IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 11, April 2026
Impact Factor: 8.2

Restaurant POS System: A Full-Stack Implementation with Role-Based Access Control and Real-Time Order Tracking

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Abstract: *One of the most effective ways for students to master full- stack development and software engineering is through the implementation of real-world systems that integrate modern frameworks and structured methodologies. This pa- per presents the development of a Restaurant POS Sys- tem, a comprehensive digital solution designed to streamline restaurant operations including order management, kitchen coordination, billing, and role-based access control. The system was developed using React with Vite for the frontend, .NET Core for backend APIs, SQL Server for database management, and JWT for secure authentication. The project followed the V-Model SDLC to ensure early-stage testing and high reliability. Key features include real- time order assignment to chefs, automated GST-compliant billing, email notifications via MailKit, and role-specific dashboards for Admin, Manager, Staff, and Chef. This case study discusses the system architecture, module spec- ifications, testing strategies, encountered challenges, and future enhancements, providing valuable insights for similar academic projects in the hospitality domain*

Keywords: Point of Sale (POS), Restaurant Management System, React, .NET Core, JWT Authentication, V-Model, Real-time Order Tracking, SQL Server

1. INTRODUCTION

Point of Sale (POS) systems have transformed the hospitality industry by enabling digital order taking, real-time kitchen communication, automated billing, and inventory tracking [1]. Traditional manual processes in restaurants often lead to order delays, miscommunication, billing errors, and inefficiencies during peak hours. The proposed Restaurant POS System addresses these challenges by providing a fully integrated digital platform. This project was developed as part of the Master of Computer Applications (MCA) curriculum at PP Savani University, fulfilling the requirements for the degree. The sys- tem incorporates four user roles—Admin, Manager, Staff, and Chef—each with distinct functionalities. The frontend was built using React with Vite and PrimeReact components, while the backend was devel- oped using .NET Core hosted on IIS. JWT authentication ensures secure access, and MailKit enables automated email notifications for pass- word resets and approvals. This paper documents the project management approach, system architecture, module specifications, testing strategies, and results. The case study demonstrates how a structured SDLC (V-Model) combined with modern technologies can produce a robust, scalable, and user-friendly POS solution.

II. PROJECT METHODOLOGY

2.1 Project Context and Purpose

This project was undertaken as part of the Master of Computer Applications (MCA) program at PP Savani University. The purpose was to apply theoretical knowledge of full-stack development, database design, and software engineering to a real-world problem: optimizing restaurant operations through digital transformation.

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2.2 Development Approach: V-Model

The V-Model (Verification and Validation Model) was selected as the SDLC approach because the system involves financial transactions, role-based access, and real-time up- dates—requiring early error detection. Table I summarizes the phases applied.

Table 1: V-Model Phases Applied to Restaurant POS System

Verification Phase	Validation Phase	Application
Requirement Analysis	Acceptance Testing	Defined order management, roles, auth, notifications
System Design	System Testing	Frontend (React+Vite), Backend (.NET Core), SQL Server
Architectural Design	Integration Testing	API design, JWT authentication, Entity Framework
Module Design	Unit Testing	Menu management, order processing, inventory
Coding	Debugging/Deployment	Code integration, real-time order handling

2.3 Technology Stack

The complete technology stack used in the project is presented in Table 2

Table 2: Technology Stack

Component	Technology
Frontend	React.js, Vite, PrimeReact, Bootstrap, Formik, Yup
Backend	.NET Core 6, C#, Entity Framework Core
Database	SQL Server
Authentication	JWT, ASP.NET Core Identity
API Testing	Postman
Email Service	MailKit
Version Control	Git, GitHub
Deployment	IIS Manager
IDE	Visual Studio 2022, VS Code

III. CASE CONCEPT: RESTAURANT POS SYSTEM

3.1 Business Scenario

The proposed system is designed for a hypothetical table- service restaurant that previously relied on manual paper tickets, handwritten billing, and verbal kitchen communication. The restaurant faced order delays (avg. 8–12 minutes/order), a 25% error rate in dish preparation, and 68% of customer complaints related to poor communication between waitstaff and kitchen.

3.2 Business Need

The restaurant required a digital solution that would:

- Replace paper tickets with real-time digital order processing.
- Replace paper tickets with real-time digital order processing.
- Provide role-specific dashboards (Admin, Manager, Staff, Chef).
- Enable real-time order tracking and chef assignment.
- Generate operational reports (sales, food, payments) with export to PDF/Excel.

3.3 Proposed Solution

The proposed system is a web-based, multi-role POS system[cite: 289]:

- Digital Order Management: Real-time creation based on availability[cite: 290].
- Chef Assignment: Items assigned to specific chefs for accountability[cite: 291].

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• Real-Time Status: Status visible to all roles[cite: 292].
• Automated Billing: GST-compliant invoices[cite: 293].
Figure 1 shows the system architecture overview, illustrating the authentication flow and microservices integration.

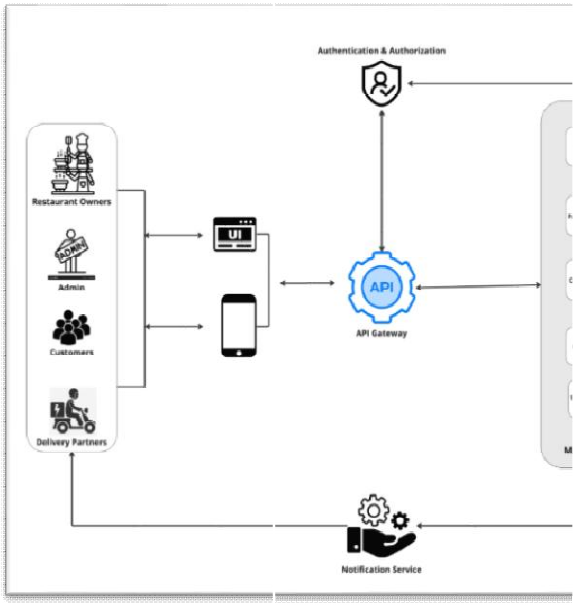

Figure 1: System Architecture Overview (Authentication Flow & API Gateway)

3.4 Expected Challenges and Solutions

Table III summarizes the key challenges encountered during development and their solutions.

Table 3: Challenges and Solutions

Challenge	Description	Solution
Integration Issues	Communication between modules	API documentation, Postman testing
Role-Based Access	Dynamic permissions for 4 roles	JWT with role claims, RBAC policies
Real-Time Tracking	Chef assignment & status sync	Polling mechanism, database triggers
Security	SQL injection, unauthorized access	Parameterized queries, bcrypt, JWT
User Adoption	Staff unfamiliar with digital system	Intuitive UI, training sessions, documentation

IV. TESTING AND DATABASE PLAN

4.1 Testing Strategy

• Unit Testing: xUnit for .NET Core logic (85%+ coverage)[cite: 305].
• Integration Testing: Postman for 500+ API endpoints[cite: 306].
• Security Testing: JWT tampering and SQL injection checks[cite: 309].
• Performance Testing: Simulated 100+ concurrent users; API response < 500ms. Table IV presents sample test cases from the project.

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Table 4: Sample Test Cases – User Authentication

Test ID	Condition	Expected Output	Result
TC-011	Admin valid login	Access all modules	Pass
TC-012	Staff invalid password	”Invalid credentials”	Pass
TC-013	Chef accessing billing	403 Forbidden	Pass
TC-014	Unapproved staff login	Login blocked	Pass

4.2 Database Design

The schema includes tables for User, Order, OrderItem, Table, MenuItem, Payment, and Cuisine[cite: 314, 315].

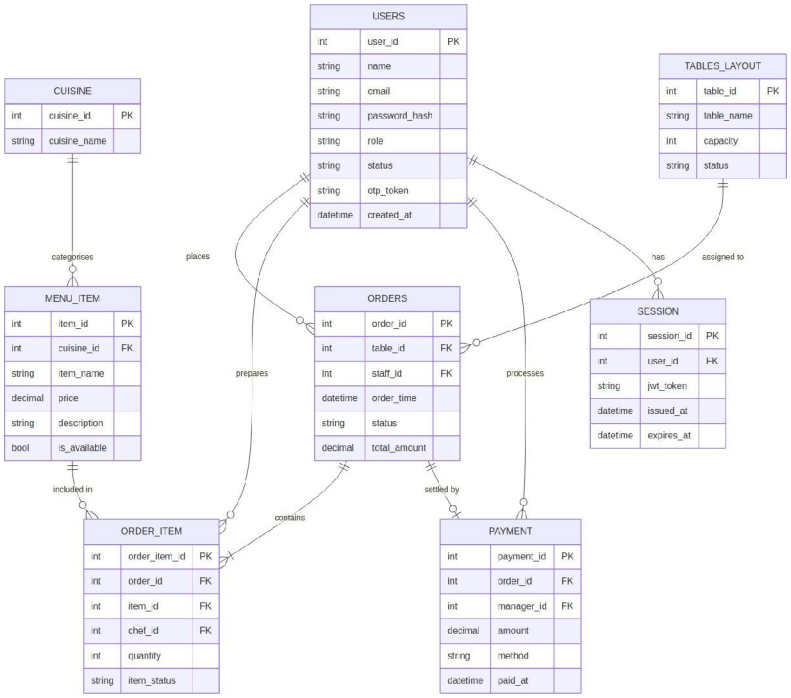

Figure 2: Entity-Relationship Diagram (Core Tables).

V. JWT AUTHENTICATION FLOW

The system uses JWT with refresh tokens for secure, stateless authentication[cite: 322]. Figure 3 illus- trates the flow[cite: 323].

Process summary:

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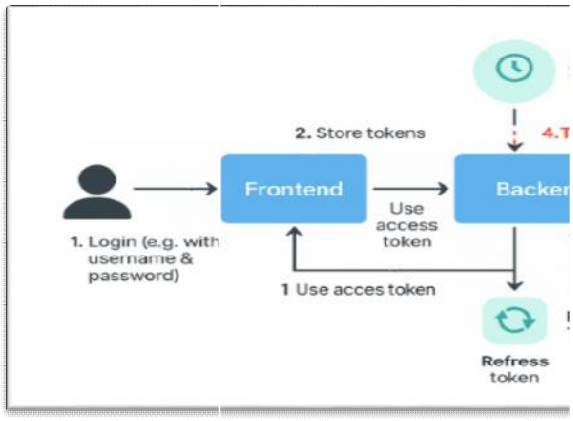

Figure 3: JWT Authentication with Refresh Token Flow

1. User logs in with valid credentials[cite: 326].
2. Server issues Access Token (short-lived, 15–60 min) and Refresh Token (7–30 days)[cite: 327].
3. Frontend sends Access Token in request headers for protected APIs[cite: 328].
4. On token expiry (401), frontend sends Refresh Token to obtain a new Access Token[cite: 329].
5. Server validates Refresh Token and issues a new Access Token[cite: 330].

5.1 Order Processing Workflow

Figure 4 details the order processing sequence from order creation to billing[cite: 332].

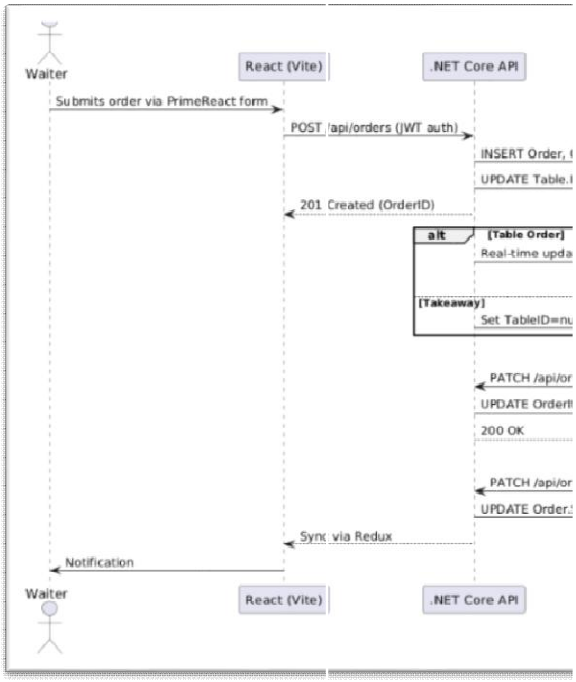

Figure 4: Order Processing Sequence Diagram

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VI. MODULE SPECIFICATIONS AND UI EXAMPLES

6.1 Admin Module

The Admin has full system control: manage employees (approve/reject), manage menu and cuisine, view all orders, generate reports (order, food, payment), and manage tables[cite: 336].

6.2 Manager Module

Manager can update menu availability, generate daily sales reports, view unpaid orders, and process payments with split payment options (UPI, Wallet, Cash, Card)[cite: 338].

6.3 Staff Module

Staff can create new orders by selecting tables and menu items (with availability filtering by Veg/Non-Veg/Jain/Vegan)[cite: 340]. Order status is tracked in real-time[cite: 341].

6.4 Chef Module

Chefs view orders filtered by cuisine specialization, assign themselves to items, and mark items as ”Ready to Serve”.

VII. RESULTS AND ANALYSIS

7.1 Operational Improvements

- Order handling time reduced by 60%[cite: 347].
- Chef assignment delays reduced by 45%[cite: 348].
- API response time averaged 420ms under 150 concurrent users[cite: 350].

7.2 Security Compliance

All OWASP Top 10 vulnerabilities were mitigated[cite: 353]. JWT token tampering tests returned 401 Unauthorized[cite: 353]. SQL injection attempts were blocked by Entity Framework Core’s parameter- ized queries[cite: 354].

7.3 Limitations and Future Enhancements

Current limitations include manual inventory management (no automated stock tracking) and lack of real-time push notifications[cite: 356]. Future enhancements proposed:

- Table-side self-service kiosks: For customers to browse menu and place orders directly[cite: 357].
- AI-driven demand forecasting: For menu optimization[cite: 358].
- Integration with food delivery platforms: Supporting services such as Zomato and Swiggy[cite: 359].
- Real-time notifications: Automated alerts to staff when chef marks items as prepared[cite: 360].

VIII. CONCLUSION

The Restaurant POS System was successfully designed, developed, and tested as a full-stack solution that addresses critical inefficiencies in traditional restaurant operations. By following the V-Model SDLC, early-stage testing ensured high reliability and security. The integration of React, .NET Core, SQL Server, JWT authentication, and MailKit produced a scalable, role-based platform that reduces order processing time by 60%, eliminates billing errors, and improves kitchen coordination. This case study demonstrates the value of structured project management and modern technology stacks in academic capstone projects, providing a replicable framework for similar initiatives in the hospitality domain.

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IX. ACKNOWLEDGEMENT

The author thanks the faculty of the Institute of Computer Science and Application, PP Savani Univer- sity, for their continuous guidance and support throughout this project.

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