

Web-Based Item Tracking System Using RFID

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Abstract—Numerous tools, kits, and other items are utilized daily by many individuals in the college laboratories. Without a proper inventory record, there is a risk of missing and misplacing some items. The system for tracking items using Radio Frequency Identification (RFID) accessed via the website has been designed to track the location of each item in the laboratory using RFID technology. The primary objective of this system is to monitor and record inventory. Information regarding the inventory is stored in a database, which can be accessed to track inventory and review the history of specific items via the Internet. The designed system is capable of tracking and managing laboratory equipment inventory using RFID, accessible through a web-based platform.

Keywords: *inventory, localization, RFID, tracking, , web-based system*

I. INTRODUCTION

Every university is equipped with numerous classrooms and laboratories, each filled with various tools, kits, and equipment utilized daily. Keeping track of these items is essential, and traditionally, this has been done manually through inventory records. However, this manual process can be time-consuming and prone to errors, such as misplacement of items.

To address these issues, a web-based Radio Frequency Identification (RFID) item tracking system has been developed. RFID is a versatile technology, widely used for automatic control of activities, particularly in the areas of identification and security [1]. RFID is an electromagnetic-based device that can identify and track RFID tags read by the RFID reader [2]. One of the key advantages of RFID is its ability to identify multiple objects simultaneously without the need for direct or close contact [3].

RFID has begun to replace traditional barcodes due to its superior features. Unlike barcodes, RFID does not require direct contact between the reader and the tag, making it a faster and more efficient method for assets tracking and inventory. For instance, RFID can inventory 658 items in just 16.25 minutes, compared to the 38.9 minutes required by barcodes [4]. Additionally, RFID has a larger reading range of about 7 to 10 meters [5] and can store more information than barcodes, with the flexibility to arrange the stored data as needed.

To facilitate easy access to inventory records, these will be stored in a MySQL database and made available on a website. This website will be developed using the Hypertext Preprocessor (PHP) language and the Bootstrap framework. MySQL, a relational database server, supports Structured Query Language (SQL), which is used to manage and manipulate data [6], [7]. Being an open-source database, MySQL is reliable and compatible with all common hosting providers [8].

PHP, a server-side scripting language, simplifies the creation of dynamic websites and supports MySQL [9]. Bootstrap, on the other hand, is a popular framework for developing mobile-first websites using Hyper Text Markup Language (HTML), Cascading Style Sheets (CSS), and JavaScript. By incorporating responsive web design principles, Bootstrap enables web applications to adapt their layout in response to varying screen resolutions [10].

II. RESEARCH METHODOLOGY

A. Hardware Designs

The proposed hardware design is illustrated in Figure 1. An RFID reader is used to scan ultra-high frequency (UHF) RFID tags (operating at frequencies between 860–960 MHz) attached to various objects. The Raspberry Pi processes the information collected by the reader. Once processed, the Raspberry Pi transmits the data to a MySQL database. This data is then displayed on a website, developed using PHP and the Bootstrap framework. During the operation, the device is strategically placed in a corner of the room and remains stationary throughout the tag monitoring process. The physical design of the device is depicted in Figure 2.

B. Software Designs

1. Database structure

The structure of the database is presented in Figure 3. It comprises three tables: inventory, items, and user. The inventory table includes fields for ID, room, location, and time, which respectively represent the tag ID, the room where the tag was detected, the location of the tag within that room, and the time of detection. The items table, consisting of ID and Item fields, is used to associate each tag ID with the corresponding item. The user table stores

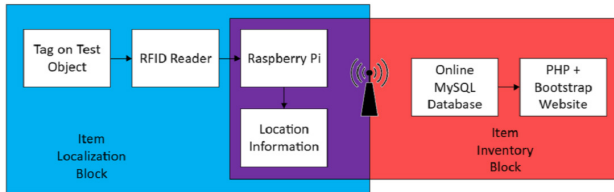


Figure 1. Block diagram of web-based system design for item monitoring and inventory

Table 1. List of website functionalities

No.	Function
1	Web access management
2	Registration
3	Login
4	Inventory management
5	Display data
6	Add data
7	Download data
8	Print data
9	Modify data
10	Remove data

account information for the website, including username, email address, password, status, and access level.

2. Website development

The website has been developed using the PHP programming language and the Bootstrap framework, a CSS tool. PHP is used for the backend, while Bootstrap enhances its visual appeal. The website functionalities are listed in Table 1.

3. Item registration process

The website will feature an Item Registration page, which includes a form for entering item details. The process of registering an item, depicted in Figure 4, involves filling in the form with the tag ID and the data of the item to be registered. Once the form is completed, the data is stored in the database and displayed in the item data table.

4. Item inventory process

The inventory process, depicted in Figure 5, is initiated by inputting the room to be scanned. Subsequently, the RFID reader detects the RFID tags. Upon detection, the tag ID is registered into the database, which then searches for the corresponding item data. Once the data is located, the Inventory page displays the ID, item data, room of the item, location of the item, and the time of tag detection. As long as the device is active, the reader continues to scan the tags in the room and update the tag locations. The database also removes data not detected in the previous scan to ensure that data from moved items is not retained in that room.

C. Testing

The testing phase involves examining whether the device can accurately detect RFID tags and transmit data to the database under various conditions. These conditions



Figure 2. Design of the RFID reader-based item identification device

include detection testing for different tag distances, different numbers of tags, and different tag conditions.

1. Detection testing for different tag distances

This test involves placing several tags at different positions and distances to determine the maximum distance at which the device can detect the tags.

2. Detection testing for different numbers of tags

This test has been conducted by placing several tags in close proximity to each other to assess the capability of the device to detect multiple tags simultaneously.

3. Detection testing for different tag conditions

This test examined tags with varying degrees of damage, such as being wet or torn, to determine the extent of defined tag damage (referring to Table 2) that can still be detected by the device before the tag becomes non-functional.

III. RESULT AND DISCUSSION

A. Website Design Results

Starting with the login page, this page provides a designated area for users to input their email and password. If users forget their password, they can click on the “Forgot Password?” link to initiate the password recovery process. Additionally, this page also offers a link for new users to create an account.

The registration page features a form that users must fill in to create an account. The form requires users to input their name, email address, and password. Upon clicking register, the website sends a One Time Password (OTP) code to the provided email address to confirm its validity.

Once users have successfully logged in or registered, they are directed to the main page. This page presents a variety of options, including the inventory page, item list, account settings, and logout, all accessible via the sidebar. The main page displays the name of the account holder and their corresponding access level. The sequence diagram of the main page is presented in Figure 6.

On the inventory page, as seen in Figure 7, there is an

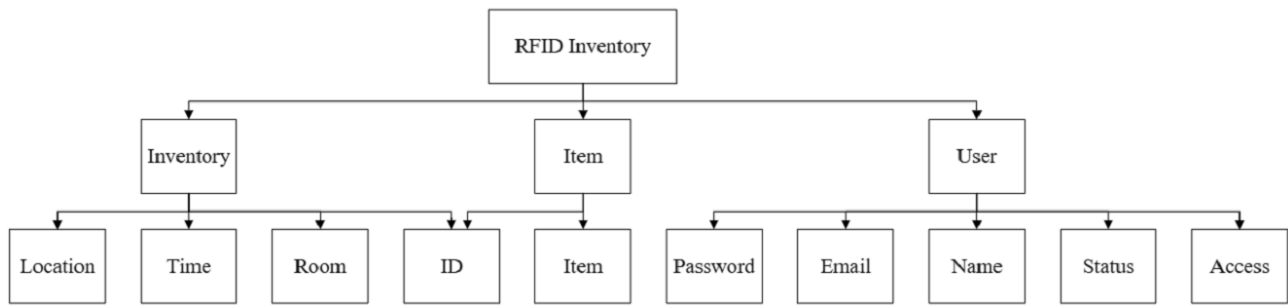


Figure 3. Structure of the developed database

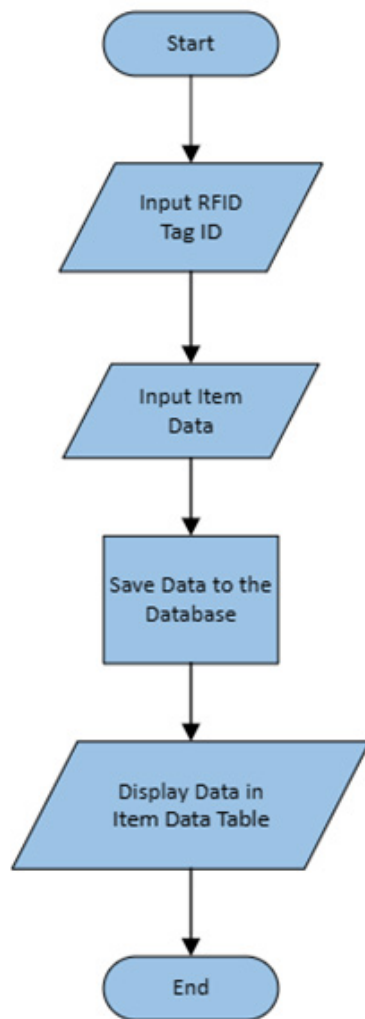


Figure 4. Flowchart of the item registration process

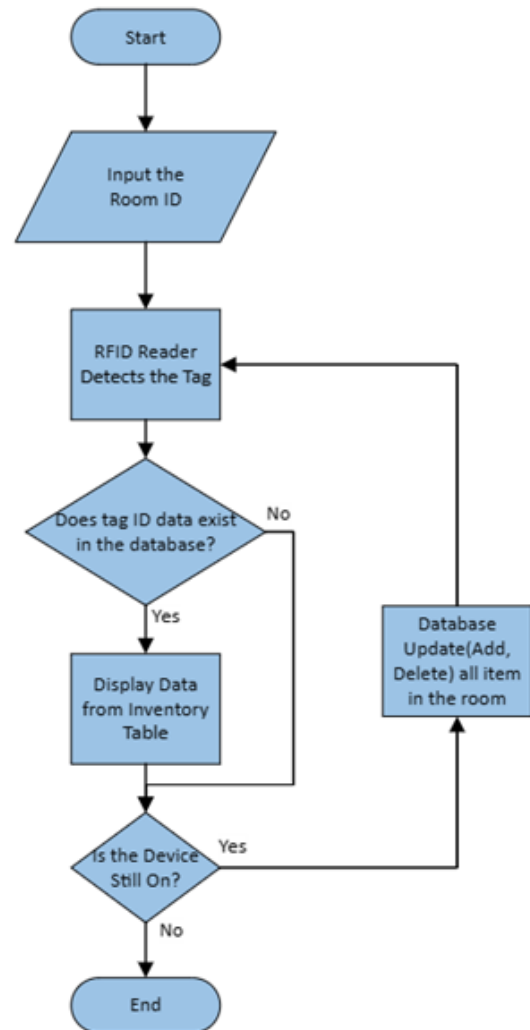


Figure 5. Flowchart of the item inventory process

inventory data table that contains tag data detected by the RFID reader. The table presents the tag ID, item name, room of the item, location of the item, and the time the tag was detected. Users can export this data to an Excel, CSV, or PDF file, print it, or copy it. Figure 8 illustrates the sequence diagram of the RFID reader adding detected item data during the inventory process.

Accounts are categorized into two access levels: Level 1 for users and Level 2 for admins. Users with Level 1 access can only view items registered in the database. Conversely, those with Level 2 access can register new

items, as shown in Figure 9. Admins with Level 2 access also have the authority to modify or delete an item from the database. To register items, they must input the tag ID and the name of the item associated with that tag.

B. System Testing Results and Analysis

1. Detection testing for different tag distances

The purpose of this test is to ascertain the detection range of the device when using a tag. The methodology involved attaching a tag to an item and placing it at

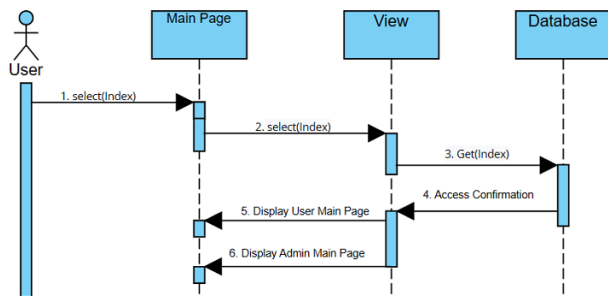


Figure 6. Flowchart of the item inventory process

No	ID	Item	Barcode	Location	Time
1	11 11 11 11 AA AA AA AA AA AA AA	Acid			
2	11 11 11 11 BB BB BB BB BB BB BB	Tag 4			
3	11 11 11 11 CC CC CC CC CC CC CC	Tag 5			
4	11 11 11 11 CC CC CC CC CC CC CC	Tag 6			
5	11 11 11 11 EE EE EE EE EE EE EE	Tag 7			
6	11 11 11 11 EE EE EE EE EE EE EE	Tag 5			
7	11 11 11 11 EE EE EE EE EE EE EE	Tag 11			
8	11 11 11 11 AA AA AA AA AA AA AA	Tag 1			

Figure 9. Item page for admin

No	ID	Item	Barcode	Location	Time
1	11 11 11 11 AA AA AA AA AA AA AA	Tag 11	2	3	2021-12-26 17:02:34

Figure 7. Inventory page

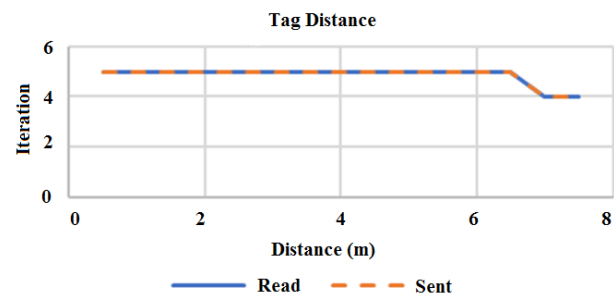


Figure 10. Compatibility test between tag data reading and transmitting with regards to distance

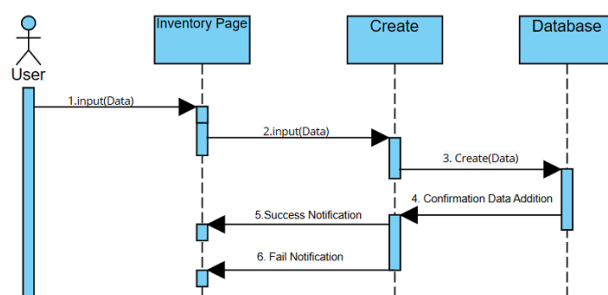


Figure 8. Inventory page

15 distinct points. Following the detection of the tag, the website was examined to verify if the device had successfully transmitted data to the database. This process was repeated five times to enhance the accuracy of the results.

As illustrated in Figure 10, the device was capable of detecting the tag up to a distance of 7.5 m. However, when the distance of the tag exceeded 6.5 m, the device began to struggle with detection.

Despite this, the device had no issues transmitting data to the database, with a success rate of 100%. The test was limited to 7.5 m due to the unavailability of a larger room. The results suggest that the device performs optimally in a room measuring 7x7 m with the reader positioned at one end, ensuring comprehensive room detection and eliminating blind spots behind the reader.

2. Detection testing for different numbers of tags

This test was designed to evaluate the capability of the device to detect multiple tags. The procedure involved scattering several tags within the detection range of the device and observing whether the device could detect and

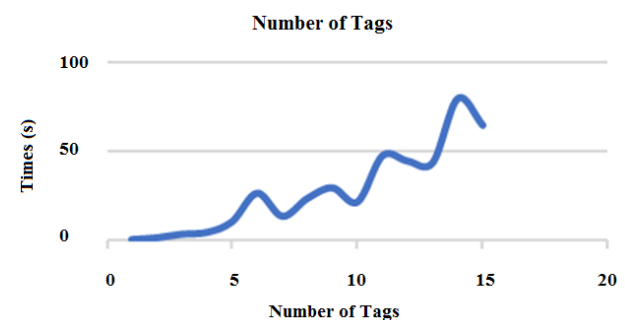


Figure 11. Comparative analysis of tag quantity with regards to tag reading time

transmit data for these tags.

The findings from this test, as depicted in Figure 11, revealed that the device was unable to simultaneously detect more than one tag. However, it was able to detect tags individually at a rapid pace, giving the impression of simultaneous detection. As the device needed to transmit data after each tag detection, the speed of detecting multiple tags was somewhat reduced.

It can be seen that the detection of more than four tags required additional time, as the device continuously re-detected previously detected tags, preventing it from detecting new ones. When detecting more than ten tags, the device encountered difficulties reading one or two of the last undetected tags. If tags were positioned close together, the front tag could obstruct the detection of the tag behind it.

3. Detection testing for different tag conditions

This test aimed to ascertain whether a tag could still be detected despite experiencing various forms of damage.

Table 2. Test result for various level of tag damage

No.	Damage	Read	Sent
1	Cut on the side	✓	✓
2	Cut in the middle	×	×
3	Splashed with water	✓	✓
4	Submerged in water	✓	✓

Four types of damage were tested: a tag cut on the side, a tag cut in the middle, a tag splashed with water, and a tag submerged in water.

The results, as presented in Table 2, revealed that the tag remained readable if it was cut on the side, splashed, or submerged in water. However, if the tag was cut in the middle, it could no longer be detected. The antenna of the tag is situated on its side. Therefore, when the side is cut, a portion of the antenna is also cut off. The chip of the tag is located in the middle. If the tag is cut in this area, the chip is also severed. The tests found that the tag could still function even if a part of its antenna was cut off. However, it would cease to function if its chip was damaged.

Interestingly, the tag remained functional even if it had been splashed or submerged in water. The tag was even detectable when submerged in water. However, the detection range of the tag decreased when it was submerged. Based on the test results, a submerged tag could only be detected from a distance of 0.5 m.

The diminished detection range of the submerged tag is due to the unsuitability of RFID, like all radio technologies, for use in water. Still water is not a natural conductor, but it can become a partial conductor when salts or other materials are dissolved in it. Table 3 shows the penetration distance of frequencies in several types of water. As electromagnetic waves cannot pass through electrical conductors, radio waves cannot be used for underwater communication in many cases [11].

IV. CONCLUSION

The conducted tests have led to several key findings. The device system has demonstrated its ability to detect and transmit data to the website effectively. Furthermore, all functionalities of the website are operating as expected.

The device can successfully read and transmit data from tags located up to 6.5 m away. Although tags positioned exceeding 6.5 m can still be read, the device loses its detection capability as the increase of distance.

The device exhibits optimal performance when deployed in a 7x7 m room, ideally situated at one end to ensure comprehensive room coverage without any blind spots. Given that the device needs to transmit data to the database, its capability to quickly read more than one tag diminishes.

If the antenna of the tag is damaged, the tag remains detectable as long as the chip is intact. Impressively, the tag retains its functionality even when submerged in water.

Table 3. Differences in tag reading abilities with various RF modules in several types of water [11]

	Low frequency (125 kHz)	High frequency (13.56 MHz)	Ultra-high frequency (800 MHz)	Microwaves (2.45 GHz)
Salt water (4 S/m)	71 cm	68 mm	9 mm	5 mm
Fresh water (30 μ S/cm)	26 m	2.5 m	32.5 cm	18.6 cm
Fresh water (2000 μ S/cm)	3.2 m	30 cm	4 cm	2.3 cm

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