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Blockchain-based Agricultural Supply Chain Management System in Malaysia

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Abstract:
Blockchain is a revolutionary immutable, shared ledger technology for recording transactions between parties in a secure, chronological chain. By distributing Blockchain databases between multiple linked-nodes, it essentially does not require legal tender nor abiding legal framework by central bank regulation thus, removing intermediaries in transaction. This decentralized approach effectively made the transaction transparent to all connected nodes in the network. In this paper, a preliminary study on the implementation of smart contract in adoption of Blockchain based system will be discussed focusing on agricultural sector in supply chain system, to prevent fraud, track and to verify that by applying smart contract, the state of an event in the supply chain transaction can be autonomously execute when specific rule are meet. A proposed solution is to embed Blockchain technology into agricultural supply chain management system with digital authentication and tagging function to track product's record of ownership and location tracking in Malaysia perspective.

Keywords— *Blockchain; smart contracts; Intelligent Information Systems, Supply Chain; Agriculture.*

I. INTRODUCTION

Blockchain is simply defined as series of time-stamped record of immutable data, which the concept getting spotlight due to the rise of bitcoin and other emerging cryptocurrencies. The three main concept of decentralization, transparency and immutability introduced by Blockchain open boundaries in term of secure digital transactions and create business opportunity to be applied in all sorts of digital operation work, including in agricultural sector. Concept wise, each block contains string of data, the signature hash of the block which act as digital fingerprint and the signature hash of the previous block. The string of data that are stored inside a block can be cryptocurrency transaction such as sender, recipient and amount on coins. The hash value is unique for each recorded data inside the block and used to verify the input contents once created. Any changes made inside the blockchain will caused the hash value to be altered and cause remaining blocks in the chain becoming invalid. Thus, hash value is essential to detect any modification made in blocks metadata. This hash value checking concept effectively creates a chain of immutable blocks and makes the whole blocks sequence tamper-proof.

The Blockchain uses open P2P network. A full duplicate of the block ledger will be given to someone joining the Blockchain network. The node can use the shared spreadsheet to verify that all entries are synced in the registry. Once the nodes create consensus, the verified block is written into the block sequence. The technology of Blockchain is rapidly evolving and smart contract is an example of the recent development of Blockchain. These contracts are computing scripts that are stored on the Blockchain and can be used to facilitate the transaction process based on certain policies and automatically enforce those rules once agreed by both parties.For agricultural supply chain sector, Blockchain does create business flexibility to improve the management services from farm to fork with minimal operational waste in labour cost, defective item exchange, missing in-transit SKU, and transportation delay. The adoption of Blockchain in supply chain management system will benefits all involved stakeholders, ranging from resource manufacturer to product until to the consumers. The implementation of Blockchain- based agricultural supply chain management system will mitigate the illegal harvesting and in-transit frauds problem. An example of operational application that benefits from Blockchain technology is procurement tracking, where commodity items can be purchased quicker hence providing the good quality of the agricultural resources to the buyer. Other beneficial example will be in term of agricultural business financial audit management, where transparency, fairness and mutual trust in entrepreneurship can be achieved.

In Malaysia, the blockchain technology implementation for agricultural supply chain sector still in the administration planning stage primarily in a bid to enhance0 transparency, reliability and growth of Halal products tracking mechanism.

II. LITERATURE REVIEW

Nowadays, exponential trend of Blockchain adoption in Internet of Thing (IoT) system and deployment have attracted supply chains experts in Agriculture and Food sector to develop efficiently auditable, transparent transaction and decentralized systems [1]. Thanks to Blockchain capabilities, which cover

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traceability, immutability and public accessibility of the overall supply chain data stream aspects while optimizing both inbound and outbound processes, including financing operation [2]. The fundamental key of Blockchain implementation is to have a decentralization, reliable chronological database, cryptographically sealed and consensus trust to ensure that the information is authentic [3]. In brief, the Blockchain consist of two main components; block and transaction. Block is a package of recorded information and transaction is the triggered action by the participated nodes.

The Blockchain is cryptographically chained together using sequential Secure Hash Algorithm (SHA) values and have consensus mechanism for example Proof of Work (PoW) and Byzantine Fault Tolerance (BFT), to mitigate the block from being tampered [4]. Blockchain mining is a process to establish consensus within the participated nodes in the Blockchain P2P network where all the nodes received complete set of Blockchain information. Since the Blockchain architecture is not centralized, there will be multiple backup exist in the network and the transaction stability is maintained even if a node exit the Blockchain network[3].

The highlight of the Blockchain mechanism to be implemented in modern chain supply system is the introduction of smart contract. The smart contract is an executable program embedded with code to enforce autonomously without human intervention, when the transaction meet specific condition set of an agreement, making full use of cryptography, digital signature and secure computation[5]. In Ethereum Blockchain, the smart contract function as tokenized asset for contract interaction initiating transaction trigger in sequence of policy entries, which will update the state of the asset within the Blockchain log[5].

In modern supply chain system, distributors seeking digital seamless integrated solution, which can automate payment transactions with retailers without the need of third parties via specific terms and conditions, and all these concerns can be satisfied by adopting smart contracts via Blockchain backbone network [6]. Specifically in agricultural sector, the supply chain involves provider who supply the raw materials, producer whose responsible in planting and harvesting the crops, processor who performs menial to complex processing material task, distributor who is in charge of transporting the output of the processor to retailer and consumer who act as final node of the chain[1].

In Asian countries' context, Malaysia has not implementing Blockchain use cases at scale yet in Agricultural chain supply sector. Prominent countries like China via high-profile firm like Alibaba and New Zealand is still in pilot program stage in implementing Blockchain solution model for product tagging using QR codes which will provide overview, monitoring and tracking to customers whereby each procedure are authenticated [7]. In worldwide, the vast majority of 87% of the recorded firms still at early POC stage, 10% of the recorded organisations still in pilot stage deploying Blockchain in at least one site and only remaining 3% of the participated organisation worldwide are currently deploying at-scale implementation [8].

III. METHODOLOGY

A. Problem Statement

The table below shows the highlighted issue of traditional supply chain in Agriculture and Blockchain implementation ways that can address the problem, side-by-side comparison. Note that the primary problem related to conventional supply chain management system can be addressed by three main pillars in the Blockchain concept which are decentralization, transparency and immutability.

TABLE I. FEATURES OF BITPAY

Traditional supply chain problems	Addressing the problem with Blockchain
Lack of traceability	Audit trail for all transaction
Risks tamper data within multiple stakeholders	Immutable: secure against undesirable changes
Lack of responsiveness	Near real-time response
Largely manual processing	Digitalized processing
Regulatory compliance	Tamper-proof data easily verifiable
Reconciliation burden	Single shared source of truth

B. Conceptual Technology Used in Blockchain

The general protocols of Blockchain as below:

1) A supply chain transaction is initiated between a supplier and customer for the PO receipt. This is to be available in the genesis - primary block metadata.
2) The transaction is represented online as a 'block' in the Blockchain.
3) The block is broadcasted to the respective connected nodes in the Blockchain distributed P2P network.
4) The 'miner' around the world is alert of an impending transaction in the Blockchain.
5) The 'miner' provides the transaction verification service for every node.
6) The 'miner' is rewarded for his verification service in bitcoins. All the nodes have to be verified by a miner for the transactions to be valid.
7) The verified block will be written to the Blockchain sequence as a legitimate transaction and it becomes an indelible and transparent record of transaction.
8) The transaction is always available in public for any auditory purpose whereby every time the product change hands; its location data and timestamp are updated and synced throughout whole Blockchain.

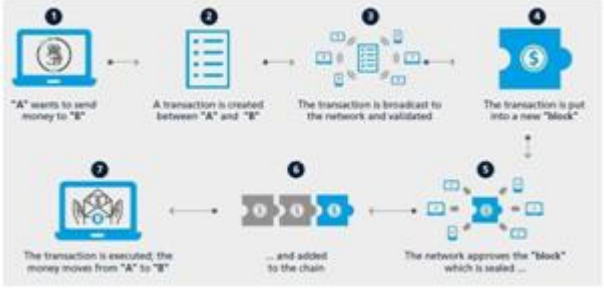

Fig. 1. Blockchain operation flow in money transaction from A to B [9]

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B. Proposed System Architecture and Flow

The proposed architecture for this paper is to build a traceability, agricultural supply chain management platform based on Blockchain technology whereby the participant of the transaction involves more than 2 parties, which normally involve supplier, distributor, and consumer. The proposed platform will adopt smart contract feature and commercial-based Digital Authentication Passport [10] in asset tracking and transaction identification, from distributor to customer. It will verify the authenticity of the product and addressing mobile, single sign-on user experience via login captive portal. Google Sheet and BigQuery database will be used for this proposed supply chain management system as to provide distributed ledger using Blockchain framework for asset registration, unique ID assignment and Google DataStudio BI act as a front-end connector to fetch data directly from back- end Blockchain network into visual presentation in form of virtual dashboard which is accessible via web and mobile.

Currently, existing Blockchain-based supply chain management system architecture adopted Hyperledger Fabric, which is a Linux Foundation open-source tool that designed for ledger framework [6]. The Digital Authentication Passport (DAP) is the passport linking user identity to a record of ownership, from origin to the last estimation. Commercially used in providing cryptographic verification of collectibles, DAP provides details containing the asset's characteristics, history log, proof-of-ownership and authenticity check [10]. The key feature of this supply chain management system is to generate unique cryptographic DAP ID for each registered agricultural product and this tag will also store all the product information as per listed in Table II below. Smart contract will record the user ID and product DAP ID and also the terms and condition of the transaction. Once agreed by both parties, the digital signature is applied on the block and sent to consensus process prior written in the Blockchain network. If the item got stolen or missing in-transit, the last location and PIC can be detected based on the information stored in smart contract.

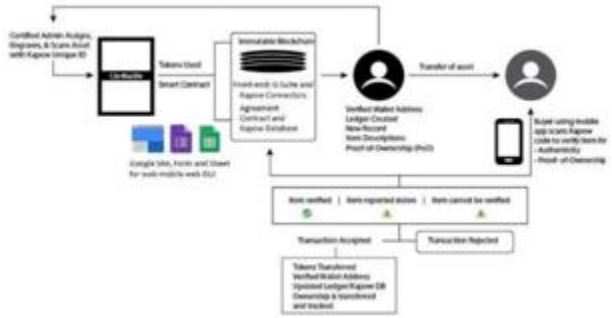

Fig. 2. The proposed Blockchain-based supply chain management system with adoption of smart contract

TABLE II. THE GENESIS BLOCK IN BLOCKCHAIN CONTAINING DATA ON ITEM DESCRIPTION AND PRODUCT DETAILS

Item	Details
Product ID details	**Identification number and displayed item label**
Date	**Operation timestamp**
Location	**The destination of the operation taking place**
Company	**The company that is responsible for that transaction**
Product-type	**Type of product in transaction e.g., fertilizer, harvested crops, seeds.**
Input	**Input of process activity e.g. type of harvested crop, quantity of fertilizer**
Memo	**Additional information if require**
Digital signature	**Digital signature of the responsible company**

Fig. 3. Application of QR code consist of unique product DAP ID for validity, tracking and audit trail purpose and used in smart contract.

C. Algorithms

The set of instruction below describe the system operation workflow:

1) Producer who owns a Verified Wallet Address create new record ledger describing the supplied item by filling up details as shown in Table 2 and data stored in Blockchain database.
2) The smart contract will record the distributor identity and their supplied item details, together with the asset- scanned code for reference in web application interface, as shown in Figure 3.
3) Access control rules will apply to the ledger record to control data visibility.
4) Distributor initiated item request record and contribute token via DAP.
5) The distributors then decide whether to accept/reject the contract requested by the producer.
6) Both request records are stored in Blockchain database and clear consensus is defined, the smart contract will be generated and distribute to both producer and distributors.
7) Both parties need to agree with the conditions before the block is added into their Blockchain.
8) Transaction will be executed whereby the token will be held for producer and the distributors will have the Kapow Unique ID to validate and track the products easily using Kapow User Interface until reach the destination.
9) Once the distributors accepted the item, the condition of the smart contract is satisfied and the

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producer will get the transferred token, credited into his verified wallet account.

10) The recorded ledger in Kapow database will updated and the ownership of the purchased item will now transfer to the distributors and recorded in their registered DAP.
11) This record is visible to public to trace all the pasts and current ownership of the accepted item.
12) Same transfer asset procedure needs to be followed for retailers and potential end-consumers.
13) If any of the participants rejected the transaction, a feedback input is needed whether the item is reported stolen from unverified distributor, retailer or the item cannot be verified since the metadata of the item details record has been tampered with false information.
14) Feedback will be collected by the Kapow database and the system will drop the block from the Blockchain since the consensus is unsatisfied and the block become invalid.

D. System Design - Graphical User Interface

The web interfaces were programmed and built by using G Suite application (Google Form, Sites and Sheet), JavaScript, Angular5 and HMTL5. By referring to the example Agreement Contract web application in Figure 4, a decentralized Blockchain network connects all registered nodes' ledger record in the supply chain management spreadsheet in view-only mode. This feature eliminates the need to go tedious paperwork process through central entities, relying updates from intermediaries or closed-door tender process. The information stored on this database is crucial as it store important detailed item tracking entries such as the shipment description, quantity and destination, as well as how the goods must be managed.

This designed web interface supports mobile Bar/QR code scanner application, which allow Bar/QR code be a referencing key item in smart contract. This feature enables authorized participants to make new item registration, reporting for defect or transaction once the QR code is scanned, since each item assigned with unique Bar/QR code. All the agreement contract can be tracked in agreement history where the supplied item is in delivering process, pending for custom check-up or safely reach the destination or warehouse.

The integration with Kapow Supply Chain Tracking Logistics (SCTL) in mobile web GUI application enable the transaction item to be tracked geographically to pinpoint the current location for example to tracked packaging lost in transit or delayed arrive to the warehouse. SCTL is a transparent customer-centric system in provisioning logistics supply.

Fig. 4. Example of Agreement Contract and Item QR code web interfaces.[6]

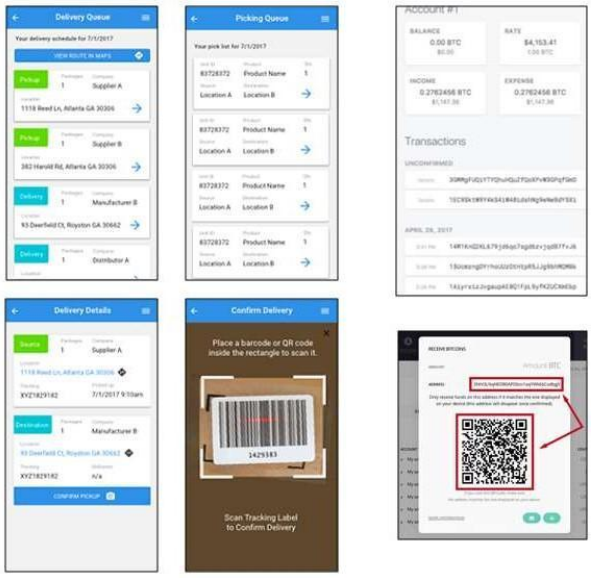

Fig. 5. General Sequence Diagram

E. Sequence Diagram

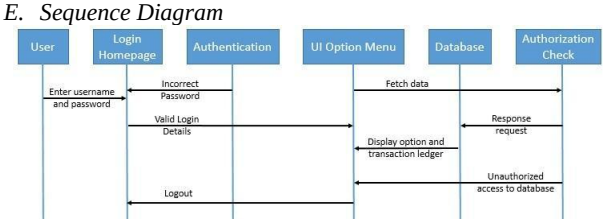

Fig. 6. Example of mobile GUI application for tracking delivery and picking queue, viewing transaction details and barcode/QR code scanner for confirmation delivery once reached delivery destination.

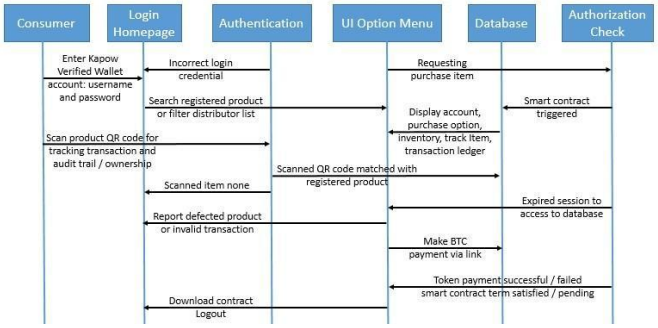

Fig. 7. Producer Sequence Diagram

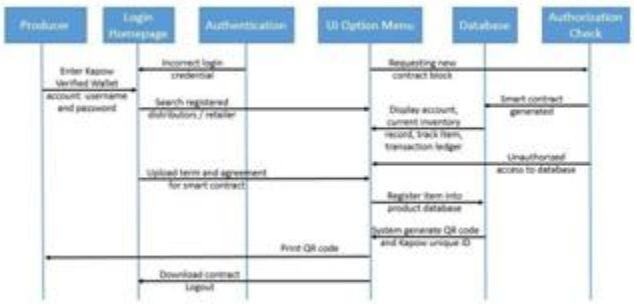

Fig. 8. Distributor Sequence Diagram

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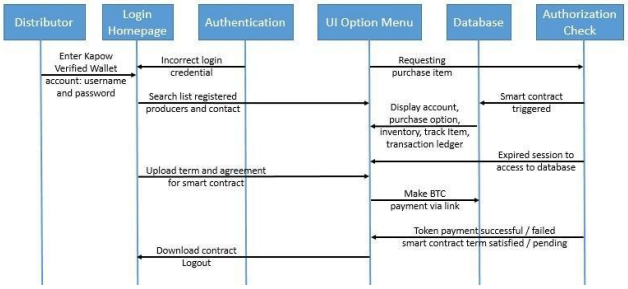

FIG. 9. CONSUMER SEQUENCE DIAGRAM

In brief, Figure 6 illustrated the sequence proccess flow for user when signin into the supply chain mangement system captive portal. The identity of the user will be authenticated based on the registered ID record stored in the DAP database. Figure 7 shows the authentication process and functionality access for the producer whereby they have capability to register item and generate product DAP IP to tag their registered item into the database. Similarly in Figure 8 is for the distributor authentication and have product query and register for reselling the item. Noted that the item DAP ID remains intact but the new ownership details is updated. Figure 9 shows the consumer authentication process diagram and option.

F. Website Page User Interface

Fig. 10. Web GUI homepage for proposed Agriculture Supply Chain project

- Login as consumer: Zahin Asyraf Mazlan

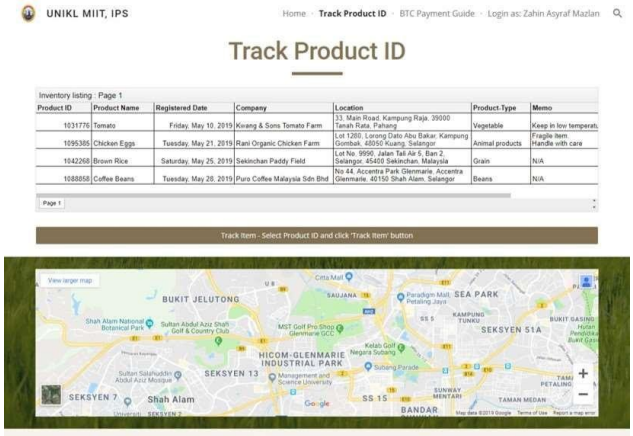

Fig. 11. Tracking the product delivery status based on Kapow's SCTL feature via QR code scanned timestamp and location

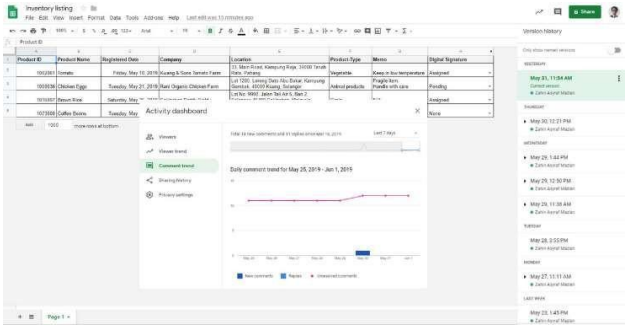

Fig. 12. Decentralized ledger render immutable record since version history and timestamp saved on every users file copy and any changes in the transaction record will lodged on version history and marked in activity dashboard, viewable to all.

IV. CONCLUSION

In order for the Blockchain to have a significant impact on local supply chain management, it has to eliminate the need for trusted third parties and intervention from monopolized body govern the supply chain system. All the stakeholder also needs to be adapted to the specific needs to Blockchain-based supply chains system, in both in terms of data requirements, and in terms of the potentially complex structures of supply chains monitoring which involved IT knowledge. More importantly, the elimination of intermediary mitigate risks of shipment frauds, product duplication, and reduce cost wastage. However, there are few challenges that need to be addressed before the Blockchain system can be widely operational, especially in Malaysia. Regulatory and legal acceptance, central administrator for Blockchains command, validity of the information stored, standardization, latency, interoperability issue and health monitoring are few limitation factors to be listed that exists, preventing Blockchain technology from expediting its adoption rate in mainstream business[11]. Further work involve the adoption of Block-Age selection for improvising the block in the Blockchain from being tampered by malicious party. Concept wise follow mechanism of Coin age-based selection in Proof of Stake (PoS) where each new added block joined the Blockchain will have time-age as zero and will count number will increase as long as the data in the block is not touched. After 30 days, the block is permanently encapsulated and no editing is allowed for the data inside the block. If there is unauthorized attempt to alter the data inside the block within 30 days, the time-age count will reset to zero. This will be seen in dashboard as anomaly since only that particular block got different time-age count compared to other blocks in the Blockchain sequence. Notification alert also can be added as improvised security wise, notification alert feature of the proposed system.

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