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Android Based Inventory Management with NFC Enabled for Faster Tracking Items at a Steel Company: A Case Study

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Abstract: One of the business activities in the company is Inventory management. Stocktaking is an important process to ensure stable operation. A conventional method for item identification is through an attached human-readable label. Employees use an inventory sheet of paper to keep track of items. We propose new system inventory management based on an android application to increase time efficiency for Obtain data tracking through NFC (Near Field Communication) tag-based system. This approach involved 11 participants who performed stocktaking to compare performance between the new and old systems. We collect 54 of the Sample data for time evaluation using a t-test to analyze the data. The result was significantly shorter time in stocktaking process of new system than conventional method ($df = 26$, $t = -7.075$, $p < .001$). Furthermore, the proposed system could be a viable solution for reduce the time needed to complete the stocktaking process in the company.

Index Terms: Inventory Tracking, Near Field Communication, NFC, Identification of Goods, Inventory Management.

1. Introduction

The development of information technology answers many companies' demands to be different and more efficient. Technology helps companies to improve efficiency. Near Field Communication (NFC) is a new technology that allows companies to use ordinary smartphones to scan assets and inventory. The reason for using NFC tags is transaction speed. Smartphone scans NFC tags instantly when held close. NFC tags can save much time, working hours, and finally, money. NFC technology is common to speed up the transaction process and avoid long queues. Tapping NFC is sufficient to get a ticket to minimize the use of paper[1].

During the development process or production company activity, inventory is among the most crucial business procedures relevant to obtain goods, marketing, and logistical operations. It was involved with stock control across the entire supply chain. Inventory management occupies the information layer where the enterprise is managed daily[2]. A warehouse is a facility that serves as a location for distributing goods from suppliers to the end-user. So that the implementation of storage of goods in the warehouse can be managed and arranged correctly. It is necessary to develop an application for Storage Management Information System. Because of many manual processes, it is not easy in terms of archiving and tracking data items. The documentation process certainly takes a long time.

The current system still uses a manual that uses human vision to search for goods, record goods, or fill inventory numbers by handwriting an inventory sheet paper. Because of human limitations, the data collection process will require much time. Other difficulties that arise when creating transaction documents or reports, which are currently still stored in Microsoft Excel, still need a relatively long time. By making Android-based mobile applications to improve efficiency by simplifying business processes, namely by utilizing the NFC feature on Android phones to identify items in the warehouse, it is no longer necessary to search for the name of things in the inventory list. Simply by scanning the Android device to the NFC tag attached to the item, these items are identified. We expect the results of this development are to be able to solve the problems that occur in the warehouse. So that users enter collected data and print periodic stock reports more quickly and efficiently into the system. Because of the usual way (manual) as it is now quite laborious in archiving and tracking data items, it took much time to find the stock of goods in the inventory.

2. Related Works

Many researchers studied NFC technologies for many applications in this current technological era. Providing different experiences to interact with can accelerate the transaction process, increase efficiency, and reduce costs. Here we survey some other related work, which shows the importance of our study.

Anita Chaudhari et al. (2016) explain in her paper that there are two types of NFC devices

1. Active device: a device that has its power supply
2. Passive devices: devices that do not have their power supply

The author uses active NFC devices on Android devices to book tickets. The benefits of Android applications with NFC, customers no longer need to queue long to get access because the ticket printing process takes a long time. NFC only needs to be neared or tapped to be able to send or read data. The use of NFC technology can also minimize paper use [1].

In the paper, Norsuzila Ya'acob et al. (2014) using NFC Mifare card tags to replace barcode scans, the hardware used to read NFC tags is Arduino ATMEGA 2560 and uses laptops to get product information. By using Arduino, it has limited capabilities and complex wiring as tested by researchers. Arduino becomes dysfunctional after adding an SD card module. Researchers suspected of having a short circuit [3].

Research conducted by Urien & Piramuthu (2013) explains the framework for authentication for transactions using existing NFC technology on smartphones. The framework connects several devices in a retail environment, such as RFID tags, barcodes, sign-in terminals, and point of sale. In every user transaction, there is an authentication protocol that aims to increase the security of clones. Researchers use a smartphone to scan goods to be purchased and then paid at the point of sale with NFC. By utilizing NFC technology can avoid long queues [4].

Irfanto et al. propose that IRSY is Inventory Reporting System [5]. It is an inventory system based on android for reporting broken facilities to the secretariat at engineering faculty. This system uses android because it is a mature technology and easy to use. Conventional manual reporting with paper-based leads to a late response to reporting is inefficient. To address those problems, the authors proposed using the inventory system.

Chang et al. developed an inventory control system using NFC technology based on an android smartphone to manage the facility. This system has many functions such as NFC card checking, stock tacking, data search, and edit data. Furthermore, integrated with the web. NFC has the advantage of paper-based, NFC tag only contact with smartphone NFC enabled, the information about the facility will right away appear, its time more efficient than paper base checking [6]

Kachingwe et al. [7] proposed a mobile inventory system using NFC technologies To reduce errors caused by manual counting. In this solution, the goods are tagged with an NFC tag so that authors can process data collection in real-time. Scanned Items automatically upload to the database server. Therefore, reducing time compared to manual counting and inventory system based on excel spreadsheets

The biometric attendance system has disadvantages, such as fingerprint attendance, sensitivity to finger condition. Masruroh et al. [8] proposed mobile attendance system using NFC with integrated cloud storage to monitor and handling data at any place. The system uses Raspberry Pi and Android. They promote design system using a combination of NFC and facial image for authorization so that the system reduces time on documentation and paper use

Sukaphat et al. [9] proposed a class attendance application using NFC technology. They developed this system for the university. The proposed system consisted of two modules, i.e., the NFC module and the Web module. NFC module runs on a lecturer's mobile phone to get student identifications. Not all mobile phones support NFC technology. If the student's phone does not have NFC, they can use a web module to process the attendance. The authors conducted A satisfaction survey results average satisfaction of 88.57%

An intelligent warehouse management system based on NFC describes in [10]. This paper describes an enhanced storage management system in a warehouse using NFC technology. NFC is suitable for intelligent storage management. It has advantages compared to other wireless technology, i.e., easy to implement, read and write incorporated directly into the phone, low energy consumption, high security, and fast identifications. This paper gives benefit to enterprises because of the efficiency of operational

Dijana [11] developed a system android application for identifying objects based on QR codes. The system consists of three-part: client android application, database, and Web services. Moreover, the Authors use the Android phone camera to scan QR codes and the Web service to prevent direct access to the database. In this paper, the authors use to record the computer equipment, but authors can use the system for other purposes.

Nicky Shetty [12] presents android based asset management system that uses NFC to identify the asset. Data integrity in medical equipment is crucial on which lives to depend. The data should not be tamper with by an unauthorized user. Therefore, they use a digital signature to protect tag data based on asymmetric cryptography. It also allows users to take a picture and add a description to its stored data. Besides, the system provides a secure login to enable the storekeeper to modify its data.

Authors [13] proposed a human resource monitoring system for a security firm. Management can track the movement of the guards with the help of NFC as a location marker and android to send information to the system. With this system, the company can proactively follow up if the guards are not present on time. Hence, the proposed approach can reduce the company's cost of providing employment services due to the penalty issue. However, this system still manually sends data using GPRS

In [14], the Authors designed a verification system for many aspects in a warehouse integrated into the warehouse management system. Authors have improved in verification by taking advantage of NFC technology. As a result of this study, the NFC verification system exceeds other methods, i.e., quick verification speed, scalable, and reliability. additionally, any NFC enabled smartphone can read NFC or an external reader

The authors [15] propose food traceability using NFC identification to comply with food safety. End-user can tap the food labels to get information on food traceability from production to consumers with their smartphone NFC enabled. RFID is helpful in the company environment but not for the consumer. NFC's use allows bringing information to the end-user. However, the paper-based system is the only way to achieve traceable products in many cases.

3. Research Method

In this study, the implementation of an inventory system using NFC. The research methodology will be carried out in six stages are shown in Fig 1.

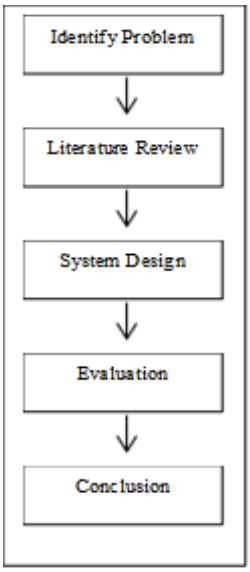

Fig.1. Stages Research Methodology

Data collection will be carried out in the system design stage by conducting interviews with parties who interact in the business process to obtain the system development data. After the data is collected, the data will be analyzed to make the application system features.

Furthermore, prototyping will be carried out to facilitate user desires and create a system that has gone through an analysis of user needs in interviews. After the programming process is complete. We perform testing to make sure it works properly

Furthermore, the application is evaluated in a way compared to the manual process. The time needed to search for goods using the application is faster to inventory goods? Suppose the application meets the time required to collect goods is more immediate than manual. In that case, the application can be recommended.

3.1. System Design

Implementation inventory management application using the NFC on a smartphone runs on the Android operating system. It uses a passive NFC tag to store inventory asset data.

In Fig 2. The flowchart describes the overall way the application system works. The hardware is operated using an Android smartphone that has an NFC feature embedded in it. The smartphone can provide power to a passive NFC tag to exchange data. A passive NFC tag with payload data in the form of item code can interact with a smartphone when the NFC tag is brought closer to a smartphone. This application can detect any NFC tags when the NFC tag is brought near to the smartphone. If the tag that is brought near contains the appropriate format data, the detail displays the item. On the contrary, if the data format does not match, an error message will be displayed. This process will continue until the scanning process gets the appropriate NFC tag.

Fig 3. is a wireframe application. When the prototype of the application is first to run, a screen design on the start page will display the start page. There is a search feature on the start page, a list of categories of goods or types of goods, the user can select the category of goods that he wants to display..

The add action button to add new items. When the user selects the add action button, a second display will be displayed, containing details of the item to be added containing an item's name. The NFC tag number is a unique code to identify the object and adds an image in the form of a display of the thing user wants to use.

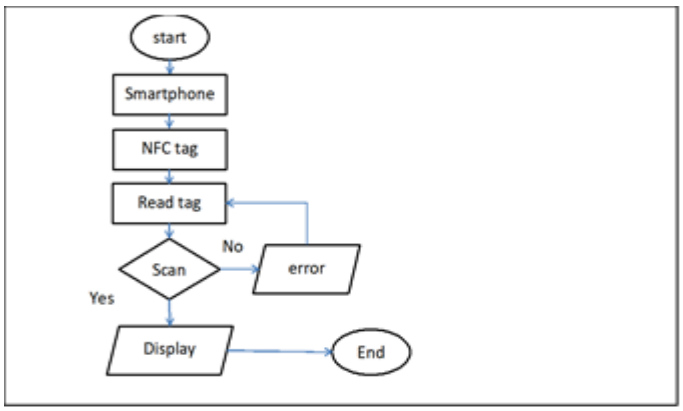

Fig.2. Flowchart of Scan Functionality

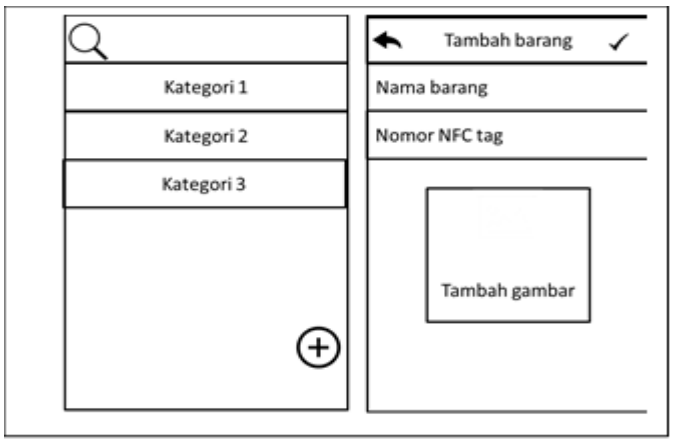

Fig.3. Wireframe of application

3.2. Data Collection Method

Through literature studies and interviews, we use for data collection method. In the literature study. We also studied the research results done by other researchers before, especially those with topics on NFC technology such as NFC in inventory systems, NFC on Android mobile devices, and applied protocols or frameworks to improve security. Interviews are conducted to obtain data from parties who interact with the business process to get the needs and problems in the current system to make it easier for the admin to produce reports.

4. Evaluation Method

Define abbreviations and acronyms the first time they are used in the text, even after they have been defined in the abstract. Do not use abbreviations in the title unless they are unavoidable.

4.1. Time Evaluation

A scenario test is carried out to find out the time needed to find an asset. The first scenario of the asset search uses an NFC-based application. In searching for goods, employees open an NFC-based inventory application on an Android smartphone. They are brought closer to the NFC tag that is labeled goods. The time needed to scan all items is recorded using a stopwatch measuring device.

The second scenario is a manual search for goods without using an application, namely the process usually done manually using an inventory sheet as a reference for item data. Employees look for items by looking at item labels, then search and adjust those in the inventory sheet, the time required for the search process for all items recorded using a stopwatch measuring instrument. The time obtained from the measurement results using the application and manual is

then compared to obtain the time difference to test the effectiveness of asset search speed

There are 2 sample groups of the measurement of the time of asset data collection, namely before the implementation and after the implementation of the new system. Each group contains 20 data on the number of samples of the test results. Each sample group calculates the average value after all values is known, then determines whether there is a difference or not. The average between the two groups before implementation and after implementation was performed a statistical paired t-test to determine the significant changes. The paired t-test was used to compare how significant the difference was between the means of the unrelated groups. By using the following formula

$$t = \frac{\sum d}{\sqrt{\frac{n\left(\sum d^2\right) - \left(\sum d\right)^2}{n-1}}} \tag{1}$$

Where

$\sum$d = sum of differences

n = sample size

To calculate the data, we do not do it by hand. The data is tested using SPSS software to determine whether the new system is suitable for use or not.

Meanwhile, to measure the increase time efficiency from previous business process, we can obtain it by comparing the total time before implementation and after implementing the formula.

$$\text{Efficiency} = \frac{TM - TS}{TM} \times 100\% \tag{2}$$

Where

TM = Amount of time manually checked

TS = Amount of time with a system checked

5. Experiments and Results

The primary purpose of conducting the study was to streamline the inventory management process that Company faces. The results obtained from system designing prototype development and testing are presented in this section. The proposed prototype application was developed to show how the fully implemented system would alleviate the inefficiency currently faced by Company.

Two experiments were conducted during the proposed system development: (a) functional testing and (b) efficiency comparison. The first experiment is to develop the mobile application with the NFC feature, which is integrated with mobile databases. Meanwhile, the second experiment compares the time using NFC System inventory with a manual system.

5.1. Functional Testing

The previous section has already mentioned that the prototype application consists of a start page, a list of goods that can be scrolled down, and a detailed display. The start page presents several options to the user to choose from what task to perform, such as searching a particular good, adding a new item, creating reports in excel formats, and the information on the current quantity of goods stock. Fig 4. The screenshot for the start page

Fig 5. shows a page for adding details of a new item. The user can add item names, item code, quantity, and pictures to the forms and write them to the database.

Fig 6. shows a screenshot for generating the stock report in excel format. The inventory report displays the description of the item, item name, item code, and quantity.

Fig 7. shows scanning data from NFC tag using a smartphone Enabled NFC. Smartphone scans the NFC tag on The item control card and captures the code item stored in the NFC tag, then shows the details page from a database

Fig 8. shows the screenshot of the detail page. When a user holds a smartphone close to the NFC tag, this display appeared, or the user can see the detail page by selecting an item from the list on the start page. This screen details the item, such as item name, code item, quantity, transfers outward. From this page, the user can take an item outward, delete an item, and write currently displayed data into the NFC tag

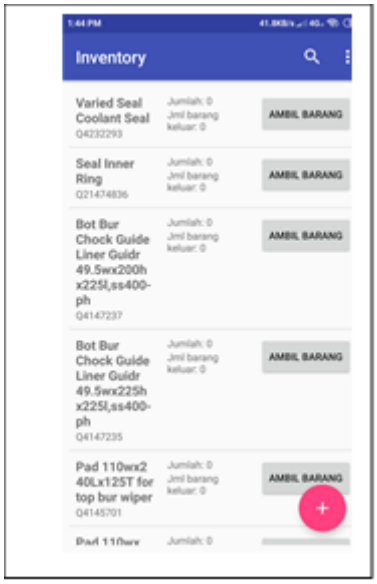

Fig.4. Start page of the application

Fig.5. Adding details of the application.

5.2. Paired Sample T-Test for Time Comparison

In this part, we use statistical analysis to evaluate if the new system is faster than the old system. Paired t-test to compare the means result of inventory checking time between the new and old system. To be able to perform a parametric statistical test, the normality assumption must be met. Thus the test of normality is performed. The results are shown in Table 1. Kolmogorov-Smirnov statistic gives a non-significant result on both variable scores Sig value are .200 and .163 respectively as both p-value greater than 0.05 data are normally distributed

The results of paired t-test analysis can be seen in table 2. Namely paired samples test showed that there was a significant decrease in time difference (value of sig (2-tailed) < 0.05) between the old system using manual search and write to inventory sheet while the new system use android and NFC tag (M1 = 568.9, M2 =759.4) (table 3.).

Table 1. Normality Test Results

	Kolmogorov-Smirnov			**Shapiro-Wilk**		
	Statistic	***df***	***Sig.***	***Statistic***	***df***	***Sig.***
system	.130	27	.200	.932	27	.078
manual	.143	27	.163	.960	27	.364

Table 2. Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	system - manual	-190.55333	139.94859	26.93312	-245.91515	-135.19151	-7.075	26	.000

Table 3. Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	system	568.9148	27	117.32935	22.58004
	manual	759.4681	27	207.03737	39.84436

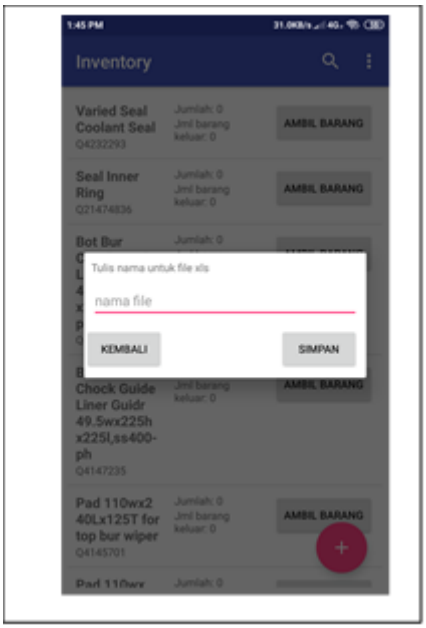

Fig.6. Generating Stock Report.

Fig.7. Scanning NFC Tag.

Fig.8. Detailed page of the application.

5.3. Time Efficiency Comparison

We first compare the time required of our approach with old method. Stopwatch method to measure the time of stocktaking by participants to obtain data point. The time required for stocktaking shown in Fig.9

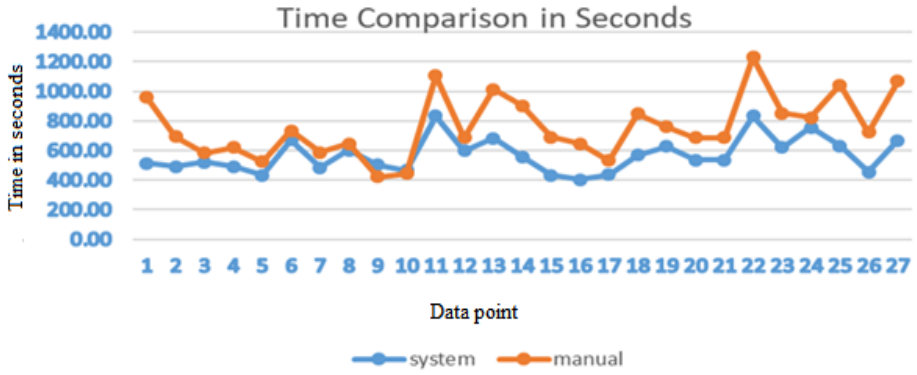

Fig.9. Stocktaking times of different approaches.

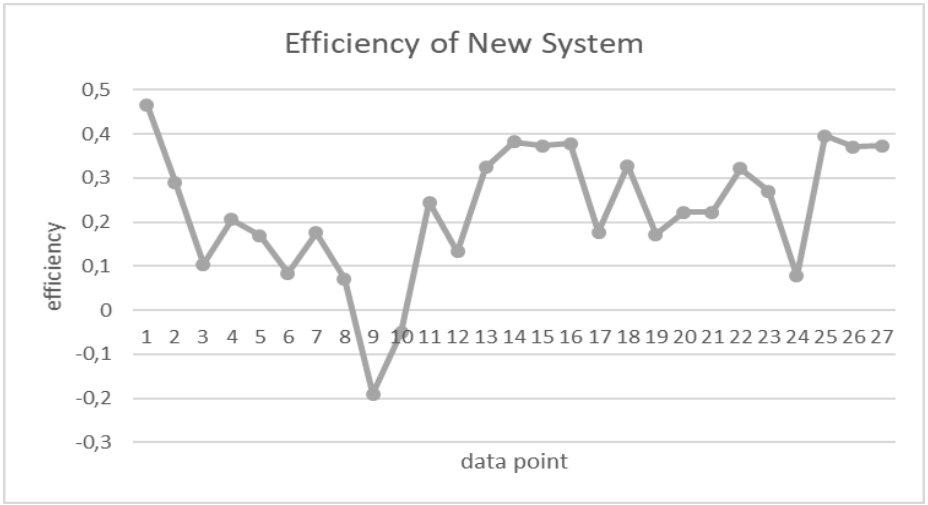

Fig.10. Efficiency of new system

Efficiency measures at each data point were calculated using our formula (2). The results in Fig.10 indicate that efficiency is being increased with a minimum of -0.19 and a maximum of 0.46. The average stocktaking time is reduced from 759.47 seconds to 568.91 seconds. Thus the efficiency is increased by 25%

6. Conclusion

In this study, we prototype a possible solution for the challenge faced by a company, which manual work in checking and tracking goods, leads to inefficiency in inventory at the company. We compare our prototype system NFC inventory with a manual system. According to the results, there was a significant difference in duration checking time between the two systems, the new and manual systems ($p < 0.05$). The developed system effectively solved the problem of slow process in inventory; the new system will be helpful in the company in terms of time efficiency. Moreover, we suggest management use this study to implement the solution for faster tracking items in inventory.

References

[1] A. Chaudhari, B. Rodrigues, P. Sakhare, and C. Fernandes, "Prototype for intelligent ticketing system using NFC," in *Proceedings of the 2015 International Conference on Green Computing and Internet of Things, ICGCIoT 2015*, 2016, pp. 877–880.
[2] J. A. Oluwaseyi, M. K. Onifade, and O. F. Odeyinka, "Evaluation of the Role of Inventory Management in Logistics Chain of an Organisation," *LOGI – Sci. J. Transp. Logist.*, vol. 8, no. 2, pp. 1–11, 2017.
[3] N. Ya'acob, M. M. M. E. Goon, M. Z. Hakim Noor, A. L. Yusof, and A. Idris, "RFID (NFC) application employment on inventory tracking to improve security," in *IEEE Symposium on Wireless Technology and Applications, ISWTA*, 2014, pp. 176–181.
[4] P. Urien and S. Piramuthu, "Framework and authentication protocols for smartphone, NFC, and RFID in retail transactions," in *Proceedings of the 2013 IEEE 8th International Conference on Intelligent Sensors, Sensor Networks and Information Processing: Sensing the Future, ISSNIP 2013*, 2013, vol. 1, pp. 77–82.
[5] A. Irfanto, T. Listyorini, and A. Murti, "An Android Based Inventory Reporting System: A Case Study in The Engineering Faculty of Muria Kudus University," 2019.
[6] R.-S. Cheng, C.-P. Lin, K. W. Lin, and W.-J. Hong, "NFC based equipment management inventory system," *J. Inf. Hiding Multimed. Signal Process*, vol. 6, pp. 1145–1155, 2015.
[7] N. M. Kachingwe and J. Phiri, "Automatic Data Capturing At Satellite Depots Based On NFC Technology.," *Int. J. Innov. Res. Comput. Commun. Eng.*, vol. 7, p. 8123, Jul. 2018.
[8] S. U. Masruroh, A. Fiade, and I. R. Julia, "NFC Based Mobile Attendence System with Facial Authorization on Raspberry Pi and Cloud Server," *2018 6th Int. Conf. Cyber IT Serv. Manag.*, no. Citsm, pp. 1–6, 2018.
[9] S. Sukaphat, W. Chaipuvaphat, S. Ketsuthi, S. Paisopa, and S. Teanrungroj, "An Application of NFC technology on class attendance systems," in *Communications in Computer and Information Science*, 2018.
[10] L. Ye, Y. Wang, and J. Chen, "Research on the Intelligent Warehouse Management System Based on Near Field Communication (NFC) Technology," *Int. J. Adv. Pervasive Ubiquitous Comput.*, vol. 8, no. 2, pp. 38–55, 2017.
[11] D. Jagodi, D. Vuji, and S. Ran, "Android system for identification of objects based on QR code," vol. 7, pp. 922–925.
[12] N. Shetty and H. Ragab-hassen, "NFC-based Asset Management for Medical Equipment," pp. 246–251, 2015.
[13] T. Hartványi and C. I. Hencz, "NFC applications in the tracking systems," in *International Conference on Industrial Logistics, ICIL 2014 - Conference Proceedings*, 2014, vol. 7, no. 2, pp. 135–142.
[14] F. Liu, Z. Qin, Y. Zhang, and X. Hou, "The Application of NFC Verification System in Warehouse Management System," no. Icimm, pp. 710–716, 2016.
[15] D. Pigini and M. Conti, "NFC-based traceability in the food chain," *Sustain.*, 2017.

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