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WAREHOUSE PICKING EFFICIENCY WITH SMART GLASSES (CASE STUDY: XYZ CORPORATE WAREHOUSE)

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ABSTRACT

The use of wearable technology devices has been widely used in industry, especially in the warehouse to carry out the picking process. Picking process can be interpreted as the process of taking goods according to the specified location in the warehouse. This research focuses on the application of smart glasses as wearable devices to increase the efficiency of warehouse picking process. The implication of this research is to show how wearable devices provide efficiency during the warehouse picking process and help employees speed up their work with hands-free atmosphere.

Keywords: *Smart Glasses*, *Wearable-Device*, *Android*, *Warehouse*, *Warehouse Picking*

1. INTRODUCTION

The use of high-tech devices, such as smartphones, smartwatches, and smart glasses, can make work easier. This beneficial are also felt in the industry, such as in warehousing area which includes the picking process (Manzini, 2012). Picking process can be defined as the process of taking item according to the specified location in the warehouse. This sounds easy because at first glance it looks like an ordinary activity whose job is only to take items in warehouse at a certain location, but when looked closer from the effort side, this activity requires extra accuracy and energy from employees to move from one location to another location to find and pick up goods that match the request on the request paper list. In addition, with the warehouse space that contains all piles of items will make the effort spent in terms of time and energy will even greater.

This condition is not effective because human error will occur, especially when searching for the location of an item. For example, when searching the location of a product, it turns out that there is more than one different location with the same product. For example, let us call it Z product, which is located at several locations, namely in the area 'A-01-02', 'D-01-02', 'B-01-03'. After finding the location, the employee may pick the Z product up, which is located closest to his current position, for example in area 'D-01-02'. In fact, the employee should have taken those in area 'A-01-02' first, because the products in that area must run out first before those in area 'D-01-02'. Thus, this error changes the value of the previously reported data.

In this paper, we would like to increase the efficiency of warehouse picking process by using wearable device, i.e., Smart Glasses. Smart Glasses can increase the performance of picking process, especially to speed up employees' work. Because of smart glasses are wearable devices, employees can do their work faster, such as picking up products while updating product data at the same time. In addition, smart glasses also offer two features that support the picking process, namely a camera and voice recognition so that employees do not need to use their hands to operate the smart glasses, and this creates a hands-free atmosphere in the picking process (Vuzix, 2015).

The rest of the paper is organized as follows: Section 2 explains research question to be answered in this paper, Section 3 describes the research method used as the solution system proposed. Then, followed by Section 4 which explain the result and analysis and we conclude our work and mention for the future research in Section 5.

2. RESEARCH QUESTION

In this paper, we aim to answer the research question on how the wearable device, such as Smart Glasses, can provide efficiency during warehouse picking process?

3. RESEARCH METHOD

3.1. Extreme Programming (XP)

This research uses Extreme Programming (XP) as software development method shown in Figure 1, which consisting of 4 stages. Every stage in this research can be described below.

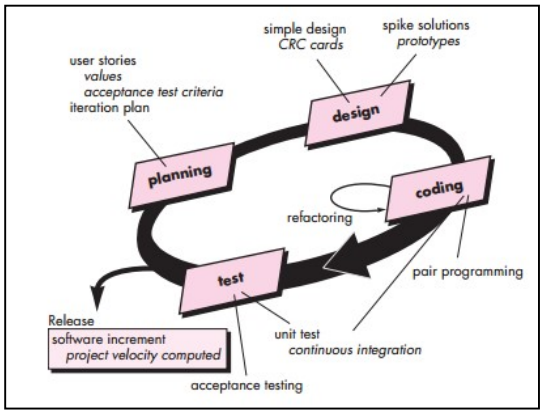

Figure 1: Extreme Programming (XP) Development Method (Pressman, 2010)

3.1.1. 1st stage: planning

Starting with gather the user requirement then dividing the requirement into user stories. After that, the priority from each user stories should be determined. The higher priority will be done first. In this stage, barcode analysis and voice analysis were also done. The barcode represented required location code data of the stored item which will be used in the picking process, while the voice represented for confirming the quantity and validate the picked item so that the efficiency in picking process can be achieved.

3.1.2. 2nd stage: design

In this stage, user interface created according to the user stories. Unified Modeling Language (UML) and Entity Relationship Diagram (ERD) were used to design the system.

3.1.3. 3rd stage: coding

Pair programming method, which required two developers code in one workstation, was used to code the application and unit testing was carried out on all user stories to make application development easier to meet the expected goals. The unit testing should be created before coding phase started. The code will embed to the smart glasses.

3.1.4. 4th stage: test

Last step in XP, which the application will be tested based on unit testing that has been created before. This test should be meet the requirement which already stated in 1st stage: planning. Smart glasses will be tested for this stage.

4. RESULT AND ANALYSIS

4.1. 1st Stage: Planning

4.1.1. User requirement

After the interview and brainstorming to gather user requirement, Table 1 below is an overview of the problems and solutions desired by XYZ Corporate.

Table 1. User Requirement XYZ Corporate

No	Problem	Solution
1	The Radio Frequency (RF) Picking method is applied to PT. XYZ. This method required a hand-held device, called RF Scanner, to scan barcode of item and its location. Every employee should carry RF Scanner to operate warehouse picking. By carrying RF Scanner, a hands-free atmosphere that cannot be realized.	A wearable device, such as Smart glasses can be offered as a solution, so that every employee can operate warehouse picking in hands free atmosphere.
2	While picking item, employees should carry RF Scanner to scan barcode of item's location, item information barcode, or tasks description. This means hands-free atmosphere cannot be realized, so that it can reduce the speed of picking item because the employee cannot pick item in parallel while holding the RF Scanner.	By using wearable devices such as smart glasses, the picking process is faster and easier because it is hands free and employees can scan barcodes via camera on the smart glasses or use voice as instructions to find out the location of items, item information, or view tasks description, while doing other work such as retrieving items as well as updating item information data.

No.	Problem	Solution
3	Embedded application in RF Scanner is different with the one in smart glasses. The application in RF Scanned can be operated by manually input using the keypad or touch screen that is available in its device. On the other hand, smart glasses only have four control buttons that can be used, so that the smart glasses must be operated using voice.	Solution of this problem is creating new application to operate smart glasses. It is impossible to reuse RF Scanner application for smart glasses due to the differences of how to operate between the two devices.

4.1.2. Barcode analysis

Barcode is one of the most important components in using smart glasses besides the voice, because picking process depends on barcode which represents required data of an item. The main purpose of using smart glasses in picking process is to improve speed performance, and of course, the speed of all inputs given to the smart glasses will affects the speed of picking process. After being analyzed, the use of barcode in picking process as an input of smart glasses will be used in:

- Login system
  The use of barcodes in login system is considered very effective. When user wants to login into the system, password is needed to be input, thus connecting user with the system. If the voice recognition is applied instead of barcode, user will have difficulty when saying the password because a password may consist of various combinations of letters, numbers, symbols and so on. In addition, although the password does not consist of combination mention before and only a word, this is certainly lack of security. So, the use of barcodes in this case is considered very effective in overcoming the lack of voice recognition, where password can be used as a barcode to login.

- Item location confirmation
  In a picking process, user must go to a predetermined location from every pick task and not all locations are in the same place, it depends on each item's placement. Meanwhile, each location in the warehouse has a unique code, where it consists of a unique combination, for example location 'A-01-02', 'B-01-02', and so on. This makes the use of barcodes in item location confirmation very effective, especially in validating the location that user is aiming for. So when user arrives at the intended location, user just need to scan the barcode which consists of the location code information and the system will validate the correctness of the location.

- Item serial product scanning
  Sometimes there are certain products that required a serial product scan in picking process, where the serial number of each product is recorded into the system. This process meant in order the system has a track record of each product issued. In addition, the number of taken items in picking process may varies, for example some are 20 pieces or maybe 40 pieces, and some are even more than 100 pieces, where each item has a serial number that may consist of more than equal to 12 letters. Therefore, it is impossible for user to mention the serial number of each item individually, so the use of barcodes is the right choice in this process where the serial number of each product will be used as a barcode.

4.1.3. Voice analysis

If every input only depends on barcode, improvement of speed performance will not be achieved. Thus, combining input with voice will help to improve the speed performance of picking process. After being analyzed, the use of voice in picking process as an input of smart glasses will be used in:

- Picked item quantity confirmation
  The use of voice recognition in the picking process is happening when user has taken the specified item, and the next step is confirming how many items were taken by saying it through the device. The most appropriate method in this process is using voice recognition because user only needs to mention the quantity of the goods taken, then the system will validate the confirmed quantity taken in accordance with the required quantity. If barcode is used in this process, it will slow down the entire process of picking process.

- Picking process validation
  The use of voice recognition is also used in picking process validation. When picking process is going on, sometimes the system requires user's response to proceed into the next stage. If each response uses a barcode, this will slow down the picking process. By using voice recognition, the system can easily validate whether the given response is appropriate with the required

response, for example, when user says "confirm", then the system needs to go to the next process; or when user says "cancel", then the system needs to go to cancel the certain process.

4.2. 2nd Stage: Design

Below is the UML Diagram and ERD that represent initial solution of Table 1 above.

4.2.1. Use Case Diagram

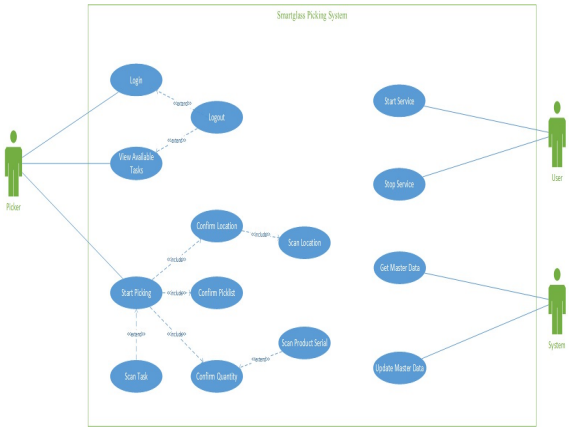

Figure 2: Use Case Diagram of Smart Glasses Picking System

Figure 2 above shows the requirement design of the Smart Glasses Picking System by using Use Case Diagram. Detail of each use case will be described in Use Case Narrative below.

4.2.2. Use Case Narrative

- **Login**

Table 2. Use Case Narrative of Login

Use case id	Usecase_login	
Actor	Picker	
Brief description	This use case explains login step that is done by the picker	
Precondition	Picker should be registered into the system	
System Flow	Actor Action	System Response
	Step 1: Picker turns on the smart glasses picking application	**Step 2:** System asks whether picker wants to login or not
	Step 3: Picker gives response	**Step 4:** System turns on the camera to scan barcode
	Step 5: Picker show barcode containing password from picker's user id to the camera	**Step 6:** System checks into database whether the scanned barcode is valid or not
		Step 7: System creates a session for the picker
		Step 8: System asks whether the picker wants to continue or not
	Step 9: Picker gives response to continue login process	
Alternate Flow	**Alt-Step 6:** If the scanned barcode is not found in the database, the system will display an error message and ask whether the Picker wants to repeat the barcode scan or not **Alt-Step 9:** If picker chooses to discontinue, the session will be deleted, and the system will repeat the step 2	
Post Condition	If successful, the system will display picker information	

- **View Available Tasks**

Table 3. Use Case Narrative of View Available Tasks

Use case id	Usecase_viewTask	
Actor	Picker	
Brief description	This use case explains how picker can see the existing tasks	
Precondition	Picker must login into the system first	
System Flow	Actor Action	System Response
		Step 1: System searches available tasks for the picker
		Step 2: System asks whether picker wants to continue or not
	Step 3: Picker gives response to continue	
Alternate Flow	**Alt-Step 2:** If it turns out that there are no tasks available for picker, then the	

	questions from the system will be slightly different **Alt-Step 3:** If the Picker responds to discontinue, the system will delete the session.
Post Condition	The system displays information about available tasks to Picker

- **Start Picking**

Table 4. Use Case Narrative of Start Picking

Use case id	Usecase_startPicking	
Actor	Picker	
Brief description	This use case explains how system show available tasks	
Precondition	Picker must login into the system first	
System Flow	Actor Action	System Response
		Step 1: System shows available picklist for the picker and asks whether the picker wants to confirm or not
	Step 2: Picker gives response	
Alternate Flow	**Alt-Step 1:** If there is no picklist for picker, the system will ask whether the picker wants to scan the picklist or not. If so, the system will turn on the camera to scan the picklist. If not, the system will return to the menu page. **Alt-Step 2.1:** Picker scans the barcode picklist. **Alt-Step 2.2:** System will validate the scanned picklist, and ask whether the picker wants to confirm the picklist or not **Alt-Step 2.3:** Picker gives response	
Post Condition	Picker directed to confirm picklist	

- **Confirm Picklist**

Table 5. Use Case Narrative of Confirm Picklist

Use case id	Usecase_confirmPicklist	
Actor	Picker	
Brief description	This use case explains how picker confirms the to do picklist	
Precondition	Picker must start picking first	
System Flow	Actor Action	System Response
	Step 1: The picker confirms the picklist to be worked on	**Step 2:** System update the status of the picklist
Alternate Flow	**Alt-Step 2:** If the picker responds to discontinue, the system will check whether the picklist is the result of the previous scan task. If so, the status of the picklist will be rolled back.	
Post Condition	The system updates the status of the picklist	

- **Confirm Location**

Table 6. Use Case Narrative of Confirm Location

Use case id	Usecase_confirmLocation	
Actor	Picker	
Brief description	This use case explains how picker confirms the intended location	
Precondition	Picker must start picking first	
System Flow	Actor Action	System Response
		Step 1: System displays picker's intended location
	Step 2: Picker confirms the location	**Step 3:** System turns on camera to scan barcode
	Step 4: Picker scans the barcode found on location	**Step 5:** System will check whether the scanned barcode is valid
Alternate Flow	**Alt-Step 5:** If it turns out that the result of the scanned barcode is match, the system will ask to repeatedly scan the barcode location, where the process will repeat from step 2.	
Post Condition	The system displays information to the picker about items that must be taken. Picker should follow the information and says the quantity of item that has been taken.	

- **Confirm Quantity**

Table 7. Use Case Narrative of Confirm Quantity

Use case id	Usecase_confirmQty
Actor	Picker
Brief description	This use case explains how picker confirms quantity of item that has been taken

Precondition	Picker must confirm the location first	
System Flow	Actor Action	System Response
	Step 1: Picker says the quantity of taken items	**Step 2:** System will validate the quantity said by picker is appropriate or not
Alternate Flow	**Alt-Step 2.1:** If the quantity said by picker does not match, then the system will ask the picker to say the appropriate quantity until it is true **Alt-Step 2.2.1:** If the quantity said by picker is appropriate, and if the taken item requires a serial scan barcode, the system will ask the Picker to confirm for a serial scan barcode **Alt-Step 2.2.2:** Picker confirms **Alt-Step 2.2.3:** System turns on camera to serial scan barcode purpose **Alt-Step 2.2.4:** Picker will perform serial scan barcode according to the quantity of taken items. **Alt-Step 2.2.5:** The system validates every scanned serial barcode. If there is a serial barcode as same as another product, the system will ask the picker to repeat the serial scan barcode on that item	
Post Condition	The system will display a success message that the item has been retrieved	

- **Start Service**

Table 8. Use Case Narrative of Start Service

Use case id	Usecase_startService	
Actor	User	
Brief description	This use case explains how user starts the service of the system	
Precondition	Service must be installed on the server	
System Flow	Actor Action	System Response
	Step 1: User starts the service on the server	**Step 2:** System shows service's status
Alternate Flow	**Alt-Step 2:** If the service fails to run, the system will display a failed message	
Post Condition	The service is running	

- **Stop Service**

Table 9. Use Case Narrative of Stop Service

Use case id	Usecase_stopService	
Actor	User	
Brief description	This use case explains how user stops the service of the system	
Precondition	Service must be installed on the server	
System Flow	Actor Action	System Response
	Step 1: User stops the service on the server	**Step 2:** System shows service's status
Post Condition	The service is stop running	

- **Get Master Data**

Table 10. Use Case Narrative of Get Master Data

Use case id	Usecase_getMasterData	
Actor	Service	
Brief description	This use case explains how service retrieves data periodically	
Precondition	Service must be installed on the server	
System Flow	Actor Action	System Response
	Step 1: Service will execute instruction to fetch data periodically	**Step 2:** System will fetch data from master server and send success status to service
Alternate Flow	**Alt-Step 2:** If data retrieval from the master server fails, the system will send a failed status to the service	
Post Condition	Data from the master server has been successfully retrieved	

- **Update Master Data**

Table 11. Use Case Narrative of Update Master Data

Use case id	Usecase_updateMasterData	
Actor	Service	
Brief description	This use case explains how service updates data periodically	
Precondition	Service must be installed on the server	
System Flow	Actor Action	System Response
	Step 1: Service will execute instruction to update data periodically	**Step 2:** System will update data to master server and send success status to service

Alternate Flow	**Alt-Step 2:** If update data to the master server fails, the system will send a failed status to the service
Post Condition	Data from the master server has been successfully updated

4.2.3. Activity Diagram

After designing the requirement system with Use Case Diagram, the workflow of the system's activity can be shown in Figure 3 until Figure 8 below.

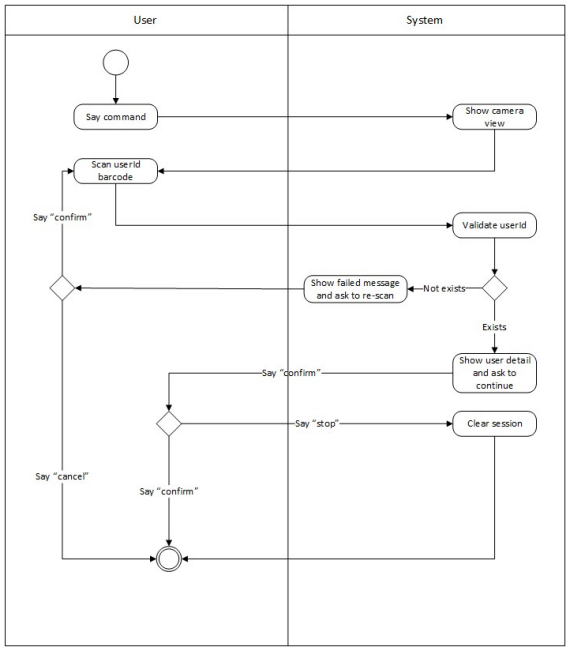

Figure 3. Activity Diagram of Login Menu in Smart Glasses Picking System

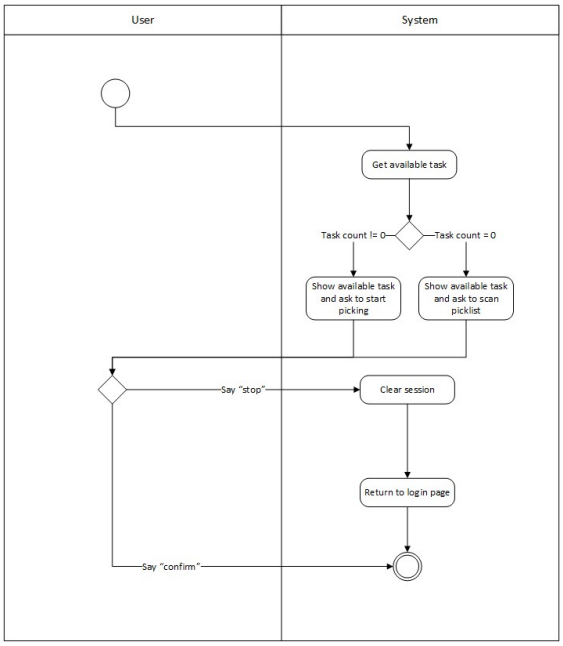

Figure 4. Activity Diagram of View Available Tasks Activity Menu in Smart Glasses Picking System

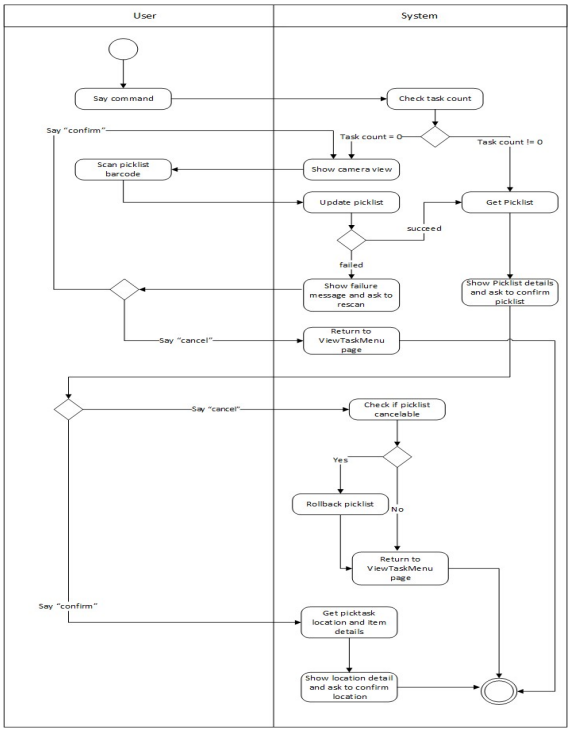

Figure 5. Activity Diagram of Start Picking and Confirm Picklist Activity in Smart Glasses Picking System

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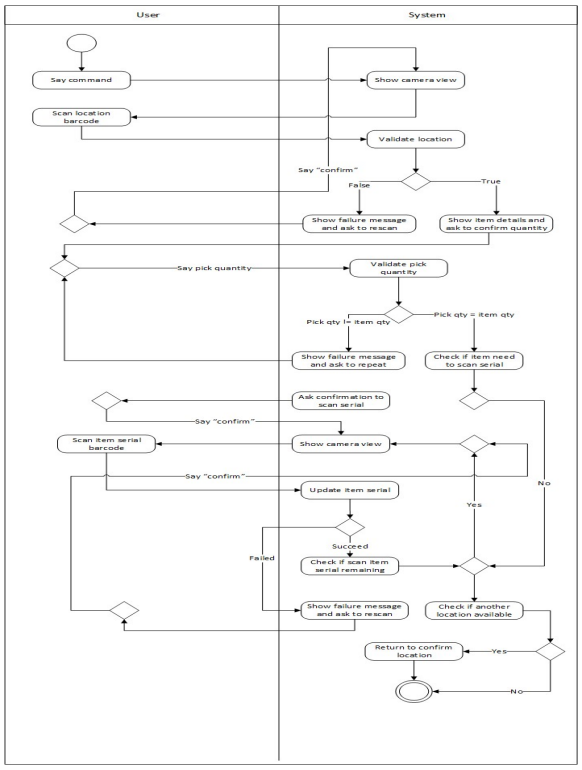

Figure 6. Activity Diagram of Confirm Location, Confirm Quantity, and Scan Serial Activity in Smart Glasses Picking System

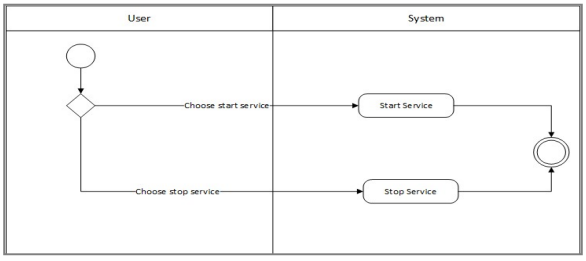

Figure 7. Activity Diagram of Start Service and Stop Service Activity in Smart Glasses Picking System

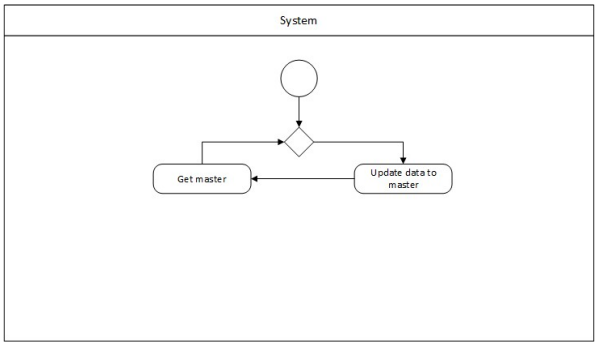

Figure 8. Activity Diagram of Get Master Data and Update Master Data Activity in Smart Glasses Picking System

4.2.4. Entity Relationship Diagram (ERD)

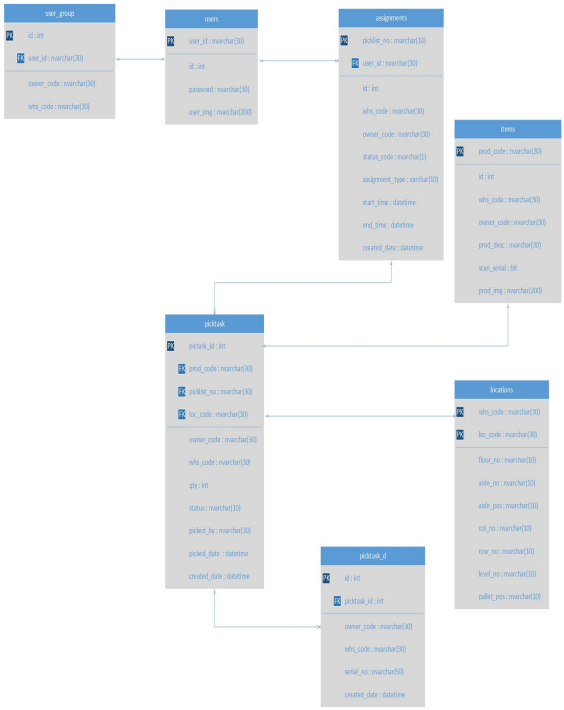

Figure 9. ERD of Smart Glasses Picking System

4.3. 3rd Stage: Coding

In this phase, the application starts to be built using Android programming language. The specifications during application development are as follows:

4.3.1. Hardware

- Notebook Intel® Core™ i5, Memory 4 GB
- Smart Glasses Device Vuzix M100

4.3.2. Software

- Visual Studio 2012
- SQL Server Management Studio
- IIS Express
- Android Studio
- Java Development Kit 7 Update 79
- Postman
- Chrome

4.4. 4th Stage: Test

Testing process by user is carried out using smart glasses with the following specifications.

4.4.1. Hardware

Smart Glasses Device Vuzix M100

4.4.2. Software

Android Operating System from Ice Cream Sandwich until Lollipop version

Meanwhile the evaluation is done by comparing the picking transaction data between RF picking and Smart Glasses picking that has been done by PT. XYZ, where results of the experiments can be seen in Table 2 below.

Table 12. RF Picking and Smart Glasses Picking Evaluation Data

Numbers of Trial	RF Picking (in seconds)	Smart Glasses Picking (in seconds)	Time Difference (in seconds)
1	31,185	10,274	20,911
2	17,671	16,614	1,057
3	28,036	11,961	16,075
4	15,016	8,996	6,020
5	10,334	10,620	-286
6	17,006	13,029	3,977
7	19,306	11,684	7,622
8	15,667	10,884	4,783
9	21,876	8,262	13,614
10	8,667	17,764	-9,097
Average	18,476	12,009	

Based on experiments that have been carried out, it can be concluded that the average speed performed using Smart Glasses picking is faster than using RF Picking. With the comparison between the two picking methods, it can be concluded that the use of smart glasses in warehouse picking will improve picking performance, in addition, the use of smart glasses also proves data picking accuracy and flexibility because of hands free during the picking process occurs.

5. CONCLUSION & FUTURE RESEARCH

The results of designing an application that combines the use of smart glasses into warehouse picking process can be summarized as follows.

- Smart Glasses picking application can improve warehouse picking performance, especially on the picking speed which can be seen through the evaluation that has been done.
- Smart Glasses picking application can also guarantee accuracy and flexibility in the picking process.
- The use of Smart Glasses picking application also creates a hands-free atmosphere that RF Picking cannot offer during the picking process.

As improvement for the future research, this paper can be better by:

- Adding other basic instruction to enrich the smart glasses voice analysis library.
- Adding the noise reduction to the smart glasses to minimize error voice instruction.
- Adding voice recognition feature in different language to the smart glasses so that users can give voice instruction more clearly in their mother language.

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