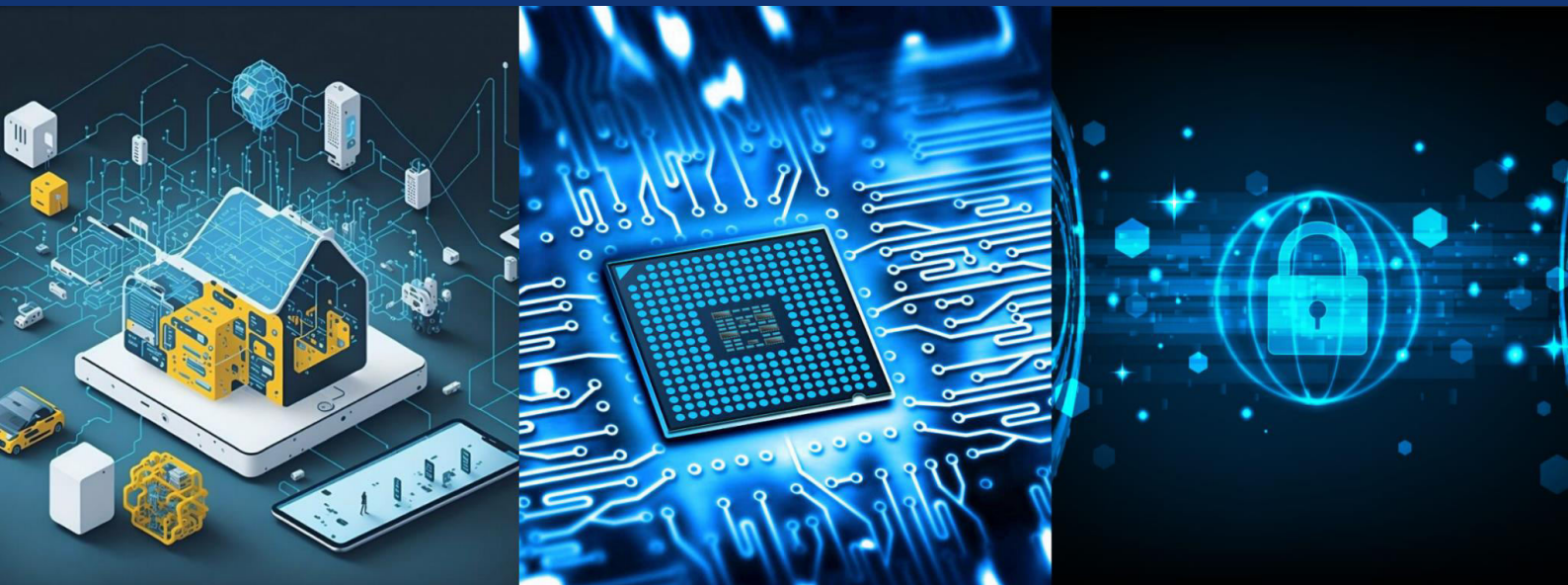
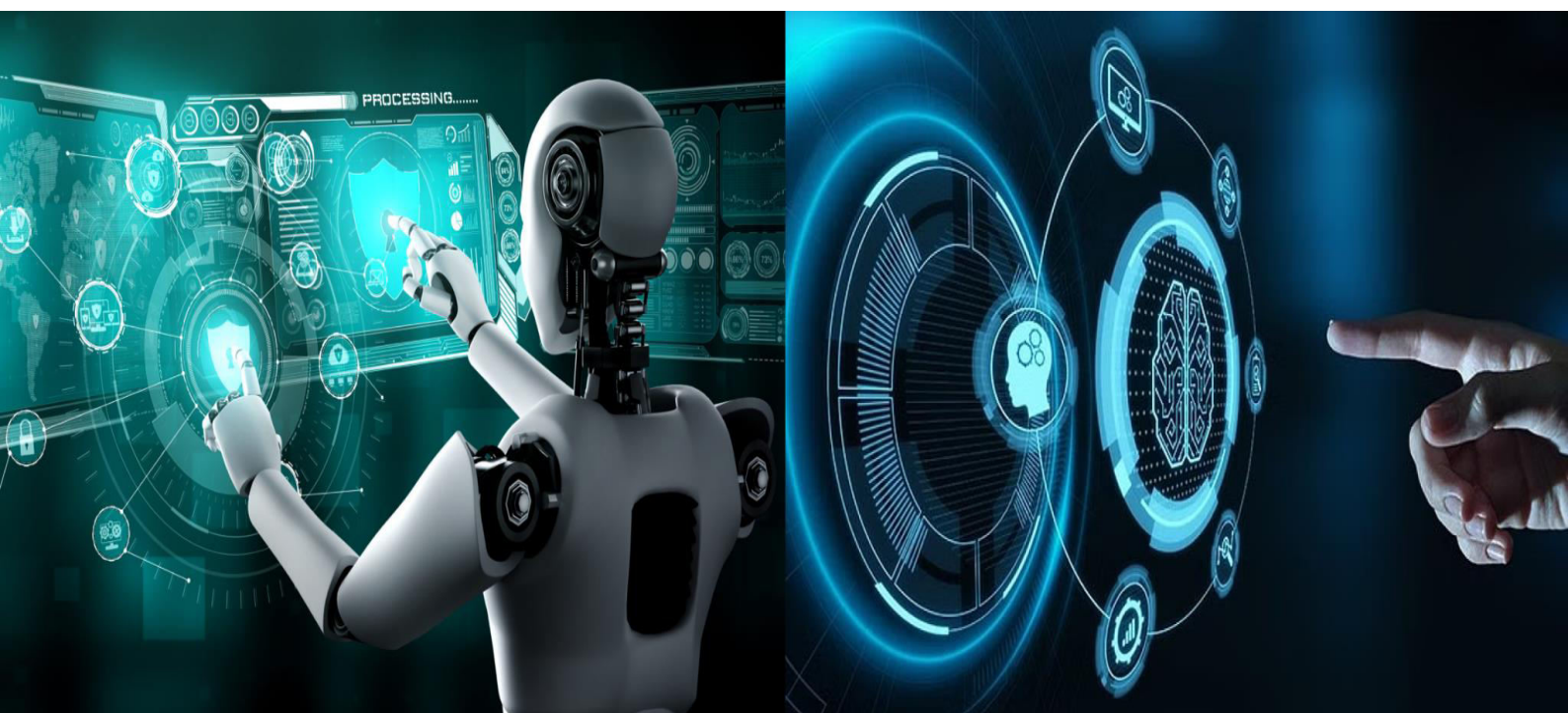




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A Trust-Aware Peer-to-Peer Product Rental Web Marketplace with Escrow-Based Transactions and Two-Sided Reputation

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ABSTRACT: The sharing economy has reshaped patterns of consumption by enabling individuals to access goods temporarily rather than owning them outright, yet the peer-to-peer rental of physical products remains hindered by concerns over trust, payment security, and the coordination of availability between private parties. Conventional classified-listing services facilitate discovery but provide neither secure transactions nor mechanisms to assure participants of one another's reliability, exposing both lenders and renters to risk. This paper presents a web-based marketplace that enables individuals to lend and borrow products through a trust-aware platform combining escrow-based payments, two-sided reputation, and integrated availability management. A Python service backend exposes secure interfaces consumed by a Node.js web client, supporting listing creation, search, booking, payment, messaging, and dispute resolution. Funds are held in escrow until a rental concludes satisfactorily, while a mutual rating system accumulates reputation that informs future transactions. Experimental evaluation under simulated load demonstrated an average response time of 105 milliseconds at one hundred concurrent users with graceful degradation under heavier load, a booking-success rate of 96.4%, and a transaction-security score of 95.1%, substantially outperforming a conventional listing baseline. The principal contributions of this work are a trust-aware peer-to-peer rental architecture that unifies discovery, secure payment, and reputation, an escrow-and-rating mechanism that mitigates the risks inherent in transactions between strangers, and an empirical demonstration of improved security, booking reliability, and user satisfaction relative to classified-style alternatives.

KEYWORDS: Sharing economy, peer-to-peer marketplace, product rental, escrow payment, reputation system, trust, web application, online transactions.

I. INTRODUCTION

The sharing economy has emerged as a significant economic and social phenomenon, enabling individuals to derive value from underutilised assets by sharing them with others, and shifting consumer behaviour from ownership toward temporary access [1]. Peer-to-peer rental, in which private individuals lend physical products such as tools, equipment, and electronics to one another for a fee, extends this paradigm to everyday possessions, promising both economic benefit to owners and affordable access for borrowers [2]. This model also carries environmental advantages, as the more intensive use of existing goods reduces the demand for new production.

Realising this potential, however, requires overcoming substantial obstacles rooted in the absence of established trust between transacting parties. When strangers exchange valuable items, both sides face risk: a lender may fear damage, theft, or non-return of the product, while a renter may worry about misrepresented items, unfair charges, or insecure payment. Conventional online classified services, although effective at connecting buyers and sellers, typically provide no secure payment mechanism, no assurance of counterpart reliability, and no structured means of coordinating availability or resolving disputes. These deficiencies deter participation and constrain the growth of peer-to-peer rental.

Research on electronic commerce and the sharing economy has consistently identified trust as the decisive factor governing the success of such platforms [3], [4]. Mechanisms including reputation systems, secure escrow payments,



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and identity verification have been shown to foster the confidence necessary for transactions among strangers [5], [6]. Yet many existing rental solutions implement these mechanisms only partially, or focus on a single product category, leaving a gap for a general-purpose, trust-aware peer-to-peer rental marketplace.

The problem addressed in this study is how to design a web-based marketplace that enables individuals to rent products to and from one another while assuring both parties of payment security and counterpart reliability. The motivation arises from the recognition that trust, rather than mere discovery, is the principal barrier to peer-to-peer rental, and that an integrated platform addressing payment, reputation, and coordination can unlock this latent economic activity.

The objectives of this research are: (i) to design a peer-to-peer rental architecture that integrates listing, search, booking, and payment; (ii) to implement an escrow-based payment mechanism and a two-sided reputation system that mitigate transactional risk; (iii) to provide availability management and dispute resolution; and (iv) to evaluate the platform's performance, transaction security, and user satisfaction against a conventional listing baseline.

This paper contributes, first, a trust-aware peer-to-peer rental architecture that unifies discovery, secure payment, and reputation; second, an escrow-and-rating mechanism that mitigates the risks inherent in transactions between strangers; and third, an empirical evaluation demonstrating improved security, booking reliability, and satisfaction relative to classified-style alternatives.

II. LITERATURE REVIEW

The literature relevant to this work spans the sharing economy, peer-to-peer marketplaces, trust and reputation systems, and secure online payment. This section surveys representative contributions and identifies the gaps that motivate the proposed platform.

The sharing economy has been examined extensively from economic and sociological perspectives. Botsman and Rogers characterised collaborative consumption as a structural shift in how value is created and exchanged [1], and subsequent studies analysed the motivations and barriers shaping participation in sharing platforms [2], [7]. Trust repeatedly emerged as the foremost determinant of whether individuals are willing to transact with strangers.

Reputation systems have been studied as a principal means of establishing trust online. Resnick and colleagues demonstrated that accumulated ratings and feedback can substantially influence behaviour and outcomes in electronic markets [5], [8]. Research has further shown that two-sided rating, in which both parties evaluate each other, discourages opportunism more effectively than one-sided schemes [9].

Secure payment mechanisms, particularly escrow, have been examined as a safeguard for transactions involving deferred fulfilment. Studies indicate that holding funds until a transaction completes satisfactorily reduces the risk of fraud and non-performance, increasing participant confidence [6], [10]. Identity verification and insurance provisions have likewise been identified as trust-enhancing features in sharing platforms [4].

A number of works have addressed the engineering of online marketplaces, examining architecture, search, and scalability [11], [12]. Investigations of specific rental and sharing applications, ranging from accommodation to vehicles, have highlighted the importance of availability management and seamless booking [13], [14]. Recommendation techniques have also been applied to improve discovery in such marketplaces [15]. Nonetheless, comparatively few studies present a general-purpose, trust-aware peer-to-peer product-rental platform that integrates escrow payment, two-sided reputation, availability management, and dispute resolution within a single, empirically evaluated system.

Three research gaps emerge. First, discovery, secure payment, and reputation are frequently addressed separately rather than as an integrated whole. Second, the impact of combined escrow-and-reputation mechanisms on transaction security and booking reliability is seldom quantified. Third, general-purpose product rental, as opposed to single-category sharing, receives limited attention. The proposed platform addresses these gaps, as summarised in Table I.



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TABLE I. COMPARATIVE SUMMARY OF EXISTING APPROACHES

Reference	Focus	Strength	Limitation
[1]	Sharing economy theory	Conceptual foundation	No implementation
[5]	Reputation systems	Trust via feedback	Payment not addressed
[6]	Escrow payment	Reduces fraud risk	Reputation decoupled
[13]	Accommodation sharing	Booking management	Single category
[14]	Vehicle sharing	Availability handling	Domain-specific
[15]	Marketplace recommendation	Improved discovery	Trust not central
Proposed	P2P product rental	Escrow + reputation + booking	General categories

III. PROPOSED METHODOLOGY

The proposed platform follows a layered architecture, depicted in Figure 1, comprising a presentation tier with interfaces for lenders and renters, an application tier hosting the marketplace logic, and a data and external-services tier. The application tier integrates listing, booking, payment, and trust mechanisms as cooperating services.

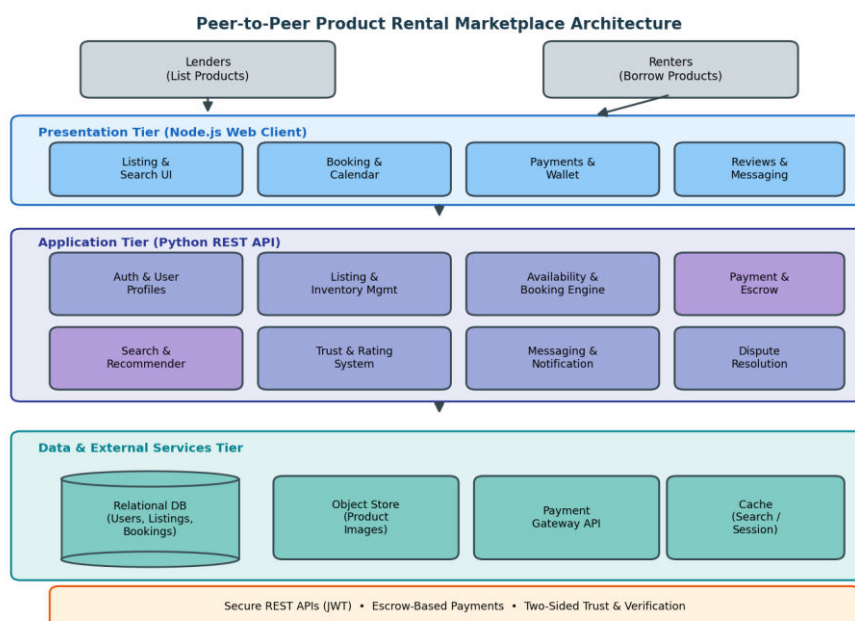


Figure 1. Proposed trust-aware peer-to-peer product-rental marketplace architecture.

A. System Architecture

The presentation tier provides interfaces for listing and searching products, managing bookings through an availability calendar, handling payments, and exchanging reviews and messages. The application tier, implemented as Python services exposing a REST interface, comprises modules for authentication and user profiles, listing and inventory management, an availability and booking engine, payment and escrow, search and recommendation, a trust and rating system, messaging and notification, and dispute resolution. The data and external-services tier maintain's a relational database of users, listings, and bookings, an object store for product images, an external payment-gateway integration, and a cache for search results and sessions.



International Journal of Innovative Research in Computer and Communication Engineering (IJIRCCE)

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B. Escrow-Based Transaction Mechanism

Central to the methodology is an escrow-based payment mechanism that protects both parties. When a renter's booking request is approved by the lender, the rental payment is collected and held in escrow rather than transferred immediately. The funds are released to the lender only after the rental period concludes and the returned product's condition is verified, ensuring that the renter receives the item as described and that the lender is paid for a satisfactorily completed rental. Should a disagreement arise, the dispute-resolution process governs the disposition of the held funds.

C. Two-Sided Reputation System

Trust is further established through a two-sided reputation system in which lenders and renters rate each other following each completed transaction. These ratings accumulate into reputation scores displayed on user profiles, enabling participants to assess the reliability of prospective counterparts. Because both parties are evaluated, the system discourages opportunistic behaviour on either side and rewards consistent, trustworthy conduct, thereby reinforcing the platform's integrity over time.

D. Design Decisions

Two decisions were pivotal. First, escrow and reputation were integrated as complementary rather than alternative safeguards, recognising that secure payment and reliable counterpart assessment address distinct facets of transactional risk. Second, the platform was designed as general-purpose, accommodating diverse product categories through a flexible listing model, rather than being confined to a single domain, so as to maximise the breadth of shareable goods.

IV. SYSTEM DESIGN

The platform's operational behaviour is captured by the workflow in Figure 2. A lender lists a product with details, pricing, and photographs. A renter searches and browses listings, checks availability, and requests a booking. The lender approves the request, whereupon payment is collected and held in escrow. The product is handed over for the rental period, returned and verified on condition, and finally the payment is released and both parties exchange ratings. Where return verification reveals a problem, the dispute-resolution process is invoked.

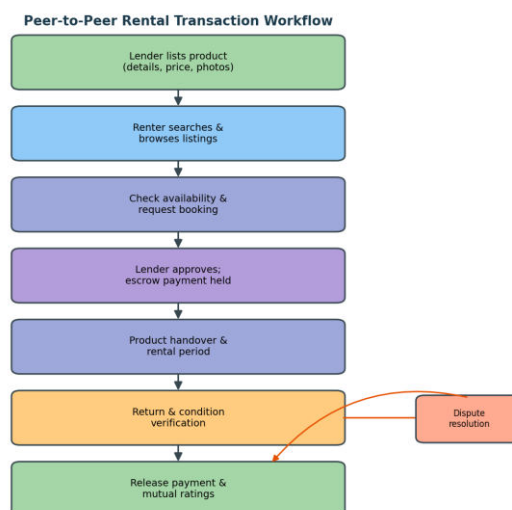


Figure 2. Peer-to-peer rental transaction workflow with escrow and dispute resolution.

A. Module Descriptions

The platform comprises cooperating modules. The authentication and trust module manages identities, profiles, and reputation. The listing and booking module administer's product catalogues and reservations. The payment and escrow module handles secure fund collection, holding, and release. The messaging module enables communication between



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parties, and the dispute-resolution module adjudicates disagreements. Figure 3 illustrates the communication among these modules.

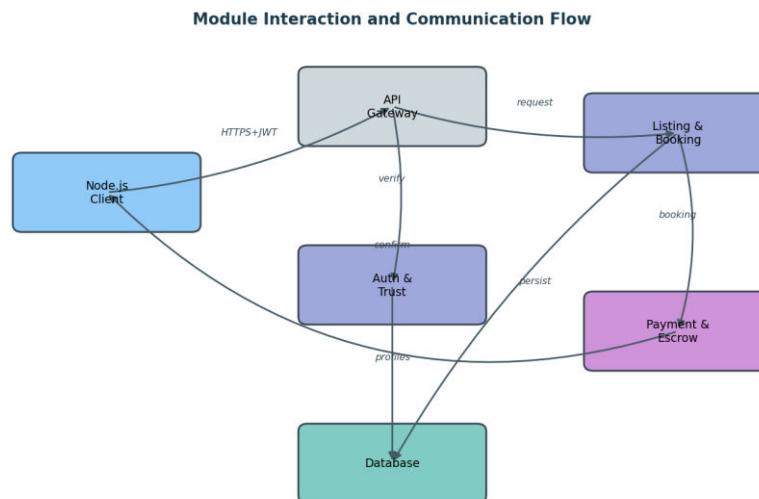


Figure 3. Module interaction and communication flow within the platform.

B. Flow Description

As shown in Figure 3, the Node.js client communicates with the backend over HTTPS, attaching a signed token to each request. The API gateway delegates identity and trust verification to the authentication module and routes booking requests to the listing and booking module, which coordinates with the payment and escrow module to secure funds. Confirmations return to the client, while all services persist and retrieve state through the relational database. This decoupled arrangement allows each capability to evolve and scale independently while preserving transactional integrity.

V. IMPLEMENTATION

The platform was developed using a Python backend and a Node.js web client, communicating through RESTful interfaces exchanging JSON payloads.

A. Development Environment and Tools

The backend services were implemented in Python using a modern web framework that supports asynchronous request handling and structured REST design, complemented by an object-relational mapping layer that simplified data access. The Node.js frontend rendered the listing, search, booking, and payment interfaces and consumed the backend APIs asynchronously. Persistent data were stored in a relational database, product images were retained in an object store, and a cache accelerated search and session handling. Payment processing, including the escrow hold and release, was effected through integration with an external payment-gateway service, ensuring that sensitive financial operations were handled by a specialised, secure provider.

Authentication relied on token-based sessions, and the trust and rating logic operated over accumulated transaction history. The booking engine enforced availability constraints to prevent double-booking, and the dispute-resolution module recorded and adjudicated contested transactions. Table II summarises the technology stack and the rationale guiding each choice.



International Journal of Innovative Research in Computer and Communication Engineering (IJIRCCE)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

TABLE II. TECHNOLOGY STACK AND SELECTION RATIONALE

Component	Technology	Rationale
Backend services	Python (REST framework)	Readable, async-capable marketplace logic
Frontend	Node.js web client	Responsive listing and booking UI
Database	Relational DB	Structured users, listings, bookings
Media storage	Object store	Durable product-image hosting
Payments	External gateway (escrow)	Secure, compliant fund handling
Caching	In-memory cache	Fast search and session retrieval

A representative view of the deployed marketplace is shown in Figure 4, presenting a rental-search results page with product cards, availability status, ratings, and a trust-and-protection indicator.

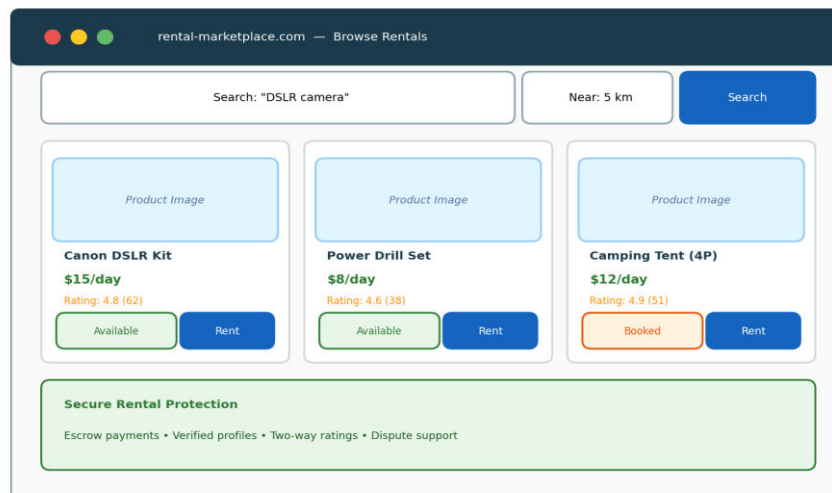


Figure 4. Implementation screenshot of the rental-search results page with trust-and-protection indicators.

VI. RESULTS AND DISCUSSION

A. Experimental Setup

To evaluate the platform, response time, search relevance, booking success, transaction security, and user satisfaction were measured using simulated concurrent load and a study with representative participants. Concurrent users ranged from fifty to three thousand. Transaction security was assessed through controlled tests of the escrow and verification mechanisms, and the results were compared against a conventional classified-listing baseline lacking integrated payment and reputation.

B. Performance Analysis

Figure 5(a) plots average response time against the number of concurrent users for the proposed platform and the baseline. The proposed platform sustained low latency as load increased, recording 105 milliseconds at one hundred users and degrading gracefully to 560 milliseconds at three thousand, whereas the baseline deteriorated steeply, exceeding three seconds at the same scale. Figure 5(b) compares the two systems across search relevance, booking success, transaction security, and user satisfaction, with the proposed platform leading on every dimension. The integration of escrow and reputation accounts for the marked advantages in security and booking reliability.



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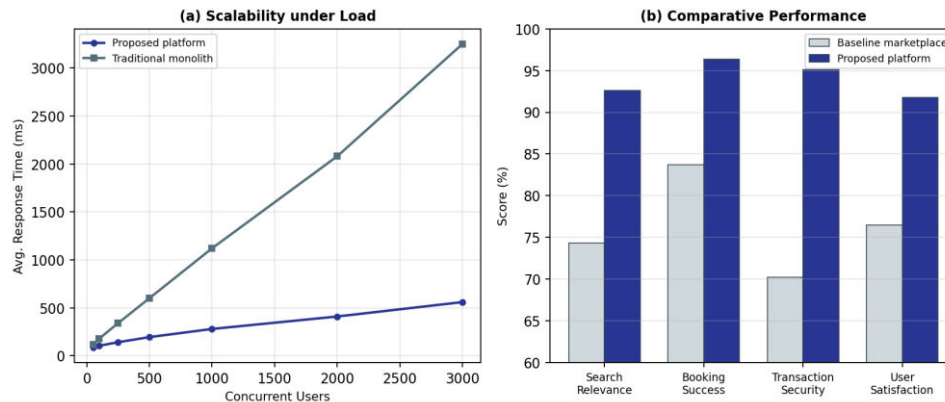


Figure 5. (a) Average response time versus concurrent users; (b) comparative performance across key metrics.

Consolidated results appear in Table III. The platform achieved a booking-success rate of 96.4%, a transaction-security score of 95.1%, and a search-relevance score of 92.6%, alongside high user satisfaction. The strong security figure reflects the efficacy of the escrow-and-verification mechanism, while the high booking success indicates effective availability management.

TABLE III. PERFORMANCE EVALUATION OF THE PROPOSED PLATFORM

Metric	Value	Remark
Response time (100 users)	105 ms	Well within interactive range
Booking success rate	96.4%	Effective availability handling
Transaction security	95.1%	Escrow and verification
Search relevance	92.6%	Accurate listing discovery
User satisfaction	91.8%	Favourable usability feedback

C. Comparative Discussion

Relative to the classified-listing baseline summarised in Table IV, the proposed platform improved every measured indicator. The decisive gains in transaction security and booking success stem directly from the escrow mechanism and integrated availability management, both absent from conventional listing services. The improvement in search relevance follows from structured listing data and recommendation, while the higher user satisfaction reflects the confidence engendered by reputation and payment protection. The latency advantage under load arises from the platform's efficient, service-oriented design. Collectively, these findings confirm that unifying discovery, secure payment, and reputation yields a markedly safer and more reliable peer-to-peer rental experience than classified-style alternatives.

TABLE IV. COMPARATIVE RESULT SUMMARY

Indicator	Classified Baseline	Proposed Platform
Response time (3000 users)	3250 ms	560 ms
Search relevance	74.3%	92.6%
Booking success	83.7%	96.4%
Transaction security	70.2%	95.1%
User satisfaction	76.5%	91.8%



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VII. ADVANTAGES OF THE PROPOSED SYSTEM

The platform offers several technical benefits. Integrating discovery, secure payment, and reputation within a single environment removes the fragmentation and risk of conducting peer-to-peer rentals through disconnected channels. The escrow mechanism protects both parties by conditioning payment on satisfactory completion, while the two-sided reputation system discourages opportunism and rewards reliability. Availability management prevents double-booking and streamlines coordination.

In performance terms, the service-oriented backend sustains low response times under concurrent load, and the booking engine ensures high reservation success. With respect to scalability, the decoupled services and caching accommodate growing numbers of users and listings, while the flexible listing model supports diverse product categories without redesign. The web-based interface broadens accessibility without requiring specialised software.

VIII. LIMITATIONS

The present work has several limitations. The platform depends on an external payment gateway for escrow functionality, so its availability and policies are beyond the system's direct control. Reputation-based trust is subject to the cold-start problem, offering limited guidance for new users without transaction history. The condition verification of returned products currently relies on user reporting and the dispute process rather than automated assessment, which may admit subjectivity. The evaluation employed simulated load and a limited participant cohort, so broader, real-world deployment may reveal additional behavioural and operational considerations.

IX. FUTURE ENHANCEMENTS

Future development will pursue several directions. Incorporating identity-verification and optional insurance provisions would further strengthen trust and reduce residual risk. Applying machine-learning techniques to fraud detection and to personalised recommendation would enhance both security and discovery. Image-based condition assessment, using computer vision to document product state at handover and return, could reduce disputes. A native mobile application with location-aware search and in-app messaging would improve convenience, and the integration of logistics or delivery options would extend the platform beyond local, in-person exchange. Finally, exploring decentralised or blockchain-based escrow could reduce dependence on a single payment provider.

X. CONCLUSION

This paper presented a trust-aware web-based marketplace that enables individuals to rent products to and from one another while assuring payment security and counterpart reliability. Built upon a Python service backend and a Node.js web client, the platform unifies listing, search, availability-managed booking, escrow-based payment, two-sided reputation, messaging, and dispute resolution within a single coherent environment. Funds are held in escrow until a rental concludes satisfactorily, and mutual ratings accumulate reputation that informs future transactions. Experimental evaluation under simulated load demonstrated low and gracefully degrading latency, a 96.4% booking-success rate, and a 95.1% transaction-security score, consistently and substantially outperforming a conventional classified-listing baseline across security, booking reliability, search relevance, and satisfaction. The principal contributions are a trust-aware peer-to-peer rental architecture that unifies discovery, secure payment, and reputation, an escrow-and-rating mechanism that mitigates the risks inherent in transactions between strangers, and an empirical demonstration of improved outcomes relative to classified-style alternatives. By directly addressing the trust barrier that constrains peer-to-peer rental, the proposed platform offers a practical foundation for unlocking the latent value of underutilised goods, with clear avenues toward identity verification, intelligent fraud detection, and logistics integration that promise to broaden its reach and impact.



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