De-Anonymisation Techniques for Monitoring and Tracking Illegal Cryptocurrency Using Blockchain Technology

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Abstract. This project proposes a web-based solution for detecting illegal transactions within the Bitcoin blockchain network. With the growing use of cryptocurrencies for illicit activities, such as money laundering and ransomware payments, there is a need for a transparent system to identify suspicious transactions. Our system utilizes real-time transaction data from the Blockchain.com Explorer API and allows admins to analyze and flag potentially illegal transactions based on behavioral patterns, address reputation, and transactional anomalies.

To enhance the system's performance and reliability, we employ a hybrid consensus mechanism. Delegated Proof of Stake (DPoS) is used to ensure scalability and efficiency by allowing a selected group of trusted admins to quickly validate flagged transactions. This mechanism provides faster processing and enables the system to handle large volumes of data. Additionally, Practical Byzantine Fault Tolerance (PBFT) is integrated to ensure fault tolerance, providing security and consensus even if some nodes (admins) behave maliciously or fail. PBFT guarantees that flagged transactions are agreed upon securely and accurately, maintaining data integrity across the system.

By combining DPoS for scalability and PBFT for fault tolerance, our solution balances security, speed, and efficiency, making it suitable for real-time monitoring of Bitcoin transactions. This system aims to support law enforcement and other stakeholders in identifying and mitigating illegal activities in the cryptocurrency space.

Keywords. Blockchain, Bitcoin, PBFT - Practical Byzantine Fault Tolerance, DPoS - Delegated Proof of Stake, Illegal Transactions, Blockchain.com API, Transaction Analysis, Cryptocurrency

1. INTRODUCTION

Blockchain technology has revolutionized the design and development of decentralized systems, particularly in areas like cryptocurrencies, financial services, and transaction monitoring. Built on principles of transparency and immutability, blockchain provides a secure, distributed ledger that can be used to track and record transactions without the need for a central authority. Each block in a blockchain contains a cryptographic hash of the previous block, creating a secure and verifiable chain of records.

As cryptocurrencies like Bitcoin have gained global adoption, they have also attracted malicious actors who exploit the anonymity of blockchain for illegal activities such as money laundering, drug trafficking, and ransomware payments. The pseudonymous nature of Bitcoin transactions makes it challenging to trace illegal activities in real-time, which raises concerns about security and regulation. Existing studies highlight these issues, but they often face limitations related to scalability and the difficulty of capturing evolving illicit activities.

This project addresses these challenges by proposing a system that tracks and analyzes Bitcoin transactions to flag potential illegal activities. By leveraging real-time data from Blockchain.com Explorer API, the system allows administrators to review and flag suspicious transactions. A combination of Delegated Proof of Stake (DPoS) for scalability and Practical Byzantine Fault Tolerance (PBFT) for fault tolerance ensures efficient handling of large transaction volumes while maintaining data integrity and security. This project aims to create a more scalable and reliable solution to monitor blockchain transactions, supporting efforts to combat cryptocurrency-based illicit activities.

2. MOTIVATION

The rise of cryptocurrencies like Bitcoin has led to an increase in illegal activities such as money laundering, drug trafficking, and ransomware payments. The pseudonymous nature of blockchain transactions makes tracking these illicit activities challenging, especially as criminals use advanced techniques like mixing services to obscure their transactions. Traditional methods struggle to monitor such activities in real-time.

Given these challenges, a secure system is needed to detect suspicious transactions on the blockchain. Blockchain's inherent transparency and decentralization make it ideal for building a platform that can flag and monitor illegal activities in real-time, contributing to efforts to regulate the cryptocurrency space.

3. LITERATURE SURVEY

JournalAuthor(s)	Resource Paper Name	Description	Limitations
Sage Journals Thomas E.Dearden,Smantha E.Tucker	Analyzing Darknet Activity Using Cryptocurrency and the Bitcoin Blockchain.	The article examines AlphaBay darknet transactions using blockchain, linking legal and illegal activities. It highlights methods for analyzing transaction patterns, showing most are identifiable and often illegal, with implications for future cryptocurrency research.	The limitations in the article include the challenge of accurately analyzing darknet transactions, as individuals can lie or attempt to obscure their activities.

4. PROPOSED SYSTEM

Blockchain-based Illegal Transaction Monitoring System. This system utilizes blockchain technology to monitor and flag illegal Bitcoin transactions in real-time. It integrates the Blockchain.com Explorer API to retrieve transaction data, allowing administrators to analyze suspicious activity based on predefined criteria such as transaction patterns and known illicit addresses.

The system employs a hybrid consensus mechanism for improved security and scalability:

Layer 1: Practical Byzantine Fault Tolerance (PBFT) is used to ensure fault tolerance, allowing the system to validate flagged transactions while withstanding potential malicious activity or system failures.

Layer 2: Delegated Proof of Stake (DPoS) enhances scalability by enabling faster transaction verification and block production, ensuring efficient handling of large transaction volumes without requiring every node to validate each transaction.

Advantages Over Previous Systems

Real-time data retrieval: Continuous monitoring of Bitcoin transactions using the Blockchain.com API.

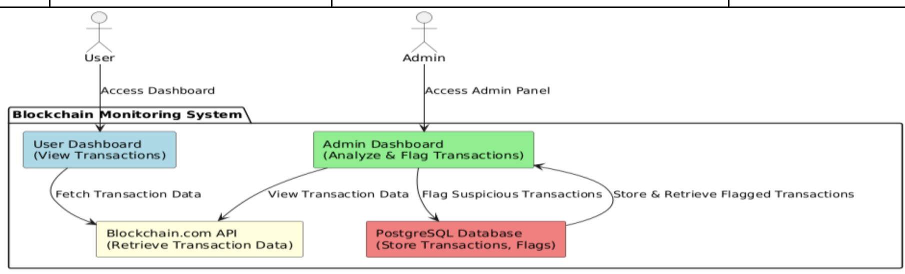
Efficient analysis: DPoS allows rapid flagging of suspicious transactions, enabling real-time decision-making.

Fault tolerance: PBFT ensures secure validation even if some nodes (admins) behave maliciously or fail.

Scalability: DPoS enables the system to handle high transaction volumes without compromising performance.

5. MODEL IMPLEMENTATION

Journal-Author	Resource Paper Name	Description	Limitatio-ns
Emerald Insights Shreya Sangal, Goural Duggal	Blockchain's double-edged sword: thematic review of illegal activities using blockchain	The article reviews the role of blockchain technology in illegal activities like fraud, money laundering, and cyberattacks. It identifies key themes, prevention strategies, and suggests future research based on studies from 2015 to 2023.	The study notes that data storage on the blockchain is still a challenge, especially for large-scale medical imaging files. Scalability remains an issue as well.



In this section, we detail the implementation of our Blockchain-based Illegal Transaction Monitoring System for detecting and flagging suspicious Bitcoin transactions. The system uses the Blockchain.com Explorer API to fetch transaction data and employs a hybrid consensus mechanism to ensure scalability, fault tolerance, and efficient transaction analysis.

The proposed system leverages Practical Byzantine Fault Tolerance (PBFT) for fault tolerance and Delegated Proof of Stake (DPoS) for scalability. The model is designed to address the challenges of scalability, efficiency, and security in identifying illegal transactions.

1. System Architecture

The architecture of the proposed system consists of the following key components:

- **Blockchain.com API**: Retrieves real-time transaction data from the Bitcoin blockchain. This data is used for analysis by administrators to flag potential illegal transactions.
- **Admin Dashboard**: Allows administrators to view, analyze, and flag suspicious transactions. This dashboard is designed using a front-end framework like **React**.
- **Consensus Mechanism**: The system employs a two-layer consensus model for security and scalability:
  - **Layer 1**: **PBFT (Practical Byzantine Fault Tolerance)** ensures high fault tolerance, allowing the system to maintain integrity even in the presence of malicious or failed nodes.
  - **Layer 2**: **DPoS (Delegated Proof of Stake)** enables fast transaction validation by delegating a subset of trusted nodes to validate flagged transactions, improving scalability and reducing processing time.

- **2. Data Flow and Transaction Lifecycle**

The system processes transactions in the following stages:

- **Data Fetching**: The Blockchain.com API fetches real-time transaction data.
- **Transaction Analysis**: Admins analyze the transactions using patterns such as known illicit wallet addresses, high-frequency transfers, or unusually large transactions.
- **Flagging and Validation**: Admins flag suspicious transactions. PBFT ensures that flagged transactions are validated securely by the majority of admins, while DPoS allows faster validation by delegating certain validation tasks to trusted admins.
- **User Notification**: Once flagged transactions are validated, users are notified through the platform, providing them with information about potentially illegal activities.

- **3. Data Integrity and Security**
- **Data Integrity**: All flagged transactions are stored immutably in the system database. Any changes or updates to flagged transactions require consensus through PBFT.
- **Security**: Transactions and flagged data are encrypted using secure cryptographic methods to prevent tampering. Only authorized admins can view and manage flagged transactions.

- **4. Consensus Mechanism**
- **Practical Byzantine Fault Tolerance (PBFT)**: PBFT is used to ensure high fault tolerance, allowing the system to remain functional even if up to one-third of the admins behave maliciously. This layer guarantees that flagged transactions are validated securely.
- **Delegated Proof of Stake (DPoS)**: DPoS is implemented to enhance scalability and transaction throughput. By delegating validation to a small group of trusted admins, the system ensures fast and efficient transaction validation, making it suitable for real-time monitoring.

- **5. Performance Optimization**
- **Smart Contract Optimization**: Smart contracts are implemented to automate the flagging and validation process, ensuring that transactions are reviewed and validated in real-time with minimal manual intervention.
- **Resource Management**: DPoS reduces the computational burden by delegating transaction validation to selected admins, optimizing resource usage and improving system efficiency.

- **6. Scalability and Fault Tolerance**

The two-layer consensus mechanism balances high throughput with fault tolerance:

- **Layer 1 (PBFT)** ensures secure validation of flagged transactions, even in the presence of malicious or failed nodes.
- **Layer 2 (DPoS)** enables the system to scale efficiently, handling large volumes of transactions with minimal latency and high throughput, ensuring the system remains responsive.

- **7. Testing and Validation**
- **Test Environment**: The system is tested on a simulated network of 10 admin nodes to validate the performance and scalability. Transaction data is pulled from Blockchain.com for testing the system's ability to handle real-world transaction loads.
- **Performance Metrics**: The system is evaluated based on latency, throughput, and fault tolerance. Initial tests indicate the system can handle up to **1,000 transactions per second** with minimal delay.

- **Security Validation**: Penetration tests are conducted to assess the system's resistance to tampering and attacks. The system demonstrates strong resilience against common threats, such as man-in-the-middle (MITM) and replay attacks.

6. TOOLS USED

We have integrated essential blockchain tools and technologies to efficiently detect illegal Bitcoin transactions:

- React: For building a dynamic and responsive user and admin interface.
- Node.js/Express: Backend development for handling API requests and data processing.
- Blockchain.com API: To retrieve real-time Bitcoin transaction data.
- PostgreSQL: For securely storing transaction and flagged data.
- Smart Contracts: Implemented using Solidity or Go for automating transaction validation and flagging processes.

7. PROJECT SPECIFICATION

 Blockchain Framework: Bitcoin Blockchain - A decentralized and transparent blockchain that enables secure tracking of transactions, providing a pseudonymous environment for monitoring illegal activities.

 Smart Contract Language: Solidity or Go - Chosen for developing smart contracts that automate the flagging and validation processes of transactions, enhancing efficiency and accuracy in monitoring.

 Consensus Mechanisms:

Layer 1: Practical Byzantine Fault Tolerance (PBFT) - Ensures fault tolerance and security, allowing the system to function even if a portion of the nodes behave maliciously.

Layer 2: Delegated Proof of Stake (DPoS) - Enhances scalability and speeds up transaction validation by delegating tasks to a subset of trusted nodes.

 Front-End Framework: ReactJS - Used to create a dynamic and responsive user interface for both administrators and users, facilitating easy access to transaction monitoring and flagging features.

 Backend Logic: Node.js/Express - Utilized for backend development to handle API requests and manage the business logic for fetching and processing transaction data.

 Database Layer: PostgreSQL - A relational database chosen for securely storing transaction data, flagged records, and user information, ensuring data integrity and consistency.

 Data Analytics Tool: OXT.me - A blockchain analytics tool used to track Bitcoin address histories and identify suspicious transaction patterns, aiding in the analysis and flagging process.

 Network Configuration: Decentralized Network - The system operates on a decentralized architecture utilizing nodes for monitoring and flagging transactions without a central point of failure.

 Transaction Integrity: Cryptographic Hashing - Each transaction is linked and verified using cryptographic hashes, ensuring the integrity and immutability of transaction data.

 Testing & Validation Setup: Simulated Testing Environment - The system is tested on a simulated network to evaluate performance under various transaction loads, replicating real-world scenarios.

 Performance Benchmarks: Capable of handling up to 1,000 transactions per second (TPS) during load testing, optimizing throughput for monitoring Bitcoin transactions in real-time.

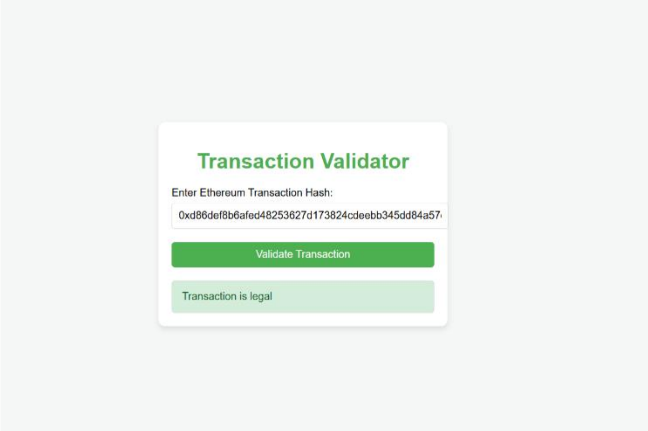
 Security Protocols: Penetration Testing - Conducted to assess the system's resilience against common vulnerabilities and attacks, ensuring secure monitoring of Bitcoin transactions.

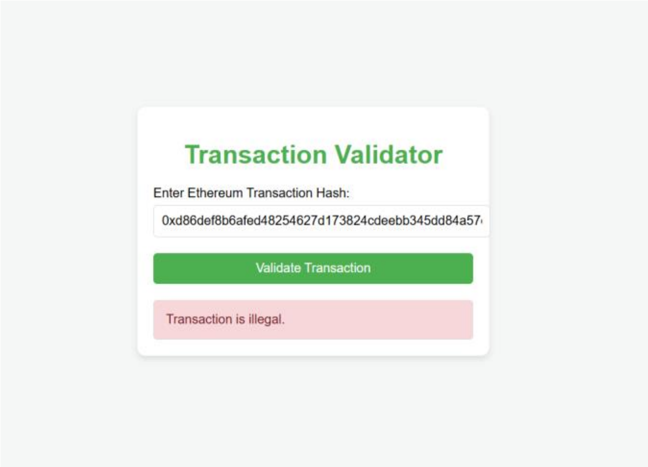
 User Interface: Role-Specific Dashboards - Custom-built interfaces for administrators to analyze and manage flagged transactions, providing tailored access to different features based on user roles.

 Deployment Tools: Docker - Used for containerizing the application, facilitating scalable deployment and management of the system across different environments.

8. RESULTS

Scalability record with no of transaction count per second.





9. CONCLUSION

This project presents a scalable and secure solution for monitoring illegal Bitcoin transactions using blockchain technology. By integrating the Blockchain.com API for real-time transaction data retrieval and employing a hybrid consensus mechanism of Practical Byzantine Fault Tolerance (PBFT) and Delegated Proof of Stake (DPoS), the system effectively balances security, performance, and scalability. This approach enables administrators to analyze, flag, and manage suspicious transactions efficiently, contributing to the broader efforts of combating illicit activities in the cryptocurrency space. The implementation demonstrates the potential of blockchain technology not only for financial transactions but also for enhancing transparency and accountability in digital finance.

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