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| **RESEARCH ARTICLE**

Information Technology Infrastructure Design for Beef Supply Chain Traceability in Indonesia

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| **ABSTRACT**
The beef supply chain in Indonesia is a long and challenging (complex) chain because it involves many actors to track beef, from breeders in the form of cattle to a slice of meat consumed by consumers. The openness (transparency) of each actor involved in the supply chain can increase the safety of beef consumed, ensuring food safety. To ensure food safety, a system is needed to make it easier for consumers to trace the origin of beef. This study discusses the infrastructure design of an information technology (IT) based beef supply chain traceability system. The design is carried out with a systems approach, where system requirements are identified based on the characteristics of the supply chain. The system modelling concept uses Unified Modelling Language (UML) and Entity Relationship (ER) Diagram combined with the Computer Based Information System (CBIS) concept to design a traceability system in the beef supply chain. The study results are a conceptual design for a traceability system infrastructure that can be developed to build a web-based traceability system.

| **KEYWORDS**

Traceability, Computer-Based Information System, Supply Chain, Information Technology

| **ARTICLE INFORMATION**

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1. Introduction

Beef is an essential source of animal protein for Indonesian society. Every year, meat consumption continues to increase, followed by increased beef prices. Statistics show that the increase in beef prices in the last five years is 9.58%. ((Waldron, 2015, (Patrick et al. 2010, Kusriatmi et al. 2014), PUSDATIN 2015). The availability of beef nationwide cannot yet be fulfilled by domestic beef supply, so the Indonesian Government still has to implement a feeder cattle and frozen beef import policy, especially from Australia (Deblitz et al., 2011, Kusriatmi et al., 2014). Local beef also has a higher price than imported beef, so beef traders in Jakarta are reluctant to slaughter local cattle. One of the reasons is that the local cattle supply chain is quite long. In a beef production process, the food safety aspect is an important thing that must be considered. Some concerns, such as mixing meat with non-standard processes of producing safe, healthy beef, Whole, Halal (ASUH) as proclaimed by the Government, are still often found. The results showed that traceability affected the willingness to buy meat products. The traceability aspect is an effort to support food security so that the community's food needs are met, which is reflected in the availability of sufficient food in terms of quantity, quality, safety, variety, nutrition, equality, and affordability and does not conflict with the religion, belief, and community's culture, healthy life, active and productive in a sustainable manner (Purnama et al. 2021). In the context of the beef commodity, food security can be defined as the fulfillment of national beef consumption needs, both in quantity and quality, safely and affordably. Beef is an essential source of animal protein for Indonesian society. Consumption of meat will continue to increase with increasing population, income, urbanization, and changes in consumer preferences for beef and its derivative products.

Other important issues in the beef supply chain in Indonesia include unregistered actors such as breeders, collectors, retail traders, and livestock that do not have an identity. Also, livestock has different identities in each region. Data are not recorded in detail and are not transferred to the next actor. One solution to this issue is to build a traceability system in which data from each actor is transferred and maintained to provide helpful information for consumers. In some countries, the beef traceability system has become mandatory or voluntary. However, in Indonesia, it has not yet become a government regulation; consequently, the current traceability system is limited only to recording animal health data at the time of livestock sale and when the livestock is slaughtered in the Government's slaughterhouse, which is only known by the related Government Offices. Incomplete data recording might create cases like improper beef weight gain, meat mixing, and adulteration. To solve this problem, it is necessary to build ICT infrastructure and develop a traceability system that can be accessed by all actors in the beef supply chain.

In several countries, the traceability system has already been implemented. It has become an effective system to improve supply chains and product quality and an effective tool for sharing information between the actors involved (Wang et al., 2009, Nga Mai et al. l 2010, Wanjie Liang et al., 2015). Traceability is a part of logistics management that captures stores. It provides relevant information for an agricultural product of the food production chain from upstream to downstream. The product can be checked for safety, quality control, and backward and forward tracking. According to Pizazzuti and Mirabelli (2015), a tracking system is needed to control food quality and safety.

Empirical studies related to traceability have been conducted before. First, Qing-Yao et al. (2007) show that a well-designed traceability system will benefit the animal/livestock /animal-derived food industry. Traceability is important for food safety. Companies with accreditation and a certified traceability system are guaranteed to reduce the possibility of catching the disease. By maintaining identity and attributes throughout the food chain, breeders can provide quality assurance, maintain company reputation, and provide information used by consumers in determining willingness to pay for meat. Traceability will provide information to consumers on resource sustainability, which can later be managed using international management standards.

Second, Grande and Vieria's (2013) research shows that Radio Frequency Identification Technology RFID technology is a traceability system that can monitor all phases of livestock/animal/animal growth (from birth, breeding, and fattening), resulting in control data such as vaccination, disease, and fattening. RFID can improve logistics control because it shows the exact position from the slaughterhouse until the product is delivered to the final consumer. RFID also helps in supply control with excellent reliability at the right time. RFID is an automated identification system that helps provide information related to people, animals, assets, and products without human intervention to reduce human error automatically. RFID technology is a tool that can store information remotely without human interaction so that it can be automated.

The developed prototype national cattle identification and database system are then implemented in a web-based application. This national cattle identity system and database are used to publish and record the identity of cattle, cattle care, and cattle health carried out by farmers and health officers from the department. The public can obtain general information about the population and individual information of the cattle (type, birth weight, weaning weight, feed, and health) by entering the RFID number, scanning the RFID, and QR-code on the ear tag (Purnama et al. l, 2021).

Third, Mai et al. (2010) research shows that companies applying traceability will benefit quality and security assurance benefits because everything must be documented. Traceability will reduce costs for retailers or managers in monitoring upstream activities. Traceability also contains information related to food safety, environmentally friendly production processes, animal breeding guarantees, animal safety, and product differentiation.

IT-based traceability systems can help share information and integrate global beef supply chains. However, the absence of a standard format for recording information is a significant problem for realizing the integration and exchange of information between actors in the supply chain. The infrastructure design framework provides guidelines for supply chain actors to prepare the tools necessary to implement a traceability system. This study is intended to design an IT-based traceability system infrastructure. A system requirements analysis is carried out at the initial stage, including the hardware and software required in the traceability system using the CBIS concept.

2. Literature Review

Traceability system development can use IT because it can trace beef from cattle breeders in the form of live cattle to meat processed in the slaughterhouse. This system is capable of capturing, storing, and sending information regarding the origin of cattle, feed, age, drug administration, processing at the slaughterhouse, as well as all activities carried out by other stakeholders in the supply chain to ensure all production practices are carried out according to standard operating procedures which have been set Traceability systems can store data inputted by perpetrators2 in the supply chain such as livestock origin, livestock age, feed, health, slaughter process in rph, health checks of cows before slaughter (ante and post mortem) and other processes to produce meat products that are by established standards. The application of IT in the traceability system has several advantages, namely (a) integrating data and information from various actors in the supply chain, (b) increasing the accuracy of data entry, and (c) having the ability to communicate and exchange information between actors in the supply chain, and (d) control and supervision can be done more easily and quickly (Rosa et al. 2014, Vanany et al. 2015). The application of IT can create transparency in the supply chain because the products produced can be managed systematically. (Kumar et al. 2017).

Information exchange is essential for achieving an effective and sustainable supply chain (Seuring et al. 2008). However, Lam et al. (2006) identified that a standard or framework that describes the information exchange process in the supply chain traceability system is still insufficient.

In the livestock industry, several studies have been carried out, including an IT-based national cattle identification system that writes cattle id to RFID and QR code as the basis for cattle traceability (Purnama), national cattle identification and database system that can store cattle data, and issue a cattle ID number which is then written into the RFID and QR code. The code can be accessed to find out information about individual cattle. Farmers to manage their cattle can use this system, and the government can use it to monitor cattle nationally. Adding actors involved in the beef supply chain can further develop this system into a cattle traceability system. This database system can be accessed using web-based applications.

For some actors, it can be accessed using android-based apps. The community can use this application to find out information about cattle by using an application based on an Android-based smartphone so that information about cattle becomes more transparent.

Architecture and traceability of tuna (Krisna), development of cattle e-traceability, which results in transparency in the supply chain for cattle (Seminars), traceability of broilers, making Broiler-trace a prototype of a web-based information system (Triyanto), pork products by (Xiong Beng Hai) developed a traceability application using barcodes and (Wanjie Liang) which developed RFID and epic traceability model. In the study, the flow of information was modeled by modeling the structure by describing DFD (krisna) and using an object-oriented (seminar et al. l). Several other studies have explained data models using object-oriented such as (who is it) by describing class diagrams and UML-based sequence diagrams. Furthermore, each stakeholder in the supply chain must record the flow of information and data, described and then modeled by the UML (Unified Modelling Language) class diagram. Hu et al. (2013) designed a traceability system framework for the vegetable supply chain in China. This study has successfully identified the structure of the vegetable supply chain. The relationship between stakeholders and the traceability system is modeled using a use-case diagram. A critical point analysis of what information should be recorded is also conducted. The results are then modeled using UML static diagrams. The results also explain the vegetable supply chain's design process and traceability system architecture. The evaluation was also conducted by Hu et al. (2013) for system improvement. Liang et al. (2015) developed a traceability system framework in the meat supply chain in China by identifying detailed information that must be recorded, modeling network architecture, and system implementation. From a traceability system development perspective, it is essential to address traceability from a data and information management point of view, which depends on the framework that has been developed (Kumar et al., 2017). An IT-based traceability infrastructure framework is needed to determine the components for building a beef traceability system.

3. Methodology

3.1. Field Survey

This research was conducted for two years, from July 2018 to December 2019, in Kupang Regency and Municipality (NTT), Bogor Regency, Tuban, Bojonegoro, and Jakarta. Kupang City, Kupang Municipality, NTT Province, is the supply area for inter-island cattle, and where they have an extensive cattle breeding system, Tuban and Bojonegoro are the No.3 cattle producers in East Java and are also considered national cattle barns with intensive care methods. Field surveys were also conducted in cattle fattening companies, i.e., PT Widodo, JKU, and PT Elders Indonesia, to find the cattle recording model. The survey was conducted in 4 slaughterhouses in Jakarta to see meat distribution from slaughterhouses to retailers. Field surveys were conducted to 1) determine Actors involved in the beef supply chain, from cattle breeders to meat traders, 2) Know the business processes in the beef supply chain, 3) Know the data needed and exchanged for each actor, 4) Know what beef information is needed by the consumer.

3.2. Data collection

Data were collected by conducting structured interviews with each actor in the beef supply chain, which includes Breeders, Collectors, Slaughterhouses, Government, and Meat Traders. The observation was conducted at the slaughterhouse to see the process of slaughtering cattle into the meat.

3.3. Traceability System Design Concept
The design of the beef traceability system uses the CBIS concept to determine how the overall system is being developed. Modelling of software design uses Unified Modelling Language (UML), and database design uses the concept of a database life cycle by making ER Diagrams to describe the relationships between actors in the traceability system.

3.4. Beef Supply Chain
According to Chopra and Meindl (2016), the supply chain consists of all parties directly or indirectly in fulfilling customer demand. The supply chain includes manufacturers, suppliers, transporters, warehouses, retailers, and customers. The main goal of any supply chain is to meet consumer needs and generate profits. The supply chain is a network of related parties that work together directly or indirectly so that a product reaches consumers. In this beef supply chain, these parties include farmers, collecting traders, inter-island traders, and RPH meat traders; in it, there are transporters and quarantines.

In order to obtain information on the process and mechanism of the Indonesian beef supply chain, a study was conducted on the various activities of actors involved in the supply chain. In digging for data and information related to the beef supply chain, several activities are conducted to determine how Indonesia's beef supply chain system is running. Figure 1 shows the structure of the cattle supply chain in Indonesia.

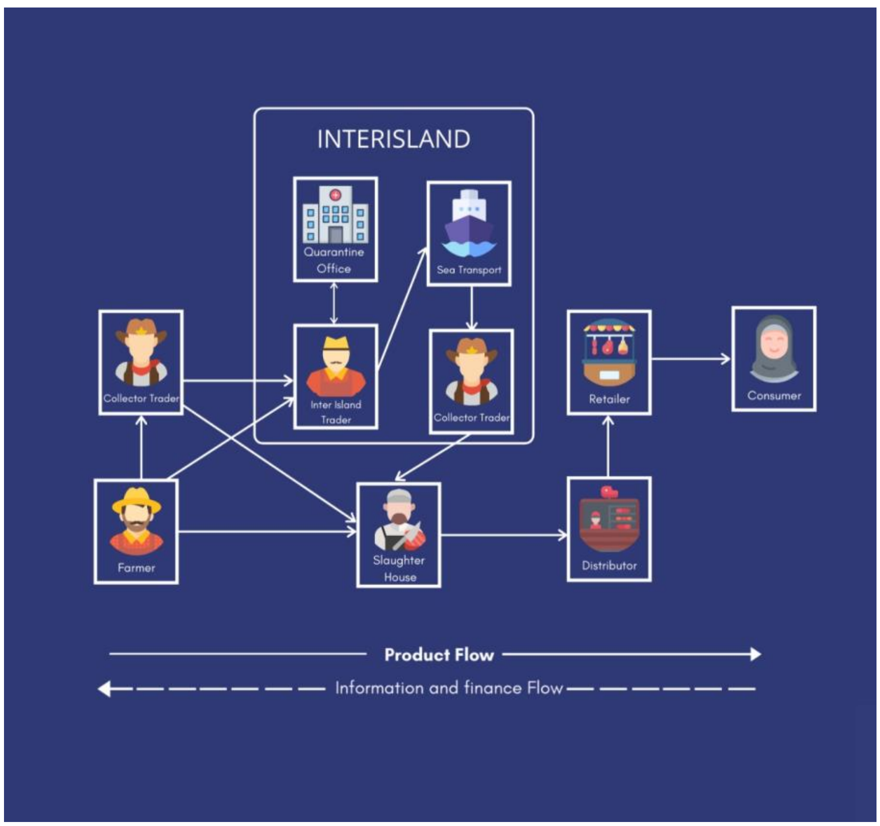

Figure 1. Beef Supply Chain in Indonesia

In general, the beef supply chain in Indonesia can be divided into two types: inner island and inter-island supply chains. In-island supply chains, for example, beef supply chains in Java. Cattles from cattle centers in East Java such as Tuban and Bojonegoro or other areas in Java are sent and slaughtered in Jakarta, and the beef is sold in markets around Jakarta. Meanwhile, the inter-island supply chain for local cattle is generally imported from cattle centers outside Java, for example, NTT, NTB, and Bali. Cattles are sent from these provinces as cattle centers by sea to islands such as Java, Kalimantan, Sulawesi, Sumatra, and other islands by ship. Sea ships are available as livestock carriers from Camara I to Camara VI ships provided by the government with various routes in Indonesia. Another sea transportation available for transporting cattle is cargo transport of modified cargo ships to transport livestock. Live cattle are sent from these areas and then kept for some time, slaughtered in destination areas such as DKI Jakarta, Jabotabek, West Java, Kalimantan, and Sumatra. Cattles purchased by collectors will be sold to other cattle traders or dealers who will slaughter cattle at the slaughterhouse. In Jakarta, there are four large slaughterhouses, i.e., Darmajaya Cakung slaughterhouse, Dharmajaya Pulogadung slaughterhouse, East Jakarta Cilangkap slaughterhouse, and West Jakarta Semanan slaughterhouse. The dealer will sell cattle slaughtered in the carcass or commercial cuts to distributors, retailers or individual consumers, or consumers of hotels, restaurants, and catering (HOREKA).

3.5. User Requirements

User requirements are software requirements that show a description of features needed in developing a beef traceability system. User requirements are obtained by extracting information from users, stakeholders, and sponsors. Based on the results of interviews and field studies, the beef traceability system that is built will need to have functional and non-functional prerequisites.

The functional requirements of the beef traceability system include:

- Registration of cattle and actors in the supply chain is a function of registering actors and cattle owned by farmers.
- Good cattle data recording includes data recording of cattle raising, cattle health care by breeders
- Cattle Transfer, transactions between actors such as breeders and collecting traders, or between collecting traders
- Recording of beef slaughter in the slaughterhouse, slaughtering of cattle in the slaughterhouse where there is a change in cattle identity in the form of RFID into a QR code on the meat
- Meat data recording is a data recording of the beef production process
- Meat transfer is a meat transaction process between slaughterhouses, distributors, and retailers.
- Cattle and Meat information that can be accessed by the public or consumers.

Figure 2, the use case, shows the model to be developed based on user requirements and how users interact with the system.
The non-functional requirements include:

- Availability
  Applications must always be available and can be accessed by users anytime and anywhere as long as they are connected to the internet. Applications can be accessed 7 x 24 hours.
- Performance
  The designed application is equipped with a user-friendly interface that is easy to use by stakeholders and has a fast response time.
- Portability
  Applications must be able to run on multiple platforms or operating systems. Web-based applications with the PHP programming language can meet these criteria

3.6. CBIS To Achieve Traceability

3.6.1 Information technology for traceability

Seminar (2016) states that the Computer Based Information System (CBIS) is an information technology approach to support the traceability system in the food chain. This system consists of several components, namely hardware, software, Data ware, Netware, info ware, and brain ware as essential resources that must be met to convert data into information in the food chain. CBIS application can support transparency, starting from the production process and delivery until the product is consumed. In designing this beef traceability system using a Computer Based Information System (CBIS) approach, a model for providing information to various actors involved in the beef supply chain (Seminar 2016). CBIS illustrates how all actors are connected to other actors so that there is an interaction between actors where the actors will share information. The system will run when the actors work properly and transparently. With the CBIS approach in designing a traceability system, this beef will discuss how each element in CBIS is needed to design a traceability system so it can run well. The CBIS flow for food chain transparency can be seen in Figure 2, showing the CBIS framework on a traceability system built by adopting and modifying it (Seminar 2016).

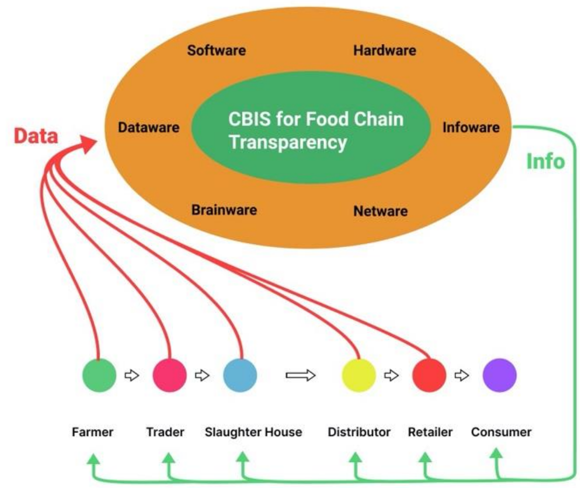

Figure 2. CBIS for food chain transparency (Modified from (Seminar 2016))

Hardware resources include various tools, such as sensors (sensing devices), data loggers, data scanners, communication tools, data storage, information displays, actuators, processing units (microprocessors), computers, smartphones, and communication networks. Software resources include operating systems, supporting applications, database management systems (DBMS), GIS software, data acquisition, report generator software, specialized Knowledge Management System (KMS) application software, Enterprises Resources Planning (ERP), Decision Support System (DSS).), Customer Relationship Management (CRM), and other intelligent systems and search engines to obtain information. Dataware resources include all relevant data (historical, real-time, spatial, and geographic) relating to each end, event activity, food products, and quality standards in the food chain. Netware resources include control and network access, communication media, directories, communication processors, web services, and network technology clusters (intra, extra, internet). Information resources include operations, managerial reports, forecast and trend analysis, early warning signals, decision scenarios, and a choice of digital or printed sheets. Brainware resources include all actors in the chain of command and CBIS, such as administrators, databases, and CIOs (Chief Information Officer, MIS manager, experts, and end users. CBIS has four essential roles in food chain transparency as follows: 1) supporting various algorithms, computer programmer scenarios; 2) supporting accurate real-time data from each actor at various stages, geographic areas, and times in the food chain. The application of CBIS allows all stakeholders to be connected, making it possible to supervise each stakeholder.

4. Results and Discussion

The first step in designing an information technology-based beef traceability system framework is to conduct system analysis and identify the need to build a beef traceability system that can integrate all actors in the beef supply chain. Identification of needs, including functional requirements and non-functional requirements.

In building a framework for a beef traceability system, this study follows the CBIS concept, where the need to build a system can be described as follows:

4.1 Data ware

In developing a beef traceability system, actors will send data to other actors in the chain. The actor must know what data is needed and will be used by the next actor (successor). In developing the beef traceability system, the data to be taken from each actor can be described in Table 1. The farmer will enter his cattle's data. Collecting traders will update the cattle data they buy from breeders. Then the slaughterhouse will enter slaughtered livestock data. The actors before the slaughterhouse used RFID as livestock identity and will be converted to a QR code after the cattle are slaughtered. The data to be input in the slaughterhouse include the slaughter date, slaughter, NKV number, and so on. After being slaughtered, the meat will be cut into commercial pieces. At the distributor, there will be input in the form of distributor data, product names such as tenderloin, sirloin, storage model, transportation from the slaughterhouse to the distributor, and others. In the retailer, additional data are retailer name, meat weight, and date of slaughter.

Traceability system development is quite complex, from planning to development. This traceability system involves many actors from upstream to downstream. The results of field observations and the data requirements of each actor can be seen in Table 1 below.

Table 1. Data on Each Actor in the Supply Chain

No.	Actor/Entity	Data
1	Breeder (individual, company, livestock group)	Breeder ID, Breeder Company ID, Animal Group ID, Date of Birth of Cattle, Cattle ID, Elder Cattle, Cattle Feed, Cattle Status, and birth weight.
2	Collector Trader	Collector Trader ID, Cattle Feed, Cattle Status, Purchase Date, Selling Date, and weight of cattle.
3	Inter-Island Trader	Inter-Island Trader ID, Cattle Feed, Status of Cattle, Date of Purchase, Date of Sale, Weight of Cattle, Type of Sea Transportation, Type of Land Transportation.
4	Bandar/RPH	Bandar ID, RPH ID, No NKV, Butcher ID, Stunner ID, Certification of the beef slaughtering process, Cattle Feed, Cattle Status, Date of arrival, Date of slaughter, Date of Production, Product Name, Date of Meat Sale, Expiration Date, Buyer Name, Carcass weight, Meat Cut weight, Animal ID, Transportation Type.
5	Distributor	Distributor ID, Date of Purchase, Date of Meat Sale, Meat Weight, Product Name, Transportation Type
6	Retailer	Retailer ID, Date of Purchase, Date of Production, Date of Meat Sale, Meat Weight, Product Name (Commercial Cut).

4.2 Brain ware

Brainware, in this case, is the actors or users who use the traceability system in the beef supply chain. All actors involved in the system must be able to use the traceability system honestly and have the integrity to ensure no data forgery by actors in the chain. Training, socialization, and support in the use of traceability and control systems by the government, in this case, the Government Livestock Directorate, are essential to run well. Brainware, in addition to users, is human resources who play a role in the development of traceability systems such as Developers, Database Administrators, system administrators at the center and city/district level, IT managers at livestock companies, slaughterhouses, meat distributors, and companies connected in the supply chain, and also individuals who use this system such as individual breeders and farmer groups.

4.3 Software

Traceability software or software must be accessible by all actors in the beef supply chain. For that, it is necessary to develop a traceability application. Traceability software will use an object-oriented approach by modeling UML diagrams, with database development using database lifecycle by making ER Diagrams. The coding will use the PHP program and the PostgreSQL database, which has the advantages of a liberal open-source license, supported by many operation systems, unlimited database size, and spatial support data (Fathansyah 2018). Figure 3 shows the use case for the beef traceability system, and Figure 4 shows the ERD for creating a beef traceability system database.

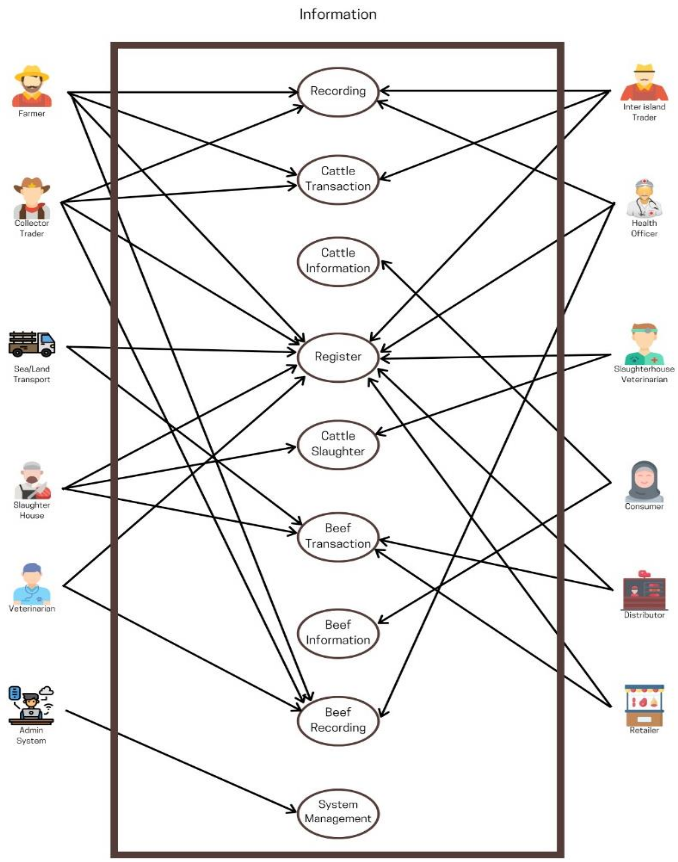

Figure 3. Use Case Diagram of Beef Traceability System

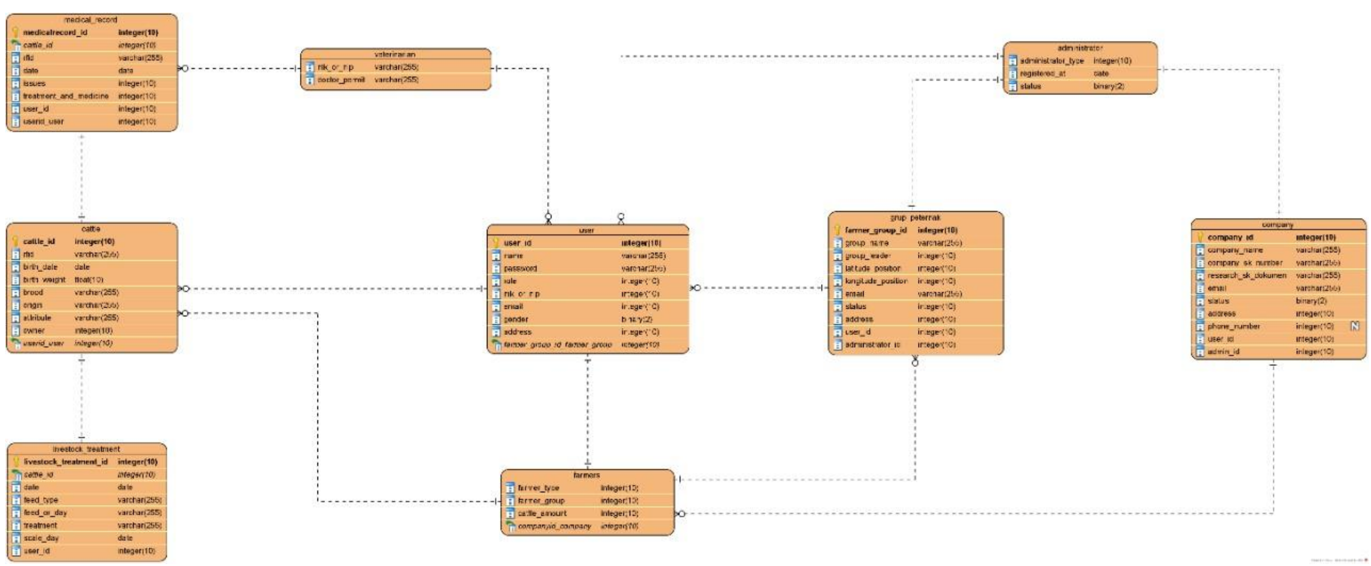

Figure 4. ERD Beef Traceability System

4.4 Netware

Actors, companies, or organizations in the supply chain have different roles. Actors can come from within or from different organizations/companies. A network that can connect all actors is required to combine these actors. The traceability system design will develop a centralized network system where a central server is proposed to be under the supervision of the Department of Agriculture / Livestock. Each actor will be connected to a central server via the internet network. Users can connect to the central server by using mobile devices, personal computers, or computers in a company connected to the local network of an organization/company. The centralized model was chosen to facilitate its implementation so that each district and municipality office did not need to build a computer system but prepared a connection to the center without the need to build complex infrastructure. The logic diagram for the beef traceability system network can be seen in Figure 5.

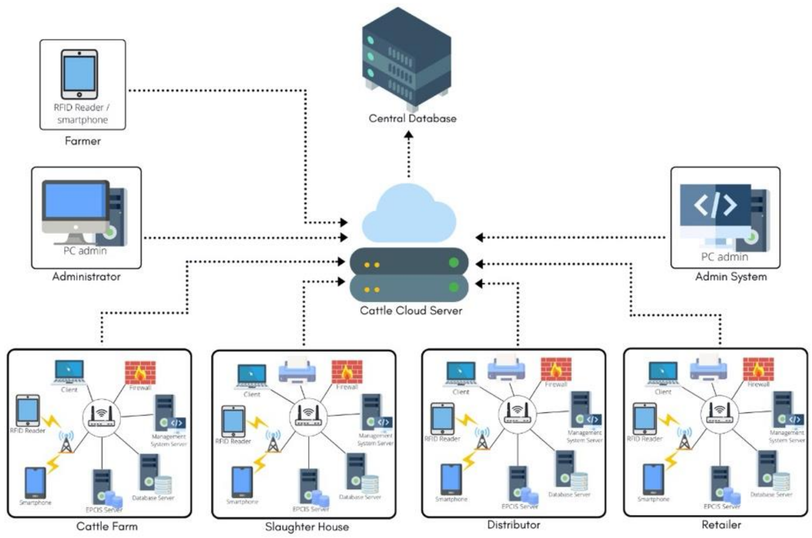

Figure 5. Beef Traceability System Computer Networks

Figure 5 shows the network design for a traceability system with a centralized system where all network devices are located at the center. The district servers are physically located on the central server; but logically, the traceability system management will be managed by the administrator in each regency/municipality.

4.5 Hardware needed to create a traceability system.

To support the traceability system requires hardware that each actor must have, such as computers, smartphones, barcode scanners, barcode printers, and other devices. Figure 6 shows the hardware requirements of the traceability system. For individual breeders and collectors, smartphones and personal computers are sufficient to access the system. In large breeders where sufficient data on cattle are managed, companies can build computer systems and local networks to support the traceability system. In the slaughterhouse, the additional equipment required is an RFID reader or an RFID scanner to scan the cattle to be slaughtered. In addition, a QR code printer is also needed to issue a QR code that will be installed on the carcass. QR codes will also be issued by meat distributors and beef retailers.

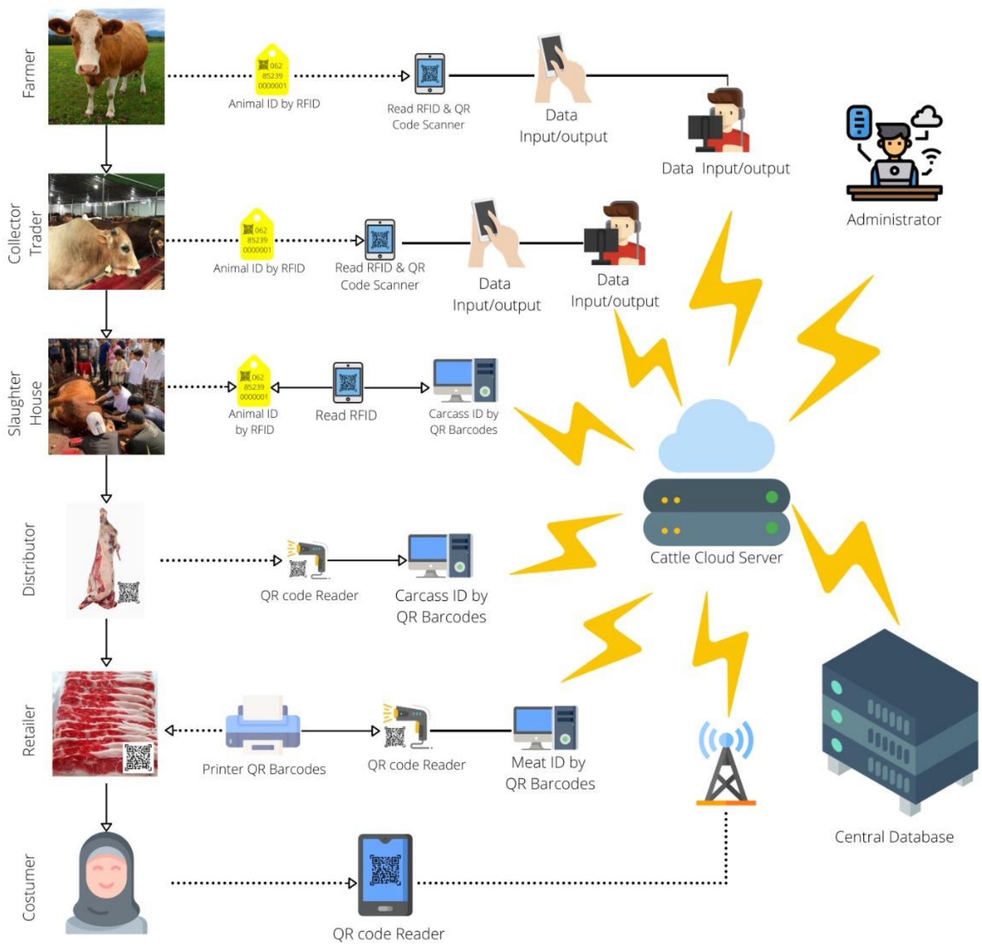

Figure 6. Hardware for each actor in the beef supply chain

4.6 Info ware

The traceability system will produce information that can be accessed by people who consume beef. This information is in the form of data printed on a QR code that can be accessed by users/communities/consumers by taking a photo of the QR code, and information about the history of beef production can be known by consumers. Figure 7 shows information that can be read by scanning the QR Code on the resulting beef packaging. Actors in the supply chain can also print other information such as cattle delivery reports, cattle health reports, and other reports generated by the system. In the built system prototype, there is also information on cattle that will be sold by breeders, and every actor involved in the beef supply chain, i.e., traders, inter-island traders, quarantine, and transportation to retailers.

Figure 7. Information on the QR code for cattle (a) and beef (b)

4.7 User Interface Design

The user interface for the beef traceability system can be seen in Figure 8. Actors in the beef supply chain can enter and use the system. Breeders, traders, slaughterhouses/dealer distributors, and retailers can enter the system by accessing the www.sicadas.com page. On this page, the initial homepage of the beef traceability system will appear. Actors who play a role in the traceability system can log into the system and use the system according to their access rights. Meanwhile, the public and end consumers can enter the web page to track livestock or beef by shooting a QR code and also to find out information about the actors involved in the beef supply chain. A summary of the data for each actor will be displayed on the start page of the web page.

Figure 8. Beef traceability system homepage

4.8 Analysis

Traceability system development requires Data ware, Brain ware, Software, Network, Hardware, and info ware. In developing a beef Data ware traceability system, actors will send data to other actors in the chain. Each actor must know the data needed and used by subsequent actors (successors) such as breeders, collectors, traders between islands, dealers, distributors, and retailers. In Brain ware, all actors involved in the system must be honest and have integrity to avoid data forgery by actors. Training, socialization, control, and Government (Livestock Directorate) support in using traceability are essential for the system to run well. In Software (design), the traceability software will use an object-oriented approach by modeling using UML diagrams, with database development using a database lifecycle by making ER Diagrams. In Netware, actors, companies/organizations in the supply chain have different roles. They can come from within different organizations or companies. To integrate these actors, a network that can connect all actors is required In Hardware. It requires Hardware that each actor must have, such as computers, smartphones, barcode scanners, barcode printers, and other devices. RFID readers and barcode scanners are only for users like RPH, Distributor, and Dinas Peternakan. In Info ware, the traceability system will produce information that can be accessed by people who consume beef. This information is in the form of data printed on a QR code which users/communities/consumers can access by taking a photo of the QR code.

The development of an IT-based traceability system has several advantages, such as (a) integrating data and information from various actors in the supply chain, (b) increasing the accuracy of data entry, and (c) having the ability to communicate and exchange information between actors in the supply chain, and (d) controlling and supervising can be done more easily and quickly (Rosa et al. 2014, Vanany et al. 2015). The application of IT can create transparency in the supply chain because the products produced can be managed systematically. (Kumar et al. 2017). E-traceability infrastructure design can be used in developing traceability systems to determine the components and configurations to be made in developing traceability systems. The results of this study also support the research conducted by Seuring et al. (2008), who show that the exchange of information is currently the main requirement for executing an effective and sustainable supply chain. This study also supports the research of Zhang et al. (2011), who developed a traceability system design framework in the tilapia supply chain in China. This study identifies stakeholders who play a role in business processes, and the supply chain structure is modeled. Furthermore, the flow of information and data that each stakeholder in the supply chain must record is described and then modelled by the UML class diagram.

5. Conclusion

A traceability system can be established if all actors in the beef supply chain are connected. Every actor must be honest and have the integrity to complete the data correctly and accurately. In building a traceability system, functional and non-functional analysis is used, and the needs can be mapped with CBIS implemented into an integrated traceability system. The system design uses the CBIS concept, including Dataware, infoware, Netware, brainware, hardware, and software. By integrating these parts, a traceability system can be built to integrate all actors involved in the beef supply chain. CBIS implementations can be used to develop traceability systems as they provide the ability to simplify the documentation process, integrate and facilitate information exchange between parties involved. The next future target is to start developing a prototype of supply chain beef traceability that is ready for testing, validating, dan deployment that can produce an implemented traceability system.

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