

Development of Warehouse Management System Using IoT for Halal Supply Chain

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Abstract

This research aims to develop a Warehouse Management System (WMS) using Internet of Things (IoT) technology to support the implementation of the Halal Supply Chain. Given the importance of monitoring and guaranteeing halal products in the supply chain, IoT in warehouse management systems can provide greater transparency, efficiency, and accuracy. This study introduces an IoT-based WMS model that enables real-time tracking from goods receipt to delivery and automates processes such as selecting storage locations and picking up goods. In addition, this system is also designed to ensure compliance with halal standards by tracking the source of raw materials and monitoring their storage conditions. System testing showed significant improvements in warehouse operational efficiency and the ability to guarantee the integrity of halal products. These results indicate that adopting an IoT-based WMS can be essential to realizing an influential and trustworthy Halal Supply Chain.

Keywords: *Halal Supply Chain, Internet of Things (IoT), Warehouse Management System (WMS), Smart Warehouse*

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A. INTRODUCTION

One of the Halal Product Assurance Law (JPH) Number 33 of 2014, article 4 mandates that every product entering, circulating and trading in Indonesia be halal certified. Indonesia has a majority Muslim population assigned a government institution under the Ministry of Religious Affairs of the Republic of Indonesia, the Halal Product Assurance Organizing Agency (BPJPH), which handles halal certificates.

In line with the implementation of the JPH Law, Indonesia has also declared the center of the world's halal producers in 2024, not only as the world's halal consumers. Product halal certificate is the main requirement in achieving the target as the center of world halal producers. The government has accelerated the number of halal-certified products through halal certificate management facilities for micro and small industries, one of which is through the free halal certificate program known as Sehati.

Micro and small industries are the most developed business units in the community and play an active role in driving the economy of the Indonesian people. Most micro and small industries need better storage warehouses. Halal Supply chain is the overall activity of entities involved along the supply chain from upstream to downstream, applying concepts by Islamic law, starting from supplier selection, production process, and storage to distribution (separating storage and delivery of halal products to avoid contamination of non-halal substances)

The warehouse is a facility used to distribute goods from suppliers to end users (Karia 2019). A smart warehouse is an intelligent warehousing system where an activity occurs in and out of goods in a warehouse that is integrated with a network located in one local area (Ab Talib, Hamid, and Zulfakar 2015) (Hashim and Shariff 2016) (Ngah, Zainuddin, and Thurasamy 2015) (Ngah, Zainuddin, and Thurasamy 2014). Smart warehouse can be seen as an innovation and transformation of warehousing systems that aim to utilize infrastructure, Information and Communication Technology (ICT), and internet networks so that all existing processes can be minimized. Smart Warehouse technology can support warehouse product management and data collection processes. A warehouse operator needs Smart Warehouse technology to overcome data collection in and out of goods in the warehouse. So Smart Warehouse has an intelligent system that occurs in and out of goods in a warehouse that is integrated with the Internet, making it easier for warehouse admins to carry out warehousing activities (Tieman 2011) (Tieman, Van der Vorst, and Ghazali 2012) (Farhan and Hidayat 2021).

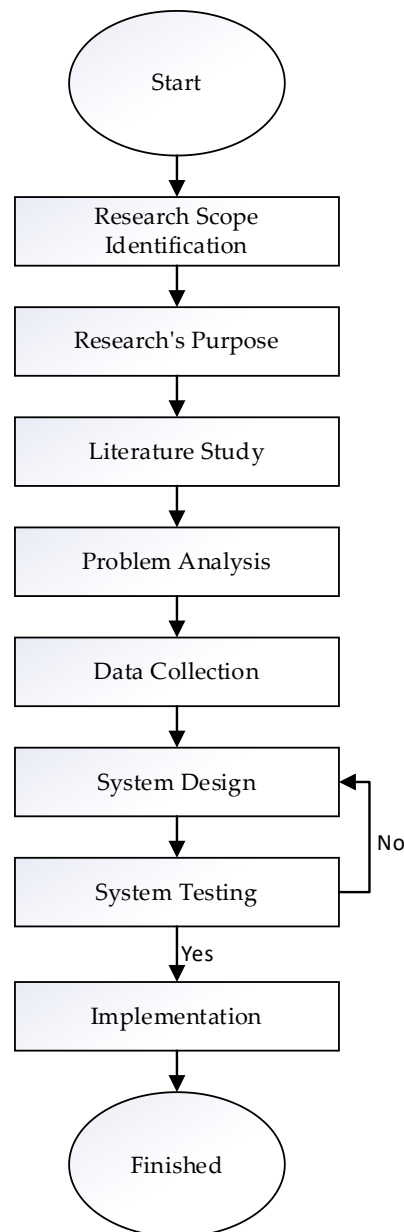
Some of the problems that exist in warehouses are:

1. Processing of goods is still carried out manually so that discrepancy occurs or the difference between the number of goods in the system and the number of goods in the warehouse (actual physical)
2. Manual compliance of goods data processing. This causes too much file hoarding and data searches that take a long time
3. Difficulty in making reports on incoming and outgoing goods. This is because all processes are done manually

Emerging information and communication technology paradigms such as data-intensive computing (Big Data), open source, Large-Scale Distributed Systems, Internet of Things (Žunić et al. 2018), Service-Oriented Physical-Cyber-Social Computing and Cloud Computing are essential for the realization of smart warehouses. Real-world Smart warehouses are enabled by combining these paradigms using a mix of architecture (centralized, decentralized, and a combination of both) and infrastructure, such as Middleware and IoT platforms, to support the development of applications and information systems for Smart warehouses (Ding 2013).

Smart warehouse is one step in reducing lead time in the entry and exit process of goods (inbound-outbound). With a smart warehouse, warehouse operators no longer manually record the flow of goods. For this reason, there needs to be innovation in the warehouse management system to increase operator productivity.

B. METHOD



1. Research Scope Identification

At this stage, researchers identify existing problems to determine the research objectives. In identifying the scope of this study, researchers determine the limits of the problem to be solved—namely, the design of a smart warehouse system with IoT technology.

2. Research Purpose

This stage determines the research's purpose, namely how to design a smart warehouse system with IoT technology.

3. Literature Study

Next, collect related literature so that researchers can determine which one will be used in this study. Various literature sources are from reputable indexed

journals and articles on warehouse management systems (WMS) and smart warehouses.

4. Problem Analysis

At this stage, it is carried out to understand the obstacles in the field. It is hoped that these obstacles can be determined for resolution by analyzing them. The obstacle referred to above is how to design a smart warehouse system with IoT technology to increase the productivity of existing operators.

5. Data Collection

At this stage, the data needed in this research is collected to design a smart warehouse system with IoT technology. The data processed is material data in the warehouse. Data collection through interviews and inventory data in the warehouse.

6. System Design

This system will later be built according to the needs of the warehouse, which will later use the waterfall method. Some applications that will be used are Microsoft Access, PHP, Macromedia Dreamweaver, and Mysql so that this application can run on WMS.

7. System Testing

At this stage, the system that has been designed is tested to determine whether it can be applied or not.

8. Implementation

The system is implemented in the warehouse so that the existing warehouse management system becomes an IoT-based warehouse management system known as a smart warehouse.

C. RESULTS AND DISCUSSION

Industrial warehouses may have a different warehouse management system (WMS) than other warehouses. One system that can be applied is the Duta system, where the incoming product will have a description of the product entered into the system. As the goods arrive, the outgoing goods are also incorporated into the process to increase inventory. Each article in the system is coded to facilitate article summarization (Affia & Aamer, 2021). The process of entering item details is very important in the inventory process. Usually, warehouse officers carry out the recording and income process manually. This greatly facilitates the occurrence of data entry errors caused by human error (Žunić et al., 2018).

Not only related to products, but many employees are involved in the warehouse. These workers are responsible for the movement of goods in the warehouse. Warehouse managers need clarity and employee information to facilitate their work. Unfortunately, employee attendance information is sometimes difficult

to obtain because it uses a manual attendance system. Conventional approaches are often inefficient, data loss is common, and data errors are likely due to human negligence (Zhen & Li, 2022).

The application of IoT in WMS will certainly help warehouse workers in doing their work. In addition, it will modernize existing work processes and increase productivity in the warehouse. IoT is seen as the answer to the weakness of barcode technology because barcodes can only be identified by holding them close to the reader, and the storage capacity of barcodes is minimal. In addition to IoT technology, other technologies can still be utilized in warehouses.

However, RFID frequencies can be disrupted if there are other frequencies emitted by other equipment that are not intended for RFID so that the chip will respond to those frequencies. The problem is identifying goods; RFID will be difficult if the LAN network is not connected. An alternative is needed to improve system performance in selecting goods, such as using conveyor belts to transport goods.

In general, a Halal Warehouse is an operation that complies with all applicable laws, regulations, halal requirements, standard operating procedures (SOPs), notifications and applicable standards from the competent authority. This can be achieved by consistency among employees and the standards applied in the process. As mentioned earlier, PLS is one of the halal-certified pharmaceutical companies and operates a warehouse within the company to store products manufactured according to halal standards. All management and relevant staff need to know the current halal standards and regulations to maintain halal compliance throughout production.

The owner can choose the menu to view stock logs, manage categories, and staff data. Manage staff data serves to add user data as staff. Manage category data in this warehousing system is used to process item category data. Item categories function to distinguish one type of item from another. The stock log in this system records all activities of goods entering and leaving the warehouse. Stock log data can be viewed based on data on specific categories of goods. Staff can manage and display data on goods and stock of goods. Managing stock of goods serves to enter goods data into the warehousing system that has yet to be recorded in the database.

Black Box Testing allows software developers to create sets of input conditions that will train a particular program's functional requirements (Kamali, 2019). System testing using the Black Box Testing method focuses more on software functionality specifications. The advantages of using the Black Box Testing method are: (1) The tester does not need to have knowledge of a particular programming language; (2) The test is done from the user's point of view. It helps to reveal ambiguities or inconsistencies in the requirement specification; (3) Programmers and testers depend on each other. The disadvantages of the Black Box Testing method are: (1) Test cases are complex to design without precise specifications; (2) The possibility of having a repeat of tests already performed by the programmer; (3) It is possible that some parts of the back end are not tested at all (Liu et al., 2018)

Table 1. System Test Results

No	Feature Name	Testing	Result
1	Update staff data	Change staff data	Staff data successfully changed
2	Delete staff data	Delete one staff data	One staff data successfully deleted
3	Add item data	Add item data	Item data added successfully
4	Update item data	Change item data	Item data successfully changed
5	Add stock data	Add stock data	Stock data of goods successfully added
6	Update stock data	Change stock data	Stock data has been successfully changed
7	View stock logs	View incoming and outgoing stock logs	Data on incoming and outgoing goods successfully displayed

Managers have access rights to several main menus, including the Manage Staff menu, Category Data, and View Item Log. On the main page, the manager is also equipped with instructions for using the system. Managers can add staff data by filling in the Full Name, Username and Password fields. Newly saved staff data will be visible in the Staff List table below. In addition to adding staff data, managers can also change and delete staff data.

Managers can switch to the Category Data page to add categories. RFID in this system is used as a medium to create the Category ID of an item so that the Item ID is different from one another. Adding categories can be done by attaching the RFID card to the RFID reader so that the Category ID column is filled automatically, entering such as Category Name and others, and selecting the Add button. To change or delete category data, managers can do so by selecting the Edit button. From the Edit button, the manager can select the Update button to modify the data or the Delete button to delete the data.

An owner can monitor the activities in and out of an item in the warehouse carried out by staff. Updated incoming and outgoing item data automatically appears in the Stock Log table. A manager can enter the Item Category ID by attaching the RFID card to the RFID reader to find out the data of certain goods. When the RFID card is pasted, the data history with the category ID will appear in the Item Data by Category table. In the Item Data by Category table, managers can choose any item according to the selected category to see the stock log in the owner's system.

Staff have access rights to the Item Master and Manage Stock. The first time, the application is run by staff after logging in using a username and password, namely instructions to manage the master of goods and stock. To add item data, several fields must be filled in, such as Item Category, Item ID, Supplier, Item Name, Type, Size, Brand, Purchase Price and Profit. The profit in this system is made in the range of 10% to 30% of the purchase price.

Staff can change item data by selecting the Edit button in the Item Master table. Item data selected for editing will appear in the field column. Then, after the data is changed as needed, select the Update button with a note that the category of

goods to be selected cannot be written but must be selected because the category of goods has been input by the manager using a unique RFID.

Staff can see the stock list of goods and search for item data by entering the item name in the Search Item Name column. The process of inputting stock of goods is carried out by writing the item's name in the Search Item Name column or by selecting the item directly in the table; then, select the type of outgoing or incoming data transaction. If the staff wants to reduce the data of goods, then the choice is outgoing transactions, and if the staff wants to add goods, select incoming transactions and then select the Update button.

D. CONCLUSION

Based on research and literature studies, a warehouse management system was designed using RFID technology. By using UHF RFID tags on products and user ID cards and installing RFID readers in each warehouse area, this system can find out the product inventory in the warehouse, the whereabouts of employees and product location information. With the current information, entering and exiting products can be more straightforward because warehouse workers no longer need to push product packages to indicate the products' presence. This can reduce common user errors (human error). In addition, by knowing the existence of products and their staff, all processes that take place in the warehouse will become more accessible, especially the delivery process. The prototype of this system is designed using an Android application with the mobility of the system user in mind. Further development is needed to implement an IoT-based RFID warehouse management system in warehouses.

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