Testing Phases for RFID Inventory Management System

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***Abstract*—The growth of a company means increases in productivity. With the increase of productivity comes an increase in products. For any growing business to succeed, it needs a good inventory management system. This study supports an RFID inventory management system and examines its usability assessment by evaluation of task performance and measurement of satisfaction using a system usability scale. This research includes the involvement of actual users with a total number of 20 staffs from Fateh Watches and 11 public users who had experience with management systems. The results showed that 90.32% of the users that tested the system were satisfied with the whole system functionality in overall. On the other hand, the other 9.78% participants are dissatisfied signifies that there is a need for improvement in the system.**

Keywords—Inventory management, RFID, Software Testing, System Usability Scale .

I. INTRODUCTION

To remain competent, businesses must guarantee that their workflow is effective and efficient. Fateh Watches is a fast-growing company that develops and manufactures watches in Malaysia with their own unique design. With the company's growth, its manual stock-tracking system is straining the productivity and workload of other activities like stocking in and out. Therefore, it is a need for Fateh Watches to obtain a reliable and functional inventory management system. The Radio Frequency Identification (RFID) is a new alternative for inventory system. Therefore, Fateh Watches applied this alternative by integrating RFID and Inventory management to increase efficiency and productivity in their business. On the other hand, to be a reliable system, the system must go through multiple tests processes to ensure no issues will occur during business operations and the system must be accepted by the client. To be accepted however, the system must undergo usability testing to determine the usability level of the system and to make some improvements based on recommendations [1].

II. LITERATURE REVIEW

A. Inventory

In addition to effective and efficient controls, a stock or inventory plays critical roles to maintain company growth to achieve large profitability in their sales. According to [2], The bottleneck of logistic companies is inventory issues, the stock of companies holds numerous amounts of money, reducing the business industry in market to quickly respond to customer service capability and standards. [3] has stated that inventory management is important to address two issues which are firstly, maintaining adequate inventory for smooth production and selling activities and secondly, minimizing the investment in inventory to enhance the company's profit.

B. Inventory Management

Inventory management is very important in this era of competition. Therefore, inventory management is always focused on to increase productivity of the company with the use of proper material management [4]. The objectives of inventory management are maximizing customer service, maximizing the efficiency of purchasing and production, maximizing inventory investment and maximizing profit. Inventory Management systems and inventory control processes provide information to efficiently manage the flow of materials, effectively utilize people and equipment, coordinate internal activities, and communicate with customers [5]. It should be noted where achieving the goal requires the balance of short- and long-term goals. In factories and distribution centres, high inventory levels also take up space and therefore involve additional storage, insurance and so on. A primary objective of inventory management is to reconcile these conflicting objectives. Inventory management systems and inventory processes provide information for effective material flow management, efficient utilization of personnel and equipment, internal coordination, and customer communications [5].

C. Benefit of Inventory Management

Organizations that maintain effective inventory management in their daily operations gain a lot of advantages [6]. The advantages are listed below:

- Warehouse space: By using inventory management systems, warehouse space can easily be utilized to its full potential as many items possible and at an accessible place. This speed up work done by workers such as processing, selecting, packaging, and shipping.
- Increase in sales: Inventory management is said to increase sales percentage up to 2% – 10%.

- Increased Information Transparency: All information regarding where items are stored, and the amount stored in the warehouse will he saved in the database. This prevents over stocking or under stocking in the inventory. It will be much easier to track all the good because supplies are coordinated.
- Increased Employee Efficiency: With a good inventory management system, less time and workload are needed to be done by workers as more work is everything is organized and easy to keep track of.
- Save time and money: Keeps track of products so that less effort needing to do inventory recounts to ensure accurate records. It also helps save money that could be wasted on slow-selling products.

D. RFID Application in Inventory Management

In manufacturing industry, RFID is used to measure efficiency, reducing counting process and work efficiency. It is an emerging technology for accurate, timely and reliable information support the management of transactions and coordinated materials streams. RFID uses radio signals to communicate and transfer between from a tag to the read and write device. Tags has a wireless chip and an antenna that is used to communicate when attached to the item that is needed to be identified. There are two tags available in the current technology, one is active, which means it is battery power and does its own transmission, and the other is passive which transmit using the power gained in electromagnetic form from the read and write device. Operations is improved with the use of RFID, as it helps in reducing misplacements of inventory [7].

Based on the findings by [8], RFID can help in monitoring and controlling inventory which is dependent on time with the use of tags, tags which are active tend to have long read ranges which makes them very good in inventory management and real-time location system. Because of the inexpensive price on the passive tag, it is more suitable in supply chains as it does not need an active tag with large range. But a cheap and simple method of gaining data of items.

III. METHODOLOGY

The assessment environment for this study involved Fateh Watches' existing staff as well as general users with system management experience. A total of 20 Fateh Watches employees and 11 general users has participated. All participants are computer and mobile literate, at the very least on a basic level, and have never used this system beforehand. The participants are between the ages of 21 and 47. Participants were required to complete two rounds of assessment: 1) directly engage with the system according to a pre-determined list of tasks in Table 1, and 2) evaluate the system using the system usability scale (SUS) instrument. The method as suggested by [9] was used to adapt the entire assessment process. The phases involved in software testing proses for RFID inventory management system are described below:

A. Phase 1 - Unit Testing

Unit testing is a method of testing that checks individual function or component [10]. This test was used to ensure the output and use process of the component follows the requirements. The RFID inventory management system for Fateh Watches was built in modules. These modules went through test cases to ensure that the components are evaluated in accordance with functional requirements.

The test was conducted at the developer's workplace where each function was tested based on the test cases. The test case contains the items to be tested, the input, expected results and the procedural steps to get the results. 19 test cases were prepared for this test.

When the output of the function tallies with the expected results of the test case, only then will the function be fully functional and correct. For example, to unit test the login functionality, the expected result must be known which the user is logged in. The tester must test the textbox and the button on the interface of the system to ensure this. The tester must input the username and password into the textbox and click on the login button. After following the procedural steps, the result is displayed, in this case a successful login.

B. Phase 2 - Integration Testing

Integration testing is used to verify performance functionality and reliability of the modules when joined and combined with another module. Other than that, it is also used to expose defects that surfaces during the integration of modules [11].

The integration testing on this system was performed on the integration of the Inventory management module and the RFID module along with the integration of the RFID scanner to the computer. The modules are tested to check their functionality after the merge. After functionality of both modules has been determined to be functional, reliable, and performing well, it is tested with different inputs and load time checks. The RFID scanner that is attached to the computer will insert the RFID code that has been integrated in the card. This RFID code will be linked to the products from Fateh watches. When the card is scanned, the scanner inputs the RFID into the textbox and submits the RFID code. The RFID code is tested by checking if the RFID code is properly linked to a product and tested if the RFID scanner itself inserts the correct RFID code. To check the performance, every time the RFID scanner submits the RFID code, the load time is taken and compared to without using the RFID scanner. The results showed that the modules are functional, reliable and has good performance without any issues.

C. Phase 3 – System Testing

Once the unit testing and integration testing were completed, the overall system test was conducted. System test was performed to prove the system fulfils the specific requirements of the client which in this case is Fateh Watches.

All inputs, outputs, functionality, system flow and buttons are checked in detail to ensure that the system works a whole and does not have any face any issues later down the line. All the completed modules must be working as intended to successfully fulfil the requirement and pass the test.

D. Phase 4 - User Acceptance Testing (UAT)

User Acceptance Testing is a test that the end user and/or client carries out for checking and accepting system before the software system is moved to the production environment. The UAT involves the participation of 20 Fateh Watches staff and 11 general users with experience in management systems in assessing the proposed system, whether it is acceptable. The result is recorded based on the test session made between the developer and users is shown in Table 3.

A usability testing was also conducted to ensure that the software being produced is a better software with maximum user satisfaction. The outcome of this test can be used by developers to further improve the software and increase user satisfaction [12].

Usability testing is a method used to evaluate the system's efficiency, and reliability with the help of 20 Fateh Watches staff and 11 general users with experience in management systems. The tests take place with the users stated to determine the user's satisfaction when using the system by conducting a test session and giving main task with different scenarios which will then follow by an online post questionnaire to gather information on respondent background and system usability review [12].

- The test session of user's tasks.

During the assessment, several tasks for the various scenarios were established. A total 17 tasks per participant was distributed. The user's tasks and description are as portrayed in Table 1.

TABLE 1 : USER'S TASK

No.	Task	Description
1	Login	User input username, password and press login button. If any input is empty or incorrect, the system will not allow access to the user and display an error message.
2	Regist-er user	Only the user that have admin role can register the other users. Admins need to click user registration button. Then, admin must input full name, username, email, password, confirm password and click the register button.
3	List of register-red users	To view registered user, the user needs to click registered user button. In this page, there will be a list of registered users and some action buttons to delete the user and change their role. Only the admin can change user's role.
4	User profile	To go to this page, the user needs to click my profile button. In my profile page, the user can only edit their username and update their password.
5	Add color	To add a new color and view the available color, the user needs to click the category tab and next click the color tab. Then, the user needs to input the color and click save button. The list below shows the available color in the system and delete button is next to the color.
6	Add collecti-on	To add collection and view the available collection, the user needs to click the category tab and next click the collection tab to redirect to the page. Then, the user needs to input the collection and click save button. The list below shows the available collection in the system and delete button is next to the collection.
7	Register product	To register a product, the user must click the register product tab, then the user has to select the collection, color and gender the user also need to insert the RFID code for link the product to the RFID code. Then it will automatically register the product to system. If the product exists in the system, an error message is displayed.
8	Add single stock	The add stock tab is to add stock 1 by 1. The user needs to scan The RFID code in the input and then it will automatically stock in without having press the button. It will show the user a success message.
9	Add multiple stock	To add multiple stock, the user needs to click add multiple stock tab. The user needs to scan the RFID code, input the quantity, and press the button to stock in the product.
10	Single stock out	To single stock out, the user needs to click stock out page. then scan the RFID code and press the stockout button. After scanning the RFID code, the amount of stock available will be deducted by 1.
11	Multipl-e stock out	To deduct multiple stock, the user must go to multiple stock out page. Scan the RFID code and insert the quantity and press the button.
12	View list of products	To view the product list, the user needs to press List of product button, and it will show all the product registered in the system.
13	View list of stock in	To view the list of products that have been stocked in, the user needs to click this list of stock in button, and it will show the total stock in of product to the user. The user can click dropdown to view result based on the month selected.
14	View list of stock out	To view list of products that have been stocked out, the user needs to click the list of stock out button and it will show the total stock out of product to the user. The user can click dropdown to view result based on the month selected.
15	Alert Noti-fication	When a product stock is below 5, the system will have a notification that stated the product is low on stock and display the remaining stock to the user
16	View list of available stock	To view the list of available stocks, the user must click the button "list of available stocks". When clicked, a table of available stocks will be displayed along with the option to switch page or choose amount entities to be show in the table.
17	View history of stock	To view history of stocks the user must click the button named "stock history" and choose a tab. There are two tabs displayed, one tabs is for the history of stock ins and the other is the history for stock outs. Both pages will display a table based on the selection of tab.

- Post questionnaire

The final step, after the participants has completed the tasks, the participants must go through a post evaluation survey that uses the System usability scoring technique. The questionnaires are distributed to 31 participants, 20 from Fateh Watches staff and 11 general users. The questionnaire consists of the respondent background information and application review in order to evaluate their satisfaction towards the system.

Respondent Background

1. What is your gender?
2. What is your age?
3. Do you have any experience using management system?

System Review

1. This system can help me finish my work quickly.
2. I thought there was too much inconsistency in this system.
3. I think this system has a pleasant interface.
4. I think that I would need the support of a technical person to be able to use this system.
5. I find the steps to execute task in this system is simple.
6. I needed to learn a lot of things before I could get going with this system.
7. I find the various functions in this system is well integrated.
8. I found the system very cumbersome to use.
9. This system notifies me when stock is running out.
10. This system needs to be improved.

The results of the test phases 1 until phase 4 will be discussed in Section IV.

IV. Results and Discussion

The results of unit testing, integration testing and system testing was a success. This is proven when 100% of the individual functionalities and modules are working correctly when tested in unit testing and when the integrated modules (RFID module and Inventory management module) do not produce any errors after merging in the integration testing. The system test shows that the system works as intended by the developer and meets the client's requirements. In phase IV, the results of the user testing done by the 31 participants, 20 from Fateh Watches staff and 11 general users displays that the tasks given were completed without any issues although not having any connection with the development of the system. This shows that the user has accepted the system as it meets user requirements. The acceptance is supported by the results of the post-evaluation survey that was distributed.

As highlighted in section III, the survey was conducted by distributing questionnaire to the respondents that had finished the set of tasks required for the usability evaluation. In terms of evaluation environment, the whole processes are conducted online via video conference due to the coronavirus pandemic outbreak which leads to a continued movement control order that was introduced by the government.

TABLE 2 : RESPONDENTS BACKGROUND

Number of participants	Age	Gender		Experienced Respondents
		Male	*Female*	
0	Below 18	0	0	0
22	19 - 30	20	2	17
9	31 - 49	6	3	8
2	Above 50	1	1	1

As recorded in Table 2, it is recorded that all the respondents are above 18 years old. 22 respondents are around 19-30 years of age, above 9 respondents are above 30 but below 49, while only 2 respondents are above 50 years old. Among the 22 respondents only 2 are female while the other 20 is male and only 17 out of the 22 are experienced in using management systems. The 9 31–39-year-old respondents consist of 6 males and 3 females with 1 inexperienced user. In the age category of 50 and above, there are only 2 respondents which are 1 male and 1 female with only one being experienced.

All the feedback from the 31 respondents on the application review, is as portrayed in Table 3. The questionnaire consists of 10 Likert scale questions ranging from Strongly Disagree (point =1) to Strongly Agree (point=5). Various studies have been conducted to assess the usability of software applications using various usability approaches in various sectors such as education [12-15], counseling [16, 17], and medical [18].

TABLE 3 : THE FEEDBACK FROM RESPONDENTS.

General	1	2	3	4	5
This system can help me finish my work quickly.	0	0	0	9	22
I thought there was too much inconsistency in this system.	13	17	1	0	0
I think this system has a pleasant interface.	0	0	0	6	25
I think that I would need the support of a technical person to be able to use this system.	19	9	3	0	0
I find the steps to execute task in this system is simple.	0	0	0	6	25
I needed to learn a lot of things before I could get going with this system.	14	15	2	0	0
I find the various functions in this system is well integrated.	0	0	1	8	22
I found the system very cumbersome to use.	24	7	0	0	0
This system notifies me when stock is running out.	0	0	1	7	23
This system needs to be improved.	13	16	2	0	0

TABLE 4 : SUS SCORE

User	SUS Raw Score	SUS Score
1	38	95
2	35	87.5
3	35	87.5
4	36	90
5	36	90
6	40	100
7	34	85
8	40	100
9	36	90
10	38	95
11	38	95
12	35	87.5
13	38	95
14	35	87.5
15	36	90
16	32	80
17	37	92.5
18	39	97.5
19	35	87.5

20	36	90
21	38	95
22	36	90
23	38	95
24	32	80
25	35	87.5
26	35	87.5
27	36	90
28	34	85
29	36	90
30	36	90
31	35	87.5
	Average of SUS Score	90.32

As shown in Table 4, the average final score of SUS is 90.32, this indicates that the acceptance level of this system is excellent. The acceptance SUS value is 68.0 [19]. Out of 31 respondents, 2 have given a score of 100% satisfaction level. However, the lowest score from this questionnaire is came from 2 participants that has given an overall mark of 85% satisfaction level. Based on the four testing phases conducted, it can be concluded that the system was built correctly, and the clients are satisfied when using the system as it meets the client's requirements.

V. CONCLUSION

In conclusion, the unit, integration, system and user acceptance testing was successfully conducted. This has been supported by the overall 90.32 satisfaction index in the user acceptance testing conducted by the end user. This rating shows that the system is working as intended as requested by the client. The test phases were successfully conducted with the involvement of real client during the tests. Overall, the RFID inventory management system was successfully built and tested. In the future, it is recommended to complete a stress test to further display the reliability of the system and increase user acceptance.

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