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BLOCKCHAIN AND IOT TRACKING SYSTEM FOR LOGISTICS

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ABSTRACT

The manufacturing industry consists of several distinct departments, and the supply chain is crucial in maintaining a seamless flow of commodities during production. Traditional supply chain lacks, data visibility and security challenges. This scientific article present a proof of concept that explores integrating IoT devices with block-chain technology to address these issues. Our aim is to enable IOT devices to autonomously sign transactions to the block-chain technology using IOT devices' authenticated private keys, removing the need for third party wallets. This approach offers scalability, efficiency, and real-time responsive benefits. By utilizing the transaction processing capabilities of devices, scalability is enhanced, enabling higher transaction volumes. Automating the signing of transactions streamlines the process, improving efficiency and removing delays caused by manual intervention. This ensures real-time responsiveness, eliminating any latency typically introduced by external wallets. we present a comprehensive workflow of the use case along with simulation results, making our research findings more accessible. Through this work, we demonstrate the viability and benefits of this approach in scenarios that require continuous, automated interaction with the block-chain via IOT devices.

1. INTRODUCTION

The manufacturing industry is typically structured into several key departments, each with its own role, yet the **supply chain management** (SCM) plays a central and foundational role in the overall success of a business. In addition to its primary function of ensuring the smooth and continuous flow of materials and products through the production process, the supply chain is also crucial for facilitating communication across department, such as sales, marketing, information technology(IT), finance, and research and development(R&D).

Poor business performance has often been linked to a lack of communication among supply chain partners. One of the key issues in today's supply chains, it is essential to manage the movement of materials across all participants with transparency and reliability. Accurate demand forecasting, inventory management, material scheduling, and production planning depend heavily on such information.

The COVIT-19 pandamic exposed the vulnerabilities within global supply chains, A shortage of semiconductors, once a minor inconvenience, became a global crisis, affecting sectors such as consume goods, automotive, healthcare, energy, and many others. This disruption underscored the fragility of supply chains even within large, well-established organizations. Significant supply chain disruption can severly impact an organization's operations, resulting in lost revenue and reduced profitability. The breakdown of supply chain networks revealed inefficiencies in companies of all sizes, industries, and regions. Even major corporations, which rely on a network of global suppliers to cut manufacturing costs, were found lacking in reliable supply chain data. Transparency and data integrity have therefore become essential for managing these complex global networks.

The growing range of products and the vast network of global suppliers have added complexity to the production chain and extended the logistics chain, creating multiple potential points of failure. As a result, businesses have become more aware of the critical need to digitize their supply chains and transportation system. To enhance data security and visibility, companies are increasingly adopting advanced technologies such as block--chain and the internet of Things (IOT). This paper presents a POC that explores the integration of IOT devices with block-chain technology, with a focus on removing the reliance on external wallets. Instead, IOT devices are empowered to sign transactions automatically using their authenticated private keys. This innovative approach offers significant benefits, including scalability, improved efficiency, and real-time responsiveness. By allowing devices to handle transaction signing, the scalability of the system is enhanced, enabling a higher volume of transactions to be processed. The automation of this process also reduces overhead, contributing to greater efficiency. Moreover, the real-time responsiveness is ensured by eliminating delays typically caused by external wallets. Our research aims to demonstrate the feasibility and advantages of this method in scenarios requiring continuous, automated block-chain interactions through IOT devices.

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2. SYSTEM MODEL

In this section, we provide a comprehensive introduction and definition of the key components that form the foundation of our system model.

A. BLOCK-CHAIN TECHNOLOGY

Block-chain, also known as distributed ledger technology, is a decentralized system that distribute data storage across numerous servers around the globe. Block-chain technology was initially used primarily in the financial sector to establish a secure and reliable environment without the need for a central authority. It helped resolve challenges like preventing double-spending attacks, particularly in the context of digital assets such as cryptocurrencies. however, over time, the scope of block-chain's potential has expanded beyond finance, finding applications in diverse industries, including supply chain management, healthcare, and others. Block-chain is made up of blocks that are chronologically linked, each containing data that is cryptographically connected to the previous block, creating an immutable chain. If an attempt is made to alter the data in any previous block, it would cause changes to all subsequent blocks, enabling the detection and correction of such alterations. Each block-chain contains index, Timestamp, Previous block's hash, Transaction details, Nonce value, Current block's hash.

The block-chain implementation utilizes a custom python class with the following key features:

- SHA-256 cryptographic hashing
- Proof-of-work consensus mechanism
- Block serialization and decentralization
- Transaction logging with geospatial metadata.

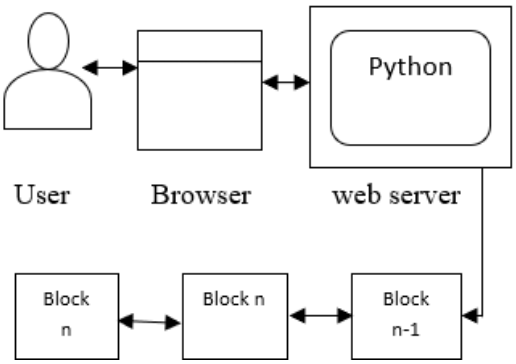

Fig 1. Block diagram of block-chain

Block-chain ledger module is in python which includes:

-Transaction management

-Block mining

-Cryptographic verification

B. INTERNET OF THINGS

The Internet of things (IOT) refers to an advanced network of physical devices capable of seamless communication and connectivity via the Internet. These devices are equipped to collect and process valuable data from their surroundings, enabling more efficient operations, cost reductions, and enhanced product quality. Central to an IOT system are physical devices embedded with sensors and actuators. These range from everyday items like thermostats, lights, and appliances to sophisticated equipment such as industrial machines and vehicles. Each device is uniquely identified and connected to the internet through either wireless or wired network.

IOT data collection module we used is Arduino**:**

- Sensor data acquisition
- Real-time tracking
- Event logging

C. MICROCONTROLLER

Microcontroller play a crucial role in the internet of Things (IOT) by enabling control and monitoring functions across a variety of devices and systems. These compact, cost-effective, and energy-efficient devices are ideal for performing specific tasks in numerous applications. A typical microcontroller integrates key components such as a processor, memory, serial ports, and peripherals like timers and counters. In this study, the Arduino Uno microcontroller was chosen for prototyping due to its exceptional features. Notably, the Arduino Uno facilitates seamless communication

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with computer system through a virtual serial port. This capability allows for easy management and coordination of various input devices, significantly improving the efficiency and functionality of IOT solutions.

Arduino Uno specifications are- Microcontroller: ATmega328, Clock Speed: 16MHz, Flash Memory: 32 KB

1). INPUT DEVICES

Sensors :

1. IR motion sensor which is HC-SR501 provides motion detection input through a digital pin.
2. GPS module which is Neo-6M provides location data through the serial/UART interface.
3. GSM module which is SIM800L which sends and receive SMS/communication through the serial/UART interface.

2). OUTPUT DEVICES

1. GSM module-SIM800L which used to sending SMS/communication.
2. alerts.

POWER SUPLLY

The 5v DC power supply provides power to the Arduino Uno and its connected components.

D). SECURITY

Security sensor-HC-SR501 PIR Motion sensor which can detect a range up to 7 meters and helps in digital output for motion detection.

E). ALERTING

Active buzzer which provides audible alerts for security events.

3. METHODOLOGY

Our proposed system integrates IOT and blockchain technologies to create a robust architecture capable of data collection, processing, and secure communication. The IOT layer is designed to gather sensor data and interface seamlessly with a private blockchain network.

An IOT device functions as the core data collection unit, capturing sensor readings and interacting with a blockchain-based application. A microcontroller within the device processes the sensor data, executes predefined virtual scripts based on the input, and transmits the processed information to the blockchain.

To optimize cost and efficiency, the device does not continuously communicate with the blockchain. Instea, updates are transmitted at regular intervals dictated by a smart contract,. This approach minimizes blockchain transaction overhead while maintaining data integrity and consistency.

The system underwent comprehensive testing to validate its functionality, security, and reliability. Identified issues were promptly addressed, and refinements were implemented to ensure optimal performance and robustness.

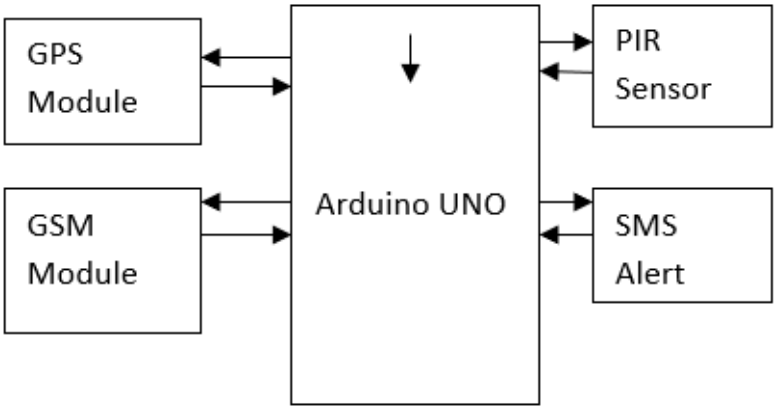

Fig 2. block diagram

4. RESULT AND DISCUSSION

An advanced tracking system combining GPS, GSM, and PIR technologies enables real-time location-based motion detection and alerts. The device continuously monitors geographical coordinates and detects movement through a PIR sensor, instantly generating SMS alerts with precise Google Maps location links. When motion is detected, the system automatically sends location details to a predefined phone number within seconds. Easily customizable configuration parameters allow seamless adaptation to various monitoring scenarios, including home security, asset tracking, and personal safety applications. Its modular design provides a robust, flexible solution for remote monitoring and rapid intrusion notification.

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A comprehensive Logistics Blockchain Ledger application that enables secure, transparent tracking of transactions across different locations using blockchain technology. The system provides a user-friendly Tkinter GUI for adding logistics transactions, mining blocks, and displaying blockchain data with robust features like transaction serialization, block validation, and cryptographic hash generation. Users can interactively add transactions, mine blocks, load specific block data, and visualize the entire blockchain's transaction history in a structured and secure manner.

5. CONCLUSION

Integrating IOT with blockchain technology can significantly enhance supply chain security, transparency, and data visibility. We developed a proof of concept(PoC) that demonstrate how IOT devices can autonomously sign blockchain transaction using authenticated private keys, eliminating the need for external wallets.

By automating transactions and seamlessly integrating IOT devices, the POC improves operationl efficiency, reduce delays, and ensures real-time responsiveness. This innovative approach highlights the secure communication and iteraction of IOT devices with the blockchain network, enabling continous and automated transaction broadcasting.

The detail workflow and simulation results outlined in this article illustrate the practical applications of the proposed solution. This POC proves it effectiveness in scenarios requiring constant, automated interaction between IOT devices and the blockchain.

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