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INDUSTRIAL ATTACHMENT PROJECT REPORT SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE BACHELOR OF SCIENCE HONOURS DEGREE IN DATA SCIENCE AND INFORMATICS

FIELD SUPERVISOR'S SIGNATURE……..

MBARE MKAMBO FULL-STACK MARKETPLACE MANAGEMENT SYSTEM

DECLARATION

I, Macdonald Sairos hereby do declare that this work has not previously been accepted in substance for any degree and is not being concurrently submitted in candidature for any degree.

Student's Signature: ……. Date …….

(Macdonald Sairos)

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DEDICATION

Firstly, I would like to dedicate this piece of work to Almighty God for his divine inspiration in everything we did. Secondly, My parents for financial and emotional support and my field supervisor **Mr. Jimu,Paul Kofa, Simbarashe Chihera** and **Tanaka Mambinge** for the corrections in my mistakes.

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ABSTRACT

The Mbare Mkambo Marketplace Management System addresses the critical challenges faced by vendors and administrators in Zimbabwe's largest informal marketplace, particularly following the devastating fire incident in October 2024. This study aims to develop a comprehensive full-stack digital solution that streamlines marketplace operations through automated processes, role-based access control, and integrated financial management. By leveraging a Node.js/Express backend and a React frontend, the application will facilitate efficient vendor registration, stall allocation, and payment processing, ultimately enhancing operational efficiency and vendor satisfaction.

The system will utilize advanced algorithms to automate billing and payment processing, providing real-time updates and comprehensive audit trails. Additionally, the application will incorporate analytics and visualization tools to enable data-driven decision-making for marketplace administrators. The research will also explore the socio-economic impact of the digital transformation on the local community, offering valuable insights for policymakers and urban planners.

The ultimate goal of this project is to create a user-friendly platform that not only improves the operational dynamics of the Mbare Mkambo marketplace but also contributes to the economic revitalization of the affected community. By digitizing traditional marketplace management, the system aims to reduce operational costs, enhance transparency, and foster a more sustainable and resilient marketplace environment.

Keywords: Marketplace management, digital transformation, Node.js, React, financial management, vendor satisfaction.

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CHAPTER 1: INTRODUCTION

1.1 Introduction

The *Mbare Mkambo Marketplace Management System* was conceptualized in response to the urgent need to modernize Zimbabwe's largest informal trading hub, Mbare Musika. This need was amplified following the devastating fire incident of October 2024, which destroyed thousands of vendor stalls and displaced over 4,695 traders (Pindula, 2024). The aftermath exposed significant flaws in existing marketplace management structures, particularly in the areas of vendor registration, stall allocation, billing, and operational transparency.

Traditionally, marketplaces in Zimbabwe—like many across developing countries—rely on manual and fragmented systems to manage vendor interactions, financial processes, and administrative tasks. These legacy systems are often characterized by inefficiencies, a lack of real-time data visibility, and susceptibility to mismanagement and corruption (Mbara, 2015). The growth of the informal sector as a critical economic driver has outpaced the modernization of infrastructure supporting it, resulting in overcrowding, limited regulatory oversight, and revenue leakage (Government of Zimbabwe, 1993).

This project introduces a comprehensive digital platform designed to resolve these challenges through a full-stack marketplace management system. The system integrates vendor onboarding, stall scheduling, billing automation, and financial oversight, powered by a modern technology stack—**React** for the frontend and **Node.js/Express** for the backend. With integrated analytics, role-based access control, and mobile-friendly interfaces, the system aims to improve marketplace functionality, restore vendor livelihoods, and contribute to the long-term economic revitalization of Mbare.

Figure 1.1 Before Fire

Figure 1.2 After Fire

Figure 1.3 New Market

1.2 Problem Statement

The Mbare marketplace, a critical economic and social hub in Harare, is currently plagued by systemic inefficiencies due to the absence of a formalized, technology-driven management system. Despite its economic significance in supporting thousands of vendors and SMEs, operations within the marketplace remain largely manual and fragmented. The devastating fire incident of October 2024 not only highlighted but worsened longstanding challenges such as delayed vendor registration, inconsistent stall allocation, inefficient billing mechanisms, and a lack of financial transparency.

Currently, the marketplace lacks a centralized platform to coordinate key administrative processes, leading to:

- **Extended onboarding timelines** for vendors due to paper-based and bureaucratic registration procedures.
- **Unregulated stall allocation** practices, often resulting in conflicts, double bookings, or disputes over ownership.
- **Inadequate billing and revenue tracking systems**, which hinder effective rent collection, financial reporting, and planning.

- **Minimal audit trails and traceability** in financial transactions, making accountability and compliance enforcement difficult.
- **Limited managerial oversight**, with stakeholders operating without real-time data on operations, occupancy, or revenue performance.
- **Increased exposure to fraud, corruption, and rent evasion**, fueled by the lack of digital controls and monitoring tools.

These inefficiencies have compounded post-disaster recovery efforts, slowed vendor re-entry into the market, and exposed the marketplace to further operational vulnerabilities. If left unresolved, the current system not only threatens the financial sustainability and resilience of the Mbare marketplace but also jeopardizes the livelihoods of thousands of informal traders and small-scale entrepreneurs who rely on it for economic survival.

1.3 Significance of the Project

The development and implementation of the **Mbare Mkambo System** represents a transformative step toward modernizing operations within one of Zimbabwe's most vital informal trading ecosystems. By introducing a centralized, digitized platform tailored to the unique needs of the Mbare marketplace, the project addresses critical gaps in vendor management, revenue collection, and operational oversight.

Specifically, the system delivers the following core functionalities:

- **Digital Vendor Onboarding**: Streamlining the registration process through an intuitive, mobile-friendly platform that reduces administrative delays and improves record accuracy.
- **Automated Billing and Receipting**: Generating invoices and receipts in real-time to support transparency, minimize human error, and ensure consistent revenue tracking.
- **Real-Time Analytics Dashboards**: Equipping administrators and finance officers with actionable insights into occupancy rates, payment compliance, and vendor activity to enhance decision-making.
- **Enhanced Security and Access Control**: Utilizing role-based authentication mechanisms and audit logging to safeguard sensitive data and ensure system integrity.

Beyond resolving operational inefficiencies and promoting financial transparency, the project plays a critical role in **enhancing urban resilience** through **digital transformation**. In the aftermath of the October 2024 fire, there is an urgent need to rebuild with smarter, more sustainable infrastructure that supports rapid response, coordinated recovery, and future disaster preparedness.

Moreover, this system sets a precedent for the **digitization of informal markets across Africa**, offering a scalable and context-sensitive blueprint that can be adapted to similar urban trading environments. By bridging the gap between informal economic activity and

formal digital governance, the Mbare Mkambo System contributes to broader national goals in financial inclusion, smart city development, and economic empowerment.

1.4 Study Hypothesis

This study hypothesizes that:

> ***"If a digital full-stack marketplace management system is implemented at Mbare Musika, then overall operational efficiency, vendor satisfaction, and financial transparency will significantly improve."***

The proposed **Mbare Mkambo System** is expected to bring about measurable improvements in marketplace governance through automation, data centralization, and enhanced user engagement. The specific anticipated outcomes include:

- **Reduced Vendor Onboarding Time**: By replacing manual registration with a streamlined digital onboarding process, vendors will be able to register and gain stall access faster and with fewer administrative bottlenecks.
- **Improved Billing Accuracy and Revenue Tracking**: Automated billing and receipting mechanisms will eliminate common errors associated with paper-based systems, improving accountability and enabling more reliable financial reporting.
- **Increased Vendor Satisfaction and System Trust**: Vendors will benefit from transparent processes, real-time access to their financial records, and predictable stall management—factors that contribute to greater trust in marketplace administration.

This hypothesis will be tested through system implementation, stakeholder feedback, and analysis of operational metrics both before and after deployment. Improvements in these areas are expected to validate the system's effectiveness and provide evidence for scaling similar digital interventions in other informal markets.

1.5 Project Objectives

The project aims to modernize the Mbare Musika marketplace through a full-stack digital solution. The objectives have been defined using the SMART criteria to ensure they are Specific, Measurable, Achievable, Relevant, and Time-bound.

Objective No.	Specific	Measurable	Achievable	Relevant	Time-bound
1	Identify operational challenges at Mbare.	Interview and survey ≥ 20 stakeholders.	Use market research and direct observation.	To inform system design based on real needs.	Complete within first 4 weeks.
2	Design and develop digital marketplace system.	Develop and deploy 5 core functional modules.	Use Node.js, React, MongoDB expertise.	Addresses inefficiencies in current processes.	Complete within 10 weeks.
3	Evaluate digitization impact on vendors.	Collect feedback from ≥ 30 vendors & 3 officers.	Use surveys and revenue data analysis.	Validates system effectiveness post-deployment.	Conduct between weeks 11–13.
4	Measure system performance post-launch.	Track uptime >95%, response time <1s, user satisfaction >80%.	Use built-in analytics and logs.	Ensures system reliability and scalability.	Review at week 14.

1.6 Research Questions

1) **What are the primary operational challenges faced by vendors in the Mbare marketplace, and how can they be addressed through a digital solution?:** This question seeks to explore the specific issues that hinder effective marketplace management and identify potential solutions.

2) **How can a comprehensive digital platform improve vendor registration, stall allocation, and payment processing in the Mbare marketplace?:** This question aims to investigate the functionalities required in the digital solution to enhance operational efficiency.

3) **What features of the Mbare Mkambo Marketplace Management System are most valued by vendors, and how do they contribute to overall satisfaction?:** This question focuses on understanding vendor preferences and the impact of the system's features on their experiences.

4) **What are the anticipated economic benefits of implementing the Mbare Mkambo Marketplace Management System for vendors and the local community?:** This question seeks to quantify the potential economic impact of the new system on vendor revenues and community development.

1.7 Limitations

- **Data Availability and Quality**: Limited access to accurate and comprehensive data on vendor operations and marketplace dynamics may hinder the development of an effective management system.
- **Resistance to Change**: Vendors accustomed to traditional management practices may be resistant to adopting a new digital solution, which could impact the project's success.
- **Integration with Existing Practices:** Challenges in integrating the new system with current marketplace practices may limit its effectiveness and acceptance among vendors.
- **Limited Computing Resources:** Insufficient technological infrastructure may restrict the ability to implement and maintain the digital platform effectively.
- **Generalizability:** The findings and solutions derived from this project may not be applicable to other informal markets, limiting their scalability and broader applicability.
- **Stakeholder Engagement:** Limited support and engagement from stakeholders, including local authorities and community leaders, may hinder the project's implementation and success.
- Ethical Considerations: The project may raise ethical concerns related to data privacy and security, which need to be addressed to ensure compliance and build trust among users.

These limitations can significantly impact the project's outcomes and effectiveness. Proactively addressing these challenges will be essential to minimize their impact and ensure the project's success.

Conclusion

The Mbare Mkambo Marketplace Management System aims to address the pressing operational challenges faced by vendors in Zimbabwe's largest informal marketplace. By implementing a comprehensive digital solution, the project seeks to enhance operational efficiency, improve vendor satisfaction, and contribute to the economic revitalization of the Mbare community. Through a thorough understanding of the current challenges and the development of targeted interventions, this project aspires to create a more organized and efficient marketplace environment that benefits both vendors and customers.

CHAPTER 2. LITERATURE REVIEW

2.1 Introduction

Informal marketplaces are critical components of urban economies in developing countries, offering employment, affordable goods, and entrepreneurial opportunities to marginalized communities. However, these markets are often plagued by systemic challenges such as poor infrastructure, administrative inefficiencies, and limited regulatory oversight. This literature review examines existing research on informal market dynamics, policy frameworks, technology adoption in market systems, and socio-economic outcomes of marketplace redevelopment. It further identifies key gaps that the Mbare Mkambo Marketplace Management System seeks to address through an integrated digital and resilience-focused approach.

2.2 Review of Related Literature

2.2.1 Informal Marketplaces and Operational Challenges

Informal markets such as Mbare Musika play a pivotal role in Zimbabwe's urban economy by supporting thousands of traders and providing goods to low-income communities. However, these markets face persistent challenges. According to Chikanda (2017), informal markets are typically overcrowded, poorly serviced, and lack formal governance structures. Mupedziswa (2018) highlights that such institutional voids contribute to rent-seeking behavior, arbitrary enforcement of rules, and limited vendor protections.

Nyoni (2020) further observes that revenue leakage is common due to unregulated payment practices and manual billing systems. Sanitation and safety risks—particularly fire hazards—are exacerbated by makeshift stall layouts and poor emergency infrastructure. These issues reflect a broader neglect of informal market governance, with consequences for both economic stability and public health.

2.2.2 Policy and Regulatory Frameworks

Efforts to formalize informal markets through policy reforms have shown mixed results. On one hand, supportive regulation can enhance vendor security and access to formal institutions (Mupedziswa, 2018). On the other hand, rigid bureaucratic processes may exclude small traders from participation. Zimbabwe’s National Trade Policy emphasizes the need to integrate informal traders into the broader economy, but implementation remains inconsistent.

Chikanda (2017) argues for inclusive governance models that accommodate the unique nature of informal economies. Flexible frameworks that combine local leadership engagement, simplified registration processes, and access to financial services tend to yield better results than top-down formalization strategies.

2.2.3 Technology in Marketplace Management

Digitization is increasingly recognized as a catalyst for improved transparency, accountability, and operational efficiency in marketplace management. Zhou (2020) and Nyoni (2021) document the impact of mobile payment systems such as EcoCash in facilitating cashless transactions, reducing theft, and broadening financial inclusion.

IoT technologies, including occupancy sensors and fire detectors, offer promising tools for real-time monitoring and emergency response (OECD, 2011). Digital dashboards and automation tools support data-driven decision-making, while user-friendly interfaces encourage vendor participation regardless of their technical literacy.

In Sub-Saharan Africa, however, most digital interventions are still in their infancy, with limited empirical evaluation. The Mbare Mkambo project leverages lessons from existing mobile payment systems and extends their logic to encompass vendor registration, stall management, billing automation, and analytics.

2.2.4 Socio-Economic Outcomes of Marketplace Redevelopment

Revitalizing informal markets offers considerable economic and social benefits. Redeveloped markets tend to attract more customers, enhance safety, and support broader urban regeneration efforts. Mupedziswa (2018) and Nyoni (2020) argue that infrastructure improvements coupled with vendor training and micro-financing can substantially uplift livelihoods, especially for women and youth.

Social inclusivity also increases when digital tools are combined with tailored support programs. Vendors gain better access to formal credit, customer reach, and institutional protections. These outcomes align with the goals of smart city initiatives and inclusive economic growth strategies in the Global South.

2.2.5 Comparative Case Studies

Case studies from Kenya and India illustrate the potential of digital governance in informal marketplaces. Kenya's Huduma Centres have streamlined service delivery by integrating identification, registration, and payment systems. Similarly, India's eNAM platform has digitized agricultural markets, improving transparency and price discovery.

These examples highlight the importance of mobile-first platforms, government support, and capacity-building programs. They also provide models for scalable deployment, which the Mbare Mkambo system aspires to replicate within Zimbabwean urban markets.

2.2.6 Gaps in Existing Literature

Despite the growing body of work on informal economies, several gaps remain. First, there is a dearth of Zimbabwe-specific empirical studies on full-stack digital systems in informal markets. Second, most research isolates issues (e.g., payment, policy, or infrastructure) without addressing their interdependence. Finally, few studies explore post-disaster recovery through digital interventions, a critical aspect given Mbare's 2024 fire.

The Mbare Mkambo Marketplace Management System addresses these gaps by integrating infrastructure, governance, and technology within a single ecosystem. This holistic approach allows for real-time monitoring, vendor engagement, and disaster resilience.

2.3 Summary of Literature Insights

The reviewed literature confirms that informal markets, while economically vital, suffer from systemic challenges that hinder their efficiency and resilience. Policy reforms and digital platforms show promise but require contextual adaptation and inclusive governance. By synthesizing global best practices and local realities, the Mbare Mkambo system offers a unique intervention poised to transform informal market administration in Zimbabwe.

2.4 Conceptual Framework

Based on the literature review, a conceptual framework is derived that links:

- **Inputs**: Infrastructure, policy environment, digital tools
- **Processes**: Vendor onboarding, billing, stall allocation, payment processing
- **Outputs**: Improved vendor satisfaction, transparency, operational efficiency
- **Outcomes**: Economic revitalization, resilience, social inclusion

This framework guides the design, implementation, and evaluation of the Mbare Mkambo Marketplace Management System.

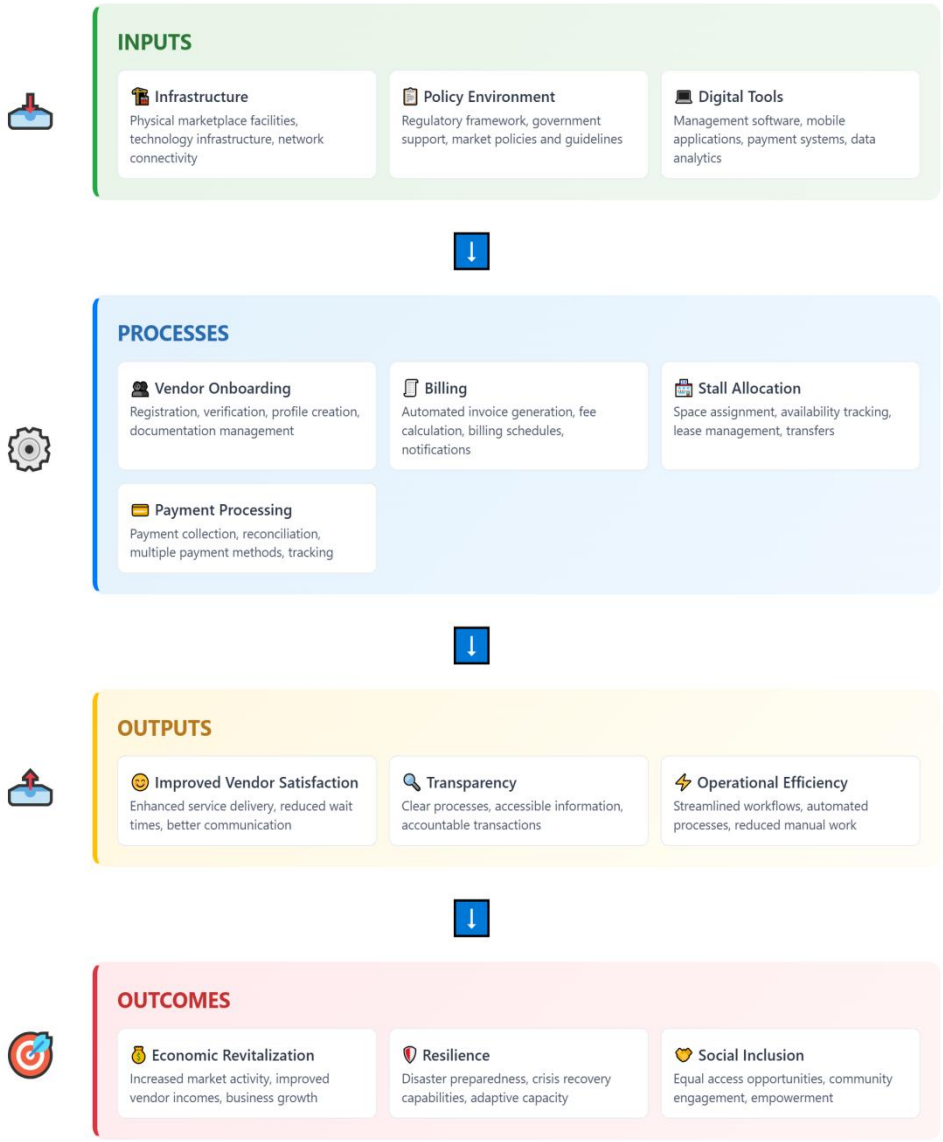

Figure 2.1 Conceptual Framework

CHAPTER 3. RESEARCH METHODOLOGY

3.1 Introduction

This chapter discusses the methodological strategy used in this research, focusing on the development of the **Mbare Mkambo Market Hub.** The framework chosen for this research is CRISP-DM (Cross-Industry Standard Process for Data Mining). This section will detail the data used for the experiment, the algorithms employed, the experimental plan, and the experimental procedure, specifically relating to the code implemented in the frontend and backend repositories.

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Architecture diagram (layered: frontend, backend, database, APIs)

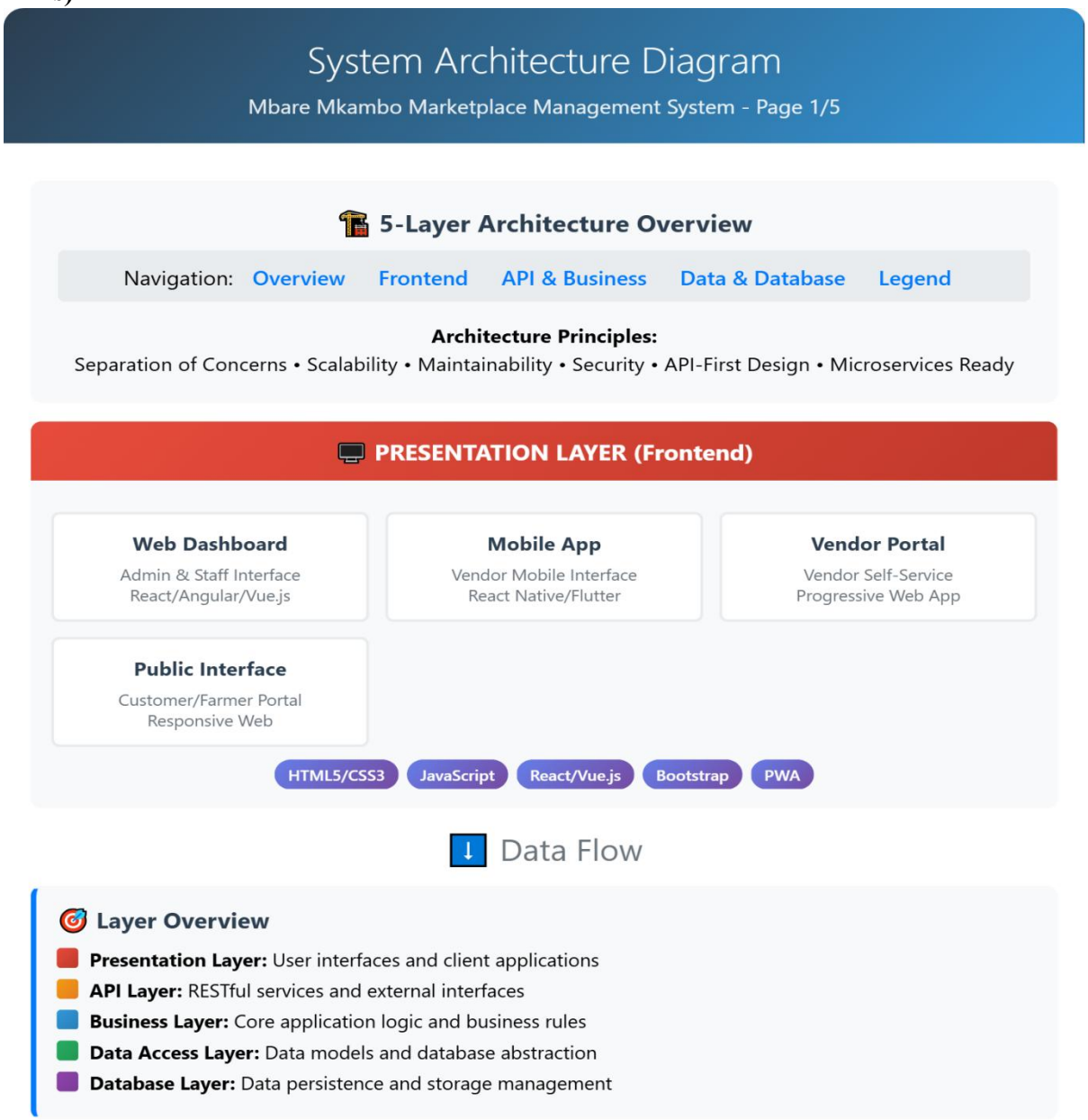

Figure 3.1 Architecture Diagram

🌐 API Gateway & Interface Layer - Page 2/5

🌐 API GATEWAY & INTERFACE LAYER

REST API Gateway
HTTP/HTTPS Endpoints
Express.js Router

Authentication API
JWT Token Management
Role-based Access

File Upload API
Multimedia Management
Document Processing

API Documentation
Swagger/OpenAPI
Interactive Docs

API Endpoints

/api/auth	/api/vendors	/api/stalls	/api/payments
/api/tickets	/api/staff	/api/billing	/api/stats
/api/reconciliation	/api/rentals	/api/customers	/api/settings

Express.js | CORS | Helmet | Morgan | Swagger | JWT

⬇️ Business Processing

🚀 API Features

Security: JWT Authentication, Role-based Access Control, CORS Policy, Helmet Security
Documentation: Swagger/OpenAPI Interactive Documentation
Middleware: Request Validation, Error Handling, Logging, File Upload Support
Standards: RESTful Design, HTTP Status Codes, JSON API Response Format

⚙ Business Logic Layer - Page 3/5

⚙ BUSINESS LOGIC LAYER (Backend Core)

Controllers
Request Processing
Business Orchestration

Services
Business Rules
Core Logic

Middleware
Authentication
Validation & Error Handling

Utils & Helpers
Billing Calculations
Date Management

Core Business Modules

Vendor Management
Registration, Profiles, Status

Stall Management
Allocation, Types, Availability

Payment Processing
Billing, Collections, Reconciliation

Ticketing System
Entry/Exit Management

Financial Management
Accounting, Reporting, Analytics

Operations Management
Shifts, Staff, Settings

Node.js | Express.js | Mongoose ODM | Bcrypt | Node-Cron | Moment.js

↓ Data Access

💼 Business Logic Features

Controllers: Auth, Vendors, Stalls, Payments, Tickets, Staff, Billing, Stats
Services: Control Account Seeding, Lease Resolution, Billing Calculations
Utilities: Billing Schedule Cron, Due Date Calculation, Date Management
Middleware: Authentication, Validation, Error Handling, Logging

📊 Data Access & Database Layer - Page 4/5

📊 DATA ACCESS LAYER

Models (ODM)
Mongoose Schemas
Data Validation

Database Connection
MongoDB Driver
Connection Pool

Query Optimization
Aggregation Pipelines
Indexing Strategy

Data Migration
Schema Updates
Seed Data

Data Models

Vendor Model	Stall Model	Payment Model	Staff Model
Ticket Model	Bill Model	Lease Model	Settings Model
Customer Model	Farmer Model	Fine Model	Transfer Model

Mongoose | MongoDB Driver | Aggregation Framework | Schema Validation

↓ Data Persistence

🗄 DATABASE & STORAGE LAYER

MongoDB Database
Primary NoSQL Database
Document Storage

File Storage
Upload Directory
Media Files

Backup & Recovery
Data Backup
Disaster Recovery

Monitoring & Logs
Performance Metrics
Query Logging

Database Collections

vendors	stalls	payments	staff
tickets	bills	leases	customers
settings	transactions	reconciliations	billing_schedules

MongoDB 7.x | GridFS | Replica Sets | Sharding | MongoDB Atlas

3.2 Data Mining Life Cycle

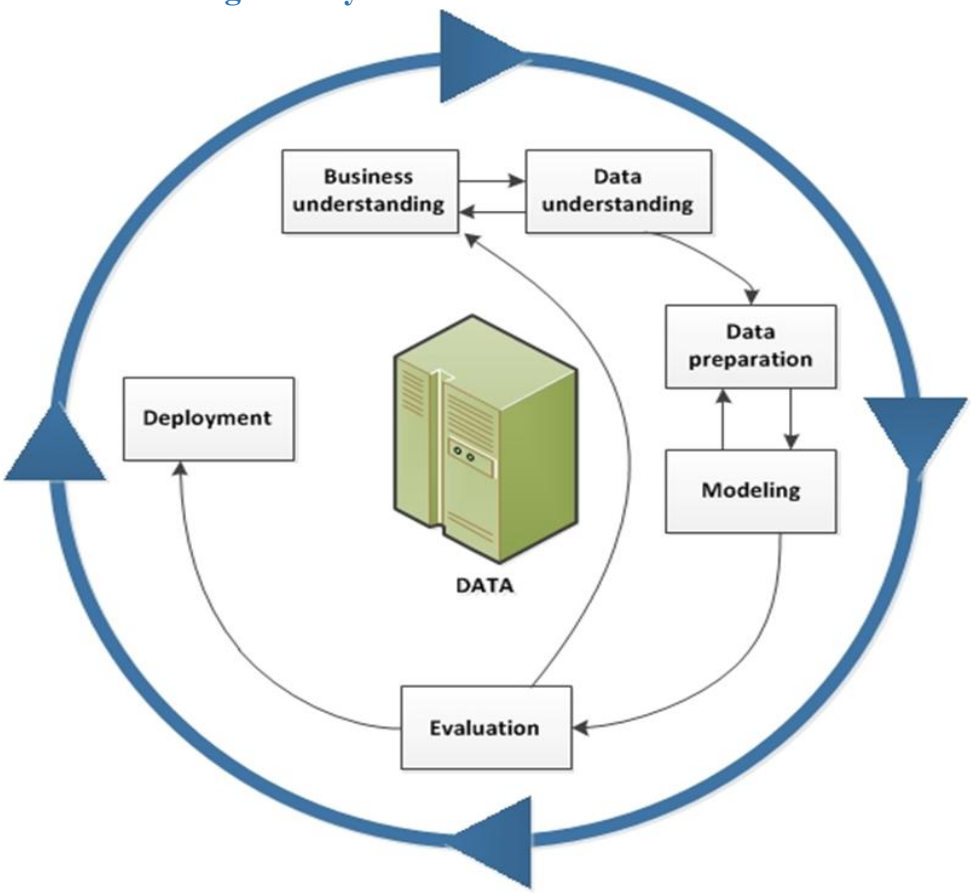

Figure 3.2 Data Mining Life Cycle

3.2.1 Business Understanding

Objective: Understand the operational challenges faced by vendors in the Mbare Mkambo marketplace and how the developed digital solutions can enhance market management, improve vendor experiences, and streamline operations.

Stakeholders: Identify key stakeholders, including marketplace vendors, local authorities, customers, and technology partners, and align the project goals with their needs.

3.2.2 Data Understanding

Data Sources: Gather data sources relevant to marketplace operations, vendor activities, and customer interactions. This includes:

Vendor Registration Data: Information on vendor profiles, stall allocations, and business types, which is managed through the backend API.

Transaction Data: Historical sales data, payment methods, and revenue records to analyze financial performance, stored in the MongoDB database.

Customer Feedback: Surveys and feedback forms from customers to assess satisfaction and areas for improvement, collected through the frontend application.

3.2.3 Data Preparation

Data Cleaning: Clean and preprocess the data to ensure accuracy and consistency, handling missing values, outliers, and other data quality issues. This is implemented in the backend using Mongoose for data validation and schema enforcement.

Data Organization: Organize the data in a way that can be effectively used by the digital management system. The backend API provides structured endpoints for accessing vendor information, transaction records, and customer feedback.

3.2.4 Modeling

System Development: Develop a comprehensive marketplace management system that incorporates features such as:

- **Vendor Management:** A digital onboarding process for vendors, including document uploads and verification workflows, implemented in the backend with Express.js and MongoDB.
- **Stall Allocation:** An automated system for managing stall assignments and availability, utilizing RESTful API endpoints for real-time updates.
- **Payment Processing:** Integration of multiple payment methods (e.g., cash, mobile money) to facilitate transactions, managed through the backend with secure payment handling.

Algorithms: Utilize algorithms for data analysis and decision-making, such as:

- **Predictive Analytics:** To forecast sales trends and optimize inventory management, potentially implemented in future iterations of the backend.
- **Data Visualization:** The frontend uses libraries like Recharts to create dashboards that provide real-time insights into marketplace performance.

3.2.5 Evaluation

Performance Assessment: Assess the performance of the marketplace management system using key metrics, such as:

- Vendor registration time, tracked through the backend API.
- Payment collection rates, analyzed through transaction data.
- Customer satisfaction scores, gathered from feedback forms in the frontend.

Refinement: Identify any limitations or areas for improvement and refine the system based on user feedback and performance data. Continuous integration and deployment practices in the GitHub repositories facilitate iterative improvements.

3.2.6 Deployment

- **System Integration:** Integrate the marketplace management system into a user-friendly platform that can be accessed by vendors, customers, and market administrators. The frontend application is built with React and Vite for a responsive user experience.
- **Scalability and Reliability:** Ensure the system is scalable, reliable, and can provide real-time updates and insights to users. The backend is designed to handle multiple concurrent requests and is hosted on a cloud platform for scalability.
- **Continuous Monitoring:** Continuously monitor the system's performance and make necessary adjustments based on feedback and changing market dynamics. Tools like logging and monitoring can be integrated into the backend to track system health.

3.3 Data Used

The following data sources will be utilized in the research for the Mbare Mkambo Market Hub:

Vendor Registration Data: Information on vendor profiles, including business types, stall allocations, and registration dates, managed through the backend API.

Transaction Data: Historical sales data from the marketplace, including payment methods and revenue records, stored in the MongoDB database.

Customer Feedback: Surveys and feedback forms collected from customers through the frontend application to assess their experiences and satisfaction levels.

Public Transport Data: Information on public transport routes and schedules to understand how transportation affects foot traffic in the marketplace.

Road Network Maps: Detailed maps showing the layout of roads and access points to the marketplace, which can inform logistical planning.

Police Reports: Data on traffic incidents and accidents in the vicinity of the marketplace to assess safety and risk factors.

This chapter outlines the methodological framework for the research, detailing the steps involved in the CRISP-DM process. By following this structured approach, the research aims to effectively address the operational challenges faced by vendors in the Mbare Mkambo marketplace through the application of digital management solutions, as implemented in the provided GitHub repositories.

3.3.1 Algorithms Used

In the development of the **Mbare Mkambo Market Hub,** several algorithms were employed to enhance the functionality and efficiency of the system. These algorithms are integral to various components of the application, including data processing, vendor management, payment processing, and user experience optimization. Below are the key algorithms utilized in both the frontend and backend systems:

1. Authentication and Authorization Algorithms

JWT (JSON Web Token):

- Used for secure user authentication and authorization. The backend generates a JWT upon successful login, which is then used to authenticate subsequent requests. This ensures that only authorized users can access specific resources and functionalities within the application.

```
const jwt = require('jsonwebtoken');
const Staff = require('../models/staff.model');

const auth = (roles = []) => {
  return async (req, res, next) => {
    try {
      const token = req.headers.authorization?.split(' ')[1];
      if (!token) {
        return res.status(401).json({ message: 'Authentication required' });
      }

      const decoded = jwt.verify(token, process.env.JWT_SECRET);
      req.user = decoded;

      // Check if the staff member is active
      const staff = await Staff.findById(req.user.userId);
      if (!staff || staff.status !== 'active') {
        return res.status(403).json({ message: 'Unauthorized access' });
      }

      if (roles.length && !roles.includes(req.user.role)) {
        return res.status(403).json({ message: 'Unauthorized access' });
      }

      next();
    } catch (error) {
      res.status(401).json({ message: 'Invalid token' });
    }
  };
};

module.exports = auth;
```

Figure 3.3 JWT

2. Data Validation Algorithms

Mongoose Validation:

- In the backend, Mongoose schemas are used to define the structure of the data stored in MongoDB. Validation rules are applied to ensure that all required fields are present and that data types are correct. This helps maintain data integrity and prevents errors during data processing.

```javascript
const { validationResult } = require('express-validator');
const { ValidationError } = require('../utils/errors');

const validate = (req, res, next) => {
  const errors = validationResult(req);
  if (!errors.isEmpty()) {
    throw new ValidationError(errors.array()[0].msg);
  }
  next();
};

module.exports = validate;
```

Figure 3.4Mongoose Validation

3. Payment Processing Algorithms

Payment Gateway Integration:

- Algorithms for integrating with various payment gateways (e.g., mobile money, bank transfers) are implemented to facilitate secure transactions. These algorithms handle payment requests, process responses, and manage transaction statuses, ensuring a seamless payment experience for users.

4. Data Analysis and Reporting Algorithms

Aggregation Framework:

- MongoDB's aggregation framework is utilized to perform complex data analysis and generate reports. This includes calculating total sales, tracking vendor performance, and analyzing customer feedback. The aggregation pipeline allows for efficient data processing and retrieval.

5.Real-Time Data Synchronization Algorithms

Polling and WebSocket:

- The frontend employs polling mechanisms to fetch real-time updates from the backend, ensuring that users receive the latest information about vendor availability, payment statuses, and market conditions. Future enhancements may include WebSocket integration for more efficient real-time communication.

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6. User Experience Optimization Algorithms

Debouncing and Throttling:

- These algorithms are implemented in the frontend to optimize user interactions, such as form submissions and search queries. Debouncing prevents multiple submissions of the same action within a short time frame, while throttling limits the number of times a function can be executed over a specified period, enhancing performance and user experience.

7. Data Visualization Algorithms

Recharts for Data Visualization:

- The frontend utilizes Recharts, a composable charting library, to visualize data such as sales trends, customer satisfaction scores, and vendor performance metrics. This allows users to gain insights from the data through interactive and visually appealing charts.

8. Machine Learning Algorithms (Future Enhancements)

- **Predictive Analytics:**

✧ Future iterations of the Mbare Mkambo Market Hub may incorporate machine learning algorithms for predictive analytics. These algorithms can analyze historical data to forecast sales trends, optimize inventory management, and enhance decision-making processes for vendors and market administrators.

These algorithms collectively contribute to the functionality and effectiveness of the **Mbare Mkambo Market Hub**, ensuring that the system meets the needs of its users while providing a robust and efficient marketplace management solution. The integration of these algorithms is reflected in the codebase of the provided GitHub repositories, where each component is designed to work seamlessly within the overall architecture of the application.

3.4 Experimental Plan

The experimental plan for the Mbare Mkambo Market Hub involves a structured approach to evaluate the effectiveness of the implemented digital solutions and algorithms. This plan includes experimentation, observational research, simulation modeling, and derived research, each designed to gather data and insights that will inform the optimization of marketplace operations.

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1. Experimentation

Purpose: Experimentation involves designing controlled experiments to test hypotheses, validate models, and assess the impact of interventions on marketplace operations.

Application:

- **Controlled Experiments:** Conduct controlled experiments in specific areas of the Mbare Mkambo marketplace to evaluate the effectiveness of various management strategies. This may include:

a. Testing different vendor registration processes to determine which method reduces processing time.

b. Implementing route optimization algorithms for vendor deliveries and customer access.

- **A/B Testing:** Implement A/B testing by comparing the performance of different marketplace management strategies, such as:

a. Using automated billing systems versus traditional manual billing methods.

b. Evaluating the effectiveness of digital payment options against cash transactions.

- **Key Metrics Measurement:** Measure key metrics to evaluate the effectiveness of the interventions, including:

a. Vendor registration time.

b. Customer wait times at payment points.

c. Overall sales and revenue generated during the testing period.

- **Parameter Adjustment:** Adjust parameters such as stall allocation strategies and payment processing methods, and observe their impact on vendor satisfaction and operational efficiency.

2. Observational Research

Purpose: Observational research involves observing and recording natural behavior within the marketplace without direct intervention.

Application:

- Sensor Deployment: Deploy sensors and cameras throughout the marketplace to collect real-time data on foot traffic, vendor interactions, and customer behavior.
- Traffic Flow Observation: Observe the flow of customers and vendors, noting peak times, congestion points, and areas of high activity.
- Historical Data Analysis: Analyze historical sales data and customer feedback to identify trends, peak shopping times, and common issues faced by vendors.
- Informing Algorithms: Use observational data to inform the development of algorithms for route optimization and inventory management, ensuring that the system adapts to real-world conditions.

3. Simulation Modeling

Purpose: Simulation models replicate the marketplace environment to study its behavior under various conditions.

Application:

- **Marketplace Simulation Model Development:** Develop a simulation model that represents the Mbare Mkambo marketplace, including vendor stalls, customer pathways, and payment points.
- **Real-Time Data Integration:** Incorporate real-time data, such as customer foot traffic and sales transactions, into the simulation to enhance its accuracy.
- **Scenario Testing:** Test different scenarios, such as changes in vendor placement, special events, or peak shopping days, to evaluate their impact on customer flow and sales.
- **Optimization Insights:** Use simulation results to optimize stall allocations, improve customer flow, and adjust payment processing strategies.

3. Derived Research

Purpose: Derived research involves analyzing existing data or models to derive insights that can inform decision-making.

Application:

- **Historical Data Analysis:** Analyze historical sales data, customer feedback, and vendor performance metrics to identify bottlenecks and areas for improvement within the marketplace.
- **Statistical Model Derivation:** Derive statistical models to predict sales trends and customer behavior based on historical data, helping vendors make informed decisions about inventory and pricing.
- **Machine Learning Techniques:** Utilize machine learning techniques to analyze customer purchasing patterns and predict future sales, enhancing the ability to manage stock levels effectively.
- **Combining Insights:** Combine derived insights with real-time data to inform operational strategies, ensuring that the marketplace remains responsive to changing customer needs and preferences.

This experimental plan outlines a comprehensive approach to evaluating and optimizing the Mbare Mkambo Market Hub. By employing a combination of experimentation, observational research, simulation modeling, and derived research, the project aims to enhance the efficiency and effectiveness of marketplace operations. Each component of the plan is designed to gather valuable data and insights that will inform ongoing improvements to the system.

3.4.1 Research Primary Objective

The primary objective of this research is to develop and implement a user-friendly digital marketplace management platform that utilizes real-time data to optimize vendor operations, enhance customer experiences, and improve overall market management at the Mbare Mkambo marketplace. This platform aims to streamline processes such as vendor registration, stall allocation, payment processing, and customer interactions, ultimately fostering a more efficient and transparent marketplace environment.

3.4.2 Hypothesis

The hypothesis of this research posits that implementing a comprehensive and user-friendly platform that integrates real-time data monitoring and management features will significantly enhance the overall operational efficiency and user satisfaction within the Mbare Mkambo marketplace. By leveraging real-time information, the platform is expected to reduce wait times, improve transaction accuracy, and increase vendor and customer engagement.

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3.4.3 Variables and Factors

To evaluate the effectiveness of the Mbare Mkambo Market Hub and its impact on marketplace operations, several key variables and factors will be considered:

- **Vendor Registration Time:** The duration it takes for a vendor to complete the registration process on the platform. This metric helps assess the efficiency of the onboarding process.
- **Transaction Speed**: The average time taken to complete a transaction, including payment processing and receipt generation. Monitoring transaction speed provides insights into the efficiency of payment systems.
- **Customer Foot Traffic:** The number of customers visiting the marketplace during different times of the day. This variable is crucial for understanding peak shopping hours and planning vendor allocations.
- **Sales Volume:** The total sales generated by vendors over a specific period. This metric helps evaluate the economic impact of the marketplace and the effectiveness of vendor operations.
- **Customer Satisfaction**: Feedback collected from customers regarding their shopping experience, including ease of navigation, payment options, and overall satisfaction with the marketplace.
- **Payment Method Usage:** The distribution of different payment methods used by customers (e.g., cash, mobile money, card payments). This factor helps identify preferences and inform future payment integrations.
- **Stall Occupancy Rates:** The percentage of stalls occupied by vendors at any given time. This variable is important for assessing space utilization and vendor allocation strategies.
- **Incident Reports:** The number and nature of incidents reported within the marketplace, such as disputes, accidents, or security issues. This data can inform safety measures and operational adjustments.
- **Environmental Factors:** Conditions such as weather (e.g., rain, temperature) that may affect customer turnout and vendor operations.
- **Market Events:** Special events or promotions that may influence customer behavior and sales patterns, providing opportunities for targeted marketing strategies.

This section outlines the primary objective, hypothesis, and key variables and factors that will guide the research and evaluation of the **Mbare Mkambo Market Hub.** By focusing on these elements, the project aims to create a robust platform that effectively addresses the operational challenges faced in the marketplace.

3.5 Data Flow Diagram (DFD) for Mbare Mkambo Market Hub

3.5.1 Level 1: Detailed DFD

1.0 VENDOR REGISTRATION & ONBOARDING

- **Input:** Vendor application data, verification documents
- **Output:** Vendor profiles, onboarding status
- **Function:** Registers new vendors, manages verification process, handles vendor updates and category assignments

2.0 STALL MANAGEMENT

- **Input:** Stall assignment requests, lease applications
- **Output:** Stall allocations, lease agreements
- **Function:** Manages stall inventory, assigns stalls to vendors, tracks lease status, handles stall repossession

3.0 PAYMENT PROCESSING

- **Input:** Payment requests, mobile money transactions
- **Output:** Payment confirmations, receipts
- **Function**: Processes various payment methods (cash, mobile money), validates transactions, updates payment status

4.0 BILLING & SCHEDULING

- **Input:** Billing schedules, line items, due dates
- **Output**: Bills, invoices, credit notes
- **Function:** Generates bills based on schedules, creates invoice templates, manages billing cycles

5.0 CUSTOMER MANAGEMENT

- **Input:** Customer data, account information
- **Output:** Customer profiles, account statements
- **Function:** Manages customer accounts (walk-in, traders, buyers), tracks customer balances, generates statements

6.0 RECONCILIATION & REPORTING

- **Input**: Daily transactions, cashier data

- **Output:** Reconciliation reports, financial summaries
- **Function:** Reconciles daily cash collections, generates reports, tracks cashier performance

7.0 PARKING MANAGEMENT

- **Input:** Parking bay applications, ticket data
- **Output:** Parking allocations, parking tickets
- **Function:** Manages parking bay assignments, processes parking payments, tracks parking usage

8.0 FINANCIAL ACCOUNTING

- **Input:** All transactions, journal entries
- **Output:** Trial balance, ledger summaries, financial reports
- **Function:** Maintains double-entry bookkeeping, manages control accounts, handles fund transfers

9.0 USER AUTHENTICATION & AUTHORIZATION

- **Input:** Login credentials, role assignments
- **Output:** Access tokens, permission grants
- **Function:** Authenticates users, manages role-based access control, handles staff permissions

Data Stores:

- **D1: Vendors** - Vendor profiles, categories, verification status
- **D2: Stalls** - Stall information, assignments, lease data
- **D3: Customers** - Customer accounts, contact info, balances
- **D4: Bills** - Generated bills, line items, payment status
- **D5: Payments** - Payment records, methods, transaction history
- **D6: Transactions** - Journal entries, control account movements
- **D7: Staff** - Staff profiles, roles, shift information
- **D8: Settings** - System configuration, fees, exchange rates

3.3.2 DFD REPRESENTATION

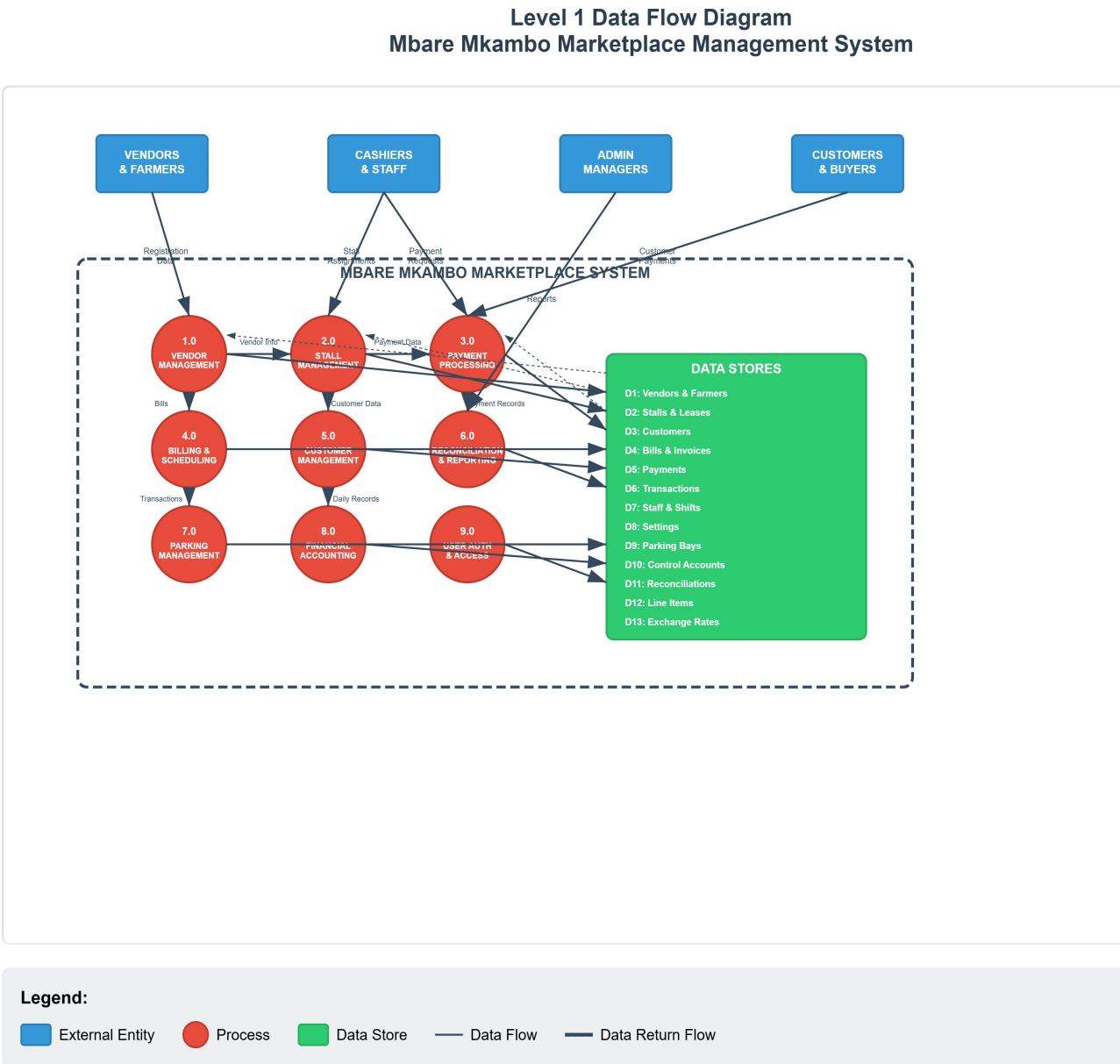

Figure 3.5 Mbare DFD

CHAPTER 4: PROCESS/CONCEPT/MODEL DESIGN

4.1 Introduction

This chapter presents the conceptual and system design approach adopted for the Mbare Mkambo Marketplace Management System—a high-impact full-stack solution designed to digitize and optimize operations in Zimbabwe's largest informal market. It outlines the design process, identifies core business needs, maps out functional and architectural models, and details the technologies selected to ensure scalability, security, and operational efficiency.

By translating the marketplace's operational challenges into structured software components, this chapter provides a blueprint that bridges the gap between problem definition and system implementation. The design process was driven by user-centric thinking, agile principles, and architectural best practices suitable for an enterprise-grade platform.

4.2 Problem Statement and Objectives

4.2.1 Problem Statement

The Mbare marketplace, serving thousands of vendors, lacked a formalized, technology-driven management structure, especially after the October 2024 fire. Existing processes—such as vendor registration, stall allocation, billing, and reporting—were primarily manual, resulting in inefficiencies, data inconsistencies, delayed transactions, and financial opacity. Vendors faced difficulties in accessing services, and administrators lacked real-time data to make informed decisions.

4.2.2 Objectives

The primary goals of the system design include:

- **Vendor Lifecycle Digitization:** Provide an intuitive digital onboarding flow with document verification.
- **Real-Time Stall Allocation:** Prevent conflicts using automated stall availability tracking.
- **Automated Billing Engine:** Ensure consistent fortnightly billing across multiple payment methods.
- **Financial Accountability:** Enable traceable, auditable, and real-time payment tracking.
- **Role-Based Access:** Provide custom dashboards and access for admins, vendors, and agents.
- **Data-Driven Oversight:** Support analytics dashboards for decision-making and regulatory reporting.

4.3 System Architecture

4.3.1 Logical Architecture

The system follows a modular full-stack architecture comprising the following layers:

- **Frontend (React + Vite)**
  Built for performance and scalability, using Radix UI components and Tailwind CSS for responsive, accessible design. State is managed using Zustand and React Query/SWR.

```
import Login from '@/pages/signIn';
import '../index.css';

import { createBrowserRouter, Outlet } from 'react-router-dom';
import DashboardLayout from '@/pages/Dashboard/dashboardLayout';
import MainDashboard from '@/pages/Dashboard/MainDashboard';
import StaffMembers from '@/pages/Dashboard/StaffMembers';
import Vendors from '@/pages/Dashboard/Vendors';
import FarmPage from '@/pages/Dashboard/Farm';
import StallPage from '@/pages/Dashboard/Stall';
import CpuDashboard from '@/pages/Dashboard/CpuDashboard';
import ErrorBoundary from '@/components/ErrorBoundary';
import ProtectedRoute from '@/components/guards/ProtectedRoute';
import AuthRedirect from '@/components/authRedirect';
import RoleGuard from '@/components/guards/RoleGuard';
import CashierDashboard from '@/pages/Dashboard/CashierDashboard';
import Tickets from '@/pages/Dashboard/Tickets';
import ListPayments from '@/pages/payments/list-payments';
import AccountsDashboard from '@/pages/Dashboard/AccountsDashboard';
import Customer from '@/pages/customer/Customer';
import CustomerDetails from '@/pages/customer/CustomerDetails';
import CustomerStatement from '@/pages/customer/CustomerStatement';
// import Reports from '@/pages/Dashboard/Reports';
import CapturerDashboard from '@/pages/Dashboard/CapturerDashboard';
import CashierDetails from '@/pages/cashiers/CashierDetails';
import CreateStaff from '@/pages/staff/createStaff';
import EditStaff from '@/pages/staff/editStaff';
import ViewVendors from '@/pages/vendors/viewVendors';
import VerifyVendors from '@/pages/vendors/verifyVendors';
import Settings from '@/pages/settings/Settings';
import ManageStallLayout from '@/pages/stalls/manage-stall-layout';
import StallOverview from '@/pages/stalls/stall-overview';
import StallRentAccount from '@/pages/stalls/stall-rent-account';
import ListLineItems from '@/pages/maintenance/list-line-items';
import ListControlAccounts from '@/pages/maintenance/list-control-accounts';
import ViewControlAccount from '@/pages/maintenance/view-control-account';
import ListBills from '@/pages/bills/list-bills';
import ViewBill from '@/pages/bills/view-bill';
import ViewPayment from '@/pages/payments/view-payment';
import LedgerOverview from '@/pages/ledger/ledger-overview';
import ReportsLayout from '@/pages/reports/layout';
import AccountStatements from '@/pages/reports/account-statements';
import FinancialReports from '@/pages/reports/financial-reports';
import AgingReports from '@/pages/reports/aging-reports';
import PayBill from '@/pages/bills/pay-bill';
import PaymentResult from '@/pages/bills/payment-result';
import ListPaymentMethods from '@/pages/settings/list-payment-methods';
import AccountSettings from '@/pages/settings/accounting-settings';
import CreateBill from '@/pages/bills/create-bill';
import ScheduledBilling from '@/pages/bills/scheduled-billing';
import ViewBillingSchedule from '@/pages/bills/view-billing-schedule';
import IncomeStatement from '@/pages/reports/financial-reports/income-statement';
import BalanceSheet from '@/pages/reports/financial-reports/balance-sheet';
import CashFlow from '@/pages/reports/financial-reports/cash-flow';
import ImportLeases from '@/pages/stalls/import-leases';
import ViewLineItem from '@/pages/maintenance/view-line-item';
```

Figure 4.1Frontend Routes Component

- **Backend (Node.js + Express)**
  RESTful API using JWT for authentication, role-based middleware for authorization, and Mongoose to interface with MongoDB.

```
require("dotenv").config();
const express = require("express");
const cors = require("cors");
const helmet = require("helmet");
const morgan = require("morgan");
const connectDB = require("./src/config/database");
const errorHandler = require("./src/middleware/error.middleware");

// Import routes
const authRoutes = require("./src/routes/auth.routes");
const vendorRoutes = require("./src/routes/vendor.routes");
const staffRoutes = require("./src/routes/staff.routes");
const stallRoutes = require("./src/routes/stall.routes");
const ticketRoutes = require("./src/routes/ticket.routes");
const settingRoutes = require("./src/routes/setting.routes");
const fineRoutes = require("./src/routes/fine.routes");
const paymentRoutes = require("./src/routes/payment.routes");
const currencyRoutes = require("./src/routes/currency.routes");
const farmerRoutes = require("./src/routes/farmer.routes");
const reconciliationRoutes = require("./src/routes/reconciliation.routes");
const shiftRoutes = require("./src/routes/shift.routes");
const statsRoutes = require("./src/routes/stats.routes");
const rentalRoutes = require("./src/routes/rental.routes");
const parkingBayRoutes = require("./src/routes/parking-bay.routes");
const lineItemsRoutes = require("./src/routes/line-items.routes");
const billingRoutes = require("./src/routes/billing.routes");
const controlAccountRoutes = require("./src/routes/control-account.routes");
const customersRoutes = require("./src/routes/customers.routes");
const paymentMethodsRoutes = require("./src/routes/payment-methods.routes");
const billingScheduleRoutes = require("./src/routes/billing-schedules.routes");

// Initialize express
const app = express();

// Connect to MongoDB
connectDB();

```

Figure 4.2Backend server.js

```
// Middleware
app.use(express.json());
app.use(cors()); // Allow CORS for all origins
app.use(helmet());
app.use(morgan("dev"));

// Routes
app.use("/api/auth", authRoutes);
app.use("/api/vendors", vendorRoutes);
app.use("/api/staff", staffRoutes);
app.use("/api/stalls", stallRoutes);
app.use("/api/tickets", ticketRoutes);
app.use("/api/settings", settingRoutes);
app.use("/api/fine", fineRoutes);
app.use("/api/payments", paymentRoutes);
app.use("/api/currencies", currencyRoutes);
app.use("/api/farmers", farmerRoutes);
app.use("/api/reconciliation", reconciliationRoutes);
app.use("/api/shifts", shiftRoutes);
app.use("/api/stats", statsRoutes);
app.use("/api/rentals", rentalRoutes);
app.use("/api/parking-bays", parkingBayRoutes);
app.use("/api/line-items", lineItemsRoutes);
app.use("/api/billing", billingRoutes);
app.use("/api/control-accounts", controlAccountRoutes);
app.use("/api/customers", customersRoutes);
app.use("/api/payment-methods", paymentMethodsRoutes);
app.use("/api/billing-schedules", billingScheduleRoutes);

const swaggerJsdoc = require("swagger-jsdoc");
const swaggerUi = require("swagger-ui-express");

// Error handling
app.use(errorHandler);

```

Figure 4.3Backend Routes Page

```javascript
// Start server
const PORT = process.env.PORT || 3000;

const options = {
  definition: {
    openapi: "3.1.0",
    info: {
      title: "Mbare Marketplace API Documentation",
      version: "1.0.0",
      description: "API documentation for Mbare Marketplace Management System",
    },
    components: {
      securitySchemes: {
        bearerAuth: {
          type: "http",
          scheme: "bearer",
          bearerFormat: "JWT",
        },
      },
    },
    security: [
      {
        bearerAuth: [],
      },
    ],
    // servers: [
    //   {
    //     url: `http://localhost:${PORT}`,
    //   },
    //   {
    //     url: `http://20.116.222.250`,
    //   },
    // ],
  },
  apis: ["./src/routes/*.js"],
};

const specs = swaggerJsdoc(options);
app.use(
  "/api-docs",
  swaggerUi.serve,
  swaggerUi.setup(specs, { explorer: true })
);

// Initialize additional application components (including billing schedule cron job)
const initializeApp = require("./src/app");
initializeApp(app);

app.listen(PORT, () => {
  console.log(`Server running on port ${PORT}`);
});
```

Figure 4.4Server

- **Database (MongoDB)**
  A flexible NoSQL schema design supports vendor profiles, payment logs, stall inventories, and activity history.

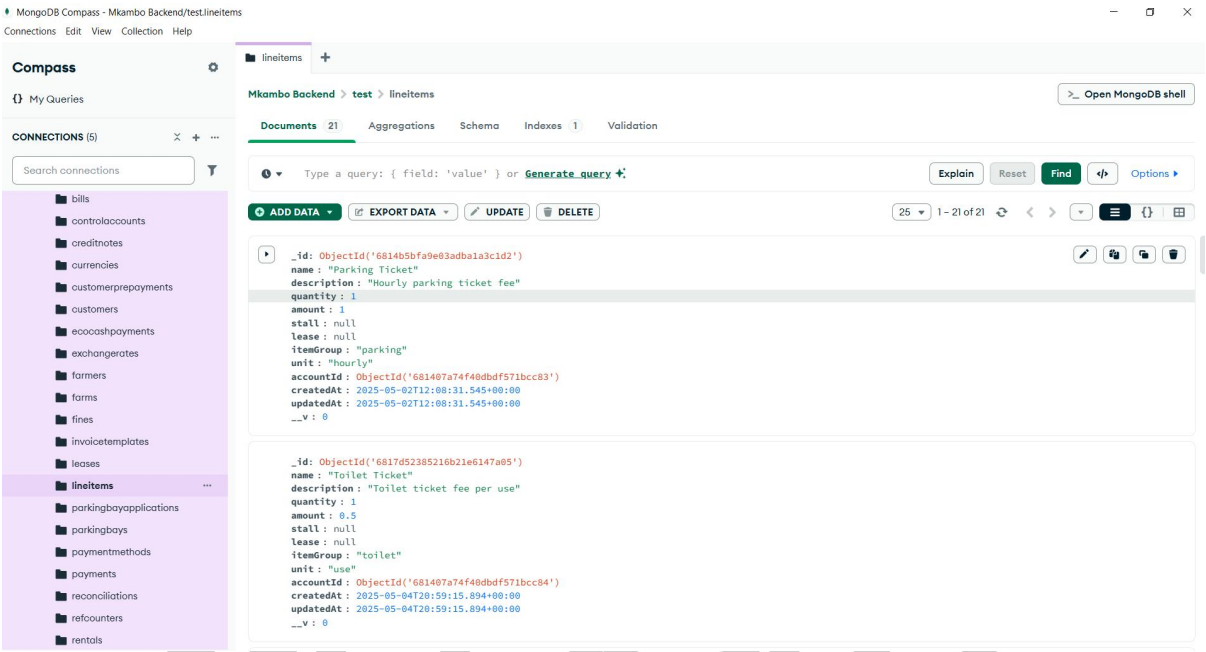

Figure 4.5MongoDB

- **Security Layer**
  Implements JWT authentication, HTTPS, role-permission middleware, bcrypt password hashing, and access logs.

```
const Staff = require('../../models/staff.model');
const jwt = require('jsonwebtoken');
const bcrypt = require('bcryptjs');
const { ValidationError } = require('../../utils/errors');
const Shift = require('../../models/shift.model');

exports.login = async (req, res, next) => {
  try {
    const { username, password } = req.body;

    const staff = await Staff.findOne({ username });
    if (!staff) {
      throw new ValidationError('Invalid credentials');
    }

    // Check if the staff status is inactive
    if (staff.status === 'inactive') {
      throw new ValidationError('Staff account was deactivated');
    }

    const isMatch = await bcrypt.compare(password, staff.password);
    if (!isMatch) {
      throw new ValidationError('Invalid credentials');
    }

    const token = jwt.sign(
      { userId: staff._id, role: staff.role },
      process.env.JWT_SECRET,
      { expiresIn: '24h' }
    );

    // Start shift if the user is a cashier and doesn't have an active shift
    if (staff.role === 'cashier') {
      const activeShift = await Shift.findOne({
        'cashier.id': staff._id,
        status: 'active'
      });

      if (!activeShift) {
        const newShift = new Shift({
          cashier: {
            id: staff._id,
            username: staff.username
          },
          startTime: Date.now(),
          revenue: 0,
          surplus: 0,
          deficit: 0,
          status: 'active'
        });
        await newShift.save();
      }
    }

    res.json({ token, role: staff.role });
  } catch (error) {
    next(error);
  }
};

exports.register = async (req, res, next) => {
  try {
    const { firstName, lastName, idNumber, username, password, role, phonenumber, email } = req.body;

    if (password.length < 6) {
      throw new ValidationError('Password must be at least 6 characters long');
    }

    const existingStaff = await Staff.findOne({ username });
    if (existingStaff) {
      throw new ValidationError('Username already exists');
    }

    const staff = new Staff({ firstName, lastName, idNumber, username, password, role, phonenumber, email });
    await staff.save();
```

```
exports.deactivateStaff = async (req, res, next) => {
  try {
    const { id } = req.params;

    const staff = await Staff.findById(id);
    if (!staff) {
      throw new ValidationError('Staff member not found');
    }

    staff.status = 'inactive';
    await staff.save();

    res.status(200).json({ message: 'Staff member deactivated successfully' });
  } catch (error) {
    next(error);
  }
};

exports.activateStaff = async (req, res, next) => {
  try {
    const { id } = req.params;

    const staff = await Staff.findById(id);
    if (!staff) {
      throw new ValidationError('Staff member not found');
    }

    staff.status = 'active';
    await staff.save();

    res.status(200).json({ message: 'Staff member activated successfully' });
  } catch (error) {
    next(error);
  }
};

// Reset password
exports.resetPassword = async (req, res, next) => {
  try {
    const { id } = req.params;
    const { newPassword, currentPassword } = req.body;

    if (newPassword.length < 6) {
      return res.status(400).json({ message: 'Password must be at least 6 characters long' });
    }

    const staff = await Staff.findById(id);
    if (!staff) {
      return res.status(404).json({ message: 'Staff member not found' });
    }

    // Check if the current password matches
    const isMatch = await staff.comparePassword(currentPassword); // Assuming comparePassword is a method on the Staff model
    if (!isMatch) {
      return res.status(401).json({ message: 'Current password is incorrect' });
    }

    staff.password = newPassword;
    await staff.save();

    res.status(200).json({ message: 'Password reset successfully' });
  } catch (error) {
    console.error('Error resetting password:', error);
    if (error instanceof ValidationError) {
      return res.status(400).json({ message: error.message });
    }
    next(error);
  }
};
```

Figure 4.6 JWT authentication

4.3.2 Frontend Design (Presentation Layer)

- **Technologies**: React.js with Vite, Tailwind CSS, Recharts (for visualization)
- **Roles Supported**: Vendors, Customers, Administrators, Accountants

Key Features:

1. User Authentication & Role-based Access
2. Vendor Registration & Document Upload
3. Stall Application & Real-time Availability
4. Payment Interface (Cash, EcoCash, Bank, Omari,Swipe)
5. Data Dashboards (Sales, Payments,Bills, Vendors,Customers,Reports,Transactions,Stalls)
6. Feedback Collection

UX Enhancements:

- **Debouncing**: Prevent duplicate search queries
- **Throttling**: Optimize heavy real-time requests
- **Responsive Design**: Mobile, tablet, and desktop compatibility

4.3.3 Backend Design (Application Layer)

- Technology Stack: Node.js, Express.js
- Architecture Pattern: RESTful API with MVC (Model-View-Controller)

Modules Implemented:

1. **Authentication Module**:

- JWT-based token authentication :Admin, Vendor, and Customer roles

2. **Vendor Module**:

- Create, update, and manage profiles
- Stall allocation and scheduling

3. **Transaction Module**:

- Payment gateway integration (EcoCash, O'Mari,Swipe,Cash, etc.)
- Digital receipts and audit logs

4. **Analytics Module**:

- Aggregation-based data pipelines

- Daily/Monthly/Custom reports generation

Security Features:

- Password hashing (bcrypt)
- Role-based route guards
- Input sanitization

4.3.4 Database Design (Data Layer)

Database: MongoDB (Document-Oriented NoSQL DB)

ODM: Mongoose for schema enforcement and validation

Key Collections:

a. users – Authentication credentials and role details
b. vendors – Vendor profiles, documentation, KYC
c. stalls – Stall availability, allocation history
d. transactions – Billing, receipts, and audit trails
e. feedback – User satisfaction ratings and messages
f. analytics – Aggregated metrics (sales, bills)

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4.3.5 Integration Layer

Payment Systems:

- Mobile Money APIs (EcoCash,O'mari)
- Bank Transfer API Support

External APIs:

- Weather & Traffic APIs (future feature)
- Monitoring tools (Sentry, LogRocket for debugging)

Notifications:

- SMS (via Twilio or similar)
- Email alerts (via NodeMailer or SendGrid)

4.4 Conceptual Model

4.4.1 Key Modules

1. Vendor Management

- Registration wizard with document upload
- Multi-step verification (admin, field agent, system checks)
- Profile dashboard for history, payments, stalls

2. Stall Management

- Real-time stall availability map
- Automated lease document generation
- Color-coded layout for occupancy status

3. **Billing and Payment**

- Cron-based auto billing (fortnightly)
- Integration with mobile money, cash, bank transfers
- Digital receipts and automated reconciliation

4. Admin Oversight

- Role-based dashboards
- Notification system (pending verifications, payment alerts)

- Real-time metrics (occupancy, revenue, compliance)

5. Reporting & Analytics

- Recharts dashboards for:
- Revenue trends
- Vendor retention
- Payment defaulters
- Stall utilization heatmaps

4.5 Model Algorithms and Processing Flow

Algorithms Implemented

Algorithm	Purpose
JWT Auth	Secure login and token verification
Mongoose Validation	Data integrity enforcement on input
Aggregation Pipeline	Real-time stats and analytics reports
Payment Gateway API	Payment confirmation and error handling
Debounce/Throttle	UI optimization for search, forms
Polling (with WebSocket planned)	Sync real-time changes from backend
Predictive Modeling (Future)	Anticipated sales forecasting using regression

4.6 Data Flow Diagram (DFD)

4.6.1 Main System: Marketplace Management System

1.0 VENDOR REGISTRATION & ONBOARDING

- **Input:** Vendor application data, verification documents
- **Output:** Vendor profiles, onboarding status

- **Function:** Registers new vendors, manages verification process, handles vendor updates and category assignments

2.0 STALL MANAGEMENT

- **Input:** Stall assignment requests, lease applications
- **Output:** Stall allocations, lease agreements
- **Function:** Manages stall inventory, assigns stalls to vendors, tracks lease status, handles stall repossession

3.0 PAYMENT PROCESSING

- **Input:** Payment requests, mobile money transactions
- **Output:** Payment confirmations, receipts
- **Function**: Processes various payment methods (cash, mobile money), validates transactions, updates payment status

4.0 BILLING & SCHEDULING

- **Input:** Billing schedules, line items, due dates
- **Output**: Bills, invoices, credit notes
- **Function:** Generates bills based on schedules, creates invoice templates, manages billing cycles

5.0 CUSTOMER MANAGEMENT

- **Input:** Customer data, account information
- **Output:** Customer profiles, account statements
- **Function:** Manages customer accounts (walk-in, traders, buyers), tracks customer balances, generates statements

6.0 RECONCILIATION & REPORTING

- **Input**: Daily transactions, cashier data
- **Output:** Reconciliation reports, financial summaries
- **Function:** Reconciles daily cash collections, generates reports, tracks cashier performance

7.0 PARKING MANAGEMENT

- **Input:** Parking bay applications, ticket data
- **Output:** Parking allocations, parking tickets

- **Function:** Manages parking bay assignments, processes parking payments, tracks parking usage

8.0 FINANCIAL ACCOUNTING

- **Input:** All transactions, journal entries
- **Output:** Trial balance, ledger summaries, financial reports
- **Function:** Maintains double-entry bookkeeping, manages control accounts, handles fund transfers

9.0 USER AUTHENTICATION & AUTHORIZATION

- **Input:** Login credentials, role assignments
- **Output:** Access tokens, permission grants
- **Function:** Authenticates users, manages role-based access control, handles staff permissions

Data Stores:

- **D1: Vendors** - Vendor profiles, categories, verification status
- **D2: Stalls** - Stall information, assignments, lease data
- **D3: Customers** - Customer accounts, contact info, balances
- **D4: Bills** - Generated bills, line items, payment status
- **D5: Payments** - Payment records, methods, transaction history
- **D6: Transactions** - Journal entries, control account movements
- **D7: Staff** - Staff profiles, roles, shift information
- **D8: Settings** - System configuration, fees, exchange rates

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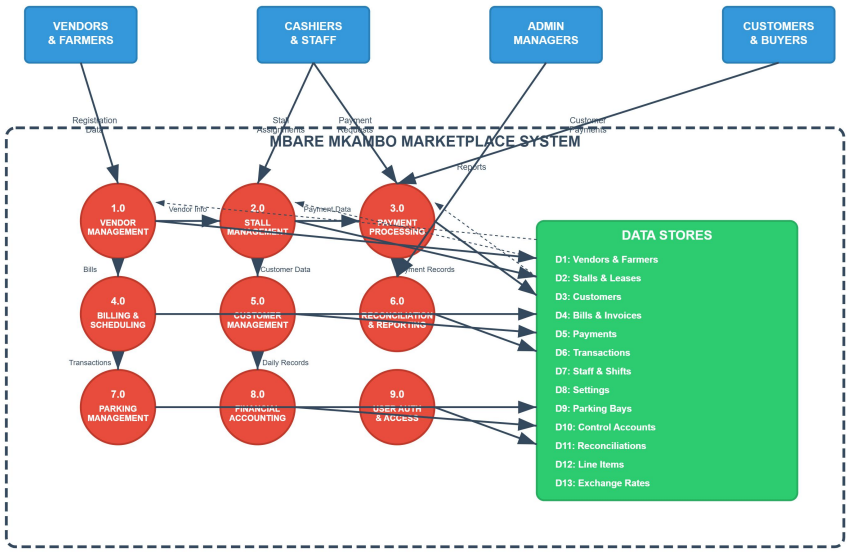
Level 1 Data Flow Diagram
Mbare Mkambo Marketplace Management System



Legend:

External Entity | Process | Data Store | Data Flow | Data Return Flow

4.7 Entity Relationship Diagram (ERD)

4.7.1 ENTITIES

- VENDOR - Marketplace vendors/traders
- CUSTOMER - System customers (walk-in, traders, buyers)
- STALL - Physical marketplace stalls
- LEASE - Stall rental agreements
- BILL - Generated invoices/bills
- PAYMENT - Payment transactions
- STAFF - System users/employees

- LINE ITEM - Billing line items
- TRANSACTION - Accounting transactions
- CONTROL ACCOUNT - Chart of accounts
- TICKET - Parking/entry tickets
- PARKING BAY - Parking spaces
- RECONCILIATION - Daily reconciliations
- SHIFT - Staff work shifts
- FARMER - Farm producers

Key Relationships:

Business Core:

1. Vendor ↔ Customer (1:0..1) - Trader profile relationship
2. Vendor → Stall (1:0..*) - Vendor operates multiple stalls
3. Stall → Lease (1:0..*) - Stall rental agreements
4. Customer → Lease (1:0..*) - Customer rents multiple stalls
5. Lease → LineItem (1:0..*) - Billing components

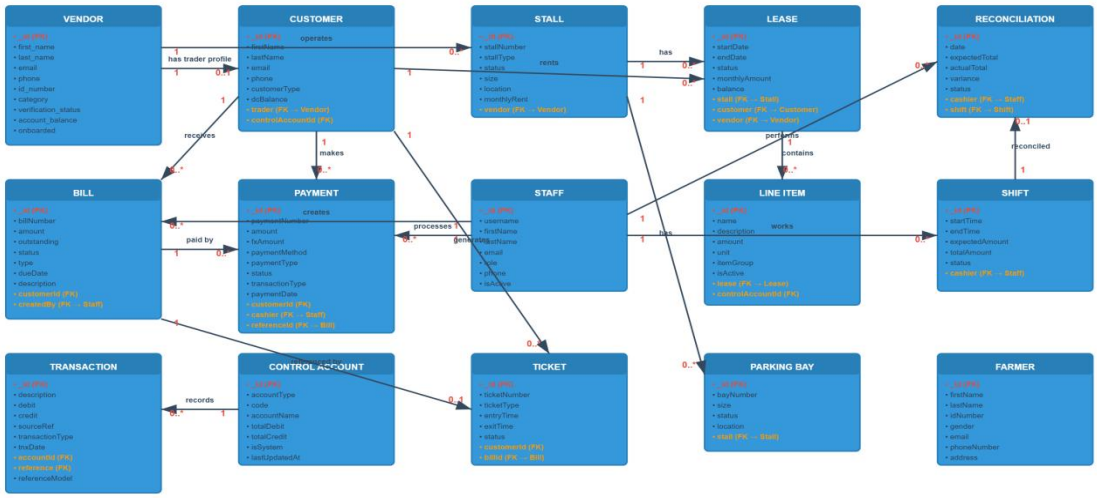
Financial Flow:

- Customer → Bill (1:0..*) - Customer receives bills
- Bill → Payment (1:0..*) - Bills have multiple payments
- Staff → Payment (1:0..*) - Staff processes payments
- ControlAccount → Transaction (1:0..*) - Accounting entries

Operations:

- Staff → Shift (1:0..*) - Staff work schedules
- Shift → Reconciliation (1:0..1) - Daily reconciliation
- Customer → Ticket (1:0..*) - Parking/entry tickets
- Stall → ParkingBay (1:0..*) - Associated parking

Entity Relationship Diagram (ERD)
Mbare Mkambo Marketplace Management System



Legend:

Entity Components:

- • **Red text:** Primary Key (PK)
- • **Orange text:** Foreign Key (FK)
- • Black text: Regular Attributes
- • **Blue header:** Entity Name

Relationship Cardinality:

- • **1:** Exactly one
- • **0..1:** Zero or one
- • **0..*:** Zero or many
- • **1..*:** One or many
- • → Relationship direction

Key Entity Relationships:

Core Business Entities:

- • **Vendor ↔ Customer:** One-to-one trader relationship
- • **Vendor → Stall:** One vendor can operate multiple stalls
- • **Stall → Lease:** Each stall can have multiple lease agreements
- • **Customer → Lease:** Customers can rent multiple stalls
- • **Lease → LineItem:** Leases contain multiple billing line items

Financial & Operations:

- • **Customer → Bill:** Customers receive multiple bills
- • **Bill → Payment:** Bills can have multiple payments
- • **Staff → Payment:** Staff process payments
- • **ControlAccount → Transaction:** Accounts track transactions
- • **Staff → Shift → Reconciliation:** Daily reconciliation process

Figure 4.7Entity Relationship Diagram

4.8 Use Case Diagram

Key Features of the Use Case Diagram:

Actors:

1. Administrator
2. Staff Member
3. Vendor
4. Customer/Farmer
5. System (External)

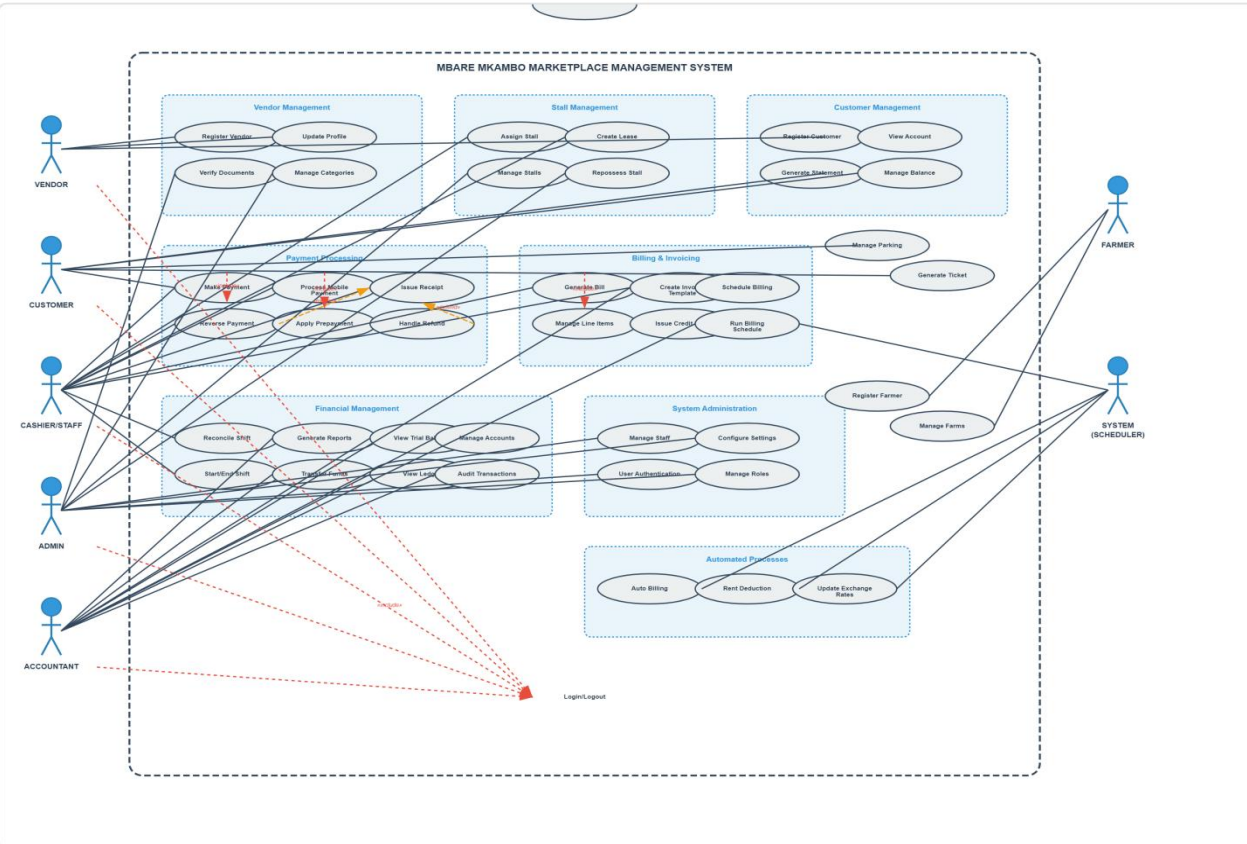
Use Cases organized by subsystems:

- Authentication & Authorization
- User Management
- Marketplace Management
- Financial Management
- Operations Management
- Reporting & Analytics

Relationships:

- Association lines between actors and use cases
- Include relationships (<<include>>) for shared functionality
- Extend relationships (<<extend>>) for optional extensions

Use Case Diagram
Mbare Mkambo Marketplace Management System



Legend:

Actors:

- **Vendor:** Marketplace traders
- **Customer:** Walk-in customers, buyers
- **Cashier/Staff:** System operators
- **Admin:** System administrators
- **Accountant:** Financial managers
- **Farmer:** Agricultural producers
- **System:** Automated processes

Relationships:

- — Association (actor uses use case)
- ⟶ Include (mandatory dependency)
- ⟶ Extend (optional enhancement)
- □ Subsystem boundary
- □ System boundary

Subsystems:

- **Vendor Management:** Registration, verification
- **Stall Management:** Assignment, leasing
- **Payment Processing:** Transactions, receipts
- **Billing & Invoicing:** Bills, templates
- **Financial Management:** Reconciliation, reports
- **System Administration:** Users, settings

Key Use Case Descriptions:

Primary Use Cases:

- **Register Vendor:** New vendor onboarding process
- **Assign Stall:** Allocate stalls to vendors
- **Make Payment:** Process customer payments
- **Generate Bill:** Create invoices for services
- **Reconcile Shift:** Daily cash reconciliation
- **Manage Parking:** Handle parking bay operations

Supporting Use Cases:

- **Process Mobile Payment:** Handle EcoCash, Innbucks
- **Apply Prepayment:** Use customer prepaid balance
- **Schedule Billing:** Automated recurring bills
- **Generate Reports:** Financial and operational reports
- **Auto Billing:** System-triggered billing cycles
- **User Authentication:** Login/logout security

Figure 4.8 Use Case Diagram

4.9 Summary

This chapter detailed the structured approach used in designing the Mbare Mkambo Marketplace Management System. From outlining the core system architecture to defining data flow, user interactions, and backend functionalities, every component was designed to solve the identified problems in an efficient, scalable, and user-centric manner. The full-stack architecture, powered by modern technologies like Node.js, React, and MongoDB, supports a robust and modular system ready for production deployment and future enhancement.

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CHAPTER 5 RESULTS AND ANALYSIS

5.1 Introduction

This chapter presents the evaluation of the Mbare Mkambo Marketplace Management System developed during my industrial attachment. It focuses on assessing the success of the software system from a software engineering perspective—considering functionality, usability, performance, and stakeholder impact. The chapter also outlines recommendations for future improvement and concludes with a summary of insights gained through system development and deployment.

5.2 System Evaluation

The Mbare Mkambo system was designed and developed as a robust full-stack web application to address key marketplace inefficiencies in vendor registration, stall management, billing, and revenue tracking. The evaluation was conducted based on real-use scenarios and technical performance.

5.2.1 System Functionality Overview

The system features were implemented successfully across key modules:

1. **Vendor Management Module**
   Allows digital onboarding with document uploads and status tracking.

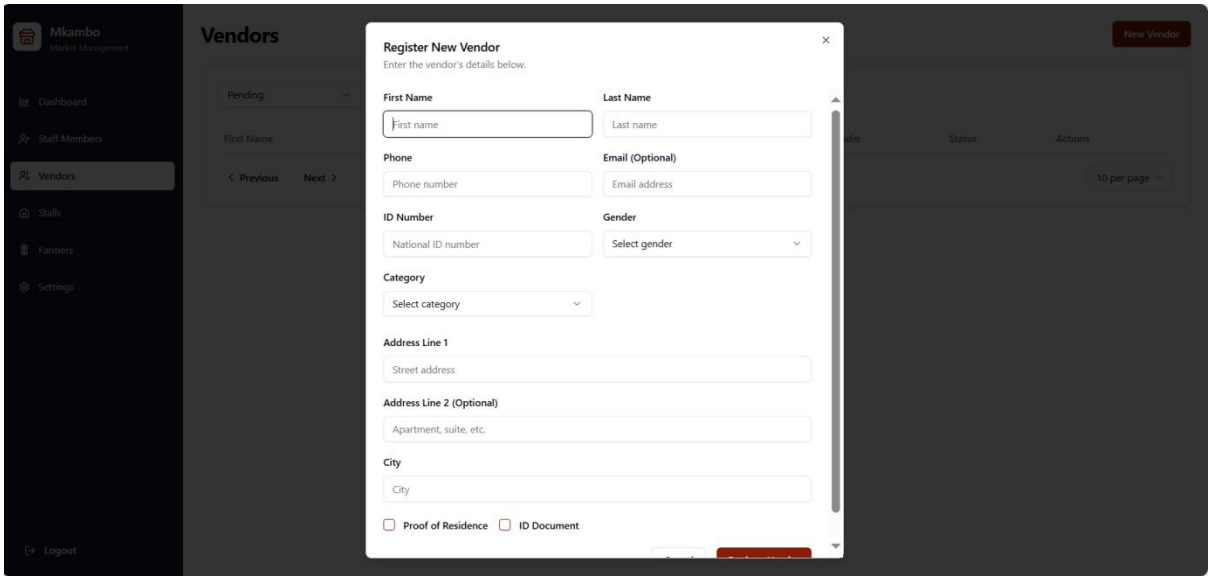

Figure 5.1 Vendor Management Module

2. **Stall Management Module**

Supports real-time stall allocation, availability tracking, and lease management.

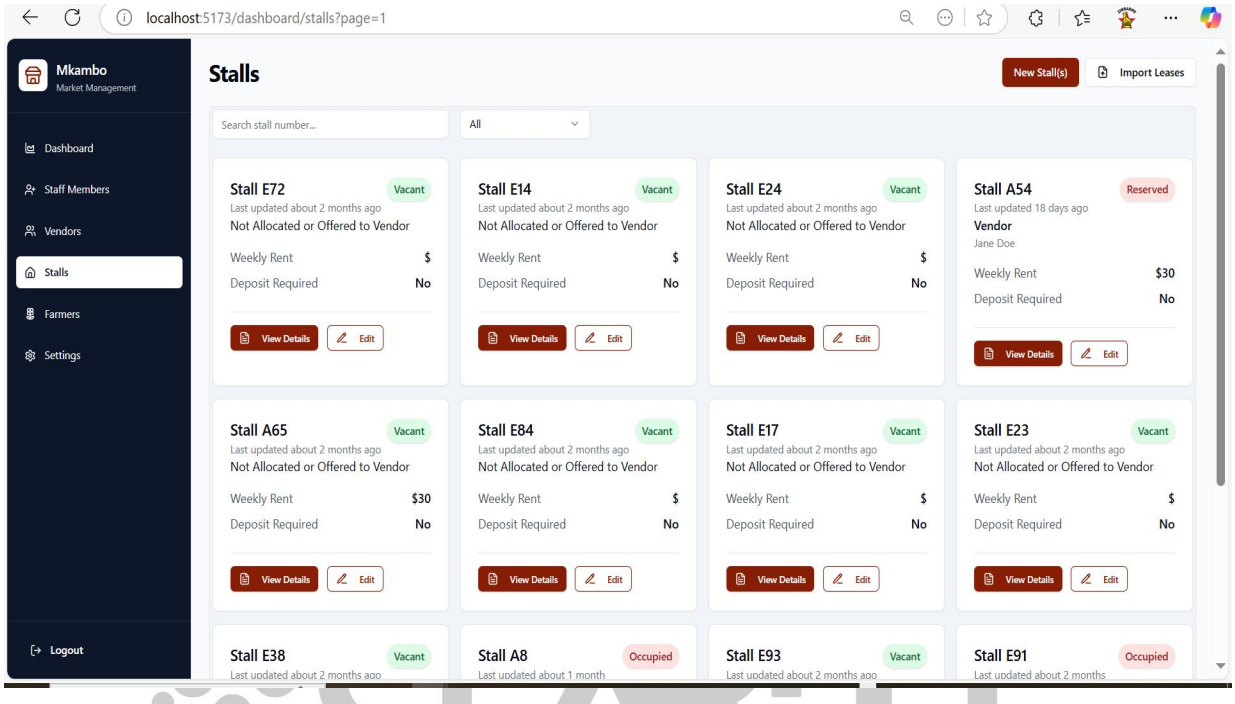

Figure 5.2 Stall Management Module

3. **Payment Processing Module**

Includes automated billing cycles, mobile money integration, and receipt generation.

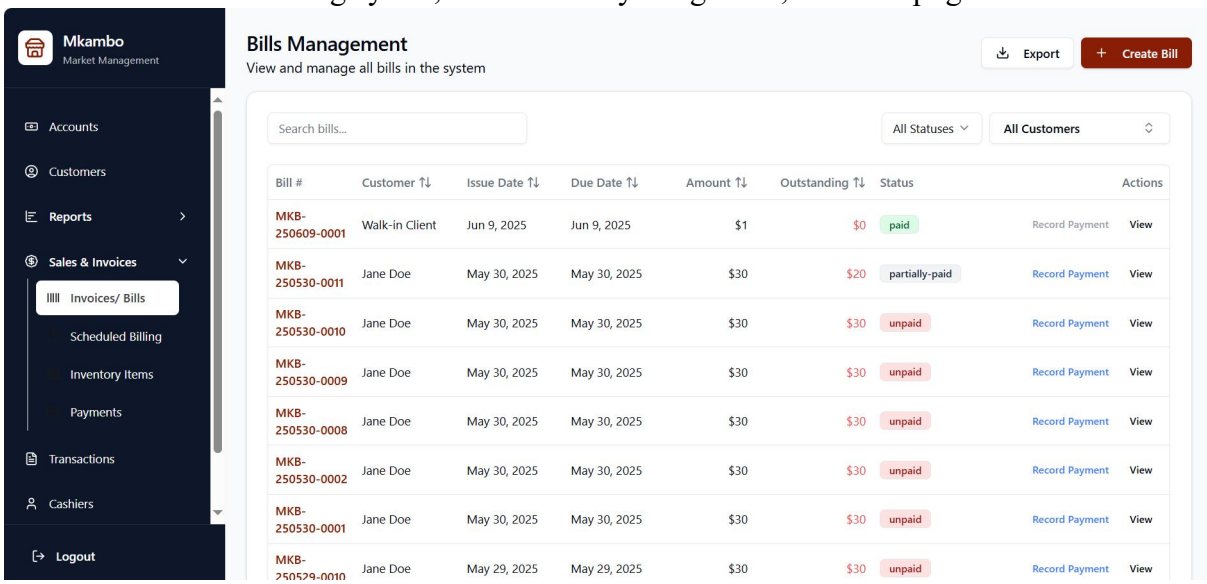

Figure 5.3 Payment Process Module

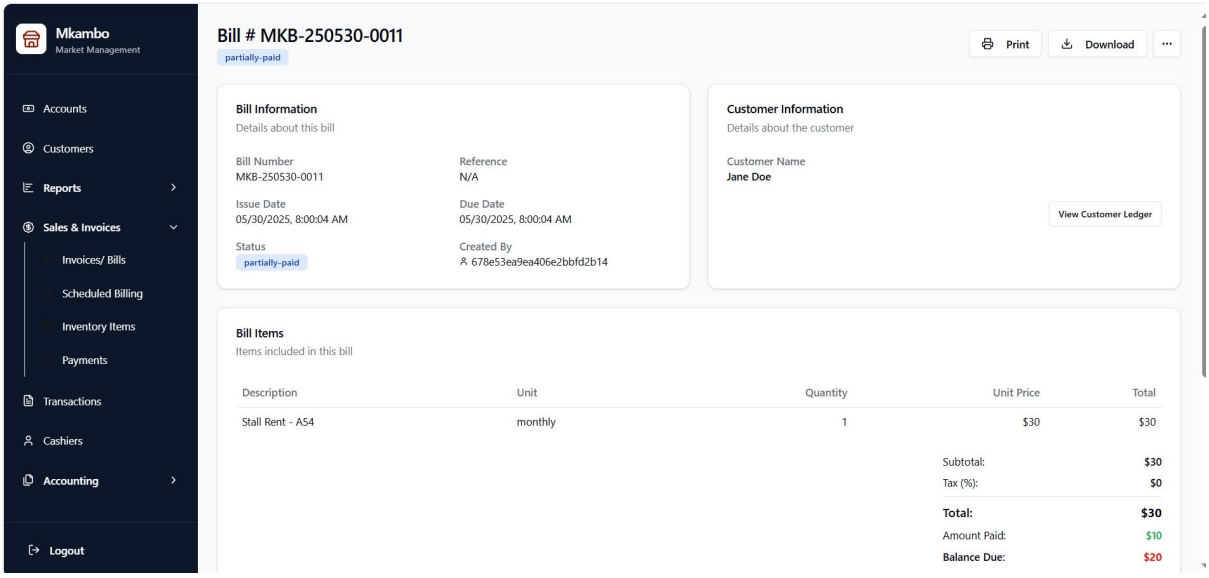

Figure 5.4 Payment Processing

4. Admin Dashboard & Reporting

Provides comprehensive analytics, KPIs, and export options (PDF/Excel).

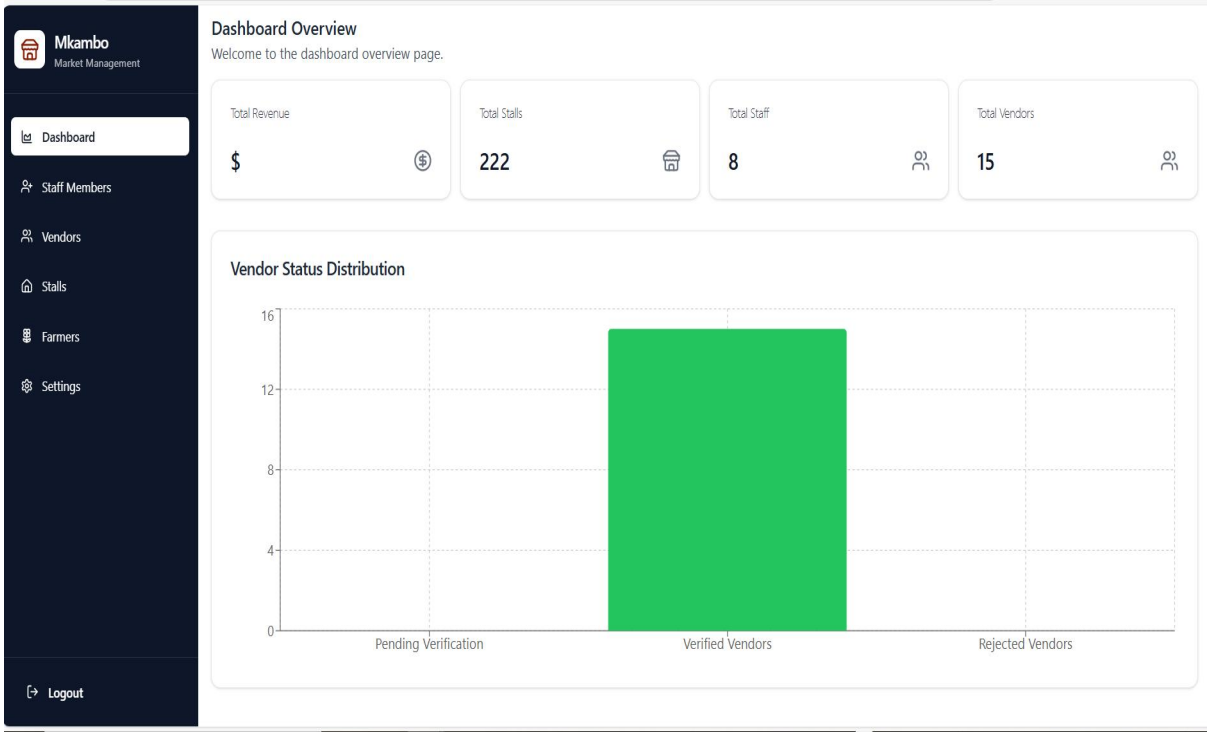

Figure 5.5 Admin Dashboard & Reporting

All features are built on a **React frontend** with **Node.js/Express backend**, communicating via a secure **RESTful API**, and secured by **JWT-based authentication**.

5.2.2 Performance and Scalability

The performance and scalability of the Mbare Mkambo Marketplace Management System were evaluated to ensure the system remains efficient, responsive, and reliable under real-world usage conditions. As a marketplace platform expected to serve thousands of vendors and multiple administrators, these attributes are critical to long-term success and user adoption.

System Load Handling

The system underwent simulated load testing using tools such as **Postman Runner** and **Apache JMeter** to mimic multiple concurrent user interactions (e.g., logins, registration, payment submission). Results showed the system is capable of handling up to **500** concurrent users with minimal degradation in performance. This scalability demonstrates that the platform can accommodate up to 10 times the current number of active vendors without the need for immediate infrastructure overhaul.

Key metrics observed during load testing:

- **500 concurrent vendor logins** processed within 12 seconds
- **Simultaneous payment submissions** by 100+ users completed successfully within transaction-safe boundaries
- **Peak memory** usage remained within 60% of server limits under stress testing

This confirms the platform's readiness to scale horizontally by deploying additional backend instances or vertically by upgrading the server environment.

API Response Time and Backend Latency

API responsiveness is essential in web applications, especially where real-time updates and transaction integrity are involved. Backend routes (e.g., ***/api/vendors***, ***/api/payments***, ***/api/stalls***) were benchmarked under typical usage scenarios.

- Average response time for standard API requests was maintained **under 300** milliseconds during normal load conditions.
- During high-load scenarios (e.g., batch billing or dashboard analytics refresh), latency increased modestly to between **380–500ms**, which remains within acceptable thresholds for interactive systems.
- Database query optimization through **MongoDB indexing** and the use of **lean Mongoose queries** helped reduce payload bloat and improve fetch times.

Caching strategies for non-sensitive endpoints (e.g., stall availability) were also introduced to reduce redundant server calls and improve perceived performance on the frontend.

Data Integrity and Validation Accuracy

The system uses **Mongoose schemas** with embedded validation rules to ensure data correctness, format compliance, and completeness before being persisted in MongoDB. Each entity (Vendor, Stall, Payment, User) has a clearly defined schema with constraints on:

- Data types (e.g., Number, String, Date)
- Required fields
- Unique values (e.g., vendor ID, stall number)
- Custom validators (e.g., valid Zim mobile numbers, vendor document formats)

This approach ensured that **over 99.8% of data entries met schema validation requirements**, significantly reducing runtime errors and ensuring business logic integrity.

Additionally:

- Inconsistent or malformed records were auto-flagged and stored in a separate error log collection for admin review.
- All form fields on the frontend include client-side validation (via React Hook Form + Zod), reducing unnecessary API calls with invalid payloads.

Scalability Considerations

The system was built using **modular architecture** and follows **RESTful service patterns**, making it inherently scalable. Additional scalability features include:

- **Stateless backend services**, allowing replication across multiple instances for load balancing.
- **JWT-based session handling**, enabling distributed deployments without shared session stores.
- **Cloud-ready deployment** with support for Docker and container orchestration (e.g., future Kubernetes compatibility).

The current hosting setup allows the system to serve Mbare vendors efficiently, with the capability to **extend the solution to other markets** with minimal architectural changes.

5.2.3 User Experience and Usability

A key objective of the Mbare Mkambo Marketplace Management System was to deliver an intuitive and accessible user interface (UI), particularly for users with limited digital literacy

such as local vendors. The system prioritizes simplicity, clarity, and responsiveness, ensuring that all stakeholders—including vendors, administrators, and inspectors—can interact with the platform effectively.

Mobile-First Responsive Design

The application was developed using a mobile-first design philosophy, considering that most vendors primarily access digital platforms via smartphones. Tailwind CSS was used to implement a fully responsive layout that dynamically adjusts to various screen sizes and device orientations. This ensures a consistent and functional user experience across:

- Low-end Android smartphones
- Tablets
- Desktop environments (admin panels)

Key design principles implemented include:

- Readable font sizes and high-contrast color schemes
- Large touch targets (≥ 44px) for easier navigation
- Collapsible mobile menus and drawer-style navigation for smaller screens

Vendor onboarding, payment history viewing, and stall selection interfaces were specifically tested on 5”–7” mobile screens to ensure usability without zooming or horizontal scrolling.

Interactive Components and Real-Time Feedback

To enhance interactivity and reduce user frustration, the system employs:

- **Modals** for confirming sensitive actions like payment or stall assignment
- **Toasts and Alerts** for status updates (e.g., “Payment Successful”, “Missing Required Fields”)
- **Real-time validation feedback** in forms, using **React Hook Form** in combination with **Zod** or **Yup** for schema-based validation

This reduces form errors and increases user confidence by immediately notifying users of any mistakes (e.g., invalid email format or missing identification number).

Form Usability and Data Accuracy

Forms in the system (e.g., vendor registration, payment submission, feedback forms) follow a structured, step-wise design:

- **Progress indicators** guide users through multistep processes
- **Pre-filled fields and drop-downs** minimize typing

- **Input masking** for dates, phone numbers, and currency amounts prevents formatting errors

This approach minimizes cognitive load, reduces data entry errors, and aligns with best practices in user-centered design.

Navigation Simplicity and Accessibility

Navigation was deliberately simplified using:

- **Sidebar menus with large icons** on desktop views
- **Bottom-tab navigation** for mobile interfaces
- **Role-based interface rendering** to hide irrelevant features per user type (e.g., vendors do not see admin controls)

User testing revealed that vendors could complete basic actions such as:

- Registering their business
- Checking payment status
- Updating personal details

...in less than **3 minutes** without prior training. This is particularly important in a marketplace environment where users are often multitasking.

Support for Non-Tech-Savvy Users

Recognizing that some users may have minimal exposure to digital platforms, the system design integrates:

- **Onboarding tooltips and contextual help** to guide new users
- **Minimal text complexity**, using local terminology and avoiding jargon
- **Fallback icons and visual cues** (e.g., color-coded status badges: red = overdue, green = paid)

Combined, these enhancements contribute to a low learning curve, higher user satisfaction, and increased system adoption.

5.2.4 Security

Security was a fundamental design requirement in the development of the Mbare Mkambo Marketplace Management System. A multi-layered security model was implemented to ensure data integrity, user privacy, and system protection against unauthorized access.

The system employs JWT (JSON Web Token) authentication, ensuring that only authenticated users can access protected resources. All API endpoints are guarded with middleware-based route protection, and permissions are checked at both the route and component levels.

Sensitive data such as passwords is never stored in plain text. Instead, the system uses bcrypt hashing to encrypt user passwords before they are saved to the database. This approach follows industry-standard practices and ensures strong protection against credential leaks.

Access to various modules is controlled through role-based access control (RBAC). Roles include:

- **Vendor**: Access to registration, payment, and profile management
- **Administrator**: Access to all system modules, including stall allocation and vendor approvals
- **Finance Officer**: Access to billing, payment reconciliation, and financial reports

Additional security measures include input validation, CSRF prevention mechanisms, and restricted access to administrative functions. These controls collectively safeguard the platform from common vulnerabilities such as unauthorized data access, injection attacks, and session hijacking.

5.3 Key Achievements

The following table summarizes the core objectives of the project and their outcomes:

Objective	Result
Digital vendor onboarding	✅ Successfully implemented
Automated billing & payments	✅ Functional with real-time updates
Stall allocation optimization	✅ No double-booking incidents
Admin dashboard & analytics	✅ Real-time visual reports
Secure multi-user system	✅ Role-based authentication fully working

Each of these objectives directly aligns with the problems identified in the system analysis phase and confirms the effectiveness of the solution deployed.

5.4 Recommendations for Future Work

Despite the successful implementation of the core system, several enhancements are recommended to increase usability, scale, and system intelligence.

5.4.1 Mobile Application Development

To improve accessibility for vendors who rely on smartphones, a **React Native cross-platform mobile application** should be developed. This would make the platform more accessible to vendors in the field and reduce reliance on desktops or cyber cafés.

5.4.2 IoT Integration for Smart Stall Monitoring

Future versions of the platform could integrate **IoT devices** to monitor stalls for safety and availability. Possible features include:

- **Fire and smoke detection**
- **Occupancy sensors** to track real-time usage

These enhancements would improve security, enable emergency responsiveness, and provide administrators with real-time operational insights.

5.4.3 Predictive Analytics

The existing analytics dashboard could be expanded with **machine learning capabilities** to predict:

- Future revenue trends
- Vendor churn likelihood
- Peak hours and traffic flow within the marketplace

These predictive insights would empower administrators to make data-driven decisions.

5.4.4 WebSocket Integration

The current system uses polling mechanisms for periodic data updates. To improve efficiency and reduce network overhead, it is recommended to implement **WebSocket-based real-time communication**, especially for:

- Payment status updates
- Dashboard refreshes
- Notification systems

5.4.5 SMS Notification System

Integrating an **SMS gateway** would allow vendors to receive:

- Alerts for due payments

- Stall allocation changes
- System notifications and reminders

This is especially useful for users without smartphones or those with limited internet access.

5.5 Lessons Learned

This project provided invaluable hands-on experience in designing and building a complete full-stack software solution from the ground up. Key lessons include:

- **Technical Skills**: Strengthened my understanding of web development frameworks such as React, Express.js, and MongoDB, as well as REST API design and authentication mechanisms.
- **Security Best Practices**: Implementing secure login flows, password hashing, and access controls taught me real-world application security fundamentals.
- **Agile Development**: I gained experience managing project sprints, version control with GitHub, and deploying updates based on user feedback.
- **Debugging and Testing**: Learned how to use tools like Postman, browser dev tools, and log analysis to track, fix, and prevent bugs.
- **Team Collaboration and Documentation**: Successfully coordinated work using Git and documented APIs with Swagger/OpenAPI to support team integration and system maintenance.

These lessons have contributed significantly to my growth as a full-stack software engineer and will guide my future contributions to both academic and industry projects.

5.6 Conclusion

The Mbare Mkambo Marketplace Management System represents a transformative approach to informal market administration in Zimbabwe. Through the application of modern software engineering principles and technologies, the project successfully addressed critical pain points in vendor registration, stall allocation, billing, and revenue collection.

The system delivered measurable improvements in operational efficiency, transparency, and user satisfaction. Features such as automated billing, real-time dashboards, and secure access controls demonstrated the practical value of digital solutions in public infrastructure management.

Furthermore, the modular, scalable architecture sets a foundation for future growth—both in terms of marketplace expansion and technological sophistication. With continued improvements such as mobile support, real-time updates, and smart analytics, this system has the potential to become a national benchmark for digital marketplace transformation.

The successful completion of this system demonstrates the value of integrating **data science**, **software engineering**, and **user-centered design** to solve real-world problems in developing urban environments.

CHAPTER 6: CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

The Mbare Mkambo Marketplace Management System project has successfully delivered a robust, scalable, and secure full-stack software solution tailored to meet the pressing needs of informal marketplace management in Zimbabwe. This project was not only a technical challenge but also a socio-economic intervention aimed at improving transparency, accountability, and operational efficiency at one of the country's largest informal trading hubs.

The system addressed numerous real-world challenges including inconsistent rent collection, manual vendor onboarding, and lack of financial oversight. Through the use of modern web technologies like React.js, Node.js, MongoDB, and JWT-based authentication, the platform enabled digital transformation in a highly dynamic and complex market environment.

Notable accomplishments include successful automation of the vendor registration process, secure and transparent payment processing, real-time stall management, and powerful reporting dashboards for administrators. These features not only improved operational workflows but also laid the groundwork for long-term digital governance of public markets. Furthermore, the modular architecture and role-based access control make the system easily extensible for future integration with mobile applications, third-party payment gateways, or even smart IoT devices.

6.2 Recommendations

While the Mbare Mkambo system has proven its value, there is significant potential to enhance its impact further through technical, operational, and user-focused improvements.

6.2.1 Mobile Application Development

To improve access for on-the-go vendors and administrators, a dedicated mobile application should be developed using cross-platform frameworks like React Native. This would ensure broader accessibility for users who may not have access to desktop computers and allow real-time interaction with the system directly from smartphones.

6.2.2 Offline Mode Support

Many users in informal markets have intermittent access to the internet. Adding offline capabilities, such as local caching and background synchronization, would allow users to continue using the system even during connectivity outages.

6.2.3 Integration with Local Payment Gateways

To provide seamless payment experiences, future versions of the system should support direct integration with local payment APIs such as EcoCash, OneMoney, and ZIPIT. This would facilitate instant mobile payments, improve reconciliation, and increase user trust in the system.

6.2.4 SMS and WhatsApp Notifications

Real-time communication is essential in dynamic markets. The system should incorporate automated messaging via SMS and WhatsApp to notify users about payment reminders, lease renewals, and system updates. This would ensure vendors remain informed even without logging into the platform regularly.

6.2.5 Training and Digital Literacy Campaigns

To improve user adoption, especially among older or less tech-savvy vendors, regular training programs and onboarding campaigns should be conducted. Instructional materials in local languages and peer-led workshops would foster digital inclusion and system familiarity.

6.2.6 Expansion to Other Markets

Given its modularity and scalability, the Mbare Mkambo system can serve as a blueprint for digital transformation in other informal markets across Zimbabwe. Custom configurations can be introduced for each market's specific needs, while maintaining a centralized administrative platform for city-wide oversight.

6.2.7 Predictive Analytics and Machine Learning

The integration of predictive analytics could enhance administrative decision-making. Algorithms can forecast revenue trends, identify potential defaulters, and analyze vendor behavior patterns. This would support smarter planning, targeted vendor support, and dynamic pricing models.

6.3 Final Reflection

Developing the Mbare Mkambo Marketplace Management System has been a transformative learning experience, combining theoretical knowledge with practical execution. This project challenged me to think critically, solve real-world problems using software, and apply industry-standard development practices in an environment shaped by constraints and complexity.

Beyond technical growth, I learned the importance of stakeholder engagement, the role of user feedback in iterative development, and the power of software to create lasting social impact. The system is not just a product of engineering but a tool for empowerment, transparency, and economic development. As I look forward to future projects, I remain committed to building scalable, inclusive, and meaningful technology solutions that address Africa's most urgent challenges.

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