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Desktop Application for Traceability System on The Printed Circuit Board (PCB) Storage Process

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Abstract

This paper discusses the development of desktop applications for traceability systems. The application was developed to facilitate data recording and tracking in an electronics manufacturing company's storage process of Printed Circuit Board (PCB) products. The application is developed using the Visual Basic language and Microsoft Excel databases. Additionally, the application is integrated with a barcode scanner to simplify the data entry process from PCBs and employee ID cards. Through the trial process conducted on the developed application, it has generally functioned in accordance with the development goals. Program control validation has been tested through several application access attempts from users registered as operators and administrators. The application has successfully recorded data from inbound and outbound processes, demonstrating storage and tracking functionality. Furthermore, the application has displayed the actual status data of the PCBs present in the warehouse. In terms of user satisfaction, seven users stated that this application was effective and efficient compared to the manual data recording process previously used by the company. This result was obtained from a questionnaire after the application was implemented in the company warehouse.

Keywords: traceability systems, barcode, product tracking, PCB

1. Introduction

The Printed Circuit Board (PCB) is one of the leading products in the electronics manufacturing industry. This product is processed through several stages, namely PCB printing, component installation, and ending with component soldering. PCBs processed at the soldering stage are then stored in warehouses for later processing in the product assembly stage. The PCBs stored in the warehouse will be retaken if the casing assembly is carried out. The storing process is called inbound, and the retaken process is called outbound.

In electronics manufacturing industries, this PCB storage recording system is still done manually. PCBs that will be stored in the warehouse will be recorded in the logbook. Then, if the PCB is returned from the warehouse, the record will be updated.

Such a recording system is ineffective if production increases, which causes more extended recording in the storage process. In addition, using paper media as a database risks damage and data loss. On the other hand, using paper incurs additional costs for companies and is not environmentally friendly. The recording by operators also has potential errors, especially in barcode data consisting of a set of unique numbers.

A traceability system is a system that can quickly and effectively help find information on a chain of product troops [1]. This traceability system is quite popular in the industry today. A traceability system is needed to track products during packaging, before and after shipment, and to locate lost items in orders [2]. Researchers in food products have widely developed the traceability system itself. For example, traceability systems in the tuna product supply chain must be able to record information that includes monitoring temperature, histamine content, Total Plate Count (TPC) quantity, bacterial pathogens, and sanitation [3]. The traceability system should include information on production, inspection, supervision, circulation, and product consumption in a logistics system.

In industries related to electronics manufacturing, research related to traceability systems has been carried out by several researchers. Research by [4] proposes a binary-like code to identify PCB production positions, improving drilling identification efficiency. The system uses photoelectric analysis and Hough detection algorithms to find and decode hole arrays on PCB boards. This system achieves reliable identification and automatic traceability of PCB production in less than 1 second. Meanwhile, [5] proposes a method for the traceability of electronic components without needing tags or labels, using individual surface patterns as unique identifiers. This method is demonstrated on 115 printed circuit boards, indicating that a fiducial marker commonly used for component alignment can serve as a

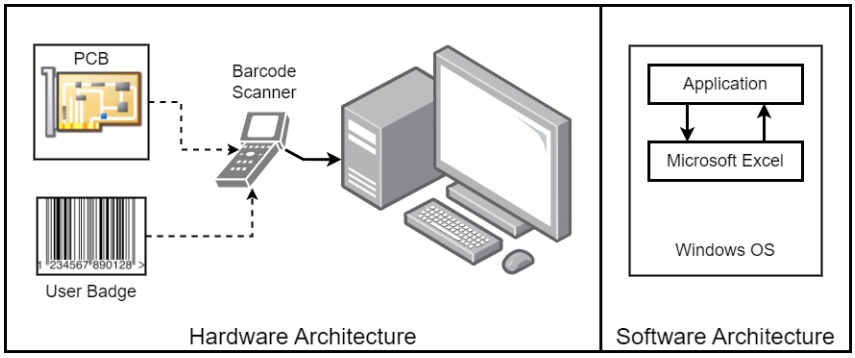

Figure 1. Hardware and software architecture for traceability system.

unique identifier. A previous study has exclusively concentrated on the production process regarding traceability systems in PCB products. No research has been conducted on the storage process of PCBs.

This research aims to develop traceability system applications to facilitate data recording in the PCB storage process. In this research, a desktop application was developed that is connected to a Microsoft Excel-based database. A barcode scanner is provided as a data entry tool to facilitate data recording. This research contributes to the application feature that uses a barcode scanner tool as a medium for data entry. Applications with features like this have never been developed before, especially for recording data on traceability systems.

The details of the discussion of this paper are described below. Section 2 explained the research methods used to develop the application. Then, proceed to Section 3, namely Results and Discussion. The paper closes with Conclusion and Further Work at the end, Section 4.

2. Research Methods

This section outlines the methods employed in the development of the traceability system. The process begins with a needs analysis for the company, followed by the database design and application design. In the concluding phase, the application undergoes testing in the actual environment. Additionally, a survey was administered to users to assess the benefits of the developed application.

2.1. Requirement Analysis

This application was developed following a needs analysis at an electronics manufacturing company in Batam City. The primary products manufactured by this company include oscilloscope devices, Programmable Logic Controllers (PLCs), and power supplies. The needs analysis involved interviews with seven respondents from the company, all of whom are employees responsible for the PCB storage process in the warehouse.

The survey results revealed that all respondents expressed dissatisfaction with the current storage process, citing inefficiencies and ineffectiveness. Some respondents outlined specific issues within the PCB storage system: (1). Still using paper in PCB stock recording, which is often lost; (2). Manual calculation is needed when inventory of the product to ensure the actual number of PCBs is the same as recorded on the record paper; (3). The calculation process takes quite a long time; (4). Knowing the actual quantity of products in the warehouse in real-time is challenging; (5). Data recording by operator frequently errors; and (6). Personnel that collect PCBs from warehouses are difficult to track.

2.2. System Architecture

The proposed hardware and software architecture design outlined in this study is depicted in Figure 1. The hardware architecture comprises a desktop computer with a barcode scanner connected to the computer through a Universal Serial Bus (USB) port. The primary function of this scanner is to decode the barcodes printed on the PCB and the operator's badge ID into text, eliminating the need for manual data entry through keyboard typing.

On the software side, the developed application is designed for compatibility with the Windows operating system. It is configured to access databases stored in Microsoft Excel files. This database choice aims to streamline the software architecture, eliminating the need for additional database servers. With this architectural model, computers are not required to be connected to a network to access the database.

Furthermore, as per [6], Microsoft Excel offers functionalities for collecting, summarizing, interpreting, and analyzing data, making it a valuable tool for researchers and statisticians. Although [7] argues that Excel lacks the capabilities of specialized database management systems for managing complex datasets, it remains advantageous for simpler applications. This advantage is substantiated by various studies, such as [8], which developed an electronic database using Microsoft Excel to hand over and coordinate patients with trauma at the District General Hospital.

Regarding application development, utilizing Microsoft Excel as a database is convenient but introduces

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potential security threats. For instance, irresponsible individuals may delete or move files, rendering the application inaccessible. To mitigate this issue, computer access is restricted solely to administrators. Operators seeking access to the computer must obtain approval from the administrator.

2.3. Database Design

The initial application development stage focuses on designing a database for recording and storing information. The database employed in this system comprises two Microsoft Excel files, specifically (1) Master Data.xlsx and (2) Store Data.xlsx. Each of these files contains worksheets utilized for storing data in tabular form. To elaborate further, we refer to these worksheets by the name of the corresponding table.

Within the file Master Data.xlsx, three tables have been established: "admin," "operator," and "pcb_model." The "admin" and "operator" tables segregate data between regular operators and application administrators. Simultaneously, the "pcb_model" table encompasses comprehensive data regarding PCBs manufactured by the company.

The structure of the tables within the Master Data.xlsx file is illustrated in Figure 2. The "operator" table encompasses columns "badge_barcode" and "operator_name," detailing information about operators responsible for storing and retrieving PCBs in the warehouse. Similarly, the "admin" table shares the same columns as the "operators" table. On the other hand, the "pcb_model" table stores data pertaining to PCBs produced by the company. This information is presented through columns such as "pcb_barcode," "model_name," "line_name," "paste_type," "solder_type," and "pcb_layer." These columns house detailed product information, including the manufacturing line, solder paste type, and tin solder type used in PCB soldering processes.

Meanwhile, the file Store Data.xlsx stores data related to the PCB storage and retrieval processes. Within this file, three tables—"pcb_inbound," "pcb_outbound," and "pcb_status"—serve distinct purposes. The "pcb_inbound" table records data on PCBs stored in the warehouse, while the "pcb_outbound" table logs information on PCBs retrieved from the warehouse. Both tables feature columns, including "pcb_barcode," "model_name," "date," and "operator_name," storing details such as the PCB model, date of storage or retrieval, and the operator responsible for the process.

The "pcb_status" table also provides insights into the current quantity of PCBs available in the warehouse. This table also furnishes details about the PCB model, facilitating the accessible location of stock in the warehouse. For a visual representation of the data table design in the file Store Data.xlsx, refer to Figure 2.

2.4. Application Design

The traceability system application in this study was created using Visual Basic, a programming language commonly employed for developing desktop applications on the Windows operating system. As demonstrated in [9], Visual Basic has been successfully utilized for stocktaking automation processes, incorporating Quick Response (QR) codes to enhance the effectiveness and efficiency of state property management. The benefits of using Visual Basic for application development include straightforward operation, seamless integration with Microsoft Excel, and efficient data processing, as highlighted in [10].

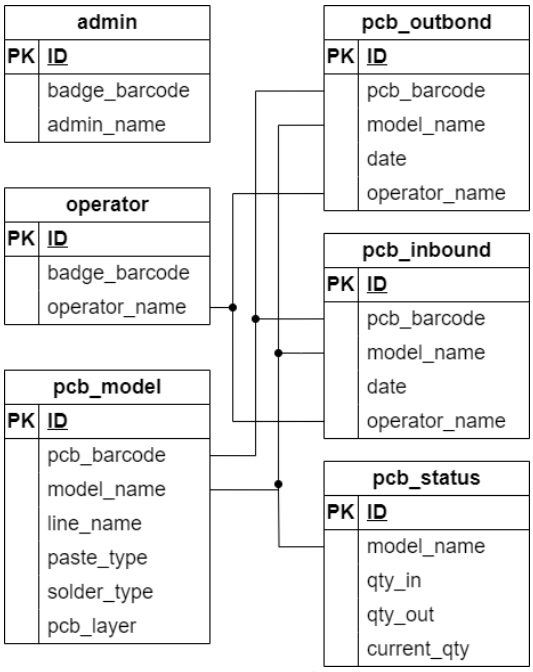

Figure 2. Data table design for traceability system.

The initial step in designing this application involves creating the User Interface (UI), which consists of several integrated Windows forms. Three forms were designed: the login form, the main menu form, and the PCB storing form. The visual design of these forms is depicted in Figure 3. Figure 3(a) illustrates the login form layout, featuring a textbox for entering barcode data from employee IDs. Additionally, a radio button option is utilized to select the user roles within the application.

Concerning the design of the PCB Storing form, various textboxes are employed to capture operator names, PCB barcodes, PCB models, and recording dates. Notably, the PCB barcode textboxes are designed to be automatically populated by scanning the barcode on the PCB using a barcode scanner device.

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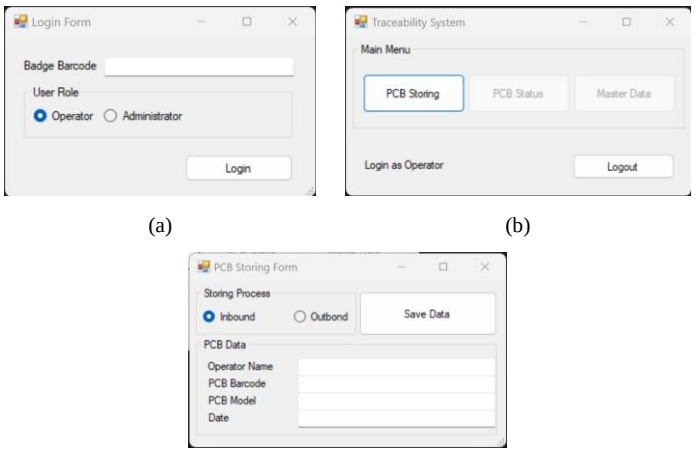

(a) (b)

(c)

Figure 3. User interface for traceability system (a) login form, (b) main form, and (c) PCB storing form.

If the PCB data is present in the file Master Data.xlsx, the model name textbox fields will be filled automatically. Conversely, the date textbox will be populated according to the computer date. The logging process initiates upon pressing the save data button. This process automatically updates the data in the predefined Excel file.

2.4. Program Flow

The program flow control is established after designing the application's UI. Figure 4 illustrates the flow chart of the traceability system. Upon execution, the program initiates a login form to ensure user access to the application. Users can log in by selecting a role as an administrator or operator. The user then scans the barcode from the badge using a barcode scanner. The scanned barcode data is automatically entered into the badge barcode textbox on the login form.

Following this, the application validates the user by cross-referencing the scanned barcode with the data in Master Data.xlsx. If the scanned barcode is found in either the "operator" or "admin" tables and the selected role is appropriate, the application proceeds to the next step. However, if not, the application prompts the user to log in again.

The subsequent process involves presenting the main menu form and accessible menus based on the user's role. The menu display is adjusted according to the user's role; if the user logs in as an operator, they can only access the PCB storing menu. In contrast, if the user logs in as an administrator, the status PCB and master data menus are accessible.

The application then awaits the user's menu selection in the main menu form. The PCB storing form is displayed if the user opts for the PCB storing menu. Here, the user must input PCB data and choose the appropriate storage process—inbound or outbound. The data to be entered includes only the PCB barcode. The application will automatically search for the PCB model and operator name in the previously created database. If the data is available, the data update process will be executed.

When the user role is an administrator, access to the PCB status and master data menus is granted. If the user chooses both menus, the application invokes the Excel file for display. Users can make direct updates to this file as necessary. Additionally, users can observe the real-time status of the PCB quantity in the warehouse and track the individuals responsible for inbound and outbound PCB processes to and from the warehouse.

3. Result and Discussion

This section will describe the tests and results of developing traceability system applications. Among the results presented are those of program control validation, followed by the validation of data records recorded in the Excel file. The last set of results pertains to user feedback on the application.

3.1. Program Flow Validity

The initial test in a traceability system application focuses on validating the user's access credentials. During this examination, we attempted to access the application by scanning an employee barcode badge with the code "OP$220404C01$R," as illustrated in Figure 5(a). Notably, this employee barcode had not been previously registered in the Excel file, Master Data.xlsx. The outcome of this test is depicted in Figure 5(b), where the application issues a notification indicating that the employee cannot access the application. In such circumstances, the application denies users access to the main form.

Our second test aimed to access the application by scanning the barcode "OP$220404C01$O," assigned to employees responsible for the inbound or outbound PCB processes. The results are depicted in Figure 6(b) after scanning the barcode. The application presented the main form with disabled menus for PCB status and master data. Furthermore, the status indicator at the

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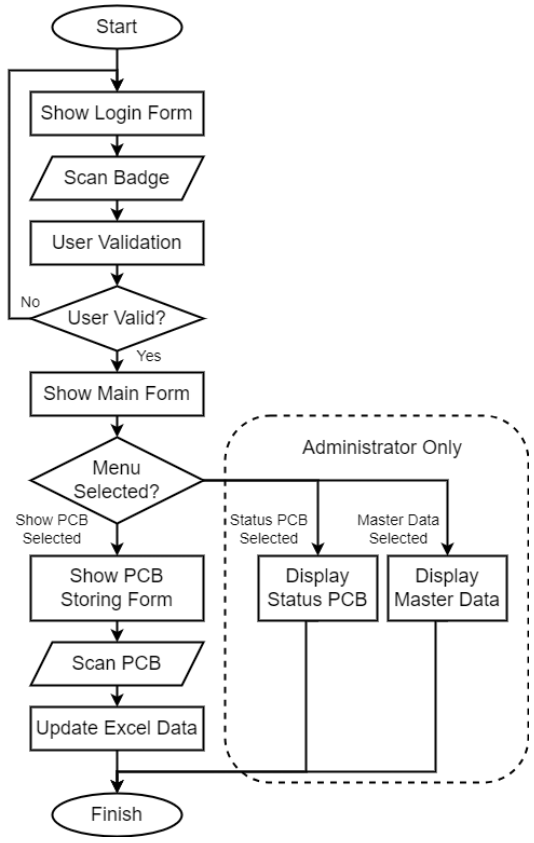

Figure 4. Flowchart traceability system application.

bottom left of the main form indicated that the user accessed the application as an operator.

The subsequent test involved scanning the employee's badge designated as the application administrator. This examination utilized a barcode with the code "OP$220404C01$A." Following the barcode scan, the main form for administrators was displayed, as illustrated in Figure 7(b). In contrast to the operator mode, the administrator mode exhibits the status PCB and master data menus, providing the user with expanded functionalities. Moreover, the status indicator in the lower left corner confirms that the user is currently accessing the application in administrator mode.

Based on the outcomes of the three tests, it can be deduced that program control, particularly concerning user validity, has operated as intended. However, from a security standpoint, the validity of user access is not yet optimal. There remains a potential risk wherein users could manually input the barcode via the keyboard if they know the barcode text data, bypassing the need to scan the barcode on the employee badge.

3.2. Data Recording Validity

Starting by checking user access, the evaluation progressed to validating the stored data in the application. The test involved accessing the application through operator accounts—specifically those belonging to Ucup and Joko—to execute inbound and outbound processes. Ucup oversees the inbound storage process, while Joko manages the outbound storing process. Following multiple iterations of the inbound and outbound processes, we accessed the application using an administrator account to confirm that the stored data aligned with the preceding procedures.

The outcomes of the recorded data in the file Store Data.xlsx are presented in Figure 8. In Figure 8(a), the "pcb_inbound" table illustrates the data recording when PCBs were introduced into the warehouse. Ucup conducted six inbound processes on June 22, 2023, and June 23, 2023. The PCBs placed in the warehouse correspond to the S9461DL model. Furthermore, Figure 8(b) depicts the "pcb_outbound" table, reflecting the removal of two PCBs from the warehouse by Joko on June 23, 2023.

Simultaneously, Figure 8(c) summarizes the PCB models and their current quantities within the warehouse. Presently, only four PCBs with the S9461DL model remain in the warehouse. This outcome confirms that the PCB recording process aligns with expectations, accurately reflecting the current status of the quantity of PCBs in the warehouse.

3.3. User Feedback

Following the implementation of the application in the company, we conducted a survey with the same individuals involved in the needs analysis phase—seven employees responsible for the PCB storage process. The survey aimed to assess the developed application's efficiency in recording warehouse data compared to traditional paper record systems. It compared the application to traditional paper record systems. The results indicated unanimous agreement among all respondents, who affirmed that the application is more effective and efficient.

Additionally, respondents were prompted to provide insights supporting their responses. Two participants highlighted the application's ease of use, while another two emphasized the elimination of manual calculations during the inventory process. The remaining three respondents cited eliminating the need for paper recordkeeping as their primary reason for considering the application advantageous.

4. Conclusion and Future Work

Based on the application trials and user feedback results, we can conclude that the traceability application for PCB products has met expectations. The conducted trials, specifically in the inbound and outbound processes, successfully captured the real-time status of PCBs within the warehouse. Furthermore, the application's accessibility was tested through various experiments utilizing the provided barcode scanner.

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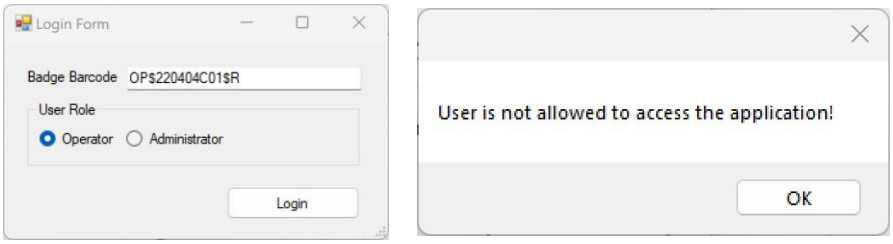
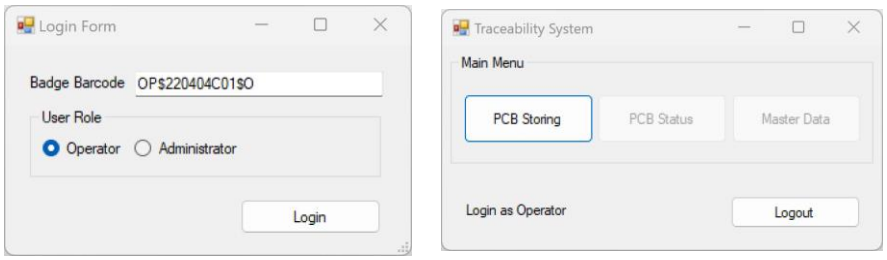


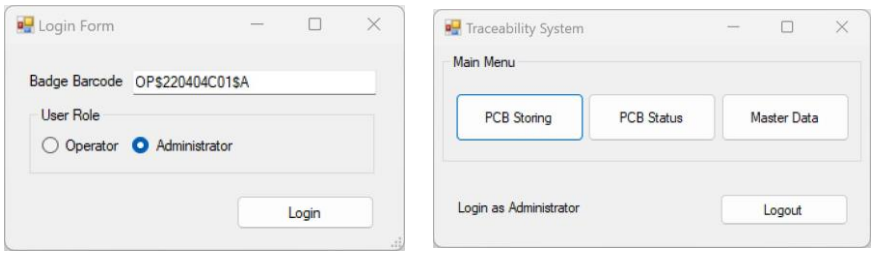
(a) (b)

Figure 5. The application testing process (a) login with unregistered user (b) notification status.



(a) (b)

Figure 6. Testing application with operator role (a) login process for operator (b) form showed up after login.



(a) (b)

Figure 7. Testing application with administrator role (a) login process for administrator (b) form showed up after login.

PCB INBOUND

No	Barcode	Model	Date	Operator
1	S9461DL0000001	S9461DL	22-Jun-23	UCUP
2	S9461DL0000002	S9461DL	23-Jun-23	UCUP
3	S9461DL0000003	S9461DL	23-Jun-23	UCUP
4	S9461DL0000004	S9461DL	23-Jun-23	UCUP
5	S9461DL0000005	S9461DL	23-Jun-23	UCUP
6	S9461DL0000006	S9461DL	23-Jun-23	UCUP

STATUS	
S9461DL	6
S9042DJ	0
S9532DL	0
S9511DL	0
S9241DG	0
S9221DG	0
S9231DG	0
B8108LM	0

(a)

PCB OUTBOND

No	Barcode	Model	Date	Operator
1	S9461DL0000001	S9461DL	23-Jun-23	JOKO
2	S9461DL0000002	S9461DL	23-Jun-23	JOKO

STATUS	
S9461DL	2
S9042DJ	0
S9532DL	0
S9511DL	0
S9241DG	0
S9221DG	0
S9231DG	0
B8108LM	0

(b)

PCB STATUS

No.	Model	Qty In	Qty Out	Current Qty
1	S9461DL	6	2	4
2	S9042DJ	0	0	0
3	S9532DL	0	0	0
4	S9511DL	0	0	0
5	S9241DG	0	0	0
6	S9221DG	0	0	0
7	S9231DG	0	0	0

(c)

Figure 8. Recorded data on (a) pcb_inbound worksheet, (b) pcb_outbound worksheet, and (c) pcb_status worksheet.

Meanwhile, the survey results from application users revealed unanimous agreement among all respondents, affirming that the application is more effective and efficient in facilitating the data recording process for PCB storage in the warehouse. Despite this application's successful implementation, there is potential for further

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research, particularly concerning centralized application security systems and services. The current data recording method using Excel files presents a potential vulnerability if unauthorized individuals accidentally delete the file. Additionally, the absence of centralized data storage in non-centralized applications poses limitations. Addressing these concerns will be the focus of future research endeavors.

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