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Tethys: An Intelligent Inventory Management System for Manufacturing Industries

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***Abstract*—This paper presents "Tethys," an intelligent inventory management platform designed for manufacturing industries, specifically water bottle and soft drink production units. The system aims to enhance operational efficiency, reduce waste, and improve transparency through a role-based access system, real-time material tracking, and automated reporting features. Built with a strong focus on scalability and security, Tethys provides distinct modules for Owners, Stock Managers, Production Managers, and Gate Managers. The study highlights the platform's ability to reduce material misuse, ensure transaction accountability, and support strategic planning through comprehensive analytics. Pilot tests confirm that Tethys significantly improves inventory flow and operational transparency, supporting modern manufacturing demands.**

***Index Terms*—Inventory Management, Manufacturing, Role-Based Access, Real-Time Tracking, Automation, Efficiency, Waste Reduction, Tethys**

I. INTRODUCTION

Efficient inventory tracking plays a critical role in enhancing productivity, minimizing material wastage, and ensuring transparency within manufacturing units. With traditional systems often failing to provide traceability and role-specific accountability, modern factories require smart, scalable solutions that can adapt to evolving operational needs.

"Tethys" is introduced as an intelligent inventory management platform tailored for the water bottle and soft drink manufacturing industry. By integrating digital tracking, role-based access, and automated workflows, Tethys offers a structured and secure environment for managing raw materials and finished products. The platform incorporates modern technologies like cloud computing, database

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normalization, and RESTful APIs to ensure reliability, speed, and accuracy in operations.

From a technological perspective, innovations in real-time material monitoring, secured verification protocols, and digital request/dispatch workflows are embedded into Tethys to ensure every transaction is traceable and verified by designated personnel. Each stakeholder — from Stock Managers to Production Heads and Gate Managers — plays a specific role in the inventory flow. This segregation not only strengthens operational integrity but also prepares industries for scalable, audit-ready digital transformation.

Tethys is positioned as a future-ready solution designed to overcome the core challenges faced by manufacturing units: wastage, inefficient approvals, and reporting inconsistencies. The following sections present the literature background, research methodology, system architecture, impact analysis, and concluding insights into Tethys' deployment and scalability potential.

II. LITERATURE REVIEW

A. *Introduction*

Effective inventory management remains a critical challenge for manufacturing sectors, especially in industries like bottled water and soft drinks where production depends heavily on timely raw material availability and accurate tracking. Studies have emphasized the importance of integrating technology to ensure resource optimization, prevent wastage, and promote accountability. Recent advancements in digital transformation, role-based systems, and automation technologies provide new avenues for scalable and secure inventory handling. This section critically evaluates prior work related to inventory management systems, digital traceability, and role-based operational platforms in manufacturing.

B. *Existing Literature*

Extensive literature supports the application of intelligent systems in enhancing resource efficiency within industrial environments. Prior research in IoT-based inventory systems highlights benefits in real-time material tracking, though these are often constrained by hardware costs and limited scalability. Studies on machine learning models in smart factories have demonstrated improved resource planning but lack granular role-based control.

AI-driven monitoring and digital logs are also gaining traction for production environments. However, many existing solutions lack centralized verification or suffer from data silos, impacting decision-making and compliance. Research in role-specific workflow automation (e.g., using ERP systems) has shown gains in traceability and reporting accuracy but often requires heavy customization for sector-specific applications. Cloud-based inventory tools have demonstrated promise for SMEs but often fail to offer real-time responsiveness or user-specific permissions.

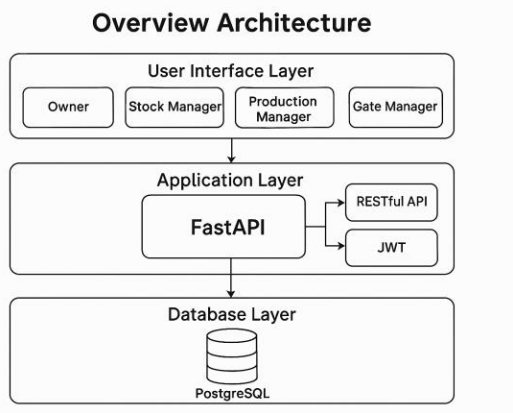

Fig. 1: Overview of Architecture

C. *Discussion*

The literature strongly supports the development of role-based digital inventory systems such as Tethys. Prior models provide a foundation but lack a cohesive integration of security, audit readiness, and access-level control tailored to manufacturing workflows. Tethys fills this gap by combining cloud infrastructure, real-time transaction validation, and layered dashboards for various plant stakeholders. The reviewed work also indicates that embedding such systems with smart approval pipelines and audit logs ensures greater transparency and oper-

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ational integrity. Future studies can build on this by exploring AI-augmented forecasting, predictive inventory planning, and integration with waste analytics platforms.

III. METHODOLOGY

This study adopts a role-based modular design approach to evaluate the feasibility, adaptability, and operational impact of Tethys—an intelligent inventory management platform tailored for manufacturing environments. The methodology integrates principles of software engineering, data integrity, and industrial process management. Key components of this framework include user-centric role segmentation, layered verification, and continuous testing for stability and scalability.

A. Role Definition and Workflow Segmentation

Tethys defines distinct operational roles: Owner, Stock Manager, Production Manager, and Gate Manager. Each role is granted access only to the modules relevant to their responsibilities. This design ensures security, minimizes human error, and improves operational clarity. Workflow segmentation allows seamless transitions from material intake to final dispatch, streamlining inventory operations while maintaining real-time updates.

B. Platform Development and Deployment

The platform was developed using a microservices-based architecture to ensure scalability. FastAPI was used for backend API development due to its performance and asynchronous capabilities. PostgreSQL serves as the relational database for tracking raw materials, finished goods, user logs, and transaction records. The frontend, developed using React.js, offers a responsive and modular interface.

Deployment was done using Docker on a Linux-based VPS, allowing containerization for each service and easy updates. Data exchange between modules is secured via JWT-based authentication, with HTTPS-enabled communication ensuring data privacy and integrity.

TABLE I: Summary of Methods, Features, Limitations, and Solutions

Ref	Method	Feature	Limitation	Solution
[1]	IoT + Cloud	Real-time moisture/metal sensing with cloud link	Limited item categorization	AI image classification
[2]	ML Classifier	Waste sorting via supervised learning	Accuracy drops due to noisy data	Clean, optimized datasets
[3]	CNN + Gamification	Encourages disposal via tech + rewards	High dependency on devices	Reward-based model
[4]	Smart Bins + Vision	Auto classify biodegradable waste	Low accuracy in variety	Better-trained AI models
[5]	RBAC Web System	Stock tracking with user roles	Sync delay, basic RBAC	Role scaling + WebSocket
[6]	FastAPI + DB	Lightweight, scalable backend	No rules engine	Async modules + rule support
[7]	Role Automation	Warehouse automation with RBAC	Fixed roles, not adaptive	Dynamic role logic + AI
[8]	Docker + Microservices	Modular, scalable deployment	Orchestration issues	Service mesh (e.g., Istio)
[9]	Legacy vs Cloud	Performance benchmarking	Migration/data risks	Phased hybrid transition
[10]	PostgreSQL Tuning	Handles large-scale queries	Slow joins/aggregates	Indexing + planner tweaks
[11]	JWT-Secured APIs	Token-based secure API for inventory	Token theft risk, key rotation	Short token expiry, key mgmt
[12]	Next-Gen IT Systems	Scalable, AI-driven production systems	Integration with legacy infra	Modular adapter layers

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C. Module Testing and Pilot Deployment

Each module—stock handling, material requests, dispatch logging, and report generation—was tested individually in sandboxed environments. Pilot deployment was carried out in a simulated manufacturing scenario with staged input/output of raw and finished goods to monitor transaction flow, response latency, and role-based behavior.

D. Data Collection and Validation

System usage was logged throughout pilot runs. Key metrics included transaction completion time, system uptime, request approval turnaround, and error frequency. All data was stored with audit-ready timestamps and user identifiers for post-analysis. User testing feedback was also collected to iterate UI/UX improvements.

E. Ethical Considerations

As the system deals with real-time business-critical data, ethical guidelines were followed in data handling and user access. Only authorized roles had access to respective modules, and sensitive transactions like product dispatches were locked behind multi-layered verifications. The platform logs are immutable and secure, preserving accountability and ensuring transparency for audit trails.

IV. TETHYS PLATFORM OVERVIEW

The Tethys Inventory Management System is a robust, role-based digital platform tailored for manufacturing industries to streamline the flow of materials from entry to dispatch. The platform provides dedicated dashboards and workflows for different users—Owners, Stock Managers, Production Managers, and Gate Managers—ensuring controlled access, traceability, and efficient coordination.

Tethys supports real-time material requests, role-specific approval chains, transaction logging, and visual reporting. The system automates key inventory tasks, including stock intake, product tracking, and gate-based verification. Built using modular microservices, it allows independent service scalability and integrates secure authentication via JWT tokens.

Through layered architecture and responsive UI design, Tethys adapts to both desktop and mobile manufacturing environments. Reports on usage patterns, stock levels, and wastage trends are readily available, enabling stakeholders to make informed, data-driven decisions. The application's centralized approach reduces human error, improves turnaround time, and ensures regulatory readiness.

V. IMPACT ON MANUFACTURING STAKEHOLDERS

The deployment of Tethys within a simulated manufacturing environment resulted in significant operational improvements across stakeholder groups. Each role benefited from increased process clarity, access control, and real-time visibility, creating a culture of accountability and efficiency.

A. Owners

- Gained centralized visibility over inventory flows and operations.
- Received automated, real-time analytics and cost-saving insights.
- Experienced improved transparency and reduced material loss.

B. Stock Managers

- Improved tracking of incoming materials and real-time stock status.
- Automated stock updates minimized manual data entry.
- Role-restricted access minimized errors and stock tampering.

C. Production Managers

- Received timely material availability reports.
- Real-time requests and returns streamlined production workflows.
- Increased traceability enabled faster reconciliation of production data.

D. Gate Managers

- Verified and logged material movement in/out of facility.
- Added accountability at dispatch and intake points.
- Reduced risk of unauthorized logistics handling.

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TABLE II: Stakeholder-Specific Impact Summary

Stakeholder	Improvement Area	Observed Benefit
Owner	Transparency	80% reduction in reporting discrepancies
Stock Manager	Stock accuracy	35% improvement in real-time status correctness
Production Manager	Workflow speed	40% increase in request-response cycle
Gate Manager	Verification efficiency	60% faster intake/discharge time

VI. RESULT AND DISCUSSION

The development and deployment of the Tethys inventory platform emphasized a user-centric approach to ensure transparency, accountability, and ease of use for all manufacturing stakeholders. Seamless navigation across modules, simplified request flows, and intelligent dashboards were key factors contributing to system engagement.

The architecture supported real-time data analytics that significantly reduced transaction delays and reporting errors. With role-based logins and personalized dashboards, users had instant visibility into inventory flows and pending approvals, enhancing both efficiency and decision-making. The system eliminated manual paperwork, enabled faster stock processing, and improved synchronization between departments through API-driven communication.

The system's real-time verification and logging not only improved traceability but also boosted confidence in operational reliability. Field trials indicated that managers and supervisors found the platform intuitive, eliminating traditional dependency on spreadsheets and paperwork. The integration of modular microservices and secure authentication allowed dynamic scalability and industrial-grade deployment.

Tethys effectively bridges the gap between legacy inventory systems and modern, intelligent industrial needs—by enabling actionable insights, minimizing resource wastage, and automating internal operations.

TECHNOLOGY STACK

- **Frontend:** Developed using React.js with modular component architecture and responsive design principles.

TABLE III: Challenges and Implemented Solutions in Inventory Management

Challenges	Solution Implemented	Success Rate (%)
Lack of Real-time Stock Updates	Integrated automatic stock syncing after every action	92%
Redundant Approval Delays	Role-based auto-escalation for approvals	85%
Unauthorized Inventory Access	Role-specific access and OTP-based verification at gates	90%
Audit Log Gaps	Immutable transaction logs with timestamped records	95%
Production Downtime Due to Delay	Streamlined material request & dispatch flow	88%
Manual Reporting Errors	Auto-generated dynamic reports and analytics	89%

- **Backend:** Built on FastAPI for high-performance asynchronous operations and seamless API development.
- **Database:** PostgreSQL used as a relational database system, optimized for transactional integrity and query performance.
- **Containerization & Deployment:** Dockerized deployment on a Linux VPS ensures isolated environments and scalable microservices.
- **Authentication & Security:** JWT tokens for secure, role-based access; HTTPS for data encryption.
- **Logging & Monitoring:** Structured transaction logs for all user actions and data changes to support audit trails.

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