xplm.com/our-solutions/plm-integrations/arena-plm/?gclid=EAIaIQobChMIrpv7mY6e5wIVFBOPCh0czw8zEAAYASAAEgIhH_D_BwE.
[Online]
[Accessed 20 January 2021].

Bamboorose, 2021. <https://www.bamboorose.com/product-lifecycle-management/>. [Online]
[Accessed 20 January 2021].

Living Better Media, 2019. *Product Life Cycle Stages*. [Online]
Available at: <http://prouctlifecyclestages.com/>
[Accessed 1 2021].

XPLM, 2021. https://www.xplm.com/our-solutions/plm-integrations/aras-innovator/?gclid=EAIaIQobChMIuKChr6ye5wIVmR0rCh3Q7w1DEAAYASAAEgJAH_D_BwE.
[Online]
[Accessed 20 January 2021].

XPLM, 2021. https://www.xplm.com/our-solutions/plm-integrations/ptc-windchill/?gclid=EAIaIQobChMI0uixwqCe5wIVyBwrCh3aVQsrEAAYASAAEgJV8vD_BwE.
[Online]
[Accessed 20 January 2021].

Appendix A – Product Lifecycle Basics

1. Product lifecycle

Product lifecycle is the period from the date of the product introduction to the market and the date of product withdrawal from the market. During this life cycle, different behaviours of profit margins, product revenue, and cost of the product can be identified. Based on these characteristics, the product lifecycle is divided into four major stages: introduction, growth, maturity, and decline. In other words, different characteristics mean different things for businesses that are trying to manage the life cycle of their particular products. (Living Better Media, 2019)

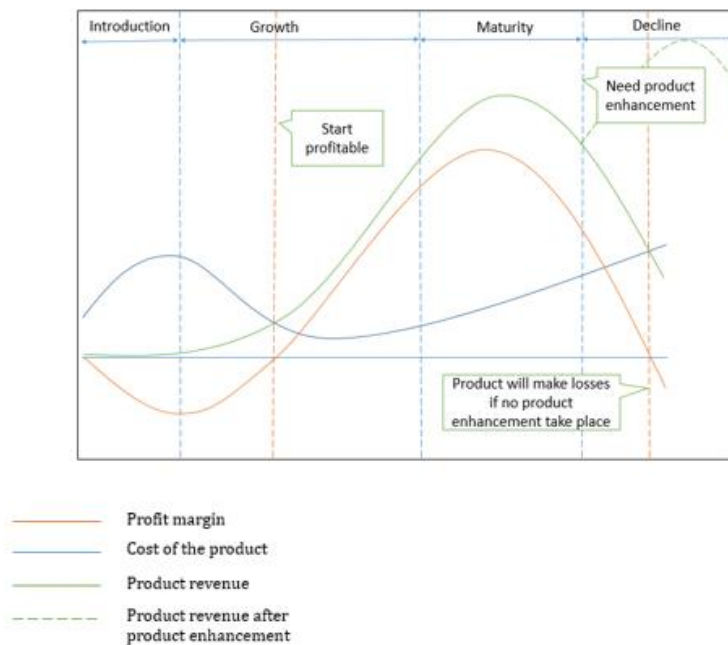


Figure A-1 - Stages of the product lifecycle

Figure A-1 illustrates the change of product performance parameters such as revenue, cost, and profitability with time with four product lifecycle stages. Understanding on different characteristics of each stage is essential to decide on product lifecycle management.

2. Introduction

In this phase, the organization needs to invest in product launches, advertising, market activations, and sales campaigns. The cost of the product is very much high in this stage compared to the revenue generated by the product. This stage organization has to follow either market development strategy or market penetration strategy. This will depend on the product idea; whether it is a new product concept or an existing product concept.

3. Growth

The growth stage is a period of rapid market acceptance and starting to generate profit. In this stage number of subscribers or number of sales will be increased while improving the revenue. In this stage, sales need to be closely monitored against annual targets and need to make necessary corrections to avoid the gap between the target and the actual performance. In the growth stage, we can either follow the market development strategy or the market penetration strategy. Early growth stage products can make losses. But, it has to make a profit within a very short period.

4. Maturity

In the maturity stage, sales growth and profitability become steady due to the market saturation and. Profits level will start to decline because of higher marketing and sales overhead to defend the product against the competition. Further loyalty offers, value-added services, etc... need to be introduced to retain the customers in this stage while mitigating churn.

5. Declining

When the product enters this stage, sales fall off and profits drop. This might be due to the outdated technology or concept of the existing product. Once this is indicated in the monitoring parameters, the organization needs to select the option such as enhancing the product with new features, product rebranding, product bundling, etc... to either grow or keep the existing sales or customer base.

6. Product Management

Product management is led by the *product* manager. It is different from project management which is led by the project manager. A project manager is responsible for a single part of a product lifecycle: product development. The product manager's responsibility is to lead a product from the germ of an idea to launch, focusing on features, business value, and the customer. (AltexSoft, n.d.) In other words, product management is the management of the marketing mix; product, price, place, and promotions.

Appendix B - Activity diagrams of the design

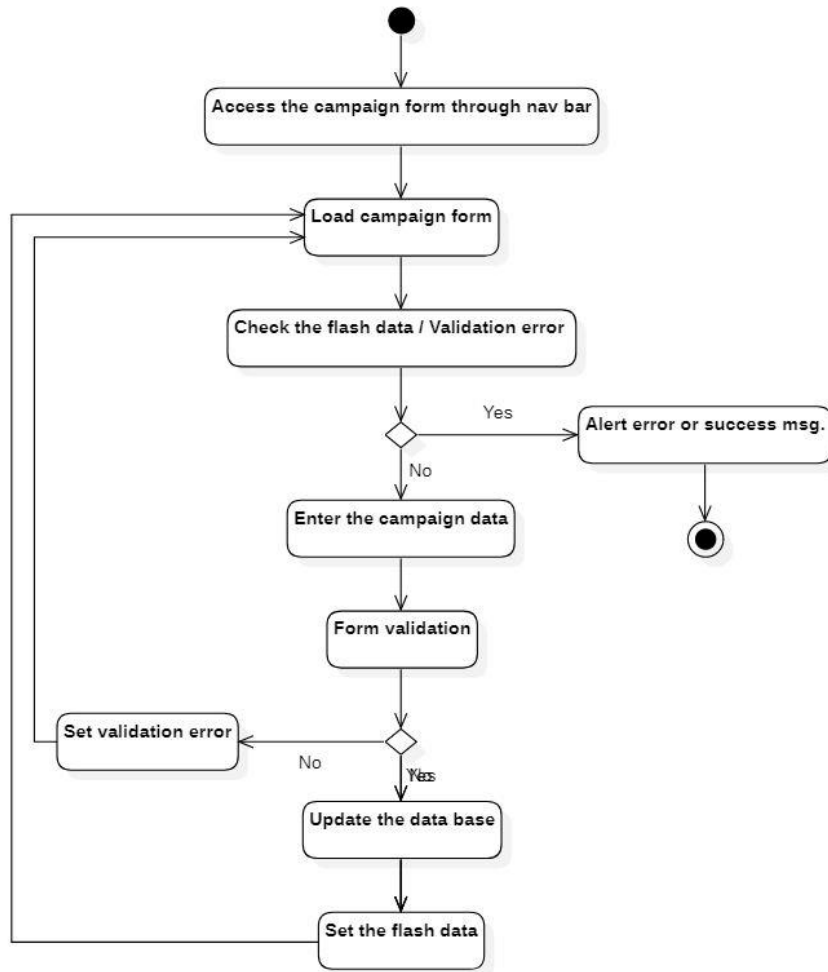


Figure B-0-1 - Activity diagram for product campaign configuration process

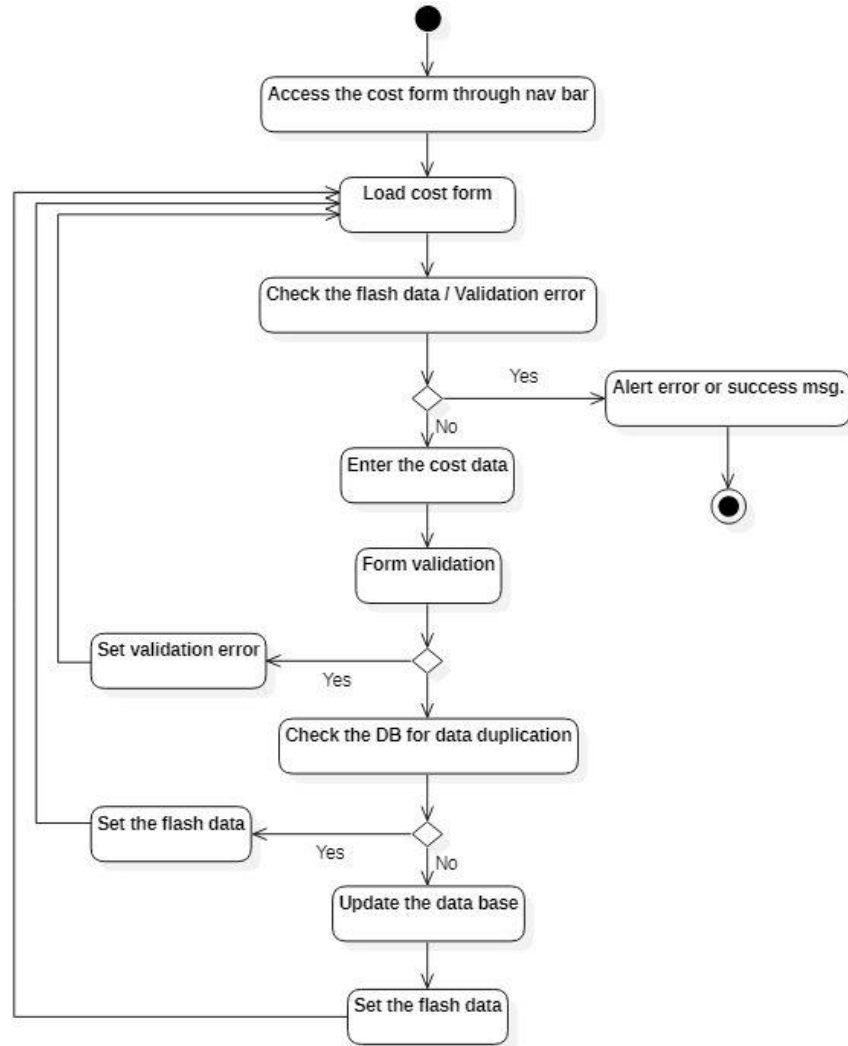
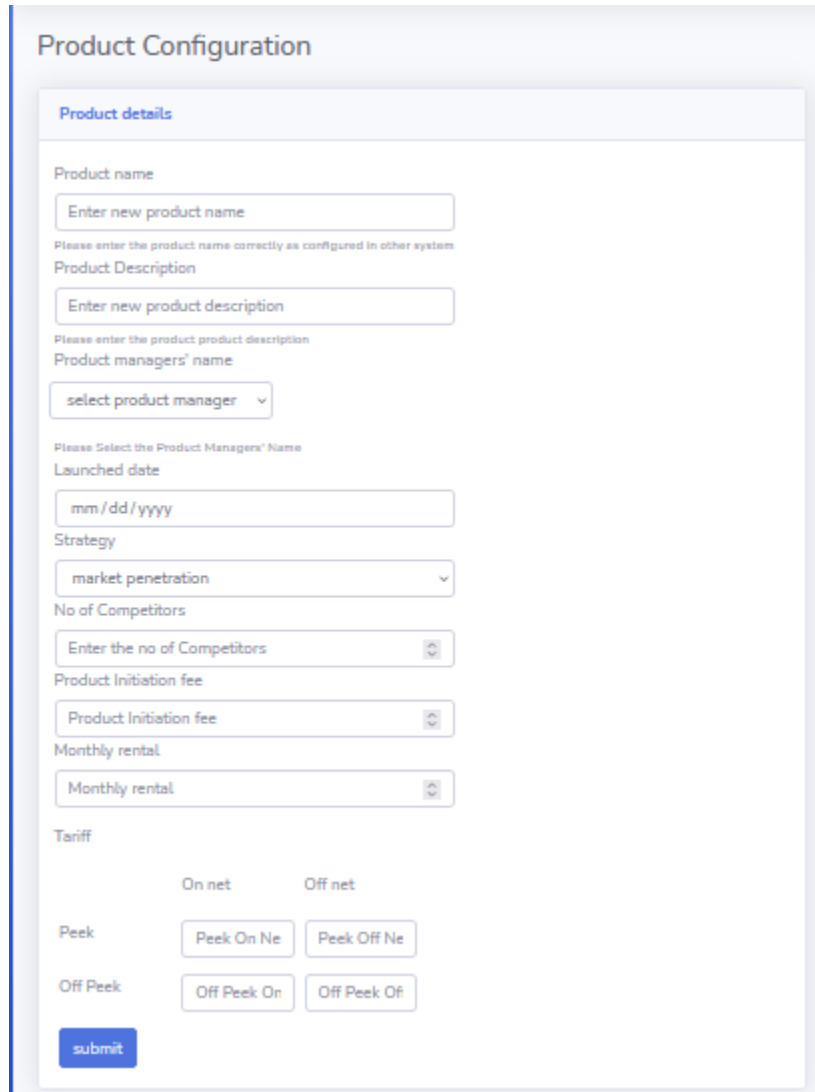


Figure B-0-2 - Activity diagram for cost data update process

Appendix C - UI designs



The image shows a web form titled "Product Configuration". The form is organized into several sections:

- Product details** (Section Header)
- Product name**: A text input field with the placeholder "Enter new product name". Below it is a note: "Please enter the product name correctly as configured in other system".
- Product Description**: A text input field with the placeholder "Enter new product description". Below it is a note: "Please enter the product product description".
- Product managers' name**: A dropdown menu with the text "select product manager". Below it is a note: "Please Select the Product Managers' Name".
- Launched date**: A date input field with the placeholder "mm/dd/yyyy".
- Strategy**: A dropdown menu with the text "market penetration".
- No of Competitors**: A numeric input field with the placeholder "Enter the no of Competitors".
- Product Initiation fee**: A numeric input field with the placeholder "Product Initiation fee".
- Monthly rental**: A numeric input field with the placeholder "Monthly rental".
- Tariff**: A section with two columns: "On net" and "Off net".
 - Under "On net": A "Peek" label with a "Peek On Ne" button.
 - Under "Off net": A "Peek" label with a "Peek Off Ne" button.
 - Under "On net": An "Off Peek" label with an "Off Peek On" button.
 - Under "Off net": An "Off Peek" label with an "Off Peek Of" button.
- submit**: A blue button at the bottom left.

Figure C-1 - Product configuration form

The screenshot shows a web form titled "Campaign configuration". At the top, there is a header "Enter your campaign details here". Below this, the form contains several input fields: a dropdown menu for "Product name" with the placeholder "select product name"; a text input for "Campaign Name" with the placeholder "Enter new campaign name"; a dropdown menu for "Campaign Initiation Fee"; two date input fields for "Campaign Start Date" and "Campaign End Date", both with the placeholder "mm / dd / yyyy"; and a dropdown menu for "Budgeted cost for campaign" with the placeholder "Budgeted cost in millions". A blue "submit" button is located at the bottom left of the form area. A small note above the Campaign Name field reads: "Please enter the product name correctly as configured in other system".

Figure C-2 - Campaign configuration form

The screenshot shows a web form titled "Progress update". It is divided into two main sections. The left section is titled "Update monthly progress of the products here" and contains several input fields: a dropdown for "Year" with "2017" selected; a dropdown for "Month" with "JANUARY" selected; a dropdown for "Product Name" with "select product name" selected; and five dropdown menus for "Revenue", "Number of New Connections", "Number of Disconnections", and "Customer Base", each with a placeholder "Number of new connections according to the BSS reports in millions" or "Customer base at the end of the month". A blue "submit" button is at the bottom left. The right section is titled "Instructions" and contains a paragraph of text: "System will not allow to update the immediate past month data, if you have missed the update of any previous month. You must edit previous month first." Below this text are two buttons: a blue "here" button and a teal "here" button. The teal button is preceded by the text "If you want to update the existing data click".

Figure C-3 - Progress update form

Annual target

Update the annual targets here

Year
2017

Product Name
select product name

Revenue

JAN	FEB	MAR	APR	MAY	JUN
JUL	AUG	SEP	OCT	NOV	DEC

Please enter the product revenue target monthly breakdown based on annual business plan

New Connections

JAN	FEB	MAR	APR	MAY	JUN
JUL	AUG	SEP	OCT	NOV	DEC

Please enter the product new connection target monthly breakdown based on annual business plan

Disconnections Forecast

JAN	FEB	MAR	APR	MAY	JUN
JUL	AUG	SEP	OCT	NOV	DEC

Please enter the product disconnections forecast monthly breakdown based on annual business plan

Customer Base
Customer base based at the beginning of the year

submit

Figure C-4 -Annual target form

Cost onfiguration

Update product cost details here

Product Name

CAPEX

Please enter the Initial investment for the product in millions (Rs.)

OPEX

Network Cost

CPE Cost

ATL Cost

BTL Cost

Other Cost

Instructions

If the system is not allowing to enter the cost data, please check the data availability .

Check the available data

If you want to update the existing cost data please click

Figure C-5 - Cost configuration form

Appendix D - Mathematical Model for Decision Support System

Mathematical equations

Year-to-date sales can be calculated according to the equation D-1 where “n” represents the month of concern, j represents the year of concern and x represent the product of concern.

$$YTDS_{jx} = \sum_{i=1}^n SA_{ijx}$$

Equation D-1

Equation D-1 - Year to date Sale

Year-to-date revenue can be calculated according to the equation D-2 where “n” represents the month of concern, j represents the year of concern and x represent the product of concern.

$$YTDR_{jx} = \sum_{i=1}^n RA_{ijx}$$

Equation D-2 - Year to date Revenue

The year-to-date customer base can be calculated according to the equation D-3 where “n” represents the month of concern, j represents the year of concern and x represent the product of concern.

$$YTDC_{jx} = CA_{njx}$$

Equation D-3- Year to date Customer Base

Year-to-date disconnection can be calculated according to the equation D-4 where “n” represents the month of concern, j represents the year of concern and x represent the product of concern.

$$YTDD_{jx} = \sum_{i=1}^n DA_{ijx}$$

Equation D-4 - Year to date disconnections

Year on year sales progress can be calculated according to the equation D-5 where “n” represents the month of concern, j represents the year of concern and x represent the product of concern.

$$YOYS_{jx} = \frac{(\sum_{i=1}^n SA_{ijx} - \sum_{i=1}^n SA_{i(j-1)x})}{\sum_{i=1}^n SA_{i(j-1)x}}$$

Equation D-5 - Year on Year Sales Progress

Year on year revenue growth can be calculated according to the equation D-6 where “n” represents the month of concern, j represents the year of concern and x represent the product of concern.

$$YOYR_{jx} = \frac{(\sum_{i=1}^n RA_{i} - \sum_{i=1}^n RA_{i(j-1)x})}{\sum_{i=1}^n RA_{i(j-1)x}}$$

Equation D-6 - Year on Year Revenue Growth

Year on year customer base growth can be calculated according to the equation D-7 where “n” represents the month of concern, j represents the year of concern and x represent the product of concern.

$$YOYC_{jx} = \frac{(RA_{ijx} - RA_{i(j-1)x})}{RA_{i(j-1)x}}$$

Equation D-7 - Year on Year Customer Base Growth

Year on year customer churn mitigation can be calculated according to the equation D-8 where “n” represents the month of concern, j represents the year of concern and x represent the product of concern.

$$YOYD_{jx} = \frac{(\sum_{i=1}^n DA_{i(j-1)x} - \sum_{i=1}^n DA_{ijx})}{\sum_{i=1}^n RA_{ijx}}$$

Equation D-8 - Year on Year Customer Churn mitigation

The sales success rate can be calculated using equation D-9 where “n” represents the month of concern, j represents the year of concern and x represent the product of concern.

$$SSR_{jx} = \frac{\sum_{i=1}^n SA_{ijx}}{\sum_{i=1}^n ST_{ijx}}$$

Equation D-9 - Sales success Rate

Revenue achievement rate can be calculated using equation D-10 where “n” represents the month of concern, j represents the year of concern and x represent the product of concern.

$$RAR_{jx} = \frac{\sum_{i=1}^n RA_{ijx}}{\sum_{i=1}^n RT_{ijx}}$$

Equation D-10 - Revenue Achievement Rate

Customer base achievement rate can be calculated using equation D-11 where “n” represents the month of concern, j represents the year of concern and x represent the product of concern.

$$CAR_{jx} = \frac{\sum_{i=1}^n CA_{ijx}}{\sum_{i=1}^n CT_{ijx}}$$

Equation D-11 - Revenue Achievement Rate

Churn mitigation achievement rate can be calculated using equation D-12 where “n” represents the month of concern, j represents the year of concern and x represent the product of concern.

$$CMAR_{jx} = \frac{\sum_{i=1}^n DT_{ijx}}{\sum_{i=1}^n DA_{ijx}}$$

Equation D-12 - Churn Mitigation Achievement Rate

The life span of the product can be calculated using equation D-13.

$$LS = \text{Today date} - \text{Product launched date}$$

Equation D-13 - The life span of the product

Stage of product lifecycle can be decided according to the logical equation D-14 where YOYR and LS are years on year revenue and Life span of the product.

$$SPL = \begin{cases} \text{Growth} & \text{if } YOYR > 0.2 \\ \text{PreMatured} & \text{if } 0.2 > YOYR > -0.2 \text{ and } LS < 4 \\ \text{Maturity} & \text{if } 0.2 > YOYR > -0.2 \text{ and } LS > 4 \\ \text{Declining} & \text{if } YOYR < -0.2 \text{ and } LS > 7 \\ \text{Product failure} & \text{else} \end{cases}$$

Equation D-14 – Stages of the product lifecycle

The revenue share of the product can be calculated using equation D-15. Where RS_{px} is the revenue share of the product x

$$RS_{px} = \frac{\sum_{i=1}^n RA_{pji}}{\sum_{j=1}^m \sum_{i=1}^n RA_{pji}}$$

Equation D-15 - Revenue share of the product

Market share significance can be decided based on logical equation D-16.

$$MS_{px} = \begin{cases} Low & \text{if } RS_{px} < 0.2 \\ High & \text{if } RS_{px} \geq 0.2 \end{cases}$$

Equation D-16 - Significance of the market share

Assumption – The company has a significant overall market share. Therefore, the market share of the individual product is proportional to the revenue share of the product.

Average sales per month can be calculated using equation D-17 where “n” represents the month of concern, j represents the year of concern and x represent the product of concern.

$$ASPM_{jx} = \frac{(\sum_{i=1}^n SA_{ijx} + \sum_{i=n+1}^{12} SA_{i(j-1)x})}{12}$$

Equation D-17 - Average sales per month

Average revenue per month can be calculated using equation D-18 where “n” represents the month of concern, j represents the year of concern and x represent the product of concern.

$$ARPM = \frac{(\sum_{i=1}^n RA_{ijx} + \sum_{i=n+1}^{12} RA_{i(j-1)x})}{12}$$

Equation D-18 - Average revenue per month

Average customer acquisition per month can be calculated using equation D-19 where “n” represents the month of concern, “j” represents the year of concern, and “x” represents the product of concern.

$$ACPM = \frac{CA_{ijx} - CA_{i(j-1)x}}{12}$$

Equation D-19 - Average customer acquisition per month

Average disconnections per month can be calculated using equation D-20 where “n” represents the month of concern, “j” represents the year of concern, and “x” represents the product of concern.

$$ADPM = \frac{(\sum_{i=1}^n DA_{ijx} + \sum_{i=n+1}^{12} DA_{i(j-1)x})}{12}$$

Equation D-20 - Average disconnections per month

Logical Equations

R – Revenue target was achieved

C – Customer base target was achieved

S - Sales target was achieved

D - Disconnections are below the estimated figure

Message type	Message
Well done	M1 - Well done! M2 - Product has achieved revenue targets M3 - Product has achieved customer base targets M4 - Product ARPU is improving
Warning	M5 - Your ARPU is dropping M6 - Be vigilant about the quality of sales M7 - Be vigilant about the suspended customer base M8 - Revenue and customer base targets are not achieving

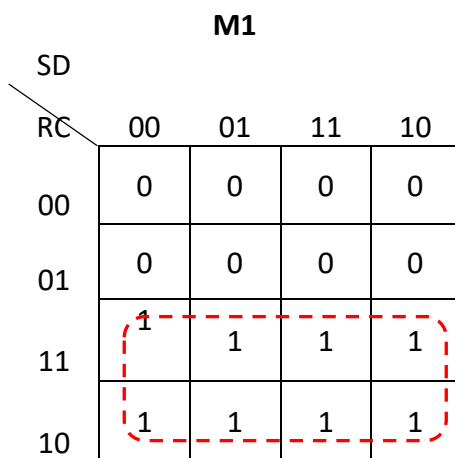
Direction	M9 - Need immediate product revision M10 - Need to intensify the marketing activities M11 - Need to improve the sales
------------------	---

Table D-1 - Messages and message types in decision support system

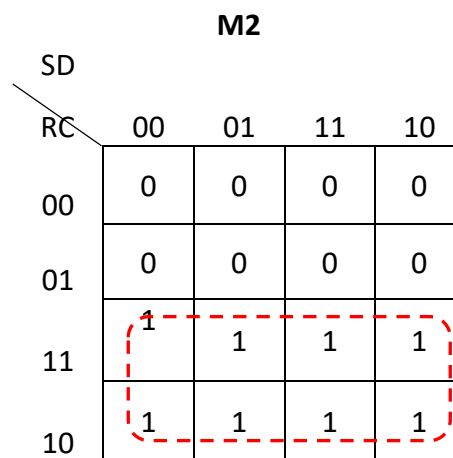
R	C	S	D	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11
0	0	0	0	0	0	0	0	0	0	0	1	1	0	1
0	0	0	1	0	0	0	0	0	0	0	1	1	0	1
0	0	1	0	0	0	0	0	0	1	0	1	1	0	0
0	0	1	1	0	0	0	0	0	0	0	1	1	0	0
0	1	0	0	0	0	0	0	1	0	0	0	1	0	0
0	1	0	1	0	0	0	0	1	0	0	0	0	1	1
0	1	1	0	0	0	0	0	1	1	1	0	0	0	0
0	1	1	1	0	0	0	0	1	1	1	0	0	0	0
1	0	0	0	1	1	0	1	0	0	0	0	0	0	0
1	0	0	1	1	1	0	1	0	0	0	0	0	0	0
1	0	1	0	1	1	0	1	0	0	0	0	0	0	0
1	0	1	1	1	1	0	1	0	0	0	0	0	0	0
1	1	0	0	1	1	1	0	0	0	0	0	0	0	0
1	1	0	1	1	1	1	0	0	0	0	0	0	0	0
1	1	1	0	1	1	1	0	0	0	0	0	0	0	0
1	1	1	1	1	1	1	0	0	0	0	0	0	0	0
1	1	1	1	1	1	1	0	0	0	0	0	0	0	0

Table D-2 - Decision table for the decision support system

K- Maps were used to simplify the logic to develop the algorithm for the decision support system



M1=R



M2=R

M3

SD \ RC	00	01	11	10
00	0	0	0	0
01	0	0	0	0
11	1	1	1	1
10	0	0	0	0

$M3=RC$

M4

SD \ RC	00	01	11	10
00	0	0	0	0
01	0	0	0	0
11	0	0	0	0
10	1	1	1	1

$M4=RC\bar{C}$

M5

SD \ RC	00	01	11	10
00	0	0	0	0
01	1	1	1	1
11	0	0	0	0
10	0	0	0	0

$M5=\bar{R}C$

M6

SD \ RC	00	01	11	10
00	0	0	0	1
01	0	0	1	1
11	0	0	0	0
10	0	0	0	0

$M6=\bar{R}CS+\bar{R}S\bar{D}$

M7

SD \ RC	00	01	11	10
00	0	0	0	0
01	0	0	1	1
11	0	0	0	0
10	0	0	0	0

$M7=\bar{R}CS$

M8

SD \ RC	00	01	11	10
00	1	1	1	1
01	0	0	0	0
11	0	0	0	0
10	0	0	0	0

$M8=\bar{R}\bar{C}$

M9

SD				
RC	00	01	11	10
00	1	1	1	1
01	1	0	0	0
11	0	0	0	0
10	0	0	0	0

$$M9 = \bar{R}\bar{C} + \bar{R}\bar{S}\bar{D}$$

M10

SD				
RC	00	01	11	10
00	0	0	0	0
01	0	1	0	0
11	0	0	0	0
10	0	0	0	0

$$M10 = \bar{R}C\bar{S}D$$

M11

SD				
RC	00	01	11	10
00	1	1	0	0
01	0	1	0	0
11	0	0	0	0
10	0	0	0	0

$$M11 = \bar{R}\bar{C}\bar{S} + \bar{R}\bar{S}D$$

Appendix E - Summary of the test result

Test case No		01	
Test Case Name		User Login	
Test environment/Preconditions		The application has not been open in the browser	
Step	Action	Expected result	Test result (Pass/Fail)
1	Open the application on a web browser	Users shall be directed to the login page	Pass
2	Enter the correct username and password	Users shall be directed to the dashboard page	Pass
3	Logout from the system	Users shall be directed to the login page	Pass
4	Enter the incorrect correct username and password	Display error message “Invalid username or password”	Pass
5	Enter the correct username and incorrect password	Display error message “Invalid username or password”	Pass
6	Press the “Sign in” button without a username	Display error message “The service Number field is required”	Pass
7	Press the “Sign in” button without a password	Display error message “The password field is required”	Pass

Table E-1 - Test cases for the login process

Test case No		02	
Test Case Name		User creation	
Test environment/Preconditions		User logged in to the system with administrator privilege	
Step	Action	Expected result	Test result (Pass/Fail)
1	Access the registration page through the navigation bar	Users will be directed to the registration form	Pass
2	Create an account with duplicate user	Display error message “The Service Number field must contain a unique value”	Pass
3	Create an account with a password mismatch	Display error message “The Second Password field does not match the Password field”	Pass
4	Create an account with missing information (Last Name)	Display error message “The Last Name field is required”	Pass
5	Create account successfully	Display message “User registered successfully”	Pass

Table E-2 - Test cases for the new user registration process

Test case No		03	
Test Case Name		New product creation	
Test environment/Preconditions		User logged in to the system and access the product configuration page through the navigation bar (Configurations>Product)	
Step	Action	Expected result	Test result (Pass/Fail)
1	Product configuration with missing field (Product Name)	Display error message “The Product Name field is required.”	Pass
2	Product configuration with missing field (Product Description)	Display error message “The Product Description field is required”	Pass
3	Product configuration with missing field (launched Date)	Display error message “The launched Date field is required”	Pass
4	Product configuration with missing field (No of Competitors)	Display error message “The No of Competitors field is required”	Pass
5	Product configuration with missing field (Product Initiation Fee)	Display error message “The Product Initiation Fee field is required”	Pass
6	Product configuration with missing field (Monthly Rental)	Display error message “The Monthly Rental field is required”	Pass
7	Product configuration with product name duplication	Display error message “The Product Name field must contain a unique value”	Pass
8	Product configuration with negative values (Product Initiation Fee)	Display error message “The Product Initiation Fee field must contain a number greater than or equal to 0”	Pass
9	Product configuration with negative values (Monthly Rental)	Display error message “The Monthly Rental field must contain a number greater than or equal to 0”	Pass
10	Product configuration with invalid launched date	Display error message “The launched Date field cannot be advanced more than 90 days”	Pass
11	Successful product configuration	Display error message “Your product data updated successfully”	Pass

Table E-3 - Test cases for the new product configuration process

Test case No		04	
Test Case Name		New campaign creation	
Test environment/Preconditions		User logged in to the system and access the campaign configuration page through the navigation bar (Configurations>Campaign)	
Step	Action	Expected result	Test result (Pass/Fail)
1	Campaign configuration with missing field (Product Name)	Display error message “The Product Name field is required”	Pass
2	Campaign configuration with missing field (Campaign Name)	Display error message “The Campaign Name field is required”	Pass
3	Campaign configuration with missing field (Campaign Initiation)	Display error message “The Campaign Initiation field is required”	Pass
4	Campaign configuration with missing field (Campaign Start Date)	Display error message “The Campaign Start Date field is required”	Pass
5	Campaign configuration with missing field (Campaign End Date)	Display error message “The Campaign End Date field is required”	Pass
6	Campaign configuration with missing field (Campaign Cost)	Display error message “The Campaign Cost field is required”	Pass
7	Campaign configuration with campaign name duplication	Display error message “The Campaign Name field must contain a unique value”	Pass
8	Campaign configuration with interchanging campaign start date and end date	Display error message “The Campaign End Date field cannot be the date before the campaign Start date”	Pass
9	Campaign configuration for already started or completed campaign	Display error message “The Campaign Start Date field cannot be the past date”	Pass
10	Campaign configuration with negative values (Campaign Initiation)	Display error message “The Campaign Initiation field must contain a number greater than or equal to 0”	Pass
11	Campaign configuration with negative values (Campaign Cost)	Display error message “The Campaign Cost field must contain a number greater than or equal to 0”	Pass
12	Successful campaign configuration	Display success message “Your campaign data updated successfully”	Pass

Table E-4 - Test cases for the new campaign configuration process

Test case No		05	
Test Case Name		Product cost update	
Test environment/Preconditions		User logged in to the system and access the cost page through the navigation bar (Updates>Cost)	
Step	Action	Expected result	Test result (Pass/Fail)
1	Cost update with missing field (Product Name)	Display error message “The product name field is required”	Pass
2	Cost update with missing field (CAPEX Investment)	Display error message “The CAPEX Investment field is required”	Pass
3	Cost update with missing field (Network Cost)	Display error message “The Network Cost field is required”	Pass
4	Cost update with missing field (CPE Cost)	Display error message “The CPE Cost field is required”	Pass
5	Cost update with missing field (ATL Marcom Cost)	Display error message “The ATL Marcom Cost field is required”	Pass
6	Cost update with missing field (BTL Marcom Cost)	Display error message “The BTL Marcom Cost field is required”	Pass
7	Product cost update with negative values (CAPEX Investment)	Display error message “The CAPEX Investment field must contain a number greater than or equal to 0.”	Pass
8	Product cost update with negative values (Network Cost)	Display error message “The Network Cost field must contain a number greater than or equal to 0.”	Pass
9	Product cost update with negative values (CPE Cost)	Display error message “The CPE Cost field must contain a number greater than or equal to 0.”	Pass
10	Product cost update with negative values (ATL Marcom Cost)	Display error message “The ATL Marcom Cost field must contain a number greater than or equal to 0.”	Pass
11	Product cost update with negative values (BTL Marcom Cost)	Display error message “The BTL Marcom Cost field must contain a number greater than or equal to 0.”	Pass
12	Accidental product cost data overwrite.	Display error message “This product cost data is already available”	Pass
13	Successful Product cost update	Display error message “Your product cost data updated successfully”	Pass

Table E-5 - Test cases for product cost update process

Test case No		06	
Test Case Name		Product progress update	
Test environment/Preconditions		The user logged in to the system and access the progress update page through the navigation bar (Updates>Progress)	
Step	Action	Expected result	Test result (Pass/Fail)
1	Progress update with missing field (Product Name)	Display error message “The Product Name field is required.	Pass
2	Progress update with missing field (Product Revenue)	Display error message “The Product Revenue field is required”	Pass
3	Progress update with missing field (No of New Connections)	Display error message “The No of New Connections field is required.”	Pass
4	Progress update with missing field (Total Disconnections)	Display error message “The Total Disconnections field is required.”	Pass
5	Progress update with missing field (Customer Base)	Display error message “The Customer Base field is required”	Pass
6	Monthly progress update with negative values (Product Revenue)	Display error message “The Product Revenue field must contain a number greater than or equal to 0.”	Pass
7	Monthly progress update with negative values (No of New Connections field)	Display error message “The No of New Connections field must contain a number greater than or equal to 0.”	Pass
8	Monthly progress update with negative values (Total Disconnections)	Display error message “The Total Disconnections field must contain a number greater than or equal to 0.”	Pass
9	Monthly progress update with negative values (Customer Base)	Display error message “The Customer Base field must contain a number greater than or equal to 0.”	Pass
10	Monthly progress update for the wrong period	Display error message “You can only update the past month”	Pass
11	Monthly progress update without a previous update	Display error message “This product progress data has not been updated for the previous month”	Pass
12	Monthly progress update accidental overwrites	Display error message “This product progress data is already available”	Pass
13	Successful monthly progress update	Display success message “Your product progress data updated successfully”	Pass

Table E-6 - Test cases for the product progress data update process

Test case No		07	
Test Case Name		Annual target update	
Test environment/Preconditions		User logged in to the system and access the target update page through the navigation bar (Updates>target)	
Step	Action	Expected result	Test result (Pass/Fail)
1	Enter annual target update in the wrong period	Display error message “The ABP Year field has to be this year or next year”	Pass
2	Enter annual update with missing data (Product Name)	Display error message “The Product Name field is required.”	Pass
3	Enter annual target update with missing data (product Revenue for 12 months)	Display error message “The productRevenueJan field is required.” (For January)	Pass
4	Enter annual target update with missing data (New Connections for 12 months)	Display error message “The newConnectionsJan field is required.” (For January)	Pass
5	Enter annual target update with missing data (Disconnections for 12 months)	Display error message “The disConnectionsJan field is required.” (For January)	Pass
6	Enter product revenue annual target update with negative values (Repeat for 12 months)	Display error message “The productRevenueXXX field must contain a number greater than or equal to 0.” (XXX represent the month)	Pass
7	Enter new connection annual target update with negative values (Repeat for 12 months)	Display error message “The newConnectionsXXX field must contain a number greater than or equal to 0.” (XXX represent the month)	Pass
8	Enter disconnection annual forecast update with negative values (Repeat for 12 months)	Display error message “The disConnectionsXXX field must contain a number greater than or equal to 0.” (XXX represent the month)	Pass
9	Enter target data already available in database	Display error message “This product target data is already updated”	Pass

Table E-7 - Test cases for annual target data update process

	Year	Product	DSM Output	Statement evaluation
1	2018	4G LTE	1. This product is in its' "Maturity" stage of the product lifecycle	Correct
			2. No product campaign declared for this product yet	Correct
			3. The product has achieved the Revenue targets	Correct
			4. The product has achieved the customer churn mitigation targets	Correct
			5. The market attraction of the product is good, and it is very competitive in the market	Correct
			6. The product has not achieved the Customer base targets	Correct
2	2019	4G LTE	1. This product is in its' "Maturity" stage of the product lifecycle	Correct
			2. No product campaign declared for this product yet	Correct
			3. The product has achieved the Revenue targets	Correct
			4. The product has achieved the Customer base targets	Correct
			5. The product has achieved the customer churn mitigation targets	Correct
			6. Product has poor market attraction but is very competitive in the market	Correct
			7. The product has not achieved the sales target	Correct
3	2020	4G LTE	1. This product is in its' "Maturity" stage of the product lifecycle	Correct
			2. No product campaign declared for this product yet	Correct
			3. The product has achieved the Revenue targets	Correct
			4. The product has achieved the sales targets	Correct
			5. The product has achieved the Customer base targets	Correct
			6. The product has achieved the customer churn mitigation targets	Correct
			7. The market attraction of the product is good, and it is very competitive in the market	Correct
4	2018	Fibre	1. This product is in its' "Maturity" stage of the product lifecycle	Correct

			2. No product campaign declared for this product yet	Correct
			3. Product has poor market attraction but is very competitive in the market	Correct
			4. The product has not achieved the Revenue targets	Correct
			5. The product has not achieved the sales targets	Correct
			6. The product has not achieved the Customer base targets	Correct
			7. The product has not achieved the customer churn mitigation targets	Correct
5	2019	Fiber	1. This product is in its' "Maturity" stage of the product lifecycle	Correct
			2. No product campaign declared for this product yet	Correct
			3. Product has poor market attraction but is very competitive in the market	Correct
			4. The product has not achieved the Revenue targets	Correct
			5. The product has not achieved the sales targets	Correct
			6. The product has not achieved the Customer base targets	Correct
			7. The product has not achieved the customer churn mitigation targets	Correct
6	2020	Fiber	1. The product has not achieved the customer churn mitigation targets	Correct
			2. Declared product campaign is not effective	Correct
			3. The product has achieved the sales targets	Correct
			4. The market attraction of the product is good, and it is very competitive in the market	Correct
			5. The product has not achieved the Revenue targets	Correct
			6. The product has not achieved the Customer base targets	Correct
			7. The product has not achieved the customer churn mitigation targets	Correct
7	2018	Mega	1. This product is in its' "Maturity" stage of the product lifecycle	Correct
			2. No product campaign declared for this product yet	Correct
			3. The product has achieved the Revenue targets	Correct

			4. The product has achieved the Customer base targets	Correct
			5. Product has poor market attraction but is very competitive in the market	Correct
			6. The product has not achieved the sales targets	Correct
8	2019	Mega	1. This product is in its' "Maturity" stage of the product lifecycle	Correct
			2. No product campaign declared for this product yet	Correct
			3. The product has achieved the Revenue targets	Correct
			4. The product has achieved the sales targets	Correct
			5. The product has achieved the Customer base targets	Correct
			6. The product has achieved the customer churn mitigation targets	Correct
			7. The market attraction of the product is good, and it is very competitive in the market	Correct
9	2020	Mega	1. This product is in its' "Maturity" stage of the product lifecycle	Correct
			2. Declared product campaign is not effective	Correct
			3. The product has achieved the Revenue targets	Correct
			4. The product has achieved the sales targets	Correct
			5. The product has achieved the Customer base targets	Correct
			6. The product has achieved the customer churn mitigation targets	Correct
			7. The market attraction of the product is good, and it is very competitive in the market	Correct

Table E-8 - DSM Output evaluation

Appendix F – Automated Test Report

Test result generated from “IntelliJ IDEA” environment by running “TestNG” unit test cases.

	Collapse Expand
Login_test	5 m 49 s
■ AnnualTargetsSuccessfulUpdate	27.83 s
■ AnnualTargetsSuccessfulUpdate.testLoginSuccess	passed 17.85 s
■ AnnualTargetswithNegativeValue	24.61 s
■ AnnualTargetswithNegativeValue.testLoginSuccess	passed 16.81 s
■ AnnualTargetWrongPeriod	25.86 s
■ AnnualTargetWrongPeriod.testLoginSuccess	passed 17.95 s
■ CostSuccessfulUpdate	21.85 s
■ CostSuccessfulUpdate.testLoginSuccess	passed 14.06 s
■ CostUpdatewithMissingValue	21.34 s
■ CostUpdatewithMissingValue.testLoginSuccess	passed 14.23 s
■ CostUpdatewithNegativeValue	22.02 s
■ CostUpdatewithNegativeValue.testLoginSuccess	passed 14.13 s
■ PLMSLogin Test	12.95 s
■ PLMSLogin Test.testLoginSuccess	passed 3.96 s
■ PLMSLogin TestFail	10.78 s
■ PLMSLogin TestFail.testLoginSuccess	passed 3.51 s
■ ProConfigSuccess Test	18.28 s
■ ProConfigSuccess Test.testLoginSuccess	passed 11.21 s
■ ProConfigwithDateValidation	21.38 s
■ ProConfigwithDateValidation.testLoginSuccess	passed 14.27 s
■ ProConfigwithDuplicateName	18.55 s
■ ProConfigwithDuplicateName.testLoginSuccess	passed 11.08 s

■ ProConfigwithMissingItem	18.57 s
ProConfigwithMissingItem.testLoginSuccess	passed 11.18 s
■ ProConfigwithNegativeValue	18.69 s
ProConfigwithNegativeValue.testLoginSuccess	passed 11.47 s
■ ProgressUpdateSuccessfull	21.34 s
ProgressUpdateSuccessfull.testLoginSuccess	passed 13.90 s
■ ProgressUpdatewithMissingValue	21.40 s
ProgressUpdatewithMissingValue.testLoginSuccess	passed 14.04 s
■ ProgressUpdatewithNegativeValue	21.89 s
ProgressUpdatewithNegativeValue.testLoginSuccess	passed 14.03 s
■ ProgressUpdatewithWrongTime	21.40 s
ProgressUpdatewithWrongTime.testLoginSuccess	passed 13.91 s

Appendix G - PDF Report Generated

ProLife

Product Lifecycle Management System

ProLife Software (Pvt) Ltd, East Avenue, Colombo 07

Web - WWW.prolife.lk email - info@prolife.lk Tel - 0117702343

Product Analysis Report

Report on 4G LTE
Report generated on 11/05/2021

Product Key Performance Indicators

Revenue Related KPI

KPI	Value	Unit
Y2D Revenue	2007	Rs.(Mn)
YOYR	30.24	%
RAR	121.12	%
ARPM	200.58	Rs.(Mn)
ARPU	885.54	Rs.

Sales Related KPI

KPI	Value	Unit
Y2D Sales	88993	Nos
YOYS	56.46	%
SAR	128.98	%
ASPM	7950.92	Nos

Churn Mitigation Related KPI

KPI	Value	Unit
Y2D Disconnections	549	Nos
YOYD	-39.87	%
CMAR	382.51	%
ADPM	72.33	Nos

Warning - This report contains business critical information and internal use only. Please take due care precautions on disseminating the report in any mean. All ITM policies applicable for internal confidential documents are applicable for this document.

System generated report of the "ProLife" Product Lifecycle Management System

Customer Base Related KPI

<i>KPI</i>	<i>Value</i>	<i>Unit</i>
Y2D Cx Base	226510	Nov
YOYC	81.67	%
CAR	107.28	%
ACBGPM	200.58	Nov

Special Observations and Comments

Product has achieved the Sales targets
Product has achieved the Customer base targets
Product has achieved the customer churn mitigation targets
Market attraction of the product is good and it is very competitive in the market

Product has achieved the Revenue targets

Attention need areas

Warning - This report contains business critical information and internal use only. Please take extra precautions on disseminating the report in any mean. All ISM policies applicable for internal confidential document are applicable for this document.

System generated report of the "ProLife" Product Lifecycle Management System

Appendix H - Questioner used for user evaluation and summary result

1. I would you like to recommend this software to other product managers

Strongly disagree	Strongly agree									
<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 10%;">1</td> <td style="width: 10%;">2</td> <td style="width: 10%;">3</td> <td style="width: 10%;">4</td> <td style="width: 10%;">5</td> <td style="width: 10%;">6</td> <td style="width: 10%;">7</td> <td style="width: 10%;">8</td> <td style="width: 10%;">9</td> <td style="width: 10%;">10</td> </tr> </table>	1	2	3	4	5	6	7	8	9	10
1	2	3	4	5	6	7	8	9	10	

2. It is very early to use this software

Strongly disagree	Strongly agree									
<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 10%;">1</td> <td style="width: 10%;">2</td> <td style="width: 10%;">3</td> <td style="width: 10%;">4</td> <td style="width: 10%;">5</td> <td style="width: 10%;">6</td> <td style="width: 10%;">7</td> <td style="width: 10%;">8</td> <td style="width: 10%;">9</td> <td style="width: 10%;">10</td> </tr> </table>	1	2	3	4	5	6	7	8	9	10
1	2	3	4	5	6	7	8	9	10	

3. I like the look and feel of this software

Strongly disagree	Strongly agree									
<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 10%;">1</td> <td style="width: 10%;">2</td> <td style="width: 10%;">3</td> <td style="width: 10%;">4</td> <td style="width: 10%;">5</td> <td style="width: 10%;">6</td> <td style="width: 10%;">7</td> <td style="width: 10%;">8</td> <td style="width: 10%;">9</td> <td style="width: 10%;">10</td> </tr> </table>	1	2	3	4	5	6	7	8	9	10
1	2	3	4	5	6	7	8	9	10	

4. It is easy to identify the menu items and other components of the software

Strongly disagree	Strongly agree									
<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 10%;">1</td> <td style="width: 10%;">2</td> <td style="width: 10%;">3</td> <td style="width: 10%;">4</td> <td style="width: 10%;">5</td> <td style="width: 10%;">6</td> <td style="width: 10%;">7</td> <td style="width: 10%;">8</td> <td style="width: 10%;">9</td> <td style="width: 10%;">10</td> </tr> </table>	1	2	3	4	5	6	7	8	9	10
1	2	3	4	5	6	7	8	9	10	

5. Once the software is introduced; it motivates me to use the software

Strongly disagree	Strongly agree									
<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 10%;">1</td> <td style="width: 10%;">2</td> <td style="width: 10%;">3</td> <td style="width: 10%;">4</td> <td style="width: 10%;">5</td> <td style="width: 10%;">6</td> <td style="width: 10%;">7</td> <td style="width: 10%;">8</td> <td style="width: 10%;">9</td> <td style="width: 10%;">10</td> </tr> </table>	1	2	3	4	5	6	7	8	9	10
1	2	3	4	5	6	7	8	9	10	

6. I think this is valuable software for the organization to purchase

Strongly disagree	Strongly agree									
<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 10%;">1</td> <td style="width: 10%;">2</td> <td style="width: 10%;">3</td> <td style="width: 10%;">4</td> <td style="width: 10%;">5</td> <td style="width: 10%;">6</td> <td style="width: 10%;">7</td> <td style="width: 10%;">8</td> <td style="width: 10%;">9</td> <td style="width: 10%;">10</td> </tr> </table>	1	2	3	4	5	6	7	8	9	10
1	2	3	4	5	6	7	8	9	10	

Summary result of the questioner

	User 1	User 2	User 3	User 4	User 5	User 6
Utility:	6	7	7	8	7	7
Usability	6	5	6	4	7	6
Aesthetics	8	9	8	7	8	9
Identification	6	5	5	6	7	6
Stimulation	6	5	6	7	5	6
Value	8	7	6	7	8	8

Table H-1 -User score given to each aspect