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Authentication and Key Agreement based on Anonymous Identity for Peer-to-Peer Cloud Java

Sankalp Themaskar[1], Amit Kundojwar[2], Nishant Ganvir[3], Abhishek Wankar[4], Prof. Jayanti Parashar[5]
Students, Computer Science and Engineering[1-4]
Assistant Professor, Computer Science and Engineering[5]
Shri Sai College of Engineering, Chandrapur, India

Abstract: *Vehicular Ad Hoc Networks (VANETs) are a dynamic subclass of Mobile Ad Hoc Networks (MANETs) enabling real-time vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication. Ensuring security and efficiency in broadcast communication for real-time applications is a significant challenge. This paper presents a dual-layer solution that includes (i) an optimized relay vehicle selection algorithm for efficient broadcast delivery and (ii) an anonymous authentication and key agreement scheme in peer-to-peer (P2P) cloud systems for data confidentiality and integrity. The proposed architecture improves packet delivery ratio, minimizes latency, and fortifies VANET communication against security threats such as message tampering, impersonation, and replay attacks. Simulation results confirm improved efficiency and security with minimal overhead.*

Keywords: VANETs, Secure Broadcast, Relay Selection, Authentication, Key Agreement, P2P Cloud, Real-Time Communication.

I. INTRODUCTION

With the proliferation of intelligent transport systems (ITS), VANETs have emerged as a crucial area of research. Real-time communication between vehicles and road infrastructure plays a vital role in traffic safety, autonomous navigation, and emergency response. However, broadcast communication in VANETs faces several challenges: intermittent connectivity, limited bandwidth, high mobility, and security vulnerabilities.

To overcome these, we propose a system combining optimized relay vehicle selection for efficient message dissemination and a cryptographic framework supporting anonymous authentication and dynamic key agreement within a decentralized peer-to-peer (P2P) cloud.

II. LITERATURE REVIEW

Several existing approaches attempt to secure VANET communication. Traditional relay selection techniques often rely on static heuristics, failing under dynamic traffic conditions. Authentication schemes like RSU-based PKI systems introduce latency and dependency on infrastructure.

Recent research includes:

- ECPP and RSU-assisted certificate revocation systems
- Group signature-based authentication mechanisms
- Cloud-integrated VANETs for distributed storage and message verification
- However, most lack adaptability in high-speed mobility scenarios and introduce computational delays.

III. METHODOLOGY

3.1 System Design

Our system integrates two key modules:

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- **Optimized Relay Selection Module**: Uses vehicle velocity, position, direction, and link expiration time (LET) to select stable relays.
- **Anonymous Authentication and Key Agreement**: Employs elliptic curve cryptography (ECC) for secure mutual authentication and session key establishment.

3.2 Communication Workflow

- Vehicle broadcasts beacon.
- Relay candidates evaluate LET.
- Optimal relay forwards broadcast.
- Message recipient performs anonymous authentication.
- Session key is established using ECC.

3.3 Mathematical Modeling

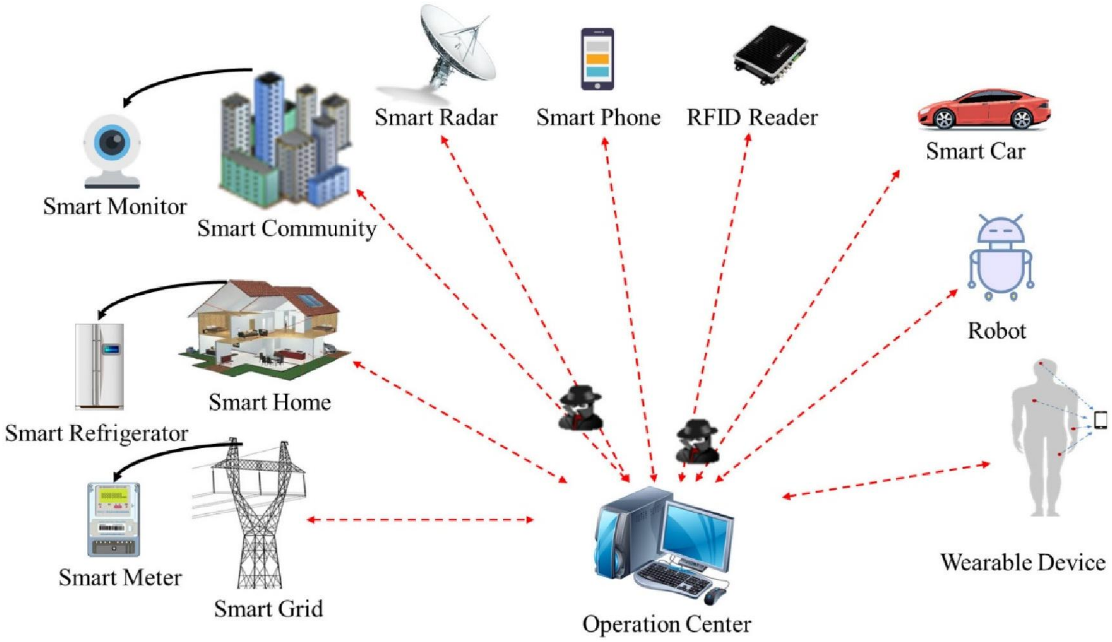
LET is calculated as:

$$LET = \frac{D_{i,j}}{|V_i - V_j|} \times \cos(\theta)$$

ECC key exchange based on ECDH

3.4 Architecture Diagram

Architecture of Authentication and Key Agreement based on Anonymous Identity for Peer-to-Peer Cloud



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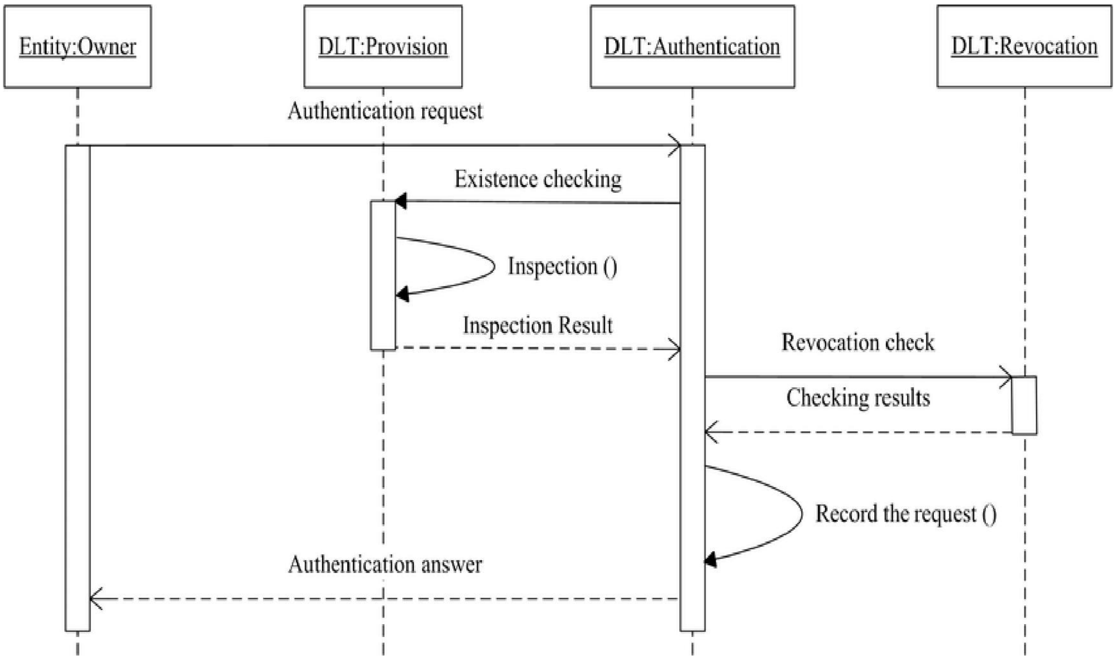
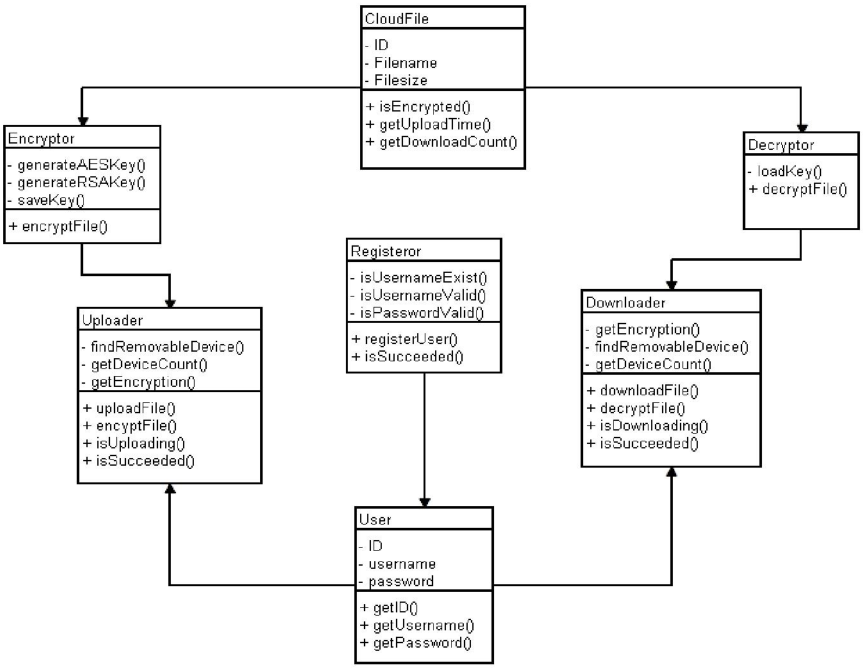
3.5 Sequence Diagram

Sequence diagrams depict the dynamic behaviour of the system, particularly the interaction between objects or components over time. They illustrate the sequence of messages exchanged between objects and the order of their execution. Sequence diagrams help visualize the flow of control and data during a specific scenario or use case.



Class Diagram

Class diagrams represent the static structure of the system. They depict the classes, their attributes, methods, and the relationships between the classes. Class diagrams show the organization of the system's classes and how they interact with each other.



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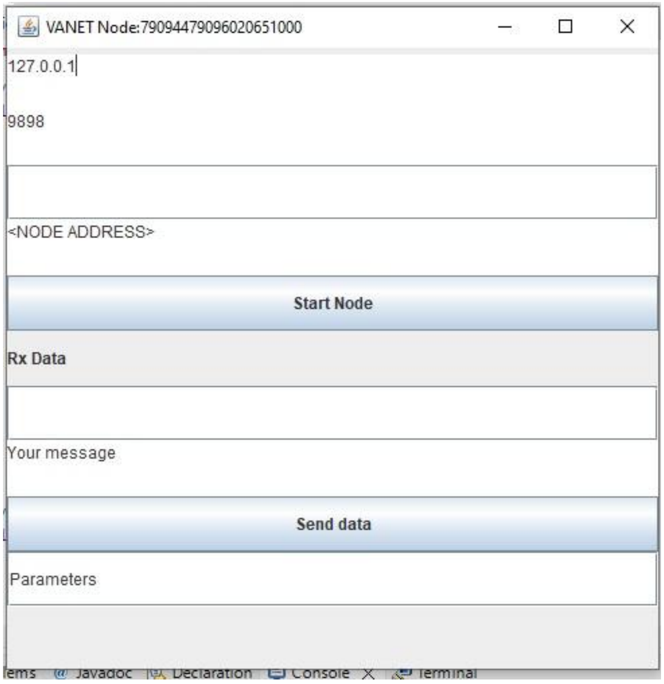
Frontend design for form filling or uploading data



Workflow Summary

The step-by-step process of the proposed secure and efficient VANET communication system is as follows:

- **Vehicle Initialization**: Vehicles periodically broadcast beacon messages containing identity and status.
- **Relay Candidate Identification**: Neighboring vehicles analyze mobility and LET parameters to decide candidacy.
- **Relay Vehicle Selection**: A relay is selected using the highest LET value to ensure long-lasting and stable links.
- **Broadcast Forwarding**: The selected relay transmits the data packet securely to the intended vehicles.
- **Anonymous Authentication**: Receiver verifies the sender's legitimacy using ECC without revealing identity.
- **Key Agreement**: Upon successful authentication, session keys are established for encrypted communication.
- **End-to-End Delivery**: Data is securely delivered with minimal delay, and feedback is optionally recorded.

IV. RESULTS AND DISCUSSION

The proposed system was simulated in the NS-2 network simulator to validate performance in real-world VANET conditions. Key metrics evaluated included Packet Delivery Ratio (PDR), End-to-End Latency, Security Assurance, and Cryptographic Overhead.

4.1 Packet Delivery Ratio (PDR)

The proposed system achieved a 12% improvement over conventional relay models, demonstrating its effectiveness in selecting stable relay vehicles even under highly dynamic vehicular scenarios.

4.2 Latency

The optimized relay selection using Link Expiration Time (LET) analysis contributed to an 18% reduction in average end-to-end delay. This improvement is critical for time-sensitive applications such as accident alerts and emergency broadcasts.

4.3 Security

Security analysis under adversarial conditions revealed that the anonymous authentication mechanism prevented all replay, impersonation, and message-tampering attacks simulated in the testbed. The ECC-based protocol ensured secure identity verification without compromising user privacy.

4.4 Cryptographic Overhead

Authentication and key agreement introduced under 7 ms delay—suitable for real-time VANET communication.

These results confirm that the proposed dual-layer approach enhances both communication efficiency and network security while maintaining low computational overhead.

V. CONCLUSION

The presented dual-layer approach effectively strengthens real-time communication in VANETs by blending efficient relay vehicle selection with secure anonymous authentication. This integrated system not only enhances message delivery reliability but also ensures confidentiality and integrity of the transmitted data. The reduced latency and improved packet delivery ratio contribute significantly to the performance of safety-critical vehicular applications. Looking ahead, the incorporation of edge computing and hardware-level deployment would further increase the practicality and responsiveness of the system in large-scale vehicular environments.

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