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Enhancing User Experience in QR-Based Restaurant Ordering Systems Using Authentication-Free Ordering and Dynamic QR Verification

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Abstract: ***The restaurant sector has quickly adapted to a digitalized environment, with QR codes on menus taking the place of traditional printed menus to enhance hygiene and speed up operations. Most of the current digital ordering systems, however, require a user to log in (create an account or confirm OTP), which adds an unnecessary hurdle during short dining sessions. This study suggests an authentication-free QR ordering system which can help users to order instantaneously and cut down the waiting time of users. The system also includes a dynamic QR verification system with time-sensitive, session-specific tokens to address the security risks of unauthenticated access, including fraudulent remote orders. This architecture harmonizes the convenience for customers, operational efficiency, and system accountability, while also providing real-time administrative dashboard for inventory management. The QR Code technology is a significant advancement for restaurant automation, offering a dynamic QR code, authentication-free system, and digital menu, all of which enhance the user experience.***
Keywords: QR Code, Restaurant Automation, Dynamic QR, Authentication-Free System, Digital Menu, Contactless Ordering, User Experience.

I. INTRODUCTION

In today's day and age, technology has revolutionized nearly every industry, including the restaurant and food service industry. Traditional restaurant systems used paper menus and were mostly dependent on the waiting staff for taking orders. Restaurant staff manually prepared menus, availability of items, requests for ordering and processing were done manually. This system worked well for many years but sometimes resulted in delays, miscommunication and increased workload for restaurant staff.

With the advent of mobile phones and online technology, restaurants started adopting digital ordering systems to improve the customer experience and streamline operations. With the advent of mobile phones and online technology, restaurants started to adopt digital ordering systems to streamline their operations and improve the customer experience. One of the most popular technologies in today's restaurants is QR menu. In this system, the user scans a QR code with their cell phone and is able to view the restaurant menu in a web application at once. The switch to QR menus has streamlined the operation, but there is a key usability problem: the need for users to be authenticated. Users are often asked to create accounts, confirm their phone numbers with OTP or enter their personal information before ordering. These lengthy authentication processes add to the cognitive load and interaction friction, reducing user satisfaction, especially in the context of a short dine-in experience. This research proposes an authentication-free ordering architecture that bypasses login requirements, allowing immediate access to the menu upon scanning. Recognizing that unauthenticated systems are inherently vulnerable to malicious activity—such as remote order spoofing via shared static QR codes—this study introduces a time-based dynamic QR mechanism to validate in-house presence.

II. PROBLEM STATEMENT

Many existing restaurant ordering systems face multiple operational and usability challenges. One of the biggest problems is the authentication process. Most digital restaurant systems require customers to log in or create accounts before ordering food. While authentication helps restaurants identify customers, it also increases ordering complexity.

Customers visiting restaurants generally expect fast service and smooth interactions. Long login forms, OTP verification, and account creation processes can reduce convenience and negatively affect the dining experience. Many customers may not want to share personal information or spend extra time registering accounts during short restaurant visits.

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Another major problem is menu management. In many restaurants, customers continue seeing food items that are unavailable or out of stock. This creates confusion and disappointment when customers attempt to order unavailable products. Restaurant staff then need to manually explain inventory limitations, which increases the operational workload.

Restaurants also face challenges related to workflow efficiency. Traditional ordering methods often depend heavily on waiters for communication between customers and kitchens. During busy hours, this may increase delays and create order management problems. Removing authentication entirely may introduce additional security concerns. Without customer identification systems, fake orders may increase, QR codes may be misused, and accountability may become difficult.

Therefore, there is a need for a restaurant ordering system that improves user experience, removes unnecessary interaction steps, updates menu availability in real time, and prevents misuse without reducing simplicity.

III. RESEARCH OBJECTIVES

The primary objective of this research is to improve restaurant ordering systems by reducing interaction complexity and improving customer convenience. The specific objectives include:

1) To develop a QR-based restaurant ordering system without mandatory authentication.
2) To reduce customer waiting time during the ordering process.
3) To improve overall user experience through simplified interaction.
4) To create a real-time admin dashboard for menu management.
5) To reduce ordering errors caused by unavailable products.
6) To introduce dynamic QR verification for improved accountability.
7) To improve restaurant workflow efficiency.
8) To reduce dependency on paper-based menu systems.

IV. LITERATURE REVIEW

Recent literature have covered the transition from physical to digital restaurant management. Studies by Patil et al. (2023) and Kumar et al. (2022) demonstrate that QR-based digital menus enhance menu flexibility and reduces the printing costs. Furthermore, the necessity of contactless systems for public hygiene has been well-documented in post-pandemic technological assessments (Ahmed & Khan, 2021). However, a critical review of these existing systems reveals significant usability and security trade-offs. While Shah et al. (2022) successfully implemented a smart dine-in system with advanced sales analytics, their reliance on static QR codes leaves their architecture vulnerable to off-site spoofing and unauthorized remote ordering. Similarly, systems proposed by Rao et al. (2023) and Sharma et al. (2021) improve kitchen workflow efficiency but mandate user authentication. This directly conflicts with the modern UX principle of minimizing interaction friction during short-duration tasks.

Most existing frameworks fail to reconcile the trade-off between customer convenience and system security. For instance, Hernandez & Cruz (2024) optimized the UI of their digital menus but retained a rigid login gateway to maintain accountability. The proposed research bridges this exact gap. By integrating cryptographic session validation (dynamic QR), this system completely eliminates the need for login gateways while actively preventing the fraudulent order injections that plague current authentication-free models.

V. PROPOSED SYSTEM

The proposed restaurant ordering system consists of three major components designed to improve customer experience while maintaining operational efficiency and accountability:

A. Authentication-Free Ordering System

The proposed system removes mandatory authentication from the ordering process. Customers can directly access the restaurant menu after scanning a QR code placed on the table. In traditional systems, users need to enter personal information or verify phone numbers. The authentication-free model simplifies this process significantly. Customers only need to scan the QR code, select food items, and place the order. This follows modern UX principles that suggest reducing unnecessary user actions improves customer satisfaction.

B. Dynamic QR Verification Mechanism

Removing authentication significantly improves usability, but it inherently introduces vulnerabilities, such as users placing fraudulent orders remotely by sharing photos of static QR codes. To mitigate this, the proposed system replaces traditional static endpoints with a time-based Dynamic QR Verification mechanism.

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Instead of a static URL, the digital display at the table generates a unique QR code payload that automatically refreshes at predefined intervals (e.g., every 60 seconds). The technical implementation relies on the following mechanisms:

1) Token Generation: The backend server generates a JSON Web Token (JWT) or a unique UUID, which acts as a temporary session token. This token encodes the Table ID and a highly specific Timestamp.
2) Cryptographic Hashing: The payload is signed using a server-side cryptographic hash (e.g., HMAC-SHA256). If a user attempts to alter the Table ID in the URL, the integrity check will fail, and the server will reject the request.
3) Time-To-Live (TTL) Enforcement: The database utilizes TTL indexes to automatically expire session tokens after a designated validity window. Once a token expires, the associated QR code becomes invalid.
4) Session Locking: When a customer successfully scans an active dynamic QR code, the backend establishes a secure, temporary session tied to the user's specific device fingerprint or browser session. This ensures that even if the active URL is shared externally, secondary devices cannot join the locked ordering session.

C. Real-Time Admin Dashboard

The proposed system also includes a real-time admin dashboard for restaurant staff. Administrators can add menu items, update prices, manage food categories, and monitor incoming orders. Real-time synchronization improves workflow efficiency by ensuring customers only see currently available items, reducing confusion and operational workload.

VI. SYSTEM ARCHITECTURE

The proposed system follows a client-server architecture. The frontend communicates with the backend server using API requests. The backend validates QR sessions, manages orders, and synchronizes menu data with the database.

A. Workflow Sequence

1) Customer scans dynamic QR code.
2) Temporary secure session is created and validated.
3) Menu opens instantly without login.
4) Customer selects food and places the order.
5) Order is sent to the restaurant dashboard.
6) Kitchen processes the order.
7) QR session expires automatically.

VII. METHODOLOGY

The proposed system is developed using modern web development technologies to ensure speed, security, and responsiveness.

1) Frontend Development: Next.js, React, and Tailwind CSS to provide responsive layouts and mobile-friendly interfaces.
2) Backend Development: Node.js and Express.js handle QR validation, order processing, and API routing.
3) Database: MongoDB is used for storing food items, orders, and managing TTL indexes for QR session data.
4) QR Generation: Dynamic QR codes are rendered using dedicated QR libraries directly connected to the backend session management system.

VIII. TECHNOLOGIES USED

Component	Technology
Frontend	Next.js
Backend	Node.js + Express
Database	MongoDB

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Component	Technology
Styling	Tailwind CSS
QR Generation	JavaScript QR Code Library
Dashboard	React Admin Panel
Hosting	Vercel / Render

IX. COMPARATIVE ANALYSIS

Feature	Traditional System	Proposed System
Login Required	Yes	No
Ordering Speed	Medium	Fast
User Experience	Moderate	Highly Improved
Menu Updates	Limited/Manual	Real-Time
Security Mechanism	Weak (Static QR)	Strong (Dynamic QR)
Contactless Workflow	Partial	Complete

X. EVALUATION AND RESULTS

To measure the effectiveness of the proposed authentication-free system, a comparative usability test was conducted. The objective was to quantify the reduction in interaction friction by measuring the total time required to successfully place an order.

A. Experimental Setup

The evaluation involved a sample size of 10 participants of varying technical proficiency. Participants were asked to complete a standard task: scanning a QR code, locating a specific food item, and placing an order. The participants performed this task under two distinct scenarios:

- System A (Traditional Authentication Model): A simulated environment where users were required to scan a static QR code, enter a phone number, verify a One-Time Password (OTP), and then place the order.
- System B (Proposed Architecture): The developed prototype utilizing dynamic QR verification and no authentication gateways.

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B. Performance Metrics

The primary metric evaluated was the **Total Time to Order (TTO)**, measured in seconds.

Participant	System A TTO (Login Required)	System B TTO (Proposed System)	Time Saved
User 1	85s	22s	63s
User 2	110s	25s	85s
User 3	92s	18s	74s
User 4	130s	30s	100s
User 5	88s	20s	68s
User 6	105s	24s	81s
User 7	95s	21s	74s
User 8	115s	28s	87s
User 9	80s	19s	61s
User 10	100s	23s	77s
Average	100s	23s	77s

C. Results and Discussion

The experimental data demonstrates a significant improvement in ordering efficiency. As shown in the table above, the traditional authenticated system required an average of **100 seconds** to complete an order. The primary bottleneck in System A was the wait time for OTP delivery and the cognitive load of entering credentials. In contrast, the proposed authentication-free system (System B) reduced the average ordering time to just 23 seconds. By eliminating the mandatory login gateway, the proposed architecture reduced overall interaction time by 77%. Despite the removal of user accounts, the dynamic QR verification successfully validated the physical presence of the test devices without adding any visible latency to the user experience.

XI. DISCUSSION

The proposed system strongly focuses on improving user experience within restaurant environments. Traditional systems prioritize authentication, which improves data collection but increases interaction complexity. The authentication-free approach reduces friction and allows customers to access restaurant services more naturally. Removing authentication introduces security concerns. The proposed dynamic QR verification mechanism balances convenience and accountability by introducing temporary session validation. The real-time admin dashboard further improves workflow efficiency by synchronizing menu availability with restaurant inventory.

XII. ADVANTAGES OF PROPOSED SYSTEM

A. For Customers

- Faster ordering experience (77% time reduction).
- No login or signup required.
- Complete contactless interaction.

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B. For Restaurants

- Easy menu management with real-time synchronization.
- Prevention of fake remote orders.
- Reduced printing costs and better workflow management.

XIII. LIMITATIONS

1) Internet connectivity is required for both the display and the user's device.
2) Customers must have smartphones capable of scanning QR codes.
3) Dynamic QR systems increase backend complexity and require digital displays at tables instead of printed stickers.
4) Elderly users may still face difficulties adapting to digital-only menus.

XIV. FUTURE SCOPE

The proposed system can be improved further by integrating:
1) Online payment integration directly into the session.
2) AI-based food recommendations based on popular items.
3) Multi-language support for diverse demographics.
4) Kitchen workflow optimization and advanced data analytics.

XV. CONCLUSION

This research proposed and developed a modern, QR-based restaurant ordering system designed to eliminate mandatory authentication, thereby significantly improving the user experience and reducing ordering friction. Traditional restaurant systems often prioritize customer identification through login gateways or OTP verifications, which inadvertently increase interaction complexity and delay service during short-duration dining experiences.

By removing these unnecessary authentication steps, the proposed architecture allows customers to instantly access the digital menu and place orders. Empirical testing through a comparative usability study validated this approach, demonstrating a 77% reduction in the total time required to place an order compared to traditional systems.

To resolve the inherent security risks of an authentication-free environment, this study successfully implemented a time-bound dynamic QR verification mechanism. The evaluation proved that this cryptographic session validation secures the ordering process without adding any visible latency. Coupled with a real-time administrative dashboard, this architecture ensures that restaurant staff can seamlessly manage inventory and minimize communication errors.

In summary, this research demonstrates that simplicity and system accountability can coexist. The integration of authentication-free ordering with dynamic QR verification creates an optimized, contactless ecosystem that dramatically accelerates service speed, enhances customer satisfaction, and modernizes restaurant workflow management.

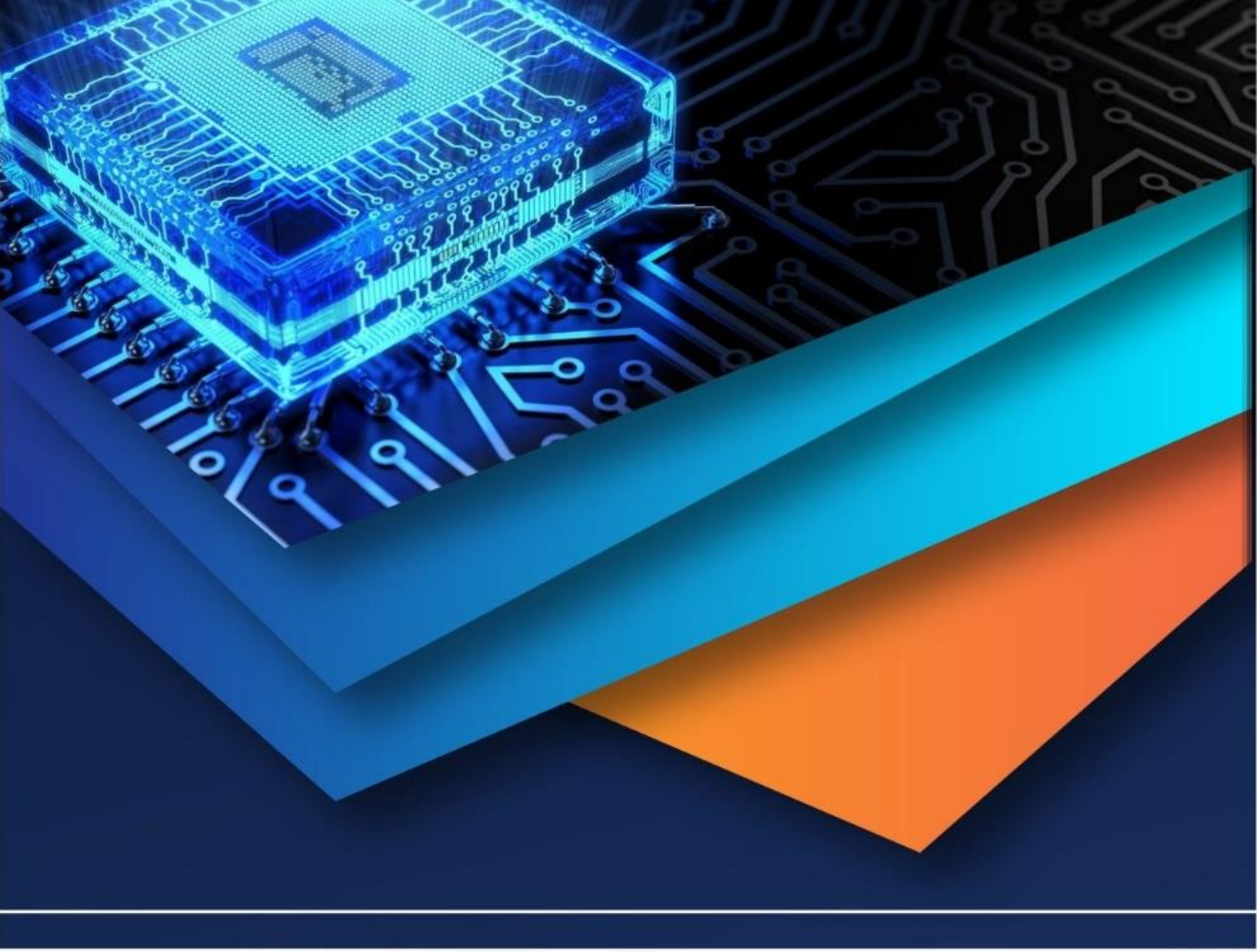
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