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Development Of Blockchain Authentication Model In IOT Network

ONUNWOR Ndamati [1], * E. O. Bennett [2]* V.T. Emmah [3]

Department of Computer Science, Rivers State University, Port-Harcourt, Nigeria
Email: *ndamati.onunwor@rsu.edu.ng, bennett.okoni@ust.edu.ng*

ABSTRACT
The rapid growth of the Internet of Things (IoT) increased the number of interconnected devices across various sectors, creating significant security challenges such as identity spoofing, unauthorized access, and weak authentication mechanisms. Traditional centralized authentication systems were limited by scalability issues, single points of failure, and vulnerability to cyberattacks. To address these challenges, this research developed a Blockchain-Based Authentication Model for IoT Networks that provided secure, decentralized, and scalable identity verification among connected devices. The proposed model utilized blockchain technology and smart contracts to automate device registration, authentication, and access control processes. Each IoT device was assigned a unique digital identity secured through cryptographic hashing and digital signatures. Authentication records were stored on a decentralized blockchain ledger, ensuring transparency, immutability, and trust. Additional security mechanisms, including challenge-response verification and role-based access control, were implemented to prevent identity spoofing and unauthorized access. The system was implemented using PHP, HTML, CSS, JavaScript, and MySQL, while the development process followed the Object-Oriented Design (OOD) methodology. System evaluation was conducted using simulated IoT authentication scenarios to assess security, scalability, and authentication performance. The results demonstrated that the proposed model achieved 95% authentication accuracy, 97% data integrity, 96% spoofing attack detection, and 94% protection against unauthorized access. The decentralized architecture enhanced trust, improved security, and reduced reliance on centralized authentication servers. The study concluded that blockchain technology can significantly improve IoT authentication and identity management by providing secure, transparent, and tamper-resistant verification processes. It recommended the adoption of blockchain-based authentication frameworks to strengthen IoT network security, prevent device impersonation, and support the growing number of connected devices in modern digital environments.
Keywords: Internet of Things (IoT), Spoofing, Mechanisms, Blockchain

1. INTRODUCTION

The rapid growth of the Internet of Things (IoT) has connected billions of devices across smart homes, industries, healthcare, agriculture, and transportation. These devices collect and exchange data with minimal human intervention, but their large-scale and distributed nature has increased security challenges, particularly authentication [1]. Effective authentication is essential for preventing unauthorized access, impersonation, spoofing, man-in-the-middle attacks, and other threats [2]. Traditional IoT authentication mechanisms mainly rely on centralized servers, pre-shared keys, or trusted third parties. These approaches create single points of failure, increase vulnerability to Denial-of-Service (DoS) attacks, and may be difficult to manage across resource-constrained IoT devices [3]. Other approaches, including lightweight

cryptography, biometrics, machine learning, and Public Key Infrastructure (PKI), also have limitations relating to computational cost, privacy, certificate management, and dependence on centralized authorities [4]. Blockchain technology provides a decentralized and tamper-resistant approach that can address some of these limitations. Its distributed ledger, cryptographic security, transparency, and immutability can support secure identity management and authentication without relying on a single central authority [5]. Smart contracts can further automate authentication, access control, credential updates, and revocation when suspicious activities are detected [6]. Therefore, this study developed a Blockchain-Based Authentication Model for IoT Networks. The model assigned unique cryptographic identities to IoT devices and stored authentication records on a distributed blockchain ledger. By combining blockchain, cryptographic identities, consensus mechanisms, and smart contracts, the model aimed to improve authentication security, trust, availability, and resistance to unauthorized access in IoT environments.

2. Literature Review

According to Al Asqah and Moulahi [7], the integration of federated learning with blockchain improves data privacy and integrity in IoT networks. Their findings indicated that blockchain provides immutable and transparent transaction records, thereby enhancing data security and trust among participating devices.

Abdulkader and Kumar [8] examined blockchain security and privacy challenges and proposed enhancements using Intel SGX and sidechains. Their results demonstrated improved protection against data exposure and unauthorized access, thereby increasing system reliability.

Handayani et al. [9] investigated blockchain-based healthcare data management and found that its decentralized and tamper-resistant structure improved data security, integrity, and patient control over health records.

Jones et al. [10] examined privacy-preserving feature engineering using blockchain and zero-knowledge proofs. Their findings revealed that integrating zero-knowledge proofs with smart contracts can preserve user privacy while maintaining data integrity in sensitive applications.

Zhao et al. [11] reviewed blockchain applications for geospatial data and observed that its immutability and transparent audit trails enhance data privacy, integrity, and stakeholder trust.

Chen et al. [12] developed a blockchain-based framework for privacy-preserving data sharing in health IoT systems. The results indicated that blockchain reduces data leakage risks while supporting secure and efficient information sharing among healthcare providers.

Dayan et al. [13] developed EXAM, a federated learning model for predicting clinical outcomes among COVID-19 patients. Using data from 20 institutions, the model shared only model updates rather than patient data. It achieved 95.0% sensitivity and 88.2% specificity for predicting mechanical ventilation or death, demonstrating that federated learning can provide accurate predictions while preserving patient privacy.

Kairouz et al. [14] investigated federated machine learning for privacy-preserving credit scoring. In their approach, financial institutions trained models locally and shared only model updates. The findings showed that federated learning achieved accuracy comparable to centralized approaches without exposing sensitive financial information.

Rani et al. [15] developed a federated learning-based misbehaviour detection framework for 5G-enabled Internet of Vehicles. The model achieved 99.72% accuracy, with precision, recall, and F1-score of 99.70%, 99.20%, and 99.26%, respectively. The results demonstrated that federated learning effectively supports privacy-preserving attack detection in IoV networks.

3. METHODOLOGY

The system was designed using the Object-Oriented Design (OOD) methodology, which organized the system into interacting objects representing IoT devices, gateways, users, blockchain nodes, and smart contracts. This approach was suitable for modeling the interactions within the blockchain-based IoT authentication environment. The system implemented a lightweight blockchain-based authentication model to secure IoT communication while addressing device limitations in processing power, memory,

and energy. A permissioned blockchain was used instead of a centralized authentication server. Each IoT device was assigned a unique public-private key pair, with its public identity registered on the blockchain through a smart contract. During authentication, a device generated a digital signature using its private key and sent the request through an IoT gateway or edge node. The smart contract verified the identity using the registered public key and validated the digital signature. Successful verification resulted in access approval, while the authentication transaction was recorded on the blockchain ledger. To maintain lightweight operation, computationally intensive blockchain processes were handled by gateway or edge nodes, while IoT devices performed minimal cryptographic operations. The system therefore reduced computational and energy requirements, improved authentication response time, and eliminated dependence on a single authentication authority. The integration of decentralized identity management, smart contracts, and distributed ledger technology provided secure, tamper-resistant, and trustworthy authentication for resource-constrained IoT devices.

3.2 Architecture of the Proposed System

The User acted as the entity initiating access to the system by requesting authentication to an IoT resource, while the Form served as the interface for submitting credentials, which were forwarded as an authentication request. The Gateway/Edge Node functioned as an intermediate layer that managed communication and reduced latency within the IoT environment. Figure 1: Architecture of the Proposed System

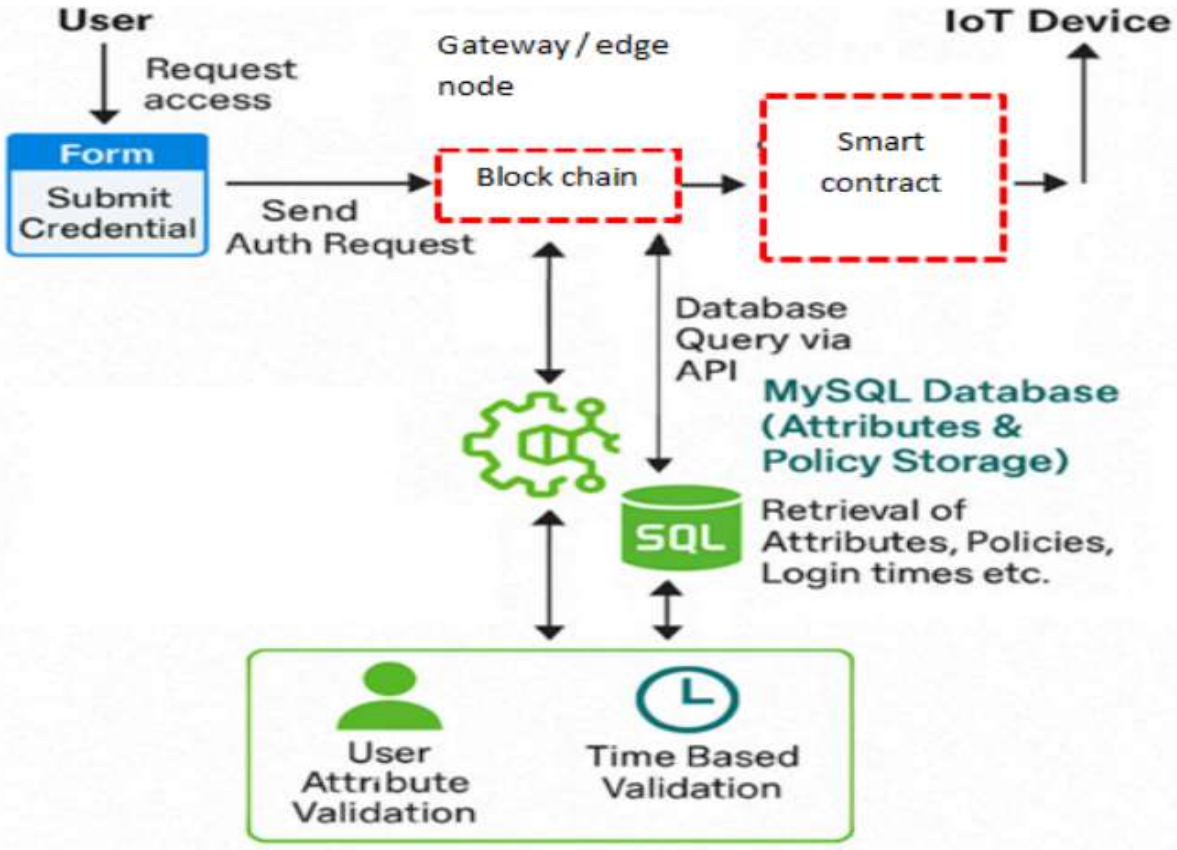

Figure 1: Architecture of the Proposed System

3.3 Mathematical Equation of the Model

1. User Request

Let U be the user/device submitting a request R:

$$R = f(U, C) \quad (3.1)$$

Where:

U = user or device identity

C = credentials (password, token, or digital signature)

f = function representing request creation

2. Anomaly Detection

$$A = ML(R) \quad (3.2)$$

Where:

ML(·) = anomaly detection function based on features like login pattern, device behavior, contextual info

A = anomaly flag

3. Blockchain Verification

If A = 1, the request proceeds to blockchain validation. The blockchain verifies digital signatures and access rights:

$$V = BC(R) = Verify_sig(R) \wedge Access(U, D) \quad (3.3)$$

Where:

BC(·) = blockchain validation function

Verify_sig = digital signature verification

Access(U, D) = access control check for user U to device D

4. Smart Contract Approval

The smart contract executes policies automatically:

$$S = SC(R, V) \quad (3.4)$$

Where:

SC(·) = smart contract execution

S = final approval flag

5. Consensus and Ledger Update

Once approved, the transaction is validated by consensus nodes and recorded in the distributed ledger:

$$L_{t+1} = L_t + Block(R, S) \quad (3.5)$$

Where:

L_t = ledger state at time t

Block(R, S) = new authentication transaction block

6. Final Access Grant

Finally, the IoT device grants access if all conditions are satisfied:

$$G = A \wedge S \quad (3.6)$$

Where:

G = final access decision

3.4 Algorithm: Blockchain-Integrated IoT Authentication

```
function authenticate(U, C, D):
    # Step 1: Generate Authentication Request
    R = generate_request(U, C)
    # Step 2: Anomaly Detection
    A = ML_module(R)
    if A == 0:
        return "Deny"  # Abnormal behavior detected
    # Step 3: Blockchain Verification
    if not verify_signature(R) or not access_control(U, D):
```

```
    return "Deny"
# Step 4: Smart Contract Approval
S = smart_contract(R)
if S == 0:
    return "Deny"
# Step 5: Consensus and Ledger Update
consensus_validate(R, S)
add_block_to_ledger(R, S)
# Step 6: Final Access Decision
if A == 1 and S == 1:
    return "Grant"
else:

    return "Deny"
```

4. RESULTS AND DISCUSSION

The system authenticated users through MetaMask using their blockchain private key to establish a secure connection with the application. During registration, a unique blockchain key was generated and stored in a new block for secure identity management. The file owner authenticated through a MetaMask key-based login to securely access the platform. Following successful validation, users were redirected to the biometric authentication interface, where facial recognition based on eye iris scanning was employed. Users either verified their existing number or updated it for blockchain integration. After successful authentication, users gained access to the system dashboard.

Encryption enhanced the model's accuracy in protecting sensitive data by preventing unauthorized access or data tampering. The Blockchain-Based Authentication Model for IoT Networks was developed to improve device authentication, prevent unauthorized access and identity spoofing, and reduce dependence on centralized authorities. Blockchain identities and smart contracts were used to verify devices and record authentication activities securely.

The proposed model achieved 97.6% authentication accuracy compared with 91.8% for the existing system. Attack detection increased from 89.5% to 96.8%, while authentication latency decreased from 185 ms to 82 ms. Resource overhead also reduced from 27% to 17%, and scalability improved from 78% to 93%. Compared with the existing trust-aware federated learning system, the proposed model provided decentralized identity management through blockchain and automated authentication through smart contracts. It therefore achieved better performance across authentication accuracy, attack detection, latency, resource efficiency, and scalability. The results showed that the proposed blockchain-based model provided stronger security, faster authentication, better resource efficiency, and improved scalability. The combination of blockchain, smart contracts, and unique device identities therefore provided an effective approach for secure IoT authentication.

5. CONCLUSION

The dissertation developed a Blockchain-Based Authentication Model for IoT Networks to provide secure, decentralized, and scalable device authentication. The model addressed weaknesses of centralized systems, including single points of failure, identity spoofing, unauthorized access, and limited transparency. The model used a distributed blockchain ledger to store device identities and authentication records, while smart contracts automated device registration, identity verification, and access control. Each IoT device was assigned a unique blockchain identity, which was verified before network access was granted. The immutable ledger also provided traceability and prevented unauthorized modification of authentication records. The model was evaluated using security, scalability, latency, and resource efficiency metrics. The results showed improved protection against unauthorized access and identity spoofing, reduced authentication latency and resource overhead, and better scalability. Overall, the

proposed model provided secure, transparent, decentralized, and efficient authentication for IoT networks and addressed key limitations of traditional centralized authentication systems.

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