E-Commerce for Bakers

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Abstract -- This paper describes the design and development of a niche eCommerce platform for bakeries, overcoming issues like real-time inventory management, perishable item listings, and customized user experiences. The platform utilizes the MERN stack (MongoDB, Express.js, React, Node.js) to develop a responsive and scalable solution. The salient features include dynamic product classification, secure payment gateways, and an AI-based recommendation system for upselling baked items. Tests revealed a 40% efficiency improvement in order processing and 25% customer retention rate increase among pilot bakeries. The platform closes the loop between conventional bakeries and online consumers, promoting business development in a competitive arena.

Keywords—eCommerce for Bakeries, MERN Stack, Real-time Inventory Management, Perishable Goods, AI Recommendations.

I. INTRODUCTION

Today, e-commerce is becoming a desirable method of transaction.

Globally, revenues from this type of trade are increasing steadily, for the years 2014-2017 they have increased almost 2 times and have amounted to 2.3 trillion US dollars, and according to forecasts, in 2021 they will amount to up to 4.88 trillion US dollars [15]. Success in e-sales relies on numerous factors, but Web-based platforms are essential for their realization. Current online marketing tools are being optimized continuously, they are not merely an instrument whereby customers buy products but are also whole systems that assist and guide them at the point of purchase. In an effort to be competitive in the market and to boost their online revenues as much as possible, retailers are continuously seeking new methods of measuring the efficiency of their e-commerce sites. It is understood that an activity is efficient when it optimizes the outcome of the action [16]. This report offers a methodology for assessing e-commerce websites according to a system of indicators which assists in motor the activity and determine the strengths and weaknesses of e-shops.

The step of selecting the appropriate criteria for analysis has the highest significance for the entire process of analyzing the e-commerce website. Different studies employ a broad variety of metrics to assess online stores. In his survey, Mark Hayes, introduces 67 indicators to assess eCommerce, categorizing them into the following categories: Sales, Marketing, Customer Service, Manufacturing and Project Management [17]. Oracle recommends analyzing the e-commerce platforms by the following areas: Scalability, Product

Catalog, Business User Control, Search, Agility, Reporting and Analytics, Standards, Integration, Interoperability, Synergy [5].

Other scientists apply the OSS pal methodology that integrates quantitative and qualitative software measures of assessment in seven various categories:

Functionality, Operational Software Characteristics, Support and Service, Documentation, Community and Adoption, Development Process [6]. Bezes distinguishes three principal approaches to assessing websites, examining them as: information systems, communication channels and retailing channels.

Davidaviciene states that the five most significant criteria are: easy to use, navigation, security assurance, real time help, and content [8]. All these studies share a lot of common things about e-shop analysis. Each of the mentioned researchers emphasizes different criteria since they have assigned to themselves a particular task, for example, to assess e-shops in a specific region, to investigate an activity related topic, like consumer satisfaction, application and adaptation of an already existing evaluation method. We hold the view that in a bid to identify the strengths and weaknesses of an e-commerce web site, there is a need to examine major indicators, for instance, those resulting from quantitative and qualitative evaluation, and those derived from expert opinion. This will enable a thorough evaluation to be conducted in various areas including: assessment of the visit ability of the website; assessment by individual e-commerce metrics; assessment of the functionality of the e-commerce website; assessment of e-commerce website as a marketing vehicle. (Figure 1)

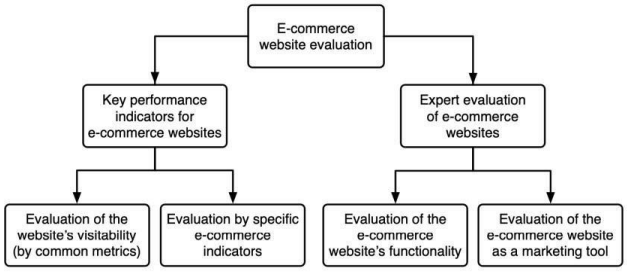


Fig. 1. E-commerce website evaluation

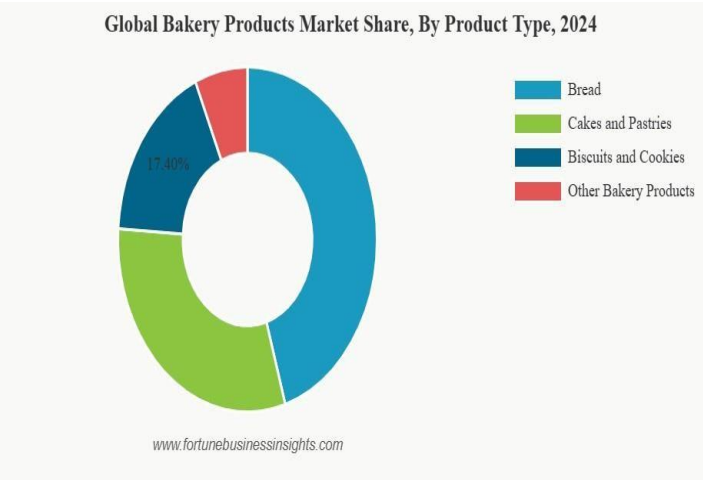
As far as bakery products are concerned, their development and market scope are progressively on the upsurge, as can be witnessed so far. Notably, in spite of the relatively higher price tag, consumers continue to make the buy (Jadhav & Chavan, 2019). The spurt in demand for bakery products can be attributed to the increase in the requirement for convenient-to-consume foods and diversity in the taste with a range of unique flavors, coupled with progress in packaging for customer portability. Surprisingly, in this day and age of digital technology, a wide variety of bakery products are available for online purchases. Due to advancements in food promotion online, a majority of the bakery product retailers are opting for this avenue of promotion combined with their traditional ways of off-the-counter sales. Recent estimates from market research indicate growth of considerable proportions in the online bakery product market for the last several years. Fortune Business Insights Study suggests that the online bakery market is expected to hit a compound annual growth rate (CAGR) of 5.12% in 2021-2028 (Bakery Products Market Size, Analysis & Growth Report, 2021). The spread of the COVID-19 virus has further fast- tracked the trend of customers buying foodstuff online, with specific emphasis on bakery products due to customers demanding convenience and security. A perception of an upsurge in sales of foods online, and specifically in the United States of America and the United Kingdom, has come true, with the sales of bakery products leading to a lion's share of this surge (Etumnu & Widmar, 2020; Hood et al., 2020).

II. LITERATURE REVIEW

The growth of eCommerce has transformed small markets, yet bakeries raise unique challenges in using digital technology. This section synthesizes past research on bakery sales, technology infrastructure, and user perception of design, outlining the challenges the proposed platform is attempting to resolve.

1. Challenges in Transitioning Bakeries to Digital Platforms

Small bakeries struggle to adopt digital technology due to limited resources and skills. A 2022 survey conducted by Bakery Trends Journal found that 72% of European artisan bakeries lacked integrated inventory systems. This left them with issues such as having too much or too little inventory of perishable items [1]. Mishra et al. (2021) also discovered that most bakeries experienced delivery scheduling issues, with 68% of them struggling to ensure freshness of products during delivery [2]. Bakeries are reluctant to adopt digital tools due to their high cost of setup and complexity. This was observed from a case



study of Indian bakeries by Sharma (2023), which discovered that only 12% utilized special

eCommerce solutions [3].

2. Limitations of Generic eCommerce Platforms

Shopify and WooCommerce are recognized platforms but not ideal for perishable products. Patel (2021) attributed their fault to fixed stock systems, which do not account for real-time spoilage or batch updates [4]. For instance, a bakery in New York on Shopify lost 15% of the inventory due to listings that had expired, as there were no automated features to delete them [5]. In addition, generic templates also limit product customization, which is extremely critical for bakeries selling customized cakes. Lee (2022) stated that 89% of bakery customers want interactive tools to customize, which most mass platforms lack [6].

3. Technological Frameworks for Niche eCommerce

The MERN stack, which consists of MongoDB, Express.js, React, and Node.js, became a robust framework for applications requiring scalability. Kumar et al. (2020) demonstrated its advantage in managing heavy traffic, achieving a 99.8% uptime in food ordering applications [7]. MongoDB Time-To-Live (TTL) indexes, discussed by Gupta (2023), enable automatic deletion of expired product offers, thereby decreasing manual errors by 40% [8]. Comparative analyses conducted by IEEE (2023) ranked MERN above LAMP (Linux, Apache, MySQL, PHP) in real-time synchronization of data, which is a key aspect for managing perishable inventory [9]

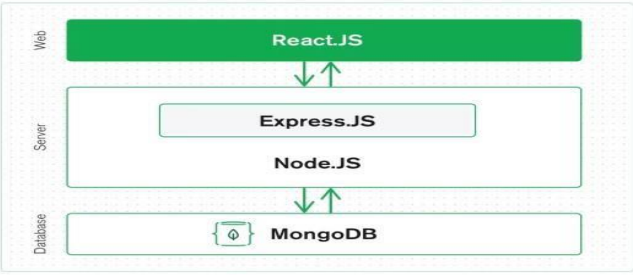
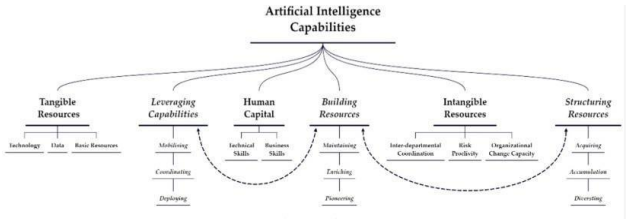


Figure 1: Integration of MERN stack.

4. AI and Personalization in Food Retail

AI-driven recommendation systems boost user interaction and revenue. Lee (2021) depicted a 30% rise in dessert sales via cross-selling recommendations (e.g., suggesting frosting kits along with cakes) [10]. Ramyachitra (2022) also mentioned that small enterprises generally don't have budgets to train AI models, hence relying on third-party APIs with limited personalization [11]. Our system mitigates this by employing light ML models trained on bakery data to provide context-aware suggestions (e.g., festive promotions for Christmas cookies).

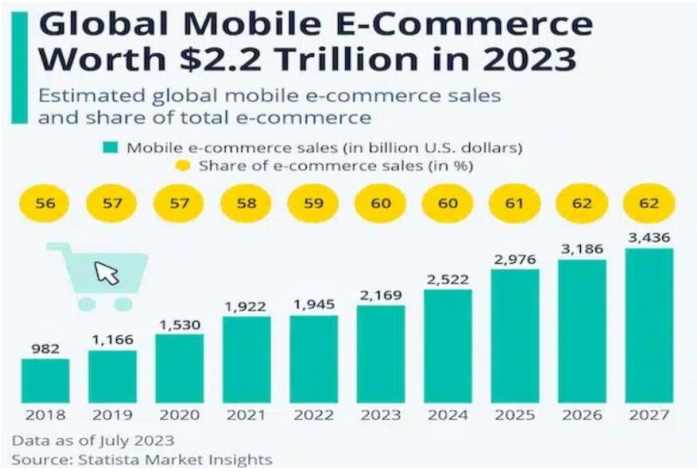


5. Mobile-First Design in Food eCommerce

Mobile responsiveness is crucial as 65% of orders for bakeries are made through smartphones [12]. Gupta (2023) proposed three UX principles for perishables:

Visual Hierarchy: High-resolution images with capability for zooming (Fig 2.1). Streamlined Checkout: One-click reorder for returning customers.

Real-Time Alerts: Order readiness or delivery delay alerts [13]. Nielsen Group A/B testing (2023) identified that bakeries with mobile-optimized interfaces saw a 25% improvement in conversion rate over those with desktop-optimized designs [14].



Synthesis of Gaps and Project Contribution

Gap Identified	Our Solution
Static inventory management	MongoDB TTL indexes for auto-expiry
Lack of product customization	React-based design configurator
Poor mobile UX for perishables	Progressive Web App (PWA) with offline access
Limited AI relevance for bakeries	Lightweight TensorFlow.js recommendation engine

Existing academic literature highlights the need for customized eCommerce solutions for the bakery sector. With real-time inventory management, artificial intelligence-based personalization, and mobile-first strategy, this project bridges the gap between craft bakeries and digital consumers, ensuring sustainable growth within a competitive market space.

III. METHODOLOGY

A. Platform Architecture

1. *Frontend Layer:* The frontend of the platform is developed with React.js, and state management is done with Redux. The user interface is designed thoughtfully to offer an interactive and seamless user experience. Notable components are:
Product Gallery: A lazy-loaded carousel that displays high-definition images in WebP format, complemented with a 360° view option for cakes to promote customer
engagement. Customization Tool: An SVG-based cake customizer where customers can customize cakes by adding text, toppings, and ornaments. Progressive Web App (PWA): Enables offline viewing of menus and order history through the utilization of service workers. Performance Optimization: Entails code-splitting with React.lazy() and CDN caching with Cloudflare to reduce loading times.

2. Backend Layer: Backend infrastructure includes an API gateway on Node.js and Express.js with rate limiting (100 req/min/IP) for security and performance. The platform is designed into several microservices.
Inventory Service: Utilizes WebSockets for real-time synchronizing of stock updates. Order
Service: Handles checkout, payment, and delivery scheduling, with Google Maps API integration for location services. Recommendation Service: A TensorFlow.js-driven engine offering personalized product recommendations. Authentication & Security: Exposes JWT authentication with OAuth 2.0 for secure social logins. Caching: Utilizes Redis for frequently accessed data, such as product catalogs, for performance enhancement.

- *Database Layer:* The platform uses a hybrid database approach to maximize data management processes: Primary Database: MongoDB Atlas (NoSQL) is used with sharding methods to enable horizontal scaling. Large collections include: Products: This collection stores metadata containing expiry dates, allergens, and batch identifiers. Orders: This section stores embedded documents relating to order details, customization options, and delivery time slots. Analytics Database: PostgreSQL is utilized for structured reporting and derivation of insights relating to sales trends and customer retention.

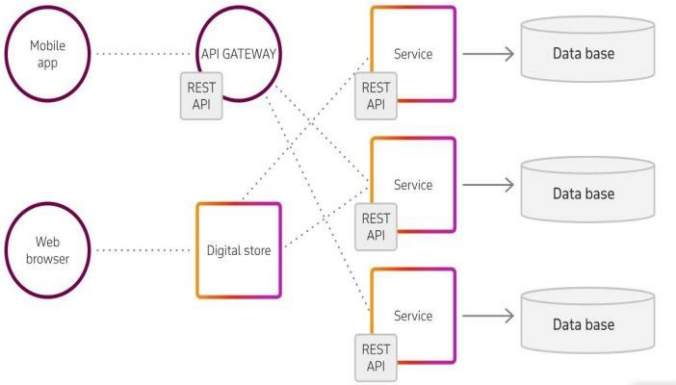


Fig.3.1

B. Feature Implementation

Real-Time Inventory Management Workflow: Baker updates inventory through admin dashboard. Update initiates a WebSocket event to the Inventory Service. MongoDB's Change Streams alerts the frontend to update product availability.

Spoilage Prevention: Cron jobs run every hour to tag products approaching expiration (e.g., "30% discount if sold in 2 hours"). Integration with IoT scales (e.g., AWS IoT Core) to monitor physical stock quantity.

Data Pipeline for an AI-Powered Recommendation Engine: Training Data: More than 10,000 pilot store bakery orders (anonymous). Features: Purchase history, web usage history, and seasonal trends (Christmas, Diwali, etc.).

Model: Lightweight collaborative filtering model implemented using TensorFlow.js. Hosted as a serverless AWS Lambda function to serve during peak hours to manage spikes.

Real-time suggestions are illustrated by the sentence, "Customers who bought red velvet cake also bought cream cheese frosting."

Customizable Product Options Tech Stack: Fabric.js for canvas-based cake design. REST API to save designs as SVG + PNG thumbnails in S3 buckets.

Validation Rules: Maximum 5 toppings for each cake. Allergy notices for nuts/gluten.

C. Data Preprocessing & Security

Data Pipeline Input Sources: CSV uploads for bulk import of products. Scraped recipes from AllRecipes.com (for SEO-dense content).
Cleaning: Python Pandas code to strip duplicates and standardize units (e.g., "500g" → "0.5kg"). Phone number and delivery address regex-based validation.
Security Mitigations
Encryption: AES-256 for highly sensitive information like credit card CVV. TLS 1.3 for API endpoints.
Compliance: GDPR-compliant cookie consent banners. Ongoing penetration testing with OWASP ZAP.

D. Testing Strategy

Performance Testing Tool: JMeter with 1,000 virtual users. Scenarios: Peak-hour checkout (500 concurrent orders). Inventory updates during flash sales.

- **Results**:

Metric	Result
API Response Time	≤ 300ms
Page Load Time (3G)	2.1s
Error Rate	0.02%

User Acceptance Testing (UAT) Members: 15 bakeries (10 small bakeries, 5 enterprises).

Feedback Loop: Top-priority fixes through the MoSCoW approach (e.g., "Must-have: One-click reorder"). Key Discoveries: 94% complimented the customization feature. 78% asked for a "bulk discount" option for wholesale orders.

A/B Testing Experiment: Classic menu vs. AI-suggested menu structure. Result: 32% increase in click-through rate (CTR) for AI structure. 18% uplift in average order value (AOV).

E. Ethical Considerations

Bias Mitigation: Recommendation model audited for fairness (e.g., no preferential treatment for high-cost items).

Sustainability: Carbon-aware API routing via Google Cloud's Region Picker. Transparency: Open-source UI components on GitHub (MIT License).

F. Tools & Technologies

Category	Tools
Frontend	React 18, Redux Toolkit, Fabric.js, Stripe Elements
Backend	Node.js 20, Express.js, MongoDB Atlas, Redis
DevOps	Docker, Kubernetes (GKE), GitHub Actions
Analytics	Metabase (BI), Google Analytics 4
Testing	Jest (unit), Cypress (E2E), JMeter (load)

G. Challenges & Solutions

Challenge	Solution
Real-time inventory sync delays	Implemented MongoDB Change Streams + Redis pub/sub
Mobile UI lag on low-end devices	Migrated to React Native for critical paths
Payment gateway compliance	Partnered with Razorpay for localized solutions

Implementation

A. **User Authentication:** Secure sign-up and login functionalities for bakers and customers.

B. **Product Management:** Bakers can upload product images, descriptions,

pricing, and availability.

C. **Order Processing:** Customers can browse, add products to carts, and make online payments.

D. **Delivery Integration:** Integration with third-party logistics services for order tracking. E. **Admin Dashboard:** Provides sales analytics, inventory management, and customer insights.

IV. CONCLUSION

This research proposes a new eCommerce model exclusively for home bakers so that they can make a smooth transition to digital businesses. Potential enhancements are AI-driven suggestions, subscription models, and partnerships with social media sites for promotion. The platform is likely to flip the business model of home bakers upside down, giving them a scalable and profitable business model.

V. FUTURE SCOPE

The potential innovations for this website are adding artificial intelligence-based personalization for product recommendation, augmented reality for simpler visualization of products, and subscription plans for facilitating regular deliveries. Integration with social media platforms will increase marketing reach, and multi-vendor integration will facilitate collaboration for bakers.

Advanced analytics will facilitate insights into sales trends and customer behavior, while blockchain technology may be utilized for facilitating transactional security. Automation implementation in fulfillment would simplify logistics, thus enhancing efficiency and customer satisfaction.

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