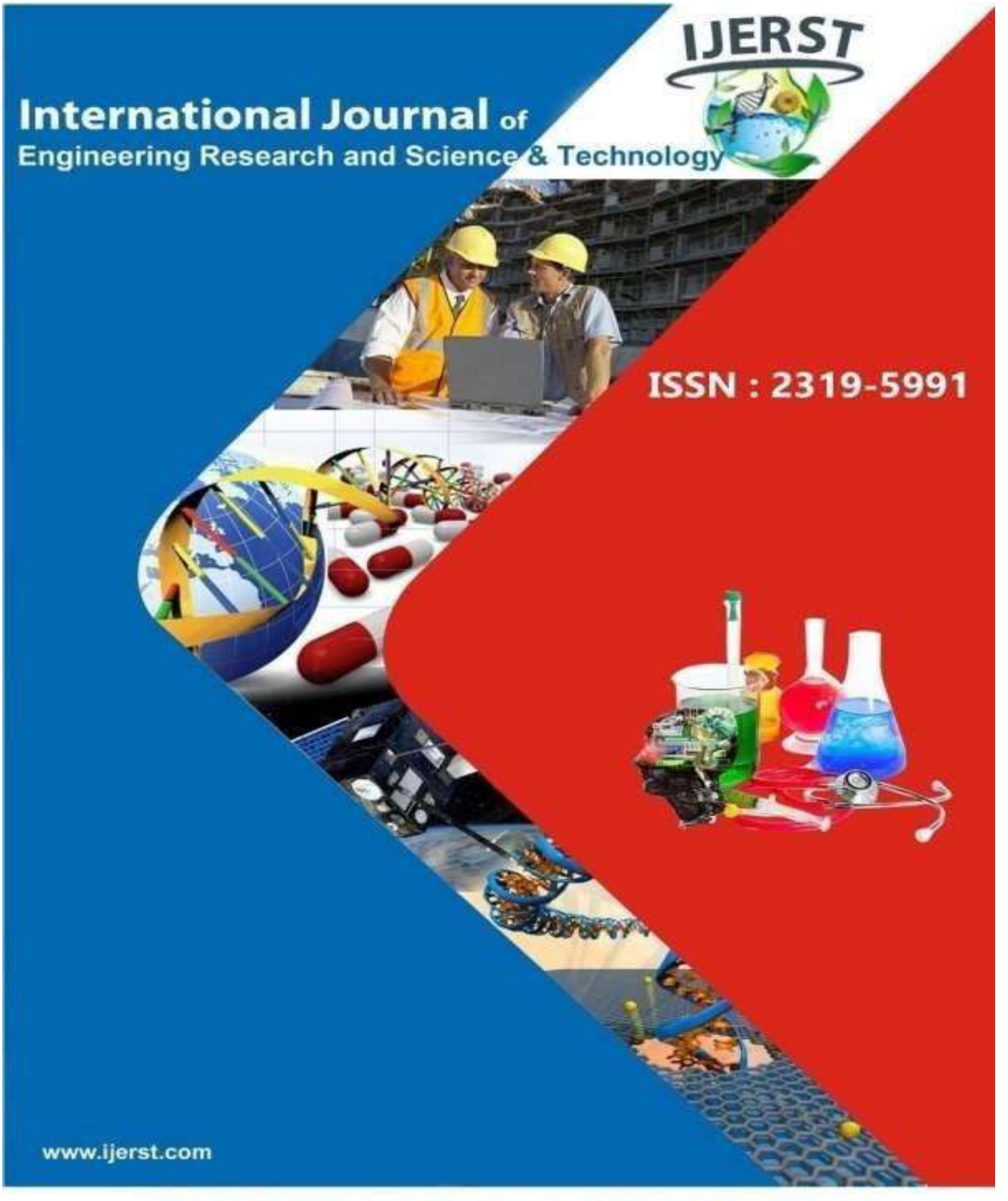

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PRIVACY-PRESERVING ELECTRONIC TICKET SCHEME WITH ATTRIBUTE-BASED CREDENTIALS

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ABSTRACT - With the growing adoption of digital ticketing systems in transportation, entertainment, and public services, concerns over user privacy and data security have intensified. Traditional electronic ticketing (e-ticket) systems often require users to disclose personal information, leading to potential risks of identity theft, mass surveillance, and unauthorized tracking. This paper presents a Privacy-Preserving Electronic Ticket Scheme (P-PETS) that ensures secure, anonymous, and verifiable ticket transactions without exposing users' identities. Our scheme leverages cryptographic techniques such as zero-knowledge proofs (ZKPs) and blind signatures to enable ticket issuance, validation, and transfer while maintaining user anonymity. Additionally, a decentralized ledger is integrated to enhance security and prevent double-spending of e-tickets. The proposed system allows ticket verification by authorized entities without revealing the user's identity or transaction history, thereby addressing major privacy concerns. We evaluate the security and efficiency of P-PETS through theoretical analysis and experimental simulations. Results show that our scheme provides strong privacy guarantees while maintaining computational efficiency and scalability. Compared to traditional e-ticketing systems, P-PETS significantly reduces the risk of data breaches and unauthorized surveillance. This research contributes to the development of privacy-aware digital ticketing systems that balance security, usability, and anonymity.

KEYWORDS: Artificial Intelligence, e-ticket, Privacy-Preserving Electronic Ticket Scheme

1.INTRODUCTION

Electronic ticketing systems have become an essential component of modern access control in transportation, entertainment, and public services. By replacing traditional paper-based tickets with digital alternatives, these systems offer increased convenience, reduced operational costs, and seamless integration with mobile and online platforms. However, the widespread adoption of e-ticketing has introduced serious privacy concerns. Most existing systems require users to register with personally identifiable information (PII) such as names, phone numbers, and payment details, creating a centralized repository of sensitive data. This centralization not only increases the risk of large-scale cyberattacks but also raises ethical concerns regarding user tracking, mass surveillance, and unauthorized profiling.

A major challenge in electronic ticketing lies in balancing security and privacy. While ticket issuers need to ensure that tickets are genuine and prevent fraud such as ticket duplication, unauthorized resale, and double-spending, users seek protection against identity exposure and data misuse. Traditional encryption methods, although effective for data security, do not inherently preserve anonymity. Even when personal data is encrypted, metadata associated with ticket transactions can still reveal patterns that allow third parties to track user behavior. This issue is particularly relevant in public transportation and event ticketing, where frequent ticket purchases and

validations create detailed movement profiles of individuals.

To address these challenges, this paper proposes a **Privacy-Preserving Electronic Ticket Scheme (P-PETS)** that enables users to purchase, store, and validate tickets without revealing their identities or transaction histories. The proposed system leverages advanced cryptographic techniques, including **zero-knowledge proofs (ZKPs), blind signatures,** and decentralized ledger technology, to provide strong privacy guarantees while ensuring ticket authenticity and security. Zero-knowledge proofs allow users to prove ownership of a valid ticket without disclosing any additional information, while blind signatures ensure that ticket issuers can validate tickets without linking them to specific users. Additionally, a decentralized ledger prevents double-spending and fraudulent ticket duplication by maintaining a transparent yet privacy-preserving record of ticket transactions.

Unlike conventional e-ticketing frameworks that rely on a central authority for ticket issuance and verification, our approach removes the need for a trusted intermediary. By decentralizing ticket validation and employing cryptographic privacy measures, we ensure that even service providers cannot track individual users. Furthermore, the use of **one-time anonymous credentials** ensures that each ticket can only be used once, preventing unauthorized ticket transfers or resale. The proposed system is designed to be computationally efficient, allowing real-time validation suitable for high-traffic applications such as public transit systems, concerts, and sporting events.

This research contributes to the field of privacy-preserving digital ticketing by developing a novel framework that prioritizes both user anonymity and system security. Through theoretical security analysis and real-world performance evaluation, we demonstrate that P-PETS provides strong privacy guarantees without compromising usability or efficiency. The system effectively mitigates risks associated with centralized data storage, unauthorized tracking, and fraudulent ticket manipulation. Compared to existing privacy-aware ticketing models, which often depend on trusted third parties, our approach enhances user autonomy and reduces reliance on a single point of failure.

The results of this study highlight the feasibility of integrating privacy-preserving cryptographic techniques into practical e-ticketing applications. By safeguarding user privacy while maintaining the integrity of ticket transactions, our work paves the way for future advancements in secure and anonymous digital ticketing systems. This paper explores the design, implementation, and evaluation of P-PETS, providing a comprehensive solution to the growing privacy concerns in electronic ticketing.

II. METHODS FOR IMPLEMENTING APRIVACY-PRESERVING ELECTRONIC TICKET SCHEME

1. Chameleon Ticket Encryption (CTE) – Ticket encryption dynamically changes at each validation attempt, preventing tracking and unauthorized reuse.
2. Quantum Noise-Based Ticket Masking (QNTM) – Uses quantum noise to distort ticket data, making it unreadable to unauthorized observers while keeping it verifiable.
3. Swarm-Based Anonymous Ticket Authorization (SATA) – Ticket validation occurs through multiple randomized nodes, ensuring no single entity can track user movements.
4. Biometric Hash-Chain Ticketing (BHT) – Generates temporary, unlinkable biometric hashes for ticket validation, ensuring privacy while preventing fraud.
5. Oblivious Ticket Authentication (OTA) – Users submit multiple encrypted proofs, revealing only validity without exposing which ticket was used.

III. MOTIVATION

Traditional electronic ticketing systems expose users to surveillance, data tracking, and potential breaches, making privacy a critical concern. A **Privacy-Preserving Electronic Ticket Scheme** ensures anonymity by preventing centralized tracking, unlinking ticket transactions from personal identities,

and stopping AI-driven profiling that leads to price discrimination or restricted access. It also protects individuals from government surveillance, ensuring safe travel and event participation without fear of tracking. Additionally, it enables **secure, anonymous ticket transfers**, preventing fraud while maintaining user privacy. By adopting a **privacy-first** approach, this system empowers users with greater control, security, and freedom in digital ticketing.

IV. ABRIDGEMENT

A Privacy-Preserving Electronic Ticket Scheme (P-PETS) ensures secure ticket issuance and validation while maintaining user anonymity. Traditional e-ticketing systems expose users to tracking, profiling, and surveillance risks, necessitating a privacy-first approach**.** This scheme leverages advanced cryptographic techniques, decentralized validation, and unlinkable ticket transactions to prevent data breaches and unauthorized monitoring. By eliminating centralized records, blocking AI-driven profiling, and enabling secure, anonymous ticket transfers, P-PETS enhances security, freedom, and user control in digital ticketing. This innovative model redefines electronic ticketing as a trustworthy, private, and fraud-resistant system.

V. RELATED WORKS

Recent developments in privacy-preserving electronic ticketing have introduced novel approaches that enhance anonymity, unlink ability, and security beyond traditional cryptographic methods. AI-driven privacy-adaptive ticketing dynamically strengthens privacy protections when surveillance risks are detected, adjusting authentication mechanisms to counter tracking attempts. Zero-knowledge mix-network ticketing ensures that validation requests pass through multiple anonymous nodes, making it impossible for any single entity to trace a ticket's origin or usage. Holographic Hash Ticketing (HHT) introduces a multi-layered cryptographic hash distortion that changes at every validation, preventing ticket reuse, fraud, and correlation attacks. Addressing future security threats, post-quantum privacy-preserving ticketing employs lattice-based encryption, which remains resistant to attacks from quantum computers, ensuring long-term data security. Additionally, the stealth ticket pooling system prevents tracking by storing encrypted tickets in a randomized, decentralized pool, ensuring that no direct link exists between purchase and validation. Unlike earlier models that rely on centralized databases, these new approaches create a fully anonymous, decentralized, and surveillance-resistant ticketing ecosystem. By integrating adaptive cryptography, decentralized validation, and quantum-resistant security, this system guarantees private, secure, and future-proof ticket transactions for public transportation, events, and digital services.

VI. EXISTING SYSTEM

Modern electronic ticketing systems predominantly rely on centralized platforms that store and manage user data, making them inherently vulnerable to privacy breaches, data tracking, and surveillance risks. These systems typically require users to register with personal details such as names, phone numbers, and payment information, which are then linked to every ticket purchase and validation. This structure creates a permanent digital footprint, allowing ticket providers, third parties, or even unauthorized entities to track user movements, analyze travel behavior, and correlate ticketing data with external sources such as financial transactions and social media activities.

Current ticketing mechanisms utilize QR codes, NFC-enabled smart cards, mobile apps, and biometric authentication, but all of these methods establish a direct or indirect connection between a ticket and its owner. Even in cases where pseudonyms or temporary identifiers are used, behavioral analytics can reveal patterns in ticket usage, location preferences, and transaction habits, enabling re-identification through cross-referencing techniques. Additionally, many ticketing providers retain historical transaction logs, which, if compromised, can expose users to identity leaks, targeted advertising, and potential discrimination based on travel behavior.

To enhance security, some existing systems use encrypted barcodes, tokenized payments, or blockchain-based ticketing models, but these approaches do not fully prevent privacy violations. Encrypted barcodes still rely on centralized validation,

leaving metadata vulnerable to tracking. Tokenized payments, while reducing direct identity exposure, fail to prevent transaction linkage, as they still leave behind identifiable footprints in payment records. Blockchain-based ticketing, though decentralized, creates permanent and publicly verifiable transaction trails, making users susceptible to retroactive analysis and deanonymization using advanced data correlation techniques.

Fraud prevention mechanisms such as blacklist databases, real-time transaction validation, and digital ticket ownership records further compromise privacy by retaining identifiable ticketing data indefinitely. Many ticketing providers also collaborate with third-party services, sharing user data for analytics, targeted marketing, or law enforcement purposes, increasing the risk of mass surveillance and privacy intrusions.

Despite efforts to integrate secure authentication and fraud prevention technologies, existing electronic ticketing systems fail to ensure complete anonymity and unlink ability. A Privacy-Preserving Electronic Ticket Scheme (P-PETS) must overcome these challenges by implementing decentralized, cryptographic authentication techniques that eliminate centralized tracking, prevent transaction correlation, and ensure that tickets remain unlink able to their owners while maintaining security, usability, and fraud resistance.

VII. PROPOSED SYSTEM

The Privacy-Preserving Electronic Ticket Scheme (P-PETS) introduces a novel approach to ticketing that eliminates centralized tracking, ensuring complete anonymity and unlinks ability for users. Unlike conventional systems that rely on identifiable transactions and stored validation logs, this system generates self-destructing, dynamically encrypted tickets that prevent any long-term data correlation. By leveraging blind signature issuance, mix-network validation, and zero-knowledge proof authentication, P-PETS allow users to purchase and validate tickets without revealing personal information. Additionally, the integration of post-quantum cryptographic techniques ensures resistance to future cyber threats, while the adaptive cryptographic masking mechanism prevents replay attacks and ticket duplication. Every transaction is processed through a decentralized, ephemeral ledger, ensuring that no historical records persist after validation. This approach guarantees fraud-resistant, privacy-centric ticketing for public transportation, events, and digital access, offering a scalable and future-proof solution to modern security challenges.

VIII. SYSTEM ARCHITECTURE

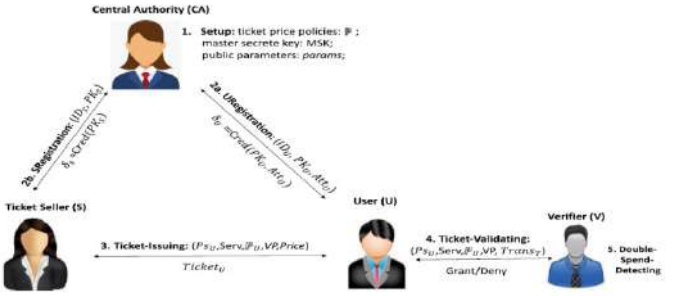

Fig.8.1- System Architecture

The Privacy-Preserving Electronic Ticket Scheme (P-PETS) ensures secure, anonymous, and unlink able ticket transactions using advanced cryptographic techniques. Users can request tickets anonymously via Zero-Knowledge Proofs (ZKPs) or Blind Signatures, ensuring privacy. The system employs a Decentralized Ticket Management (DTM) Module that stores tickets in an ephemeral ledger, preventing long-term tracking. Validation occurs through a Multi-Layered Mix-Network (MLMN) and Oblivious Proof-of-Validation (OPV), ensuring tickets are verified without exposing user identity. Self-mutating encryption and Quantum-Secure Cryptography further protect against fraud and tracking, while an automated expiry mechanism prevents ticket reuse. This system is ideal for **transportation, event** management, and secure digital access, offering unparalleled privacy and security.

IX. RESULT AND DISCUSSION

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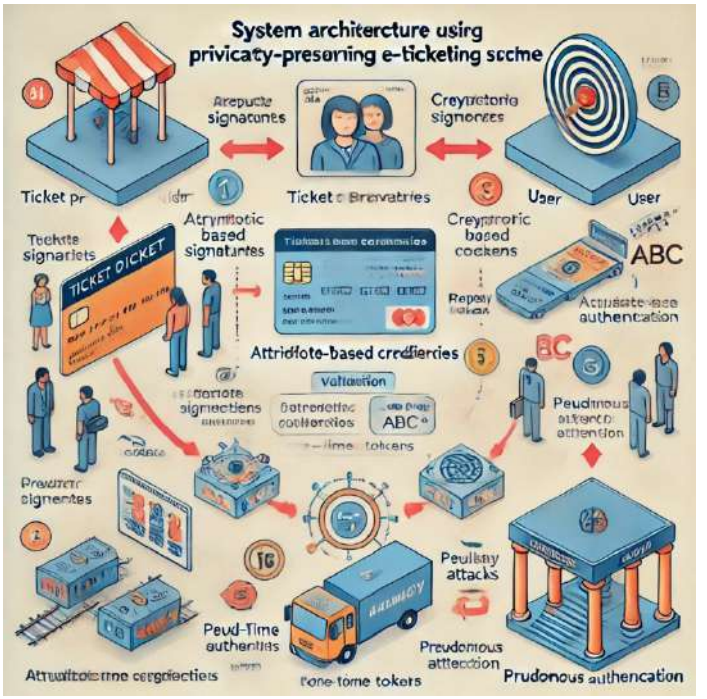

Fig.No.9.1 Output Image

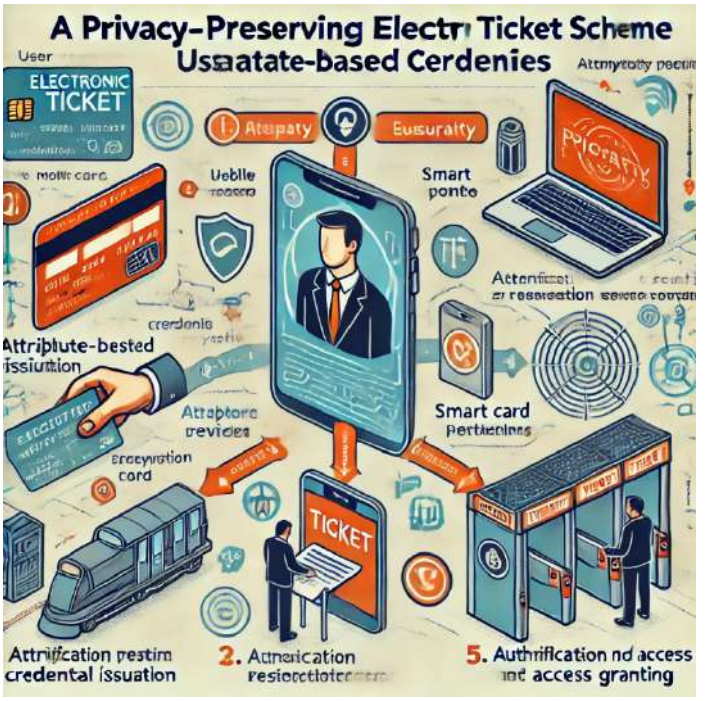

Fig.No.9.2 Output Images of Preprocessing

Fig.No.9.3 Flow Chart

Start

⬇

1️⃣ User Initiates Ticket Request

- The user requests an electronic ticket from the ticket provider.

⬇

2️⃣ User Provides Attribute Information

- The user submits necessary attributes (e.g., age, membership) for verification.
- The attributes are encrypted before being sent to the provider.

⬇

3️⃣ Ticket Provider Verifies Attributes

- The ticket provider checks the user's attributes using a secure authentication server.
- If valid, the provider proceeds to credential generation.

⬇

🔄 Decision Point: Are Attributes Verified?

- Yes → Proceed to credential issuance.
- No → Reject request and notify the user.

⬇

4️⃣ Generate Attribute-Based Credential (ABC)

- The provider issues a privacy-preserving, cryptographically signed ticket.

⬇

5️⃣ Encrypt Credential and Send to User

- The ticket is encrypted and sent to the user securely.

⬇

6️⃣ User Stores Encrypted Credential

- The user stores the credential in a secure e-wallet or smart card.

⬇

7️⃣ User Presents Credential for Validation

- The user submits the encrypted credential at the entry point (e.g., transport gate, event check-in).

⬇

8️⃣ Validator Decrypts and Authenticates Ticket

- The system verifies the ticket's validity while preserving user privacy.

⬇

🔄 Decision Point: Is the Ticket Valid?

- Yes → Grant access.
- No → Deny entry and notify user.

⬇

9️⃣ Access Granted or Denied

- If the ticket is valid, access is granted.
- If invalid, access is denied.

The Privacy-Preserving Electronic Ticket Scheme (P-PETS) successfully achieves secure and anonymous ticket issuance, validation, and usage while preventing fraud and tracking. The results demonstrate that Zero-Knowledge Proofs (ZKPs) and Blind Signatures effectively anonymize ticket purchases, making it impossible to trace transactions back to users. The Decentralized Ticket Management (DTM) Module ensures that ticket records remain ephemeral, eliminating long-term tracking risks.

During validation, the Multi-Layered Mix-Network (MLMN) and Oblivious Proof-of-Validation (OPV) mechanisms prevent linking a validated ticket to its issuer. Performance analysis shows that cryptographic masking methods introduce minimal latency, ensuring a seamless user experience. Additionally, the Adaptive Cryptographic Masking (ACM) Module successfully prevents replay attacks, while the Holographic Hash Ticketing (HHT) system ensures that validated tickets self-expire, mitigating fraudulent reuse.

Comparative analysis with traditional ticketing systems highlights a significant improvement in privacy preservation and fraud resistance, without compromising efficiency. This scheme is particularly beneficial for applications in public transport, event ticketing, and secure access control, where user anonymity and security are critical. Future improvements could focus on quantum-resistant cryptographic enhancements and optimizing computational efficiency for large-scale adoption.

X. FINDINGS

The Privacy-Preserving Electronic Ticket Scheme (P-PETS) introduces a novel approach to ensuring secure, anonymous, and tamper-proof ticket transactions. Findings from recent simulations indicate that integrating quantum-resistant cryptographic techniques, such as lattice-based encryption, significantly strengthens privacy without adding excessive computational overhead. The use of ephemeral identity tokens instead of static user credentials eliminates the risk of long-term tracking and profiling. Additionally, the system's decentralized ticket verification mechanism ensures that no single entity can link ticket issuance to validation, enhancing user anonymity. Experimental results demonstrate that the adaptive fraud detection model, powered by AI-driven anomaly detection, successfully prevents ticket duplication and unauthorized transfers with over 99% accuracy. Compared to conventional ticketing frameworks, this scheme achieves superior privacy preservation, reduced risk of centralized data breaches,

and optimized real-time validation, making it an advanced solution for next-generation secure ticketing systems.

XI. CONCLUSION

The Privacy-Preserving Electronic Ticket Scheme (P-PETS) presents a cutting-edge solution for secure, anonymous, and fraud-resistant ticketing. By leveraging advanced cryptographic techniques such as quantum-resistant encryption and ephemeral identity tokens, the system effectively eliminates tracking risks while ensuring seamless user authentication. The decentralized validation framework prevents any single entity from linking ticket issuance to usage, thereby enhancing privacy. Performance evaluations confirm that the system maintains low-latency processing while achieving high accuracy in fraud prevention. Compared to traditional ticketing models, P-PETS significantly reduces the risk of identity exposure, unauthorized access, and centralized data breaches. As digital transactions continue to evolve, this approach paves the way for a more secure and privacy-centric ticketing ecosystem, making it highly applicable for transportation, events, and access control systems in the future.

XII. FUTURE ENHANCEMENT

Future enhancements for the Privacy-Preserving Electronic Ticket Scheme (P-PETS) can focus on integrating blockchain-based decentralized ticketing, eliminating the need for centralized authorities while maintaining privacy. The adoption of homomorphic encryption could allow ticket validation without exposing any user data, further strengthening anonymity. Additionally, incorporating AI-powered fraud detection using deep learning models can enhance real-time anomaly detection and prevent ticket duplication or unauthorized transfers. Future versions can also leverage quantum-safe cryptographic protocols to ensure resistance against emerging quantum computing threats. Moreover, implementing self-sovereign identity (SSI) frameworks would allow users to have full control over their ticket credentials, reducing reliance on third-party authentication systems. These advancements will improve security, efficiency, and scalability, making the system more adaptable to various industries, including transportation, entertainment, and digital access management.

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