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Improving Halal Certification Distribution Traceability: A Case Study on Retail Purchase

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Ensuring the integrity and authenticity of halal foods is of paramount importance to both consumers and regulatory bodies worldwide. However, challenges in traceability within the halal food supply chain persist, leading to concerns regarding compliance with halal standards and the prevention of fraud. This paper presents a comprehensive case study on enhancing food traceability, specifically tailored for halal products within the retail sector. A group of businesses from five different industries—the food processing industry, meat slaughter, catering, restaurants, and halal agencies—created the Hyperledger fabric network by providing contextual process flow and a framework for implantation on the platform. The network shelters two transaction channels: the halal supply chain channel and the halal certification channel. The halal agency is invited to join the network and is given access to the latter channel. The Halal supply chain channel simulates the flow of block data across the network, where buy-sell transactions happen between two parties in the channel. On the other hand, the halal certification channel provides a means for any company member in the network to request halal certification from the agency. The simulation promises future real-world applications in operational networks. The simulation of blockchain for halal certificates, on the other hand, shows that the application of Hyperledger Fabric will not improve the speed of halal certificate awards from halal agencies. However, it really improves the openness of the certification process to the members concerned. This simulation is carried out in a limited environment and configuration setting. To make it operational, further research should be envisioned, particularly on the limitations of the open-source coding for accommodating the real number of participants that may occur in one channel or in the network. Hyperledger fabric

open-source code also experiences instability during the simulation. This research contributes to the ongoing discourse on enhancing food traceability and integrity, particularly within the context of halal foods in the retail sector.
Keywords: Halal certification, Catering, Food processor restaurant, Slaughterhouse.

1. Introduction

One of the newest technologies in use today is the blockchain, which has the potential to completely change how society functions and how value is created. Blockchain is an open distributed ledger that can effectively and permanently record transactions between two parties [1]. For many years now, blockchain technology has been incorporated into the food business. The majority of retail corporations and food companies implement it for a variety of reasons, including improving food traceability, ensuring food safety, choosing suppliers for the food industry, meeting operational demands, improving inventory management, preventing price gouging, eliminating counterfeit goods, reducing food waste, providing food supply chain provenance, and substantiating label claims [2]. In the food industry, the food chain must become more sustainable to increase consumer confidence and purchase intent [3]. To identify and resolve sources of contamination and support sustainability management in food chains, tracking and validating the information throughout the entire food supply chain is essential [4], [5]. With the largest Muslim population in the world, Indonesia offers halal food producers a sizable global market. Citizens demand halal food and services. Halal food integrity being an issue that has emerged following food integrity, religious factors influence the importance of the integration of halal food in terms of safety, health, and quality of food [6].

Compared with the emerging application of blockchain technology in the real business world, there is not much research on the application of blockchain technology in the halal food supply chain. In 2019, Rohmah et al. [7] looked into how halal food can be tracked and how blockchain could be used in these systems. In 2020, Vanany et al.[8] suggested a concept framework and blockchain architecture for Indonesian halal food integrity and Hyperledger Fabric. Vanany et al.[8] separate the halal ledger from the value chain ledger. Alamsyah et al. [9] proposed a blockchain-based halal traceability system model where only the process would be certified, not the product. Based on those research results, it is understood that the simulation of halal food integrity in a blockchain has hardly been done yet; hence, this study aims to contribute to a simulation of halal food integrity using Hyperledger Fabric in Indonesia's case. This paper has become a bridge from the conceptual model to the implementation of halal food traceability, especially in Indonesia. This study also clarifies that halal certification may operate on blockchain technology, especially using Hyperledger Fabric. The halal certification requirements are transformed into certain data processes in blockchain; hence, the processes are open and can be traced.

There are five important players in Indonesia’s halal food industry, namely food processors, restaurant slaughterhouses, caterers, and halal agencies, which are called BPJPH. BPJPH is an abbreviation for Badan Penyelenggara Jaminan Produk Halal (the Halal Agency in this study). Food processor that processes food starting from farmer up to food market;

slaughterhouse that processes all kinds of meat susceptible to haram (not halal) process as well as contamination of pork aspect during process from slaughtering to packaging for meat market; catering that sells cooked meal to organization; and restaurant that cooks food for individuals in leisure fashion. These four players create a sort of split halal food supply chain where traceability of halal is done, represented by the propagation of halal stamps along the blockchain network, and stored in a common ledger accordingly.

After the approval of Law Number 33 of 2014 on the Guarantee of Halal Products, the certification process for halal products underwent a considerable transformation. Now there are more institutions involved in the halal certification procedure than the Indonesian Ulema Council, or in Indonesian, Majelis Ulama Indonesia (MUI). Since 2020, halal certification involves 3 institutions, and each institution already has its own obligations under the halal certification process, from the submission of the owner of the product until the issuance of the certificate [10], [11]. Blockchain technology is seen as a promising technology that can help create trust mechanisms to resolve difficulties with transparency and security because no participant in the supply chain can change information that has already been recorded. There is still a lack of a country that has a specific framework, architecture, and data structure for the integration of halal foods using blockchain technology [12]. Fothriani and Annisa [13] stated that some developed countries with a non-Muslim majority are more interested in halal food because it is considered safer and has gone through various inspection and supervision processes. This becomes the urgency of this study.

Although Indonesia is a large Muslim nation and could lead the global halal market, technology and procedural standards still do not allow for sufficient levels of process transparency, traceability, and information granularity [9]. This study aims to contribute to a use case where the Vanany et al. [8] framework has been proposed and where Alamsyah et al. [9] claims for transparency are addressed. It poses the main question: How are the halal food supply chain and halal certificate processes simulated using Hyperledger Fabric Coding?

2. Definition

This section describes the definitions, scenarios, actor functions, and stages passed during the process flow in Halal Product Tracing.

Halal, in the context of food and dietary practices, refers to items that are permissible or lawful for consumption according to Islamic law (Sharia). The term "halal" is derived from Arabic and translates to "permissible" or "allowed." For food to be considered halal, it must adhere to specific guidelines outlined in Islamic jurisprudence. Some key principles include:
1) Prohibited Ingredients: Any substance that is explicitly prohibited in Islam, such as pork and its by-products, blood, alcohol, and meat from animals not slaughtered according to Islamic rites. The food should be free from pork, alcohol, and guilt. 2) Slaughter Method: Animals permitted for consumption must be slaughtered by Islamic rituals, known as "Zabiha" or "Dhabiha." This entails a Muslim slaughtering the animal while pronouncing the name of Allah (God), ensuring the animal's welfare and proper bleeding out. 3) Cleanliness and Hygiene: Food preparation and handling must adhere to principles of cleanliness and

hygiene as prescribed in Islamic teachings and 4) Absence of Contamination: Halal food should not come into contact with non-halal items during preparation, cooking, or serving to avoid contamination.

To ensure adherence to these requirements, Islamic authorities or certification bodies frequently provide halal certification. Halal food is not only important for Muslims but also for individuals who seek food produced by certain ethical and religious standards.

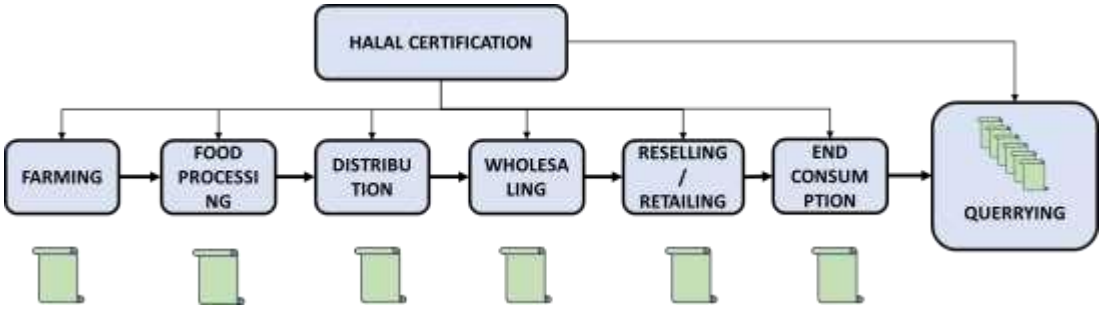

Figure 1. The Process Flow of Halal Product Tracing

Generically, regulatory bodies, production, logistics parties (raw material suppliers, producers, distributors, wholesalers, and resellers), and end consumers, create a consortium of blockchain. They operate inside the supply chain with halal certification to perform the whole food process as shown in Figure 1. Each member of the consortium is responsible for a specific process depicted in Figure 1.

Function in a process of food supply chain with halal certification distribution traceability shown in Figure 1 can be described as follows:

1. End consumption: Organizations or individuals seeking assurance that the food they purchase adheres to kosher dietary laws.

2. Reselling/retailing: Entities (retail store, food and beverage, small seller) responsible for reselling in retail format halal-certified food products.

3. Wholesaler: Entities responsible for selling in wholesale format halal-certified food products.

4. Distribution: Entities responsible for food preparation and distribution of processed food.

5. Food processing: Entities (slaughterhouses, agriculture food processors) that provide facilities where animals are slaughtered and agricultural products processed according to halal dietary laws.

6. Farming: Entities (large, medium, small farmers) who facilitate the supply of raw material to the meat and agri-products to the market.

7. Certification Authority (BPJPH): An organization responsible for verifying and certifying that food products meet halal dietary requirements as well as foreseeing the transfer of halal assets following regulation.

8. Blockchain Network (Hyperledger): The decentralized network where smart contracts operate to ensure transparency and integrity in the certification process,

As the members of the consortium are interconnected through blockchain technology, a variety of systems is proposed. Chandra [14] proposed a IOT based blockchain in which regulatory bodies in the network validate product quality before approving transactions on the blockchain, IoT devices like QR codes, RFID chips, and sensors automatically collect and upload product data, and the blockchain ensures data accuracy regarding the product's origin and purity, smart contracts automate actions based on pre-defined conditions, such as triggering payments upon fulfilling order requirements, consumers can scan product codes to view its history and Shariah compliance on the blockchain, and user feedback and ratings stored on the blockchain for all stakeholders to improve their services. Vanany et.al [8] devise a conceptual framework for Indonesian halal food integrity in the design of interconnected blockchain architecture using the concept of Hyperledger Fabric from IBM with some proposed lists of assets relevant to the certification process in Indonesia.

The following scenario is envisaged:

1. Certification Creation: The Certification Authority creates a smart contract on the blockchain specifying the criteria for halal certification, including ingredients, production processes, and any other relevant requirements. The contract is programmed to execute certain conditions (No.2 above) to validate the Halal status of food products.

2. Product Registration: Food producers register their products on the blockchain, providing detailed information about ingredients, production methods, and sources. The smart contract automatically verifies the compliance of the registered products with the predefined halal criteria.

3. Product Purchase: Consumers can access the blockchain platform or scan product QR codes (to see the smart contract) to verify the halal certification of food items. The smart contract confirms the halal status of the product in real time, providing assurance to the consumer

4. Transaction Execution: When a consumer purchases a halal-certified product, a transaction is initiated on the blockchain. The smart contract ensures that the purchased product meets the halal standards before finalizing the transaction.

In the process in Figure 1, it is not necessary for end consumption that the actor requires all certificates to be presented. This is because, to get certification in every process, the input as well as the process are the object of scrutiny by the certification process. The output of the process is guaranteed to comply with the halal rule once the certificate is granted. However, the facility to inquiry is available if required.

3. Literature Review

3.1 Blockchain

A blockchain is like a database; it is a way of storing value and a record of transactions. Almost anything can be recorded on the blockchain; the blockchain eliminates the

middleman and allows people to transact directly with each other [15]. Blockchain technology has the potential to handle various security attacks, and blockchain can eliminate the need for a central authority to perform various operations [16]. Generally, a blockchain is an immutable ledger of transactions maintained on a distributed network of peer nodes. Each of these nodes maintains a copy of the ledger with transactions verified by the consensus protocol, grouped into blocks containing the hash connecting each block to the previous block. Key elements of blockchain architecture include nodes, hash functions, proof-of-work, mining, and timestamp servers. Nodes are associated with network participants, a hash function is a mathematical algorithm that takes some input data and creates output data, proof of work is a consensus mechanism to secure transactions and develop tamper-proof protocols, mining adds a new public ledger and a timestamp server that adds a block from a transaction log to a blockchain indicates that data must exist at that point in time to be included in a hash [17].

Companies across the industry are building platforms based on blockchain technology. Currently available use-case platforms include EOS [18] , Hyperledger Fabric [19], Quorum[20], and so on. Start-ups like Filament [21] for IoT, Algorand [22] for remittances, and more. Use cases in the food industry have also attracted attention recently. Organizations implement blockchain technology for various purposes, such as improving food traceability, ensuring food safety, selecting suppliers in the food industry, meeting operational requirements, improving inventory management, preventing price pressure, eliminating counterfeit products, reducing food waste, providing traceability, and label claim verification for the food supply chain [23]. According to Mishra et al. [24] study on the use of blockchain, it is also based on the argument of providing a remedy for the imbalance of information between organizations. Some research on blockchain utilization is in property [25], logistics [26], pharmaceutical industry [27], [28] automotive [29] and food supply chain [30], [31]

In the food industry, proper traceability records, storage, and transfer of information related to food-producing animals at all stages of the food supply chain are available. Products can be tested for safety and quality control with traceability to the top and tracked at any time [32], [33]. It includes product, process, genetics, traceability of inputs, pests, and measurements [34]. There are three main characteristics of a traceability system: i) identification units or batches of all ingredients and products; ii) information about when and where they are moved and transformed; and iii) a system linking these data [33]. These three characteristics of a traceability system enhance food security [35]. Clapp et al. [35] defined food security using six dimensions: availability, access, utilization, stability, agency, and sustainability. All six dimensions are exposed to security features of food production and processing. Today, food industry sectors are utilizing the immutability, traceability, and security features of the blockchain for food to grow their businesses and resolve the counterfeit challenges that have plagued millions of brands for decades in various industries, including the food industry.

3.2 Hyperledger

Blockchain networks can be classified into two categories: permissionless and permissioned. A permissionless blockchain is a blockchain network that is open to any user. Bitcoin is an

example of a public, or permissionless, blockchain. Anybody can put their computer processor into the network as a node in the chain, participating in agreeing to relay and verifying transactions on the network. Joining the blockchain is as simple as downloading the software and the bitcoin ledger from the internet. Like any other blockchain, Bitcoin keeps a list of all transactions and reflects the full transaction history and account balances of all parties.

Permissionless blockchains have intractable limitations when applied to networks of business entities. When creating a blockchain, transaction volume or size can be adjusted according to the best technology available. As the technology advances, the initial setup may become a limitation that renders the blockchain obsolete and may slow down transactions. Permissionless blockchain users should also know that anyone who downloads the database will be able to see their transaction history if the database is active. While it may be difficult for external parties to identify participants on the blockchain, if participants are identified, their entire transaction history becomes public [36]

Some organizations are considering the use of private or permissioned/consortium blockchains, which restrict blockchain network participants to those who have received a license from the protocol administrator due to the limitations of permission-free blockchains. These blockchains address some of the shortcomings of public blockchains but also sacrifice some of their potential benefits (e.g., decentralized transactions, broad ledgers, and a truly decentralized environment without intermediaries). Allowed blockchains are likely to be built by a consortium of parties that can collectively benefit from a shared ledger system. For example, a food supply chain network might want to use blockchain to track the origin and movement of goods or ingredients. For this purpose, the Linux Foundation released their Hyperledger project, which is focused on blockchain. Hyperledger is an open-source collaboration to advance blockchain technology. It is also cross-industry and not limited to one industry. Technology, finance, and blockchain start-ups are part of the overall Hyperledger ecosystem [37]

One use case of using a permissioned blockchain network is as described by [38]. They provide an example of how a company in the Midwest of the United States implemented blockchain technology in its farm-to-fork egg production and supply chain delivery system. The goal is to track products from farm to consumer using blockchain and Internet of Things (IoT)-powered technologies. By creating a traceable and transparent food supply chain, consumers can have the information they need to make informed decisions about the food they buy and the businesses they support. It uses distributed ledger technology from Hyperledger Sawtooth. A conceptual framework put forth by Vanany et al. [8] is another use case. Vanany et al. provide a framework for Indonesian halal food integrity in the design of blockchain architecture using the concept of Hyperledger Fabric from IBM. Conceptually, the use of blockchain technology is feasible in the food industry to achieve halal food integrity in Indonesia. Increasing halal food transparency and trust can be achieved by implementing blockchain technology among food business players. The concept also foresees the promise of upcoming research into integrating various business and halal players with government halal authority. This study is mostly triggered by the work of Vanany et al.[8] and Alamsyah et al. [9], which both provide frameworks for halal blockchain networks. It will ensure Vikaliana et al.'s [39] statement that the need for new

traceability and assurance mechanisms arose first and foremost from the need to make halal assurance available to everyone in the supply chain, thereby providing transparency and direct halal commitment to consumers. Second, there is the requirement of transaction security; therefore, fake halal certificates will not be distributed to companies because halal traceability is associated with increasing consumer confidence in the food safety of halal food.

This work uses Hyperledger Fabric. Hyperledger Fabric is proposed as a basis for building applications or solutions with a modular architecture. It allows for plug-and-play components, including membership services and consensus. It has a wide range of modular and versatile designs to meet the needs of various industrial use cases [40]. Hyperledger Fabric offers a key feature, which is a network-enabled network. Fabric network members work together, while the companies can keep some of their data private. By maintaining distinct relationships within their network, they are able to keep this private information. The transaction relationship between buyer and seller should be private and not visible to all sellers by enabling the channel feature in Hyperledger Fabric. A single hyperledger network can consist of several channels, each serving a private data function. Some of its advantages over other platforms are that it offers some features that differentiate Hyperledger Fabric from other platforms: highly modular, finalized low latency, Solidity and EVM support, multilingual smart contract support, pluggable consensus, quarriable data, and multilingual smart contract support. A test has been conducted by Shalaby et al. [41] that measures the latency of the network created using Hyperledger Fabric. The result of the test on latency shows that latency increases with the number of transactions and batch timeouts. The number of blocks generated and the number of transactions per block have an impact on the achieved throughput. It has also been observed that increasing the batching timeout leads to increased latency, as each block must wait for the timeout even though it has received all transactions. Hyperledger Fabric is operational among scholars, and while this work will not consider latency as a blocking factor, it serves the purpose of creating sufficiently sizeable blockchain blocks[41].

4. Methodology

In this study, we simulate the process of halal certification by using blockchain. The steps that we take are identifying the involved organizations, configuring and testing the halal Hyperledger network, halal supply chain processes, halal certification processes, and commercializing halal certificates.

4.1 The Organization

The organizations involved in this simulation may have different types of businesses as well as processes. For the sake of this study, what is meant by food processing companies, slaughterhouses, caterers, and restaurants is as described, but not limited to, in the below.

4.1.1 Food Processing Company

This study takes for reference Preserving Food at Home: 10 Ways to Preserve Food at Home, written by Neverman [42]. Neverman has compared different ways to preserve food at home. Whether they are grown in own food or bought in bulk, home food preservation can

help people stock up on food and save money. It adds variety to a meal, and the taste of homemade food can make most commercial products stand out. The ten ways food preservation is identified by Neverman are: 1. Minimal Processing: Root Cellars, Cool Storage, and Room Temperature Storage 2. Drying/Dehydrating, 3. Canning: Water Bath Canning, Steam Canning, and Pressure Canning; Water Bath Canning, Steam Canning, and Pressure Canning 4. Freezing, 5. Freeze drying, 6. Fermentation, 7. Preserving in Salt and Sugar, 8. Immersion in alcohol, 9. vinegar pickling; and 10. immersion in olive oil. These 10 ways will be considered when a food processing organization classifies its product.

4.1.2 Slaughterhouse

Slaughterhouses can use two types of processes: the red meat slaughter process and the poultry slaughtering process. The Food and Agriculture Organization (FAO) [43] describes the fundamental procedure. In slaughterhouses, animals are received and kept in stockyards and pens for one day. The animals are watered but, in most cases, not fed unless they are kept for more than one day. The animals are then driven from the holding pens to the slaughtering area, where the following activities take place: stunning; suspension from an overhead rail by the hind legs; sticking and bleeding over a collecting trough. Hide removal (cattle) or scalding and dehairing (hogs). In some plants, hogs are skinned to eliminate scaling and dehairing. Scalding is a method to loosen hair before removal. For several minutes, the hogs are held in a scalding tank at 45°C to 65°C. The hogs are mechanically abrasion-dehaired following scalding, then singed in a gas flame to finish the hair removal process. The next process is decapitation, opening of the carcass by cutting, inspection of the carcass, evisceration (removal of intestines and internal organs), splitting and cutting of the carcass, and chilling or freezing.

4.1.3 Catering

Catering can provide six types of services: corporate catering, wedding catering, social event catering, concession catering, food truck catering, and restaurant catering. It is important to know the different types of catering services available when choosing a caterer for an event. Especially in the halal food community, the food served at an event is as important as the event itself because it brings people together and since people have different beliefs in relation to food tastes and dietary needs. Halal Catering shall present menus that make its customers trust the company.

4.1.4 Restaurant

At least there are 87 types of restaurants, as described by Spacey [44], but in general, a restaurant is a place where prepared food and drinks are served to customers. Restaurants can also provide intangible assets such as service, decor, ambiance, social setting, social status, entertainment, and experience. Restaurants are the most diverse players in the food industry. It usually does not need to be described exclusively. However, for uniformity of understanding, this study takes the description of the restaurant as described by Spacey.

4.2 Halal Hyperledger Network

In this study, the simulation follows the guidelines or instructions given by the documentation of Hyperledger Fabric Version 2.4.6. The Hyperledger model involves six design features for blockchain solutions for companies. Firstly, assets are all things that are

exchangeable for monetary value via the network. Secondly, chain code execution is partitioned from the reservation of transactions, limiting the level of confidence and verification necessary in all types of nodes and optimizing the scalability and performance of the network. Thirdly, the features of the registers or ledgers, which cannot be modified and share the entire transaction history for each channel, include the capacity of requests such as SQL for effective audits and dispute resolution. Fourthly, the collections of confidentiality and personal data that allow multilateral and secret transactions, which are generally necessary by competitive companies and regulated industries that exchange assets on public networks, Fifthly, security and membership services are authorized to provide a blockchain network where participants know that all transactions can be detected and followed by official regulators and listeners. And finally, sixth, the unique approach to consensus that allows flexibility and scalability necessary for the company.

During the simulation, a single Hyperledger network with two channels is emulated by slightly modifying the code referenced at https://github.com/hyperledger/fabric. The modified network configuration is depicted in Figure 1.

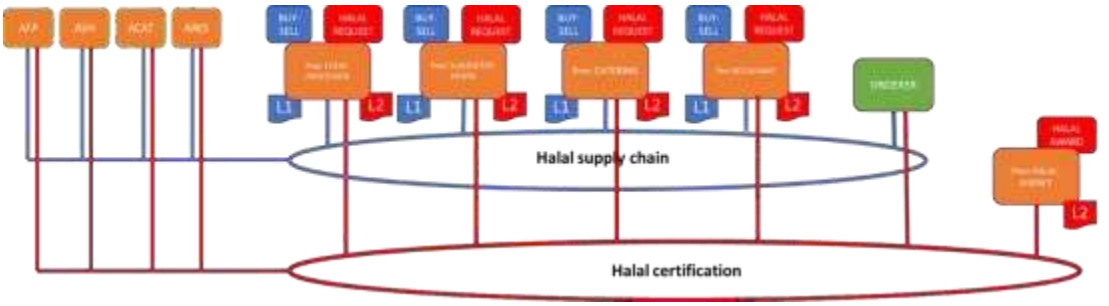

Figure 2. The network configuration used in the simulation

The Hyperledger Fabric Network was created by a consortium of companies from five categories of industries: the food processing industry, meat slaughter, catering, restaurants, and halal agencies. The network shelters two transaction channels: the halal supply chain channel and the halal certification channel. The halal agency is invited to join the network and is given access to the latter channel. The Halal supply chain channel simulates the flow of block data across the network where buy-sell transactions happen between two parties in the channel. On the other hand, the halal certification channel provides the means for any company member in the network to request halal certification from the agency. As it is pointed out in the documentation [45], the reference facilitates asset transfer and queries (asset-transfer-basic, asset-transfer-ledger-queries) as well as paper issuance and redemption (commercial paper). With slight modifications in the coding, it satisfies the emulation of halal transfer assets as well as halal certification requests and awards. The code is run in JavaScript.

Initially, the network is created according to the guidelines, starting with the merger of two companies, Organization 1 (Org1) and Organization 2 (Org2). In this study, Org1 is a Food Processor, while Org2 is Catering. Org1 and Org2 each have their own peer stationing logically Ledger 1 (L1). L1 constitutes the common ledger, which, together with the peers of every organization connected to the channel Halal Supply Chain, The Orderer (O), which

stores the parameters and policy of the network, is created together with Org1 and Org2. Peer for Org1, peer for Org2, and O are the entities that build the blockchain channel halal supply chain. The next step is to grow the network by introducing Organization 3 (Org3). Adding Org3 means integrating the meat slaughter company into the network and then connecting Org3 peer to the halal channel. Peer Org3 also accommodates ledger L1. The other member of the consortium, Organization 4(Org4), is added to the network the same way Org3 is, but with a slightly tricky method. Adding a fourth organization is not facilitated in the source code of the Hyperledger fabric; however, the steps are given to follow suit. Org4 is a restaurant company.

The second channel, the halal certification channel, is created by adding channel 2, which is facilitated in the Hyperledger source code. Peers belonging to Org1, Org2, Org3, and Org4 are then connected to Channel 2. Ledger 2 (L2) must be stationed with each peer. Because of the different nature of ledgers between the supply chain and certification, each peer is then stationing two ledgers: L1 and L2. L1 and L2 are ledgers for chaincode 1 (smart contract for buy-sell) in supply chain service and chaincode 2 (smart contract for request-award) in certification service, respectively. Organization 5 (Org5) is added to this second channel. Org5 is a halal agency. The Org5 application serves to receive a certification request and grant the certification award.

Although Figure 2 shows that the halal supply chain channel and the halal certification channel are integrated via Orderer (O), simulation is carried out separately, one at a time. Product ownership status is carried out in channel 1 (the halal supply-chain channel), and request-award halal certification is carried out in channel 2 (the halal certification channel). There is one additional channel, channel 3, whose function is to commercially transfer the certificate from the halal agency to the requesting company using the commercial paper model in the hyperledger-fabric example code.

Applications Food Processor (AFP,) Applications Slaughterhouse (ASH), Application Catering (ACAT) and Applications Restaurant (ARES) are clients applications that interact with peers to access the ledger, applications always connect to peers when they need to access ledgers and chaincodes or execute chaincodes to query or update a ledger.

4.3 Halal Supply Chain Process

The Halal supply chain process is basically a process of asset transfer. An asset is transferred between two different parties when a transaction is executed in the network. Once the network is up and the supply chain channel is created, all peers are connected to the channel. The next step is to deploy a smart contract service for buy-sell in the channel. This simulation uses asset-transfer-basic/chaincode-javascript as a reference. After the chaincode has been deployed, the chaincode is invoked, and transactions are carried out using the functions available in this application: CreateAsset, ReadAsset, UpdateAsset, DeleteAsset, and TransferAsset.

Table 1. Asset block information content in the halal supply chain process

Ledger 1: Buy-Sell status	
product	product identification: productID
	product name: productName
	product type: productType
	food processing method: productProcess
	product base list: productBase
ownership	seller name: SName
	seller type: sellerType
	seller filed business permit number: sellerNIB
	seller channel: Channel
	buyer name: BName
	buyer line of business type: buyertype
	buyer filed business permit number: buyerNIB
halal certificate	seller halal certificate ID currently in posession: sellerHID
	seller halal certificate currently in posession expire date: sellerCertExpDate
transaction	transaction ID: TranxID
date of creation and update	Creation Date and Time: CreateDateTime MMDDYYYY
	last update Date and Time: UpdateDateTime MMDDYYYY

The asset block information content, as shown in Table 1, consists of five groups of data: product data, ownership of product data, halal status data, transaction data, and the date when the transaction is effectuated. The asset block information content is depicted in Table 1. During the supply chain process, product data is essentially unchanged. What changes is the ownership status. Every organization will induce changes in the ledger L1 by updating the ownership status throughout the process. The status will be stable by the time the inducement arrives at the end user, where a change of status is no longer required.

In this simulation, product offerings are first input by the organization using CreateAsset. Function CreateAsset is defined as a communication from the organization (seller) wishing to publish an offering on the ledger. It loads all parameters in Table 1. Each organization joining the channel can use the function appropriate to each offering but not for other organizations offerings. The organization can use the function UpdateAsset if there is an update of channel information necessary to the product parameters and halal status, as long as TransferAsset has not been applied to the said asset. If the TransferAsset function has been activated for the asset in question, then no update is allowed. UpdateAsset as well as DeleteAsset are normally functions that are reserved for certain levels of security in the network and are not available in user applications. To change asset ownership, every organization then uses TransferAsset to update the status of ownership for a certain product ID. Organization 1 transfers the ownership status of its offering to Organization 2 using the function TransferAsset. ReadAsset is used to query a certain asset ID. Another function that can be used by the administrator of each organization is GetAllAssets. The GetAllAssets function is basically a query command to the database, whose response will be a list of all assets in their final status of ownership.

4.4 Halal Certification Process

The halal certification process differs from country to country. In Indonesia, it follows the

guidance stipulated in Government Regulation of the Republic of Indonesia Number 39 of 2021 concerning the implementation of the Halal Product Guarantee (PP39/2021). In essence, it is the process that a requestor for a halal fatwa initiates that results in the awarding of halal certification to the requestor. PP39/2021 recognizes four parties or agencies involved in the process. Those are:

1. Business actors are individuals or business entities in the form of legal entities or non -legal entities that carry out business activities in the territory of Indonesia.

2. Halal examining agencies, hereinafter abbreviated as LPH, are institutions that carry out inspection activities and forms or testing of product halal.

3. The Indonesian Ulema Council, hereinafter abbreviated as MUI, is a place for deliberation to the ulamas, Zuamas (organizational leader, government, etc.), and Muslim scholars.

4. Halal Product Guarantee Organizing Agency, hereinafter abbreviated as BPJPH, is a body formed by the government to organize Halal Product Guarantees (JPH).

The process consists of three sub-processes: submission of halal certificate requests, inspection and product halal testing, and determination (fatwa) of product halal. Submission of halal certificate requests involves sub-flows 1 and 2: 1. The company sends the registration application to BPJPH; 2. BPJPH establishes LPH to carry out examinations and testing. Sub flow 3. LPH conducts inspections and testing for the company and subflow. 4. LPH reports BBPJPH falls into subprocess inspection and product halal testing. During the subprocess determination (fatwa) of product halal, subflow 5. BPJPH coordinating with MUI, subflow 6. MUI issued a halal fatwa to BPJPH, and subflow 7. BPJPH issued a halal certificate for the company, which is activated.

The application for a halal certificate must contain complete documents of business actors' data: name and type of product; list of products and materials used; product processing process; and Halal Product Guarantee System. Data A business number or other business permit documents serve as proof of business actors. The name and type of product must be in accordance with the name and type of product to be halal certified. The list of products and materials used is a product and halal material as evidenced by a halal certificate, except that the material originates from nature without going through processing or is categorized as having no risk of containing a forbidden ingredient. The product processing document contains information regarding purchases, receipts, storage of materials used, processing, packaging, storage of finished products, and distribution. The Halal Product Guarantee System is determined by the Head of BPJPH.

Table 2. Certification block information content in the certification process

Ledger 2: Certificate Request and Award	
product	product identification: productID
	product name: productName
	product type: productType
	food processing method: productProcess
	product base list: productBase
requestor	company / requestor name: reqCoName
	requestor line of business: reqType
	requestor filed business permit number: reqNIB
halal auditor	appointed auditor name: AName
	appointed auditor lisence ID: ANameID
halal satus	halal certificate ID already in possesion: HID
	halal certificate expired date: MMDDYY
	halal supervisor institution name: supHalal
	halal system documentation: HalalDoc
	halal certificate request / issuance ID: HRID
transaction	transaction ID: TranxID
date of creation and update	Creation Date and Time: CreateDateTime MMDDYYYY
	last update Date and Time: UpdateDateTime MMDDYYYY

However, for ease of process in this simulation, not all the above data is necessary to be in the block; the content is reduced to the essential. The certification block information content in the certification process, as shown in Table 2, consists of five groups of data: product data, requestor data, auditor data, halal status data, transaction data, and the date the request or award of certification is submitted to chaincode. The information contents are depicted in Table 2. In the case of a request, the date of creation and update will be the same, while in the case of a certification award, the creation date stays at the request submission date, while the update date is the date where a response from the halal agency is sent to the ledger for the knowledge of all member organizations of the certification channel. The status of it, together with the halal certificate recently issued (HRID), can be queried by all members of the channel.

Although the actual process involves several parties or agencies, namely the requestor, BPPJH, LPH, MUI, and halal auditor, in this simulation, all those agencies will only be represented by a single entity: the halal agency. The process within Halal Agency will require the creation of the third channel, which in this conceptual simulation will serve only to add complexity.

In this simulation, the request for halal certification from a halal agency is carried out using the function CreateAsset. The Create Asset command or function lists all parameters in Table 2. Once the request is submitted as a block to the Orderer, no update function is allowed. An update to the asset can only be done upon request for further information from a halal agency. In response to the request by the requestor, the halal agency will further issue a block updating the content of the halal status and send it to the ledger using the function TransferAsset.

4.5 Commercializing Halal Certificate

The purpose of commercializing a halal certificate is to officially, under the payable term applicable to the transfer of commercially valuable paper, transfer the issued certificate from the Halal Agency to the requesting company. In this case, a certificate is considered to be a commercial paper, and BPJH issues it rather than a bank. To claim possession of the certificate, the requesting company, analogously to a commercial paper purchase payment, must trade it for some amount of currency. For the transfer of certificates to be effective, each of the organizations involved must enrol in the paper-net channel and create a wallet. The transfer of certificates happens from BPJH's wallet to the requesting company's wallet.

The process of certificate transfer starts with the issuance of the said certificate by the halal agency (BPJPH) using the command "issue.js." Once the certificate is issued, the requesting company can request the certificate using the command "request.js." The transfer of certificates process is then terminated by BPJPH transferring the certificate to the requesting company walle t using the command "transfer.js."

5. Result

5.1 Setting up the network

The following command is used to start the test network and create the channels:

```
root@DESKTOP-24B9NEA:~/halal-certif/fabric-samples/test-network# ./network.sh up createChannel -c channel1

root@DESKTOP-24B9NEA:~/halal-certif/fabric-samples/test-network# ./network.sh up createChannel -c channel2
```

The command run four containers: one for command line interface (cli), two for peer node Org1 (peer0.org1.example.com) and Org2 (peer0.org2.example.com), and one for orderer (orderer.example.com). The container detail is tabulated in Table 3.

Table 3. Docker image while the network is set to up

CONTAINER ID	IMAGE	COMMAND	CREATED	STATUS	PORTS	NAMES
f24fcda8443a	hyperledger/fabric-tools: latest	"/bin/bash"	3 seconds ago	Up less than a second		cli
1ef9d94f82fa	hyperledger/fabric-peer: latest	"peer node start"	6 seconds ago	Up 2 seconds	0.0.0.0:7051-> 7051/tcp, 0.0.0.0:9444-> 9444/tcp	peer0.org1.example.com
fae29915e0fe	hyperledger/fabric-orderer:l atest	"orderer"	6 seconds ago	Up 1 second	0.0.0.0:7050-> 7050/tcp, 0.0.0.0:7053-> 7053/tcp, 0.0.0.0:9443-> 9443/tcp	orderer.example.com
ae57557cf2da	hyperledger/fabric-peer: latest	"peer node start"	6 seconds ago	Up 3 second	0.0.0.0:9051-> 9051/tcp, 7051/tcp, 0.0.0.0:9445-> 9445/tcp	peer0.org2.example.com

The command also joins peers that belongs to each organization to the channel. Next step is to create channels simulated using localhost:7053.

Table 4. Creating halal supply chain channel channel1 - Using organization 1 and 2

+ osnadmin channel join --channelID	channel1
--config-block	./channel-artifacts/ channel1.block
-o	localhost:7053
--ca-file	/root/halal-certif/fabric-samples/ test-network/ organizations/ ordererOrganizations/ example.com/tlsca/ tlsca.example.com-cert.pem
--client-cert	/root/halal-certif/fabric-samples/test-network/ organizations/ordererOrganizations/ example.com/orderers/orderer.example.com/ tls/server.crt
--client-key	/root/halal-certif/fabric-samples/test-network/organizations/ordererOrganizations/example.com/orderers/ orderer.example.com/tls/ server.key
+ res=0	Channel 'channel1' created
Status: 201	{"name": "channel1", "url": "/participation/v1/channels/channel1", "consensusRelation": "consenter", "status": "active", "height": 1}

Table 5. Creating Halal certification channel channel2 - Using organization 1 and 2

+ osnadmin channel join --channelID	channel2
--config-block	./channel-artifacts/channel2.block
-o	localhost:7053
--ca-file	/root/halal-certif/fabric-samples/test-network/organizations/ ordererOrganizations/ example.com/tlsca/tlsca.example.com-cert.pem
--client-cert	/root/halal-certif/fabric-samples/test-network/ organizations/ordererOrganizations/example.com/ orderers/ orderer.example.com/tls/server.crt
--client-key	/root/halal-certif/fabric-samples/test-network/ organizations/ordererOrganizations/example.com/orderers/orderer.example.com/tls/ server.key
+ res=0	Channel 'channel2' created
Status: 201	{"name": "channel2", "url": "/participation/v1/channels/channel2", "consensusRelation": "consenter", "status": "active", "height": 1}

Once the channels are created, organization1 peer and organization2 peer are then joined to both channels, configured, and connections are initialized. Endorsers and orderer connections are also initiated. Peer version is Version: 2.4.6, Commit SHA: 83596078d, Go version: go1.18.2, OS/Arch: linux/amd64, Chaincode: [Base Docker Label: org.hyperledger.fabric, Docker Namespace: hyperledger].

Table 6. Deploying the chaincode - for halal supply chain channel (channel1)

create the chaincode package	
root@DESKTOP-24B9NEA:~/halal-certif/fabric-samples/test-network# peer lifecycle chaincode package basic.tar.gz --path ../asset-transfer-basic/halal-javascript/ --lang node --label basic_1.0	
COMMAND	RESPONSE
install the chaincode on peer0.org1.example.com	
root@DESKTOP-24B9NEA:~/halal-certif/fabric-samples/test-network# peer lifecycle chaincode install basic.tar.gz	2022-10-31 08:03:47.671 +07 0001 INFO [cli.lifecycle.chaincode] submitInstallProposal -> Installed remotely: response:<status:200 payload:"\nJbasic_1.0:8b2ba1cfe14583e19b32ae88eb9d607bf7c60 477e3a462759d7b1521f73d1cdf\022\tbasic_1.0" > 2022-10-31 08:03:47.671 +07 0002 INFO [cli.lifecycle.chaincode] submitInstallProposal -> Chaincode code package identifier: basic_1.0:8b2ba1cfe14583e19b32ae88eb9d607bf7c60477e3a4627 59d7b1521f73d1cdf
install the chaincode on peer0.org2.example.com	
root@DESKTOP-24B9NEA:~/halal-certif/fabric-samples/test-network# peer lifecycle chaincode install basic.tar.gz	2022-10-31 08:04:12.504 +07 0001 INFO [cli.lifecycle.chaincode] submitInstallProposal -> Installed remotely: response:<status:200

	payload:"\nJbasic_1.0:8b2ba1cfe14583e19b32ae88eb9d607bf7c60 477e3a462759d7b1521f73d1cdf\022\tbasic_1.0" > 2022-10-31 08:04:12.504 +07 0002 INFO [cli.lifecycle.chaincode] submitInstallProposal -> Chaincode code package identifier: basic_1.0:8b2ba1cfe14583e19b32ae88eb9d607bf7c60477e3a4627 59d7b1521f73d1cdf
Approve a chaincode definition	
package ID	
root@DESKTOP-24B9NEA:~/halal-certif/fabric-samples/test-network# peer lifecycle chaincode queryinstalled	Installed chaincodes on peer: Package ID: basic_1.0:8b2ba1cfe14583e19b32ae88eb9d607bf7c60477e3a4627 59d7b1521f73d1cdf, Label: basic_1.0
As Org2	
root@DESKTOP-24B9NEA:~/halal-certif/fabric-samples/test-network# peer lifecycle chaincode approveformyorg -o localhost:7050 --ordererTLSHostnameOverride orderer.example.com --channelID channel1 --name basic --version 1.0 --package-id $CC_PACKAGE_ID --sequence 1 --tls --cafile "${PWD}/organizations/ordererOrganizations/example.com/orderers/orderer.example.com/msp/tlscacerts/tlsca.example.com-cert.pem"	2022-10-31 08:05:42.663 +07 0001 INFO [chaincodeCmd] ClientWait -> txid [d1f9b2d91a84a84f63446ff93d7b2481a3b992b8e82dbb2a3f677f3 ea6ddd1a9] committed with status (VALID) at localhost:9051
As Org1	
root@DESKTOP-24B9NEA:~/halal-certif/fabric-samples/test-network# peer lifecycle chaincode approveformyorg -o localhost:7050 --ordererTLSHostnameOverride orderer.example.com --channelID channel1 --name basic --version 1.0 --package-id $CC_PACKAGE_ID --sequence 1 --tls --cafile "${PWD}/organizations/ordererOrganizations/example.com/orderers/orderer.example.com/msp/tlscacerts/tlsca.example.com-cert.pem"	2022-10-31 08:06:09.283 +07 0001 INFO [chaincodeCmd] ClientWait -> txid [bf40450853c392ffe5b8ea610e6dda1745904d604cf56ae9ad34837 eb3e3acfc] committed with status (VALID) at localhost:7051
commit readiness of the cannel	
root@DESKTOP-24B9NEA:~/halal-certif/fabric-samples/test-network# peer lifecycle chaincode checkcommitreadiness --channelID channel1 --name basic --version 1.0 --sequence 1 --tls --cafile "${PWD}/organizations/ordererOrganizations/example.com/orderers/orderer.example.com/msp/tlscacerts/tlsca.example.com-cert.pem" --output json	{ "approvals": { "Org1MSP": true, "Org2MSP": true } }
commiting the chaincode definition to the channel	
root@DESKTOP-24B9NEA:~/halal-certif/fabric-samples/test-network# peer lifecycle chaincode commit -o localhost:7050 --ordererTLSHostnameOverride orderer.example.com --channelID channel1 --name basic --version 1.0 --sequence 1 --tls --cafile "${PWD}/organizations/ordererOrganizations/example.com/orderers/orderer.example.com/msp/tlscacerts/tlsca.example.com-cert.pem" --peerAddresses localhost:7051 --tlsRootCertFiles "${PWD}/organizations/peerOrganizations/org1.example.com/peers/peer0.org1.example.com/tls/ca.crt" --peerAddresses localhost:9051 --tlsRootCertFiles "${PWD}/organizations/peerOrganizations/org2.example.com/peers/peer0.org2.example.com/tls/ca.crt"	2022-10-31 08:07:56.432 +07 0001 INFO [chaincodeCmd] ClientWait -> txid [ac1b7c5e697df43735df2ec5ad90641a89a5e24b9e9e31098fdc53f 1211a9526] committed with status (VALID) at localhost:9051 2022-10-31 08:07:56.442 +07 0002 INFO [chaincodeCmd] ClientWait -> txid [ac1b7c5e697df43735df2ec5ad90641a89a5e24b9e9e31098fdc53f 1211a9526] committed with status (VALID) at localhost:7051
confirm that the chaincode definition has been committed to the channel.	
root@DESKTOP-24B9NEA:~/halal-certif/fabric-samples/test-network# peer lifecycle chaincode querycommitted --channelID channel1 --name basic --cafile "${PWD}/organizations/ordererOrganizations/example.com/orderers/orderer.example.com/msp/tlscacerts/tlsca.example.com-cert.pem"	Committed chaincode definition for chaincode 'basic' on channel 'channel1': Version: 1.0, Sequence: 1, Endorsement Plugin: escc, Validation Plugin: vscc, Approvals: [Org1MSP: true, Org2MSP: true]

Table 7. Deploying the chaincode - for halal certificate channel (channel2)

create the chaincode package	
root@DESKTOP-24B9NEA:~/halal-certif/fabric-samples/test-network# peer lifecycle chaincode package basic_2.tar.gz --path ../asset-transfer-basic/certificate/ --lang node --label basic_2.0	
COMMAND	RESPONSE
install the chaincode on peer0.org1.example.com	
root@DESKTOP-24B9NEA:~/halal-certif/fabric-samples/test-network# peer lifecycle chaincode install basic_2.tar.gz	2022-10-03 19:55:36.722 +07 0001 INFO [cli.lifecycle.chaincode] submitInstallProposal -> Installed remotely: response:<status:200 payload:"\nJbasic_2.0:717fcc27d5dadcd918ca5209ea79b36b63711bfc87a0082a2250bc5f84945a25\022\tbasic_2.0" > 2022-10-03 19:55:36.722 +07 0002 INFO [cli.lifecycle.chaincode] submitInstallProposal -> Chaincode code package identifier: basic_2.0:717fcc27d5dadcd918ca5209ea79b36b63711bfc87a0082a2250bc5f84945a25
install the chaincode on peer0.org2.example.com	
root@DESKTOP-24B9NEA:~/halal-certif/fabric-samples/test-network# peer lifecycle chaincode install basic_2.tar.gz	2022-10-03 19:56:05.941 +07 0001 INFO [cli.lifecycle.chaincode] submitInstallProposal -> Installed remotely: response:<status:200 payload:"\nJbasic_2.0:717fcc27d5dadcd918ca5209ea79b36b63711bfc87a0082a2250bc5f84945a25\022\tbasic_2.0" > 2022-10-03 19:56:05.942 +07 0002 INFO [cli.lifecycle.chaincode] submitInstallProposal -> Chaincode code package identifier: basic_2.0:717fcc27d5dadcd918ca5209ea79b36b63711bfc87a0082a2250bc5f84945a25
Approve a chaincode definition	
root@DESKTOP-24B9NEA:~/halal-certif/fabric-samples/test-network# peer lifecycle chaincode queryinstalled	Installed chaincodes on peer: Package ID: basic_1.0:1163991a70053fc5b032d1388a495db8cc215aea4874d9b76b15d0d82ec347c1, Label: basic_1.0 Package ID: basic_2.0:717fcc27d5dadcd918ca5209ea79b36b63711bfc87a0082a2250bc5f84945a25, Label: basic_2.0
As Org2	
root@DESKTOP-24B9NEA:~/halal-certif/fabric-samples/test-network# export CC_PACKAGE_ID=basic_2.0:717fcc27d5dadcd918ca5209ea79b36b63711bfc87a0082a2250bc5f84945a25 root@DESKTOP-24B9NEA:~/halal-certif/fabric-samples/test-network# peer lifecycle chaincode approveformyorg -o localhost:7050 --ordererTLSHostnameOverride orderer.example.com --channelID channel2 --name basic --version 2.0 --package-id $CC_PACKAGE_ID --sequence 2 --tls --cafile "${PWD}/organizations/ordererOrganizations/example.com/orderers/orderer.example.com/msp/tlscacerts/tlsca.example.com-cert.pem"	2022-10-03 20:47:10.687 +07 0001 INFO [chaincodeCmd] ClientWait -> txid [bff13b1fc096577bdeed5ce3710fc705f8abbe59b7209155f77c7a80f1b49e1f] committed with status (VALID) at localhost:9051
As Org1	
root@DESKTOP-24B9NEA:~/halal-certif/fabric-samples/test-network# peer lifecycle chaincode approveformyorg -o localhost:7050 --ordererTLSHostnameOverride orderer.example.com --channelID channel2 --name basic --version 2.0 --package-id $CC_PACKAGE_ID --sequence 1 --tls --cafile "${PWD}/organizations/ordererOrganizations/example.com/orderers/orderer.example.com/msp/tlscacerts/tlsca.example.com-cert.pem"	2022-10-03 20:47:52.120 +07 0001 INFO [chaincodeCmd] ClientWait -> txid [ff749cd38a96664e2923dbcc7769a657a851a7b8857d78594eb7acb3818045b6] committed with status (VALID) at localhost:7051
commit readiness of the cannel	

root@DESKTOP-24B9NEA:~/halal-certif/fabric-samples/test-network# peer lifecycle chaincode checkcommitreadiness --channelID channel2 --name basic --version 2.0 --sequence	{
	"approvals": {
	"Org1MSP": true,

1 --tls --cafile "${PWD}/organizations/ordererOrganizations/example.com/orderers/orderer.example.com/msp/tlscacerts/tlsca.example.com-cert.pem" --output json	"Org2MSP": true } }
commit the chaincode definition to the channel	
root@DESKTOP-24B9NEA:~/halal-certif/fabric-samples/test-network# peer lifecycle chaincode commit -o localhost:7050 --ordererTLSHostnameOverride orderer.example.com --channelID channel2 --name basic --version 2.0 --sequence 2 --tls --cafile "${PWD}/organizations/ordererOrganizations/example.com/orderers/orderer.example.com/msp/tlscacerts/tlsca.example.com-cert.pem" --peerAddresses localhost:7051 --tlsRootCertFiles "${PWD}/organizations/peerOrganizations/org1.example.com/peers/peer0.org1.example.com/tls/ca.crt" --peerAddresses localhost:9051 --tlsRootCertFiles "${PWD}/organizations/peerOrganizations/org2.example.com/peers/peer0.org2.example.com/tls/ca.crt"	2022-10-03 20:49:23.999 +07 0001 INFO [chaincodeCmd] ClientWait -> txid [1c43d14579c59535580300603e5667124b25b5cd5a36cc65380d929ecb464ef6] committed with status (VALID) at localhost:7051 2022-10-03 20:49:23.999 +07 0002 INFO [chaincodeCmd] ClientWait -> txid [1c43d14579c59535580300603e5667124b25b5cd5a36cc65380d929ecb464ef6] committed with status (VALID) at localhost:9051
confirm that the chaincode definition has been committed to the channel.	
root@DESKTOP-24B9NEA:~/halal-certif/fabric-samples/test-network# peer lifecycle chaincode querycommitted --channelID channel2 --name basic --cafile "${PWD}/organizations/ordererOrganizations/example.com/orderers/orderer.example.com/msp/tlscacerts/tlsca.example.com-cert.pem"	Committed chaincode definition for chaincode 'basic' on channel 'channel2': Version: 2.0, Sequence: 1, Endorsement Plugin: escc, Validation Plugin: vscc, Approvals: [Org1MSP: true, Org2MSP: true]

5.2 Transfering asset in Channel 1 – Halal Supply Chain channel

Transfering asset in channel1 start with the publication of the product into the ledger using function CreatAsset. All parameters in Table 1 above should be published. Once the publication is validated, then it will be recorded in the block database as asset that will be ready to be transferred from a seller (OrgX, X can be 1 or 2) to a buyer (one of other company member of the consortium represented by OrgX, X can be 1 or 2). Transfer of asset is carried out in a bilateral fashion.

In the simulation, a company name “PT A”, which line of business is “Food Processor” filed to the local government licence list number “00002”, wishes to publish its product ID “Batch003”, which is “Frozen fruit”, classified as “KlasifikasiHalX”, processing type “Canning”, while the product based is “Bahan Olahan” on October 4, 2022. Complying to the smart contract, the publication of product also cites information on halal certificate ID “12345” with certification expiration date “December 22,2024”. The transaction ID is “00022”. Last update date is similar to the creation date for it is created and submitted at the same day.

Table 8. Transferring asset in Channel 1 – Halal Supply Chain channel

COMMAND	RESPONSE
Get all asset (querry existing database, Batch1001, Batch1002)	
root@DESKTOP-24B9NEA:~/halal-certif/fabric-samples/test-network# peer chaincode query -C channel1 -n basic -c '{"Args":["GetAllAssets"]}'	[{"Key":"Batch1001","Record":{"ID":"Batch1001","ProductName":"Kopi Robusta","ProductType":"KlasifikasiHalX", "ProductProcess":"Canning","ProductBase":"Bahan baku","SellerName":"PT. Indo Process","SellerType":"Food Processor","SellerNIB":"00001","SellerChannel":"B2B","BuyerName":"PT. Bandung Grocery","BuyerType":"Retail Store","BuyerNIB":"00011","SellerHIID":"030797","SellerCertExpDate":"Oct 22, 2022","TxID":"00002", "CreateDT":"Oct 22, 2020","UpdateDT":"Oct 01, 2022","docType":"asset"}},

	{"Key":"Batch1002","Record":{"ID":"Batch1002","ProductName":"Ikan Sarden", "ProductType":"KlasifikasiHalX", "ProductProcess":"Canning","ProductBase":"Bahan baku","SellerName":"PT. ADC Food","SellerType":"Food Processor", SellerNIB":"00002", "SellerChannel":"B2C", "BuyerName":"PT. Indostore", "BuyerType":"Retail Store", "BuyerNIB":"00012", "SellerHIID":"020922", "SellerCertExpDate":"Oct 10, 2022","TxID":"00002", "CreateDT":"Oct 10, 2022", "UpdateDT":"Oct 22, 2022","docType":"asset"}}]
Create Asset (Batch1003)	
root@DESKTOP-24B9NEA:~/halal-certif/fabric-samples/test-network# peer chaincode invoke -o localhost:7050 --ordererTLSHostnameOverride orderer.example.com --tls --cafile ${PWD}/organizations/ordererOrganizations/example.com/orderers/orderer.example.com/msp/tlscacerts/tlsca.example.com-cert.pem -C channel1 -n basic --peerAddresses localhost:7051 --tlsRootCertFiles ${PWD}/organizations/peerOrganizations/org1.example.com/peers/peer0.org1.example.com/tls/ca.crt --peerAddresses localhost:9051 --tlsRootCertFiles ${PWD}/organizations/peerOrganizations/org2.example.com/peers/peer0.org2.example.com/tls/ca.crt -c '{"function":"CreateAsset","Args":["Batch1003", "Frozen fruit", "KlasifikasiHalX", "Canning", "Bahan olahan", "PT Indobuah", "Food Processor", "00003", "B2C", "PT Buah Kaleng", "Retail Store", "00013", "030922", "Oct 25, 2002", "00003", "Oct 20, 2020", "Oct 29, 2022"]}'	2022-10-31 08:38:13.856 +07 0001 INFO [chaincodeCmd] chaincodeInvokeOrQuery -> Chaincode invoke successful. result: status:200 payload:"{\"Id\":\"Batch1003\", \"ProductName\":\"Frozenfruit\",\"ProductType\":\"KlasifikasiHalX\",\"ProductProcess\":\"Canning\",\"ProductBase\":\"Bahan olahan\", \"SellerName\":\"PT Indobuah\", \"SellerType\":\"Food Processor\", \"SellerNIB\":\"00003\",\"SellerChannel\":\"B2C\",\"BuyerName\":\"PT Buah Kaleng\", \"BuyerType\":\"Retail Store\",\"BuyerNIB\":\"00013\",\"SellerHIID\":\"030922\", \"SellerCertExpDate\":\"Oct 25, 2002\", \"TxID\":\"00003\",\"CreateDT\":\"Oct 20, 2020\", \"UpdateDT\":\"Oct 29, 2022\"}"
- Read Asset (Batch1003)	
root@DESKTOP-24B9NEA:~/halal-certif/fabric-samples/test-network# peer chaincode query -C channel1 -n basic -c '{"Args":["ReadAsset","Batch1003"]}'	{"Id":"Batch1003","ProductName":"Frozen fruit","ProductType":"KlasifikasiHalX","ProductProcess":"Canning","ProductBase":"Bahan olahan","SellerName":"PT Indobuah","SellerType":"Food Processor", "SellerNIB":"00003","SellerChannel":"B2C","BuyerName":"PT Buah Kaleng","BuyerType":"Retail Store", "BuyerNIB":"00013","SellerHIID":"030922","SellerCertExpDate":"Oct 25, 2002","TxID":"00003", "CreateDT":"Oct 20, 2020","UpdateDT":"Oct 29, 2022"}
- Update Asset (new certificate expired date & last update)	
root@DESKTOP-24B9NEA:~/halal-certif/fabric-samples/test-network# peer chaincode invoke -o localhost:7050 --ordererTLSHostnameOverride orderer.example.com --tls --cafile ${PWD}/organizations/ordererOrganizations/example.com/orderers/orderer.example.com/msp/tlscacerts/tlsca.example.com-cert.pem -C channel1 -n basic --peerAddresses localhost:7051 --tlsRootCertFiles ${PWD}/organizations/peerOrganizations/org1.example.com/peers/peer0.org1.example.com/tls/ca.crt --peerAddresses localhost:9051 --tlsRootCertFiles ${PWD}/organizations/peerOrganizations/org2.example.com/peers/peer0.org2.example.com/tls/ca.crt -c '{"function":"UpdateAsset","Args":["Batch1003", "PT Indobuah", "Food Processor", "00003", "B2C", "030922", "Oct 29, 2024", "Oct 29, 2022"]}'	2022-10-31 08:41:24.946 +07 0001 INFO [chaincodeCmd] chaincodeInvokeOrQuery -> Chaincode invoke successful. result: status:200 payload:"{\"type\":\"Buffer\",\"data\":[]}"
- Update Asset (retail update)	
root@DESKTOP-24B9NEA:~/halal-certif/fabric-samples/test-network# peer chaincode invoke -o localhost:7050 --ordererTLSHostnameOverride orderer.example.com --tls --cafile ${PWD}/organizations/ordererOrganizations/example.com/orderers/orderer.example.com/msp/tlscacerts/tlsca.example.com-cert.pem -C channel1 -n basic --peerAddresses localhost:7051 --tlsRootCertFiles	2022-10-31 08:41:54.946 +07 0001 INFO [chaincodeCmd] chaincodeInvokeOrQuery -> Chaincode invoke successful. result: status:200 payload:"{\"type\":\"Buffer\",\"data\":[]}"

${PWD}/organizations/peerOrganizations/org1.example.com/peers/peer0.org1.example.com/tls/ca.crt --peerAddresses localhost:9051 --tlsRootCertFiles ${PWD}/organizations/peerOrganizations/org2.example.com/peers/peer0.org2.example.com/tls/ca.crt -c '{"function":"UpdateAsset","Args":["Batch1001", "PT AB", "Retail", "0002"]}'	
- Transfer Asset	
root@DESKTOP-24B9NEA:~/halal-certif/fabric-samples/test-network# peer chaincode invoke -o localhost:7050 --ordererTLSHostnameOverride orderer.example.com --tls --cafile ${PWD}/organizations/ordererOrganizations/example.com/orderers/orderer.example.com/msp/tlscacerts/tlsca.example.com-cert.pem -C channel1 -n basic --peerAddresses localhost:7051 --tlsRootCertFiles ${PWD}/organizations/peerOrganizations/org1.example.com/peers/peer0.org1.example.com/tls/ca.crt --peerAddresses localhost:9051 --tlsRootCertFiles ${PWD}/organizations/peerOrganizations/org2.example.com/peers/peer0.org2.example.com/tls/ca.crt -c '{"function":"TransferAsset","Args":["Batch1001", "IU", "Retail", "0002"]}'	Prior to transfer: {"Key":"Batch1002","Record":{"ID":"Batch1002","ProductName":"Kopi arabika","ProductType":"KlasifikasiHalX", "ProductProcess":"Canning","ProductBase":"Bahan baku","SellerName":"Aku","SellerType":"Food Processor", "SellerNIB":"00002","BuyerName":"Aku","BuyerType":"Food Processor","BuyerNIB":"00002", "HalalCertExp": "020797","PenyediaHalal":"PT Telkom Halal 2", "DocSJH":"Halal Halal 2","CreateDT":"Sept 17, 2022", "LastUpdated":"Sept 17, 2022", "HalalCertID": "123456", "TxID":"00003","docType":"asset"}}
	After transfer 2022-10-02 19:00:53.162 +07 0001 INFO [chaincodeCmd] chaincodeInvokeOrQuery -> Chaincode invoke successful. result: status:200 payload: "{\"type\":\"Buffer\",\"data\ ":[]}" {"Key":"Batch1002","Record":{"ID":"Batch1002","ProductName":"Kopi arabika","ProductType":"KlasifikasiHalX", "ProductProcess":"Canning","ProductBase":"Bahan baku", "SellerName":"Aku","SellerType":"Food Processor", "SellerNIB":"00002","BuyerName":"Kamu","BuyerType":"Kita Store","BuyerNIB":"00012", "HalalCertExp": "020797","PenyediaHalal":"PT Telkom Halal 2", "DocSJH":"Halal Halal 2","CreateDT":"Sept 17, 2022", "LastUpdated":"Oct 2, 2022", "HalalCertID": "123456", "TxID":"00003","docType":"asset"}}
Querying the database for all assets from Org1 application: GetAllAssets	JSON result of the query: three assets in the database
root@DESKTOP-24B9NEA: ~/newfabric/fabric-samples/test-network# peer chaincode query -C channel1 -n basic -c '{"Args":["GetAllAssets"]}'	[{"Key":"Batch1001","Record": {"ID":"Batch1001","ProductName":"Kopi robusta", "ProductType":"KlasifikasiHalX", "ProductProcess":"Canning", "ProductBase":"Bahan baku", "SellerName":"Alfi", "SellerType":"Food Processor", "SellerNIB":"00001", "BuyerName":"Tia", "BuyerType":"Retail Store", "BuyerNIB":"00011", "HalalCertExp":"030797", "PenyediaHalal":"PT Telkom Halal", "DocSJH":"Halal Halal", "CreateDT":"Sept 17, 2022","LastUpdated":"Sept 16, 2022", "HalalCertID": "12345", "TxID":"00002", "docType":"asset"}},
	{"Key":"Batch1002","Record":{"ID":"Batch1002","ProductName":"Kopi arabika","ProductType":"KlasifikasiHalX", "ProductProcess":"Canning","ProductBase":"Bahan baku", "SellerName":"Aku","SellerType":"Food Processor", "SellerNIB":"00002","BuyerName":"Kamu","BuyerType":"Retail Store","BuyerNIB":"00012", "HalalCertExp": "020797","PenyediaHalal":"PT Telkom Halal 2", "DocSJH":"Halal Halal 2","CreateDT":"Sept 17, 2022", "LastUpdated":"Oct 2, 2022", "HalalCertID": "123456", "TxID":"00003","docType":"asset"}},
	{"Key":"Batch1003","Record": {"ID":"Batch003","ProductName":"Frozen fruit", "ProductType":"KlasifikasiHalX", "ProductProcess": "Canning", "ProductBase":"Bahan olahan", "SellerName":"PT A", "SellerType":"Food Processor",

	"SellerNIB":"00002","BuyerName":"PT B", "BuyerType":"Food Processor", "BuyerNIB":"01234", "HalalCertExp":"1112233", "PenyediaHalal":"MUI", "DocSJH":"MUI001", "CreateDT":"Oct 4, 2022", "LastUpdated":"Oct 4, 2022", "HalalCertID":"12345", "TxID":"00022"}}]

5.3 Transfering asset in Channel 2 – Halal Certificate channel - Request – award of Halal Certificate

The requestor in this simulation is represented by Org2 sending a halal certificate request to the Halal Agency (represented by Org1) using the function CreateAsset. All necessary parameters as shown in Table 2 are submitted in compliance with the halal certificate request protocol. In this application, the company name is “PT B,” registered in local government trade file number ABC002, which is a food processor company, and the halal certificate requested is a process class “KlasifikasiHalX” for its sample product number Batch1002, whose name is "Bandeng," a local name for a specific type of fish. Along with the application, the protocol also requires that the company propose its preference for halal auditor “Konsultan X,” whose license number is "A00002." The company applicant must also appoint one halal institution out of those on the halal institution list to carry out the necessary test for the halal process and ingredient “PT PenHal." The protocol also requires that the applicant register a halal system and procedure documentation referenced by the company in daily operation, "SisHalR2." In addition to the product, requestor, and auditor information, the applicant also needs to complete the request with the status of the halal certificate currently in possession, its expiration date of “December 2021,” and the certificate currently held number "Halal0002." The request is created on “August 20, 2022” and transacted on the same day. Halal certificate ID “HalalCertID” is set to “null” because this field is reserved for the response from Halal Agency when a new certificate ID will be issued.

Table 9. Transfering asset in Channel 2 – Halal Certificate channel - Request – award of Halal Certificate

COMMAND	RESPONSE
-Create asset	
${PWD}/organizations/peerOrganizations/org2.example.com/peers/peer0.org2.example.com/tls/ca.crt -c '{"function":"CreateAsset","Args":["Batch1002", "Bandeng", "KlasifikasiHalX", "Canning", "Ikan", "PT B", "Food Processor", "ABC002", "Konsultan X", "A00002", "Desember 2021", "PT PenHal", "SisHalR2", "Aug 20, 2018", "Aug 20, 2022", "Halal0002", "null", "20"]}'	2022-10-04 16:14:15.359 +07 0001 INFO [chaincodeCmd] chaincodeInvokeOrQuery -> Chaincode invoke successful. result: status:200 payload:"{\"Id\":\"Batch1002\",\"ProductName\":\"Bandeng\",\"ProductType\":\"KlasifikasiHalX\",\"ProductProcess\":\"Canning\",\"ProductBase\":\"Ikan\", \"RequestCoName\":\"PT B\", \"RequestorType\":\"Food Processor\", \"RequestorNIB\":\"ABC002\", \"AuditorName\":\"Konsultan X\", \"AuditorLicenseID\":\"A00002\",\"HalalCertExp\": \"Desember 2021\",\"PenyediaHalal\":\"PT PenHal\", \"DocSJH\":\"SisHalR2\",\"CreateDT\":\"Aug 20, 2022\", \"LastUpdated\":\"Aug 20, 2022\", \"HalalCertReqID\":\"Halal0002\",\"HalalCertID\":\"null\", \"TxID\":\"20\"}"
- Read Asset	
root@DESKTOP-24B9NEA:~/halal-certif/fabric-samples/test-network# peer chaincode query -C channel2 -n basic -c '{"Args":["ReadAsset","Batch1002"]}'	{"Id":"Batch1002","ProductName":"Bandeng","ProductType":"KlasifikasiHalX","ProductProcess":"Canning","ProductBase":"Ikan","RequestCoName":"PT B", "RequestorType":"Food Processor", "RequestorNIB":"ABC002", "AuditorName":"Konsultan X","AuditorLicenseID":"A00002", "HalalCertExp":"Desember

	2021","PenyediaHalal":"PT PenHal","DocSJH":"SisHalR2","CreateDT":"Aug 20, 2018", "LastUpdated":"Aug 20, 2022", "HalalCertReqID":"Halal0002", "HalalCertID":"null","TxID":"20"}
- Update Asset	
root@DESKTOP-24B9NEA:~/halal-certif/fabric-samples/test-network# peer chaincode invoke -o localhost:7050 --ordererTLSHostnameOverride orderer.example.com --tls --cafile ${PWD}/organizations/ordererOrganizations/example.com/orderers/orderer.example.com/msp/tlscacerts/tlsca.example.com-cert.pem -C channel2 -n basic --peerAddresses localhost:7051 --tlsRootCertFiles ${PWD}/organizations/peerOrganizations/org1.example.com/peers/peer0.org1.example.com/tls/ca.crt --peerAddresses localhost:9051 --tlsRootCertFiles ${PWD}/organizations/peerOrganizations/org2.example.com/peers/peer0.org2.example.com/tls/ca.crt -c '{"function":"UpdateAsset","Args":["Batch1001", "MUI/XI/10/2022"]}'	2022-10-04 19:24:12.097 +07 0001 INFO [chaincodeCmd] chaincodeInvokeOrQuery -> Chaincode invoke successful. result: status:200 payload:"{\"type\":\"Buffer\",\"data\":[]}"
- Transfer Asset	
root@DESKTOP-24B9NEA:~/halal-certif/fabric-samples/test-network# peer chaincode invoke -o localhost:7050 --ordererTLSHostnameOverride orderer.example.com --tls --cafile ${PWD}/organizations/ordererOrganizations/example.com/orderers/orderer.example.com/msp/tlscacerts/tlsca.example.com-cert.pem -C channel2 -n basic --peerAddresses localhost:7051 --tlsRootCertFiles ${PWD}/organizations/peerOrganizations/org1.example.com/peers/peer0.org1.example.com/tls/ca.crt --peerAddresses localhost:9051 --tlsRootCertFiles ${PWD}/organizations/peerOrganizations/org2.example.com/peers/peer0.org2.example.com/tls/ca.crt -c '{"function":"TransferAsset","Args":["Batch1001", "Kopi robusta", "KlasifikasiHalX", "Canning", "Kopi", "PT A", "Food Processor", "XYZ001", "Konsultan X", "A00001", "Desember 2025", "PT PenHal", "SisHalR1", "Aug 18, 2022", "Oct 2, 2022", "Halal0001", " MUI/XI/101/2022", "10"]}'	2022-10-04 19:14:09.325 +07 0001 INFO [chaincodeCmd] chaincodeInvokeOrQuery -> Chaincode invoke successful. result: status:200 payload:"{\"type\":\"Buffer\",\"data\":[]}"
Querying the database for all assets from Org1 application: GetAllAssets	JSON result of the query: two assets in the database
root@DESKTOP-24B9NEA:~/halal-certif/fabric-samples/test-network# peer chaincode query -C channel2 -n basic -c '{"Args":["GetAllAssets"]}'	[{"Key":"Batch1001","Record":{"Id":"Batch1001","HalalCertID":" MUI/XI/10/2022"}}, {"Key":"Batch1002","Record":{"Id":"Batch1002","HalalCertID":"M UI/XI/101/2022"}}]

During the halal certification request process, any inquiry about the status of the request is allowed. The inquiry may have two forms of function. One is by using the Read Asset function. In the example simulation, a query is carried out using the argument [“Read Asset”, “Batch1002”], requesting the status of the request, whose batch sample number is “Batch1002”. The function “UpdateAsset” is reserved for halal agencies only and is in use in case there is a necessity to update the halal certificate ID, which is usually very rare. Once the application for the requestor has been received, it requires the halal agency some calendar days to process. Once all the processes are completed, Halal Agency will reply to the requestor by creating a block containing the newly issued certificate number, together with all necessary parameters in its application, using the function TransferAsset. In this example simulation, the application in question is "Batch1002," submitted by requestor “PT

B.". It can be verified using the GetAllAsset function that halal certificate ID "MUI/XI/101/2022" is associated with sample product "Batch1002" and "MUI/XI/10/2022" is associated with "Batch1001". The ID numbering is arbitrary; in this case, it could be regarded as coming from the same company but for a different product ID. "Batch1001" has already been in the database for some time, while "Batch1002" was recently added with the associated halal certificate identity associated with it.

5.4 Issuance/Request of halal certificate

In this simulation, two organizations, Requestor with client user "Balaji" and Halal Agency with client user "Isabela," trade certificates with each other using PaperNet, a Hyperledger Fabric blockchain network. Handover of halal certificates requires wallets on both sides: wallets for Isabella and for Balaji, respectively.

Table 10. Request of halal certificate

COMMAND	RESPONSE
Run as Halal Agency	
Isabella's wallet identity information	
root@DESKTOP-24B9NEA:~/halal-certif/fabric-samples/commercial-paper/organization/halal-agency/application# node enrollUser.js	Wallet path: /root/halal-certif/fabric-samples/ commercial-paper/organization/halal-agency/ identity/user/isabella/wallet Successfully enrolled client user "isabella" and imported it into the wallet
root@DESKTOP-24B9NEA:~/halal-certif/fabric-samples/commercial-paper/organization/halal-agency/application# ls ../identity/user/isabella/wallet	isabella.id
Issue application	
root@DESKTOP-24B9NEA:~/halal-certif/fabric-samples/commercial-paper/organization/halal-agency/application# node issue.js	Connect to Fabric gateway. Use network channel: channel3. Use org.papernet.commercialpaper smart contract. Submit commercial paper issue transaction. Process issue transaction response. {"class":"org.papernet.commercialpaper","currentState":1,"issuer":"halal-agency", "paperNumber":"00001", "issueDateTime": "2022-10-31", "maturityDateTime": "2024-10-30", "faceValue":5000000,"mspid":"Org2MSP", "owner":"halal-agency"} halal-agency commercial paper: 00001 successfully issued for value 5000000 Transaction complete. Disconnect from Fabric gateway. Issue program complete.
Run as requestor	
Generate a certificate and private key and them to Balaji's wallet	
root@DESKTOP-24B9NEA:~/halal-certif/fabric-samples/commercial-paper/organization/ requestor/application# node enrollUser.js	Wallet path: /root/halal-certif/fabric-samples/commercial-paper/ organization/ requestor/ identity/user/ balaji/wallet. Successfully enrolled client user "balaji" and imported it into the wallet
Submit a transaction that will transfer ownership of Halal Certificate 00001 to Requestor (Balaji).	
root@DESKTOP-24B9NEA:~/halal-certif/fabric-samples/commercial-paper/organization/ requestor/application# node request.js	Connect to Fabric gateway. Use network channel: channel3. Use org.papernet.commercialpaper smart contract. Submit commercial paper buy transaction. Process buy transaction response. halal-agency commercial paper : 00001 successfully requested by requestor Transaction complete. Disconnect from Fabric gateway. Request program complete.

6. Discussion

During the simulation, it was found that the application of blockchain can serve to improve the traceability of the flow of food by tracking the transfer of ownership. This is served by a supply chain channel in the blockchain (Hyperledger Fabric) network that seals the ledger from non-concerning parties or organizations, hence guaranteeing private data flowing only among concerned parties.

Batch numbers serve as an index for the flow of goods among supply chain channel participants. If the transfer of ownership is only part of the said batch, it cannot be identified. Then it is possible that one batch of goods can be shared among different members at different times. In the usual case, the transfer of ownership will flow in the direction of the food processor or slaughterhouse to the catering or restaurant, or from catering to restaurant. In such cases, restaurants are always considered end-users. Food processors may also receive batches from slaughterhouses. But it is a rare case, as slaughterhouses usually process their meat batches until they are ready to deliver to retail stores by themselves. A corresponding halal certificate or certificates are always present with every batch of ownership transfers. The defined asset is a sizeable block that consists of identifiable chinks of batch information: product, ownership status, halal certificate status, transaction ID, and date of transaction. If more detailed information is required, it will increase the block size and add latency to the channel in return. The simulation of supply chain channels on Hyperledger Fabric foresees the possibility of implementation in a real operational network.

The simulation of blockchain for halal certificates, on the other hand, shows that the application of Hyperledger Fabric will not improve the speed of halal certificate awards from halal agencies (BPJPH). However, it really improves the openness of the certificate process to the members concerned. Currently, halal agencies only serve to assess the food process rather than the degree of halal of the food itself. The halal agency certifies that all food processes, from the very beginning of the food supplier to the very end of the food user, comply with all halal regulations. The asset defined in the halal certificate channel is required to be submitted by the halal certificate requestor. It consists of a batch of the sample product, requestor information, halal supervisor, halal status at the time of request submission, and the date of the transaction. The process of request and award operates perfectly on channel 2. Due to the different process nature, the certificate request process channel (Channel 2) should be separated from the supply chain process flow (Channel 1). The simulation promises future real-world applications in operational networks.

The third channel, which is not shown in Figure 1, is the handover of the certificate from the Halal agency to the organization or company requesting it. It is done through the channel simulation of commercial paper transfer on PaperNet. This third channel was created because the handover of a certificate requires a wallet. And while the certificate ID must be transparent to the public, the handover must comply with the fact that the certificate must not be at risk of counterfeiting or duplication for mischievous intentions.

Finally, all three simulations are running sufficiently satisfactorily, despite the unpleasant experience of coding instability due to the rapid change of the Hyperledger fabric version and the inconsistency of support for some outdated versions. In this simulation, two organizations, Requestor with client user “Balaji” and Halal Agency with client user

"Isabela," trade certificates with each other using PaperNet, a Hyperledger Fabric blockchain network. The handover of halal certificates requires wallets on both sides: wallets for Isabella and for Balaji, respectively.

7. Conclusion

In view of answering the aforementioned question, how is the halal food supply chain and halal certificate process simulated using Hyperledger Fabric Coding? This study has proposed new perspectives on how blockchain technology is used in the halal food industry.

It starts by providing a use case for the Vanany concept [8] and answering Alamsyah's claim [9] that blockchain will accelerate the halal process. However, in detail, the definition of an asset from Vanany has been modified accordingly due to the fact that different players in the food industry will require different descriptions of assets. Blockchain in the halal food industry does indeed improve food batch traceability; however, what comes along with the batch is only a certificate ID. For certificate processing, different chaincodes (smart contracts) should be devised separately. Separation of chaincodes has also been done for the handover of halal certificates from the halal agency to the requestor. While this simulation is carried out in a relatively limited environment and configuration setting, it foresees its application in a live operational blockchain network using Hyperledger Fabric, providing several bugs are overcome. It may require further study for the implementation to be realized.

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