World Journal of Advanced Research and Reviews

eISSN: 2581-9615 CODEN (USA): WJARAI

Cross Ref DOI: 10.30574/wjarr

Journal homepage: https://wjarr.com/

(Research Article)

Check for updates

Blockchain and IOT for the sustainable agriculture census system development

Wahyu Kurnia Dewanto [1,*], Muhammad Hafidh Firmansyah [1], Hariyono Rakhmad [1] and Seok Joo Koh [2]

[1] *Information Technology Department, State Polytechnic of Jember, Indonesia.*

[2] *Computer Science and Engineering Department, Kyungpook National University, South Korea.*

World Journal of Advanced Research and Reviews, 2023, 20(03), 982–987

Publication history: Received on 05 November 2023; revised on 13 December 2023; accepted on 15 December 2023

Article DOI: https://doi.org/10.30574/wjarr.2023.20.3.2537

Abstract

The integration of Blockchain and the Internet of Things (IoT) technologies has revolutionized various sectors, including agriculture, by enhancing transparency, security, and efficiency. This abstract provides an overview of a groundbreaking project aimed at developing Blockchain and IoT technologies for agriculture. The conventional agriculture census process is often plagued by inefficiencies, data inaccuracies, and vulnerability to fraud. to fraud often plague the conventional agriculture census process. To address these challenges, this project leverages Blockchain's immutable ledger capabilities to ensure the integrity of agricultural data collected during the census. Furthermore, IoT devices, such as sensors and drones, are deployed to automate data collection and monitor various aspects of agricultural operations, promoting sustainability and resource optimization. Through the combination of Blockchain and IoT, the SACS provides several advantages. It offers secure, tamper-proof storage of agricultural data, ensuring its accuracy and reliability. Smart contracts on the Blockchain facilitate automated and transparent transactions, streamlining interactions among stakeholders in the agriculture ecosystem. Moreover, the real-time data collected by IoT devices enable farmers and policymakers to make data-driven decisions that improve crop yields, resource utilization, and environmental sustainability.

Keywords: IoT; Blockchain; ESP32; Transaction

1. Introduction

At present, technology has become an integral part of human life. Some technologies applied in various aspects of life are blockchain technology and the Internet of Things. Blockchain technology is crucial as it can enhance security, and transaction transparency, and ensure the authenticity of data. On the other hand, the Internet of Things technology involves the use of simple hardware devices connected through the Internet. These simple hardware devices play a role in data collection in the field, with a simpler and more reliable system, making Internet of Things technology a solution for data collection processes. Currently, data collection processes are still carried out manually, emphasizing the use of paper for data collection. After the data is collected, operators must re-enter the previously owned data. This process is time-consuming, and the costs incurred are not more economical than using technology. Additionally, the possibility of field personnel making errors when inputting data is a significant consideration, despite regulations related to this issue. However, the input data error process by field personnel remains the primary factor, causing the data entered into the main system to be potentially inaccurate. This data serves as a reference for agricultural policies and government analyses of current agricultural needs.

The presence of blockchain technology in the system also helps in the data transmission process from field personnel to the integrated system. As a result, every piece of data sent has a clear audit trail, indicating who sent the data, when it was last updated, or where the data was input. This makes the data trustworthy, and the system cannot be manipulated by attackers or individuals intending to compromise the existing data. Each data entry has a specific hash

* Corresponding author: Wahyu Kurnia Dewanto

code that can be checked for authenticity. If there is any external data alteration, the hash of a data entry will change, rendering the data invalid, thus ensuring its authenticity.

2. Related Works

2.1. Internet of Things

The Internet of Things (IoT) is a system component comprising sensors and actuators, as well as microcontrollers. In this system, it combines hardware and software to obtain data originating from related sensors. In various sources, IoT is considered a new paradigm for acquiring data. Moreover, IoT can be applied to various systems, such as smart houses and other locations (1). Despite the convenience offered by IoT in data acquisition and management, there are also risks associated with its use, including attacks on network layers, applications, and the physical layer(2).

2.2. Blockchain

One of the key elements of any service is the presence of a Service Level Agreement or SLA, which ensures the trust of users in the offered service. The use of IoT also requires an SLA, which guarantees the reliability of the processed data, making blockchain a crucial component in the transactions of IoT devices. Blockchain is a decentralized framework where there are established rules that ensure the integrity of every transaction. (3) Therefore, it is almost certain that if there is data that has undergone changes, the change process will be detected because each transaction has its own unique hash code. This hash code must be validated by the system and serves as a safeguard in case data changes occur that are not initiated by the authorized user. Based on the fundamental function of blockchain, it can be applied to IoT devices. (4), It has its own protocols and architecture that can be implemented in IoT devices.

2.3. MQTT

MQTT is a protocol used for communication between IoT devices and a cloud system, where the cloud system serves as a container for processing all incoming data. MQTT features "publish" and "subscribe," enabling IoT devices to send data from sensors and receive commands from the cloud(5). Many IoT devices use the MQTT protocol because it has a lightweight design and can be implemented on various types of software or hardware. (6)(7).

2.4. ESP32

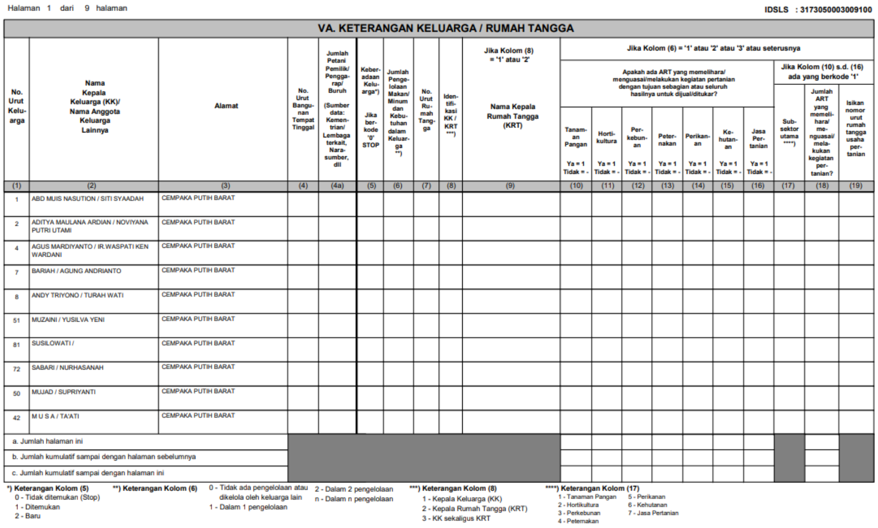
In this research, we used ESP32, which is an affordable device that can be used in IoT device development. (8)The device is highly suitable for implementing lightweight and cost-effective systems. The ESP32 has specifications that include a dual-core processor, 4MB of Flash memory, and built-in Wi-Fi, which can be connected directly to a router.

3. Proposed Scheme

In this section, we will explain the proposed scheme we have studied. The components of the proposed scheme involve several elements, such as:

- Data collection personnel, responsible for inputting data into the IoT device provided.
- IoT devices, which serve as the tools used by data collection personnel to input data.
- IoT server, acting as the bridge between IoT devices and the blockchain system.
- Blockchain system, responsible for recording every transaction and validating the transactions.
- Backend system, used as the storage location for well-validated data.

Our proposed scheme involves the process of converting traditional data into digital format. In Figure 1, you can see an example that originates from the Central Statistics Agency (Badan Pusat Statistik). (9), In the image, many fields emphasize the codes that need to be entered into the system. Therefore, it would be more effective if there was a system that eliminates the need for field personnel to input data on paper but instead allows them to use pre-provided data.



Halaman 1 dari 9 halaman

IDSLS : 3173050003009100

VA. KETERANGAN KELUARGA / RUMAH TANGGA

No. Urut Kelu-arga	Nama Kepala Keluarga (KK)/ Nama Anggota Keluarga Lainnya	Alamat	No. Urut Bangu-nan Tempat Tinggal	Jumlah Petani Pemilik/ Pengga-rap/ Buruh (Sumber data: Kemen-trian/ Lembaga terkait, Nara-sumber, dll	Keber-adaan Kelu-arga*) Jika ber-kode '0' STOP	Jumlah Penge-lolaan Makan/ Minum dan Kebu-tuhan dalam Keluar-ga **)	No. Urut Ru-mah Tang-ga	Iden-tifi-kasi KK / KRT ***)	Jika Kolom (8) = '1' atau '2' Nama Kepala Rumah Tangga (KRT)	Jika Kolom (6) = '1' atau '2' atau '3' atau seterusnya — Apakah ada ART yang memelihara/ menguasai/melakukan kegiatan pertanian dengan tujuan sebagian atau seluruh hasilnya untuk dijual/ditukar? Tanam-an Pangan Ya = 1 Tidak = -	Horti-kultura Ya = 1 Tidak = -	Per-kebun-an Ya = 1 Tidak = -	Peter-nakan Ya = 1 Tidak = -	Perikan-an Ya = 1 Tidak = -	Ke-hutan-an Ya = 1 Tidak = -	Jasa Per-tanian Ya = 1 Tidak = -	Jika Kolom (10) s.d. (16) ada yang berkode '1' — Sub-sektor utama ****)	Jumlah ART yang memeli-hara/ me-nguasai/ mela-kukan kegiatan per-tanian?	Isikan nomor urut rumah tangga usaha per-tanian
(1)	(2)	(3)	(4)	(4a)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
1	ABD MUIS NASUTION / SITI SYAADAH	CEMPAKA PUTIH BARAT																	
2	ADITYA MAULANA ARDIAN / NOVIYANA PUTRI UTAMI	CEMPAKA PUTIH BARAT																	
4	AGUS MARDIYANTO / IR.WASPATI KEN WARDANI	CEMPAKA PUTIH BARAT																	
7	BARIAH / AGUNG ANDRIANTO	CEMPAKA PUTIH BARAT																	
8	ANDY TRIYONO / TURAH WATI	CEMPAKA PUTIH BARAT																	
51	MUZAINI / YUSILVA YENI	CEMPAKA PUTIH BARAT																	
81	SUSILOWATI /	CEMPAKA PUTIH BARAT																	
72	SABARI / NURHASANAH	CEMPAKA PUTIH BARAT																	
50	MUJAD / SUPRIYANTI	CEMPAKA PUTIH BARAT																	
42	M U S A / TA'ATI	CEMPAKA PUTIH BARAT																	
a. Jumlah halaman ini																			
b. Jumlah kumulatif sampai dengan halaman sebelumnya																			
c. Jumlah kumulatif sampai dengan halaman ini																			

*) Keterangan Kolom (5)
0 - Tidak ditemukan (Stop)
1 - Ditemukan
2 - Baru

**) Keterangan Kolom (6)
0 - Tidak ada pengelolaan atau dikelola oleh keluarga lain
1 - Dalam 1 pengelolaan
2 - Dalam 2 pengelolaan
n - Dalam n pengelolaan

***) Keterangan Kolom (8)
1 - Kepala Keluarga (KK)
2 - Kepala Rumah Tangga (KRT)
3 - KK sekaligus KRT

****) Keterangan Kolom (17)
1 - Tanaman Pangan
2 - Hortikultura
3 - Perkebunan
4 - Peternakan
5 - Perikanan
6 - Kehutanan
7 - Jasa Pertanian

Figure 1 Census Data Input using Paper Based

In the proposed scheme, we have divided the process into two stages. Here are the steps for each stage:

3.1. Data Collection

In this stage, as illustrated in Figure 2, field personnel perform the data input process using the provided IoT devices. Every inputted data will be transmitted to the IoT server, and from there, it will be forwarded to the blockchain system for the recording of each transaction.

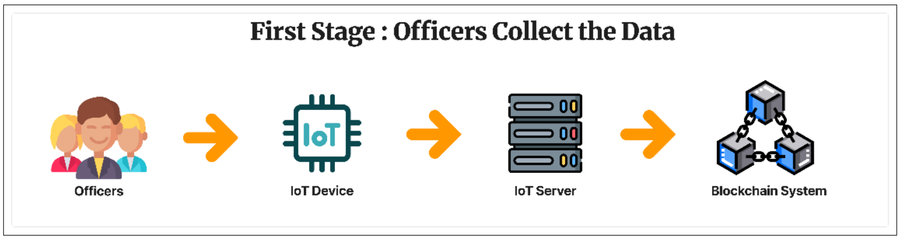


Figure 2 Officers Collect the Data

3.2. Data Storing

After data validation, the next step is to process the storage of data in the database system. Each piece of data will be ensured to be validated first. If the data is not valid, it will not be sent to the backend system for data storage. This second step is depicted in the figure 3.

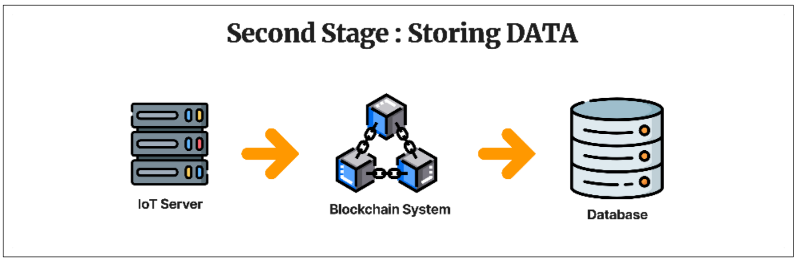


Figure 3 Storing Data

Based on the two steps described above, the data stored in the database has been validated and can be accounted for its accuracy. If any data changes occur, the change process can be traced for the existing data.

4. Results and discussion

For the implementation, we have divided it into two parts: hardware and software. On the hardware side, we have developed a device capable of receiving input data in the form of codes that have been agreed upon in advance.

4.1. Hardware

In this section, we have created the hardware device as shown in Figure 4 (1). The function of this device is to facilitate data input by field personnel. This hardware device is designed to operate on low power and can be powered by a power bank.

Figure 4 IoT hardware

The hardware device consists of several components:

1. LCD
2. ESP32
3. Keypad
4. Type C Charger
5. Stepdown DC-DC

In this setup, users are required to input data and can send the data by pressing the "#" button on the keypad. Each piece of data is recorded and sent to the IoT server and the Blockchain system for validation before being incorporated into the database system. This process ensures that only validated and accurate data is stored in the database.

4.2. Software

In this section, we have designed the software components to be used. The software that supports this system is divided into two main categories:

4.2.1. Blockchain Transaction

The blockchain system has been integrated with an API system, allowing it to be used on a broader platform. The processes within the blockchain system are depicted in Figure

```
2023/10/27 03:00:03 Adding Block Data: User Registration: Username: alip22, Amount: %!s(int=0)
2023/10/27 03:00:03 New Block Hash: 0000aae3e8ea56b7a5665c6e244cc0a4b98d6af1d1945a8d2b8dbac8d53ad040
```

Figure 5 Add New Transaction

The blockchain system has been integrated with an API system, allowing it to be used on a broader platform. The processes within the blockchain system are depicted in Figure 5.

Figure 6 Blockchain Hash generated

Furthermore, every hash will be validated by the system, as depicted in Figure 7. Each transaction undergoes validation, and only valid hashes are retained. A valid hash is a calculation based on the values sent by field personnel through the provided device. In case of data changes and invalid hashes, it will be easy to detect that data has been altered without following the correct process. This validation process adds an additional layer of security and data integrity to the system.

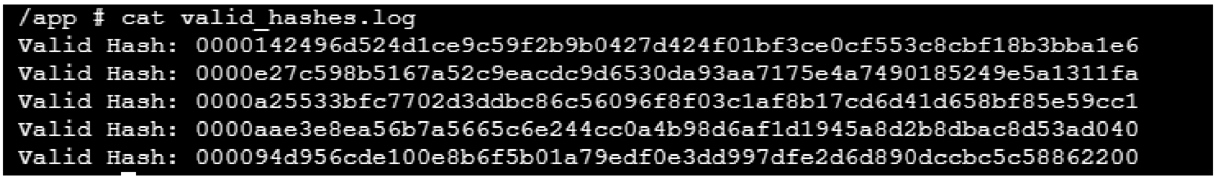


Figure 7 Valid Hash Transaction

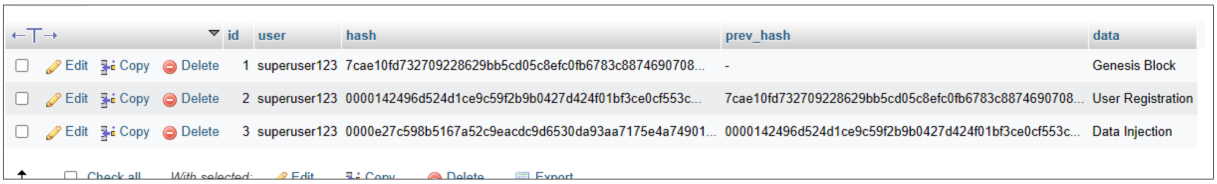
Each transaction is linked to the previous hash in the blockchain. The first block in the blockchain is referred to as the "genesis block," and every subsequent processing step calls the previous hash. This ensures the integrity of the blockchain system. Therefore, if there are any unauthorized data changes that don't conform to the hash procedures, the hash will change and no longer match the previously processed hash, as shown in Table 1. This mechanism makes it possible to detect and prevent unauthorized changes to the data.

Table 1 Current Hash and Previous Hash Blockchain

Index	Timestamp	Data	Hash	Previous Hash
0	2023-10-25 08:03:45	Genesis Block	7cae10fd732709228629bb5cd05c8efc0fb6783c887469070855348cc2ad5c42	-
1	2023-10-26 13:04:27	User Registration	0000142496d524d1ce9c59f2b9b0427d424f01bf3ce0cf553c8cbf18b3bba1e6	7cae10fd732709228629bb5cd05c8efc0fb6783c887469070855348cc2ad5c42
2	2023-10-26 13:04:34	Data Injection	0000e27c598b5167a52c9eacdc9d6530da93aa7175e4a7490185249e5a1311fa	0000142496d524d1ce9c59f2b9b0427d424f01bf3ce0cf553c8cbf18b3bba1e6

4.2.2. System Data Storage

Once the blockchain system has validated the data and deemed it to be correct, the data is then entered into the prepared database system, as illustrated in Figure 8. This step ensures that only valid and verified data is stored in the database for further use and analysis.



	id	user	hash	prev_hash	data
Edit Copy Delete	1	superuser123	7cae10fd732709228629bb5cd05c8efc0fb6783c8874690708...	-	Genesis Block
Edit Copy Delete	2	superuser123	0000142496d524d1ce9c59f2b9b0427d424f01bf3ce0cf553c...	7cae10fd732709228629bb5cd05c8efc0fb6783c8874690708...	User Registration
Edit Copy Delete	3	superuser123	0000e27c598b5167a52c9eacdc9d6530da93aa7175e4a74901...	0000142496d524d1ce9c59f2b9b0427d424f01bf3ce0cf553c...	Data Injection

Figure 8 Blockchain Data on Database

In Figure 8, you can see the workflow of the database system implementation process. Once data has been validated and confirmed to be accurate, it is stored and can be used for further system development and analysis. This step ensures that reliable and verified data is available for future applications and enhancements. And also the data that can be used as strong reference for data validation. Then we have evidence data for analytical for the next research.

5. Conclusion

The IoT system can help address issues such as ensuring the trustworthiness of data through the use of blockchain. If there are unauthorized data changes outside the established procedures, these can be quickly detected through differing hashes compared to those validated by the system. Additionally, IoT devices can simplify work processes by converting manual data input, previously done on paper, into a digital format, making the process more efficient and reliable.

Compliance with ethical standards

Acknowledgements

This research is supported by the Research Program for Lecturers at State Polytechnic of Jember, under Contract Number: 877/PL17.4/PG/2023.

Disclosure of conflict of interest

No conflict of interest to be disclosed.

References

[1] Kumar S, Tiwari P, Zymbler M. Internet of Things is a revolutionary approach for future technology enhancement: a review. J Big Data. 2019 Dec 1;6(1).

[2] Kandasamy K, Srinivas S, Achuthan K, Rangan VP. IoT cyber risk: a holistic analysis of cyber risk assessment frameworks, risk vectors, and risk ranking process. EURASIP J Inf Secur. 2020 Dec 1;2020(1).

[3] Li W, Wu J, Cao J, Chen N, Zhang Q, Buyya R. Blockchain-based trust management in cloud computing systems: a taxonomy, review and future directions. Journal of Cloud Computing. 2021 Dec 1;10(1).

[4] Shafarenko A. A PLS blockchain for IoT applications: protocols and architecture. Cybersecurity. 2021 Dec 1;4(1).

[5] Latin I, Transactions A. MQTT Protocol: Fundamentals, Tools and Future Directions. Vol. 17. 2019.

[6] Kegenbekov Z, Saparova A. Using the MQTT Protocol to Transmit Vehicle Telemetry Data. Transportation Research Procedia. 2022;61:410–7.

[7] Nikolov N. Research of MQTT, CoAP, HTTP and XMPP IoT Communication protocols for Embedded Systems. 2020 29th International Scientific Conference Electronics, ET 2020 - Proceedings. 2020;18–21.

[8] Hercog D, Lerher T, Truntič M, Težak O. Design and Implementation of ESP32-Based IoT Devices. Sensors. 2023 Aug 1;23(15).

[9] BPS. Sensur Pertanian 2023 [Internet]. 2023 [cited 2023 Oct 26]. Available from: https://sensus.bps.go.id/st2023