Final Report

Final Year Project I

Warehouse Automation and Production Line Control

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Problem statement:

Traditional warehouse management depends on non-automatic system which is based on recorded paper document to pursuing the import and export goods, completely performed by personnel. So the depot management rate is very low and the scale of the warehouse is very small. Manual work reduces the production rate and stop the success of an organization.

Literature review:

With the development of information technology and application of logistics management, the warehouse management system (WMS) is introduced nowadays in order to enhance the efficiency of warehouse management and reduce corresponding costs. However, many traditional WMS still focuses on the management of materials' loading and unloading, and the work of statistics and stock-taking remains manual operation. These problems limit efficiency of warehouse management. Hence how to combine the location technology and WMS, make the location technology more effective, and improve the efficiency of warehouse management becomes an urgent problem, which is the main aim of this project to solve.

In the past decade, the change in the global economy has significantly redefined the way enterprises are operated. One of the major changes is that the core activity of warehousing in supply chain is no longer confined to keeping a large amount of stock. Instead, small quantities of goods are delivered promptly from a significantly wide variety of stock keeping unit (SKU) throughout its supply chain. Planning and control of warehouse facilities and systems are therefore made even more complex. In general, most warehouse managers lack timely and quality information derived from accurate monitoring and measurement of resources. They usually rely on their knowledge to formulate material handling solutions to handle different orders. In doing so, bias judgment easily occurs. In order to formulate optimal load item storage/retrieval decision and optimal material handling solution with all kinds of methods after receiving storage/retrieval order, it is vital for warehouse managers not only to acquire load item information about storage, but also to collect operation process and position information of material handling equipment.

Barcodes have widely used in warehouse management systems. However, their short-range reading ability limits their further application in load item identification and warehouse equipment positioning.

To position material handling equipment in warehouses, Harry K.H. Chow et al. apply the ultra-wideband technology (UWB) to transfer, define and process variable logistics data between the reader and tags. Its system contains a collection of active tags, four UWB readers and a hub processor to track the resource location . The UWB active tags consist of an internal battery and a short pulse transmitter to provide a much longer reading range and a shorter pulse radio frequency to the readers. The tag emits the short pulse signals several times every second. Various UWB readers receive the signals and send them back to the hub processor. With the triangulation logic setup as read by the various readers, the exact x, y, z co-ordinates of the active tag can be calculated .

Though Harry's system is a useful initiation to position material handling equipment, there are still some potential disadvantages listed as following:

1. The signals from the active tags are vulnerably hampered by the metal warehouse structure or the metal load items stored in warehouses.
2. The transmission range of the active RFID tag is not infinite, so it is hard to make sure of its effectiveness in big warehouse.
3. This system cannot reach high accuracy because of its datum acquisition method.

Since 1990s, the mode of production in enterprises has changed from the traditional mass production mode led by products into the mass customization production mode to facilitate increasing global market competition. Hence, the supply chain activity has been reformulated to achieve its competitive advantage . Harmon noted that warehouses should be redesigned and automated to achieve high throughput rate and high productivity, thereby reducing the order processing cost. In such sense, warehouse operation does no longer serve as a large stock keeping; instead, it has become a critical activity in the supply chain to outperform competitors on customer service, lead times and costs.

A brief survey of the related work in the area of video segmentation and traffic surveillance is presented in this section. Video segmentation helps in the extraction of information about the shape of moving object in the video sequences. Sikora T. [1] used this concept for intelligent signal processing and content-based video coding. Here an image scene consists of video objects and the attempt is to encode the sequence that allows separate decoding and construction of objects. Nack et al., [2] and Salembier et al., [3] have discussed Multimedia content description related to the generation of region-based representation with respect to MPEG-4 and MPEG-7.

Video segmentation algorithms can be broadly classified into two types based on their primary criteria for segmentation. Wang D. in [4] proposes a technique for unsupervised video segmentation that consists of two phases i.e. initial segmentation and temporal tracking. Y. Yokahama et al. in [5] discusses concept of initial segmentation as applied to the first frame of the video sequence, which performs spatial segmentation, and then partitions the first frame into homogeneous regions based on intensity. Motion estimation is then computed for determining the motion parameters for each region, and finally motion-based region merging is performed by grouping the regions to obtain the moving objects. L, Wu et al., [6] explains how temporal tracking is performed in detail after initial segmentation.

P. Salembier [7] found better results using spatial homogeneity as the primary criteria, which incorporates luminance and motion information simultaneously. The procedure includes the steps like joint marker extraction [8], [9], boundary decision and motion-based region fusion. Spatio-temporal boundaries are then decided by the watershed algorithm. Choi et al., [10] discusses Joint similarity method for the same purpose and finally, motion-based region fusion is used for eliminating the redundant regions. Initially filters are used to simplify the image and then Watershed algorithm is applied for boundary detection [11]. Later the motion vector is computed using motion estimation and regions with similar motion are merged to constitute the final object region. As watershed algorithm is being used they generate object boundaries which are more efficient and precise than any other methods. Aach T. et al., [12], discusses the change detection method which is used as the primary segmentation criteria in many applications. The major issue here is to guarantee robust detection in the results, in presence of noise. Many shortcomings are overcome by using Markov random field based on refining method. The position and shape of the moving object is determined using the frame difference concept, followed by a boundary fine-tuning process based on temporal information. Algorithms that deal with spatial domain processing first, without knowing much regarding the motion information will waste much of the computing power in segmenting the background.

Neri et al., [13] describes a solution to eliminate the uncovered background region by applying motion estimation on regions with significant frame difference. The object in the foreground is then identified when a good match is found between two frame differences. The remaining region is then discarded as unwanted areas. Stauder et al., [14] considers the effect of shadow of an object in the background region which affects the output in change detection-based approach.

Dailey et al., [24] presents the background subtraction and modelling technique that estimates the traffic speed using a sequence of images from an uncalibrated camera. The combination of moving cameras and lack of calibration makes the concept of speed estimation a challenging job. In [25] Grimson et al., analyses a vision-based system that monitors activities in a site, over a period of time using sensor networks.

Proposed System

The proposed solution suggests pasting or hanging or stitching RFID tags / labels on every carton / box / sack as its identity. The packages are of standard pack size in terms of quantities that gives an advantage of accurate quantity. The processes proposed in this solution are as under.

Production Process:

As soon as the packing of items in packages is done at the production department, RFID tag will be printed as well as encoded (writing data in the chip of RFID tag) with the item description, Date of production etc. by a printer cum encoder machine. These packages will be moved to warehouse.

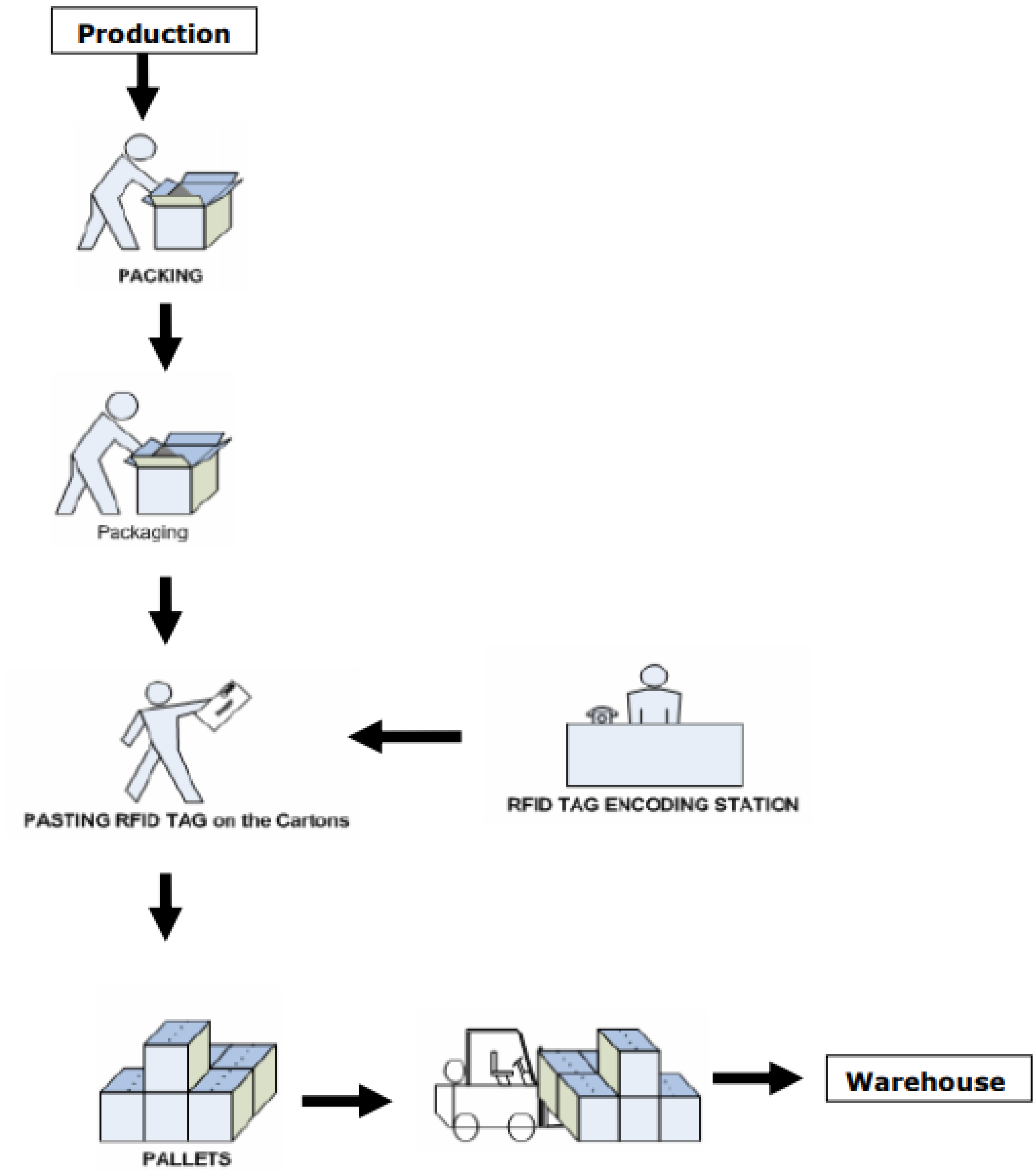


Figure 1 RFID Based Process flow Diagram

Project Plan

FYP 1

Week #	01	02	03	04	05	06	07	08	09	10	11	12	13	14
Literature Review														
Defense														
Web Front-end														
Database														
Start developing web app														
Testing														
Production line control														
Final Report of FYP-1														

FYP 2

Week #	01	02	03	04	05	06	07	08	09	10	11	12	13	14
RFID Testing using Scanner														
RFID Interface with Database														
Complete web App testing with RFID														
Microcontroller Programming														
Robot Designing														
Combine Testing														
Progress Report														
Final Report of FYP-2														

Methodology

Radio Frequency Identification (RFID) technology has been in existence for many decades, but it is only recently that RFID is being increasingly used to its full potential. RFID or radio frequency identification is a system that transmits identity in the form of a unique serial number of a product wirelessly. RFID, a type of Auto-ID technology is used to reduce time and labor and improve real time data accuracy. Warehouse operations like planning and control of warehouse facilities and systems has become more complex in supply chain. Warehousing is often needed to perform routine logistics operations such as stock storage, order status, paper processes, sorting, cycle counts, loading/unloading and customer service. Poor utilization of costly warehouse space, manual errors, wrong identification of the product during receipt & dispatch, locating items in warehouse will impact the productivity & profitability which results in organization's reputation & losses. RFID in conjunction with a WMS is an excellent real-time business tool that helps better manage supply chains, covers goods entry, picking, checking, delivery and many other operation flows & increases profit, and decreases the cost by improving visibility into Warehouse management system.

Basically, the steps below will be done:

- 1st - Reading the ID of the RFID tag.
- 2nd - Preparation of the (payload) message for sending.
- 3rd - Sending the payload through the MQTT protocol.
- 3rd - The back-end service will be listening to the related topic.
- 4th - Received the payload (basically it is the ID of the tag), a query will be made in our database.
- 5th - After the tag is consulted, a (conditional) check will be made if it is activated or deactivated.
- 6th - Having our feedback (reading response) in 'hands', the message (0 or 1) will be published in the related topic.
- 7th - The shipper, in turn, will be subscribing to the topic. Therefore, the message will soon be received and dealt with in the callback.
- 8th - ... this step is the freedom for you to implement the action / feedback that will be taken. I simply pressed the return status on the serial monitor. Below is a list of actions and / or feedbacks that can be taken.

Block Diagram

Database ERD

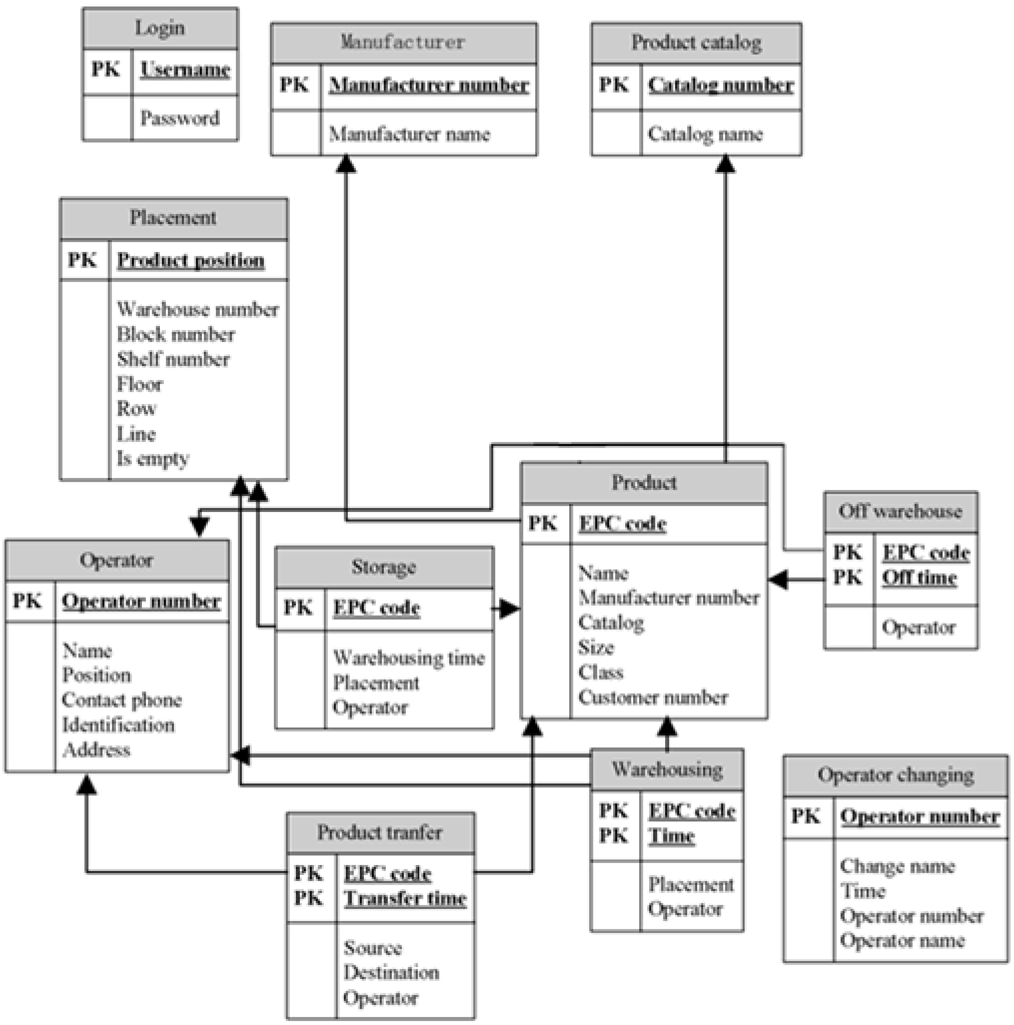


Figure 2 ERD Diagram

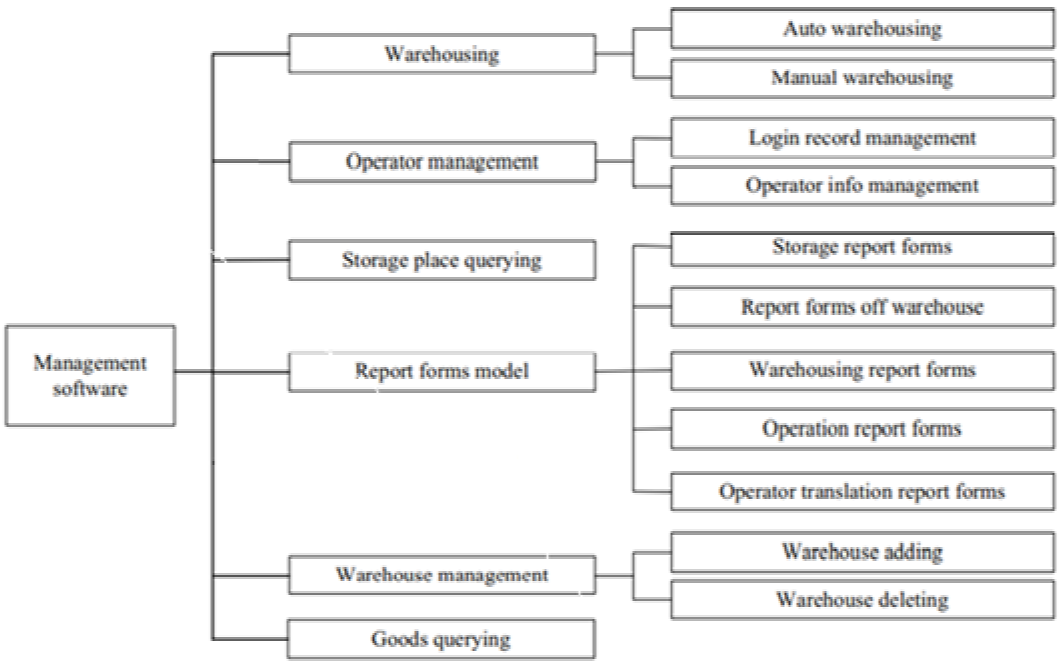


Figure 3 Management Processes

Flowchart and Main Process

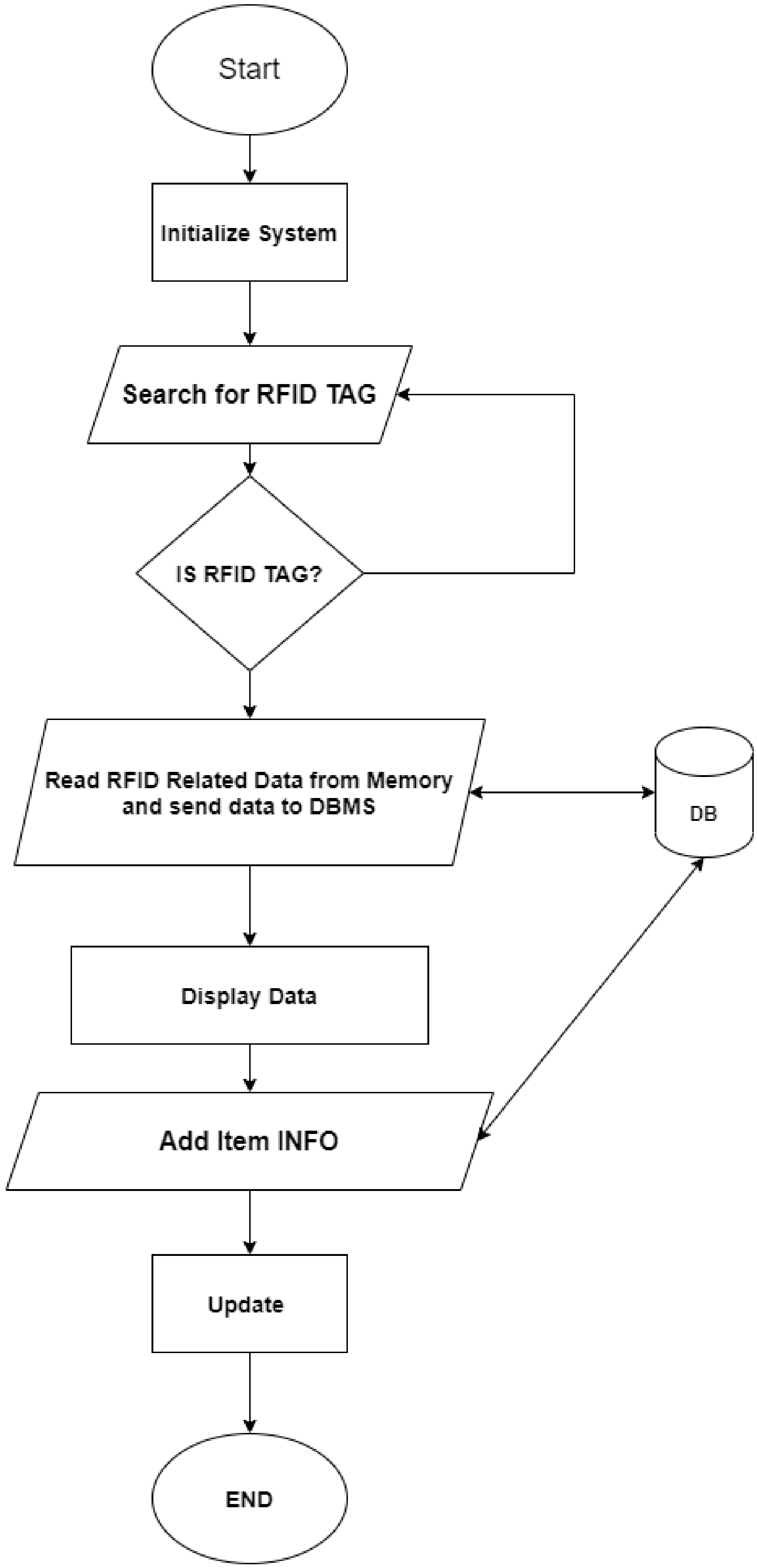


Figure 4 Flow Chart

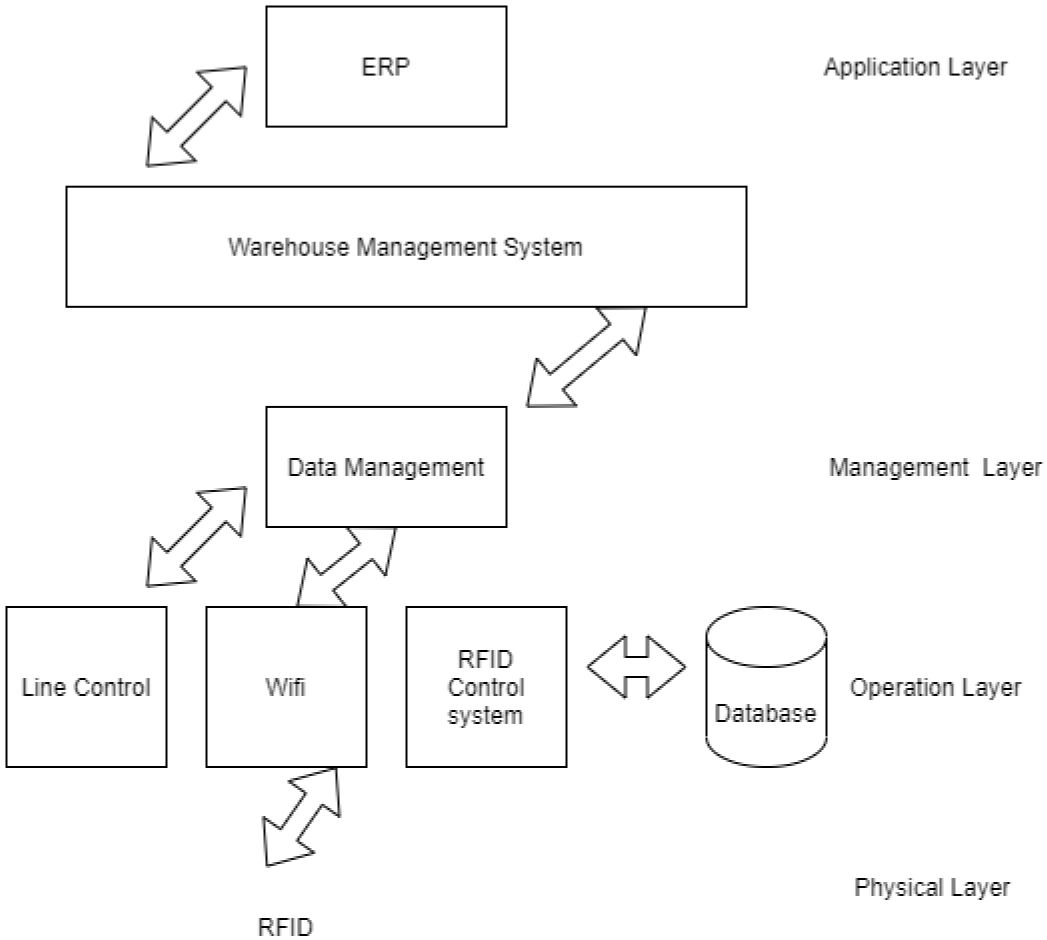


Figure 5 Main Processes

Hardware and Software

Hardware

i. RFID Tag

The RC522 RFID module based on MFRC522 IC from NXP is one of the most inexpensive RFID options. It usually comes with a RFID card tag and key fob tag having 1KB memory. And best of all, we write a tag, so we can store some sort of message in it.

Figure 6 RFID tag Module

ii. Arduino

We use Arduino ATMega to read data from tag and send it to MySQL server.

Figure 7 Arduino ATMEGA 2560

iii. Servo Motor

We use servo motor to build a robot to control its motors. A servomotor is a rotary actuator or linear actuator that allows for precise control of angular or linear position, velocity and acceleration. It consists of a suitable motor coupled to a sensor for position feedback.

Figure 8 Servo Motor

iv. Robot Wheels

These wheels mount directly on servo splines and are generally intended for use with continuous rotation servos.

Figure 9 Servo motor wheels

v. Rack

Rack is used to put goods in inventory in deferent sections.

Figure 10 Rack

vi. Battery

Batteries are used to power up motors and Arduino. Batteries with 24V and 10000mAh are used.

Figure 11 Lipo Battery

Software

i. MySQL

MySQL is used to store tag info and inventory info in database. So that we can retrieve desired information from database when we need it through queries.

Figure 12 MySQL

ii. SQL Server

MySQL Server is used to build windows form application and windows universal app to store data in database.

Figure 13 SQL Server

iii. VSCode

VScode is used as a editor of code for various languages and for coding purpose.

Figure 14 VScode

iv. Arduino IDE

Arduino IDE is used for program the RFID tag to send data on MYSQL. Basically it is an editor whole compile the code for Arduino Microcontrollers.

Figure 15 Arduino IDE

v. Visual Studio

We used Visual studio to build Windows form application and for Debugging.

Figure 16 Visual studio

vi. Flask Web framework

To build a website for easy user interaction with whole system we use Flask framework.

Figure 17 Flask Framework

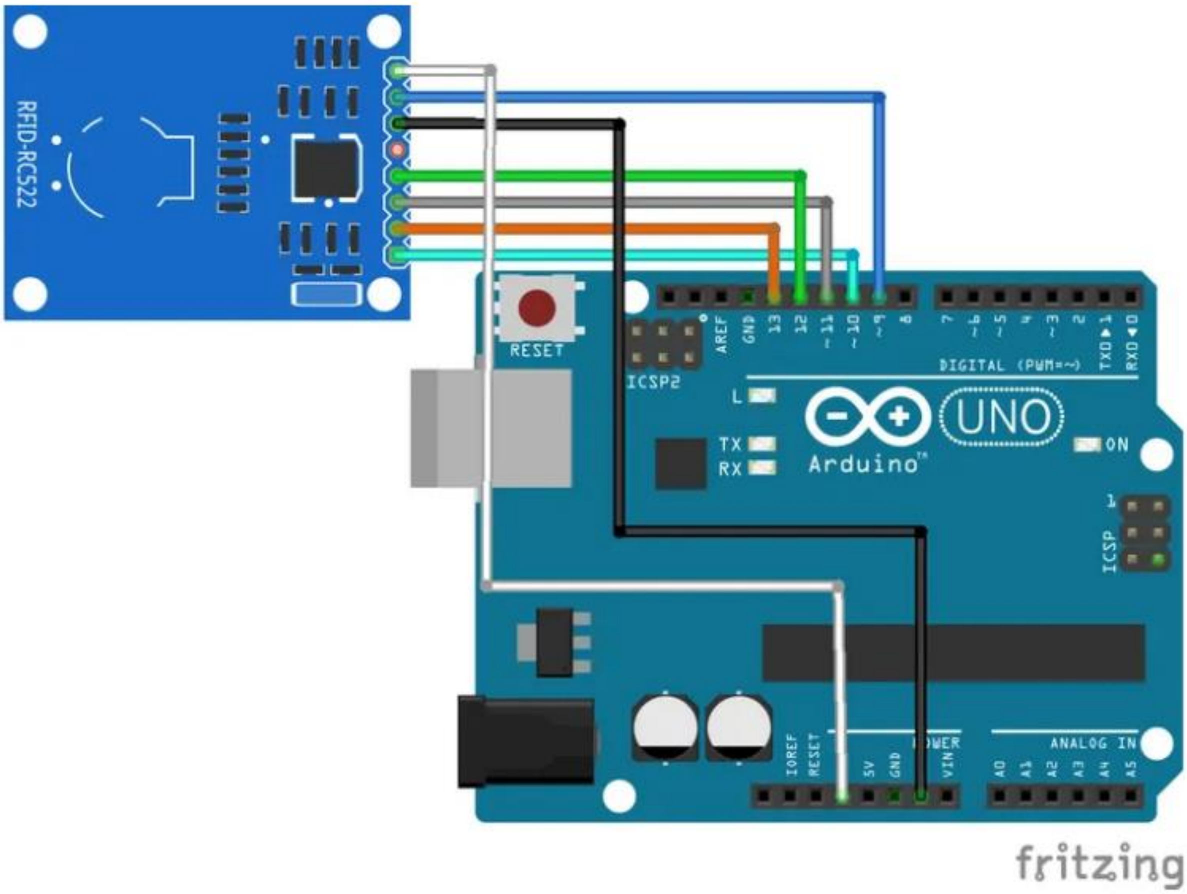


Figure 18 Schematic view of RFID and Arduino Connection

Windows Forms Application Based on RFID tag Database

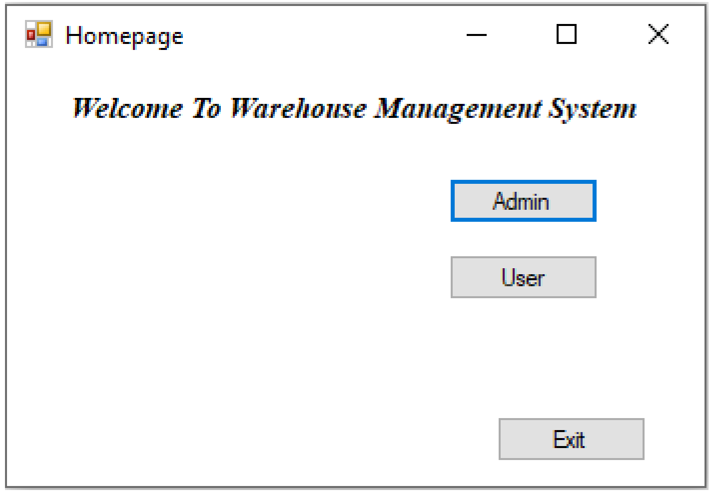


Figure 19 Welcome Form

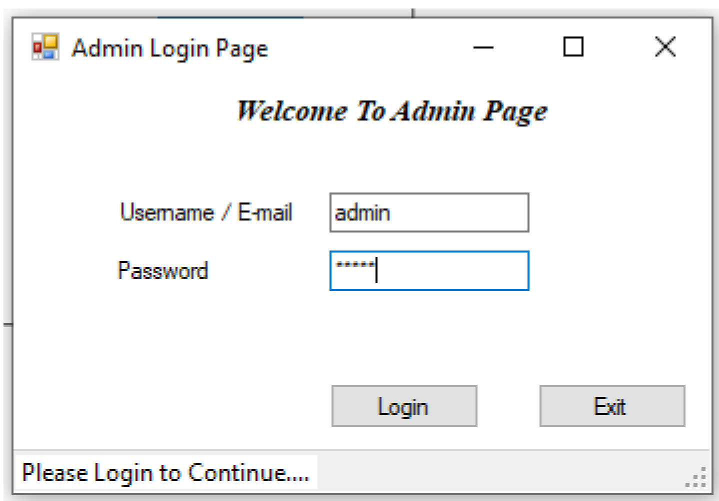


Figure 20 Login Form

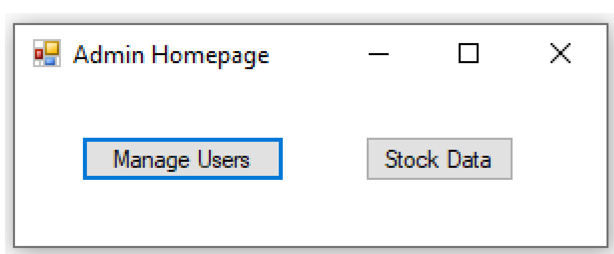


Figure 21 Admin Dashboard

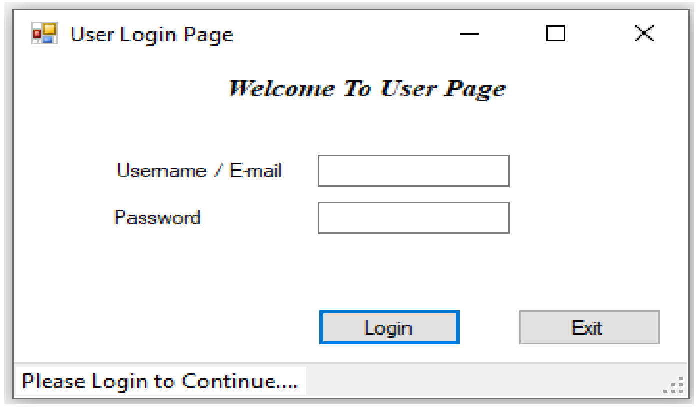


Figure 22 User Login Form

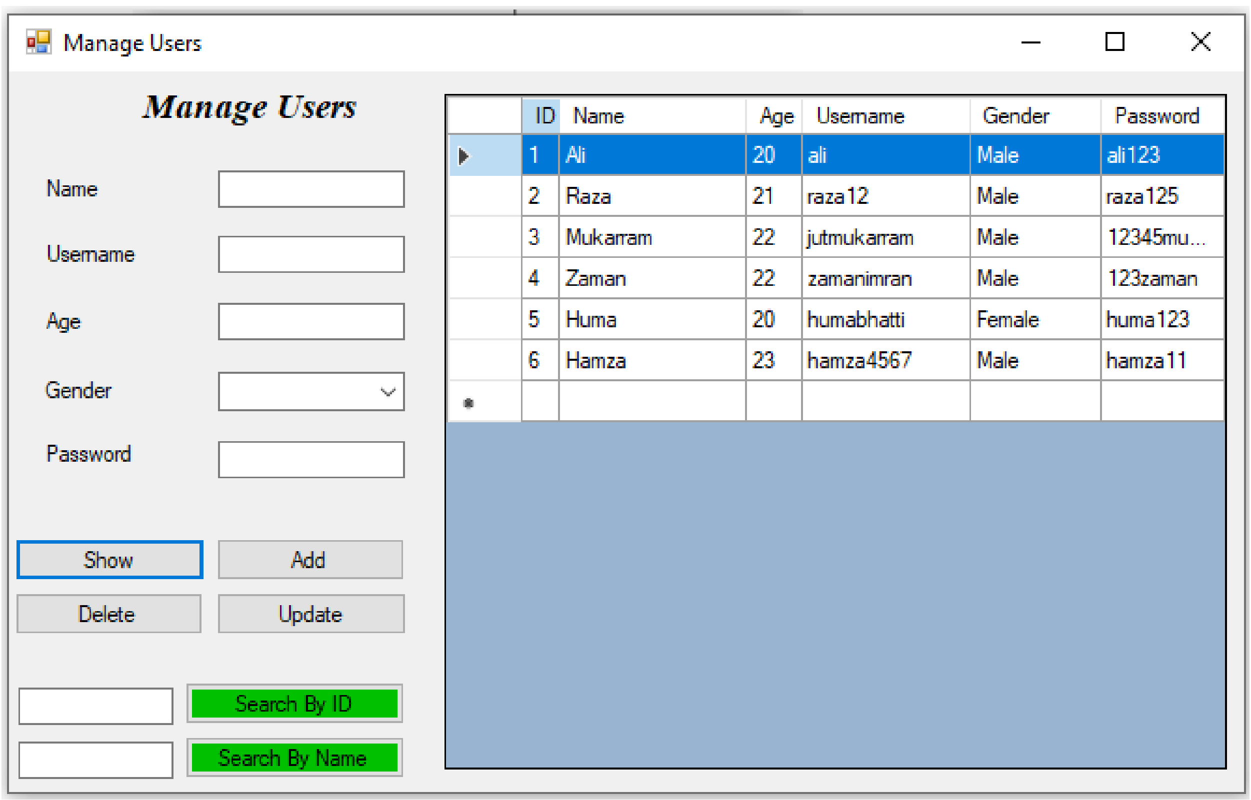


Figure 23 User Management Dashboard

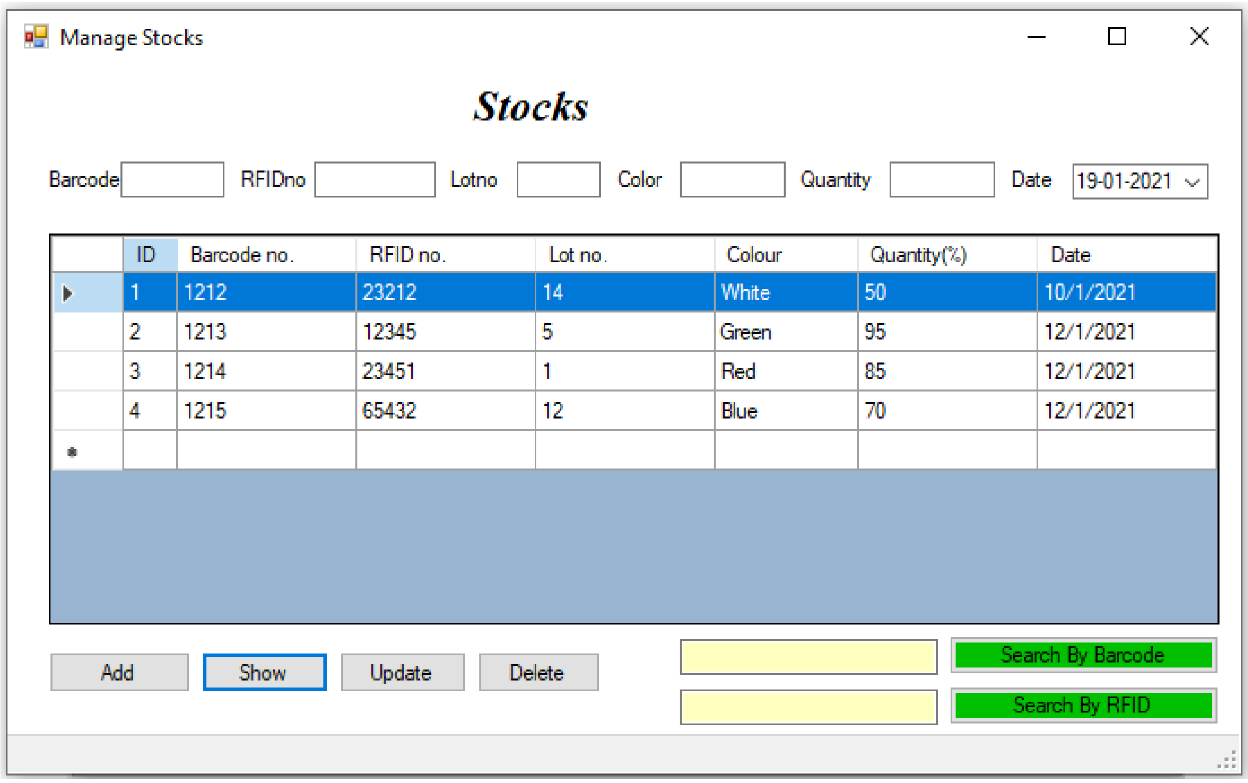


Figure 24 Stocks Management Dashboard

Web Application Based on Flask Web Framework

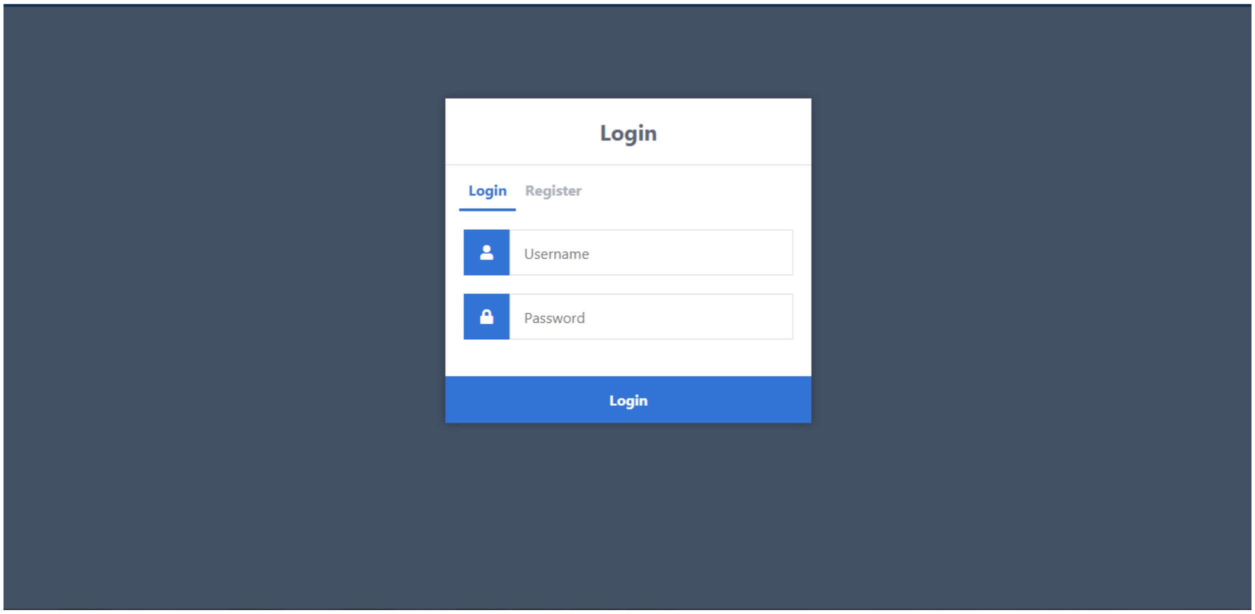


Figure 25 Login Web view

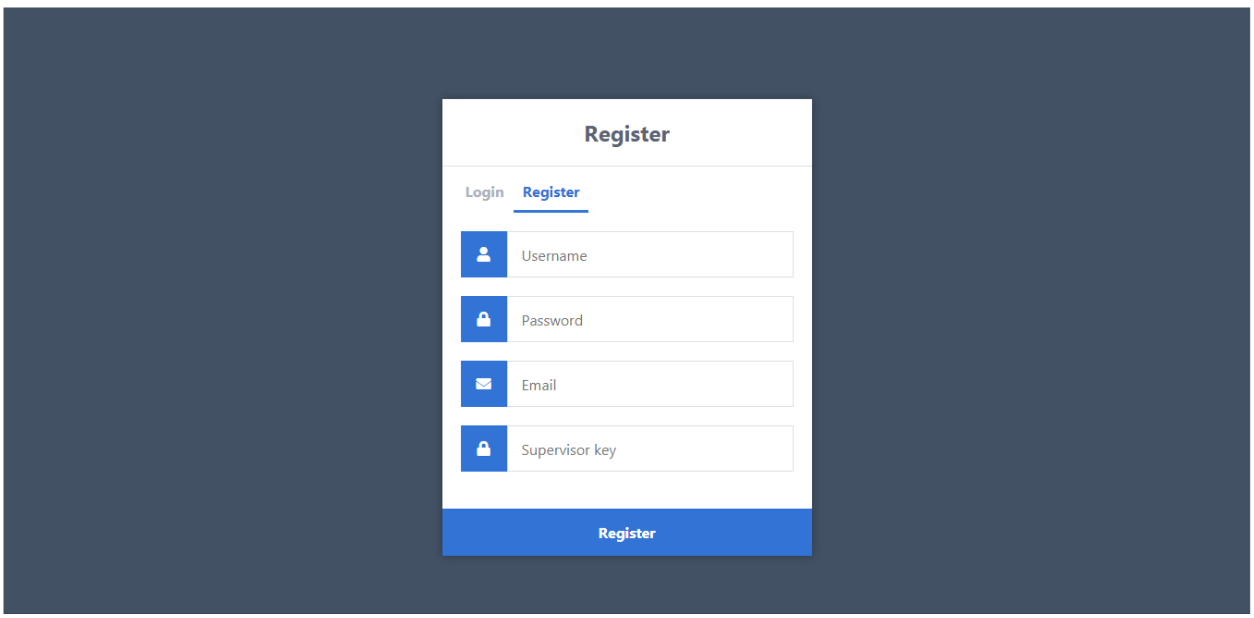


Figure 26 Registration Web view

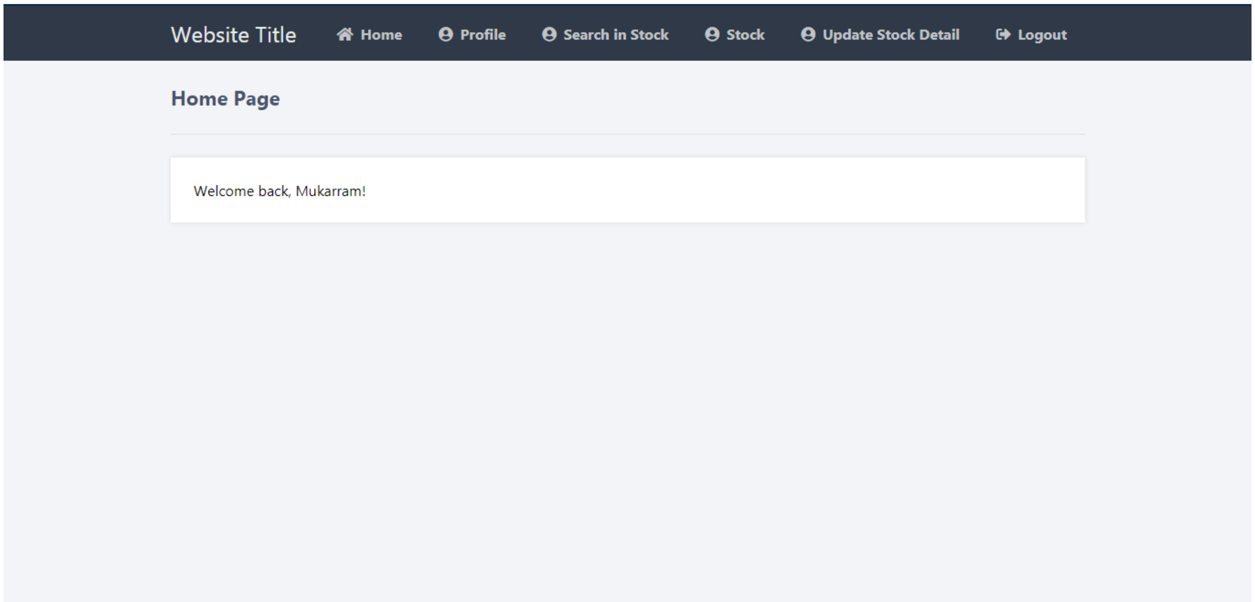


Figure 27 Welcome Home page

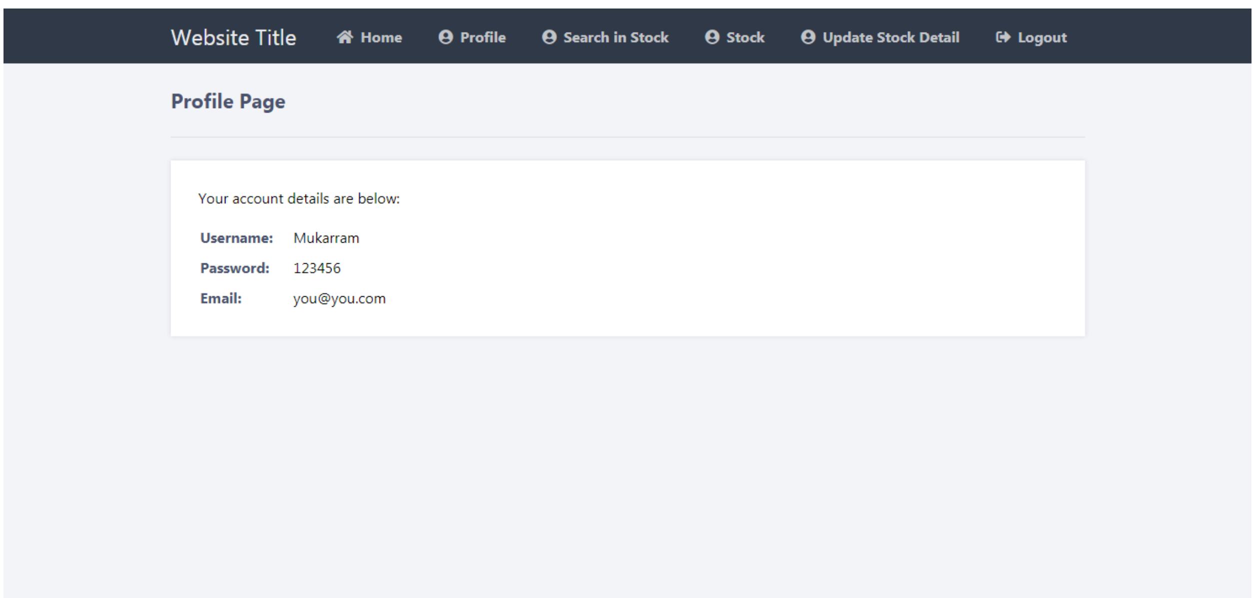
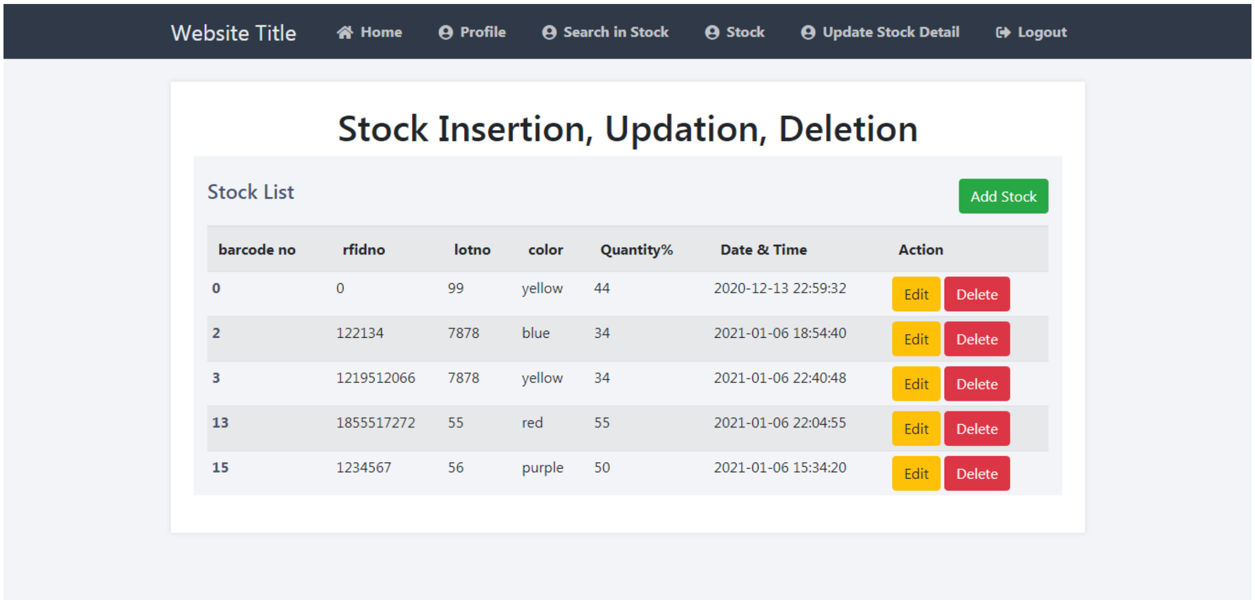
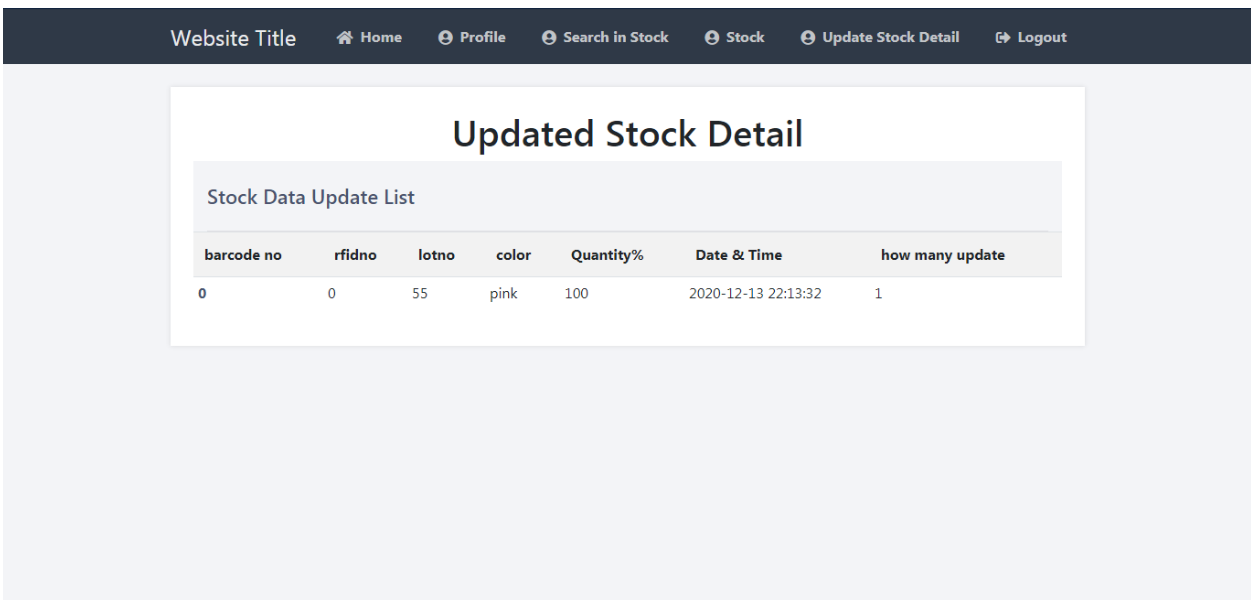


Figure 28 Profile Page



barcode no	rfidno	lotno	color	Quantity%	Date & Time	Action
0	0	99	yellow	44	2020-12-13 22:59:32	Edit Delete
2	122134	7878	blue	34	2021-01-06 18:54:40	Edit Delete
3	1219512066	7878	yellow	34	2021-01-06 22:40:48	Edit Delete
13	1855517272	55	red	55	2021-01-06 22:04:55	Edit Delete
15	1234567	56	purple	50	2021-01-06 15:34:20	Edit Delete

Figure 29 Stock Management



barcode no	rfidno	lotno	color	Quantity%	Date & Time	how many update
0	0	55	pink	100	2020-12-13 22:13:32	1

Figure 30 Updating Stock

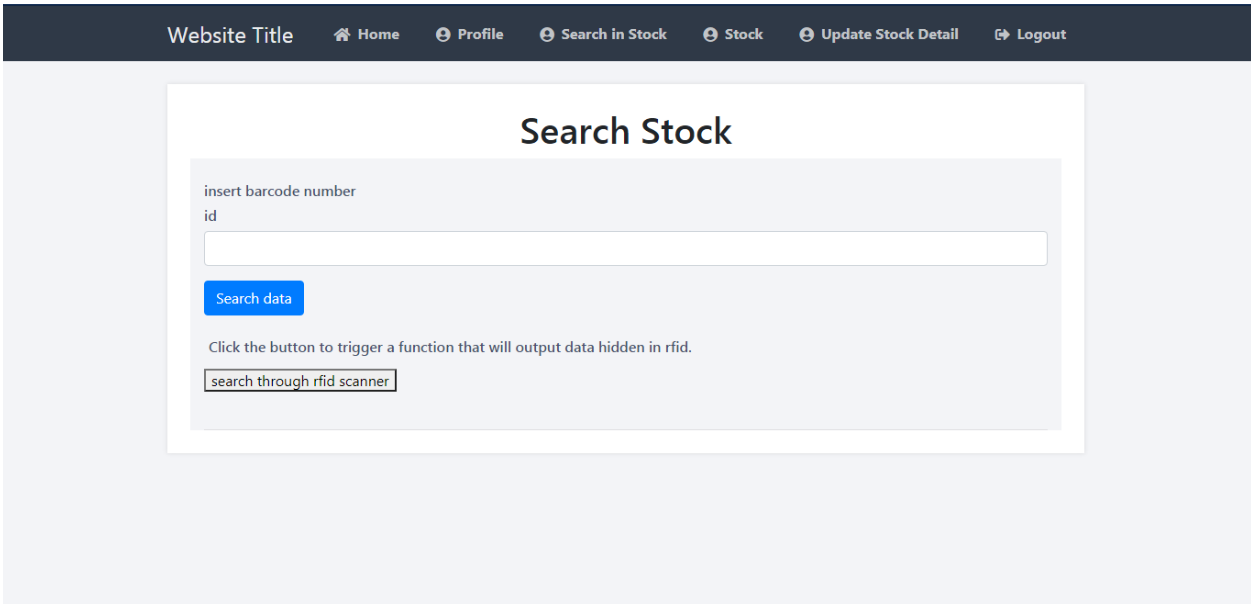


Figure 31 Searching Stock.

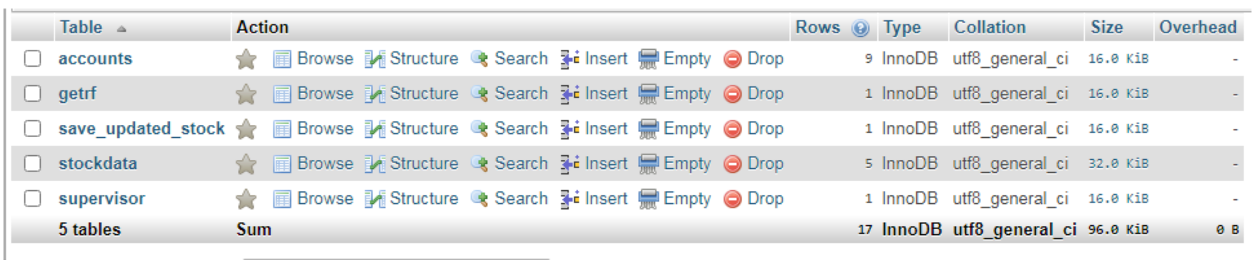
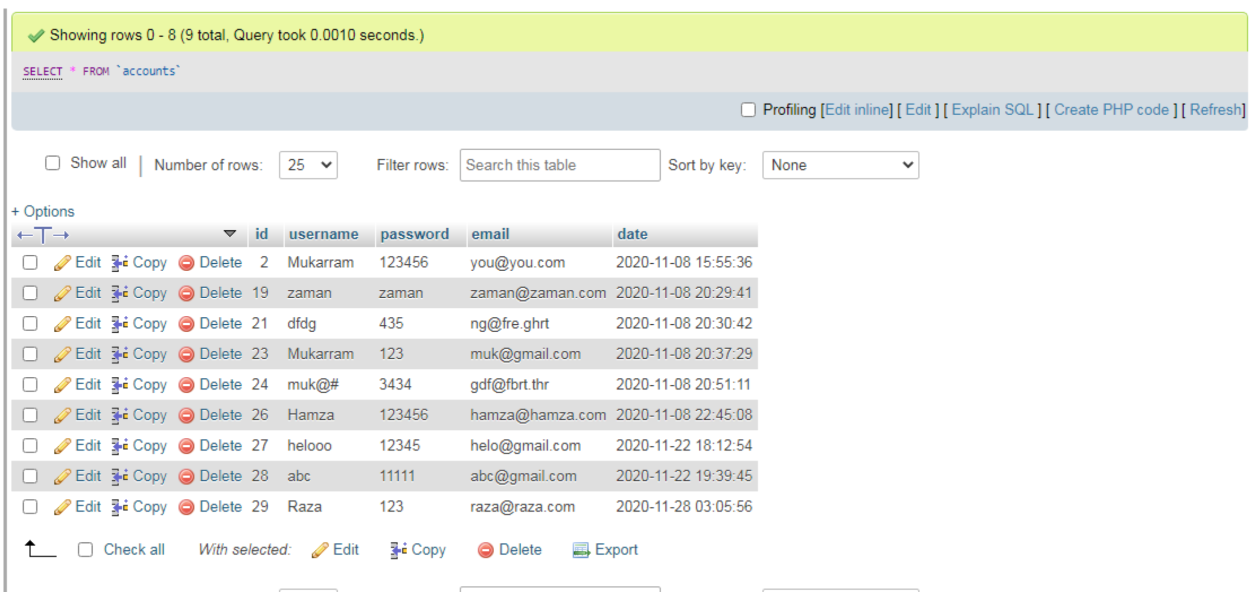


Table	Action	Rows	Type	Collation	Size	Overhead
accounts	Browse Structure Search Insert Empty Drop	9	InnoDB	utf8_general_ci	16.0 KiB	-
getrf	Browse Structure Search Insert Empty Drop	1	InnoDB	utf8_general_ci	16.0 KiB	-
save_updated_stock	Browse Structure Search Insert Empty Drop	1	InnoDB	utf8_general_ci	16.0 KiB	-
stockdata	Browse Structure Search Insert Empty Drop	5	InnoDB	utf8_general_ci	32.0 KiB	-
supervisor	Browse Structure Search Insert Empty Drop	1	InnoDB	utf8_general_ci	16.0 KiB	-
5 tables	Sum	17	InnoDB	utf8_general_ci	96.0 KiB	0 B

Figure 32 Database Tables



Showing rows 0 - 8 (9 total, Query took 0.0010 seconds.)

```
SELECT * FROM `accounts`
```

Profiling [Edit inline] [Edit] [Explain SQL] [Create PHP code] [Refresh]

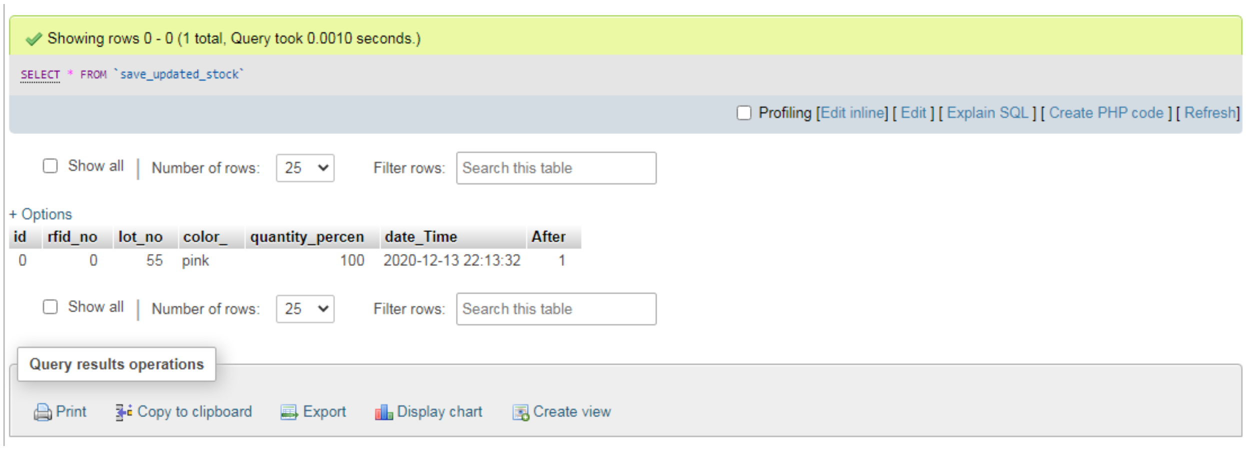
Show all | Number of rows: 25 Filter rows: Search this table Sort by key: None

+ Options

	id	username	password	email	date
Edit Copy Delete	2	Mukarram	123456	you@you.com	2020-11-08 15:55:36
Edit Copy Delete	19	zaman	zaman	zaman@zaman.com	2020-11-08 20:29:41
Edit Copy Delete	21	dfdg	435	ng@fre.ghrt	2020-11-08 20:30:42
Edit Copy Delete	23	Mukarram	123	muk@gmail.com	2020-11-08 20:37:29
Edit Copy Delete	24	muk@#	3434	gdf@fbrt.thr	2020-11-08 20:51:11
Edit Copy Delete	26	Hamza	123456	hamza@hamza.com	2020-11-08 22:45:08
Edit Copy Delete	27	helooo	12345	helo@gmail.com	2020-11-22 18:12:54
Edit Copy Delete	28	abc	11111	abc@gmail.com	2020-11-22 19:39:45
Edit Copy Delete	29	Raza	123	raza@raza.com	2020-11-28 03:05:56

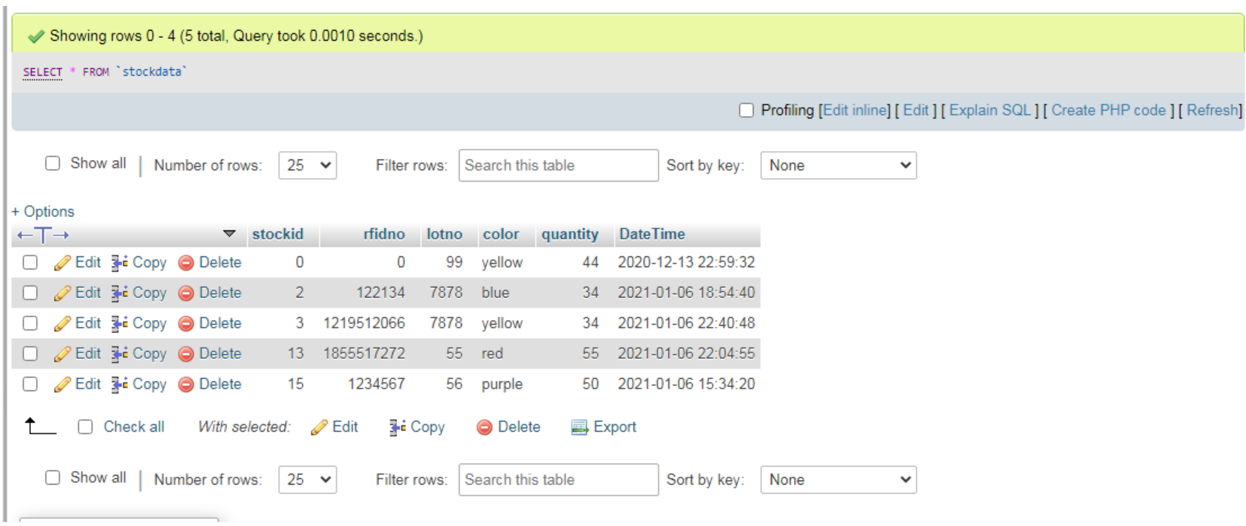
Check all With selected: Edit Copy Delete Export

Figure 33 Database User Registered



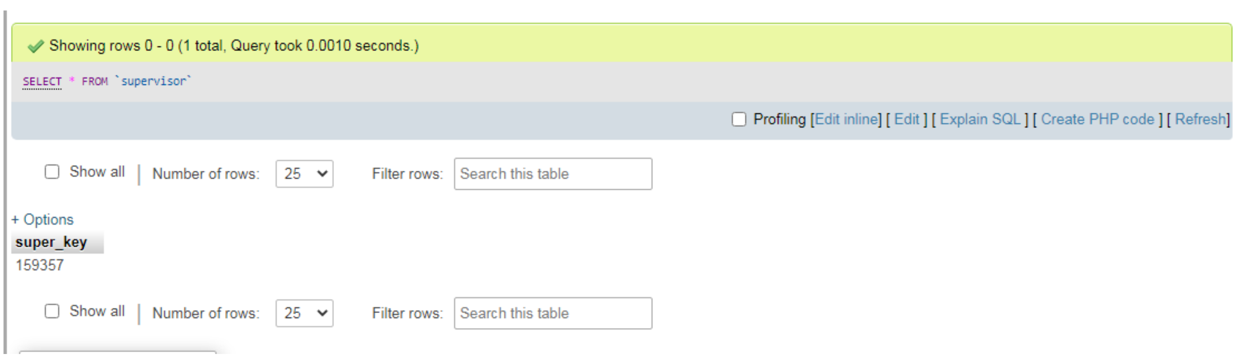
id	rfid_no	lot_no	color_	quantity_percen	date_Time	After
0	0	55	pink	100	2020-12-13 22:13:32	1

Figure 34 Sending Data to Database using RFID



	stockid	rfidno	lotno	color	quantity	DateTime
Edit Copy Delete	0	0	99	yellow	44	2020-12-13 22:59:32
Edit Copy Delete	2	122134	7878	blue	34	2021-01-06 18:54:40
Edit Copy Delete	3	1219512066	7878	yellow	34	2021-01-06 22:40:48
Edit Copy Delete	13	1855517272	55	red	55	2021-01-06 22:04:55
Edit Copy Delete	15	1234567	56	purple	50	2021-01-06 15:34:20

Figure 35 Product in stocks



super_key
159357

Figure 36 Super Key

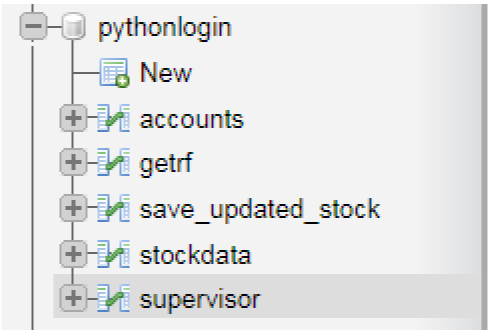


Figure 37 Data tables

Results & Discussion

I. Application of RFID in Warehouse:

The efficiency and effectiveness of the supply chain network is depending on the performance of its functional elements warehousing operations. They facilitate storage and buffer functions between upstream and downstream points of the supply chain. The core warehouse operations revolve around the flow of materials in the facility, which are receiving, put away, storage, order picking and dispatching. Receiving is the start of the warehousing process, in which the arriving items are unloaded from the transport carriers. Their identity, quantity and condition is checked at this stage, and items may be repacked to different stock keeping units.

II. Inventory/storage management:

As the technology advances, applications have been found incorporating RFID with other technologies/systems, on both software and hardware aspects. Software applications include a multi agent system used in the warehouse for controlling inventory and communicating with suppliers. The hardware aspect of RFID applications includes an unique method of material tracking (using RFID and IR) in the warehouse.

III. RFID system configuration:

RFID system set up for warehouse consisting of tags, readers, middleware and WMS. The system configuration can be tuned depending on the specific requirements.

IV. WMS

WMS and RFID technology are integrated at three levels: data collection, data movement and data management. Data collection is realized by RFID readers communicating with WMS via IT network and is analyzed and used by WMS as part of data management. However, continuous stream of data in regard to identification and location of tags puts a strain of WMS causing long processing times. In addition, WMS may not be readily able to communicate with RFID system, thus it is necessary to add an additional software layer that will enable data exchange.

A prototype of the RFID-inventory management system was built and the backbone of it is an Arduino interface which interacts with the RFID system. RFID tags and subsequently printing out RFID codes over an USB port terminal (COM4).

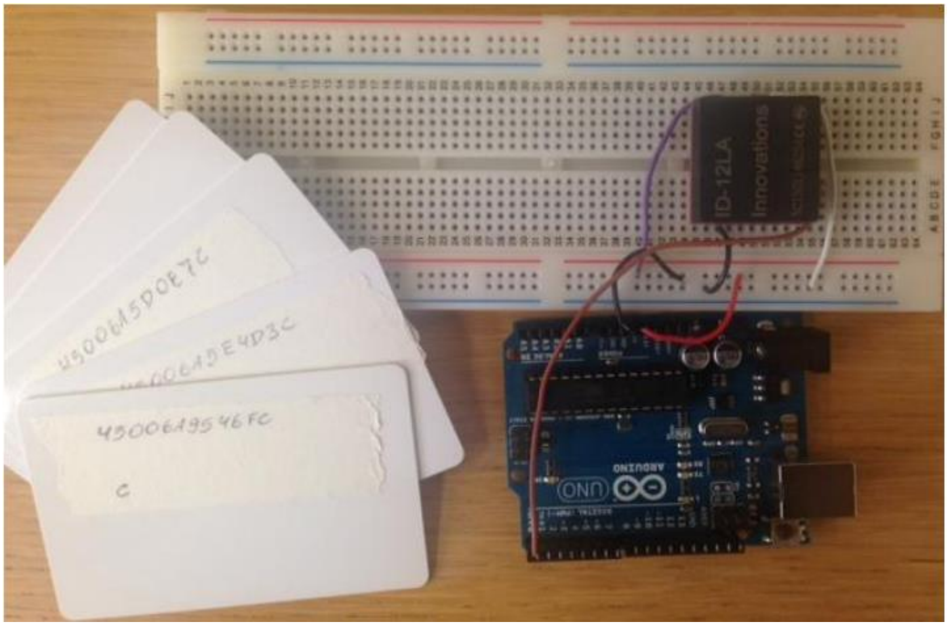


Figure 38 Components

RFID tags based on the following rules:

1) location of an ordered item

2) state of an ordered item

3) identity of an ordered item at a location

The developed RFID-based management system automatically identifies and detects several locations of the ordered item by displaying object rows and columns on storage racks.

Conclusion

The Project synchronize the products and information flow, both the RFID-inventory management system and the warehousing control system are integrated in order to communicate effectively through a developed interface on which a framework of this on-going work. The methodology for systems integration including hardware and software were identified and proposed as part of this work.

Future Work

An autonomous pick-and-place robotic system is presented. It is built to perform the tedious task of picking items in e-commerce fulfillment warehouses. The proposed robotic system comprises a lightweight robot manipulator, stereo cameras and other devices combined with their corresponding software modules. The software system is built using the modular approach.

Budget

S.No.	Items	Price/Unit	Unit	Price
1	Robot	40000	1	30000
2	Rack	10000	1	10000
3	Conveyor Belt	10000	1	5000
4	RFID / NFC Cards	200	10	2000
5	RFID Reader	20000	1	20000
6	Camera	20000	1	20000
	Total cost of Project			87000

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