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Research article

Designing Halal Product Traceability System using UML and Integration of Blockchain with ERP

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ABSTRACT

Consuming halal food is mandatory for Muslims, but meeting the growing demand for halal products has been a challenge for Muslim producers. Importing halal products from non-Muslim countries can raise doubts about their halal status. Therefore, a traceability system is needed to ensure the halalness of products. This research proposes a new traceability system by utilizing ERP, Blockchain, and smart contract technologies based on HAS 23000. This study is the first to combine these technologies. Using the System Development Life Cycle (SDLC) method, the design diagram has been successfully developed into an application system prototype. The use of ERP can help companies reduce operational costs, while the combination with blockchain technology ensures more transparent information, data protection, and system security. The system also uses smart contracts to make automated decisions. By managing the procurement of halal products, companies can ensure that products with halal assurance reach consumers.

1. Introduction

According to Islamic law, adherents of Islam are obliged to consume halal food only [1]. Thus, the provision of halal food can potentially boost the economy [2], especially if we consider the number of adherents of Islam in Indonesia and globally. World Population Review data reported that the Muslim population in Indonesia in 2021 was 229 million out of 276 million total population, which means they account for 87.2% [3][4], while the world's Muslim population is approximately 1.9 billion out of the 7.5 billion total world population. The halal industry contributes to Indonesia's Gross Domestic Product of US$ 3.8 billion annually [5]. The estimated global Muslim spending is expected to reach $2.3 trillion by 2024, with a Cumulative Annual Growth Rate (CAGR) of 3.1% [6]. Every year the population increases, including that of the Indonesian people. Statistics Indonesia (BPS) data reported that during 2010-2020, Indonesia's average population growth rate was 1.25 percent [7]. Of course, by default, the Muslim population increases too, which also increases the consumption of halal products. However, Muslim producers have not been able to meet these halal products' needs thoroughly. In fact, the largest exporters of halal products worldwide are not countries with a predominantly Muslim population. The Global Islamic Economy (SGIE) reported that in 2020/2021 the five world's largest exporters of halal products are the United States, India, Brazil, France, and Russia [6]. Therefore, importing halal products from non-Muslim countries can raise doubts about their halalness [8]. Another problem with halal products is the incidents of halal

products counterfeiting, such as the case of mixing beef and pork [9][10] and the provision of a fake halal certificate [11].

Food, medicine, and cosmetics need to be halal-guaranteed, not only by revealing the producers and the raw materials but also by exposing the supply chain process, starting from the process at the producers to the hands of consumers. The raw materials from the producer may be already halal, but on the way to the consumer, additional ingredients are not halal. The untraceable shipping process may cause possible counterfeits. The standard that regulates halal assurance in Indonesia is the Halal Assurance System (HAS) 23000 [12]. The HAS 23000 standard is set by the Institute for the Study of Food, Drugs, and Cosmetics of the Indonesian Ulema Council (LPPOM MUI), known as HAS LPPOM MUI, which is used to ensure that the halal certification process of a product that complies with the requirements. The businesses that must obtain the Halal Assurance System (HAS) 23000 standard include kitchens, catering, restaurants, slaughterhouses, and management industries (food, medicine, cosmetics). The standard of the HAS 23000 consists of two parts, the Criteria for the Halal Assurance System (HAS 23000: 1) and the Procedure for the implementation of HAS 23000 (HAS 23000: 2). If all the requirements and documents are fulfilled and approved, then the HAS 23000 certificate can be issued.

One important aspect of obtaining a halal certificate is knowing the critical halal point of the production process [13]. Halal critical points are needed to identify traceability points. Traceability systems facilitate tracing, improve supply assurance, and provide safety and food quality. It also helps differentiate foods with subtle or undetectable quality attributes [14]. The development of research in the traceability of halal food is increasing every year based on the results of literature studies before, such as [15], [16], [17], which will be further discussed in section 2.1. However, an integration system model between Enterprise Resource Planning (ERP), Blockchain and smart contracts for the traceability of halal products using HAS 23000 has never been conducted before. Most studies only discuss the use of technology in the supply chain. Research in Blockchain has also continued to develop in the last five years [18]. ERP was used because it has a module that can trace a product, such as an inventory or purchasing module. In addition, ERP can accommodate HAS 23000 standards, in which it is possible to add and reduce supply chain participants to make the supply chain flexible [19]. Blockchain can prevent counterfeits and smart contracts enable HAS 23000 procedures to run automatically. Blockchain technology has a block hash mechanism that is useful for eliminating risks in the authentication process [20] [21] [22]. Therefore, this research aims to build a traceability system design for halal products using ERP and Blockchain, which can make it easier for anyone to trace the routes of halal products from the producers to the consumers.

The design of the traceability system in the current study has a sequence of steps, starting from the data inputted by supply chain participants via ERP. Next, the data were selected using a smart contract before inputting them into the blockchain network. The data remained in the blockchain network without change, and users could view the travel data of halal products. Applying the beef halal traceability system for this industry can facilitate the implementation of HAS 23000 and increase consumer confidence in the product. For the government, the system can help improve the sharia economy in Indonesia and make Indonesia a center of world halal products.

2. Materials and Methods

2.1. Traceability of Halal Food

Research on traceability of halal food products needs to be developed. Therefore, a literature study with the keywords "traceability AND Food AND Halal" was conducted, and results are shown in Figure 1. The graph shows an annual increase in the number. The blue line indicates the number of publications obtained from Google Scholar, and the figure repesented in the red line was obtained from Scopus. The increasing number of studies shows that this topic is worth researching.

Fig. 1. Number of Publications Related to the Word "Traceability AND Food AND Halal"

The selected search results were those obtained from the Scopus database, so only quality publications were used. The search in Scopus Database using the keywords above found 35 publications in the forms of proceedings and journals during the periods of 2015 and 2021. A manual selection was then conducted, which resulted in 11 articles related to the topic of the current research [15],[16],[17],[23],[24],[25],[26],[27],[28],[29],[30]. The manual selection concluded that there was a research gap: the integration of the system model between ERP, Blockchain, and smart contracts for the traceability of halal meat using HAS 23000.

2.2. Blockchain for Halal Food

Blockchain technology can improve traceability in the supply chain by improving data security and increasing consumer confidence. Likewise, research in supply chain and Blockchain for traceability in agriculture is currently a research area that is increasingly in demand. In the study conducted by [31], A total of 60 articles were reviewed. The study discussed research studies related to the agricultural sector and farm products. The only publication related to halal food was conducted by Rejeb [32]. However, after a recheck, it was found that the paper was not in the Scopus index. This indicates that research in halal food blockchain has not been in Scopus-indexed journals yet from 2017 to 2019. Therefore, the literature study was conducted again by expanding the search within the extended period from 2015 to 2021. "Although the number of publications in Scopus-indexed journals is increasing, the results obtained show that it is still below 20 publications. The total number of publications from 2015 to 2021 was 17, consisting of 4 conference papers and two lecture notes. In 2018, only one publication was produced, and in 2021, there were only five; the rest were journal papers [33],[34],[35],[36],[37],[38],[16],[39],[40],[41]. The conclusion is that there has been no system integration model between ERP, Blockchain and smart contracts for the traceability of halal meat using HAS 23000.

2.3. Method

The development of this halal food traceability system design follows the stages of the System Development Life Cycle (SDLC)[42], with a cycle described in Figure 2 below.
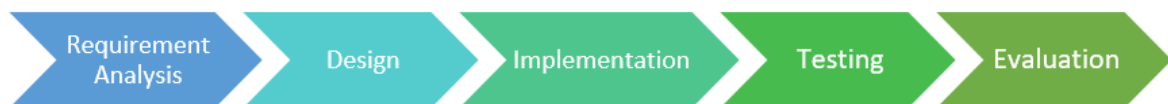

Fig. 2. System Development Life Cycle (SDLC)

The stages of software development involve six steps: requirements analysis, design, implementation, testing, and maintenance. However, in this study, only the first two stages were covered, namely requirements analysis and design, as this publication is limited to offering a conceptual design of the system. An example of the implementation is using the halal beef supply chain, in general, to make the implementation easier. The idea of this method cycle is that it is necessary to go through all the stages. If there are improvements or changes after the evaluation stage, it is necessary to return to the needs analysis stage until all requirements are met. However, if the implementation results are appropriate after the evaluation stage in the first cycle, then the cycle is finished.

2.4. Requirements Analysis

At this stage, studies related to SCM theories, traceability, ERP, smart contracts, Blockchain, HAS 23000, and halal certificates in companies were conducted using several references in the form of books, journal articles, and previous studies. The criteria were relevance, modernity, and authenticity. Relevance in this research refers to the theory being studied, while up-to-date pertains to the latest references or ideas that have been used. The time frame of concern is within the last five years. Authenticity means that the researcher uses the source to present the theory. In addition, field studies were carried out by conducting observations and interviews with relevant parties and experts regarding materials and data pertaining to this research. There were two experts in halal beef, ERP and Blockchain and two managers from the companies interviewed. At this stage, the business processes of the beef supply chain in general, specifically within the halal beef supply chain in Indonesia, are identified.

2.5. Design

Unified Modelling Language (UML) was used in this study to assist system development by visualizing and documenting the previous stage's results, namely the requirements analysis stage, and then modelling the results visually [43]. UML is usually used to build documents from software-intensive systems [44]. The diagrama were in the forms of case, class, activity, and sequence diagrams. Besides, UML also uses Business Process Modelling (BPM) to represent functions related to business activities in the halal meat supply chain, such as input, output, resource, and data flow. The function of business process modeling is to identify which parts of the business process still require improvement. Business Process Design and Modeling utilizes the BPM (Business Process Management) Cycle, which consists of Process Design, Modeling, Execution, Monitoring, and Optimization. However, this study only focuses on the design stage, which aims to determine the business processes that need to be managed based on business needs.

2.6. Implementation

The implementation of this design is part of future work. The current research focuses on making designs according to the SDLC sequence.

3. Results and Discussion

3.1. Requirements Analysis

The results of field studies, observations, and expert interviews include the identification of the beef supply chain in Indonesia, as illustrated in Figure 3.
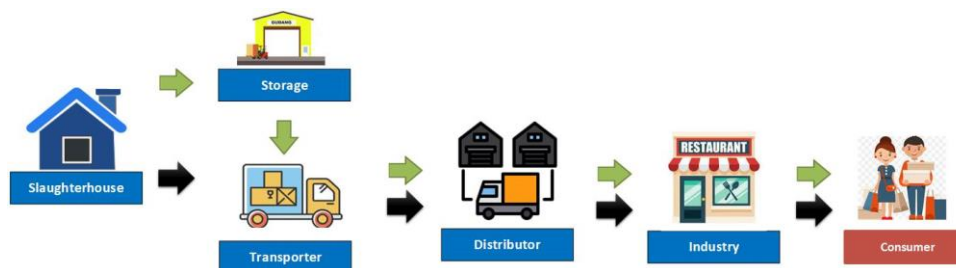

Fig. 3. The Existing Halal Beef Supply Chain

Information
Channel 1: RPH – Storage – Transporter – Distributor – Industry – Consumer
Channel 2: RPH – Transporter – Distributor – Industry – Consumer

The product flow in channel 1 begins at the abattoir, followed by the RPH's supervision and inspection of slaughtered beef. The meat is then stored, transported, and distributed to the industry, and ultimately reaches the consumer through merchants. In additon, the product flow in channel 2 also starts at the abattoir. Figure 4 illustrates the ongoing business process using BPMN (Business Process Modeling Notation), which depicts the process flow from the beginning to the end of the business process.
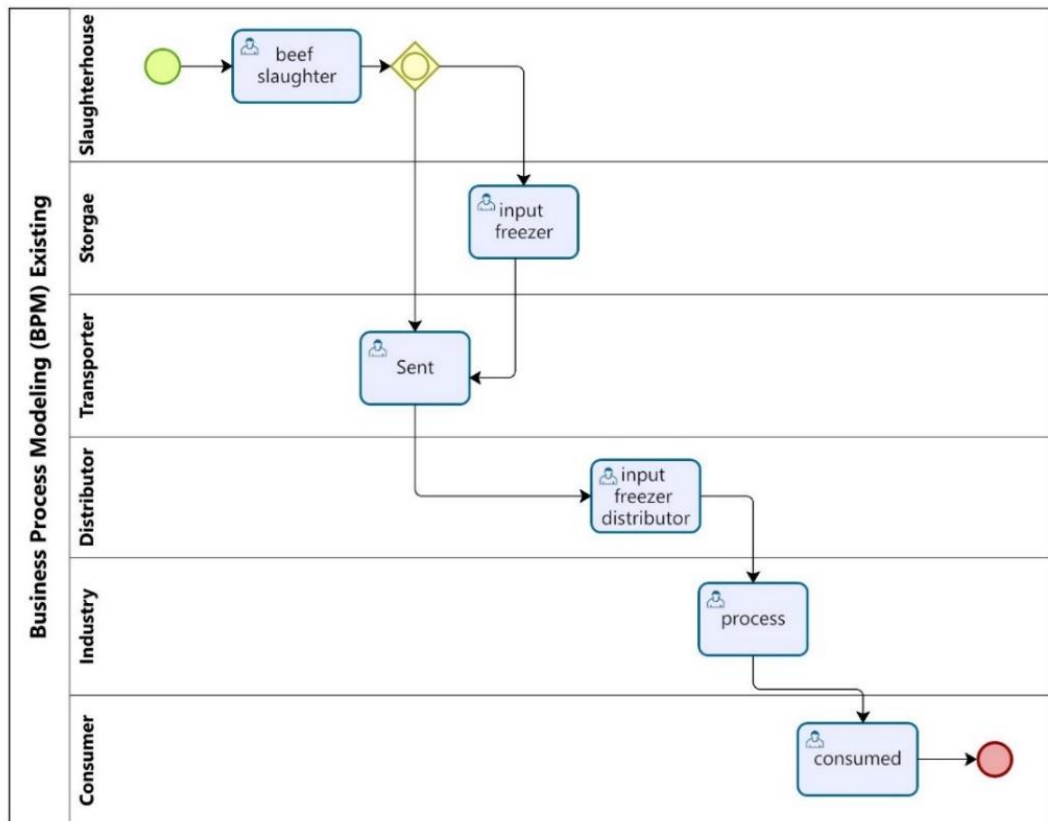
Fig. 4. Business Process of Halal Beef Supply Chain Existing

The business process of the halal beef supply chain begins with beef slaughter. The input freezer is then sent to the distributor's freezer, where it is processed and eventually arrives at the consumer. In the traditional business processes currently in place, beef moves from the abattoir to the hands of consumers without any structured data flow. This lack of data in the process is one of the reasons why some people can easily produce and distribute fake halal products and foods. Therefore, an improved diagram (Business Process Improvement) is needed, as shown in Figure 10.

3.2. Design

To solve the problems in the business process of the halal beef supply chain, we begin with designing an improved system concept (refer to Figure 5). The system design starts at the slaughterhouse, followed by storage, transmission, and distribution of beef until it reaches the industry. In the halal beef supply chain, every main participant, except for consumers, must input actor and product data through an ERP system, such as company ID, product ID, and halal certificate. The data will then be distributed to all actors via Blockchain. To make the concept easier to understand, Figure 6 shows an activity diagram that explains the process stages. Each data inputted by all actors will be uploaded to the blockchain network and hashed before being returned to Odoo. The smart contract determines the halal status of the meat based on the entered data before it enters the blockchain network.
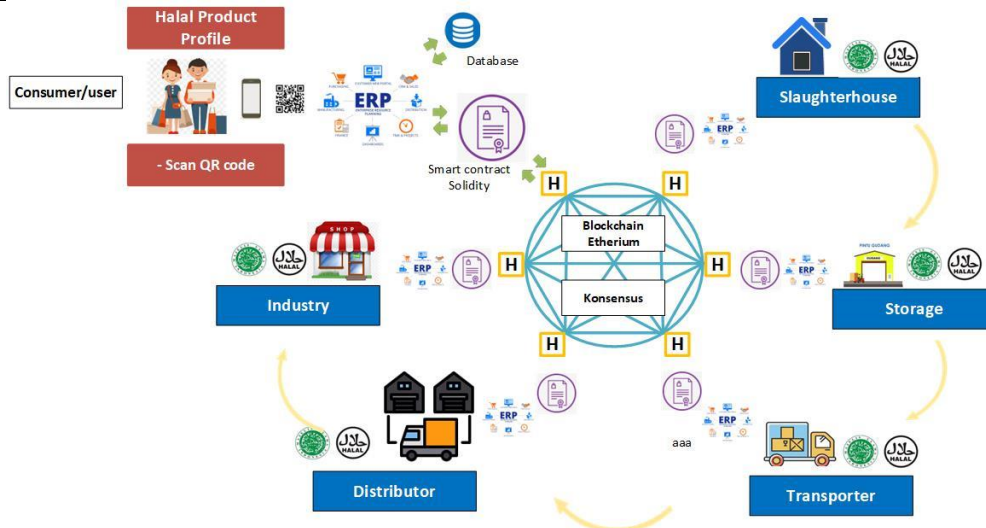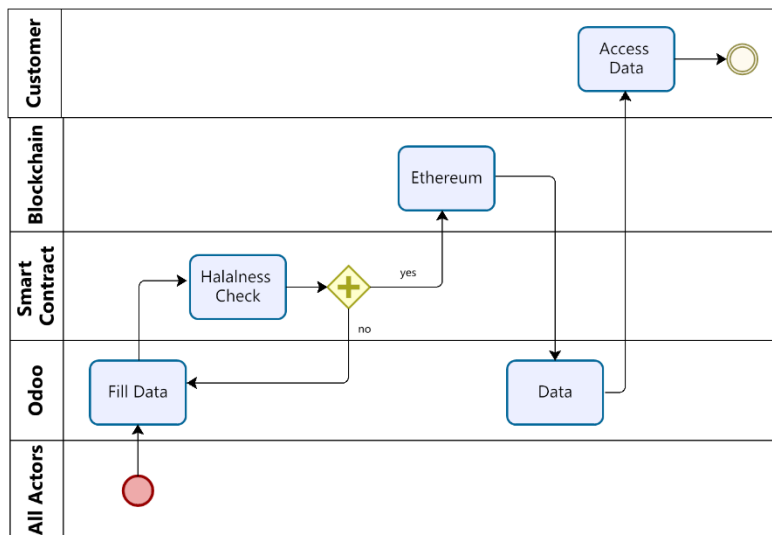
Fig. 5. System Design Concept offered

Fig. 6. Activity Diagram of the Method's Concept

The ERP system generates a product identifier such as a Serial Number/Lot/QR Code. Then, the ERP output is entered into a smart contract for an automatic decision on whether the beef is halal or not. However, only the halal status of the meat is inputted into the Blockchain. Other actors in the ERP system can use data blocks for traceability purposes (system traceability). The ERP system can perform various functions, as illustrated in the use case diagram in Figure 7. An explanation of each feature in the use case diagram is provided using an activity diagram. However, due to space limitations, this paper only shows the product profile view or traceability features as performed by consumer participants (Figure 8). Viewing product profiles is a traceability process that can be accomplished through the inventory module on the ERP mobile application by scanning a QR code or entering the serial number/Lot. The product profile includes information on whether the product is halal or not.
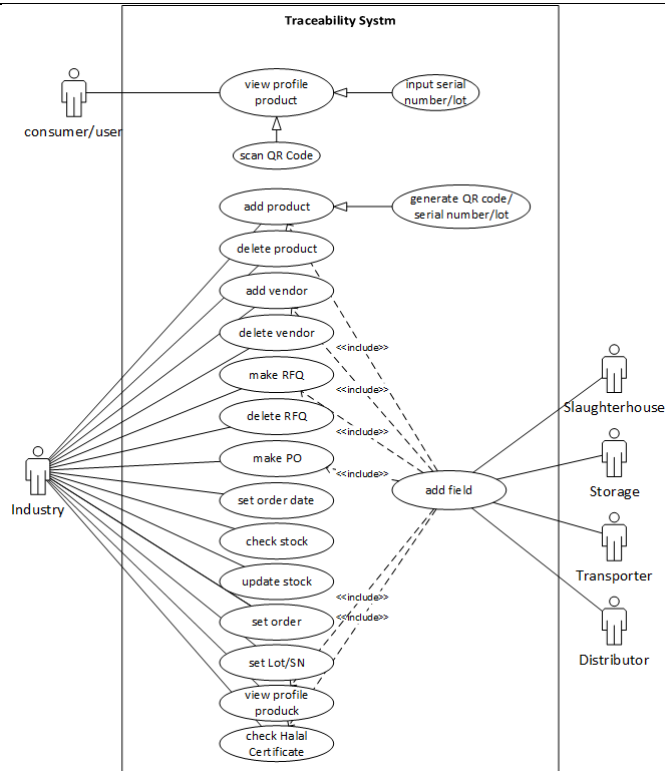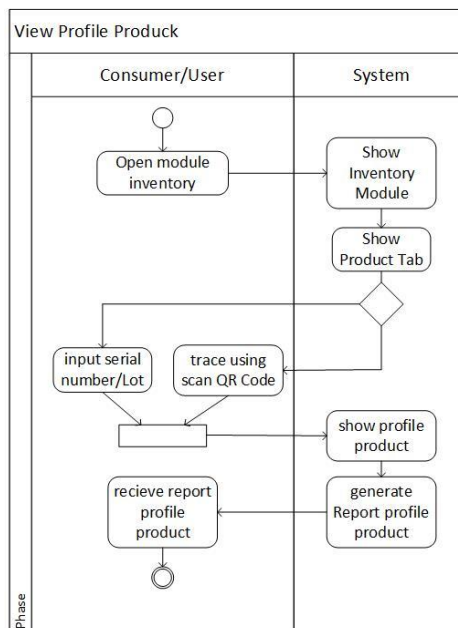
Fig. 7. Use Case Diagrams

Fig. 8. Traceability Activity Diagram

Traceability begins with checking the inventory list and creating a purchase order that includes the product number. Next, the product name and type are verified by checking the product catalogue and matching it with the vendor catalogue. Prior to examining the vendor's records, the buyer must also consider the slaughterhouse docking, storage, transportation, distributors, and industry. The traceability system consists of five classes, each with their own objects, attributes, and methods/operations. The class diagram design is also tailored to the modules within the ERP (Figure 9).
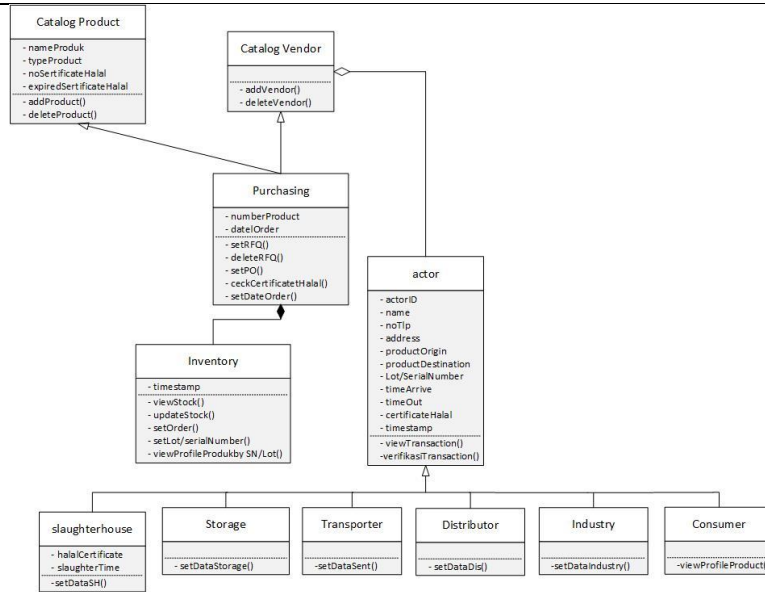
Fig. 9. Traceability Activity Diagram

Sequence diagrams depict the process activities in a sequential manner. Figure 10 illustrates a sequence diagram for viewing product profiles. The user initiates the process by opening the inventory module, displaying the inventory list, inputting the serial number, and scanning the QR code to view the product profile. The serial number input is processed by the Blockchain, which adds vendor and halal input status, as well as industry, distributor, storage, and slaughterhouse information.
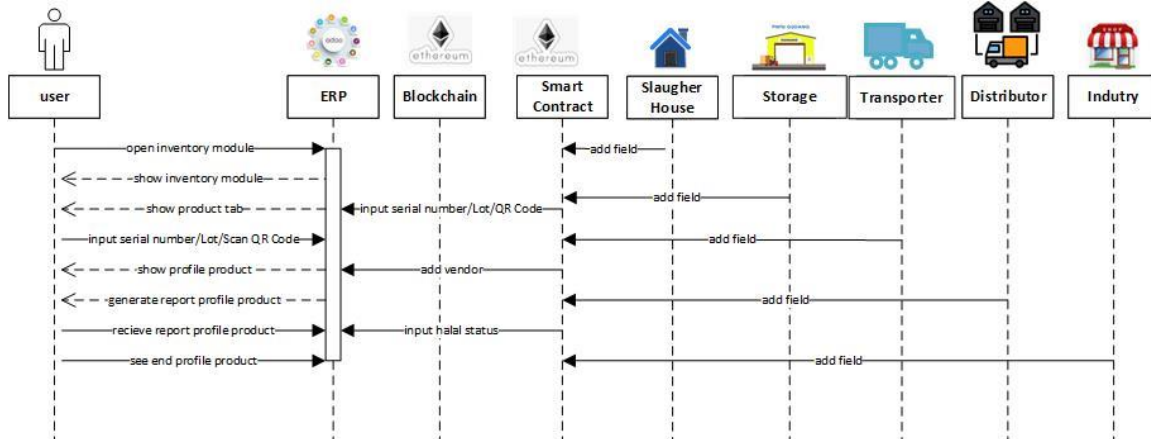

Fig. 10. Sequence Diagram

Figure 11 illustrates the process of slaughtering livestock at the RPH, which begins with the slaughtering and cutting of the slaughtered animals. Prior to slaughter, the cattle are allowed to rest for 12 hours. The slaughtering process takes place in a restraining box where the cow is doused with cold water and then slaughtered using the halal method. The resulting carcass is separated from the head, feet, skin, digestive organs, heart, liver, spleen, and lungs, resulting in meat, woven fat, bones, veins, blood vessels, and nervous tissue. The beef is then stored before being sent to distributors or for further processing.

This entire process is improved using ERP and Blockchain technology. For instance, all actors who enter the ERP system are required to input data and proceed to the smart contract before entering the blockchain network. If the beef is not halal, it will automatically be rejected by the smart contract. Primary data such as halal food data according to HAS 23000 or based on a halal certificate number are entered, and all actors can confirm the validity of the data through the consensus method. This mechanism guarantees the authenticity of the beef halal data without the possibility of being changed by participants, thus eliminating cases of mixing beef with non-halal meat and counterfeiting halal certificates.
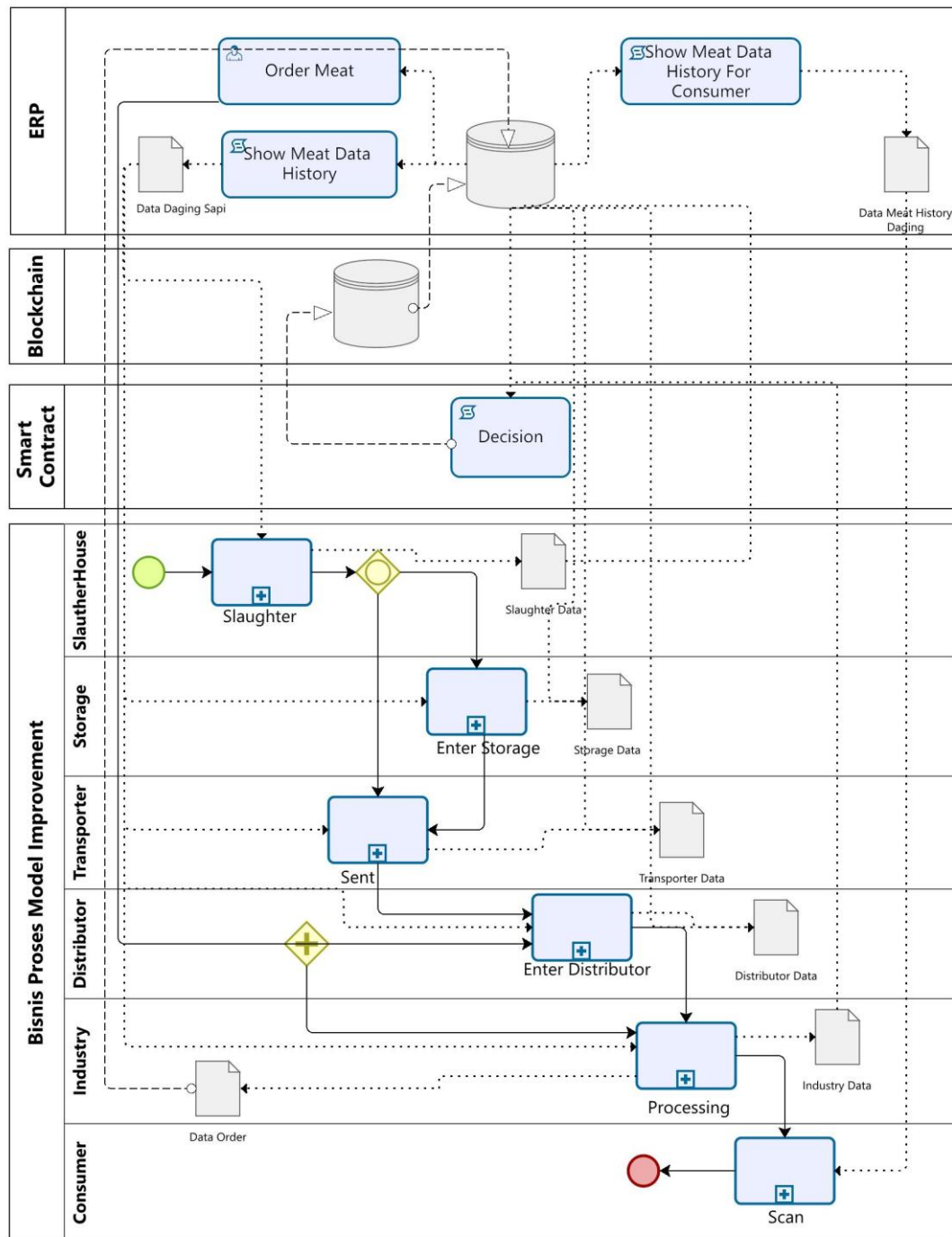
Fig. 11. The Existing Business Process Improvement of Existing Halal Beef Supply Chain

Figure 11 illustrates how the combination of blockchain technology and ERP technology can be implemented. The integration is not difficult, as Odoo can be connected to smart contracts using Odoo plugins or extensions, and blockchain APIs can be used as well [45]. Further connections can be made using tools like MyEtherWallet or MetaMask to create and send blockchain transactions that interact with smart contracts [46]. The use of blockchain technology improves ERP by providing greater transparency and protecting data and systems. Additionally, the implementation of smart contracts enables the system to operate automatically. This meat research not only enables effective management of beef procurement, but also ensures that beef reaches consumers with halal assurance.

3.3. Discussion

Theoretically, Blockchain and ERP have a significant portion in common. ERP operates on a system with a single data modification [47], while Blockchain controls a single data table shared by millions of users on the web. Information is accessible to every member node in the Blockchain, but no one can change

or modify reports without consensus. The distributed ledger variation feature is the most critical point in integrating ERP with Blockchain. This type of coordination can be effective in building trust between different organizations. There are several advantages to integrating the ERP system into the Blockchain. First, it speeds up the process. The creation of a smart contract provides equal testimony. Integrating Blockchain with the ERP system makes optimizing internal data control, business process flow, and transactions across the enterprise easier. Blockchain shares stable data, storing all activities between stakeholders - companies, vendors, and suppliers [48]. When compared to other methods not using ERP, such as studies by [49] and [50], the lack of an ERP system can cause several issues. First, there is a lack of visibility: ERP provides complete visibility over the entire supply chain, from customer requests to product delivery. Second, there is a lack of integration: ERP allows companies to integrate all aspects of their operations, from inventory management to product delivery. Third, there is a lack of efficiency: ERP allows companies to optimize their operational processes by minimizing the time and cost required to complete tasks. Fourth, there is a risk of manual errors: Without an ERP, companies may have to rely on manual processes that allow errors and data loss.

Second, Blockchain has transformed how transfer between companies occurs within the parent company and its subsidiaries. Nearly half of the industry leaders are adopting Blockchain as their primary intercompany transaction management, as it offers more transparent supply chain actions [47]. Third, Blockchain facilitates risk-free payment procedures, calming payment transactions and ensuring that they are automated and risk-free. Blockchain provides peer-to-peer transaction facilities that support trading of financial resources in a secure atmosphere [48]. As it works on a decentralized model, hackers find it difficult to penetrate the system and steal money. Additionally, Blockchain ensures that every transaction is subject to the law. Fourth, it secures data records by helping track users who make any changes. It confirms authorized personnel using digital signatures based on public key cryptography and holding secret keys to determine the owner[51]. When integrated with an ERP system, the business functions ideally and earns higher profits in the long run. Implementation in the example of the halal beef case, besides guaranteeing halalness as demonstrated in research [52], can also be managed in an enterprise manner, allowing small to large scale companies to use this system. All modules contained in the ERP can be used to manage halal beef.

4. Conclusions

Various technologies can be used to enhance business processes, and each technology has its own unique advantages that complement each other when combined. As an enterprise technology, ERP can reduce operational costs, integrate business and data, enhance collaboration, and offer many other benefits. When combined with blockchain technology, ERP's advantages are amplified, as information becomes more transparent, data is protected, and the system is secured. Smart contracts also allow the system to run automatically, further improving efficiency. For instance, in the case of the halal beef supply chain, integrating ERP and blockchain technology can help manage the procurement of meat stocks and ensure that beef reaches consumers with halal guarantees. This research aimed to design a traceability system by combining ERP and Blockchain to maximize profits, and this goal has been successfully achieved. The technology used in this research is not difficult and is based on previous studies that have used similar technologies.

One weakness of this research is that it has not presented all participants involved, so additional information is needed. However, if successfully combined with other modules such as manufacturing, finance, and others, it can become an enterprise system that benefits the company and is secure. Another weakness is that although it has been successfully combined theoretically, it has not been tested from a functional, economic, and SWOT analysis perspective, which includes strengths, weaknesses, opportunities, and threats. A suggestion for improving the system is to develop blockchain technology for further research to maintain transparency and authenticity of data or information in the supply chain. The government's role is also needed in developing beef traceability systems in Indonesia, such as regulations and IT infrastructure.

Future research can be conducted in the business field to fully realize the advantages gained from integrating Blockchain and ERP. This integration can help improve corporate governance and ultimately enhance company performance.

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