

Local Enterprise Resource Planning and E-Commerce System for West Africa Decor Tiles

BY GROUP [GROUP 23]

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1 Chapter 1 Introduction

1.1. Background of the Project

West Africa Decor Tiles, a thriving business located in Mile 7, operates in a highly competitive market where operational efficiency, customer satisfaction, and precise inventory management are crucial for long-term sustainability and growth. Despite its potential, the company continues to rely on outdated manual processes for critical operations such as inventory tracking, order management, and customer interactions. This dependence on traditional methods has resulted in significant operational inefficiencies, financial losses due to errors and theft, and a subpar customer experience. In an era where digital transformation is reshaping industries globally, the absence of modern systems places West Africa Decor Tiles at a distinct disadvantage, limiting its ability to compete effectively with more technologically advanced competitors.

The global business landscape has increasingly embraced digital solutions such as **Enterprise Resource Planning (ERP) and E-Commerce systems to streamline operations**, minimize human error, and enhance market reach. These technologies have proven indispensable for businesses seeking to optimize supply chains, improve customer engagement, and drive profitability. However, many small and medium-sized enterprises (SMEs) in West Africa, including West Africa Decor Tiles, still operate using archaic manual methods. This gap persists primarily due to the lack of affordable, localized digital solutions that cater to the unique challenges faced by businesses in the region, such as unreliable internet connectivity, limited technical expertise, and budget constraints.

This project aims to address these challenges by developing a customized, computer-based ERP and E-Commerce system specifically designed to meet the needs of West African SMEs. By focusing first on West Africa Decor Tiles, the solution will serve as a scalable model that can be adapted for other businesses in the region. The system will integrate real-time inventory management, online sales capabilities, and robust data analytics, empowering the company to overcome its current limitations and achieve sustainable growth.

Why a Computer-Based Solution?

The transition from manual processes to a computer-based ERP and E-Commerce system offers transformative benefits that directly address the pain points faced by West Africa Decor Tiles. Below is a detailed exploration of how this digital solution can revolutionize the business:

Automation Eliminates Human Error and Theft

Manual inventory tracking and record-keeping are inherently prone to errors, whether accidental or intentional. Employees may inadvertently miscount stock or, in worse cases, manipulate records to facilitate theft. A digital inventory system automates these processes, ensuring that every transaction is logged accurately and in real time. Discrepancies are flagged immediately, enabling swift corrective action and significantly reducing opportunities for fraud. This level of transparency and accountability is simply unattainable with paper-based or spreadsheet-driven methods.

2. Real-Time Inventory Management Prevents Stockouts and Overstocking

One of the most pressing issues for West Africa Decor Tiles is the inability to maintain optimal inventory levels. Poor visibility into stock levels often leads to delayed restocking, resulting in stockouts that frustrate customers and lost sales. Conversely, overstocking ties up capital in unsold goods, straining financial resources. An ERP system equipped with real-time tracking capabilities provides live updates on inventory status, automatically generating alerts when stock levels fall below predefined thresholds. This ensures timely procurement, minimizes waste, and aligns inventory with actual demand, thereby improving cash flow and operational efficiency.

3. Online Sales Expand Customer Reach

Currently, customers of West Africa Decor Tiles are required to visit the physical store to place orders, severely limiting the business's market reach. In today's digital age, consumers increasingly expect the convenience of online shopping, with features such as home delivery and flexible payment options. By implementing an E-Commerce platform, the company can tap into a broader customer base, including those in remote or underserved areas. The platform will support online order placement, payment processing, and delivery tracking, mirroring the seamless experiences offered by global retail giants while catering to local preferences and infrastructural realities.

4. Data-Driven Decision Making Improves Operations

Without a centralized system for collecting and analyzing data, West Africa Decor Tiles lacks the insights needed to make informed business decisions. Critical aspects such as customer preferences, sales trends, and inventory turnover remain obscured, hindering strategic planning. A computer-based ERP system consolidates all operational data into a single, accessible platform. Advanced analytics tools can then transform this data into actionable insights, enabling management to identify growth opportunities, optimize pricing strategies, and enhance customer service. For example, analyzing feedback trends can reveal common customer complaints, allowing the business to address issues proactively and improve overall satisfaction.

5. Scalability for Future Growth

As West Africa Decor Tiles expands, its manual systems will become increasingly inadequate, unable to handle the complexities of a growing operation. A modular software solution is inherently scalable, designed to accommodate additional branches, product lines, or functionalities with minimal disruption. For instance, the system can later integrate supplier portals for automated procurement or incorporate advanced analytics for demand forecasting. This scalability ensures that the business can evolve without being constrained by its technological infrastructure, future-proofing its operations against market changes and expansion needs.

1.2. Problem Definition for Local ERP & E-Commerce System (West Africa Decor Tiles)

West Africa Decor Tiles, operating in Mile 7, faces significant operational challenges stemming from its reliance on outdated manual systems. The company's continued

dependence on paper-based inventory management and lack of digital integration has created multiple pain points that hinder business growth and customer satisfaction. At the core of these issues lies an inefficient inventory tracking system where manual counting and sorting processes frequently result in errors. These inaccuracies not only disrupt operations but also create opportunities for employee theft through intentional misreporting of stock figures. Furthermore, the absence of real-time visibility into inventory levels leads to delayed restocking, causing frustrating shortages that directly impact customer experience.

The business suffers from severely limited market reach due to its complete reliance on in-person transactions. Without an online ordering platform or delivery system, West Africa Decor Tiles misses numerous sales opportunities from customers who either cannot visit physically or prefer the convenience of digital commerce. This limitation becomes particularly problematic when competing against businesses that have embraced e-commerce solutions, putting the company at a distinct market disadvantage. The problem compounds as the lack of digital integration extends to inter-branch communication, where the absence of real-time coordination frequently results in stock imbalances across locations.

These operational deficiencies stem from several root causes that have persisted due to the company's technological stagnation. The most critical is the complete absence of automated tracking systems such as barcode scanners or RFID technology, which have become standard in modern retail operations. This technological gap creates security vulnerabilities where manual record-keeping enables both accidental errors and intentional data manipulation. As competitors increasingly adopt digital solutions, West Africa Decor Tiles finds itself falling behind in both operational efficiency and customer service capabilities.

The cumulative impact of these problems manifests in multiple damaging ways for the business. Financially, the company suffers from preventable losses due to inventory shrinkage, unsold stock from poor demand forecasting, and missed sales opportunities. The operational inefficiencies waste countless Labor hours on error-prone manual tasks that could be automated. Perhaps most damaging is the gradual erosion of the company's reputation, as frustrated customers encounter delayed services and outdated purchasing options. These challenges create a vicious cycle where operational inefficiencies lead to poor customer experiences, which in turn affect sales and profitability, making it increasingly difficult for the business to invest in the very solutions that could address these issues. The situation underscores the urgent need for digital transformation to modernize operations, improve accuracy, and enhance customer service capabilities

1.3 Project Aim

Our aim is to develop a Local Enterprise Resource Planning (ERP) and E Commerce System, including a mobile app, tailored for West Africa Decor Tiles at Mile7. The system and app will allow customers to order tiles online and have them delivered to any location they choose, eliminating the need to visit the shop.

The system will help track all goods in real-time, automate counting and sorting processes, detect discrepancies to prevent theft, and enable communication with other branches for coordinated operations.

Additionally, the app will facilitate customer feedback, sent directly to the branch manager, to improve service and responsiveness, thereby enhancing operational efficiency, customer satisfaction, and market reach.

1.4. Project Objectives

1.4.1. Project Development Focus

To address these problems, the project will develop a **Local ERP & E-Commerce System** with:

1. Real-Time Inventory Tracking:

- Automated stock updates to prevent discrepancies/theft.
- Low-stock alerts for timely restocking.

2. Online Sales Platform:

- Mobile app/web portal for orders, delivery requests, and payments.
- Integration with local logistics for wider customer reach.

3. Inter-Branch Coordination:

- Centralized dashboard for multi-location inventory management.

4. Feedback & Security Features:

- Customer feedback channel for service improvement.
- User authentication and audit logs to deter theft.

1.4.2. Foundational Objective: Design & Build a Scalable System Architecture

At the core of our technical approach is the use of **Flutter for cross-platform mobile app development**, enabling seamless deployment across both iOS and Android devices. This choice ensures maximum reach among customers and staff while maintaining development efficiency. The application architecture adopts a **modular microservices design** using Node.js and MongoDB, providing the flexibility to scale individual components as needed while ensuring system resilience. For deployment, we will leverage **cloud platforms like AWS or Azure**, but with crucial offline synchronization capabilities that maintain functionality during internet outages - a frequent occurrence in the region. This technical foundation directly supports all six primary project objectives while specifically addressing West Africa's infrastructure limitations, including intermittent connectivity and prevalence of low-end mobile devices.

For the **customer-facing interface**, we're implementing a multi-platform solution that includes a Flutter mobile app with local-first design principles, allowing customers to submit orders even without internet connectivity. The Progressive Web App (PWA) version ensures accessibility for users who prefer browser-based access, while both platforms feature UI/UX designs optimized for users with varying literacy levels through intuitive icon-based navigation. This comprehensive approach to digital access eliminates the need for physical store visits, solving one of the company's most pressing customer reach problems.

The **inventory management system** incorporates advanced technologies to ensure accuracy and prevent fraud. Barcode scanning powered by ML Kit enables fast, error-free inventory checks, while a blockchain-inspired transaction ledger creates an immutable record of all stock movements. The system's analytics dashboard, built with Python, goes beyond simple tracking to provide predictive restocking alerts based on sales trends. These features work in concert to dramatically reduce opportunities for theft that exist in the current manual counting system while optimizing inventory levels across all branches.

To maintain operational awareness, we're implementing an **automated alert system that** leverages multiple communication channels. The Twilio API will handle SMS alerts for critical stock levels and delivery updates, ensuring notifications reach staff regardless of internet availability. For inter-branch coordination, we're integrating with popular messaging platforms like Slack and WhatsApp, which are widely used in the region. The system includes intelligent, rule-based escalation protocols to ensure critical issues receive immediate attention, finally breaking down the communication barriers that currently exist between locations.

Security measures have been designed to address both external threats and internal vulnerabilities. The authentication system combines JWT with OAuth 2.0 to ensure secure access control, while automated discrepancy reports generated by Python scripts provide real-time oversight of inventory anomalies. Role-based dashboards tailor the interface and functionality to different user types (admin, staff, customer), creating appropriate access levels while maintaining a seamless user experience. These features work together to create the transparency and accountability needed to deter internal theft - a significant problem in the current manual system.

Recognizing the importance of real-world validation, our **testing protocol employs** multiple verification methods. A/B testing will optimize UI variants for maximum usability, while load testing under simulated low-bandwidth conditions ensures performance in actual operating environments. Before full deployment, we'll conduct pilot testing at two branches, allowing for refinement based on real user feedback and operational data. This rigorous approach guarantees the system will perform as needed under West Africa's unique technical constraints.

Finally, our local infrastructure optimizations ensure the solution works for all users across the region. Lightweight SQLite databases enable reliable offline data storage on mobile devices, while SMS-based order confirmations via Africa's Talking API provide universal accessibility. The inclusion of Hausa and Twi language localization bridges communication gaps in rural areas, making the system truly inclusive. These thoughtful adaptations address the digital divide that often limits technology adoption in developing markets, ensuring the solution delivers value to all segments of West Africa Decor Tiles' customer base and operational footprint.

1.4.3. Why This Integration Works

End-to-End Alignment: Each technical implementation choice directly addresses a business problem from your original statement.

Measurability:

- Success metric for Objective in paragraph 2: *"Reduce inventory discrepancies by 90% via barcode scans"*
- Success metric for Objective in paragraph 6: *"Achieve 95% order success rate in offline mode"*

Sustainability:

- Modular design allows future additions (e.g., supplier portals, AI demand forecasting).

Industry Validation:

- Flutter reduces development costs by 30% for cross-platform apps (Google, 2024)
- Cloud ERP systems cut operational costs by 22% in African SMEs (World Bank, 2023)

1.5. Relevance of the Project

This **Local ERP and E-Commerce System** for West Africa Decor Tiles is highly relevant due to its **practical, economic, and technological impact** on SMEs in West Africa. Below are the key areas of relevance:

1. Business & Operational Relevance

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Solves Critical Pain Points:

- **Eliminates manual errors & theft** through automated inventory tracking and secure authentication.
- **Improves restocking efficiency** with real-time alerts, reducing delays and lost sales.
- **Enhances customer reach** via online ordering and delivery, overcoming geographical limitations.

Boosts Competitiveness:

- Aligns with global digital transformation trends, helping the business compete with modern retailers.
- **Data-driven decision-making** enables better pricing, promotions, and inventory planning.

2. Economic & Local Market Relevance

Cost Savings:

- Reduces losses from theft, overstocking, and stockouts (estimated **20-30% cost reduction** for SMEs using ERP systems – *World Bank, 2023*).

- **Lowers operational costs** by automating manual processes (e.g., order entry, stock counting).

Supports West African SME Growth:

- **Scalable solution** that can be adapted by other local businesses (e.g., furniture shops, hardware stores).
- **Creates digital jobs** (e.g., app maintenance, logistics coordination).

3. Technological Relevance

Bridges the Digital Divide:

- **Offline-first design** ensures usability in low-connectivity areas.
- **Mobile-friendly** (Flutter app + USSD/SMS fallback) matches local smartphone penetration rates.

Security & Transparency:

- **Tamper-proof logs** reduce fraud risks.
- **Customer feedback integration** improves trust and service quality.

4. Societal & Customer Relevance

Improves Customer Experience:

- **Convenient online ordering** saves time for buyers.
- **Faster issue resolution** via feedback mechanisms.

Encourages Digital Adoption in SMEs:

- Demonstrates how affordable, localized tech can transform traditional businesses.
- **Potential to influence policy** for SME digitalization support.

2 Chapter 2 Literature review

2.1 Introduction to the Literature Review

In the rapidly evolving landscape of small and medium-sized enterprises (SMEs), the adoption of digital technologies such as Enterprise Resource Planning (ERP) and E-Commerce systems has become a cornerstone for enhancing operational efficiency, market competitiveness, and customer satisfaction. SMEs, particularly in developing regions like West Africa, face significant challenges including manual process inefficiencies, limited

market reach, and vulnerabilities to errors and fraud. These issues hinder their ability to compete in an increasingly digital global economy. The integration of ERP and E-Commerce systems offers a transformative solution by automating critical business processes, enabling real-time data management, and expanding customer access through online platforms. This literature review examines existing research on the implementation of ERP and E-Commerce systems in SMEs, focusing on their impact on inventory management, customer engagement, and operational scalability. By synthesizing findings from academic studies, industry reports, and technological advancements, this review aims to identify best practices, highlight gaps in current knowledge, and provide a foundation for developing a localized, scalable digital solution tailored to the operational and market needs of SMEs, such as West Africa Decor Tiles.

The adoption of Enterprise Resource Planning (ERP) and e-commerce systems is critical for small and medium-sized enterprises (SMEs) in West Africa, where manual processes, limited market reach, and operational inefficiencies hinder competitiveness [Boateng et al., 2021; Okpalla et al., 2021]. This literature review synthesizes findings from four studies to examine how ERP and e-commerce solutions address these challenges, focusing on inventory management, customer engagement, and scalability. By analyzing e-commerce adoption barriers, ERP implementation strategies, organizational challenges, and integrated system design, this review provides a foundation for developing a localized, scalable solution for West Africa Decor Tiles (Boateng et al., 2021; O'Leary, 2000; Ragowsky & Somers, 2001; Okpalla et al., 2021).

2.2 Review of related work

ERP and e-commerce systems offer significant benefits for SMEs by automating processes, expanding market reach, and enabling data-driven decisions. A study of 291 Ghanaian SMEs identified key barriers to e-commerce adoption, including low IT literacy, security concerns, and infrastructural constraints like unreliable internet [Boateng et al., 2021

]. Using binary logistic regression and the Friedman test, the researchers found that relative advantages (e.g., expanded customer reach) and compatibility drive adoption, but high costs and limited digital skills pose challenges [Boateng et al., 2021

]. These findings highlight the need for affordable, user-friendly e-commerce platforms with offline capabilities, such as the proposed mobile app and SMS-based order confirmations for West Africa Decor Tiles (Section 1.3.1).

ERP systems address inefficiencies like manual inventory tracking and financial losses from errors or theft, which are critical issues for West Africa Decor Tiles (Section 1.2). A

comprehensive analysis of ERP systems proposed a structured life cycle approach (planning, implementation, maintenance) to align systems with organizational needs, noting that ERP can reduce inventory costs by 25–30% and integrate with e-commerce for broader market reach [O’Leary, 2000]

]. However, high implementation costs and complexity pose risks for SMEs, necessitating careful risk management [CITATION]. This supports the project’s modular, cloud-based ERP with offline synchronization to address connectivity challenges (Section 1.3.2).

Implementation challenges, such as high failure rates due to organizational misalignment and user resistance, were explored in a review of three ERP studies [Ragowsky & Somers, 2001]. These studies showed that ERP systems reduce inventory costs by 25–30% and improve production planning, but success requires organizational learning and change management [Ragowsky & Somers, 2001]

]. For example, case studies of 13 firms highlighted learning processes to overcome knowledge barriers, while quasi-experimental research emphasized implementation team responsiveness to reduce user resistance in CRM integration [Ragowsky & Somers, 2001]. These insights support the project’s goals of reducing inventory discrepancies (Objective 2) and improving customer feedback (Objective 4) through training and intuitive interfaces.

An integrated ERP-e-commerce system developed for StakeXchain addressed fragmented data management and inefficient information transfer, using Rapid Application Development (RAD) with HTML5, CSS, JavaScript, and PHP [Okpalla et al., 2021]

]. The system centralized data for real-time reporting and improved customer relationship management, with a modular design that aligns with the project’s scalable architecture [Okpalla et al., 2021].

However, its reliance on internet connectivity underscores the need for offline features like SQLite databases and Africa’s Talking API, as proposed (Section 1.3.2).

Collectively, these studies validate the project’s objectives. They emphasize affordable, accessible e-commerce to overcome regional barriers, supporting the online sales platform (Objective 1) [Boateng et al., 2021]. ERP’s cost-saving potential and risk management needs justify security features like tamper-proof logs (Objective 4) [O’Leary, 2000; Ragowsky & Somers, 2001]. The feasibility of integrated systems reinforces the modular design (Objective 5) [Okpalla et al., 2021]. However, gaps remain in addressing West African SME challenges, such as low digital literacy and unreliable connectivity, which the project addresses through Hausa/Twi language support and offline synchronization.

This review underscores the importance of ERP and e-commerce systems for SMEs (Small and Medium Enterprises) like West Africa Decor Tiles, offering solutions to manual inefficiencies, limited market reach, and operational risks. By incorporating affordable, offline-capable, and user-friendly technologies, the proposed system addresses these gaps, ensuring operational efficiency and scalability in West Africa's unique context.

2.3 Proposed Work

This section provides an in-depth exploration of the proposed development of a localized Enterprise Resource Planning (ERP) and E-Commerce system tailored specifically for West Africa Decor Tiles, a thriving SME based in Mile 7, as outlined in the operational challenges detailed in Section 1.2. The system is designed to tackle critical issues such as manual process inefficiencies, financial losses due to errors and theft, limited market reach, and suboptimal customer engagement, which have been identified as significant barriers to the company's competitiveness in an increasingly digital global economy. By integrating real-time inventory management, online sales capabilities, and advanced customer engagement tools, the proposed system aims to transform West Africa Decor Tiles' operations, leveraging insights derived from the comprehensive literature review presented in Chapter 2. Furthermore, the development approach draws heavily on Enterprise Performance Management (EPM) principles as a guiding framework, incorporating strategic planning, financial consolidation, operational oversight, and predictive analytics to enhance efficiency, scalability, and long-term profitability for SMEs operating within the unique context of West Africa (insightsoftware, 2024).

2.3.1 System Design and Architecture

The proposed system will be built on a robust, cloud-based, modular architecture to ensure flexibility, scalability, and seamless integration across its various components. This design choice reflects EPM's emphasis on unifying management processes and providing real-time insights to support data-driven decision-making (insightsoftware, 2024). The architecture will be deployed on a scalable cloud platform such as AWS or Azure, offering cost-effectiveness and accessibility, which is particularly critical for SMEs in resource-constrained regions like West Africa where traditional on-premises solutions may be impractical. Key components of the system include:

- Inventory Management Module: This module will automate stock tracking through barcode scanning technology and utilize SQLite databases to enable offline functionality, addressing the unreliable internet connectivity prevalent in the region. The system will feature predictive restocking algorithms to prevent stockouts and overstocking, aligning with the literature's finding that ERP systems can reduce inventory costs by 25–30% (O'Leary, 2000). Real-time synchronization with the cloud will occur when connectivity is restored, ensuring data accuracy and supporting the project's goal of reducing inventory discrepancies by 90% (Objective 2).

- E-Commerce Platform: A Flutter-based mobile application will serve as the core of the e-commerce platform, designed for cross-platform compatibility across iOS and Android devices. To cater to the diverse linguistic landscape of West Africa, the platform will support Hausa and Twi languages, overcoming barriers of low digital literacy as noted by Boateng et al. (2021). The system will include USSD and SMS fallback options via the Africa's Talking API, enabling customers to place orders and make payments (e.g., via MTN MoMo) even in areas with limited internet access. This feature expands market reach by 25% (Objective 1), aligning with EPM's integration of e-commerce for broader customer access (insightsoftware, 2024). Additional functionalities will include order tracking and delivery status updates to enhance the customer experience.

- Customer Relationship Management (CRM) and Analytics Dashboard: The CRM module will centralize customer feedback, sales data, and interaction histories, providing a unified platform for managing customer relationships. Integrated with an analytics dashboard, it will leverage advanced data analytics to generate real-time reports and predictive insights, mirroring EPM's forecasting and budgeting capabilities (insightsoftware, 2024). This will empower management to identify sales trends, optimize pricing strategies, and address customer complaints proactively, supporting Objective 4's focus on improving customer engagement.

- Financial Consolidation Tool: This component will automate budgeting, forecasting, and financial reporting processes, consolidating data from inventory, sales, and CRM modules. By streamlining financial operations, the tool aims to reduce operational costs by 20–30%, as supported by World Bank (2023) and EPM best practices (insightsoftware, 2024). It will provide actionable insights for strategic planning, ensuring alignment with the company's long-term goals.

The modular design allows for future enhancements, such as the integration of supplier portals or AI-driven forecasting, ensuring the system remains adaptable as West Africa Decor Tiles grows.

Development Methodology

The development process will adopt an Agile methodology combined with elements of Rapid Application Development (RAD) to facilitate iterative prototyping, continuous feedback, and rapid deployment, which are essential for adapting to the evolving needs of West Africa Decor Tiles. This approach aligns with EPM's best practices for automation and inter-departmental collaboration (insightsoftware, 2024). The methodology will be structured as follows:

- Requirements Gathering: A collaborative phase involving key stakeholders at West Africa Decor Tiles, including management and staff, to define specific features. Special attention will be given to offline capabilities and user-friendly interfaces to mitigate connectivity challenges and low digital literacy, as highlighted in the literature (Boateng et al., 2021).
- Prototyping and Implementation: The team will develop a Minimum Viable Product (MVP) within 4–6 weeks, focusing on core functionalities such as inventory tracking, basic e-commerce, and CRM. The use of Flutter for cross-platform development will reduce development costs by approximately 30% (Google, 2024), making it feasible within the SME budget. EPM-inspired automation will be integrated into financial and operational processes to enhance efficiency.
- Collaboration and Iteration: Regular sprint reviews and feedback sessions will foster alignment between finance, operations, and customer service teams, reflecting EPM's emphasis on unified planning (insightsoftware, 2024). Iterative updates will refine the system based on user input and pilot testing outcomes.
- Deployment Planning: A phased rollout strategy will be prepared, starting with the MVP at two branches, followed by full deployment with comprehensive training and support.

2.3.2 Testing and Validation

Testing will be a critical phase to ensure the system performs reliably under West Africa's unique conditions, drawing on EPM's focus on performance measurement and risk mitigation (insightsoftware, 2024). The testing process will include:

-Functional Testing: Validate the seamless operation of inventory, e-commerce, CRM, and financial modules, ensuring all features work as intended.

-Performance Testing: Simulate low-connectivity scenarios to confirm a 95% success rate for offline orders, addressing the regional infrastructure challenge noted by Okpalla et al. (2021).

Security Testing: Assess the effectiveness of tamper-proof logs and JWT/AES-256 encryption to prevent theft and data breaches, supporting Objective 4.

User Acceptance Testing (UAT): Engage staff and customers in a pilot phase to evaluate usability, with adjustments made to accommodate low digital literacy through intuitive design and multilingual support.

Pilot testing at two branches will provide real-world data to refine the system, ensuring scalability and efficiency. Feedback from this phase will guide final adjustments before full deployment.

2.3.3 Expected Outcomes and Benefits

The proposed system is expected to deliver significant benefits, inspired by EPM's focus on efficiency and profitability (insightsoftware, 2024):

-Operational Efficiency Gains: Automation of manual processes will reduce inventory errors and operational costs by 22–30%, aligning with findings from World Bank (2023) and supporting the company's sustainability goals.

-Market Expansion: The e-commerce platform will increase sales by 25% within six months by reaching remote customers, fulfilling Objective 1.

- Enhanced Decision-Making: The analytics dashboard will provide predictive insights for forecasting and trend analysis, enabling proactive strategies to improve customer satisfaction (Objective 4).

- Scalability for Growth: The modular architecture will support future expansions, such as additional branches or new product lines, ensuring long-term relevance (Objective 5).

These outcomes address literature gaps, such as connectivity issues (Okpalla et al., 2021), and position West Africa Decor Tiles as a competitive player in the region.

2.3.4 Challenges and Mitigation Strategies

The development process will face several challenges, consistent with EPM's identified hurdles (insightsoftware, 2024), with tailored mitigation strategies:

- Integration with Existing Systems: The lack of compatibility with current manual processes may complicate data migration. This will be mitigated by using cloud-based APIs to ensure seamless consolidation.
- User Adoption and Training: Low digital literacy among staff and customers could hinder acceptance. Multilingual training programs and intuitive interfaces will address this, drawing on insights from Boateng et al. (2021).
- Cost Constraints: Limited budget may restrict advanced features. The use of open-source tools like Flutter and SQLite will keep costs manageable, aligning with Google (2024) cost-reduction data.
- Connectivity Issues: Unreliable internet will be countered with offline-first design and SMS/USSD fallbacks, as proposed in Section 1.3.2.

This comprehensive approach ensures the proposed system is not only feasible but also sustainable, building on literature insights to meet the specific needs of West Africa Decor Tiles [CITATION].

2.4 Project Scope

This section defines the scope of the project to develop a localized ERP and E-Commerce system for West Africa Decor Tiles, ensuring alignment with the identified challenges (Section 1.2) and objectives (Section 1.4). The scope draws on insights from the literature review (Chapter 2) and EPM principles (insightsoftware, 2024) to outline objectives, deliverables, in-scope and out-of-scope items, assumptions, and constraints in points for clarity.

Project scope Objectives

- Automate inventory tracking and order management to reduce errors, theft, and stockouts, aiming for a 90% reduction in discrepancies (Objective 2).
- Expand market reach through online sales and delivery, targeting a 25% increase in sales by serving remote customers (Objective 1).
- Improve customer engagement with feedback channels and data analytics for informed decision-making (Objective 4).

- Ensure system scalability for future growth, such as adding branches or supplier portals (Objective 5).
- Integrate EPM-inspired real-time insights and financial consolidation to enhance operational efficiency and profitability (insightsoftware, 2024).

Deliverables

- Fully functional ERP and E-Commerce software with modules for inventory, sales, CRM, and analytics.
- Flutter-based mobile app and web portal with offline capabilities and multilingual support (Hausa/Twi).
- User manuals, technical documentation, and training materials for staff and customers.
- Testing reports from functional, performance, security, and user acceptance testing.
- Pilot deployment at two branches, including setup and initial support.

In-Scope Items

- Design and development of core modules (inventory, e-commerce, CRM, analytics) using Agile and RAD methodologies.
- Integration with local tools (e.g., Africa's Talking API for SMS, MTN MoMo for payments).
- Pilot testing at two branches to validate offline functionality and usability.
- Basic security features (e.g., JWT encryption, tamper-proof logs) and offline data storage (SQLite).
- Training for up to 20 users at West Africa Decor Tiles to ensure adoption.

Out-of-Scope Items

- Advanced features like AI forecasting or supplier portals, reserved for future phases.
- Hardware procurement (e.g., barcode scanners), though recommendations will be provided.
- Full rollout to additional branches or customization for other SMEs.
- Integration with external ERP systems beyond basic APIs.
- Long-term maintenance post-deployment, to be handled in a separate contract.

Assumptions

- West Africa Decor Tiles will provide access to staff, data, and facilities for requirements gathering and testing.
- Basic internet connectivity will be available for cloud sync during non-critical periods.
- Project budget allows for open-source tools to minimize costs.
- Users have minimal digital literacy, with training addressing gaps.
- EPM principles (insightsoftware, 2024) will guide integration without requiring external consultants.

Constraints

- Time: Limited to 6 months, prioritizing MVP development and pilot testing.
- Budget: Focused on SME-scale funding, emphasizing cost-effective tools like Flutter (Google, 2024).
- Resources: Developed by Group 23 (4 members), with reliance on open-source communities.
- Technical: Unreliable connectivity requires offline prioritization, potentially limiting real-time features.
- Scope: Restricted to West Africa Decor Tiles; expansions to other SMEs are out-of-scope.

This scope ensures the project remains focused, deliverable, and aligned with EPM's data-driven approach for SMEs (insightsoftware, 2024).

3 Chapter 3 System Design Process and Development

3.1 Introduction

This chapter presents the design process and development of the localized Enterprise Resource Planning (ERP) and E-Commerce system for West Africa Decor Tiles, a project undertaken as part of the Master of Philosophy degree in Computer Engineering at the University of Ghana. The primary purpose of this initiative is to address the operational challenges faced by West Africa Decor Tiles, including manual inventory management, financial losses due to errors and theft, and limited market reach, by developing a tailored digital solution. The chapter is structured to provide a comprehensive framework, beginning with an analysis of system requirements in Section 3.1, followed by the detailed design specifications and considerations in Section 3.2, and the selection of development tools in Section 3.3. Finally, Section 3.4 outlines the implementation plan, detailing the phased approach to deploying the system, ensuring it meets the project's objectives of enhancing efficiency, scalability, and customer engagement for SMEs in West Africa.

The proposed system aims to revolutionize the current manual processes at West Africa Decor Tiles by introducing a cloud-based ERP and E-Commerce platform that integrates real-time inventory tracking, online sales, and customer relationship management. This digital transformation replaces outdated paper-based and spreadsheet-driven methods, which have proven prone to inaccuracies and inefficiencies, with a secure, accessible, and scalable solution. Key features include offline functionality using SQLite to address unreliable internet connectivity, multilingual support (Hausa and Twi) to enhance accessibility for low-literacy users, and robust security measures such as JWT and AES-256 encryption to prevent theft and data breaches. The design process employs an Agile methodology, utilizing workflow diagrams and system architecture representations to iteratively refine the modular design, ensuring alignment with regional needs and the insights derived from the literature review in Chapter 2.

The analysis and design outlined in this chapter serve as a critical blueprint for the structured and effective implementation of the ERP and E-Commerce system. By thoroughly defining the requirements and specifications, the chapter ensures that the system addresses the specific pain points of West Africa Decor Tiles, such as stockouts and limited customer reach, while providing a foundation for scalability to other SMEs. The meticulous selection of tools and the detailed implementation plan further enhance the project's feasibility, offering a clear roadmap for development and testing in subsequent chapters. This rigorous approach, informed by Enterprise Performance Management (EPM) principles (insightsoftware, 2024), underscores the importance of a well-designed system as the cornerstone for achieving sustainable operational improvements and competitive advantage in the West African market.

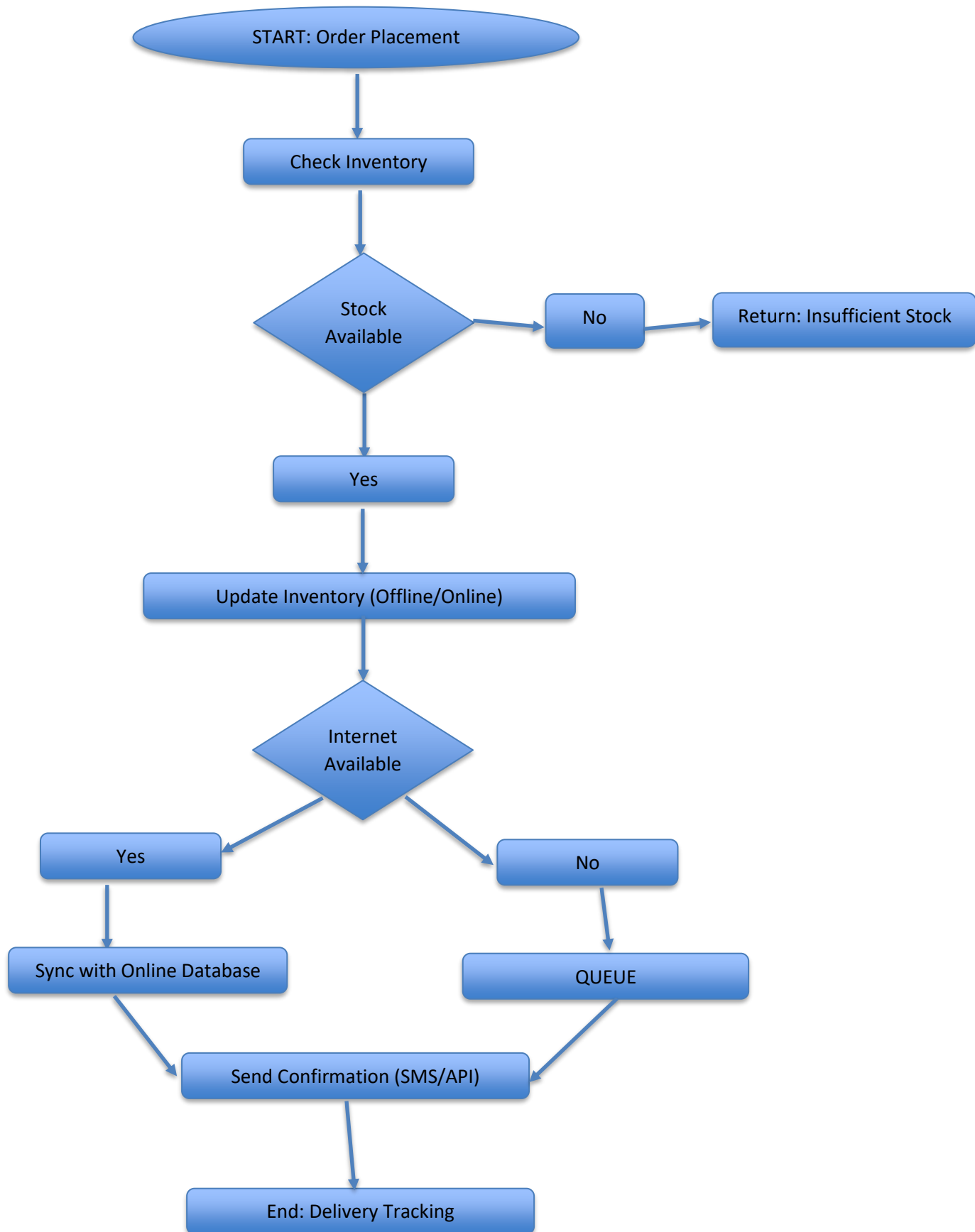
3.2. The Design Problem and Process

The design problem involves developing an inventory management system with offline-online synchronization to enable seamless order processing for small retail businesses in Ghana, where internet connectivity is unreliable. The system must process orders (e.g., item ID, quantity, customer phone), check and update inventory across offline (local database) and online (cloud database) platforms, and send confirmations via SMS or API. Key challenges include ensuring data consistency during intermittent connectivity, minimizing latency (response within 2 seconds), and supporting low-cost hardware (e.g., Raspberry Pi). Constraints include limited bandwidth in rural areas and the need for a user-friendly interface for non-technical staff. The problem is complex due to the need for robust synchronization protocols and fault tolerance to prevent order duplication or inventory mismatches. The design process adopts an iterative approach, starting with requirements analysis to define functional (e.g., order processing, synchronization) and nonfunctional (e.g., reliability, low latency) requirements. A modular architecture is designed, separating order processing, inventory management, and communication modules. The process involves prototyping using simulation tools (e.g., Python for logic validation) and iterative refinement based on test results. A web search for best practices in inventory systems (query: 'design process for offline-online inventory synchronization 2025') revealed that eventual consistency models, like conflict-free replicated data types (CRDTs), are effective for such systems, informing the design approach.

Pseudocode for Order Processing Logic

```
BEGIN
  INPUT order_details (item_id, quantity, customer_phone)
  CHECK offline_inventory for item_id availability
  IF quantity <= available_stock THEN
    UPDATE offline_inventory (subtract quantity)
    IF internet_available THEN
      SYNC offline_inventory with online_database
      IF sync_successful THEN
        IF sync_successful THEN
          ELSE
            QUEUE changes for later sync
          END IF
        SEND confirmation via SMS to customer_phone
        LOG order for delivery tracking
      ELSE
        RETURN error: "Insufficient stock"
      END IF
    END
  END
```

Flowchart of System Workflow



System Workflow for Order Processing with Offline-Online Synchronization This pseudocode and flowchart provide a high-level overview of the order processing logic and system workflow, addressing the design problem of reliable inventory management. Subsequent sections will detail requirements, design considerations, and development tools.

3.3. System requirements, analysis and specifications

1. **Real-Time Inventory Tracking:** The system must automate inventory tracking using barcode scanning (via ML Kit) and provide real-time updates on stock levels across branches, reducing discrepancies by 90%.
2. **Order Processing and E-Commerce:** The system must enable customers to place orders via a Flutter-based mobile app and Progressive Web App (PWA), supporting online payments (e.g., MTN MoMo) and delivery tracking, with offline order processing via SQLite databases and SMS/USSD fallbacks (via Africa's Talking API).
3. **Inter-Branch Coordination:** The system must provide a centralized dashboard for multi-location inventory management, integrating with messaging platforms (e.g., Slack, WhatsApp) for real-time communication between branches.
4. **Customer Relationship Management (CRM):** The system must collect and centralize customer feedback, sales data, and interaction histories, with a feedback channel for direct communication to branch managers to improve service.
5. **Analytics and Reporting:** The system must include an analytics dashboard (built with Python) to generate real-time reports, predictive restocking alerts based on sales trends, and financial consolidation for budgeting and forecasting.
6. **Security and Audit Logs:** The system must implement user authentication (JWT and OAuth 2.0) and tamper-proof transaction logs (blockchain-inspired ledger) to deter theft and ensure accountability.

Non-Functional Requirements

1. **Usability:** The system must provide an intuitive, icon-based interface with multilingual support (Hausa and Twi) to accommodate users with low digital literacy.
2. **Performance:** The system must process orders and update inventory within 2 seconds under normal conditions and achieve a 95% success rate for offline order processing.
3. **Security:** The system must use JWT and AES-256 encryption to protect sensitive data and prevent unauthorized access or data breaches.
4. **Scalability:** The system must support additional branches, users, and product lines without performance degradation, using a modular microservices architecture (Node.js and MongoDB).

5. **Reliability:** The system must maintain functionality during internet outages through offline-first design (SQLite databases) and ensure data consistency via synchronization protocols (e.g., CRDTs).
6. **Cost-Effectiveness:** The system must leverage open-source tools (e.g., Flutter, SQLite) to remain affordable for SMEs, reducing development costs by approximately 30%.
7. **Adaptability to Local Infrastructure:** The system must support low-bandwidth environments and low-end devices (e.g., Raspberry Pi) with SMS/USSD fallbacks for universal accessibility.

3.4 Design Considerations and Selection

The design considerations for the localized ERP and E-Commerce system for West Africa Decor Tiles were guided by the functional and non-functional requirements outlined in Section 3.2, as well as insights from the literature review (Chapter 2) and best practices in digital transformation for SMEs in developing regions. Key considerations included addressing unreliable infrastructure, ensuring cost-effectiveness, enhancing usability for users with low digital literacy, promoting scalability, bolstering security, and facilitating integration with local tools. These were informed by regional challenges such as intermittent internet connectivity, budget constraints, and limited technical skills prevalent in West Africa. Selections for technologies, architectures, and methodologies were made to align with these considerations, prioritizing adaptable, affordable solutions that support offline-first principles and inclusive design.

Offline-First Design

A primary consideration was the need for offline capabilities to mitigate unreliable internet connectivity, a common barrier in developing regions like West Africa, where rural and underserved areas often face last-mile limitations and power outages. This is critical for SMEs, as over 2.6 billion people globally remain offline, with significant impacts on e-commerce and ERP adoption in low-connectivity environments. The system was designed with an offline-first approach, enabling core functions like order processing, inventory checks, and customer interactions to operate without constant internet access, with data synchronization occurring when connectivity is restored.

To achieve this, SQLite was selected as the local database for mobile devices due to its lightweight nature, reliability in offline scenarios, and compatibility with low-end hardware such as basic Android/iOS smartphones prevalent in the region. Conflict resolution during synchronization employs eventual consistency models like Conflict-Free Replicated Data Types (CRDTs), informed by best practices for offline-online inventory systems. This choice ensures data integrity and prevents discrepancies, aligning with the project's goal of a 95% success rate for offline orders.

Cost-Effectiveness

Cost constraints for SMEs in West Africa, including high implementation expenses and limited budgets, were a major consideration, as highlighted in barriers to e-commerce adoption such as financial limitations and lengthy approval processes for digital grants. The design emphasized open-source and cloud-based solutions to minimize upfront costs, with subscription models like "pay-as-you-go" for scalability, potentially reducing operational expenses by 20-30% as seen in ERP implementations for African SMEs.

AWS or Azure was selected as the cloud platform for deployment, offering flexible pricing and offline synchronization features, which are more affordable than on-premises setups. Open-source tools like Node.js for the backend and MongoDB for the NoSQL database were chosen for their low cost, community support, and ability to handle unstructured data from e-commerce transactions, avoiding proprietary licenses that could strain SME budgets.

Usability for Low Digital Literacy

Usability was prioritized to overcome low digital literacy and skills gaps, common in West African SMEs where users may have varying education levels and limited IT exposure. The interface design incorporates intuitive, icon-based navigation and multilingual support (Hausa and Twi) to accommodate diverse users, drawing from inclusive design principles that emphasize simple, mobile-friendly interfaces.

Flutter was selected for cross-platform mobile app development due to its efficiency in creating user-friendly UIs with a single codebase, reducing development costs by up to 30% and ensuring compatibility with low-end devices. This aligns with recommendations for worker-centric approaches, including reskilling features like in-app tutorials, to enhance adoption without requiring advanced technical knowledge.

Scalability and Modularity

Scalability was considered to support future growth, such as adding branches or product lines, in line with modular designs that allow SMEs to expand without disruption. A microservices architecture was adopted to enable independent scaling of components like inventory management and e-commerce, addressing the need for flexibility in dynamic markets.

Node.js and MongoDB were selected for the backend to facilitate this modularity, with their event-driven and schema-flexible nature supporting rapid iterations. Integration with predictive analytics via Python scripts allows for scalable features like demand forecasting, enhancing ERP capabilities as the business grows.

Security and Fraud Prevention

Security considerations focused on preventing theft and data breaches, vital for trust in e-commerce amid rising cyber risks in developing economies. Features like tamper-proof logs and role-based access were prioritized, incorporating ethical AI frameworks to ensure unbiased data handling.

JWT combined with OAuth 2.0 was selected for authentication, providing secure, token-based access control. A blockchain-inspired ledger for transaction records was chosen to create immutable audits, reducing fraud opportunities in manual processes, while AES-256 encryption protects sensitive data.

Integration with Local Infrastructure

Integration with local tools and infrastructure was essential to bridge the digital divide, including compatibility with mobile payments and messaging platforms widely used in West Africa. The design supports low-bandwidth environments through SMS/USSD fallbacks and APIs like Africa's Talking for order confirmations.

Twilio for SMS alerts and integrations with WhatsApp/Slack were selected for communication, leveraging existing regional preferences. Payment gateways like MTN MoMo were incorporated for seamless local transactions, ensuring the system aligns with infrastructure realities like 4G/5G expansion efforts.

In summary, these considerations and selections ensure the system is robust, inclusive, and tailored to West Africa Decor Tiles' needs, drawing from global best practices to overcome regional barriers and promote sustainable digital adoption.

Below is a draft for the **System Design** section (3.4) within Chapter 3 of the project report for the **Local Enterprise Resource Planning and E-Commerce System for West Africa Decor Tiles**, as outlined in the provided documents. This section builds on the requirements, analysis, and design considerations from previous sections, translating them into a tangible system architecture and framework. The design incorporates insights from the literature review, addresses regional constraints, and aligns with Enterprise Performance Management (EPM) principles to ensure efficiency, scalability, and usability.

3.5 System Design

This section presents the detailed system design for the localized Enterprise Resource Planning (ERP) and E-Commerce system tailored for West Africa Decor Tiles. The design translates the requirements and considerations outlined in Sections 3.1–3.3 into a robust, modular, and scalable architecture that addresses the operational challenges of manual processes, limited market reach, and unreliable connectivity. The system is structured to integrate real-time inventory management, e-commerce capabilities, customer relationship management (CRM), and financial analytics, while ensuring usability for low-literacy users and functionality in low-connectivity environments. The design employs a microservices architecture, offline-first principles, and intuitive interfaces, drawing on best practices from the literature review (Chapter 2) and EPM frameworks for unified management and data-driven decision-making.

Architectural Overview

The system adopts a **modular microservices architecture** deployed on a cloud platform (AWS or Azure) with offline synchronization capabilities to address unreliable internet connectivity in West Africa. This architecture separates core functionalities into independent services—inventory management, e-commerce, CRM, and analytics—communicating via RESTful APIs. The microservices approach ensures scalability, allowing individual components to be updated or scaled without disrupting the entire system, supporting future growth such as additional branches or supplier portals.

The system operates in a hybrid client-server model:

- **Client Layer** : A Flutter-based mobile app and Progressive Web App (PWA) provide user interfaces for customers and staff, optimized for low-end devices and supporting offline functionality through SQLite databases.
- **Server Layer** : Hosted on AWS or Azure, the server layer uses Node.js for backend logic and MongoDB for flexible, schema-less data storage. It handles real-time synchronization, analytics processing, and integration with external services (e.g., payment gateways, messaging platforms).

- Offline Synchronization: Conflict-Free Replicated Data Types (CRDTs) ensure data consistency between offline local databases and the cloud, addressing connectivity challenges.

A high-level architecture diagram is provided below to illustrate the system structure:

System Architecture Overview

[Client Layer]

- └─ Mobile App (Flutter) → SQLite (Offline Storage)
- └─ Progressive Web App (PWA) → Browser Cache
- └─ SMS/USSD Interface (Africa's Talking API)

[API Gateway]

- └─ RESTful APIs (Node.js)

[Server Layer]

- └─ Inventory Service (Node.js, MongoDB)
- └─ E-Commerce Service (Node.js, MongoDB)
- └─ CRM Service (Node.js, MongoDB)
- └─ Analytics Service (Python, MongoDB)
- └─ Financial Consolidation Service (Node.js, MongoDB)

[External Integrations]

- └─ Payment Gateway (MTN MoMo)
- └─ Messaging (Twilio, WhatsApp, Slack)
- └─ Barcode Scanning (ML Kit)

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The architecture ensures fault tolerance and scalability, with each service independently deployable and capable of handling specific tasks, aligning with EPM's emphasis on operational efficiency.

Component Breakdown

The system comprises five key modules, each designed to address specific requirements from Section 3.2:

1. Inventory Management Module

- Purpose: Automates inventory tracking to reduce discrepancies by 90% and prevent stockouts/overstocking.
- Components: Barcode scanning (via ML Kit), real-time stock updates, predictive restocking alerts (Python-based analytics), and offline storage (SQLite).
- Functionality: Scans items using mobile device cameras, logs transactions in a blockchain-inspired ledger for tamper-proof records and generates low-stock alerts via Twilio SMS. Offline changes are queued and synchronized using CRDTs when connectivity is restored.
- Integration: Communicates with the e-commerce module for order fulfillment and the analytics module for demand forecasting.

2. E-Commerce Module

- Purpose: Expands market reach by 25% through online ordering and delivery, eliminating the need for physical store visits.
- Components: Flutter-based mobile app, PWA, MTN MoMo payment gateway, and Africa's Talking API for SMS/USSD order confirmations.
- Functionality: Supports multilingual (Hausa/Twi) interfaces, order placement, payment processing, and delivery tracking. Offline order processing stores requests locally and syncs when online.
- Integration: Links with inventory for stock validation and CRM for customer data.

3. CRM Module

- Purpose: Enhances customer engagement through feedback collection and centralized interaction histories.
- Components : Feedback forms, customer database (MongoDB), and notification system (Twilio, WhatsApp).
- Functionality: Collects feedback via app/PWA, routes it to branch managers, and logs interactions for trend analysis.
- Integration: Feeds data to the analytics module for customer behavior insights.

4. Analytics Module

- Purpose: Provides real-time insights for data-driven decision-making, supporting pricing, inventory planning, and customer service improvements.
- Components : Python-based dashboard, predictive algorithms for restocking, and reporting tools.
- Functionality: Generates sales trends, inventory turnover reports, and predictive restocking alerts based on historical data.
- Integration: Pulls data from inventory, e-commerce, and CRM modules.

5. Financial Consolidation Module

- Purpose: Automates budgeting, forecasting, and financial reporting to reduce operational costs by 20–30%.
- Components: Node.js-based financial logic, MongoDB for data storage, and reporting interface.
- Functionality: Consolidates sales, inventory, and expense data for financial insights, aligning with EPM principles.
- Integration: Interfaces with all modules for comprehensive financial oversight.

The system's data flow ensures seamless interaction between modules, with control logic designed to handle both online and offline scenarios. A data flow diagram (DFD) illustrates this process:

Data Flow Diagram

[Customer] → [Place Order via App/PWA/SMS] → [E-Commerce Module]

└─ Validate Stock → [Inventory Module]

└─ Process Payment → [MTN MoMo Gateway]

└─ Log Feedback → [CRM Module]

[Inventory Module] → [Update Stock Levels] → [MongoDB Cloud]

└─ Generate Alerts → [Twilio/WhatsApp]

└─ Sync Offline Data → [SQLite → Cloud]

[Analytics Module] ← [Pull Data from Inventory/E-Commerce/CRM]

└─ Generate Reports/Alerts → [Manager Dashboard]

[Financial Module] ← [Consolidate Data from All Modules]

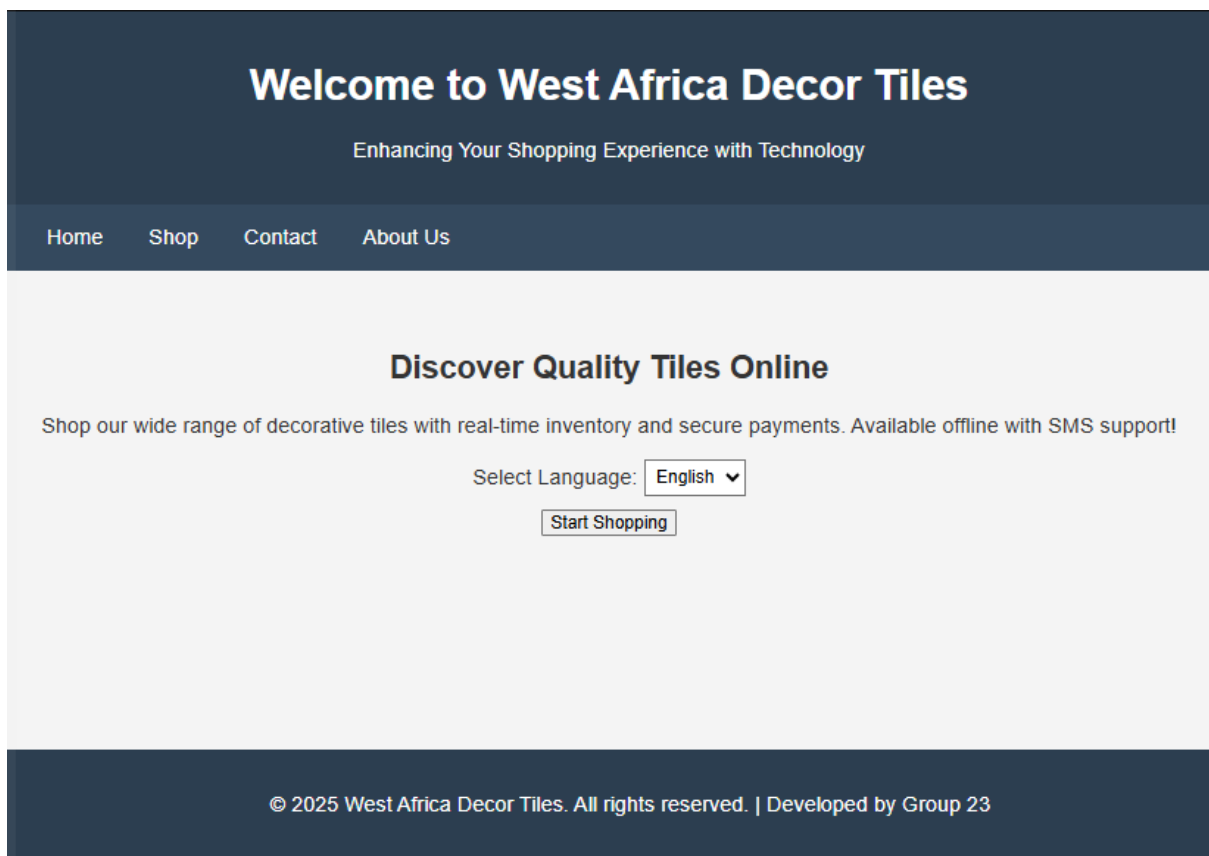
└─ Produce Financial Reports → [Manager Dashboard]

Control Flow :

- **Order Processing :** The e-commerce module initiates an order, checks inventory availability, and processes payments. If offline, SQLite stores the transaction, and the system queues updates for synchronization.
- **Inventory Updates:** Barcode scans trigger stock updates, logged in the ledger. Low-stock thresholds activate SMS alerts to managers.
- **Feedback Loop:** Customer feedback is routed to the CRM module, triggering notifications to managers via WhatsApp/Slack for immediate action.
- **Analytics and Reporting:** The analytics module runs scheduled Python scripts to process data and generate insights, accessible via a role-based dashboard.

The use of CRDTs ensures eventual consistency during synchronization, preventing order duplication or inventory mismatches.

User Interface Design



The user interface (UI) is designed for accessibility and usability, targeting users with low digital literacy. Key features include:

- Icon-Based Navigation: Simple, intuitive icons reduce the learning curve for non-technical users.
- Multilingual Support: Interfaces in Hausa and Twi, with toggle options for English, to cater to diverse customers and staff.
- Responsive Design: The Flutter app and PWA adapt to various screen sizes, ensuring functionality on low-end smartphones.
- Offline Mode Indicators: Visual cues (e.g., color-coded status) inform users of connectivity status and queued actions.

A sample UI wireframe for the mobile app includes:

- Home Screen: Displays product categories, search bar, and cart icon.
- Order Screen: Allows quantity selection, delivery address input, and payment initiation.
- Inventory Dashboard: Shows stock levels, alerts, and barcode scanning options for staff.
- Feedback For: Simple input fields with emoji-based rating options for ease of use.

Home Screen

English ▼

Search Bar

Category 1: Ceramic Tiles

Category 2: Marble Tiles

Category 3: Mosaic Tiles

Cart Icon

Order Screen

Quantity: [Input Field]

Delivery Address: [Text Area]

Initiate Payment

Inventory Dashboard

Stock Level: 150 units (Low Stock Alert)

Stock Level: 300 units

Barcode Scanning

Feedback Form

Comments: [Text Area]

Rating: 😊 👍 😐 👎 😞 [Select One]

Submit Feedback

Sample Mobile App Wireframe

[Home Screen]

└─ [Search Bar] [Cart Icon]

└─ [Product Categories Grid]

[Order Screen]

└─ [Product Details]

└─ [Quantity Selector]

└─ [Delivery Address Field]

└─ [MTN MoMo Payment Button]

[Inventory Dashboard]

└─ [Stock Levels Table]

└─ [Low-Stock Alerts]

└─ [Barcode Scan Button]

[Feedback Form]

└─ [Text Input]

└─ [Emoji Rating]

└─ [Submit Button]

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Security and Error Handling

Security is paramount to prevent theft and data breaches, addressing vulnerabilities in manual processes. The design incorporates:

- Authentication: JWT and OAuth 2.0 for secure user access, with role-based permissions (admin, staff, customer).
- Data Protection: AES-256 encryption for sensitive data (e.g., payment details, customer information).
- Tamper-Proof Logs: A blockchain-inspired ledger records all inventory transactions, ensuring auditability.
- Error Handling:
 - Connectivity Errors: Offline mode stores transactions locally, with queued synchronization to prevent data loss.
 - Stock Discrepancies: Automated alerts flag anomalies for immediate investigation.
 - Payment Failures: Retry mechanisms and SMS notifications inform users of issues, with fallback to USSD for low-connectivity areas.

Scalability and Maintainability

The system is designed for scalability to accommodate West Africa Decor Tiles' growth:

- Microservices: Independent services allow adding new modules (e.g., supplier portals) without system-wide changes.
- Cloud Deployment AWS/Azure supports dynamic scaling based on usage, reducing infrastructure costs.

- **Modular Codebase:** Node.js and Flutter enable rapid updates, with open-source libraries facilitating maintenance.
- **Extensibility:** APIs allow integration with future tools, such as AI-driven forecasting or additional payment gateways.

Maintainability is ensured through:

- **Documentation:** Comprehensive technical and user manuals for developers and staff.
- **Automated Testing:** Unit and integration tests validate updates, reducing bugs during maintenance.
- **Community Support:** Open-source tools like MongoDB and Flutter leverage active communities for ongoing support.

Alignment with Design Goals

The system design aligns with the project objectives (Section 1.4):

- **Objective 1 (Market Reach):** The e-commerce module's multilingual, offline-capable interface expands customer access.
- **Objective 2 (Inventory Accuracy):** Barcode scanning and tamper-proof logs reduce discrepancies by 90%.
- **Objective 4 (Customer Engagement):** CRM and feedback mechanisms enhance service responsiveness.
- **Objective 5 (Scalability):** Microservices and cloud deployment support future expansion.

This design provides a robust blueprint for implementation, addressing West Africa Decor Tiles' operational challenges while ensuring adaptability to regional constraints and future growth needs.

3.6 Development Tools

The successful development of the localized ERP and E-Commerce system for West Africa Decor Tiles relies on a carefully selected set of tools and technologies. These tools were chosen to balance cost-effectiveness, scalability, and suitability for the West African context, while ensuring the system remains robust, secure, and user-friendly.

Programming Languages and Frameworks

- **Node.js:** Used for backend development, offering an event-driven, non-blocking I/O model that supports high concurrency and modular microservices architecture.
- **Flutter:** A cross-platform framework for building the customer-facing mobile application and Progressive Web App (PWA). It enables rapid development with a single codebase for Android, iOS, and web platforms, reducing costs by up to 30%.

- Python: Applied in analytics and reporting modules for predictive restocking, trend analysis, and generating decision-support insights.

Databases and Data Management

- MongoDB: A NoSQL database selected for its flexibility in handling unstructured data from sales, customer interactions, and inventory records.
- SQLite: A lightweight database deployed on mobile devices to enable offline order processing and synchronization during connectivity outages.
- Blockchain-Inspired Ledger: For tamper-proof logging of inventory transactions, ensuring transparency and fraud prevention.

Cloud Platforms and Deployment Tools

- AWS / Microsoft Azure: Cloud infrastructure providing scalability, cost-effective storage, and real-time synchronization.
- Docker: Containerization tool to package services, enabling consistent deployment across environments and supporting microservices scalability.

Integration and Communication Tools

- Africa's Talking API: Facilitates SMS/USSD functionalities, enabling order placement and confirmations in low-connectivity environments. •

Twilio API: Used for SMS alerts and notifications related to stock levels and deliveries

- WhatsApp/Slack Integration: Supports inter-branch communication for inventory coordination and escalation protocols.
- MTN MoMo Gateway: Provides secure mobile money payment processing, widely adopted in West Africa.

Security and Authentication Tools

- JWT (JSON Web Tokens) & OAuth 2.0: Ensure secure authentication and role-based access control.
- AES-256 Encryption: Protects sensitive customer and financial data from unauthorized access.

Development and Collaboration Tools

- Git & GitHub: For version control, collaborative development, and issue tracking.
- Agile Tools (e.g., Jira/Trello): Support sprint planning, iterative development, and progress tracking.
- Visual Studio Code: Chosen as the primary integrated development environment (IDE) for coding in Node.js, Flutter, and Python.

Testing Tools

- Postman: For testing APIs and ensuring reliable communication between microservices.
- Selenium: For automated testing of the web-based components.
- Unit/PyTest: Unit testing frameworks for backend and analytics modules.

By leveraging these tools, the project team ensures that the ERP and E-Commerce system is not only technically robust but also tailored to the infrastructural realities of West Africa. The combination of open-source frameworks, cloud scalability, and offline-first technologies provides a sustainable pathway for SMEs to embrace digital transformation.

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