A PROJECT REPORT ON

OPTIMIZING PROCUREMENT PROCESS USING AI/ML

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Projects are great opportunities offered to those who are specializing in certain skills and career development. This will help an aspirant develop working ethics and set great working standards that could help build his/her working foundations in a group. With this, it is important to expose these aspirants to a great and competitive working environment that could enhance their skills, capabilities, standards, and outputs. The journey started as a student towards professional life with the aim in mind to learn the practical aspect of life, ended as a memorable experience, and also helped me to come off with flying colours. No work can be completed without others' help or contribution. The preparation of the presentation of this humble work encompasses the immense and unlimited help and sound thought of innumerable people.

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Abstract

The project at hand focuses on the development and implementation of a sophisticated AI/ML-driven e-procurement system, termed the ProcurEase, to revolutionize and optimize procurement operations within organizations. In today's dynamic business environment, efficient procurement processes play a pivotal role in enhancing operational efficiency, reducing costs, and building strong supplier relationships. ProcurEase is designed to achieve these goals and more, offering a digital, user-friendly platform that leverages cutting-edge artificial intelligence and machine learning technologies.

The core objectives of this project encompass enhancing operational efficiency, cost reduction, and improving data-driven decision-making. By integrating AI/ML capabilities into the procurement process, the system enables organizations to automate repetitive tasks, forecast demand accurately, and make informed decisions based on real-time data analysis. Furthermore, it addresses the critical issue of reducing human errors, thereby increasing the reliability of procurement processes. With scalability and transparency at its core, ProcurEase sets out to transform traditional procurement practices, ensuring that businesses can adapt, thrive, and stay competitive in an ever-evolving marketplace.

List of Figures

List of Tables

Abbreviations

ERP	Enterprise Resource Planning
RBAC	Role Based Access Control
EOQ	Economic Order Quantity
TOPSIS	Technique for Order Preference by Similarity to Ideal Solution

Table of Contents

Chapter - 1
Introduction

1.1 Background and Basics

A procurement system is the backbone of an organization's efforts to source the goods, services, and works it needs from external suppliers. It encompasses a series of structured processes and procedures aimed at securing these essential resources efficiently and economically. This system is integral to the larger supply chain ecosystem and plays a pivotal role in determining an organization's operational efficiency and cost management strategies. At its core, the procurement system is about more than just buying products or services. It involves careful planning, meticulous supplier selection, negotiation, contract management, order placement, and ongoing supplier performance evaluation. These steps are critical to ensuring that an organization gets the best value for its investments.

In today's digital age, e-procurement systems have become increasingly popular, harnessing technology and the internet to automate and streamline the procurement process. They offer online catalogs, electronic requisition systems, and sourcing tools to improve efficiency.

Overall, a well-implemented procurement system is an essential component of an organization's success, directly impacting its financial health, operational agility, and competitive edge in the marketplace.

1.2 Literature Survey

1.2.1 What is Procurement Process?

The procurement process is a structured method of procuring goods and services needed for an organization. This process saves cost, reduces time, and builds win-win supplier relationships. The procurement process is the series of processes that are essential to get products or services from requisition to purchase order and invoice approval. Although we use procurement and purchasing interchangeably, they differ slightly.

Procurement constitutes a comprehensive process involving the sourcing, acquisition, and payment for goods and services essential to an organization's operations. While terms like 'procurement,' 'purchasing,' and 'sourcing' are sometimes used interchangeably, they actually represent distinct aspects within the broader realm of procurement.

Purchasing primarily centers around the activities associated with ordering and ensuring the delivery of required items. On the other hand, sourcing is concerned with identifying and establishing relationships with the suppliers instrumental in fulfilling the organization's procurement needs. It's important to note that procurement encapsulates the entire spectrum of activities. This encompasses not only sourcing and purchasing but also the critical phases of settlement, comprehensive analysis of procurement data, and strategic planning for future expenditures.

In essence, procurement is a holistic process that extends beyond mere transactions; it encompasses the strategic aspects of supplier management, data analysis, and long-term financial planning, ultimately contributing to the overall efficiency and effectiveness of an organization's procurement function.

Effective procurement practices rely on a well-defined and optimized process that is repeatable for sourcing, acquiring, and paying for goods and services. While each procurement team may tailor its process to its specific needs, the procurement cycle generally adheres to the following stages:

1. **Need Identification**: The procurement process kicks off when a stakeholder identifies the requirement for products, materials, software, or services essential for business operations. This need is typically documented in an intake or requisition form.
2. **Purchase Requisition Submission**: The stakeholder initiates a purchase request, which includes comprehensive information necessary for purchase approval and processing. Recommendations for potential solutions or service providers may also be included in the requisition.
3. **Supplier Evaluation**: Depending on the purchase process and type, procurement assesses available solutions and selects the most suitable vendor to fulfill the request. This might involve competitive bidding processes like requests for proposal (RFP), requests for quote (RFQ), or "three bids and a buy."
4. **Negotiate Terms and Conditions**: After choosing the preferred supplier, negotiations commence. The procurement team collaborates with the supplier's sales representative to

establish pricing and terms for the purchase. Negotiations should only conclude once all departmental prerequisites have been met.

5. **Purchase Order Creation**: Procurement drafts a purchase order (PO) to officially procure the goods or services from the selected supplier. Typically, the PO undergoes a separate approval process to ensure that all transactions align with expectations and identify potential discrepancies. The finalized purchase order is then transmitted to the supplier for order fulfillment.
6. **Goods Receipt and Review**: Upon the supplier's delivery of the goods or services, the procurement team receives and thoroughly inspects the shipment to ensure it aligns with expected quality and accuracy. In cases where the order falls short of expectations, the receiver may request adjustments or return the shipment.
7. **Reconciliation and Matching**: Following the goods' receipt, a three-way match process is conducted to validate the accuracy of the shipment, invoice, and purchase order. The procurement team also conducts supplier evaluations to ensure that all delivery expectations and contractual conditions are met.
8. **Invoice Approval and Payment**: Once the three-way matching process is successfully completed, the supplier's invoice is submitted for processing. The invoice is batched, coded, and scheduled for payment.
9. **Post-Close Activities**: The procurement team is responsible for post-closure operations and procurement analysis. This may encompass tasks such as record-keeping, reporting, spend analysis, supplier evaluations, contract management, and supplier onboarding (in cases where contracts are initiated or terminated). These activities contribute to the ongoing efficiency and effectiveness of the procurement process.

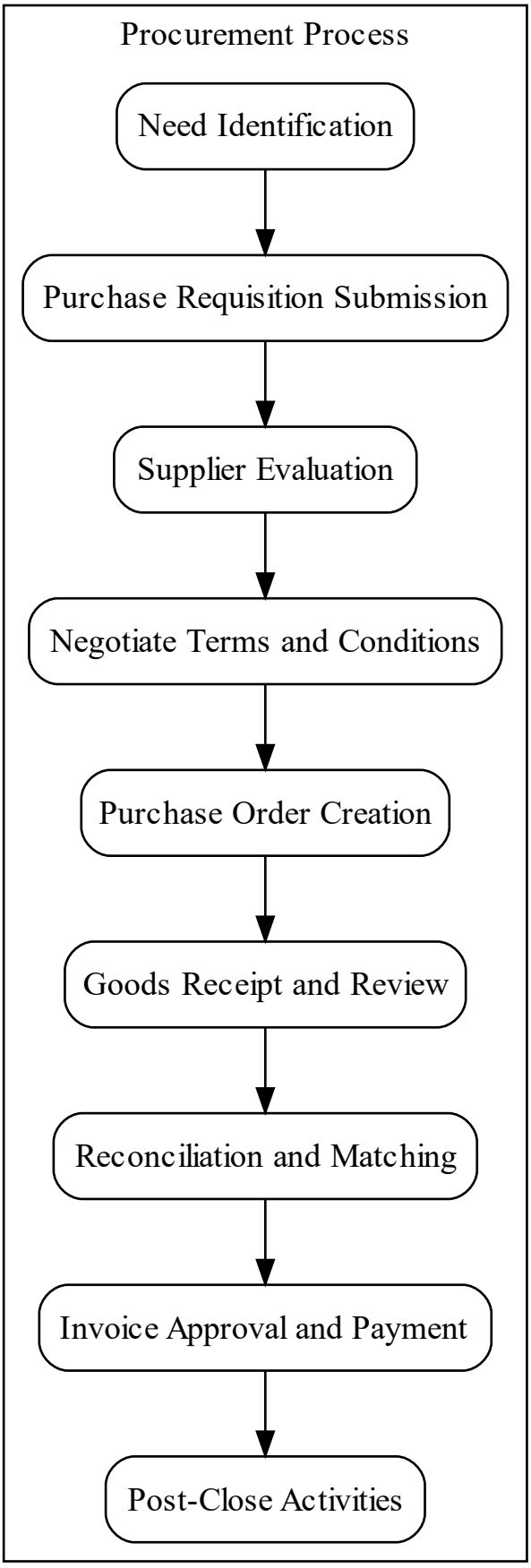

Fig. (1.1) Procurement Process Flowchart

1.2.2 Procurement vs ERP

Table 1.1 Comparison between Procurement System and ERP System

Aspect	Procurement System	ERP System
Primary Purpose	Manages procurement and purchasing processes.	Integrates and manages various core business functions across the organization. Procurement is a component of ERP.
Scope	Focused on procurement-related activities.	Covers a broad range of business functions beyond procurement.
Integration	May integrate with other systems but primarily focuses on procurement.	Integrates and streamlines multiple business processes and departments.
Functionality	Includes procurement-specific features like supplier management, purchase orders, etc.	Encompasses a wide range of functions, including accounting, HR, inventory, sales, and more.
Data Visibility	Provides visibility into procurement data and supplier performance.	Offers a comprehensive view of an organization's data, including financials, inventory, and more.
Implementation Complexity	Implementation is typically less complex and quicker.	Implementation can be complex, involving integration of various functions, and may take more time.

1.2.3 Efficiency Implications of E-Procurement System Capabilities and Usage Behavior: Status Quo and Directions for Future Research

The activities of procurement departments in the last decade have been characterized by strategic sourcing initiatives, resulting in a low degree of vertical integration and increased competition between supply chains. The corporate procurement function plays a vital role in resource allocation and welfare generation in supply networks, with e-procurement systems enabling procurement practices.

The paper aims to provide an integrated view on the efficiency implications of e-procurement system capabilities and the corresponding usage behavior of purchasers from a welfare economics perspective. It closes the gap in existing research by conducting a comprehensive literature review and deriving efficiency measures, managerial implications, and an agenda for future research.

1.2.4 TOPSIS in Multi-Criteria Decision Making: A Survey

The paper provides a comprehensive review of an outranked multi-criteria decision-making (MCDM) method, known as the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS). TOPSIS is a powerful analytical tool designed to facilitate the process of decision-making in situations where multiple criteria need to be considered simultaneously. It allows decision-makers to identify the most suitable option from a set of alternatives by comparing each alternative's similarity to the ideal solution.

1.2.5 Demand Forecasting for E-Commerce Platforms

This paper is a comparative study of the Seasonal Autoregressive Integrated Moving Average (SARIMA) model and Long Short-Term Memory network (LSTM) to predict product demand for the given dataset. Performance, scalability, execution time, accessibility and convenience are the various factors based on which the two models are compared.

The paper focuses on using two different forecasting techniques, the Seasonal Autoregressive Integrated Moving Average (SARIMA) model and Long Short-Term Memory network (LSTM) model, to forecast sales for an online store. The authors compare the results of both models using the superstore dataset.

Looking at the results, the RMSE value for ARIMA was 1.24 whereas for LSTM it was 1.55.

1.2.6 Forecasting of Optimum Raw Material Inventory Level using Artificial Neural Network

The paper addresses the issue of forecasting the optimum raw material inventory level in order to improve efficiency and reduce costs in inventory management. The authors propose the use of Artificial Neural Network (ANN) as a tool for predicting the optimal inventory level .The objective is to develop a model that can accurately forecast the inventory level, taking into account various factors such as demand patterns, lead times, and production schedules .

The paper highlights the importance of accurate inventory forecasting in order to avoid stockouts or excess inventory, which can lead to financial losses. The authors aim to contribute to the field of inventory management by introducing a novel approach using ANN for inventory forecasting.

1.2.7 Forecasting Models Selection Mechanism for Supply Chain Demand Estimation

The paper discusses the importance of accurate demand forecasting in supply chain management and the role it plays in reducing inventory costs and improving decision-making. The authors propose a selection mechanism for forecast models that can contribute to demand estimation in a supply chain. The selection mechanism aims to identify the best forecast model without the need to estimate all the forecast models or rely solely on visual analysis.

The paper presents the theoretical foundations of the methodology and applies it to two real cases of Chilean companies to evaluate its effectiveness. The authors also mention the possibility of developing an algorithm to automate the selection of forecast methods and propose a decision tree to determine the most appropriate forecast models for different data patterns.

1.2.8 Demand Forecasting and Supplier Selection for Incoming Material in RMG Industry: A Case Study

The paper discusses the use of different techniques for demand forecasting in the RMG industry, including simple average, moving average, exponential smoothing, and linear regression . It also implements the Analytic Hierarchy Process (AHP) for supplier selection, which is a widely used multi-criteria decision-making approach. The AHP has been applied in various industrial engineering applications, such as integrated manufacturing, technology investment decisions, location planning, software development, and project risk assessment.

The paper emphasizes the importance of selecting the most suitable forecasting technique for each specific raw material, considering criteria such as cumulative forecast error, mean absolute deviation, mean square error, mean absolute percent error, and tracking signal.

1.2.9 Profit Prediction Using ARIMA, SARIMA and LSTM Models in Time Series Forecasting: A Comparison

The paper discusses the use of Autoregressive Integrated Moving Average (ARIMA), Seasonal ARIMA (SARIMA), and Long Short-Term Memory (LSTM) models for profit prediction in time series forecasting. The authors mention that various researchers have used ARIMA, SARIMA, and vector ARIMA models for time series analysis in different domains such as finance, weather forecasting, road safety research, traffic flow characteristics, and stock market prediction. The paper also highlights the use of ARIMA and SARIMA models for predicting solar radiation in the field of renewable energy.

Comparative analysis between ARIMA, SARIMA, and LSTM models has been conducted in the paper, with LSTM outperforming the statistical models in constructing the best profit prediction model. The authors conclude that LSTM is the best method for financial time series forecasting problems. The paper also includes a comparative analysis of forecasting algorithms, including ARIMA, MVFTS, CNN, LSTM, and CBLSTM, for various domains' time series data. The authors mention that LSTM performs better than ARIMA in calculating forecasts for financial time series data.

1.2.10 Comparison between currently available procurement systems

Table 1.2 Comparison between available Procurement Systems

Features	inFlow Inventory	Coupa	SAP Ariba
Overall Rating	4.5 (453)	4.2 (85)	3.5 (48)
Ease-of-Use	4.5 / 5	4 / 5	3 / 5
Value for Money	4.5 / 5	4 / 5	3 / 5
Customer Support	4.5 / 5	4 / 5	3.5 / 5
Functionality	4.5 / 5	4 / 5	3.5 / 5
Pros	Customer service is excellent. Comprehensive inventory functionalities. Ease of use and instant sync with the cloud.	Reliable software with good security measures. Multiple functionalities, including receiving POs. Vendor-friendly and easy for vendors to use.	Integrates nicely with ERP and offers a quality UI. Best customer service and standard in the market.
Cons	Confusing differences between product versions. Limited web app.	Disputed invoices are hard to delete. Supplier integration challenges.	Incorrect information can prevent invoice migration. Vendors may be charged for a service they dislike.

What makes our solution unique?

In a market saturated with procurement systems, our project emerges as a unique and innovative solution, standing out from existing options in several key ways. This differentiation becomes evident when we delve into a detailed comparison with established players like inFlow Inventory, Coupa, and SAP Ariba.

One of the most notable distinctions is that our procurement system is entirely cost-free. Unlike many existing solutions that come with substantial licensing fees or subscription costs, our project is designed to be accessible to a wide range of users, making it an attractive choice for businesses, especially small and medium-sized enterprises seeking to optimize their procurement processes without a significant financial outlay.

However, it's not just the cost factor that sets our project apart. We have integrated cutting-edge Machine Learning (ML) capabilities into the system. This integration offers an unparalleled advantage in bid evaluation and demand forecasting for raw materials, an essential aspect of effective procurement. ML algorithms can analyze historical data, supplier performance, and market trends to make informed predictions, thereby aiding in the selection of the best-suited bids and ensuring efficient inventory optimization. This level of intelligence and automation brings a competitive edge that many other systems lack.

Furthermore, while some existing solutions may face limitations in terms of web-based applications, our project has been designed with a user-friendly and responsive web app, ensuring that stakeholders can conveniently access and operate the system from various devices and locations. Additionally, it emphasizes seamless vendor integration, making it not only user-friendly for the procurement team but also for vendors who interact with the system regularly.

In summary, the combination of being cost-free, ML-powered for advanced bid evaluation and demand forecasting, and offering an intuitive web app experience positions our project as a promising contender in the procurement software landscape. This unique blend of accessibility and innovation has the potential to redefine how businesses approach procurement and optimize their supply chain operations.

1.3 Project Undertaken

The central objective of our project is to revolutionize the procurement process by harnessing the power of Artificial Intelligence and Machine Learning (AI/ML) to develop a sophisticated web application - ProcurEase. With this endeavor, we seek to streamline and optimize the complex landscape of procurement, enhancing its efficiency, accuracy, and cost-effectiveness. By integrating AI and ML, our web application will automate tedious tasks, offer predictive insights, and facilitate data-driven decisions, ultimately reshaping how organizations source goods and services. Our project aims to empower procurement professionals, enhance supplier relationships, and drive significant cost savings. In doing so, we aspire to elevate the operational agility, financial health, and competitive advantage of organizations in an ever-evolving business environment.

1.3.1 Problem Definition

The procurement process, despite being an essential component of any organization's operations, often grapples with numerous challenges. Current procurement systems frequently involve manual, time-consuming tasks, leading to inefficiencies, errors, and increased operational costs. Supplier selection and management can be suboptimal, hampering organizations' ability to secure the best value for their investments. Additionally, forecasting demand, optimizing inventory, and addressing supply chain disruptions remain complex tasks.

Our project's problem definition, therefore, revolves around these challenges. We aim to address the inefficiencies, complexities, and limitations of traditional procurement systems by developing a smart procurement system web application that leverages AI/ML technologies. This application will automate manual processes, enhance supplier selection and management, provide predictive analytics for demand forecasting and inventory optimization, and mitigate supply chain risks. By doing so, our project seeks to optimize the procurement process, making it more efficient, cost-effective, and capable of delivering substantial benefits to organizations.

1.3.2 Scope Statement

The scope of our project, "Optimizing Procurement Process using AI/ML", encompasses several key aspects and functionalities:

Automation and Efficiency: The project will focus on automating various manual tasks within the procurement process. This includes order processing, document handling, and routine communications, reducing the time and effort required for these activities.

Supplier Selection and Management: ProcurEase will include features for the systematic evaluation and selection of suppliers. It will help assess supplier performance, track supplier relationships, and provide recommendations for supplier diversification or consolidation.

Demand Forecasting: Utilizing AI and ML algorithms, the system will enable accurate demand forecasting, which is vital for optimizing inventory levels, reducing carrying costs, and avoiding stockouts or overstock situations.

Inventory Optimization: The application will offer tools for optimizing inventory management, ensuring that organizations maintain an optimal balance between supply and demand, minimizing costs while meeting customer needs.

Data-Driven Decision-Making: The project will enable data-driven decision-making, offering analytics and insights derived from AI/ML algorithms. This empowers procurement professionals to make informed choices regarding suppliers, contracts, and procurement strategies.

User-Friendly Web Application: The project will result in a web application with an intuitive and user-friendly interface, making it accessible to both procurement professionals and users with limited technical expertise.

Scalability: The application will be scalable to accommodate varying data volumes and organizational needs as the business grows.

1.4 Organization of Project Report

Chapter 1: Introduction

Chapter 1 sets the stage for the project, providing an overview of the significance of procurement systems and the central role they play in sourcing goods, services, and works from external suppliers. It begins with an exploration of the project's foundational aspects, such as the background and basics of procurement, underscoring its importance for organizational operational efficiency and cost management. Following this, the chapter delves into a literature survey to highlight the existing body of research in procurement, particularly the application of AI and ML in this context. The chapter proceeds to define the project's objectives, including problem definition and scope, offering a clear picture of what the project aims to achieve. Lastly, it outlines the structure of the project report, providing readers with a roadmap for the following chapters.

Chapter 2: Project Planning and Management

Chapter 2 delves into the details of project planning and management, beginning with an introduction to this phase's significance. It covers the system requirement specification (SRS), offering a comprehensive view of the project's requirements, from system overview to functional and non-functional requirements, deployment environment, external interfaces, and other relevant requirements. The chapter further outlines the project process modeling adopted for the project, along with cost and effort estimates. It also includes a project scheduling section, providing a timeline and milestones to keep the project on track.

Chapter 3: Analysis and Design

Chapter 3 transitions to the analysis and design phase. It introduces this phase, highlighting its role in shaping the project's development. The chapter includes an IDEA Matrix, mathematical model (if applicable), feasibility analysis, and an architecture diagram. Additionally, it delves into the world of UML diagrams, providing detailed insights into their use. The UML diagrams discussed include use-case, activity, class, ER, sequence, component/interface, state machine, and deployment diagrams.

Chapter 4: Implementation and Coding

Chapter 4 delves into the technical implementation and coding details of the project. It covers the database schema, operational details, and includes screenshots of the main to provide readers with insights into the project's development process.

Chapter 5: Testing

Chapter 5 focuses on testing and its significance within the project. It starts with an introduction to the testing phase, followed by descriptions of unit testing, integration testing, and acceptance testing. This chapter is crucial to ensure the quality and reliability of the project.

Chapter 6: Results and Discussions

Chapter 6 presents the results and discussions derived from the project. It encompasses main GUI screenshots and discussions that analyze the project outcomes. This chapter offers an in-depth examination of the findings, comparisons with project objectives, and insights into potential future enhancements or extensions.

Chapter 7: Conclusion

Chapter 7 marks the conclusion of the project report, summarizing the key findings and achievements of the project, providing readers with a comprehensive understanding of the project's outcomes.

Chapter 8: Future Work

Chapter 8 explores potential avenues for future work and enhancements to the project. It identifies areas where further research or development could be beneficial, such as extending functionality, improving performance, incorporating additional features, or expanding the project's scope. This chapter aims to inspire future projects or initiatives by proposing innovative ideas and suggesting directions for continued improvement and evolution.

Additionally, it discusses potential challenges and considerations that may arise in pursuing these future endeavors, providing insights for project stakeholders and researchers.

References

This chapter catalogs all the sources, including books, websites, and research papers, that were referenced and consulted during the course of the project, providing transparency and credibility to the research.

Chapter – 2
Project Planning and Management

2.1 Introduction

Within this chapter, we delve into the intricacies of project planning and management, all while placing a significant emphasis on System Requirement Specifications (SRS). As the linchpin of our project, SRS lays the foundation for our effort estimations and project scheduling. This chapter is designed to provide a comprehensive understanding of the meticulous planning and management that underpin the project's successful execution. It underscores the pivotal role played by SRS in shaping the project's roadmap and ensuring that we allocate resources and time effectively throughout the project's lifecycle.

2.2 System Requirement Specification

This section provides an in-depth exposition of the various requirements that the system under development must meet and satisfy.

2.2.1 System Overview

ProcurEase is a sophisticated web application designed to revolutionize and optimize the procurement process through the integration of Artificial Intelligence (AI) and Machine Learning (ML). At its core, the system prioritizes robust authentication and authorization mechanisms to ensure secure user access and data protection.

This innovative system consists of several interrelated modules, each harnessing the potential of AI and ML to enhance and automate various facets of procurement. The primary components of the system include:

1. **Authentication and Authorization:** Serving as a foundational layer, this component establishes secure user access and role-based permissions to safeguard sensitive procurement data.

2. **Inventory Management:** Efficiently tracking and managing inventory resources, this module enables smarter allocation and utilization.
3. **Purchase Requisition:** Streamlining the process of creating, submitting, and approving purchase requisitions, this module incorporates data-driven insights to inform decision-making.
4. **Bidding and Evaluation:** Leveraging AI and ML algorithms, this component facilitates vendor bidding and comprehensive evaluation, ultimately aiding in optimal vendor selection.
5. **Procurement Management:** Automation and optimization are central to this module, from vendor selection to order placement, aiming to reduce manual intervention and enhance efficiency.
6. **Inventory Receipts and Inspection:** AI-driven insights ensure a seamless inventory receipt process and inspection, eliminating inefficiencies and reducing manual effort.
7. **Inventory Optimization – Demand Forecasting and Reordering:** AI and ML techniques are applied for demand forecasting, inventory optimization, and automated reorder suggestions, resulting in streamlined inventory management.
8. **Invoice Management:** This module efficiently manages invoices, expediting the approval and payment processes for a seamless financial workflow.
9. **Vendor Evaluation:** Continuous improvement in vendor performance is facilitated through data analytics, ensuring that the procurement process benefits from insights and optimizations.
10. **Analytics Dashboard:** Users have access to a centralized platform for data analysis, reporting, and decision support, empowering them with actionable information.
11. **Notifications and Alerts:** The system employs a comprehensive notification system to keep users informed of important events and updates within the procurement process.

ProcurEase represents a game-changing approach to procurement management, empowering organizations with advanced AI and ML capabilities to achieve operational agility, cost-effectiveness, and a competitive edge in the ever-evolving marketplace. It aims to deliver a comprehensive and efficient solution for end-to-end procurement processes.

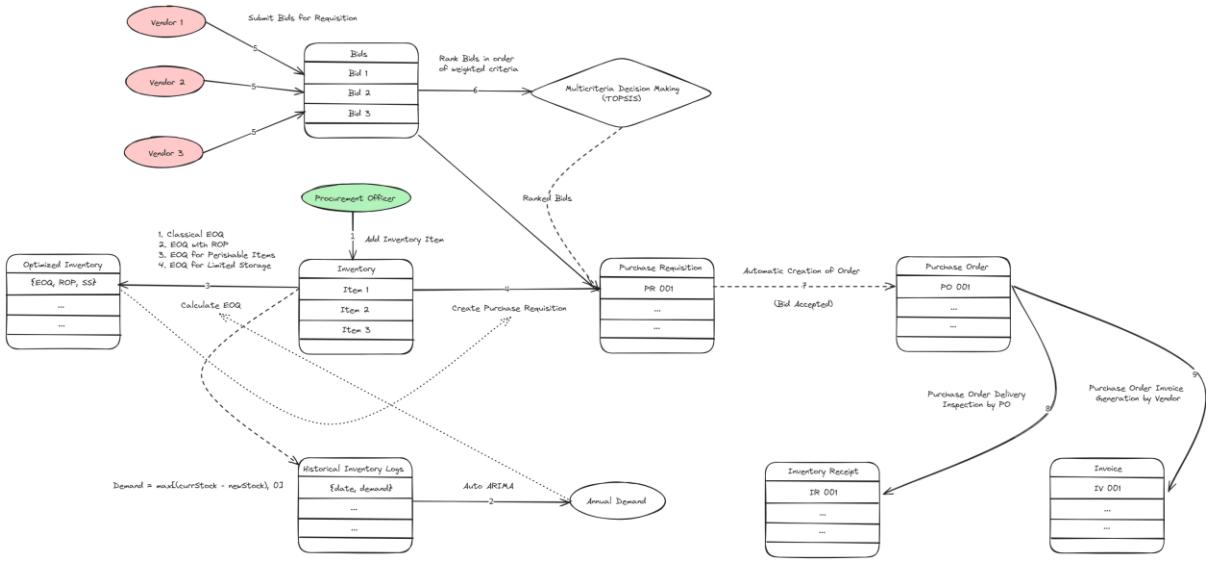

Fig. (2.1) System Overview Diagram

In a Role-Based Access Control (RBAC) system for a smart procurement system, each role (admin, procurement officer, and vendor) plays a distinct role in managing and interacting with the system. Here's how each role would typically function in an RBAC setup:

1. Admin:

- **Role Description**: The admin role has the highest level of access and control over the procurement system.
- **Responsibilities**:
    - **Manage User Accounts**: Admins can create, update, and delete user accounts. They can also assign roles to users.
    - **System Configuration**: Admins can configure system settings, such as default approval workflows, access control policies, and security settings.
    - **Vendor Management**: Admins have full control over vendor management, including adding, modifying, and removing vendor profiles.
    - **Monitoring and Reporting**: Admins can access advanced reporting and monitoring tools to oversee system performance, user activities, and compliance.
    - **Troubleshooting**: In case of issues or errors, admins have the authority to resolve technical problems and maintain system integrity.

2. Procurement Officer:

- **Role Description**: Procurement officers are responsible for managing the procurement process within the organization.
- **Responsibilities**:
    - **Requisitions**: Procurement officers can create and manage purchase requisitions, specifying the items, quantities, and preferred vendors.
    - **Bid Management**: They oversee the supplier bidding process, review and analyze bids, and make supplier selection recommendations.
    - **Purchase Orders**: Procurement officers generate purchase orders based on approved requisitions and negotiate terms and conditions with vendors.
    - **Inventory Management**: They have access to inventory data, can check stock levels, and initiate orders to replenish inventory.
    - **Invoice Verification**: Procurement officers play a role in verifying supplier invoices against purchase orders and received goods.

3. Vendor:

- **Role Description**: Vendors are external entities that provide goods or services to the organization.
- **Responsibilities**:
    - **Bidding/Auction**: Vendors participate in the bidding or auction process initiated by procurement officers, submitting their bids for requested items.
    - **Profile Management**: Vendors can update their profiles, including contact information, product catalog, and pricing details.
    - **Order Fulfillment**: Once selected, vendors are responsible for fulfilling purchase orders, delivering goods or services as per the agreed terms.
    - **Invoice Submission**: Vendors submit invoices to the organization for payment, typically including details of the delivered goods or services.
    - **Communication**: Vendors may communicate with procurement officers regarding order status, delivery schedules, and inquiries.

Table 2.1 RBAC Matrix

Permissions / Roles	**Admin**	**Procurement Officer**	**Vendor**
Manage User Accounts	✓		
Configure System	✓		
Vendor Management	✓		
Monitor and Report	✓		
Troubleshoot	✓		
Create Requisitions		✓	
Manage Requisitions		✓	
Bid Management		✓	
Generate Purchase Orders		✓	
Inventory Management		✓	
Verify Invoices		✓	
Participate in Bidding			✓
Update Vendor Profile			✓
Order Fulfillment			✓
Invoice Submission			✓
Communication		✓	✓

This RBAC matrix reflects the specific permissions and responsibilities associated with each role in the procurement process, providing a clear and comprehensive overview of access control within our system.

2.2.2 Functional Requirements

Below are the functional requirements for our project:

2.2.2.1 Authentication and Authorization

Description and Priority: Secure user access and data protection are of utmost importance in the system. This feature ensures that only authorized users can interact with the system and access specific functionalities.

Stimulus/Response Sequence: Users will attempt to access the system. The system will prompt them to provide valid credentials for authentication. Upon successful authentication, the system will grant the appropriate level of access and permissions based on user roles.

Functional Requirements:

- The system shall provide a login page with fields for username and password.
- User roles (e.g., admin, procurement manager, supplier) shall be defined within the system.
- The system shall validate user credentials for accuracy and completeness.
- Upon successful authentication, the system shall grant access to features and data based on the user's role.

Main Flow:

- A user accesses the login page and enters their username and password.
- The system validates the credentials.
- If the credentials are correct, the system grants access according to the user's role.

Exceptional Flow:

- If the provided credentials are incorrect, the system prompts the user to re-enter them.

2.2.2.2 Inventory Management

Description and Priority: Efficient tracking and management of inventory resources are critical to the procurement process. This feature ensures that inventory items are cataloged, monitored, and maintained effectively.

Stimulus/Response Sequence: Users will input and interact with inventory data. The system will record, update, and retrieve information related to inventory items.

Functional Requirements:

- The system shall provide a user-friendly interface for inventory management.
- Users shall be able to add new inventory items, update existing items, and view the inventory catalog.
- The system shall track item details, including product name, quantity, supplier information, and purchase history.
- Users shall be able to generate reports and insights on inventory status.

Main Flow:

- Users access the inventory management interface.
- Users add or update inventory items, providing product details and quantities.
- The system records the information and updates the inventory catalog.
- Users can view the updated inventory catalog.

Exceptional Flow:

- If an error occurs during data entry, the system prompts users to correct the information.

2.2.2.3 Purchase Requisition

Description and Priority: The purchase requisition process is essential for requesting and approving procurement needs. This feature ensures that users can create, submit, and review purchase requisitions seamlessly.

Stimulus/Response Sequence: Users, such as procurement managers or employees, initiate purchase requisitions. The system manages requisition creation, submission, and approval processes.

Functional Requirements:

- The system shall provide a dedicated interface for creating purchase requisitions.
- Users shall enter details for the requested items, including quantity, specifications, and required delivery dates.

- The system shall support requisition submission, workflow routing, and approval based on user roles.
- Users shall receive notifications regarding the status of their requisitions.

Main Flow:

- Users access the purchase requisition interface and provide details for requested items.
- Users submit requisitions, which are routed for approval based on predefined workflows.
- Approvers review requisitions and either approve or reject them.
- Users receive notifications regarding requisition status.

Exceptional Flow:

- If a requisition is rejected, the system provides a means for users to make necessary adjustments.

2.2.2.4 Bidding and Evaluation

Description and Priority: The bidding and evaluation feature facilitates the procurement of goods and services. It enables suppliers to submit bids, and the system evaluates these bids for selection.

Stimulus/Response Sequence: Suppliers submit bids, and the system processes and evaluates these bids to determine the most suitable vendor for a particular procurement.

Functional Requirements:

- The system shall provide a platform for suppliers to submit bids for procurement requests.
- Bids shall include details such as pricing, delivery timelines, and product specifications.
- The system shall perform bid evaluations, considering factors like cost, quality, and delivery performance.
- The system shall notify suppliers of bid results.

Main Flow:

- Suppliers access the bidding platform and submit bids for procurement requests.
- The system collects and processes bid information.

- Bid evaluations are conducted, and the system identifies the winning bid.
- Suppliers receive notifications regarding bid outcomes.

Exceptional Flow:

- If none of the submitted bids meet the criteria, the system provides options for procurement managers to reassess requirements or extend the bidding process.

2.2.2.5 Inventory Optimization – Demand Forecasting and Reordering

Description and Priority: Efficient inventory management depends on accurate demand forecasting and timely reordering. This feature ensures that inventory levels are optimized based on demand and lead times.

Stimulus/Response Sequence: The system continuously monitors inventory levels and demand patterns. When necessary, it generates reorder recommendations and automates the procurement process.

Functional Requirements:

- The system shall regularly analyze historical data to forecast demand for inventory items.
- When inventory levels fall below predefined thresholds, the system shall generate reorder recommendations.
- The system shall automate the procurement process for reorder items, considering lead times and vendor performance.
- Users shall be able to review and approve automated reorder recommendations.

Main Flow:

- The system periodically reviews historical data and forecasts demand for inventory items.
- When inventory levels reach reorder points, the system generates reorder recommendations.
- Automated procurement processes are initiated, considering lead times and supplier performance.
- Users review and approve reorder recommendations when necessary.

Exceptional Flow:

- In cases of significant demand fluctuations or unexpected delays, the system allows users to adjust reorder parameters manually.

2.2.2.6 Vendor Evaluation

Description and Priority: Assessing and improving vendor performance is essential for successful procurement. This feature provides tools for ongoing vendor evaluation and collaboration.

Stimulus/Response Sequence: The system collects data on vendor performance and provides reports and feedback mechanisms for continuous improvement.

Functional Requirements:

- The system shall collect data on vendor performance, including delivery times, quality, and adherence to terms.
- Users shall be able to generate vendor performance reports and ratings based on predefined criteria.
- The system shall provide a feedback mechanism for users to communicate with vendors and provide recommendations for improvement.
- Users shall have access to historical vendor performance data.

Main Flow:

- The system collects data on vendor performance through various interactions and transactions.
- Users can generate performance reports and ratings based on predefined criteria.
- Users can communicate with vendors through the system to provide feedback and suggestions for improvement.
- Historical vendor performance data is accessible for reference.

Exceptional Flow:

- In cases of significant performance issues or concerns, users have the option to initiate discussions or negotiations for improved vendor performance.

2.2.2.7 Analytics Dashboard

Description and Priority: Decision-making in procurement benefits from data-driven insights. This feature provides an analytics dashboard for users to access actionable information and reports.

Stimulus/Response Sequence: Users access the analytics dashboard, which responds by providing real-time data insights, visualizations, and reports.

Functional Requirements:

- The system shall offer an analytics dashboard with real-time data on procurement activities, costs, and performance.
- Users shall be able to customize and filter data to gain specific insights.
- The system shall generate reports, charts, and visualizations to support informed decision-making.
- Data on procurement activities and trends shall be accessible through the dashboard.

Main Flow:

- Users access the analytics dashboard and select specific data parameters for analysis.
- The system responds by presenting real-time data insights, visualizations, and reports.
- Users can explore data on procurement activities, costs, and performance to make informed decisions.

Exceptional Flow:

- In cases of anomalies or significant changes in procurement data, the system provides alerts and notifications for immediate attention.

2.2.3 Non-Functional Requirements

The following section outlines the non-functional requirements that our system should adhere to.

2.2.3.1 Performance Requirements

- **Performance under Varied Network Conditions**: The system must demonstrate reliable performance even under adverse network conditions, including slow internet connections and limited device battery life. It should maintain functionality and responsiveness in these scenarios.
- **Search Response Time**: The system should aim to fetch searched information, such as procurement records, within a reasonable time frame, targeting an O(n) time complexity for efficient search operations.
- **Uninterrupted Connectivity**: The system must ensure uninterrupted connections for users, minimizing service downtime and maintaining consistent access to procurement data.
- **High Data Transfer Rate**: The system should support a high data transfer rate to facilitate efficient procurement data exchange, ensuring quick and seamless data transmission.

2.2.3.2 Security Requirements

- **User Authentication and Data Security**: The system must securely authenticate users and protect against unauthorized access to procurement data. Robust user authentication mechanisms and data encryption should be implemented to safeguard data confidentiality and integrity.
- **Data Security with AI/ML Algorithms**: Given the integration of AI/ML algorithms, data security remains a priority. The system should ensure the confidentiality and integrity of data used in AI/ML processing, and any sensitive data should be protected against breaches.

2.2.3.3 Software Quality Attributes

- **Scalability**: The system is initially designed to support the procurement needs of a moderate user base. It should be scalable to accommodate future growth, allowing for the inclusion of additional users and expanded procurement activities.

- **Availability**: The system's core procurement functionalities and the AI/ML algorithms must be available 24 hours a day to provide continuous service to users. Any scheduled maintenance or downtime should be minimized and communicated in advance.
- **Correctness and Data Integrity**: All newly introduced features and AI/ML algorithms must operate correctly and accurately, ensuring the correctness and integrity of procurement data. The system should prevent data loss and ensure that all operations align with specified requirements and user expectations.
- **Usability**: The system should be user-friendly and provide an intuitive interface to facilitate easy interaction for users with varying levels of technical expertise.

2.2.4 Deployment Environment

The deployment environment for ProcurEase incorporates modern technologies to ensure efficient development, continuous integration, and delivery. Here's an extended description of the deployment environment:

- **Frontend Framework**: React
- **Backend Framework**: Django Rest Framework
- **Email Service**: Gmail
- **Task Queue**: Celery (with Redis)
- **Database Management System**: PostgreSQL
- **Media Storage and Content Delivery Network (CDN)**: Cloudinary
- **Cache System**: Redis
- **Containerization**: Docker
- **Continuous Integration/Continuous Deployment (CI/CD)**: GitHub Actions
- **Operating System**: Any modern operating system
- **Hardware Platform**: Any modern web browser
- **RAM**: 4 GB

2.2.5 External Interface Requirements

ProcurEase relies on several external interfaces to fulfill its procurement and AI/ML-related functionalities, and this section provides a comprehensive overview of these requirements.

2.2.5.1 User Interfaces

In the ProcurEase project, we are focused on creating intuitive and user-friendly interfaces that cater to the diverse needs of our users. The user interfaces are a critical aspect of our project, as they directly impact the user experience and efficiency of the procurement process. Our user interface design encompasses various aspects:

User-Friendly Web Application: The primary user interface for ProcurEase will be a web application developed using React. This web-based interface offers a familiar and user-friendly experience accessible from different devices, making it easy for users to interact with the system.

Dashboard: The system will feature an interactive dashboard where users can access vital information at a glance. This dashboard will provide an overview of procurement processes, inventory status, analytics, and notifications, enabling users to make informed decisions quickly.

User Profiles: We plan to implement user profiles with personalized settings and preferences. Users can customize their profiles, update contact information, and manage notification preferences to suit their requirements.

Intuitive Navigation: The user interfaces will incorporate intuitive navigation menus and responsive design, ensuring that users can effortlessly move through various sections of the application. This includes sections for procurement management, inventory monitoring, analytics, and more.

Procurement Forms: For creating and managing procurement requests, we will design user-friendly forms. These forms will guide users through the process of specifying their procurement needs, attaching necessary documents, and tracking the status of their requests.

2.2.5.2 Software Interfaces

ProcurEase will rely on several critical software interfaces to ensure seamless integration and efficient operation. These interfaces play a pivotal role in connecting our system with various components, both internal and external. They are essential for the overall functionality, data exchange, and communication processes of our project.

Backend Communication (Django Rest Framework): Our project's backend, developed using Django Rest Framework, will serve as the primary software interface. This RESTful API interface will facilitate interactions between the frontend and backend, enabling essential operations such as procurement request management, order processing, and user authentication.

Database Integration (Django ORM): ProcurEase will make extensive use of Django's Object-Relational Mapping (ORM) facility. This ORM interface is instrumental for database integration, offering a high-level and Pythonic way to interact with the SQLite database. It simplifies data modeling and management, supporting core functionalities like user profiles, procurement records, and transaction history.

Post-save Transaction Processing (Django Signals): Django Signals will be utilized to perform post-save transaction processing. This interface allows the system to execute custom logic or trigger specific actions automatically after certain database operations, ensuring data consistency and enabling seamless integration of additional functionalities.

Asynchronous Task Processing (Celery and Celery Beat Scheduler): ProcurEase will leverage Celery and Celery Beat Scheduler for asynchronous task processing. This interface enables the system to handle time-consuming tasks, such as sending emails, generating reports, or performing data analysis, in the background, improving system responsiveness and scalability.

Authentication (Django Rest Framework - SimpleJWT): To secure user interactions, ProcurEase will implement token-based authentication using Django Rest Framework's SimpleJWT. This interface ensures that only authorized users can access and modify procurement-related data, enhancing the system's security and compliance with authentication standards.

Containerization (Docker): Docker containers will be employed to create isolated and consistent runtime environments for both the frontend and backend components. This interface

ensures compatibility and ease of deployment across various hosting environments, enhancing the portability and maintainability of our system.

Continuous Integration and Continuous Deployment (CI/CD, GitHub Actions): The project will incorporate Continuous Integration and Continuous Deployment (CI/CD) pipelines using GitHub Actions. These pipelines will serve as interfaces to automate testing and deployment processes, ensuring rapid, error-free updates, and seamless deployments. This critical interface streamlines development workflows and maintains system reliability.

2.2.5.3 Communication Interfaces

In our project, ProcurEase will leverage Gmail as the email service provider for asynchronous email communication from the Django backend. This integration will be facilitated by Celery, a distributed task queue, enabling the system to delegate email sending tasks to background processes. By decoupling email sending from the main application flow, Celery ensures the system's responsiveness and scalability, particularly during periods of heightened email activity.

Email Communication with Gmail and Celery: ProcurEase will utilize Gmail as the email service provider for sending emails from the Django backend asynchronously. This integration will be achieved using Celery, a distributed task queue, which allows the system to offload email sending tasks to background processes. By decoupling email sending from the main application flow, Celery ensures that the system remains responsive and scalable even during periods of high email traffic.

Scheduled Mails with Celery Beat: Additionally, ProcurEase will employ Celery Beat, a scheduler included with Celery, to manage scheduled email sending tasks. This feature enables the system to automatically trigger email notifications at predetermined times or intervals, such as sending weekly procurement reports or reminders for pending tasks. Celery Beat ensures timely and efficient delivery of scheduled emails, enhancing the overall effectiveness of the communication system.

2.3 Project Process Modeling

For our project aimed at building a smart procurement system with a diverse range of features, we have opted to employ the Scrum project process model as our framework. This decision is rooted in the model's compatibility with the size and nature of our project, as well as the characteristics of our team - a group of four final year college students. Scrum offers a flexible and highly collaborative approach to project management, promoting incremental development and constant adaptability.

We have chosen to employ the Scrum project management model for our ambitious smart procurement system project for several compelling reasons. First and foremost, the nature of our project, which encompasses diverse modules like inventory management, procurement, and AI/ML algorithms, necessitates a project management approach that is highly adaptable. The Scrum model offers precisely that - adaptability and flexibility. In a project involving complex and dynamic components, it's crucial to have a methodology that can seamlessly handle change and refinement as our understanding deepens.

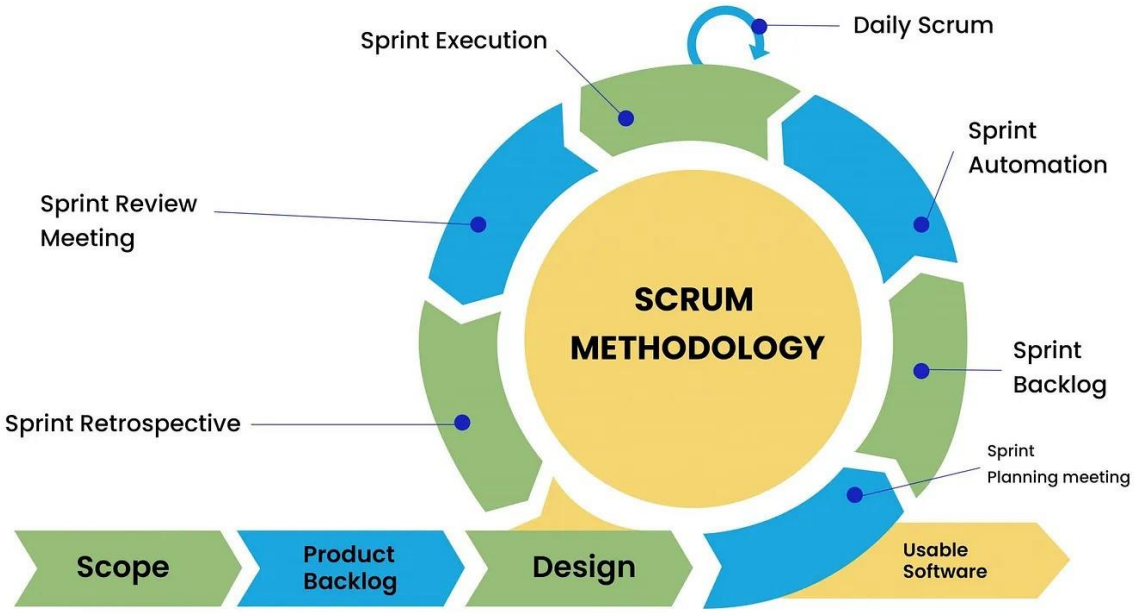

Fig. (2.2) Scrum Process Model

Scrum Overview: Scrum is an Agile project management framework that centers on iterative and incremental development. It is characterized by dividing the project into smaller, manageable work units called sprints, typically lasting 2-4 weeks. Each sprint results in a potentially shippable increment of the product. Scrum is built on transparency, inspection, and adaptation. It emphasizes collaboration, accountability, and the involvement of stakeholders

throughout the project. Scrum's core roles include the Product Owner, Scrum Master, and Development Team. These roles collectively ensure that the project stays on course, follows a well-defined prioritization, and continues to deliver value to the stakeholders.

Advantages of Scrum: There are several key advantages to using the Scrum model for our project:

- **Flexibility:** Scrum embraces change and can adapt to evolving project requirements, making it an excellent choice for a dynamic project like ours.
- **Iterative Development:** The incremental approach allows us to work on different project features in cycles, ensuring that each part is fully functional and tested before moving on to the next.
- **Stakeholder Involvement:** Regular feedback and collaboration with stakeholders help align the project with their needs and expectations.
- **Transparency:** Scrum provides clear visibility into project progress, making it easier to identify and address issues as they arise.
- **Accountability:** Scrum roles and ceremonies enforce accountability, ensuring that team members are responsible for their commitments.
- **Efficiency:** By focusing on value-driven development, Scrum promotes a high level of productivity and eliminates unnecessary work.
- **Quality Assurance:** Frequent testing and inspection during sprints result in high-quality, potentially shippable increments.

By utilizing Scrum, we aim to capitalize on these advantages to efficiently navigate the complexities of our project, foster collaboration within our team, and deliver a top-notch smart procurement system web application.

2.4 Cost and Efforts Estimates

This section provides an in-depth exposition of the various requirements that the system under development must meet and satisfy.

For our project, we have chosen to use Story Point Estimation as our primary method for estimating the size and complexity of user stories. Story points are a relative sizing technique commonly used in Agile methodologies like Scrum. This decision is based on several considerations:

Why Story Point Estimation:

- **Relative Sizing:** Story point estimation allows us to size and compare user stories in a relative manner. Instead of estimating the absolute time each task will take in hours, we estimate the complexity, effort, and risk of each user story relative to others. This approach provides a more intuitive way to understand the project's scope and prioritize tasks.
- **Risk, Complexity, and Repetition:** Story points take into account the risk associated with each user story (e.g., vague requirements, third-party dependencies), its complexity (how difficult it is to develop), and the repetition (familiarity and monotony). This comprehensive assessment helps us make more informed estimations.
- **Team Collaboration:** Story point estimation involves the entire project team, encouraging collaboration and shared understanding. Team members bring their unique perspectives, and discussions help clarify ambiguities and align everyone's understanding of the work.

Advantages of Story Point Estimation:

- **Flexibility:** Story points allow for greater flexibility in the estimation process. They are not tied to specific time units (e.g., hours), making it easier to accommodate the uncertainties and complexities inherent in software development.
- **Team Focus:** Story point estimation shifts the focus from the clock to the actual work involved. Team members concentrate on the relative size and effort of tasks, fostering a sense of ownership and commitment to the project's success.
- **Predictability:** Story points help in creating more accurate forecasts and planning. By tracking the team's velocity (the number of story points completed in a sprint), we can better predict when specific features or the entire project will be delivered.

Why Not Time Estimation in Hours:

While time estimation in hours is a valid approach in some project management methodologies, it has several limitations that make it less suitable for Agile projects like ours:

- **Inherent Uncertainty:** Software development is inherently uncertain, and providing precise hour-based estimates can lead to unrealistic expectations. Tasks often involve unexpected challenges and complexities.
- **Pressure and Micromanagement:** Hour-based estimates may create pressure on team members to meet specific hour targets, potentially compromising quality. This approach

can also lead to micromanagement, as stakeholders may constantly monitor progress in hourly increments.

- **Lack of Flexibility:** Hours don't account for variations in the team's performance, learning curves, and external dependencies. Agile projects require adaptability, and story points provide a better tool for planning and adapting to change.

In summary, story point estimation aligns well with Agile principles, promotes collaboration, and provides a more reliable and adaptable way to estimate the size and complexity of user stories. It enables our team to focus on delivering value while accommodating the inherent uncertainties of software development.

Table 2.2 Story Point Estimation Table

User Story	Description	Risk	Complexity	Repetition	Story Points
Authentication and Authorization	Implement a secure user authentication and authorization system to control access to the system.	Moderate	High	Low	8
Inventory Management	Develop a module for managing inventory items, tracking quantities, and updating inventory levels.	Low	Moderate	High	13
Purchase Requisition	Create a feature that allows users to submit purchase requisitions for necessary items.	Moderate	Low	Low	5

Bidding and Evaluation	Design a system for managing the bidding process and evaluating supplier proposals.	High	High	Low	13
Procurement Management	Develop a comprehensive procurement management system that includes supplier selection, order placement, and tracking.	High	High	Low	13
Inventory Receipts and Inspection	Implement a process for receiving and inspecting inventory items upon delivery.	Moderate	Moderate	Low	8
Inventory Optimization – Demand Forecasting and Reordering	Build a module that optimizes inventory levels based on demand forecasting and automates reordering.	Moderate	High	Low	8
Invoice Management	Develop a system for managing and processing supplier invoices.	Low	Moderate	Low	5
Vendor Evaluation	Create a feature for evaluating supplier performance and	High	Low	Low	5

	maintaining vendor records.				
Analytics Dashboard	Design an analytics dashboard that provides insights into procurement metrics and trends.	Moderate	High	Low	8
Notifications and Alerts	Implement a notification system that sends alerts and updates to users regarding procurement events.	Low	Low	Low	3

2.5 Project Scheduling

We have developed a comprehensive timeline chart or Gantt chart to effectively plan and visualize the project's schedule, milestones, and task dependencies.

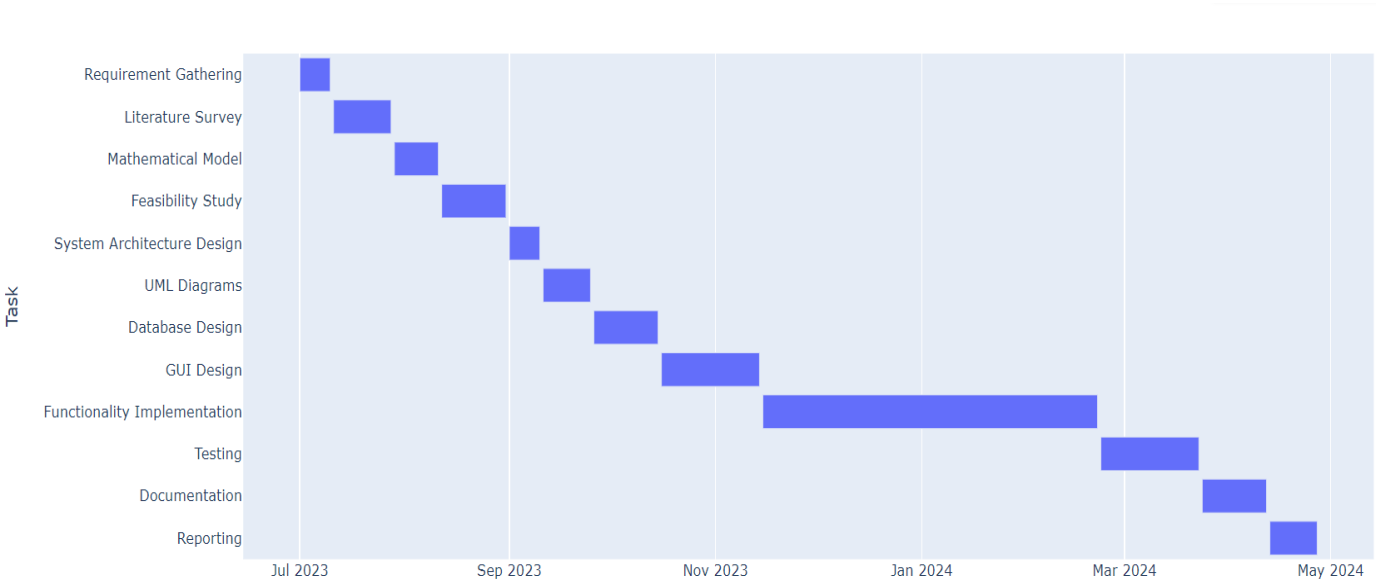

Fig. (2.3) Gantt Chart

Chapter – 3
Analysis and Design

3.1 Introduction

The Analysis and Design phase of our project is a critical milestone in the development of our comprehensive Procurement Management System. During this phase, our team undertakes a detailed examination of the project requirements, design objectives, and architectural considerations. This process serves as the foundation for the entire project, ensuring that it aligns with our business goals and delivers a robust, scalable, and user-friendly solution.

3.2 IDEA Matrix

Table 3.1 I Elements

I	Use	Parameters Affected
Improve	To make the procurement process more efficient and cost-effective	Inventory control, purchasing efficiency, cost reduction
Increase	To handle a larger volume of procurement requests and operations	Procurement capacity, workload management, scalability
Innovation	To introduce cutting-edge technologies and practices for proactive procurement	Predictive analytics, AI integration, advanced procurement practices

Table 3.2 D Elements

D	Use	Parameters Affected
Detect	Identify inefficiencies in current procurement processes	Efficiency, Cost, Data Quality
Decrease	Reduce procurement costs	Cost, Resource Allocation
Drive	Enhance user experience and supplier interactions	User Satisfaction, Supplier Relationships

Table 3.3 E Elements

E	Use	Parameters Affected
Exchange	Implement a centralized communication platform	Team Collaboration, Information Flow
Enhance	Improve user experience	User Satisfaction, Productivity
Extract	Extract valuable insights	Data Analysis, Business Intelligence

Table 3.4 A Elements

A	Use	Parameters Affected
Avoid	Implement compliance measures	Legal Compliance, Risk Exposure
Assure	Conduct regular security audits	Data Protection, Confidentiality
Associate	Foster supplier relationships	User Satisfaction, Supplier Relationships

3.3 Mathematical Model

In this section, we delve into the mathematical foundations that underpin two crucial aspects of our project: TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution) for supplier bid evaluation and SARIMA (Seasonal Autoregressive Integrated Moving Average) for demand forecasting within the context of inventory optimization. These mathematical models serve as the cornerstones of our project, providing the analytical rigor and precision required to make informed decisions in the domains of procurement and inventory management.

We will explore these mathematical models in detail, starting with TOPSIS, which offers a structured approach to evaluating and ranking supplier bids based on multiple criteria. TOPSIS enables us to identify the most suitable suppliers by considering the ideal solution and the worst-case solution, allowing us to make well-informed procurement decisions.

Following our exploration of TOPSIS, we will shift our focus to SARIMA, a powerful time series forecasting model. SARIMA equips us with the capabilities to analyze historical demand patterns and generate forecasts that are vital for optimizing inventory levels. By understanding the mathematical intricacies of SARIMA, we can ensure that our inventory management system remains robust and responsive to dynamic market demands.

This section serves as the bridge between theoretical concepts and their practical applications in our project, elucidating the significance of these mathematical models in enhancing the efficiency and effectiveness of our procurement management system.

3.3.1 TOPSIS

TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution) is a multi-criteria decision-making method that aims to find the best alternative from a set of options based on multiple criteria. The mathematical model of TOPSIS involves several steps:

1. **Decision Matrix**: Start with a decision matrix (X) where each row represents an alternative and each column represents a criterion. Let's denote this matrix as X, where X[i][j] represents the performance of alternative i on criterion j.
2. **Normalization**: Normalize the decision matrix. This step ensures that all criteria are on the same scale and gives equal weight to each criterion. To normalize, divide each value in the

matrix by the square root of the sum of the squares of all values in the same column. This yields the normalized decision matrix (R).

R[i][j] = X[i][j] / √(Σ(X[k][j]^2), for k = 1 to m

Where:

- i = 1, 2, ..., n (number of alternatives)
- j = 1, 2, ..., m (number of criteria)

3. **Weighting**: Assign weights (w_j) to each criterion, reflecting their relative importance. These weights can be obtained through expert opinions, surveys, or other methods. The sum of all weights should equal 1.
4. **Weighted Normalized Decision Matrix**: Multiply each column of the normalized decision matrix by the corresponding weight to obtain the weighted normalized decision matrix (Y).

   Y[i][j] = R[i][j] * w_j
5. **Ideal and Anti-Ideal Solutions**: Determine the ideal (A^+) and anti-ideal (A^-) solutions. The ideal solution is the alternative that maximizes each criterion (column) in Y, and the anti-ideal solution is the one that minimizes each criterion.

   A^+[j] = max(Y[i][j]), for i = 1 to n

   A^-[j] = min(Y[i][j]), for i = 1 to n
6. **Distance Calculation**: Calculate the Euclidean distance (or other distance measures, such as Manhattan distance) between each alternative and the ideal and anti-ideal solutions. For the ideal solution, the distance is calculated as the Euclidean distance from A^+. For the anti-ideal solution, it is the distance from A^-.

   S^+[i] = √(Σ(Y[i][j] - A^+[j])^2), for j = 1 to m

   S^-[i] = √(Σ(Y[i][j] - A^-[j])^2), for j = 1 to m
7. **Relative Closeness to Ideal Solution**: Determine the relative closeness (C_i) of each alternative to the ideal solution. This measure is typically calculated as:

   C_i = S^-[i] / (S^+[i] + S^-[i])
8. **Ranking**: Rank the alternatives based on their C_i values. The alternative with the highest C_i value is considered the best choice.

TOPSIS provides a systematic approach to multi-criteria decision-making by considering both the proximity to the ideal solution and the distance from the anti-ideal solution. It allows decision-makers to select the best alternative based on their preferences and priorities for different criteria.

3.3.2 SARIMA

SARIMA combines the principles of three main components: Autoregressive (AR), Integrated (I), and Moving Average (MA) models, and extends them to include seasonality. Here's how the mathematical model of SARIMA can be expressed:

1. **Autoregressive Component (AR)**:

   AR(p): This component represents the relationship between the current value (yt) and the previous p values (yt-1, yt-2, ..., yt-p) in the time series. It can be expressed as:

   $yt = \varphi1 * yt-1 + \varphi2 * yt-2 + ... + \varphi p * yt-p + \varepsilon t$

   Where:

   - yt is the current value in the time series.
   - $\varphi1, \varphi2, ..., \varphi p$ are autoregressive parameters.
   - εt is the error term at time t.

2. **Integrated Component (I)**:

   I(d): This component indicates the order of differencing required to make the time series stationary. Differencing helps remove trends and ensure the data has a constant mean and variance. It can be expressed as:

   $yt' = yt - yt-1$

   Repeating this process d times until the series becomes stationary.

3. **Moving Average Component (MA)**:

   MA(q): This component represents the relationship between the current value (yt) and the previous q forecast errors or residuals ($\varepsilon t-1, \varepsilon t-2, ..., \varepsilon t-q$). It can be expressed as:

   $yt = \varepsilon t + \theta1 * \varepsilon t-1 + \theta2 * \varepsilon t-2 + ... + \theta q * \varepsilon t-q$

   Where:

   - $\theta1, \theta2, ..., \theta q$ are moving average parameters.
   - εt is the error term at time t.

4. **Seasonal Component (S)**:

   SAR(P, D, Q, s): SARIMA includes a seasonal component, indicated by four additional parameters: P, D, Q, and s.

   - P: Seasonal order of autoregressive component.
   - D: Seasonal order of differencing.
   - Q: Seasonal order of moving average component.
   - s: Seasonal period, which represents the number of time periods per season (e.g., 12 for monthly data with annual seasonality).

SARIMA combines these components to model the time series data, incorporating both non-seasonal and seasonal components to make forecasts. The parameters (p, d, q, P, D, Q, and s) need to be estimated based on the specific characteristics of the time series data.

The SARIMA model is often estimated using statistical software, and the model's coefficients and orders are determined through a process of model selection, diagnostic checks, and validation against historical data. Once the model is fitted, it can be used for time series forecasting.

3.4 Feasibility Analysis

Within this chapter, we delve into the intricacies of project planning and management, all while placing a significant emphasis on System Requirement Specifications (SRS). As the linchpin of our project, SRS lays the foundation for our effort estimations and project scheduling. This chapter is designed to provide a comprehensive understanding of the meticulous planning and management that underpin the project's successful execution. It underscores the pivotal role played by SRS in shaping the project's roadmap and ensuring that we allocate resources and time effectively throughout the project's lifecycle.

Table 3.5 Feasibility Analysis

Feasibility Aspect	**Project Feasibility Analysis**
Technical Feasibility	The project's technical feasibility is high. The required technology and tools for developing the Procurement Management System, including the database schema and user interface, are planned. The project leverages standard technologies for authentication, data management, and reporting, making it technically feasible.
Operational Feasibility	The project's operational feasibility is positive. The procurement system aligns with existing procurement processes and practices. The roles of procurement officers, vendors, and administrators are well-defined, ensuring a smooth transition to the new system. Training and support can be provided to ensure successful operation.

Economic Feasibility	The project demonstrates strong economic feasibility. It utilizes open-source and free tools, resulting in minimal initial costs. The long-term benefits include improved vendor selection, inventory optimization, and invoice management, leading to cost reductions and potential savings for organizations implementing such a system.
Schedule Feasibility	The project is deemed feasible within the project schedule. Key milestones and deadlines have been established, and the development phases are structured to meet the intended timeline. Effective project management practices contribute to schedule feasibility.

3.5 Architecture Diagram

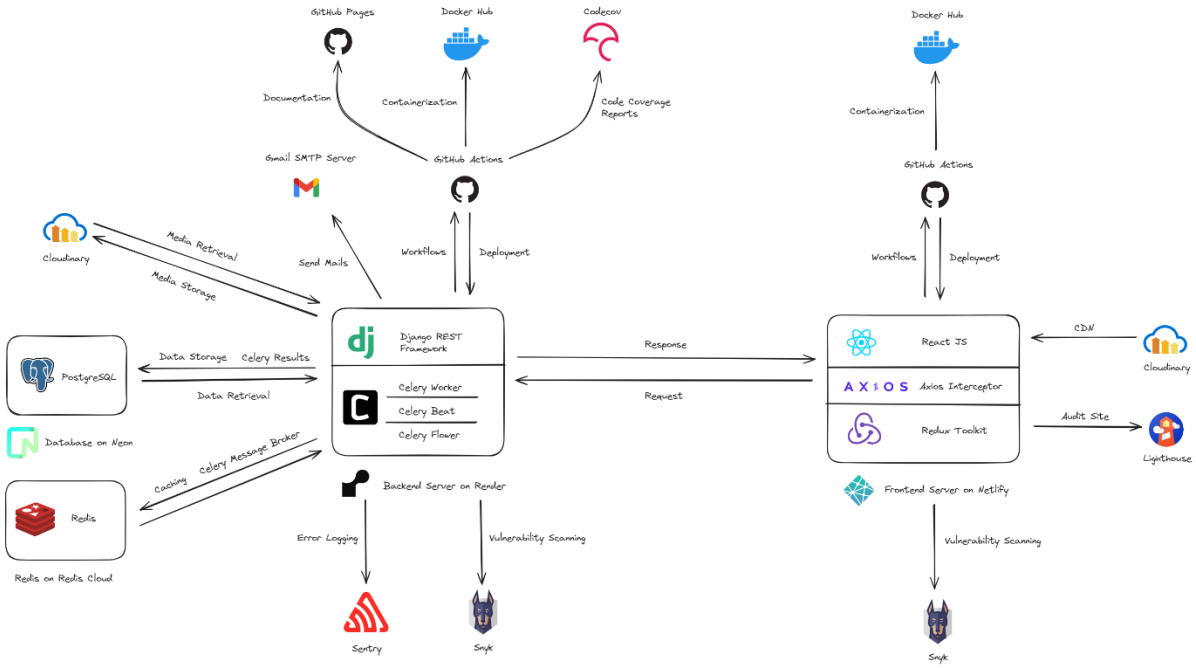

Fig. (3.1) Architecture Diagram

3.6 UML Diagrams

3.6.1 Use-Case Diagram

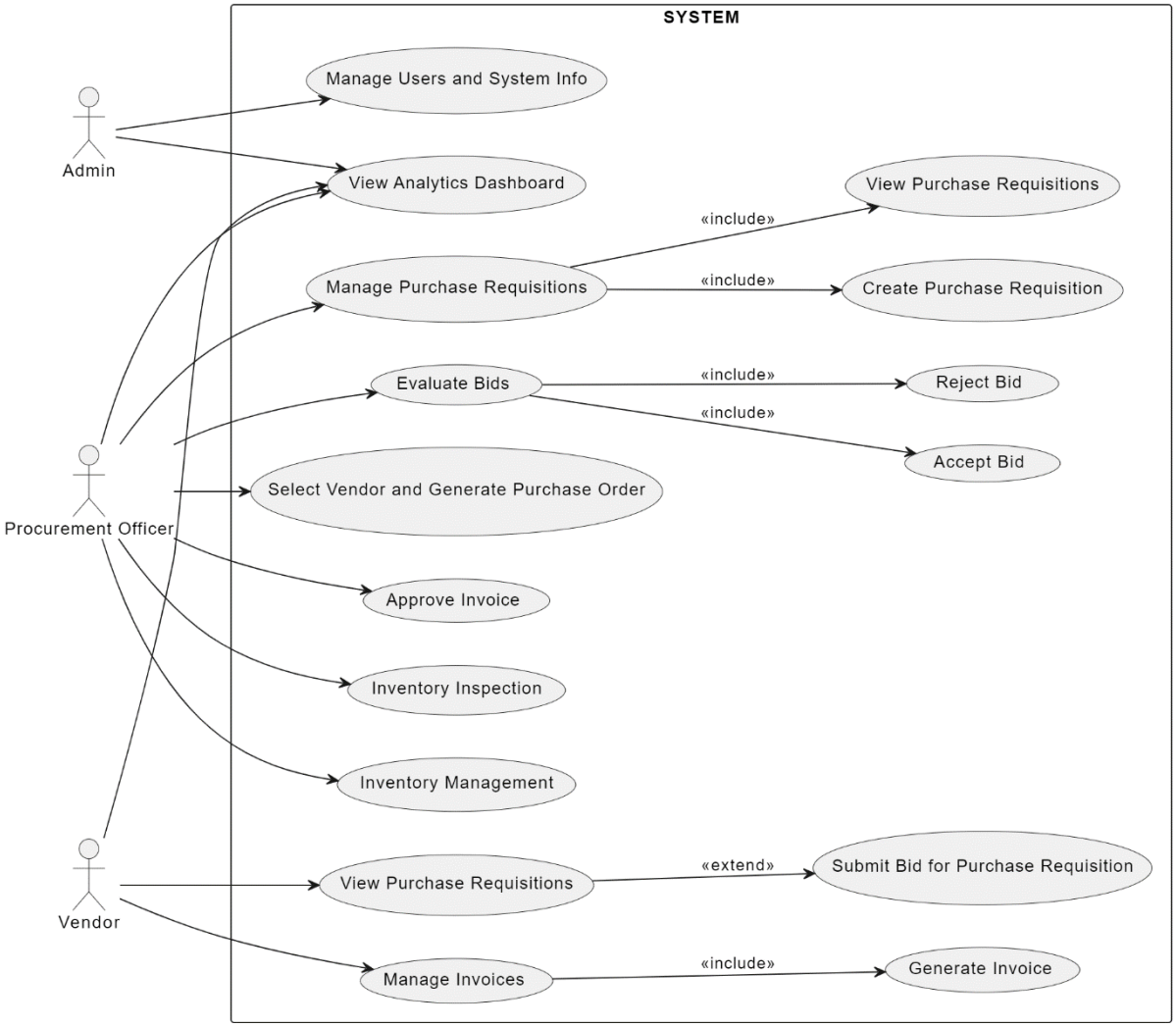

Fig. (3.2) Use-Case Diagram

3.6.2 Activity Diagram

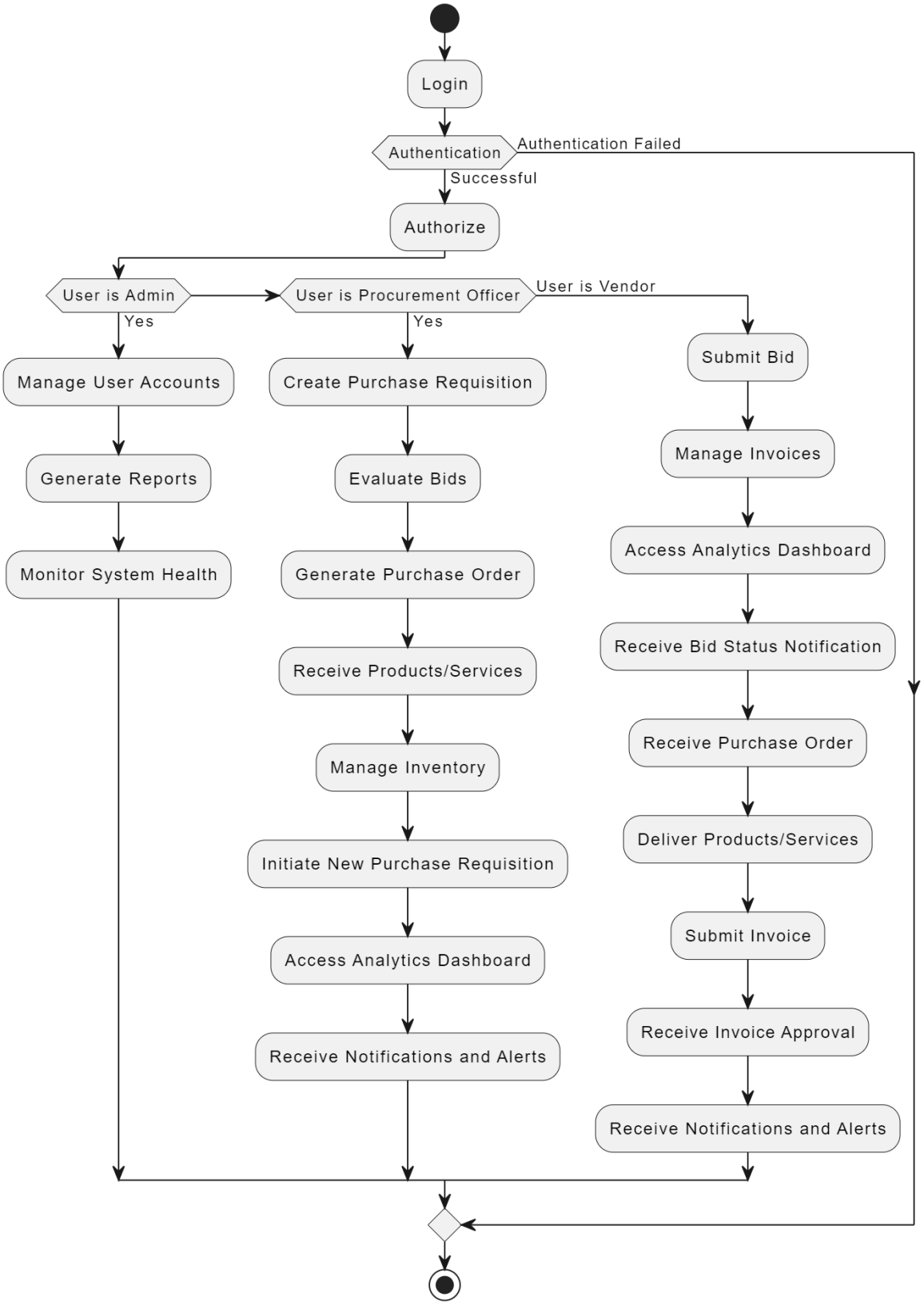

Fig. (3.3) Activity Diagram

3.6.3 Class Diagram

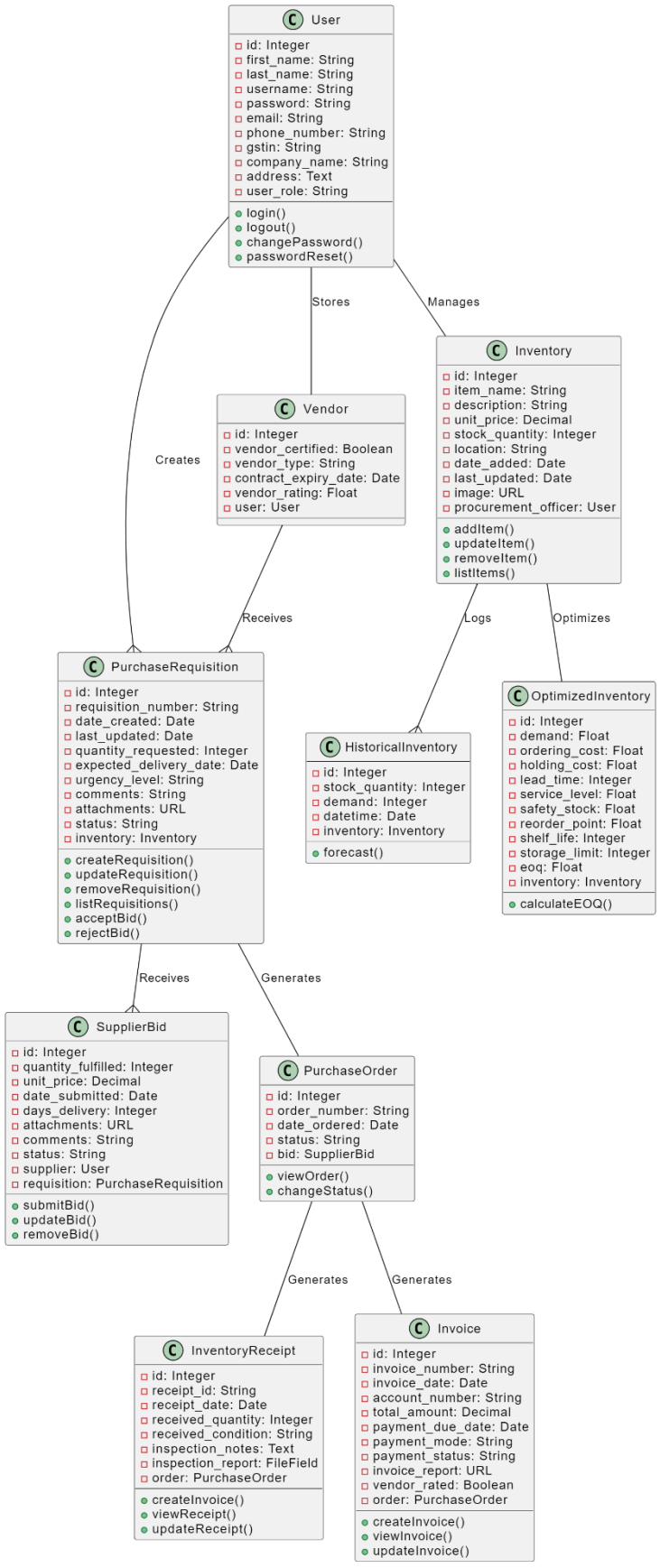

Fig. (3.4) Class Diagram

3.6.4 ER Diagram

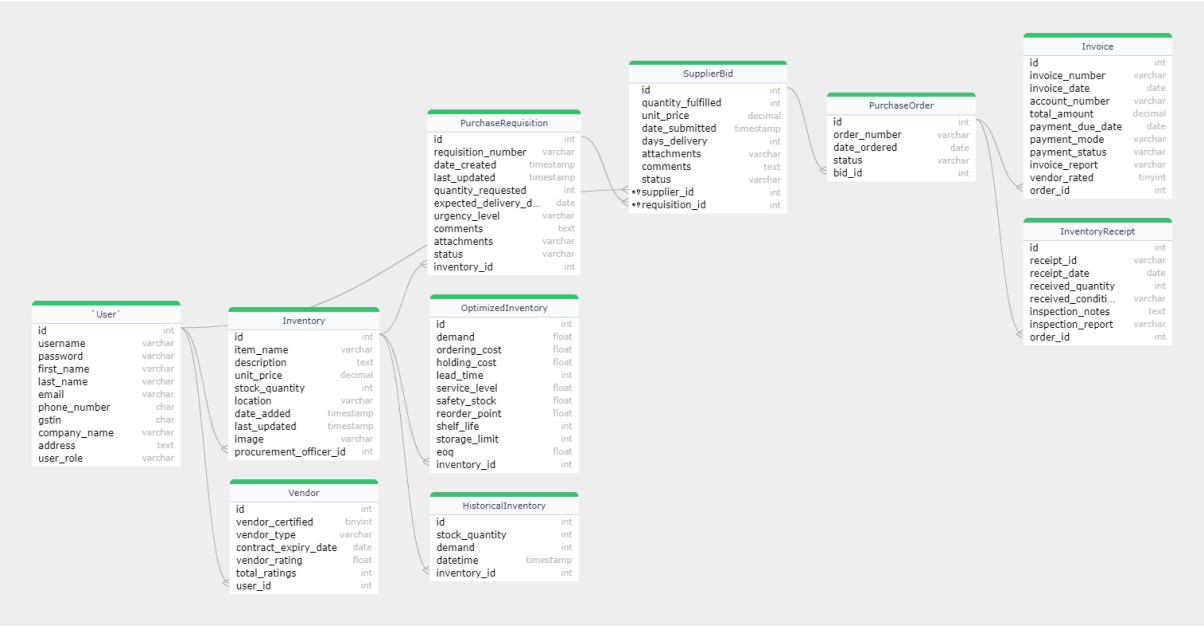

Fig. (3.5) ER Diagram Crow's Foot Notation

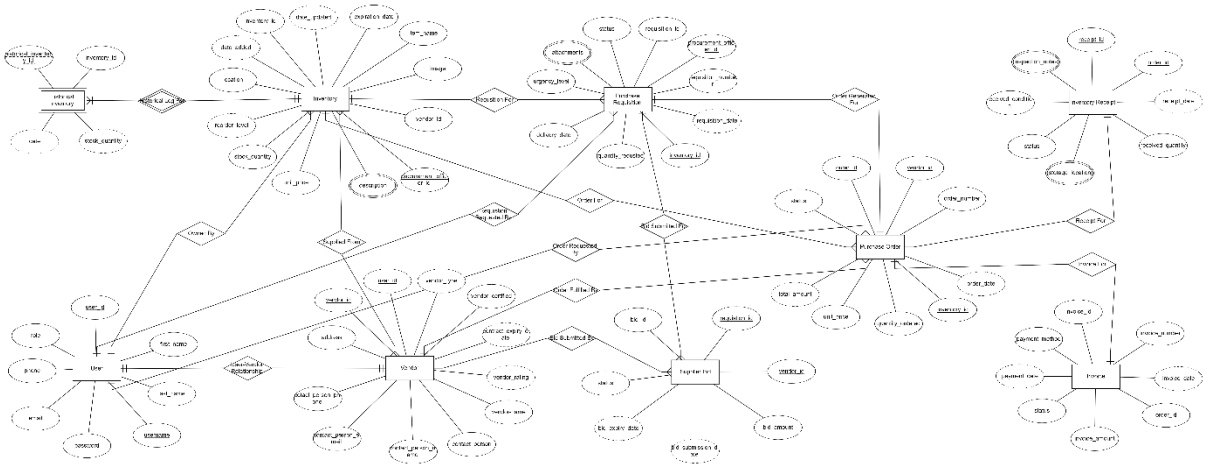

Fig. (3.6) ER Diagram Chen's Notation

3.6.5 Sequence Diagram

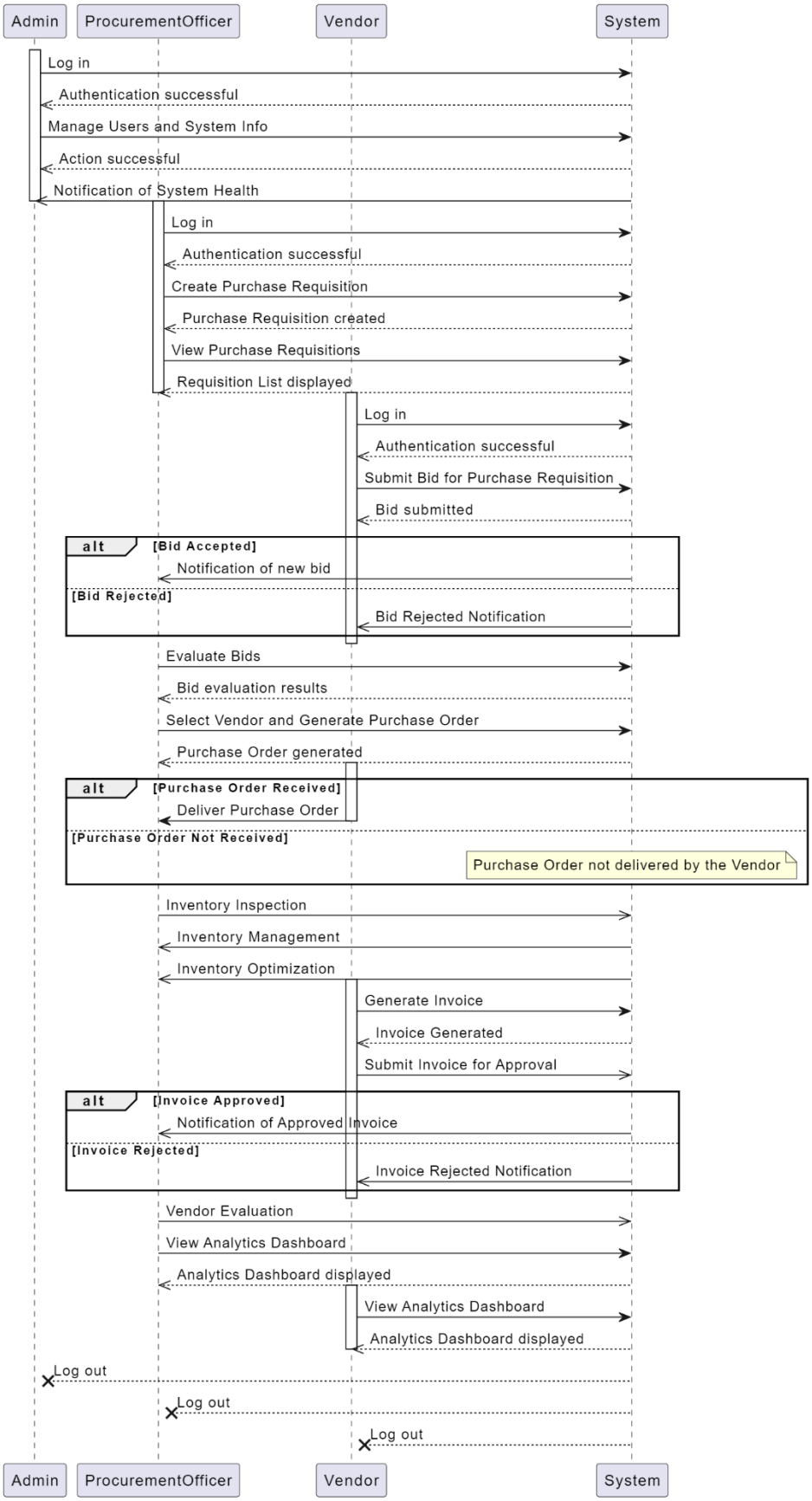

Fig. (3.7) Sequence Diagram

3.6.6 Component Diagram

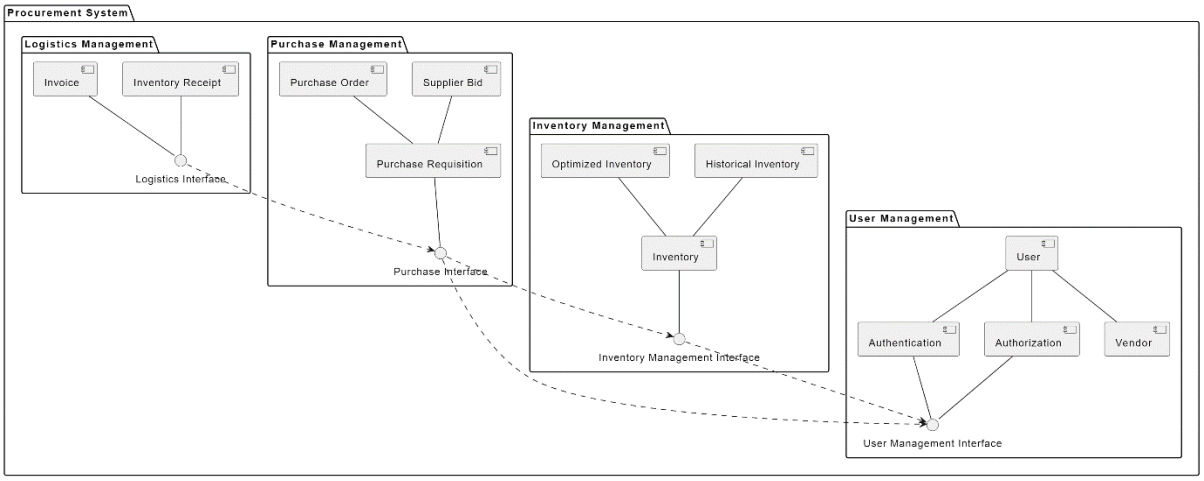

Fig. (3.8) Component Diagram

3.6.7 State Machine Diagram

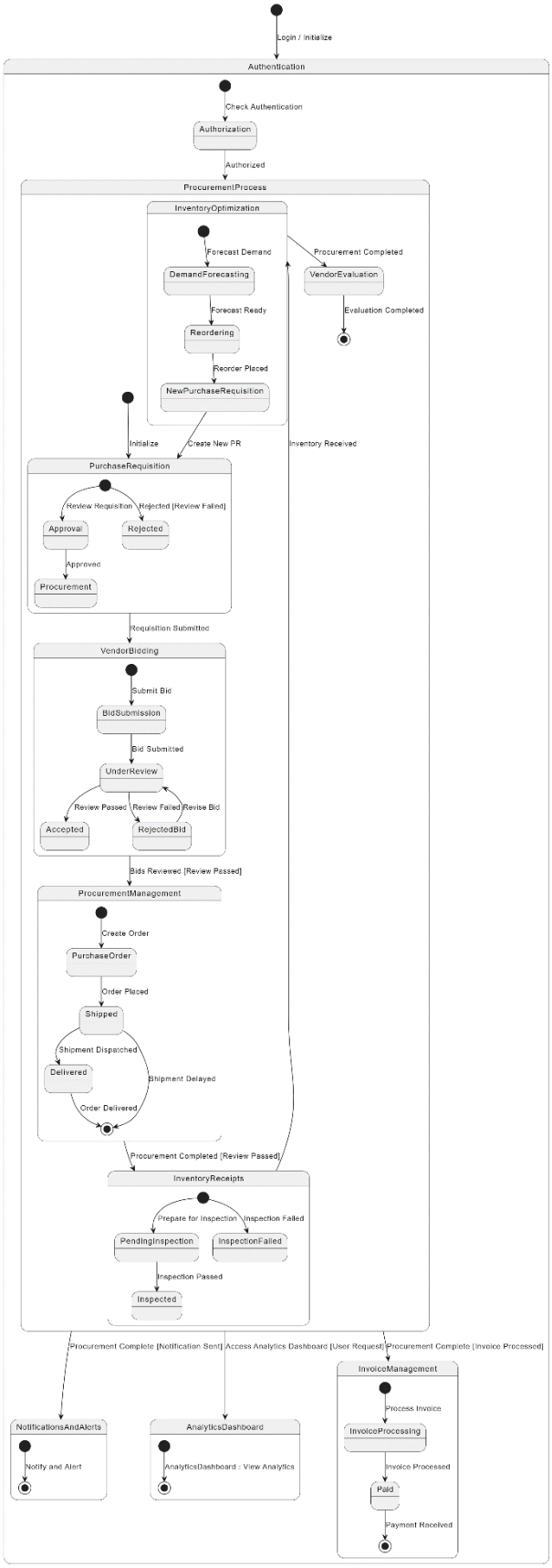

Fig. (3.9) State Machine Diagram

3.6.8 Deployment Diagram

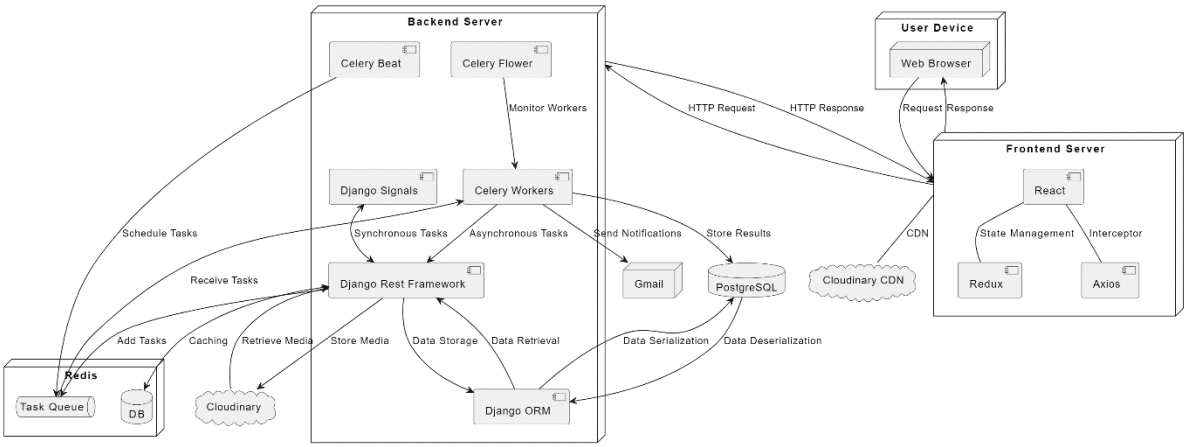

Fig. (3.10) Deployment Diagram

Chapter – 4
Implementation and Coding

4.1 Introduction

The implementation and coding chapter of our project report delves into the technical intricacies and methodologies employed in realizing the envisioned solution. This section serves as a comprehensive guide detailing the development process, from conceptualization to deployment. Through meticulous planning, rigorous coding practices, and adherence to industry best practices, we have brought our project to fruition. This chapter elucidates the technologies utilized, architectural decisions made, algorithmic implementations, and code structure. It provides insights into the development environment setup, version control strategies, testing procedures, and deployment methodologies employed. By offering a detailed exposition of the implementation phase, this chapter aims to provide a comprehensive understanding of the technical underpinnings that power our procurement optimization web application.

4.2 Database Schema

The database schema forms the backbone of our procurement optimization system, outlining the structure and relationships of essential data entities. It defines the fields and their respective data types for entities like users, vendors, inventory, purchase requisitions, supplier bids, purchase orders, inventory receipts, and invoices. This structured framework ensures efficient data organization and retrieval, fostering consistency and reliability throughout the procurement process.

Table 4.1 Database Schema

Table	Columns
User	id: integer first_name: varchar(150) last_name: varchar(150) username: varchar(150) email: varchar(254) phone_number: varchar(10) gstin: varchar(15) company_name: varchar(255) address: text user_role: varchar(255) is_superuser: bool
Vendor	id: integer vendor_certified: bool vendor_type: varchar(20) contract_expiry_date: date vendor_rating: real total_ratings: integer unsigned user_id: bigint
Inventory	id: integer item_name: varchar(255) description: text unit_price: decimal stock_quantity: integer unsigned location: varchar(255) date_added: datetime last_updated: datetime image: varchar(100) procurement_officer_id: bigint
HistoricalInventory	id: integer stock_quantity: integer unsigned demand: integer unsigned

	datetime: datetime inventory_id: bigint
OptimizedInventory	id: integer demand: real ordering_cost: real holding_cost: real lead_time: integer unsigned service_level: real safety_stock: real reorder_point: real shelf_life: integer unsigned storage_limit: integer unsigned eoq: real inventory_id: bigint
PurchaseRequisition	id: integer requisition_number: varchar(255) date_created: datetime last_updated: datetime quantity_requested: integer expected_delivery_date: date urgency_level: varchar(10) comments: text attachments: varchar(100) report: varchar(100) status: varchar(10) inventory_id: bigint
SupplierBid	id: integer quantity_fulfilled: integer unit_price: real date_submitted: datetime days_delivery: integer attachments: varchar(100) comments: text status: varchar(20)

	supplier_id: bigint requisition_id: bigint
PurchaseOrder	id: integer order_number: varchar(255) date_ordered: date status: varchar(20) bid_id: bigint
InventoryReceipt	id: integer receipt_id: varchar(255) receipt_date: date received_quantity: integer received_condition: varchar(20) inspection_notes: text inspection_report: varchar(255) order_id: bigint
Invoice	id: integer invoice_number: varchar(255) invoice_date: date account_number: varchar(255) total_amount: decimal payment_due_date: date payment_mode: varchar(20) payment_status: varchar(20) invoice_report: varchar(100) vendor_rated: bool order_id: bigint

4.3 Operational Details

The operational details of our procurement optimization system encapsulate the intricate processes and functionalities that govern its day-to-day functioning. Spanning across user management, inventory control, purchase requisition, logistics coordination, and analytical insights, these operational aspects ensure the seamless execution of procurement activities. By

delving into the operational intricacies of each module, stakeholders gain a holistic understanding of the system's capabilities and workflows.

4.3.1 Modules

Our procurement optimization system comprises five distinct modules, each tailored to address specific user roles and requirements. These modules, namely User Management, Inventory Management, Purchase Management, Logistics Management, and Dashboard Analytics, collectively contribute to streamlining procurement processes and enhancing operational efficiency. Below is a brief overview of each module and its purpose:

User Management Module: This module focuses on managing user-related functionalities within the system. It facilitates user registration, authentication, and authorization processes. Administrators can create and manage user accounts, assign roles, and regulate access permissions. Additionally, this module ensures seamless communication and collaboration among users involved in procurement activities.

Inventory Management Module: The Inventory Management module is designed to oversee the procurement officer's tasks related to inventory control and optimization. It enables users to track inventory items, manage stock quantities, monitor item prices, and analyze inventory aging. By providing insights into inventory status and trends, this module aids in optimizing inventory levels, minimizing stockouts, and reducing holding costs.

Purchase Management Module: The Purchase Management module focuses on managing the procurement requisition and order lifecycle. Procurement officers utilize this module to create purchase requisitions, specify required quantities, and define urgency levels. Furthermore, it facilitates the evaluation and processing of supplier bids, creation of purchase orders, and monitoring of order statuses. This module aims to streamline the procurement workflow, ensure compliance with procurement policies, and expedite the procurement process.

Logistics Management Module: The Logistics Management module addresses the logistical aspects of procurement, including receipt and inspection of purchased goods. It enables users to record inventory receipts, inspect received items for quality and condition, and generate inspection reports. Additionally, this module tracks the movement of goods within the supply chain, coordinates deliveries, and manages inventory replenishment activities. By optimizing

logistics operations, this module enhances supply chain efficiency and ensures timely delivery of goods.

Dashboard Analytics Module: The Dashboard Analytics module provides users with actionable insights and visualizations derived from procurement data. It offers comprehensive dashboards tailored to different user roles, such as administrators, procurement officers, and vendors. Users can access key performance indicators, trend analyses, and data visualizations related to user demographics, inventory status, purchase requisitions, supplier bids, purchase orders, and more. This module empowers decision-makers to make informed choices, identify areas for improvement, and optimize procurement strategies based on data-driven insights.

Collectively, these modules constitute a comprehensive solution for optimizing procurement processes, fostering collaboration, and driving efficiency across the procurement lifecycle.

4.3.2 Code Listing

auto_arima.py

```python
def calculate_auto_arima(monthly_demand):
    decomposed = seasonal_decompose(monthly_demand["demand"])
    data = monthly_demand["demand"]
    trend = decomposed.trend
    seasonal = decomposed.seasonal
    residual = decomposed.resid
    data_trace = go.Scatter(x=monthly_demand.index, y=data, mode="lines", name="Data")
    trend_trace = go.Scatter(
        x=monthly_demand.index, y=trend, mode="lines", name="Trend"
    )
    seasonal_trace = go.Scatter(
        x=monthly_demand.index, y=seasonal, mode="lines", name="Seasonal"
    )
    residual_trace = go.Scatter(
        x=monthly_demand.index, y=residual, mode="lines", name="Residual"
    )
    layout = go.Layout(
        title="Decomposed Components",
        xaxis=dict(title="Date"),
        yaxis=dict(title="Value"),
        xaxis_rangeslider_visible=True,
    )
    fig = go.Figure(
        data=[data_trace, trend_trace, seasonal_trace, residual_trace], layout=layout
    )
    decomposed_json = pio.to_json(fig)

    model = auto_arima(
        monthly_demand["demand"],
        seasonal=True,
        m=12,
        test="adf",
        maxiter=100,
        max_order=None,
        d=None,
        error_action="ignore",
        suppress_warnings=True,
        stepwise=True,
        trace=True,
    )

    forecast_results = model.predict(n_periods=12, return_conf_int=False)

    trace1 = go.Scatter(
        x=monthly_demand.index,
        y=monthly_demand["demand"],
        mode="lines+markers",
        name="Original Data",
    )
    forecast_dates = pd.date_range(
        start=monthly_demand.index[-1], periods=13, freq="M"
    )[
        1:
    ]  # Next 12 months
    trace2 = go.Scatter(
        x=forecast_dates, y=forecast_results, mode="lines+markers", name="Forecast Data"
    )
    layout = go.Layout(
        title="Demand Forecast",
        xaxis=dict(title="Date"),
        yaxis=dict(title="Demand"),
        xaxis_rangeslider_visible=True,
    )
    fig = go.Figure(data=[trace1, trace2], layout=layout)
    graph_json = pio.to_json(fig)

    forecast_data = {
        "decomposed": decomposed_json,
        "forecast": list(forecast_results),
        "annual_forecast": sum(forecast_results),
        "graph": graph_json,
    }
    return forecast_data
```

eoq.py

```python
def calculate_eoq_classical(demand, ordering_cost, holding_cost):
    eoq = np.sqrt((2 * demand * ordering_cost) / holding_cost)
    return eoq


def calculate_safety_stock_reorder_point(demand, lead_time, service_level):
    demand_per_day = demand / 365
    lead_time_demand = demand_per_day * lead_time
    z_score = norm.ppf(service_level + (1 - service_level) / 2)
    safety_stock = z_score * math.sqrt(lead_time * demand_per_day * demand_per_day)
    reorder_point = lead_time_demand + safety_stock
    return safety_stock, reorder_point


def calculate_eoq_with_rop(
    demand, ordering_cost, holding_cost, lead_time, service_level
):
    _, reorder_point = calculate_safety_stock_reorder_point(
        demand, lead_time, service_level
    )
    eoq_with_rop = math.sqrt(
        (2 * demand * ordering_cost) * (reorder_point) / holding_cost
    )
    return eoq_with_rop


def calculate_eoq_perishable(demand, ordering_cost, holding_cost, shelf_life):
    demand_per_day = demand / 365
    eoq_perishable = math.sqrt(
        (2 * demand_per_day * ordering_cost) * shelf_life / holding_cost
    )
    return eoq_perishable


def calculate_eoq_limited_storage(
    demand, ordering_cost, holding_cost, storage_capacity
):
    eoq = math.sqrt((2 * demand * ordering_cost) / holding_cost)
    eoq_limited_storage = min(eoq, storage_capacity)
    return eoq_limited_storage
```

topsis.py

```python
class SupplierBidProcurementOfficerRankingView(generics.GenericAPIView):
    def post(self, request, requisition_id, *args, **kwargs):
        # Check if there are at least two bids
        if bids.count() < 2:
            return Response(
                {"error": "There must be at least two bids to perform ranking."},
                status=status.HTTP_400_BAD_REQUEST,
            )

        serializer = self.serializer_class(bids, many=True)
        data = serializer.data

        df = pd.DataFrame(data)
        df["unit_price"] = pd.to_numeric(df["unit_price"])
        df["quantity_fulfilled"] = pd.to_numeric(df["quantity_fulfilled"])
        df["days_delivery"] = pd.to_numeric(df["days_delivery"])
        df["supplier_rating"] = pd.to_numeric(df["supplier_rating"])
        df["total_ratings"] = pd.to_numeric(df["total_ratings"])
        df["total_cost"] = df["unit_price"] * df["quantity_fulfilled"]

        # Multi-Criteria Evaluation using TOPSIS - Technique for Order of Preference by Similarity to Ideal Solution

        # 1. Normalize the Decision Matrix
        norm_df = df.copy()
        norm_df = norm_df[
            [
                "unit_price",
                "total_cost",
                "days_delivery",
                "supplier_rating",
                "total_ratings",
            ]
        ]
        norm_df = (norm_df - norm_df.min()) / (norm_df.max() - norm_df.min())

        # 2. Define weights for each criterion
        serializer = self.get_serializer(data=request.data)
        serializer.is_valid(raise_exception=True)
        weights = {
            "unit_price": serializer.validated_data["weight_unit_price"],
            "total_cost": serializer.validated_data["weight_total_cost"],
            "days_delivery": serializer.validated_data["weight_days_delivery"],
            "supplier_rating": serializer.validated_data["weight_supplier_rating"],
            "total_ratings": serializer.validated_data["weight_total_ratings"],
        }

        # 3. Multiply the normalized decision matrix by the weights to get the weighted normalized decision matrix
        for col in norm_df.columns:
            norm_df[col] *= weights[col]

        # 4. Determine the positive ideal solution (PIS) and negative ideal solution (NIS)
        PIS = pd.Series(
            {
                "unit_price": norm_df["unit_price"].min(),
                "total_cost": norm_df["total_cost"].min(),
                "days_delivery": norm_df["days_delivery"].min(),
                "supplier_rating": norm_df["supplier_rating"].max(),
                "total_ratings": norm_df["total_ratings"].max(),
            }
        )

        NIS = pd.Series(
            {
                "unit_price": norm_df["unit_price"].max(),
                "total_cost": norm_df["total_cost"].max(),
                "days_delivery": norm_df["days_delivery"].max(),
                "supplier_rating": norm_df["supplier_rating"].min(),
                "total_ratings": norm_df["total_ratings"].min(),
            }
        )

        # 5. Calculate euclidean distances from PIS and NIS
        dist_PIS = np.sqrt(((norm_df - PIS) ** 2).sum(axis=1))
        dist_NIS = np.sqrt(((norm_df - NIS) ** 2).sum(axis=1))

        # 6. Calculate relative closeness
        closeness = dist_NIS / (dist_PIS + dist_NIS)
        df["closeness"] = closeness
        norm_df["closeness"] = closeness

        # 7. Rank the alternatives based on closeness values
        df["rank"] = df["closeness"].rank(ascending=False)
        norm_df["rank"] = norm_df["closeness"].rank(ascending=False)

        # Sort the dataframes by rank
        df = df.sort_values(by="rank")
        norm_df = norm_df.sort_values(by="rank")

        return Response(response_data, content_type="application/json")
```

4.4 Screenshots

Visual representations are paramount in comprehending the user interface and functionalities of our procurement optimization system. The following screenshots provide a glimpse into the intuitive design and operational workflows of the system, offering stakeholders a tangible insight into its user experience and features.

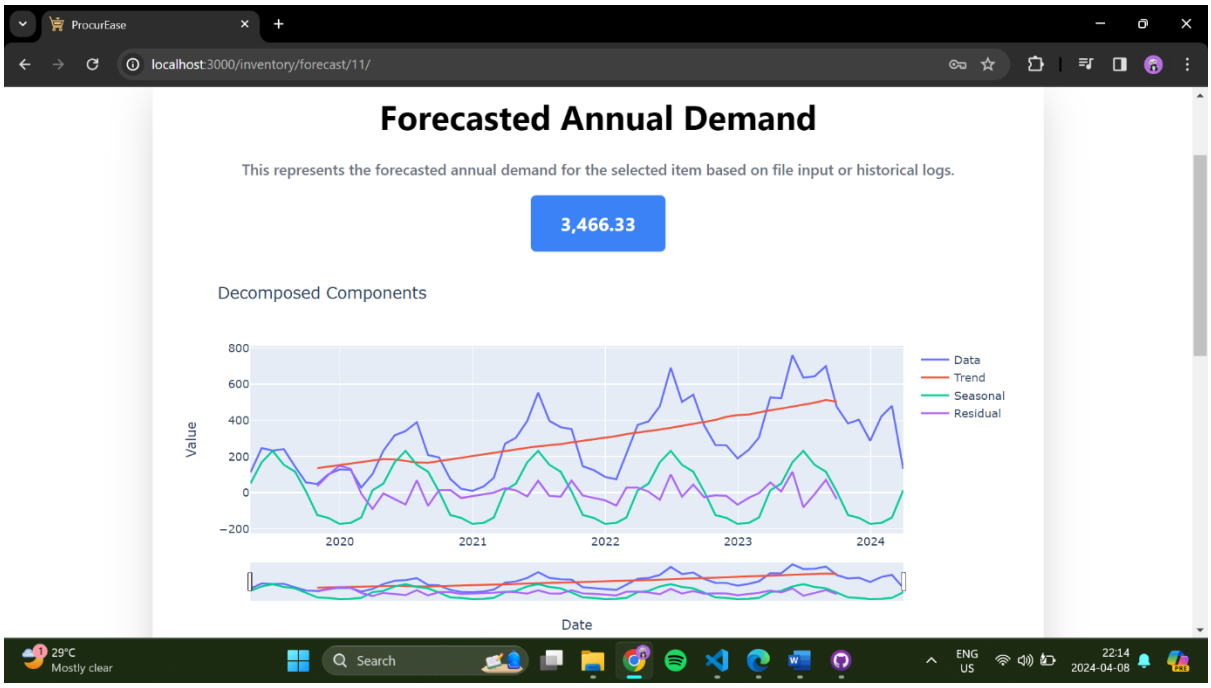

Fig. (4.1) Seasonal Decomposition Chart

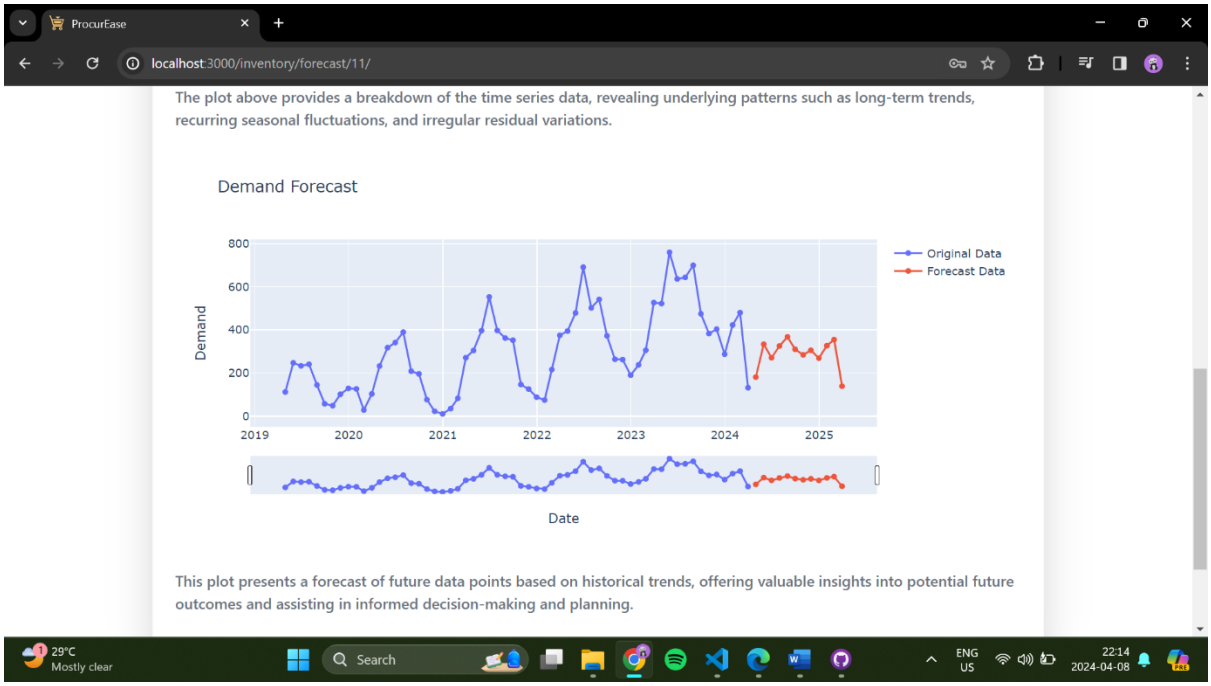

Fig. (4.2) Demand Forecast Chart

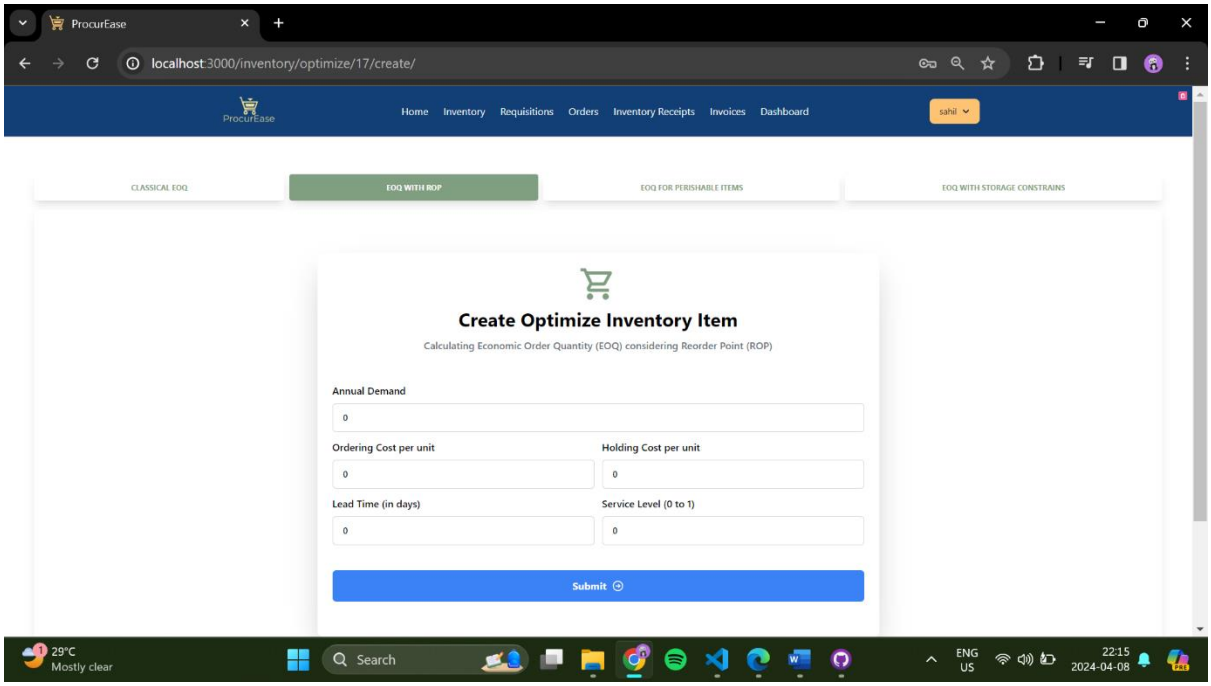

Fig. (4.3) Economic Order Quantity Forms

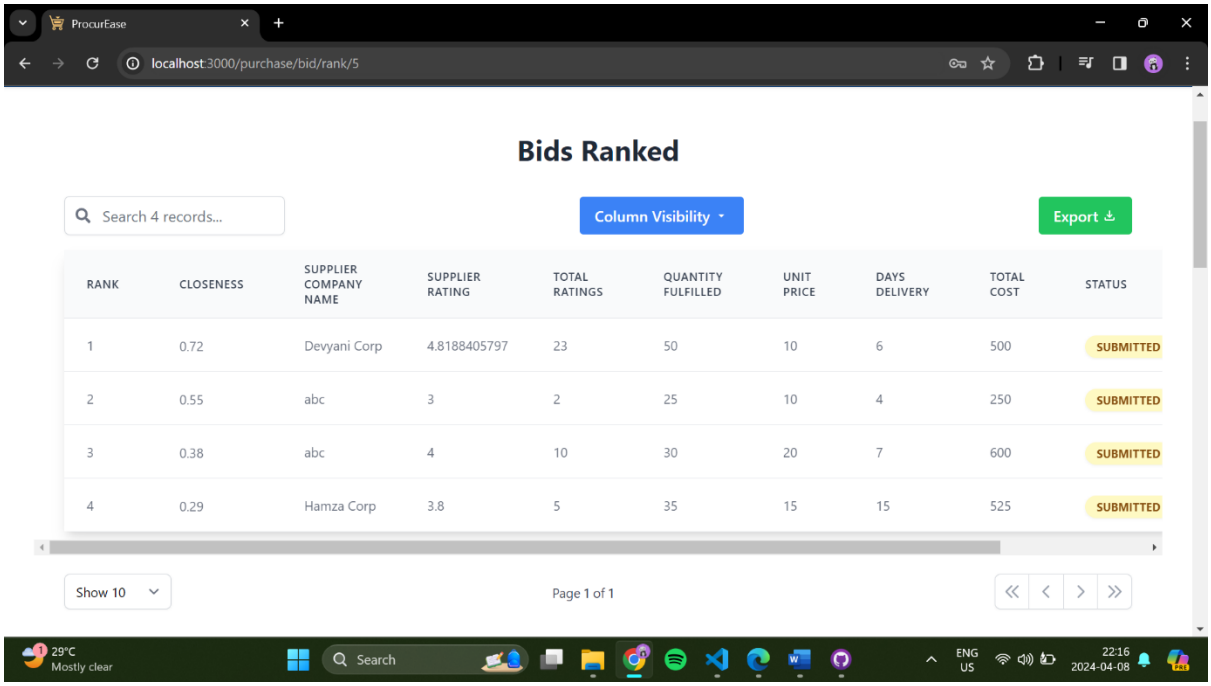

Fig. (4.4) Ranked Bids Table

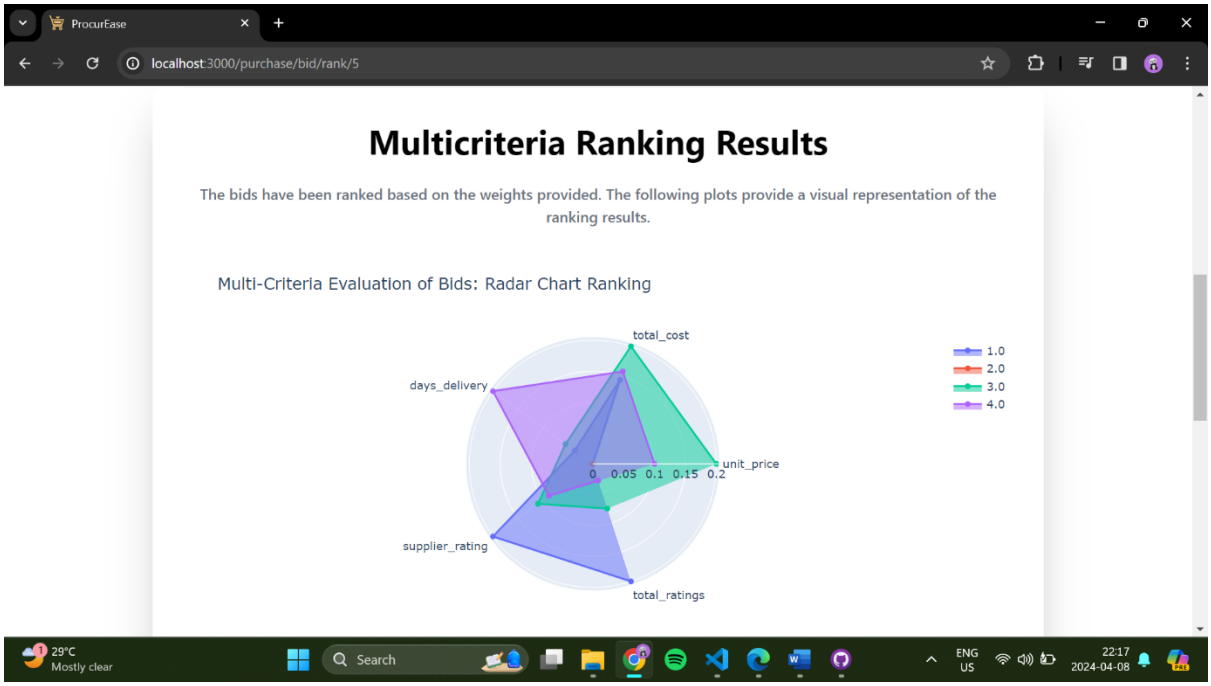

Fig. (4.5) Radar Chart of Bids

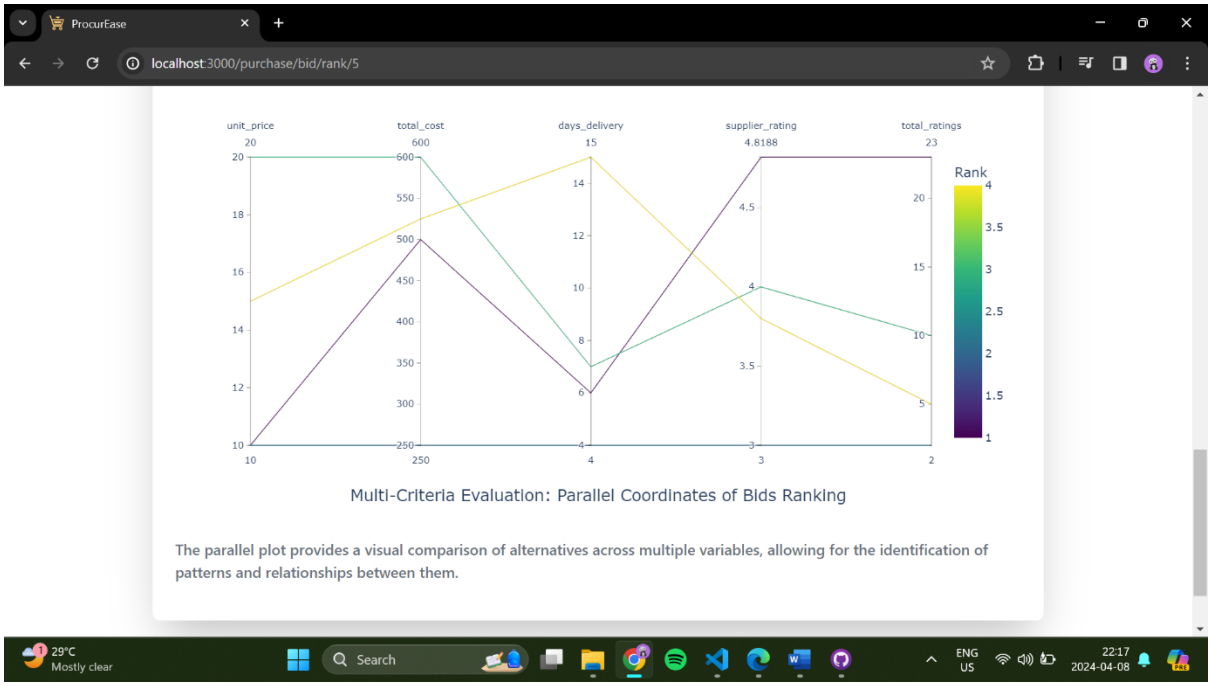

Fig. (4.6) Parallel Plot of Bids

Chapter – 5
Testing

5.1 Introduction

The testing phase is a critical chapter in our project's development journey, as it focuses on ensuring the reliability, functionality, and overall quality of our comprehensive Procurement Management System. This chapter delves into three fundamental aspects of testing: unit testing, integration testing, and acceptance testing.

Throughout this chapter, we provide an in-depth exploration of our testing strategies, methodologies, test cases, and expected outcomes for each testing phase. Our meticulous approach to testing is designed to identify and rectify any issues, guaranteeing that our Procurement Management System is not only technically sound but also fully aligned with the practical needs and expectations of our diverse user base.

5.2 Unit Testing

This initial phase involves examining individual components or units of our software. Developers test each unit independently to ensure that it functions as expected, with a focus on code-level testing. By conducting unit tests, we can identify and rectify issues at an early stage, ensuring that the foundation of our system is robust and reliable.

Table 5.1 Unit Testing Testcases

Module	Description	Expected Output	Actual Output	Result
Authentication	User login with valid credentials	User should be logged in successfully	User is logged in successfully	Pass
Authentication	User login with invalid password	User should not be logged in, receive an error message	User is not logged in, received an error message	Pass

Authentication	User login with invalid username	User should not be logged in, receive an error message	User is not be logged in, received an error message	Pass
Inventory	Add a new item to inventory	Item should be added successfully	Item is added successfully	Pass
Inventory	Update item details	Item details should be updated	Item details are updated	Pass
Purchase Requisition	Create a new requisition	Requisition should be created	Requisition is created	Pass
Purchase Requisition	Reject a requisition	Requisition should be rejected	Requisition is rejected	Pass
Vendor Bidding	Submit a bid for a requisition	Bid should be submitted successfully	Bid is submitted successfully	Pass
Vendor Bidding	View open requisitions	List of open requisitions should be displayed	List of open requisitions is displayed	Pass
Inventory Receipt	Receive inventory	Inventory should be received	Inventory is received	Pass
Inventory Receipt	Inspect received items	Items should be inspected	Items are inspected	Pass
Invoice Management	Process an invoice	Invoice should be processed	Invoice is processed	Pass
Invoice Management	Mark invoice as paid	Invoice should be marked as paid	Invoice is marked as paid	Pass
Vendor Evaluation	Evaluate a vendor	Vendor should be evaluated	Vendor is evaluated	Pass
Vendor Evaluation	Rate a vendor	Vendor should be rated	Vendor is rated	Pass

Analytics Dashboard	Access dashboard	Dashboard should be displayed	Dashboard is displayed	Pass
Notifications and Alerts	Receive a notification	Notification should be received	Notification is received	Pass

5.3 Integration Testing

Once individual units are verified, integration testing comes into play. This phase evaluates how different components work together as an integrated whole. It examines the interactions and data flow between various units, ensuring that the system functions cohesively. Integration testing identifies any issues that may arise when different units interact, allowing us to address these challenges proactively.

Table 5.2 Integration Testing Testcases

Module Integration	**Description**	**Expected Output**	**Actual Output**	**Result**
Authentication & Inventory	Log in and access inventory	User should log in successfully and access inventory	User is logged in successfully and can access inventory	Pass
Authentication & Purchase Requisition	Log in and create a requisition	User should log in successfully and create a requisition	User is logged in successfully and can create a requisition	Pass
Purchase Requisition & Vendor Bidding	Create a requisition and submit a bid	Requisition should be created, bid submitted	Requisition is created and bid is submitted	Pass
Vendor Bidding & Procurement Management	Submit a bid and approve requisition	Bid should be submitted, requisition approved	Bid is submitted and requisition is approved	Pass

Procurement Management & Inventory Receipt	Approve requisition and receive inventory	Requisition should be approved, inventory received	Requisition is approved and inventory is received	Pass
Inventory Receipt & Invoice Management	Receive inventory and process invoice	Inventory should be received, invoice processed	Inventory is received and invoice is processed	Pass
Invoice Management & Vendor Evaluation	Process invoice and evaluate a vendor	Invoice should be processed, vendor evaluated	Invoice is processed and vendor is evaluated	Pass
Vendor Evaluation & Analytics Dashboard	Evaluate a vendor and access dashboard	Vendor should be evaluated, dashboard displayed	Vendor is evaluated and dashboard is displayed	Pass
Analytics Dashboard & Notifications	Access dashboard and receive a notification	Dashboard should be displayed, notification received	Dashboard is displayed and notification is received	Pass

5.4 Acceptance Testing

The acceptance testing phase is the final stage where our Procurement Management System is tested against predetermined acceptance criteria. This phase ensures that the system aligns with the stakeholders' requirements and objectives. Acceptance testing allows users and stakeholders to validate that the system meets their needs and functions as intended in a real-world environment.

Table 5.3 Acceptance Testing Testcases

Test Case	Description	Expected Outcome	Actual Outcome	Result
User Login	Authenticate as a registered user	Successfully log in to the system	Successfully logged in to the system	Pass
Requisition Creation	Create a purchase requisition	Requisition is created and submitted successfully	Requisition is created and submitted successfully	Pass
Bid Submission	Submit a bid as a vendor	Bid is submitted and marked as "under review"	Bid is submitted and marked as "under review"	Pass
Requisition Approval	Approve a purchase requisition	Requisition is approved and marked as "pending delivery"	Requisition is approved and marked as "pending delivery"	Pass
Inventory Receipt	Receive inventory for approved requisition	Inventory is received and marked as "inspected"	Inventory is received and marked as "inspected"	Pass
Invoice Processing	Process an invoice	Invoice is processed and marked as "paid"	Invoice is processed and marked as "paid"	Pass
Vendor Evaluation	Evaluate a vendor	Vendor is evaluated, and rating is updated	Vendor is evaluated, and rating is updated	Pass
Dashboard Access	Access the analytics dashboard	Analytics dashboard is displayed	Analytics dashboard is displayed	Pass
Notifications	Receive system notifications	Notifications are received and displayed	Notifications are received and displayed	Pass

Chapter – 6
Results and Discussions

6.1 Main GUI Snapshots

The main graphical user interface (GUI) snapshots showcase the central hub of our procurement optimization system, offering a visual representation of its core functionalities and navigation pathways. These snapshots provide stakeholders with a firsthand look at the system's user-friendly interface and highlight key elements essential for efficient procurement management.

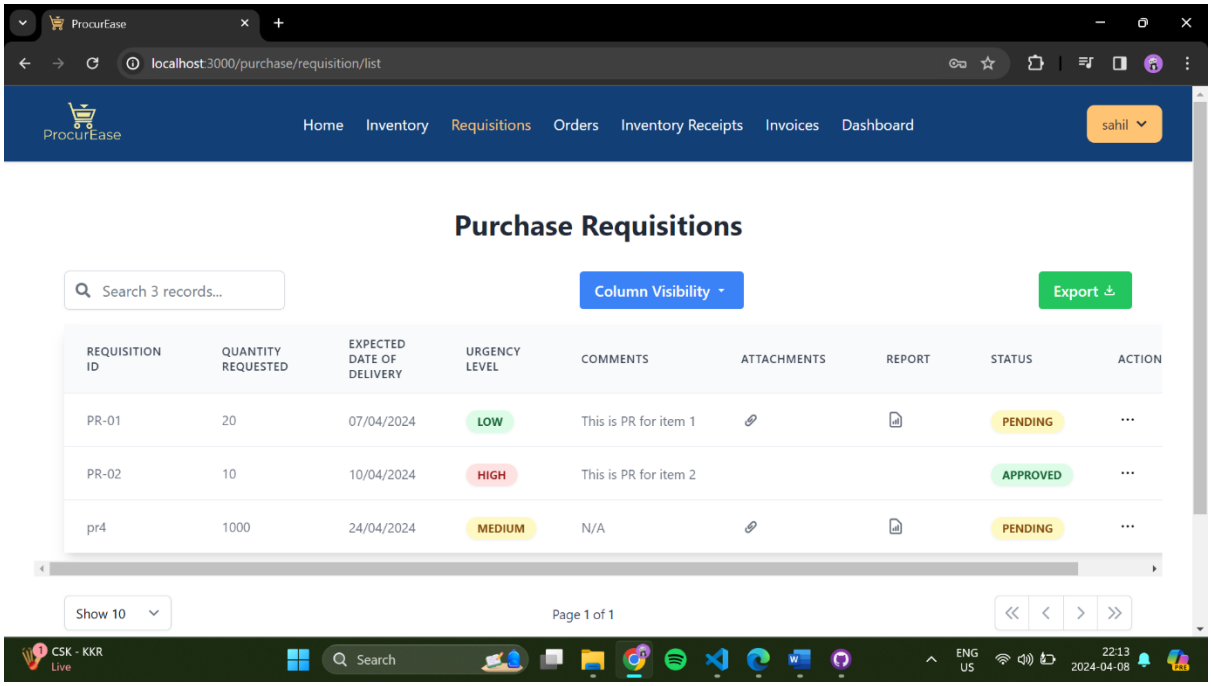

Fig. (6.1) Purchase Requisitions Table

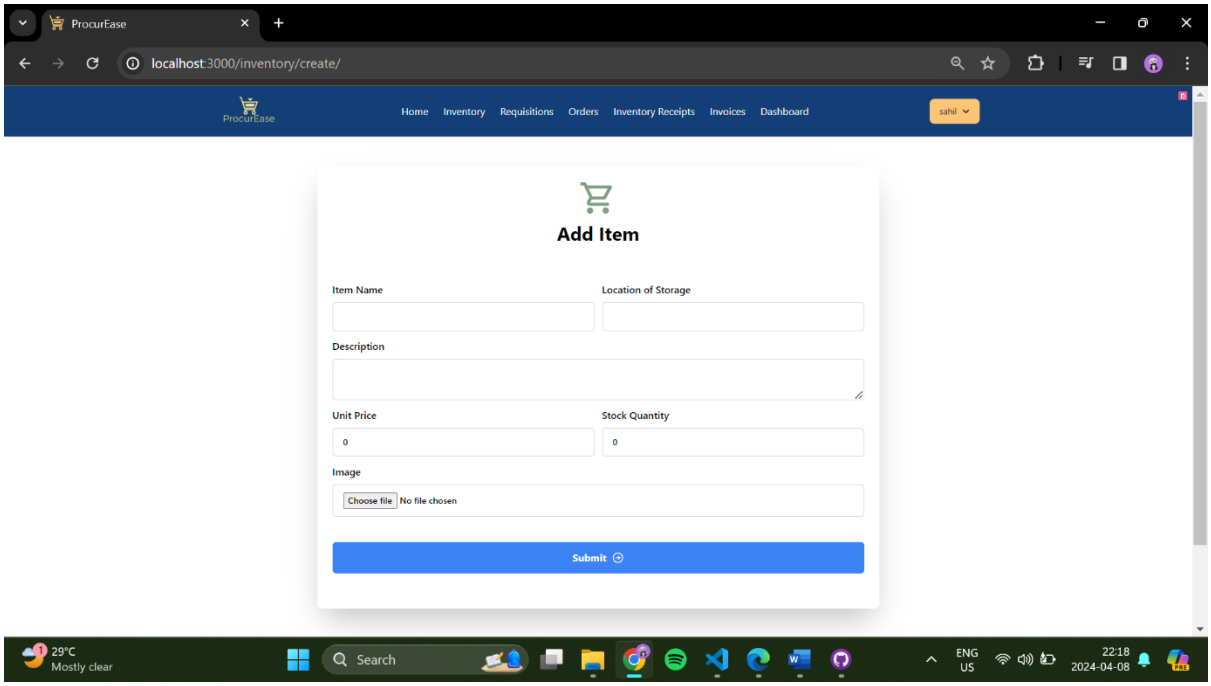

Fig. (6.2) Create Inventory Item Form

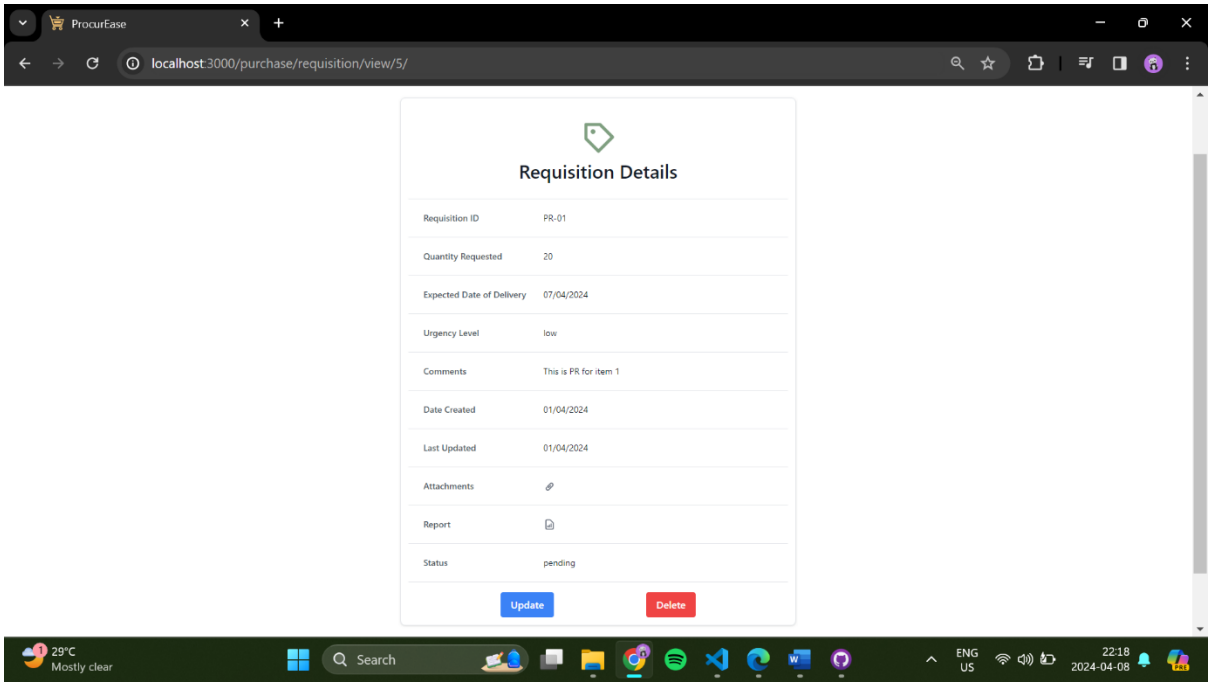

Fig. (6.3) View Requsition Card

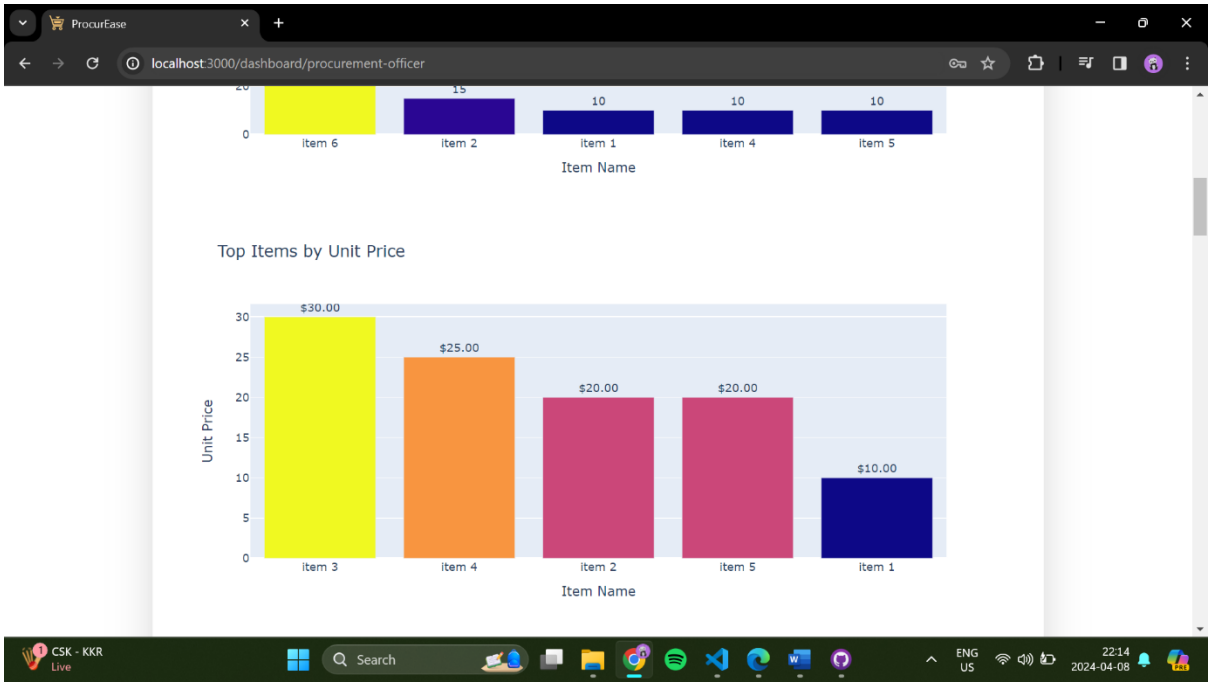

Fig. (6.4) Top Items by Unit Price Chart on Dashboard

6.2 Discussions

The optimization of procurement processes through the implementation of AI/ML technologies represents a significant advancement in streamlining and enhancing efficiency within organizational operations. Through the development of a web application utilizing a sophisticated stack of technologies including React, Django REST Framework (DRF), GitHub Actions, Docker, PostgreSQL, Redis, Celery, Cloudinary, Gmail service, and Django signals, our project aims to revolutionize traditional procurement methodologies.

Central to our approach is the integration of AI/ML algorithms into the procurement workflow, enabling predictive analytics, intelligent decision-making, and automated task execution. By leveraging historical data, machine learning models can forecast demand, identify trends, and optimize inventory levels, thereby reducing costs and minimizing wastage.

Moreover, the seamless integration of various technologies facilitates a comprehensive and user-friendly procurement platform. Utilizing React for the frontend ensures a responsive and intuitive user interface, while DRF powers the robust backend API, enabling seamless communication between client and server. GitHub Actions automates the testing and deployment process, ensuring continuous integration and delivery. Docker containerization enhances scalability and portability, allowing for easy deployment across different

environments. PostgreSQL and Redis databases store and manage data efficiently, while Celery enables asynchronous task execution for resource-intensive operations. Integration with Cloudinary facilitates seamless management of multimedia assets, enhancing user experience, while the Gmail service ensures effective communication and notification mechanisms. Additionally, Django signals enable real-time event handling and trigger actions based on specific conditions, further enhancing the agility and responsiveness of the system.

In conclusion, our project represents a comprehensive and innovative solution for optimizing procurement processes through the integration of AI/ML technologies and a sophisticated stack of web development tools. By harnessing the power of data-driven insights and automation, we aim to revolutionize the way organizations manage their procurement activities, driving efficiency, cost savings, and overall operational excellence.

Chapter – 7
Conclusion

In conclusion, the development of our project represents a significant stride in the realm of efficient and intelligent procurement solutions. Through meticulous planning, rigorous design, and dedicated implementation, our team has harnessed the power of advanced technologies, such as Django for the backend, React for the frontend, and the integration of AI/ML algorithms, to create a system that streamlines the entire procurement process.

This project aims to address key challenges in the procurement domain, enhancing it with features like Inventory Management, Purchase Requisition, Bidding and Evaluation, and more. With a robust backend, secure authentication, and data integrity measures in place, the system ensures that procurement processes are both seamless and safeguarded. The incorporation of Docker and CI/CD pipelines through GitHub Actions optimizes deployment and continuous integration, further underscoring our commitment to efficiency and reliability.

As we move forward, our commitment to innovation, scalability, and the incorporation of future technologies remains unwavering. We believe that ProcurEase has the potential to redefine and elevate the procurement landscape, driving efficiency, accuracy, and cost-effectiveness for organizations across various sectors. The journey from conceptualization to implementation has been one of learning, challenges, and dedication, and we are excited to continue refining and expanding our system to make it an indispensable asset for modern procurement processes.

Chapter – 8
Future Work

In this chapter, we outline the envisioned future developments and enhancements for ProcurEase, our innovative procurement solution. As our project continues to evolve, we aspire to incorporate a range of new features and concepts to further elevate its functionality, efficiency, and impact in the procurement domain.

Short-Term Goals: In the short term, our focus will be on implementing real-time notifications using Django Channels, enhancing our system's responsiveness and interactivity. Additionally, we plan to integrate advanced AI/ML algorithms to provide more intelligent insights and decision-making capabilities. Furthermore, we aim to introduce additional features tailored specifically for vendors, fostering stronger engagement and collaboration within the procurement ecosystem.

Medium-Term Objectives: Moving forward, our medium-term objectives center around infrastructure scaling and cloud migration. We intend to optimize our system's performance and scalability by migrating to cloud-based infrastructure and implementing advanced scaling mechanisms. Moreover, we aim to establish seamless integrations with third-party systems such as ERP (Enterprise Resource Planning) and CRM (Customer Relationship Management), enabling seamless data exchange and enhancing overall workflow efficiency.

Long-Term Vision: Looking ahead, our long-term vision encompasses the integration of emerging technologies to further augment ProcurEase's capabilities. We envision incorporating blockchain technology to enhance transparency, security, and traceability within the procurement process. Additionally, we aspire to explore immersive technologies such as augmented reality (AR), virtual reality (VR), as well as Internet of Things (IoT) and robotics to revolutionize procurement operations and user experiences.

As we embark on this journey of continuous innovation and advancement, our commitment to delivering cutting-edge solutions for modern procurement remains steadfast. We believe that by embracing these future developments, ProcurEase will continue to redefine the procurement landscape, driving efficiency, innovation, and value for organizations across diverse industries.

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