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BSFR-SH: Blockchain-enabled security framework against ransomware attacks using machine learning

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ABSTRACT:

This study presents a Blockchain-Enabled Security Framework integrated with Machine Learning (ML) to detect and mitigate ransomware attacks. Ransomware poses a significant threat to organizations and individuals, causing financial and reputational damage. The proposed framework leverages blockchain's tamper-proof and decentralized nature to ensure secure logging and data integrity, while ML algorithms enhance real-time detection of ransomware through behavioral analysis and anomaly detection. The system continuously monitors for suspicious activities, automatically removes malicious files, and maintains secure backups to facilitate recovery. Experimental results demonstrate the framework's effectiveness in detecting ransomware with high accuracy. Future enhancements include integrating cloud-based threat intelligence and federated learning for improved performance and privacy.

Keywords : Blockchain, Machine Learning, Ransomware Detection, Cybersecurity, Decentralized Security, Anomaly Detection, Data Integrity.

Introduction

Ransomware attacks have emerged as one of the most severe cyber threats, targeting critical sectors like healthcare, finance, and government institutions. These attacks encrypt victims' data and demand ransom for decryption, leading to significant disruptions and losses. Traditional security systems often fail to prevent such attacks due to their reactive nature and centralized vulnerabilities. This paper proposes a novel Blockchain-Enabled Security Framework that combines blockchain technology with ML to proactively detect and mitigate ransomware. Blockchain ensures tamper-proof logging and decentralized security, while ML algorithms analyze patterns and anomalies in real-time. The framework aims to provide a robust, transparent, and resilient defense mechanism against ransomware, addressing both prevention and recovery.

Related Work

Existing solutions for ransomware detection primarily focus on post-attack recovery and signature-based detection, leaving systems vulnerable to zero-day attacks. Recent studies highlight the potential of blockchain and ML in cybersecurity. For instance, Chakkaravarthy et al. [1] proposed an intrusion detection honeypot using ML, while Ferrag et al. [8] explored blockchain for IoT security. However, few studies integrate both technologies for ransomware mitigation. Almashhadani et al. [11] and Hwang et al. [12] demonstrated the effectiveness of ML in ransomware detection, but their frameworks lack blockchain's decentralized advantages. This work bridges the gap by combining blockchain's immutability with ML's predictive capabilities.

Methodology

The proposed framework consists of three main components:

- Blockchain Layer: Ensures secure, tamper-proof logging of system activities and backups.
- Machine Learning Layer: Uses K-Nearest Neighbors (KNN) and feature extraction techniques to detect ransomware in Portable Executable (PE) files.
- User Interface: A React-based interface for file scanning and system monitoring.

The workflow involves:

- Extracting features from PE files (e.g., entropy, section counts).
- Training ML models on honeypot datasets for classification.
    - Deploying smart contracts for automated responses to detected threats.
    - Continuously monitoring and updating the system with new threat intelligence.

Experimental Results

The framework was tested on a dataset of legitimate and infected PE files. Key findings include:

- The KNN classifier achieved an accuracy of 95% in distinguishing ransomware from legitimate files.
- Blockchain ensured secure and immutable logging of all detected threats.
- Real-time monitoring reduced the response time to suspicious activities by 80%.
- The system successfully demonstrated automatic removal of malicious files and secure backup recovery.

Screenshots of the React interface (Figs. 8.1–8.9) illustrate the user-friendly design and functionality.

Conclusion and Future Work

The Blockchain-Enabled Security Framework effectively combines blockchain and ML to address ransomware threats proactively. Its decentralized architecture and real-time detection capabilities offer significant improvements over traditional systems. Future enhancements include:

- Integrating cloud-based threat intelligence for up-to-date ML models.
- Implementing federated learning to enhance privacy and collaborative training.
- Developing smart contracts for automated incident response.
- Extending compatibility to IoT devices and other platforms.

This framework sets a foundation for resilient and adaptive cybersecurity solutions in the era of evolving ransomware threats.

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