Blockchain and IoT Integration for Smart Transportation in Cargo

Merry James[1*], Chinchu M.[2]

[1]M. Tech Wireless Technology, College of Engineering, Kidangoor, Kottayam, India

[2]Electronics and Communication Engineering, College of Engineering, Kidangoor, Kottayam, India

*Corresponding author's e-mail: merryjames20@gmail.com

doi: https://doi.org/10.21467/proceedings.160.35

ABSTRACT

Ensuring the safe transportation of hazardous materials is crucial for safeguarding both the environment and human well-being. The integration of IoT and blockchain technology in smart transportation systems has the potential to transform the cargo industry by providing efficient, secure, and reliable tracking and management of cargo throughout the supply chain. By utilizing IoT sensors to track cargo in real-time and storing the data on a decentralized blockchain platform, intermediaries can be eliminated, reducing costs, and increasing transparency. The use of smart contracts can automate many processes, reducing manual intervention and improving the speed and accuracy of transactions. This paper suggests a blockchain and IoT-based smart transportation model for cargo to monitor the sensor data in a safe and secure way.

Keywords: Blockchain, IoT, Smart contracts

1 Introduction

Transportation of goods is a pivotal element of the global economy. The ability to move goods quickly and efficiently is essential for businesses to succeed in a highly competitive market. The cargo industry is responsible for the transportation of goods across the world, and it is constantly looking for ways to enhance efficiency and reduce costs. The rise of technology has brought significant changes to the transportation industry, and two technologies that are transforming the cargo industry are blockchain and the Internet of Things (IoT). Smart transportation systems are a result of the integration of various technologies that enhance the efficiency and safety of transportation.

Data can be stored and transferred securely and transparently using blockchain technology. It is a decentralized ledger that allows for secure and immutable data storage. Blockchain technology is transforming the cargo industry by enabling the tracking and tracing of goods from the point of origin to the point of delivery. This technology provides a tamper-proof record of all transactions, making it an effective way to prevent fraud and improve transparency. In the cargo industry, blockchain technology is being used to improve supply chain management [7]. By using blockchain, transportation companies can keep track of the movement of goods, ensuring that they reach their intended destination on time. This technology enables the creation of smart contracts, which automate the payment process and reduce the risk of payment delays and errors.

Another technology that is transforming the cargo industry is the Internet of Things (IoT). IoT refers to a network of interconnected devices that are capable of swapping data. In the cargo industry, IoT devices are being used to monitor the conditions of cargo during transportation. IoT sensors can track the temperature, humidity, the weight of the cargo, and other environmental conditions that can affect the quality of goods. By monitoring cargo conditions, transportation companies can ensure that goods are transported in optimal conditions, reducing the risk of damage or spoilage. By using IoT, transportation companies can also track the location of goods during transportation [3]. This technology enables the creation of real-time tracking systems that provide accurate information about the location of goods. This information can be used to optimize the routing of goods, reduce delivery times, and improve customer satisfaction [1].

Proceedings DOI: 10.21467/proceedings.160; Series: AIJR Proceedings; ISSN: 2582-3922; ISBN: 978-81-965621-9-9

The entire supply chain must be strictly controlled when transporting dangerous cargo such as explosives, corrosive liquids, aerosols, or biological samples, as well as expensive goods [4]. Taking a small risk or being negligent can cause disaster. It is essential to monitor sensors in real-time to identify potential issues and take immediate action to prevent adverse events. If values exceed the allowable range, stakeholders such as owners, dispatchers, drivers, freight forwarders, and insurers can receive alerts immediately. By analyzing the time of an insured event, insurers can determine whether it is due to negligence or incompetence of the driver, loader, or packer. In addition, insurers can determine if it is covered by compensation. Insurers can clearly identify the time an insured event occurred using the sensors' chronology of events. In this paper, we propose a model based on Blockchain technology and IoT for tracking cargo requiring sensor monitoring [2]. This includes hazardous goods or those with special conditions, such as perishables, works of art, and goods governed by temperature.

2 Model Based on Blockchain and IoT

The model for smart transportations consists of mainly two sections:

1) The IoT system for monitoring the conditions of the cargo during transportation which is the hardware part.
2) The Blockchain technology for secure and immutable data storage, which is the software.

2.1 Block Diagram of the System

The Smart Transportation system proposed here enables the collection and secure storage of sensor data of cargos as well as the ability to analyze and visualize that data through a web application giving a live update of the transportation. As shown in Figure 1, in this system, the NodeMCU is connected to a power source, an OLED display, a GPS module, and various sensors. The NodeMCU is also connected to the backend of a blockchain network, which is an Ethereum network. A blockchain is a decentralized ledger system that is used to record transactions and other types of data. By connecting the NodeMCU to the blockchain network, it stores data collected by the sensors in a secure and immutable way.

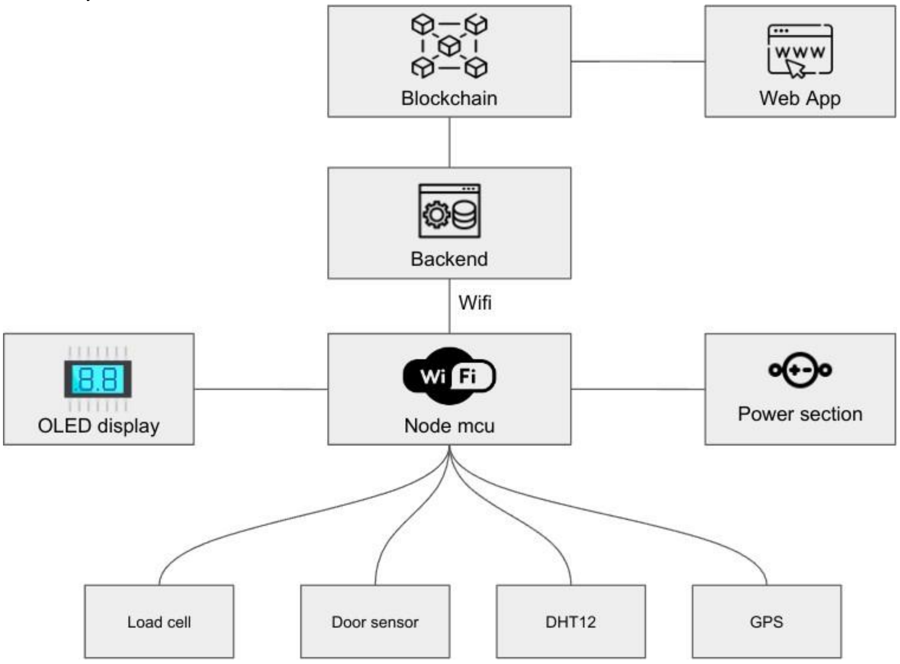

Figure 1: *Block Diagram*

Finally, the blockchain network is connected to a web application that is used to view and analyze the data collected by the sensors. This web application provides real-time monitoring of sensor data and could generate alerts or notifications based on specific conditions.

2.2 Hardware Components of the IoT System

2.2.1 Open Door Sensor or the Leaf Switch

An open-door sensor or leaf switch is a type of sensor used to detect whether a door or window is open or closed which is shown in Figure 2. It consists of two metal or plastic leaves that are positioned on the door frame and the door itself. When the door is closed, the two leaves contact each other, which completes an electrical circuit. Conversely, when the door is opened, the leaves separate, interrupting the circuit and triggering the sensor. Open door sensors or leaf switches are used here to detect when a door or window is opened or tampered with.

Figure 2: *Open Door Sensor*

2.2.2 Temperature and Humidity Sensor (DHT12)

DHT12 is a type of digital temperature and humidity sensor. It is a small and low-cost sensor that can measure temperature from -20 to 60 degrees Celsius and humidity from 0% to 100%. The DHT12 sensor shown in Figure 3 uses a one-wire interface to communicate with microcontrollers, which makes it easy to use with a wide variety of microcontroller boards such as Arduino, Raspberry Pi, and other similar platforms. Here this sensor is used to measure the temperature and humidity inside the cargo.

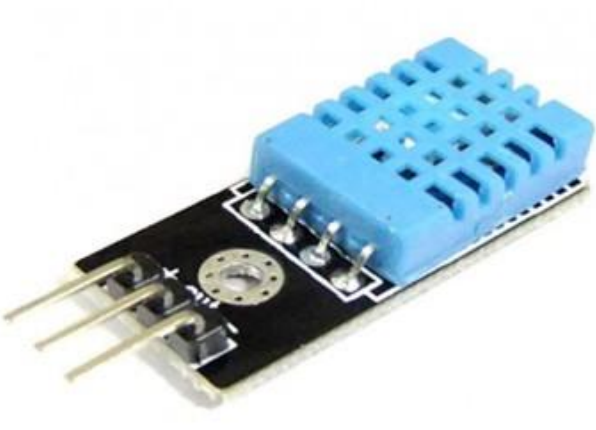

Figure 3: *Temperature and Humidity Sensor (DHT12)*

Proceedings DOI: 10.21467/proceedings.160
ISBN: 978-81-965621-9-9

Series: AIJR Proceedings
ISSN: 2582-3922

2.2.3 Load Cell

A load cell is a device used for measuring force or weight as shown in Figure 4. Basically, it's a device that converts force into an electrical signal. Load cells are commonly used in various applications where the measurement of weight or force is required, such as in industrial weighing systems, material testing machines, and force measurement instruments. In this system we use a load cell amplifier. A load cell amplifier is an electronic device used to amplify the electrical signal output by a load cell. Load cells typically produce very small electrical signals in response to applied forces, and these signals need to be amplified before they can be accurately measured and processed. They typically provide a high level of accuracy and stability, which is important for applications that require precise weight or force measurements.

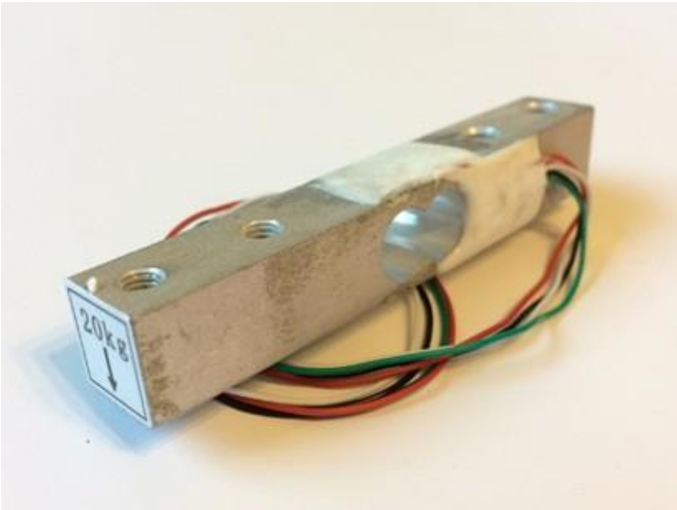

Figure 4: *Load Cell*

2.2.4 NEO 6M-GPS Module

The NEO 6M GPS module is a compact, low-cost Global Positioning System (GPS) receiver module that can provide accurate positioning, velocity, and time information to any microcontroller or embedded system as shown in Figure 5.

Figure 5: *NEO 6M -GPS Module*

2.2.5 NodeMCU ESP8266

The ESP8266 is a widely utilized Wi-Fi microchip in the realm of embedded systems and IoT due to its popularity which is shown in Figure 6. It is a cost-effective, energy-efficient chip that offers a wireless connectivity option for devices with limited computing capabilities. In this project, the information is transmitted via the nodeMCU's WiFi and stored in the Blockchain network.

Figure 6: *NodeMCU ESP8266*

2.3 Schematic Diagram of the IoT System

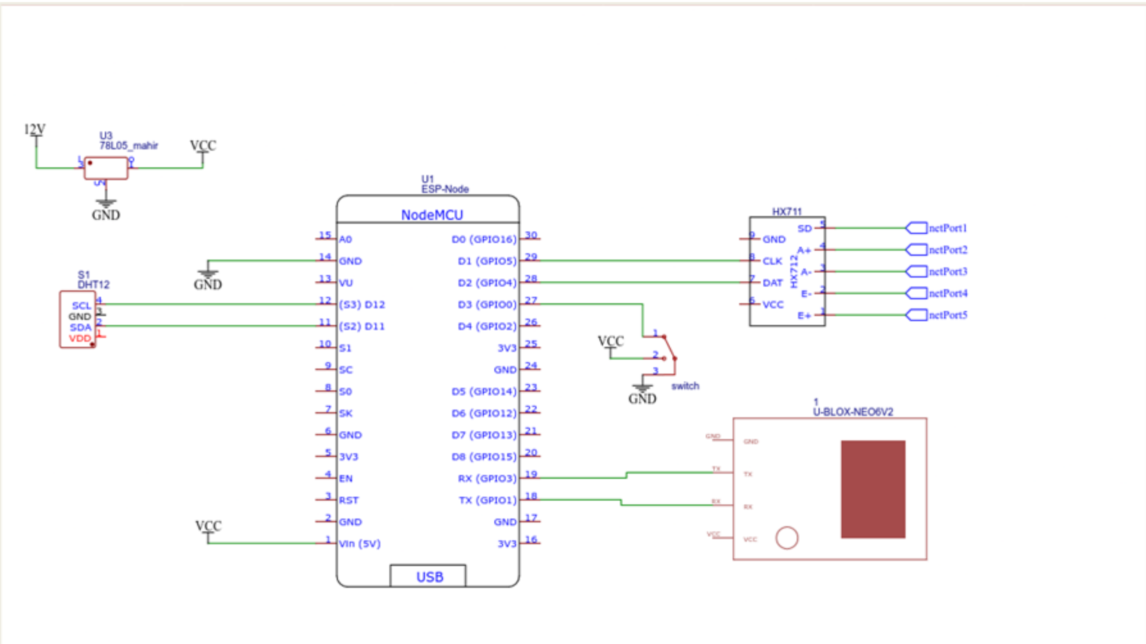

Figure 7: *Schematic Diagram of the IoT System*

The sensors are connected to the NodeMCU at different pins. A voltage regulator is used in this system to make the input voltage to the NodeMCU at 5 V at VCC. As shown in Figure 7, the SCL and SDA pins of the DHT12 are connected to D12 and D11 of the NodeMCU respectively. In the DHT12 sensor, SCL and SDA pins are used to communicate temperature and humidity data to the microcontroller. The DHT12 sensor has a built- in I2C interface, which allows it to communicate with the microcontroller using these pins. HX711 is a precision Analog- to-Digital converter (ADC) IC that is used here to convert analog signals from load cells into digital data that can be read and processed by NodeMCU. U-BLOX- NEO6V2 is the GPS module used here. The transmitter pin of NEO6V2 is connected to the receiver pin of NodeMCU and vice versa. The Open Door Sensor works as a switch. One of the

Proceedings DOI: 10.21467/proceedings.160
ISBN: 978-81-965621-9-9

Series: AIJR Proceedings
ISSN: 2582-3922

switch's leads is connected to pin D3 on the NodeMCU, while the other lead is connected to a ground pin on the board.

2.4 Hardware of the IoT System

An OLED display is given additionally to the system to display the sensor measurements from the IoT system is shown in Figure 8.

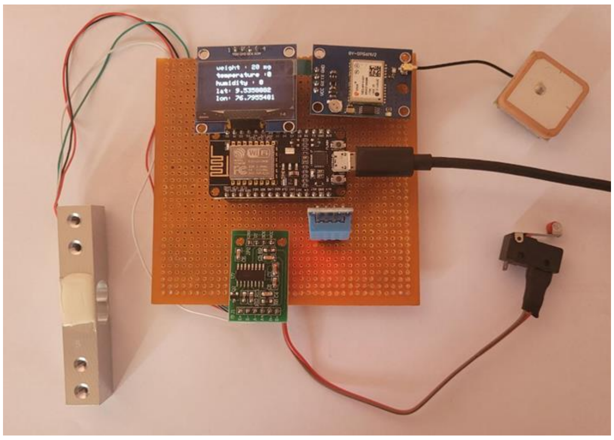

Figure 8: *Hardware of the System*

2.5 Blockchain Network

An Ethereum blockchain is used here in the Smart Transportation system for cargo to provide a secure and transparent platform for recording and tracking cargo movements [6].

The IoT system consists of various devices, sensors, and networks that are used to collect and transmit data about cargo. This data includes information about the location, temperature, humidity, and other conditions of the cargo. This data is securely stored on an Ethereum blockchain, which provides a decentralized and immutable ledger system. Each cargo movement is recorded as a transaction on the blockchain, which is verified and authenticated by a network of nodes. Smart contracts are used to automate certain aspects of the cargo transportation process [5]. See Figure 9 for the reference of smart contract. Solidity is the programming language used in this system. An Ethereum blockchain can help to reduce the risk of fraud and theft and ensure the integrity of the data collected by the IoT system.

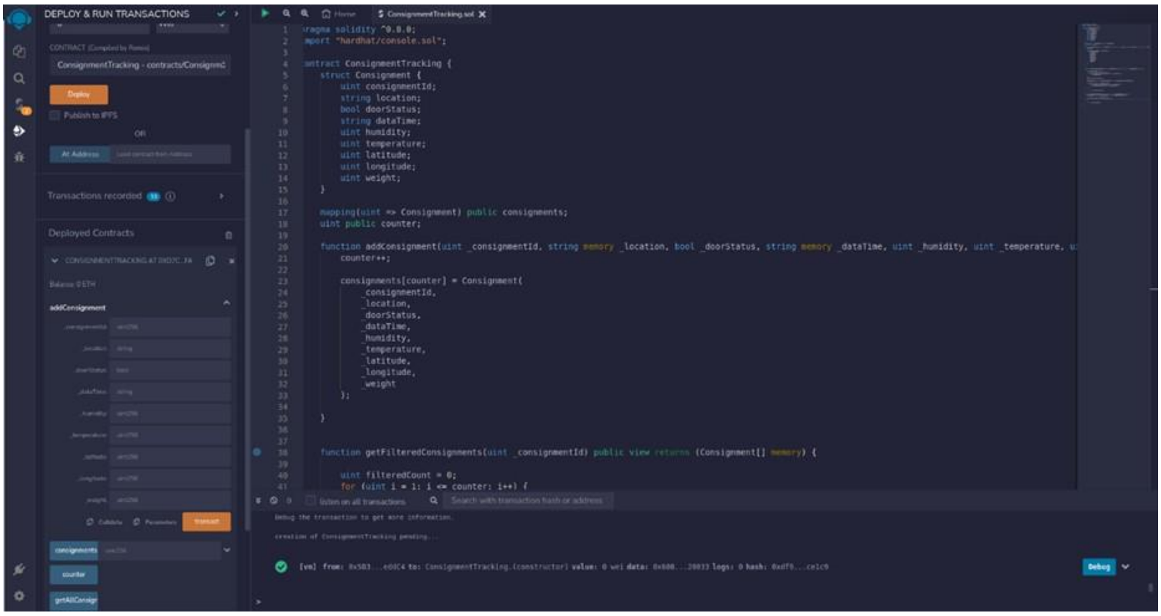

Figure 9: *Smart Contract in Remix IDE*

Remix IDE is used in this project for developing, testing, and deploying smart contracts on the Ethereum blockchain. With Remix IDE, Ethereum-based applications can be developed efficiently and easily.

3 Results

The Smart Transportation system proposed here consists of IoT hardware which is connected to the blockchain network, and the results are analysed on a webpage. Through the webpage, we can analyse the sensor measurements of the cargo. The webpage shown in Figure 10 is developed in React.js.

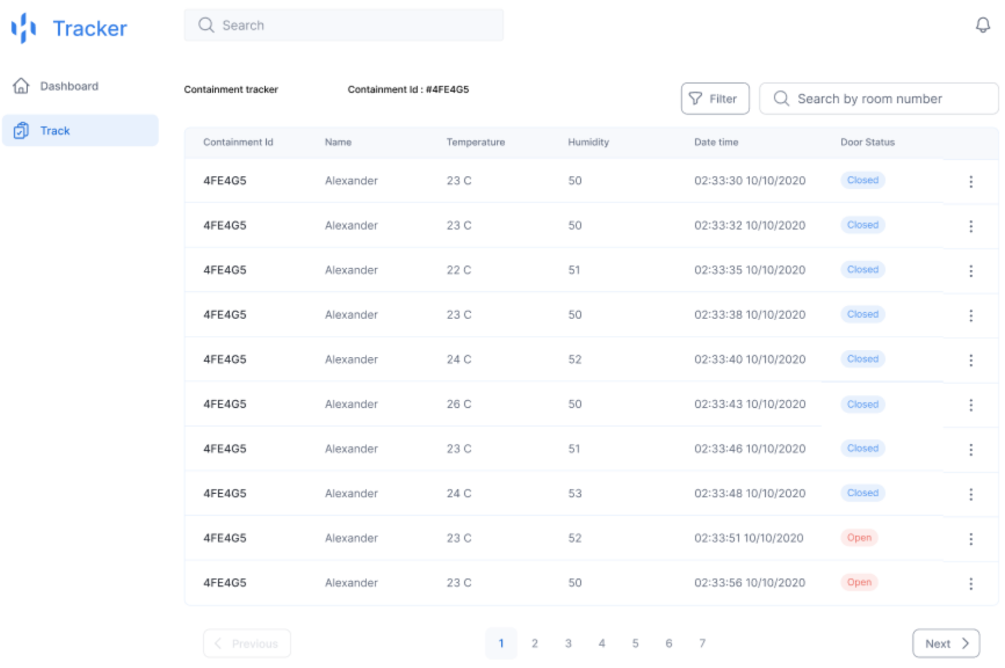

Figure 10: *Webpage*

4 Conclusion

The integration of IoT and Blockchain technologies in the cargo transportation industry has the potential to revolutionize the way goods are moved around the world. By leveraging IoT sensors, cargo companies can collect valuable data on the location, condition, and security of their shipments, while Blockchain provides an immutable and secure ledger to store this information. This combination enables enhanced visibility and traceability throughout the entire supply chain, ultimately leading to more efficient and cost-effective operations. This paper introduces a novel model that employs Blockchain, IoT, and smart contract technologies to track cargo, specifically those that require monitoring with sensors, such as dangerous goods or perishable items. The proposed model ensures transparent and chronological tracking of sensor data, which is collected from containers/vehicles, and alerts stakeholders promptly when sensor readings exceed pre-set thresholds. Additionally, this model can eliminate paperwork, lower operating costs for insurers, reduce fraud, and improve customer satisfaction by simplifying the claims process. As these technologies continue to mature and gain widespread adoption, it is likely that we will see even more innovative solutions emerge in the smart transportation space.

5 Declarations

5.1 Acknowledgment

I am grateful to the Department of Electronics and Communication of College of Engineering Kidangoor for their timely and effective support throughout this project.

5.2 Publisher's Note

AIJR remains neutral with regard to jurisdictional claims in institutional affiliations.

How to Cite

James & Chinchu (2023). Blockchain and IoT Integration for Smart Transportation in Cargo. *AIJR Proceedings*, 274-281. https://doi.org/10.21467/proceedings.160.35

References

[1] Khizar Abbas,1Lo'Ai A. Tawalbeh,2Ahsan Rafiq,3Ammar Muthanna,4,5Ibrahim A. Elgendy,6,7and Ahmed A. Abd El-Latif8 Convergence of Blockchain and IoT for Secure Transportation Systems in Smart Cities, Volume 2021 — Article ID 5597679

[2] A. Goudz and V. Steiner, "An Evaluation for the Use of Blockchain Technology in Logistics," Complexity 1, 2019, vol. 4

[3] M. Humayun, N. Jhanjhi, B. Hamid and G. Ahmed, "Emerging Smart Logistics and Transportation Using IoT and Blockchain," in IEEE Internet of Things Magazine, vol. 3, no. 2, pp. 58-62, June 2020, doi: 10.1109/IOTM.0001.1900097.

[4] Blockchain and IoT integration for smart transportation - Journal of Physics: Conference Series - Valchanov, H- Aleksieva, V 2022 - 2022/09/01 - IOP Publishing - 012012 1 SN - 1742-6596

[5] Khan, S.N., Loukil, F., Ghedira-Guegan, C. et al. Blockchain smart contracts: Applications, challenges, and future trends. Peer-to-Peer Netw. Appl. 14, 2901–2925 (2021).

[6] Yuxin Huang, Ben Wang and Yinggui Wang, Research and Ap- plication of Smart Contract Based on Ethereum Blockchain, Jour- nal of Physics: Conference Series, 2021/01/01 doi:10.1088/1742- 6596/1748/4/042016

[7] Yassine Issaoui, Azeddine Khiat, Ayoub Bahnasse, Hassan Ouajji, Smart logistics: Study of the application of blockchain technology, Procedia Computer Science,Volume 160,2019, Pages 266-271, ISSN 1877-0509