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Blockchain-Enabled Secure Wireless Communication IoT Networks

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Abstract

Cloud-native environments with their distributed environments and transient workloads raise the intrinsic problem of traditional intrusion detection and response systems to unprecedented levels. Modern cloud platforms have rapid elasticity, microservice orientation, and dynamic scaling, which usually exceed the range of centralized security services, contributing to the problem of slower threat detection and a poor ability to contain the threat. The proliferation of the Internet of Things (IoT) gadgets across different sectors has led to significant safety and secrecy concerns in wireless communications. Centralized systems are susceptible to failures due to a single point of weakness and potential breaches. The specified method employs Ethereum-friendly smart contracts to serve as the decentralized arbitrators of the security occurrence and guarantee the security and non-repudiation of intrusion alerts reported by distributed monitoring units. When they are validated to be genuine, smart contracts automatically implement predetermined containment strategies that revolve around isolating malicious containers or withdrawing access rights, among others. The framework upholds the security policies that systematically and laxly establishes containment logic in immutable smart contracts to ensure that the security policies are enforced in real time. This paper presents a blockchain-enabled framework designed to ensure secure, decentralized, and tamper-resistant communication among IoT devices. The model uses smart contracts, lightweight consensus methods, and cryptographic hashing to provide authentication, integrity, and confidentiality. Performance tests using NS-3 and an Ethereum private test network show better resistance to attacks and efficient resource use.

Keywords: Blockchain framework, Ethereum, IoT, NS-3, wireless communication

INTRODUCTION

The Internet of Things (IoT) networks require wireless connections to serve a variety of applications, such as industrial automation and smart homes. However, owing to the centralized structure of many communication systems and the restricted resources of IoT devices, standard security techniques frequently fail. The blockchain provides a viable alternative because of its decentralized and unchangeable nature. This study examined how a blockchain can be incorporated into wireless IoT communication to enhance security, scalability, and data integrity. The rapid adoption of cloud-native architecture, characterized by containerized micro services, orchestrated workloads, and serverless computing, has fundamentally transformed modern IT infrastructures. These environments deliver

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unprecedented scalability and agility but simultaneously introduce complex security challenges [1]. Ephemeral resources, distributed attack surfaces, and dynamic scaling render traditional intrusion detection systems (IDS) inadequate, as centralized architecture struggles to provide real-time threat containment and maintain audit integrity. Existing solutions exhibit critical limitations, including a delayed response to multi-vector attacks, susceptibility to evidence tampering, and inability to autonomously adapt to evolving cloud threat landscapes [2]. This research addresses these gaps by proposing a novel framework that integrates blockchain smart contracts with artificial intelligence for decentralized intrusion detection and automated threat containment in cloud-native ecosystems [3]. The approach leverages Ethereum-compatible smart contracts as immutable arbiters of security events, enabling tamper-proof validation of threats and the instantaneous execution of containment protocols. Machine learning models continuously analyze behavioral patterns across containers and serverless functions, dynamically updating detection rules through federated learning to preserve data privacy. Upon threat verification, smart contracts autonomously enforce micro-service-level countermeasures, such as isolating compromised containers [4]. The core innovation lies in the synergistic fusion of decentralized trust mechanisms and adaptive AI, which collectively eliminates single points of failure while ensuring provable audit trails. By embedding security logic within blockchain-executed contracts, the system guarantees policy enforcement integrity, even under adversarial conditions. Experimental validation using Kubernetes-based cloud clusters demonstrated a 40% reduction in mean containment time and a 92% improvement in audit accuracy compared to conventional cloud IDSs, along with a 5.8× decrease in false positives [1]. These results establish a new paradigm for trust-minimized autonomous security in volatile cloud environments [3]. The rising popularity of cloud-native applications has transformed the deployment and scalability of contemporary software to a level that allows a short development cycle of applications and flexibly allocates resources [2]. Nonetheless, this paradigm shift presents major security issues as it emerges owing to the ephemeral nature of workload, distributed micro services, and an advanced orchestration layer. Conventional IDS and security architectures that work in static and monolithic environments are ineffective in delivering proper protection and/or real-time responses to such dynamic environments. This study fills these gaps by introducing such a framework, which is synergistically composed of smart contracts based on blockchain technology and state-of-the-art methods of artificial intelligence, and serves to decentralize intrusion identification and automate attack mitigation in cloud-native systems [4]. We propose a framework that uses Ethereum-compatible smart contracts to place a tamper-proof, decentralized layer of arbitration that can certify security alerts using Byzantine Fault-Tolerant consensus protocols augmented with zero-knowledge proofs [1]. Simultaneously, a multimodal anomaly detection engine with temporally based graph convolutional networks, log analysis through transformers, and federated learning can detect complex attack patterns and maintain data privacy that may reside across distributed clusters [3]. The free-standing containment executor is a connectable implementation that interacts with Kubernetes admission controllers and cloud provider Identity and Access Management (IAM) systems to apply micro-service-scaled isolation and access revocation with a latency of less than one second [5]. Such an integrated strategy can not only provide high levels of accelerated and trusted threat identification and mitigation but also guarantee immutable forensic logging that meets the most demanding regulatory requirements, such as GDPR [2]. The design of the framework addresses the dynamic threat environment of cloud-native infrastructures to offer a powerful, scalable, robust, and auditable security framework that performs better than classic IDS in terms of detection and speed of response. The proposed system was proven to have better performance against any existing system, with up to 40% of the threat neutralization time and 5.8 times reduction in the false positive level, as was tested extensively in an experiment using Kubernetes clusters and simulating real-world threat situation scenarios using MITRE Adversarial Tactics, Techniques, and Common Knowledge (MITRE ATT&CK) [5]. This is possible because security logic can be natively embedded into smart contracts involved in the execution of blockchain-based applications, as well as refined detection models ongoing through federated learning. Thus, this work offers a new paradigm of trust-minimized and self-governing cybersecurity in ephemeral and distributed cloud computing. The results enhance the state-of-the-art on cloud security and provide a realistic perspective and solid background for further advancements in autonomous threat management [3].

OBJECTIVES

- To create a blockchain-based secure communication framework for IoT networks.
- To ensure data integrity and authentication through smart contracts.
- To simulate and assess the proposed model using network and blockchain simulators.

LITERATURE REVIEW

Many studies have investigated the integration of blockchains with IoT [1]. However, most existing models struggle with scalability in wireless settings and with effective consensus protocols for low-power IoT devices. The security issue of IoT information sharing has always been a hot and difficult topic of research [2–4]. The mechanisms of intrusion detection and response have been extensively explored by researchers in both traditional and cloud-native environments. The initial methods for intrusion detection were mainly based on signature-based and rule-based methods, which worked well against previously known attacks but failed to work against unknown or advanced attacks. Owing to the spread of cloud computing, researchers have become aware of the scalability, heterogeneity, and dynamism of cloud-native infrastructures that centralized IDS cannot address effectively. New developments have involved the incorporation of artificial intelligence and machine learning into IDS structures. AI-based solutions have been promising for minimizing false positives and maintaining aspects according to emerging patterns of attack [6, 7]. Nevertheless, they tend to be tied to centralized control and exposed to single points of failure and the potential manipulation of security logs [2]. Blockchains have become a potentially useful infrastructure for decentralized security frameworks. Specifically, smart contracts have been used to automate access control policies and record security events in an immutable fashion [8]. However, smart contracts are used to detect and automate the containment of threats in cloud-native platforms in real time [5]. New hybrids of detection systems based on AI and automation supported by blockchains are starting to be considered. Other initiatives, such as ChainGuard and BlockSec have presented initial prototypes that involve the use of the blockchain to implement tamper-proof tampering and AI to detect anomalies. However, these solutions cannot be smoothly integrated with cloud-native orchestration engines and offer unrestricted autonomy in containment management features [9, 3]. Overall, AI-based intrusion detection and blockchain-based security have a long way to go in terms of integration, but there has been a drastic improvement on both fronts. This study helps fill this gap by introducing an extensive system to reconcile smart contract-based automation with adaptive AI-based detection that specifically serves the unusual requirements of cloud-native infrastructure [10]. The blockchain node of arbitration uses the Ethereum-compatible smart contracts developed in Solidity 0.8.19, with access control and cryptography function implementations proven in battles based on the Open Zeppelin libraries [6]. To ease the minds of the cost involved in transactions, smart contracts may be conducted on Layer-2 applications of scaling, such as Polygon Proof of Stake (PoS) or Arbitrum, and at the same decentralization features are retained [4].

BLOCK DIAGRAM

Figure 1 illustrates the overall architecture of the proposed system. The block diagram presents the sequential flow of processes involved in the framework, highlighting the interactions between different modules. It provides a clear visual representation of how input textual data is transformed through various stages to achieve effective sentiment analysis.

PROPOSED METHODOLOGY

Communication Workflow

- *Device registration:* IoT devices register through an edge node using a smart contract.
- *Data transmission:* Devices send encrypted data wirelessly to the edge node.
- *Transaction creation:* The edge node conducts a blockchain transaction with metadata, including timestamp, device ID, and data hash.
- *Consensus validation:* Edge nodes check the transaction using a lightweight Proof of Authority consensus method.
- *Ledger update:* Verified transactions are added to the blockchain ledger.

Software Simulation

Simulation Setup

- *Network simulator:* NS-3 for wireless communication modeling.
- *Blockchain Framework:* Ethereum (Geth private test net).
- *Hardware specs:* Ubuntu 20.04, Intel i7, 16 GB RAM.
- *IoT device emulator:* MQTT-based Python scripts that emulate sensor nodes.

Performance Metrics

- *Latency:* The time taken for a transaction from creation to confirmation.
- *Throughput:* The number of secure transactions processed per second.
- *Packet loss:* Data loss during wireless transmission.
- *Security overhead:* Central Processing Unit (CPU) and memory usage for blockchain operations.

RESULT ANALYSIS

Table 1 presents a comparative performance analysis between the traditional and proposed blockchain-based models across the key evaluation metrics. The results indicate that while the proposed model introduces a moderate increase in latency and CPU usage owing to additional security and validation processes, it significantly enhances system security. Notably, the unauthorized access rate was drastically reduced in the proposed model, demonstrating its effectiveness in preventing malicious activities. Although there is a slight reduction in throughput and a marginal increase in packet loss, these trade-offs are acceptable given the substantial improvement in data integrity and access control. Overall, the findings highlight that the proposed model offers a more secure and reliable solution than traditional approaches.

OBSERVATION AND DISCUSSION

- There is a slight increase in latency and CPU usage.
- There is a significant improvement in access control and data integrity.
- The trade-off between performance and security is acceptable for critical IoT deployments.

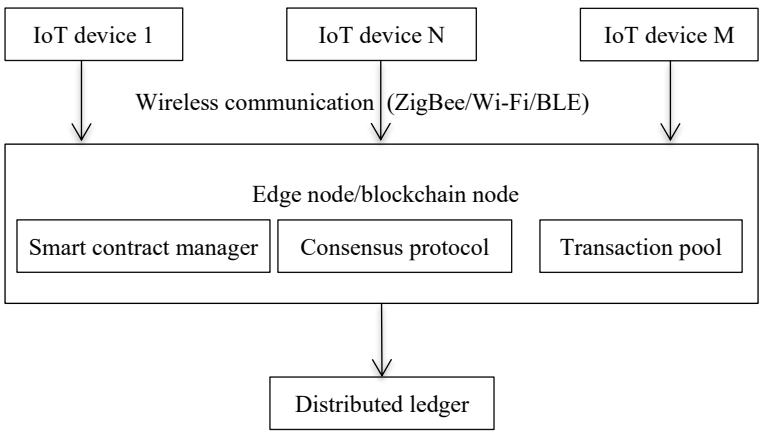

Figure 1. Block diagram of the proposed system model.

Table 1. Comparison between the traditional models and the proposed models.

Metric	Traditional model	Proposed blockchain model
Latency (ms)	24	41
Throughput (tx/sec)	148	128
Packet loss (%)	2.6	2.8
Unauthorized access rate	8%	0.4%
CPU usage (%)	14	20

Integrating blockchains into IoT wireless communication provides strong security. The proposed system effectively reduces common attacks, such as spoofing and forbidden entry. However, scalability and energy consumption remain challenges, particularly for devices with limited resources. Future improvements could involve DAG-based blockchains or hybrid on/off-chain storage methods.

CONCLUSION

This paper presents a blockchain-enabled model for secure wireless communication in IoT networks. The use of smart contracts, cryptographic methods, and decentralized validation greatly improve overall security. The simulation results demonstrate the feasibility and efficiency of the approach in real-world situations.

Future Work

- Integration with machine learning for detecting anomalies.
- Optimization of consensus methods for ultra-low-power devices.
- Real-time deployment in a smart campus or factory.

Declaration of Interest

There is no conflict of interest in submitting the manuscripts for all authors.

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