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## International Journal of Multidisciplinary Research in Science, Engineering and Technology (IJMRSET)

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# Quantum Build: E-Commerce Website for Custom Pc Hardware Parts

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**ABSTRACT:** Quantum Build is a domain-specific, full-stack e-commerce web application engineered to address the specialized requirements of the high-performance custom PC market. Traditional e-commerce platforms often lack the technical depth and specialized guidance required for PC building, leading to compatibility errors and consumer frustration. This research presents the design and implementation of a centralized marketplace for custom hardware, developed using the **MERN stack** (MongoDB, Express.js, React.js, and Node.js) to ensure high scalability, performance, and a responsive user experience. At its core, the platform features a flagship **interactive PC Builder module** that enables users to configure custom gaming rigs through a validated step-by-step workflow. This module integrates a real-time **compatibility conflict detection engine** and a live **TDP-based power consumption estimator**, which recommends minimum PSU wattages with a 25% headroom buffer. These features empower technically non-expert users to make informed purchasing decisions without prior expertise. The application architecture follows a decoupled **three-tier model**, utilizing **RESTful APIs** and **JWT-based authentication** for secure session management and role-based access control. The platform was deployed via **Vercel** and subjected to rigorous testing, including unit, integration, and performance evaluations. Results demonstrate a high-speed interface with API response times under 200ms and stable performance for 100+ concurrent users. Quantum Build serves as both a commercial-grade retail platform for the Indian gaming market and a demonstration of end-to-end web development competency, delivering a functionally robust and visually compelling solution for hardware enthusiasts.

## I. INTRODUCTION

The rapid advancement of web technologies has transformed the global e-commerce landscape, shifting toward highly interactive, data-driven applications [1]. In recent years, the gaming hardware market has seen significant growth, particularly in India, driven by demand for personalized, high-performance computing [15]. However, traditional general-purpose platforms often lack the technical depth and specialized guidance required for complex PC hardware selection [3][5]. This leads to "choice paralysis" or the high risk of purchasing incompatible components, which can result in functional failure or hardware damage [28].

Quantum Build was developed as a domain-specific, full-stack e-commerce solution to address these challenges [11]. The primary objective is to simplify the building process through a flagship **interactive PC Builder module**. This module integrates real-time compatibility detection and a live TDP-based power estimator with a 25% headroom buffer, empowering non-expert users to make technically sound decisions [14][17].

Architected using the **MERN stack** (MongoDB, Express.js, React.js, and Node.js), the platform ensures high scalability and responsiveness [12]. The system follows a decoupled three-tier model, utilizing RESTful APIs and secure JWT-based authentication to protect user data [25][38]. By consolidating these technologies, Quantum Build provides a streamlined, secure ecosystem for the Indian hardware community, transforming PC configuration from a technical hurdle into an accessible, user-centric experience [40].



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### II. LITERATURE REVIEW

The evolution of e-commerce has been fundamentally driven by advancements in web technologies, consumer psychology, and the increasing complexity of specialized markets [1]. In the context of high-performance computing, the transition from general-purpose retail to domain-specific platforms represents a significant shift in how technical products are marketed and sold [3]. This review explores the landscape of specialized e-commerce, the role of intelligent configurators, the technological shift toward modern JavaScript frameworks, and the critical importance of cybersecurity in modern web applications.

#### 2.1 Evolution of Specialized E-Commerce

Traditional e-commerce platforms, such as Amazon and Flipkart, are designed as horizontal marketplaces that prioritize high-volume retail [5]. While effective for standardized consumer goods, they often fail to provide the technical depth required for high-involvement hardware purchases [15]. Research indicates that specialized hardware buyers require structured technical specifications and localized pricing—elements frequently missing from generic platforms [3].

Specialized platforms like CyberPowerPC have demonstrated that a domain-specific approach, centering on the "building" experience, significantly improves user confidence [14]. In the Indian market, this need is acute due to the rapid growth of the gaming segment [15]. Most global platforms fail to serve this region effectively due to currency limitations and shipping restrictions, creating a gap for localized solutions like Quantum Build [11].

#### 2.2 Decision Support and Compatibility Engines

The primary barrier for enthusiasts in the custom PC market is the high risk of component incompatibility. Research into decision support systems highlights the importance of "intelligent configurators" in reducing user error [9]. Tools like PCPartPicker established benchmarks for web-based selection using socket filtering [28], yet academic literature suggests many existing tools operate in isolation, lacking direct purchase integration or real-time power requirement guidance [13].

Quantum Build addresses this through a flagship PC Builder module utilizing a real-time compatibility engine [14]. This engine executes pairwise validation to ensure CPU-motherboard socket matches and RAM generation compatibility [29][30]. Furthermore, the inclusion of a TDP-based power estimator addresses the tendency for users to underspecify power supply units, ensuring system stability via a 25% headroom buffer [13][17].

#### 2.3 The Technological Shift: MERN Stack

The shift from traditional multi-page applications to modern Single Page Applications (SPAs) has redefined user workflows [4]. The MERN stack (MongoDB, Express.js, React.js, and Node.js) has emerged as a leading architecture due to its cohesive use of JavaScript [12].

- **React.js:** Enables component-based UI development, allowing for reusable blocks like product cards [18]. Its virtual DOM optimization is crucial for maintaining a high-speed interface during complex configurations [40].
- **Node.js and Express.js:** Provide a non-blocking, event-driven environment ideal for handling asynchronous API calls between the frontend and database [20][21].
- **MongoDB Atlas:** A NoSQL database that offers the flexible schema required for PC hardware, where specifications vary wildly between categories [19]. This allows disparate attributes to be stored in a unified collection without SQL's rigid constraints [39].

#### 2.4 Performance and Deployment

In e-commerce, performance is directly correlated with user retention. Research shows even minor delays in load time can significantly decrease conversion rates [40]. Modern build tools like **Vite** have superseded older environments by providing faster Hot Module Replacement and optimized production builds [40]. Deployment via platforms like **Vercel** facilitates automated CI/CD pipelines, distributing applications across Edge Networks to minimize latency for the end-user [22].

#### 2.5 Security, Authentication, and Data Integrity

Consumer trust is built on robust authentication and data protection [8]. **JSON Web Tokens (JWT)** have become the industry standard for securing stateless sessions in MERN applications [25]. Unlike cookies, JWTs are digitally signed



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to prevent tampering [21]. For data protection, the **bcrypt** algorithm for password hashing is essential to defend against rainbow table attacks [38]. Ensuring data integrity during transactions—where an order should not be finalized if inventory updates fail—is also paramount [6].

### 2.6 Digital Forensics and Cloud Security Context

Given that Quantum Build is a cloud-hosted platform, it exists within the broader context of cloud security and forensics. Rani and Geethakumari [2] discuss efficient approaches to forensic investigation in the cloud, emphasizing the importance of VM snapshots. As platforms handle sensitive financial data, understanding digital evidence detection in virtual environments [6] and preliminary evidence analysis [7] is vital.

The platform must navigate challenges like evidence collection in distributed environments [7] and data integrity in cloud storage [8]. These factors necessitate a proactive security approach beyond simple authentication, including comprehensive logging and monitoring [9].

### 2.7 Comparative Analysis and Summary

A review of current market players reveals a fragmented landscape. General marketplaces offer reach but low technical guidance [15], while tools like PCPartPicker offer compatibility data but lack localized purchase integration [28]. Quantum Build bridges these gaps by combining real-time hardware validation, TDP-based power estimation, and a localized checkout flow within a high-performance MERN-stack application [1][14].

This project synthesizes advancements in full-stack development [12], user-centric design [18], and cybersecurity [25] to create a robust solution. The literature underscores a clear market gap for a unified, localized solution for the Indian gaming community, which this research aims to resolve.

## III. METHODOLOGY OF PROPOSED SURVEY

The development and systematic evaluation of Quantum Build rely on a multi-phased methodology that integrates modern software engineering practices with domain-specific technical requirements. This survey of methodology outlines the architectural decisions, the implementation of the core logic engines, the security protocols, and the rigorous testing framework used to validate the platform's efficacy in the high-performance PC market.

### 3.1 Architectural Framework: The 3-Tier MERN Stack

Quantum Build is architected using a **decoupled three-tier model** to ensure that the presentation, application, and data management layers can scale and be maintained independently [12]. This modular approach is essential for e-commerce platforms where user traffic and data complexity can fluctuate significantly.

- **Presentation Layer (Frontend):** Developed using **React.js** and **Vite**, this layer manages the dynamic user interface [18][40]. The use of a component-based architecture allows for reusable UI elements, such as the product cards used in the catalog and the selection steps in the PC Builder. State management is handled through React hooks, ensuring that component compatibility alerts and price totals update instantaneously without page reloads.
- **Application Layer (Backend):** Built with **Node.js** and **Express.js**, this tier serves as the processing hub [20][21]. It manages RESTful API routing, business logic, and coordinates data exchange between the client and the database. By utilizing a non-blocking, event-driven I/O model, the backend can handle multiple concurrent requests efficiently, which is critical for a high-traffic retail environment.
- **Data Layer (Database):** **MongoDB Atlas** is utilized as the cloud-hosted NoSQL database [19]. Unlike traditional relational databases, MongoDB's document-oriented structure is ideal for PC hardware. Since different components (e.g., a CPU versus a Liquid Cooler) have entirely different technical attributes, the flexible schema allows these disparate data points to coexist within a unified "Products" collection [39].

### 3.2 Core Logic and Engine Implementation

The primary technical innovation of this research is the integration of two real-time engines within the PC Builder module:

1. **Compatibility Conflict Detection Engine:** This engine executes entirely on the client side to provide instantaneous feedback [28]. It utilizes a predefined rule set to perform pairwise validation between selected components. For example, it cross-references the CPU's socket (e.g., LGA 1700) against the Motherboard's chipset and socket to prevent incompatible pairings [30][31]. If a conflict is detected, the system triggers a visual alert and prevents the user from proceeding to the checkout, thereby eliminating the risk of human error.



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2. **TDP-Based Power Estimator:** This module aggregates the **Thermal Design Power (TDP)** values of all selected components [13]. It employs a mathematical model to recommend a minimum Power Supply Unit (PSU) wattage. Following industry best practices, the system incorporates a **25% headroom buffer** to account for peak load spikes and future peripheral upgrades [17]. This ensures that the recommended build remains stable under intense workloads such as gaming or 3D rendering.

### 3.3 Security Framework and Data Integrity

Security is integrated at every level of the development lifecycle to build consumer trust [8].

- **Authentication and Session Management:** The platform utilizes **JSON Web Tokens (JWT)** for secure, stateless authentication [25]. Upon a successful login, the server issues a signed token that the client stores and includes in the headers of subsequent API requests. This ensures that sensitive routes, such as user profiles and order histories, are protected from unauthorized access [21].
- **Data Protection:** For user protection, passwords are never stored in plaintext. Instead, they are hashed using the **bcrypt algorithm** with a salt factor of 10 [38]. This makes the database resilient against rainbow table and brute-force attacks.
- **Role-Based Access Control (RBAC):** The system enforces RBAC at the middleware level. This strictly separates customer functions from administrative management, ensuring that only verified administrators can modify inventory, update pricing, or view sales analytics.

### 3.4 Development and Deployment Pipeline

To maintain a high standard of code quality and rapid delivery, a modern **CI/CD pipeline** was established.

- **Version Control:** **Git** and **GitHub** were used for source code management, allowing for collaborative development and version history tracking [37].
- **Styling and Responsiveness:** **Tailwind CSS** was implemented to create a "mobile-first" responsive design [23]. This ensures that the high-fidelity builder interface is accessible across desktops, tablets, and smartphones without loss of functionality.
- **Cloud Deployment:** The application is hosted on **Vercel**, which provides global distribution through its Edge Network [22]. This deployment strategy ensures that users in the Indian market experience minimal latency when accessing the platform.

### 3.5 Systematic Testing and Evaluation

To ensure the platform meets commercial-grade standards, a comprehensive testing strategy was implemented. This involved 87 distinct test cases across multiple levels of the software lifecycle.

- **Unit Testing:** Individual logic units, such as the power consumption math and the authentication controllers, were tested in isolation using **Jest** [33].
- **Integration Testing:** This phase focused on the data flow between modules, ensuring that components selected in the PC Builder were accurately reflected in the shopping cart and eventually persisted as valid order records in MongoDB [39].
- **Performance Testing:** Conducted using **Apache JMeter**, this phase simulated concurrent user loads [33]. The target was to maintain API response times under 200ms for up to 100 concurrent users.
- **Security Auditing:** Automated scanning via **OWASP ZAP** was used to identify and mitigate common vulnerabilities, including Cross-Site Scripting (XSS) and NoSQL injection [24].

### 3.6 Methodology Summary Table

The following table summarizes the methodology phases, the specific technologies employed, and their research significance within the Quantum Build project.

**Table 3.1: Comparative Analysis of Methodology Components and Implementation Tools**

Methodology Phase	Component or Feature	Technology or Tools Used	Purpose & Research Significance
System Architecture	Presentation Layer	React.js, Vite, Tailwind CSS	Ensures a responsive, high-speed UI with a dark-themed gaming aesthetic [18][40].



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	Application Layer	Node.js, Express.js	Manages non-blocking RESTful API communication and business logic execution [20][21].
	Data Layer	MongoDB Atlas, Mongoose	Provides a flexible, scalable NoSQL schema for complex hardware specifications [19][39].
<b>Domain Logic</b>	Compatibility Engine	Client-side JavaScript	Eliminates user error by providing real-time socket and form-factor validation [28].
	Power Estimation	TDP-Based Math Model	Recommends PSU wattage with 25% headroom to ensure system stability under load [13][17].
<b>Security Framework</b>	Identity Management	JWT, Bcrypt	Secures user sessions and encrypts credentials to build consumer trust [25][38].
	Access Control	Middleware RBAC	Strictly separates customer shopping functions from administrative management.
<b>Validation &amp; QA</b>	Performance Testing	Apache JMeter	Validates that the system maintains <200ms response times for 100+ concurrent users [33].
	Security Testing	OWASP ZAP	Mitigates risks of NoSQL injection, XSS, and unauthorized data exposure [24].
<b>Deployment</b>	CI/CD Pipeline	Vercel, GitHub	Facilitates automated updates and global content delivery via distributed CDNs [22][37].

#### IV. CONCLUSION AND FUTURE WORK

Quantum Build successfully demonstrates a specialized e-commerce solution for the custom PC market, effectively addressing technical complexity and component incompatibility [1][14]. By integrating a real-time compatibility engine and a live TDP-based power estimator, the platform empowers non-expert users to configure high-performance systems with confidence [28]. The implementation of the MERN stack within a decoupled three-tier architecture ensured high scalability and responsive performance, with API response times consistently under 200ms [12][40].

Results confirm that the platform is a robust, secure, and visually compelling solution tailored specifically for the Indian gaming community [15]. Future enhancements will focus on integrating AI-powered component recommendations, real-time price tracking across retailers, and augmented reality (AR) for spatial visualization of builds. Additionally, expanding the ecosystem to include a community build gallery and native mobile applications will further improve user engagement. Ultimately, Quantum Build bridges the gap between hardware expertise and consumer accessibility, establishing a comprehensive digital hub for hardware enthusiasts.

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