Desktop-Based Expiry Date Application for Retailers Inventory Management

Nur Hazwani Ahmad Halil, Suzi Seroja Sarnin, Nani Fadzlina Naim, Azlina Idris, Wan Norsyafizan W Muhamad, Darmawaty Mohd Ali, Mohd Nor Md Tan, Mohd Rizal Dohad, Ros Shilawani S Abdul Kadir, Nur Syahirah Saipul
Universiti Teknologi MARA (UiTM) Shah Alam, 40450 Shah Alam, Selangor, Malaysia.

Zarina Baharudin Zamani
Universiti Teknikal Melaka, Durian Tunggal, Malaysia

E-mail: suzis045@uitm.edu.my, nanifadzlina@uitm.edu.my, azlina831@uitm.edu.my, syafizan@uitm.edu.my, darma504@uitm.edu.my, mohdn829@uitm.edu.my, ros885@uitm.edu.my, syahirah.saipul25@gmail.com, zarina@utem.edu.my

Abstract

Inventory management is a complex process that requires constant evaluation and control. It is essential for retailers to perform inspections regularly to ensure that all goods are available for sale and in good condition to meet customer expectations. While many retailers are still dependent on manual paper-based method, it poses a high risk of human error and causes negative impact on inventory management and eventually the business. It is not only labor-extensive, but also time-consuming. This project is proposed to automate inventory management process by developing a real-time inventory monitoring system and notify user on low stock items and items close to expiration. The desktop-based inventory management application is equipped with a PC and a handheld scanner and involve three main inventory processes; scan incoming inventory, scan outgoing inventory during customer checkout and allow users to manage stock counts and update data if necessary. The desktop application is developed using Windows Forms form as user interface and SQL Server as the database engine which enables the users to monitor stocks in real-time. As a result, users can use the desktop application to monitor inventory levels and receive notifications when items need to be restocked or nearing their expiration date. As different item categories may need different reminder durations based on expiry dates, users entering the correct password are able to update the minimum quantity and minimum duration for each item category for notification purposes. With this system, issues related to inventory can be resolved quickly based on real-time data monitoring, less time spent for repetitive works while providing a better customer experience.

Keywords: inventory management; desktop application; expiry data tracking.

1. Introduction

Inventory management has been widely studied as part of Industry 4.0 movement while helping retailers to manage businesses better. Inventory management is crucial for any retail industry be it huge organizations or small businesses. Retailers are expected to sell only good products and ensure products remain available for customers. A well-established organization has a team of inventory planners dedicated in managing and controlling inventory. However, small businesses do not have the luxury of establishing a team and dedicate only one person in managing stock incoming and stock checking manually at the end of the day. In fact, many retailers are still dependent on manual paper-based methods to inspect their inventory, which poses a high risk to inventory management. This is due to retailers often failing to notice low stock and expired items, which can lead to a negative customer shopping experience. While retailers often perform inventory checking periodically, this process is time-consuming when resources can be directed to a more prioritized task. As there is a possibility of human error in conducting inventory inspection, the consequences include food waste and eventually lesser revenues for retailers. This is due to unsold items having passed the expiry date without retailers' knowledge. In the European Union, nearly 57 million tons of food waste (127 kg/inhabitant) are generated annually with estimated market value at 130 billion euros [1]. 17 percent of food produced globally is wasted at the retail, food service, and consumer stages [2]. A lot of parties are accountable to address food waste issues, but the primary entity is the retailer. Furthermore, food waste is recognized as a setback in achieving Sustainable Development Goal (SDG) as it is mentioned in the United Nations 2030 Agenda for SDG where target 12.3 states "…to halve per capita global food waste by 2030 at the retail and consumer levels and reduce food losses along production and supply chains". The achievement of SDG 12 can be enhanced by the implementation of circular economy strategies based on the reduction of food waste [3]. With up to 60% of supermarket sales deriving from the perishable category [4], food retailers face an ongoing challenge in managing sell-by dates effectively and this matter can certainly be avoided with a good inventory management system.

In order to address the inventory issues discussed, this project is proposed to improve inventory management. With this project, retailers will be able to use the system to monitor inventory and reduce workload by automating repetitive tasks with less risk of mishandling inventory inspection. Real-time monitoring feature supports Industry 4.0 move by making the system agile, easily accessible and provide a summarized dashboard that is extremely beneficial for the user. Apart from improving operational efficiency, this project enables retailers to make informed business decisions, such as selling items nearing expiration at a discounted price, which ultimately reduces food waste.

1.1. *Review of Related Studies*

Many studies have focused on developing applications to automate inventory tracking. In [5], the author designed a web application for inventory management using full-stack framework RedwoodJS and TypeScript. Although extensive experiments were conducted, the possibility of an unstable internet connection was not considered. This is a high-risk factor that could prevent users from using the system, as web-based applications are heavily reliant on the internet. In [6], author conducts performance analysis of inventory management by developing a mobile PC-based stock management using Java for real-time inventory management and based on customers' orders. However, the author does not include product conditions or expiry date tracking and it works solely based on orders. Authors in [7] developed a desktop-based web application for production industries in managing inventory and keeping records. This paper presented a development using Model-View-Controller (MVC) architecture for administrators use. However, the scope of this project is limited to the production industry and does not include retailers.

There have been several significant studies on inventory expiry date tracking. In [8], authors focus on detection and recognition of expiry date on food packaging using deep neural network (DNN) approach where image processing takes place to record the expiry date printed. However, this paper does not discuss inventory management and data storage. In [9] and [10], author experimented on integrating IoT into food inventory tracking system where Arduino UNO microcontroller is used as the 'brain', load cell, MQTT broker, desktop application and Android application are used to display real-time data. The system simulated is for inventory tracking purpose only through weight sensing. Despite this, expiry date monitoring is not included in the mobile application. The application is suitable for inventory monitoring, but not when there is a large amount of data stored on the server, especially if the application is meant for retailers. In [11], authors studied on packaged food expiry tracking to reduce food waste. A web application is designed for users to enter products and the expiry dates. The data is stored in MongoDB as database and user will receive an SMS to notify any products close to expiring. The same concern arises when considering the condition where Internet condition is unstable when using a web application.

Based on the review, this paper shall focus on improving inventory management. To automate the inventory management process, a desktop-based application is proposed with SQL Server as the database. Desktop application is selected so user can always use the system despite unstable Internet connection. An alternative of local data storage is proposed, and data will be stored once connection to SQL Server is established again. Furthermore, a desktop application has the benefit of lower exposure to security risks, more robust and providing consistent user experience. With just one desktop application, users can perform many activities that include scanning incoming inventory and outgoing items by installing a scanner to the PC while monitoring inventory levels and receiving notifications of low stocks and expiring items. This is not only helpful for inventory inspection but also provides solution and ease of business decisions for retailers.

2. Methodology

2.1. *System Design*

Fig. 1 illustrates the proposed overall system design. Users can utilize the desktop application at an PCs after software deployment and connection to SQL Server is established. The application can be used whether during incoming inventory scan-in, at the cashier counter during customers checkouts or if any users require to monitor the stock levels. The system is equipped with a scanner for scanning processes

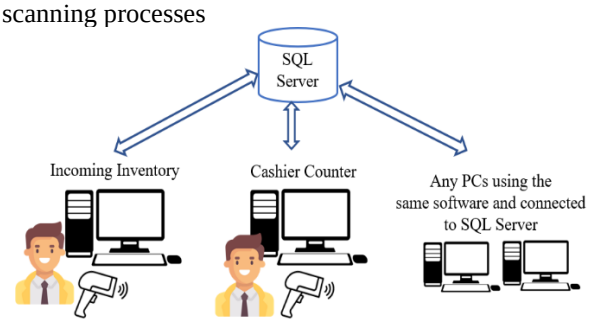

Fig.1 System Design.

The system must be capable of below processes (Fig. 1):

i. Scan-In:
Users scan incoming inventory and enter all required data such as quantity, price, and expiry date. All data will be stored in SQL Server.

ii. Scan-Out:
Users scan outgoing inventory at the cashier counter and system can calculate total price and quantity of each item during checkout. SQL will deduct the input quantity from inventory data.

iii. Notification:
User will be notified through the application once low stocks detected and items nearing expiration based on items categories such as canned food and milk. The notification shall stop appearing once the user acknowledge and entered the correct password.

iv. Inventory Management:
Users can monitor and update stock levels and data through the desktop application. As notifications are given based on categories, users can customize their notifications to fit their needs by specifying the minimum stock level, and the minimum duration until expiry date to receive notifications.

2.2. *Inventory System Flowchart*

Fig. 2 illustrates the sequence of the proposed system. Before any users can utilize the system, the user must install a scanner to the PC and connect to the Internet for server connection to SQL Server. Firstly, connection to SQL Server must be established with specified user login details and password. The system can be categorized into three processes. The first process is scan-in during incoming inventory. After connection is established, the user must be able to scan in item barcode for incoming stocks and enter required data such as item name, item category, quantity, expiry date, price. An alternative is needed in the case of unstable Internet connection that affects data storage activity. To cater for unsuccessful data logging to SQL Server, data is stored locally in .csv

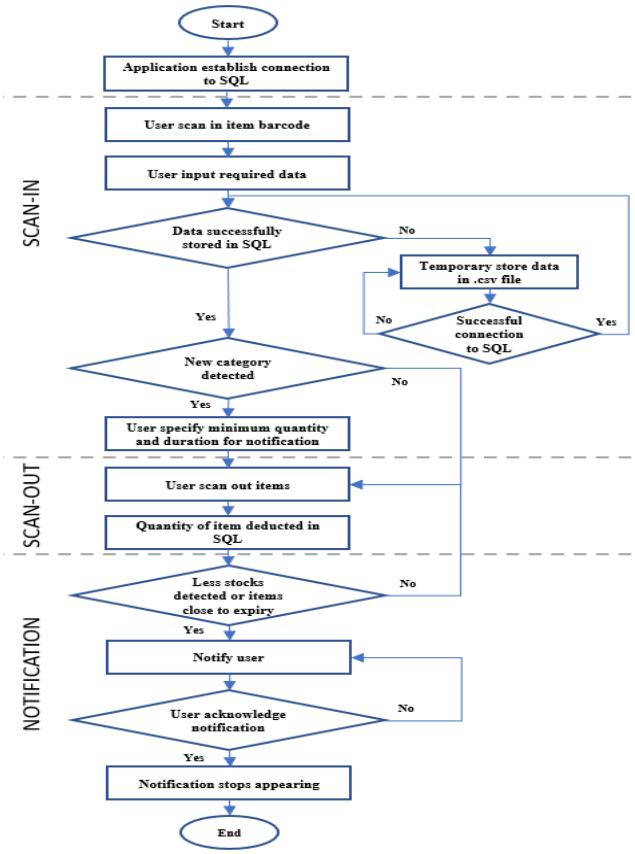

Fig.2 Overall Flowchart of Inventory System.

file and stored in SQL Server once connection is established again as the system is designed to continuously try to reconnect to database.

Secondly, scan-out process during checkout. Users can continue using the system at the checkout counter where the application can display prices and automatically deduct quantity in the database. Thirdly, notification for the users. When low stock or items close to expiry date are detected, an alert will continue to display on the application until the user acts. User must acknowledge for the notification to disappear. A display of inventory summary is helpful for inventory analysis and enables retailers to make business decisions.

2.3. *Overall Software Architecture*

This project uses three-tier architecture as shown in Fig. 3. The closest to client is called the presentation tier. This tier contains Windows Forms form as an interface between the user and the system, to display data and get input data from user. This tier is the most crucial as it plays the role of communicating with users through the interface. The interface must be planned and designed properly to ensure a great view of system as it mirrors how well-structured a system is. Despite data transfer can go through two-tier architecture from presentation tier to data tier, a business layer in three-tier architecture is vital in ensuring input and output data from data tier are validated. This layer prevents the presentation tier to have direct access to data tier, where an additional gate to verify input and output data are correct before proceeding to access data tier. This can avoid assertion errors from database as well as output to presentation layer. The data tier is where information is stored and retrieved from a database of file system. The information is then passed back to the business tier for processing and eventually back to the user. The three-tier architecture in this project consists of presentation layer using Windows Forms form programmed with Microsoft Visual Studio in .NET environment and C# language while data tier uses SQL Server.

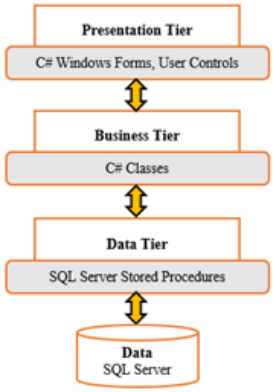

Fig.3 Three-Tier Architecture.

2.4. *Hardware and Software Setup*

2.4.1. *Hardware*

This project requires a handheld scanner for items barcode scanning and one PC for desktop application.

2.4.2. *SQL Server*

For storing and retrieving data, SQL Server is used as the database engine. This project is tested with a server and specifically created login ID and password. As a validation gate, stored procedures are created for data insertion, data update and constant checking of inventory status. Fig. 4 illustrates the software flowchart for notification purposes if user chose to enable notification.

Fig.4 Software Flowchart for Notification.

2.4.3. *Microsoft Visual Studio*

Microsoft Visual Studio acts as the brain in this project as it is widely used for programming environment and the most popular framework among programmers. Some advantages include its capability to support multiple programming languages, Intelli-Sense feature that helps programmers to detect incomplete portions of the code, cross-platform support on Windows, Linux, or Mac Systems and most importantly the ease of use for multi-projects management. As for programming language, this project uses C# in .NET 4.0 framework. Fig. 5 shows the flowchart of how .NET C# works. As for interface, a Windows Forms form is created to display out data from SQL Server. The interfaces are for users scan incoming items, scan outgoing items, show summary of inventory and alert user.

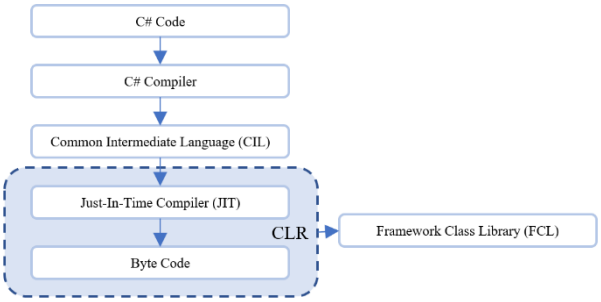

Fig.5 NET C# Structure.

3. Results

Through one desktop application, three tabs are created for users namely “Scan In”, “Scan Out” and “Summary” to fulfil the retailer’s needs.

3.1. *Scan In*

Fig. 6 shows the interface of scan in process during incoming inventory. Once the scanner is connected, the user can scan barcode and enter required data where all fields are not nullable.

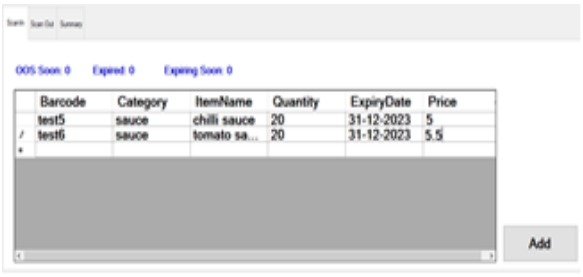

Fig.6 Scan-In Process

Two possibilities are expected when the user clicks the Add button. Fig. 7 shows the alert popup once items are stored successfully. Meanwhile, Fig. 7 shows a popup when the category entered is not found in history. User needs to define the minimum quantity and minimum duration for notification purposes. Otherwise, data will not be stored. In the case where Internet connection is unstable, data are alternatively stored in a .csv file until connection is established again. Fig. 7 shows the popup when application sensed connection to SQL is interrupted.

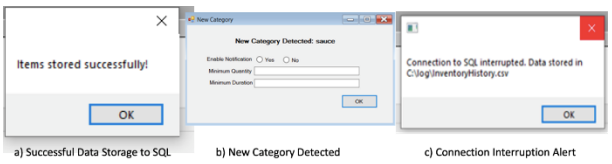

Fig.7 Scan in Possibilities.

3.2. *Scan Out*

The scan out process occurs during customers checkout at the counter. In this process, the important parameters are quantity and price. Fig. 8 shows the interface during scan out and item quantity in database will automatically be deducted once button Done is clicked.

Fig.8 Scan-Out Process.

3.3. *Notification*

The most crucial output of this project is the notification to the user. In each of the tabs created, a one-liner status is displayed so users will always notice the alert. Three categories of alert are "OOS Soon" indicating low stock, "Expired" for expired items and "Expiring Soon" for items nearing expiration. Fig. 9 shows the one-liner status displayed at the top and Fig. 10 shows a popup alert that displays at 10 a.m., 3 p.m. and 10 p.m. These timeframes are chosen based on the usual store's operating hours.

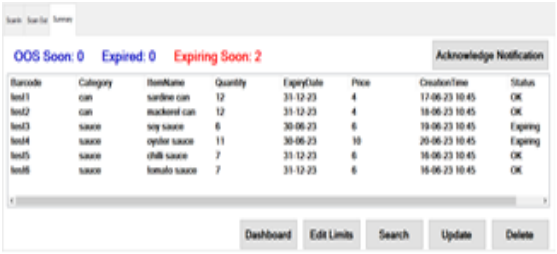

Fig.9 Summary View.

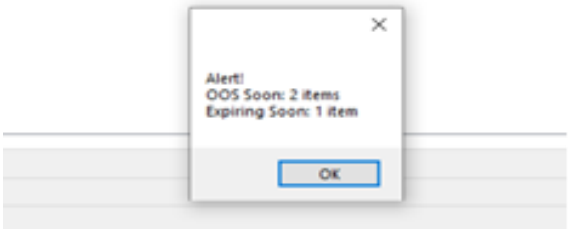

Fig.10 Notification Alert.

To ensure user acknowledge the notification and avoid the constant popup, user may enter the correct password once button "Acknowledge Notification" shown in Fig. 10 is clicked. Fig. 11 shows the password prompt box when any administrators activities initiated.

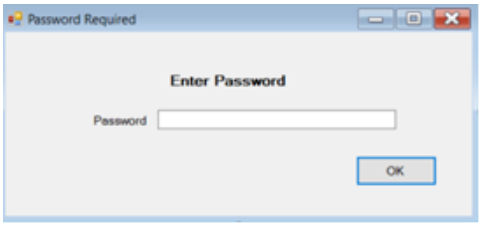

Fig.11 Password Prompt.

3.4. *Administrator Activities*

The same password prompt of Fig. 12 will pop up and correct password will allow the action to proceed. Meanwhile, the button "Edit Limits" is meant for user to edit the low stock and nearing expiration notification based on category. Fig. 12 shows the display when user clicks on "Edit Limits" button. Application will fetch existing categories from SQL and displayed in combo box. Users can decide to enable notification for the item categories and specify minimum quantity and duration until expiration for notification purposes. Considering the case where items remain idle in the inventory system, an alert will pop up for user to decide whether to delete the item from history or let it remain in the system. As for "Dashboard" button, user is capable to view items based on the overall inventory status. This will give the user an overall view of current stock levels and thus help the user to decide on next sales actions. Fig. 12 shows the dashboard view.

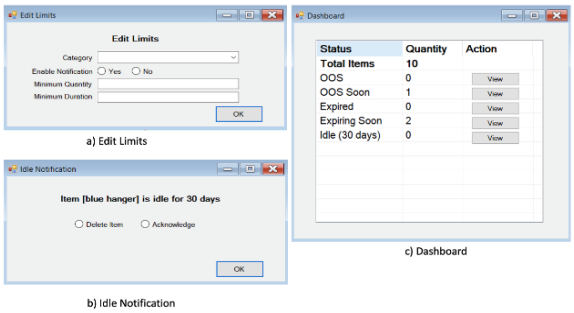

Fig.12 Administrator Activities.

This section has presented all the results gathered and discussion for each part of the system. Apart from monitoring quantities and expiry dates, the application provides retailers an overall view of inventory stocks with added features. Furthermore, a system connected to SQL allows users to monitor data in real-time.

4. Conclusion

In this project, a desktop-based application for inventory management is proposed. The inventory system aims to automate manual inventory management

process, provide real-time data accessible in many hosts and notify users on low stock items and items close to expiration. The efficiency is evident as the application is tested and demonstrated all the scopes mentioned; to manage incoming and outgoing inventory while monitoring stock levels. For future developments, it is suggested that the dashboard view should have a user-friendly display such as bar charts summary display as the development in this project has limitation in terms of the .NET framework. Secondly, notification to users' mobile phone would be extremely helpful to alert users more prominently. Apart from that, a shelf based IoT system can be integrated into the system to have double validation between quantity at the shelf in comparison to quantity in database.

Acknowledgements

The authors would convey their profound appreciation and gratitude to the College of Engineering, Universiti Teknologi MARA, Shah Alam, Selangor, Malaysia for permitting us to perform this study. Special thanks to those who contributed to this project directly and indirectly.

References

1. Eurostat, "Food waste and food waste prevention – estimates" October 2022.
2. UNEP, "Planetary Action: climate, nature, chemicals & pollution," 2021.
3. United Nations, "The 2030 Agenda for Sustainable Development. Sustainable Development Goals," 2022.
4. B. Weber, S. Herrlein and G. Hodge, "PlanetRetail : The Challenge of Food Waste," 2022.
5. X. X. Ong, "Inventory management web application," Nanyang Technological University, Singapore, 2023.
6. H. K. Krishnappa and S. Abbigeri, "Performance analysis of Store Inventory Management (SIM) an Enterprise Application developed using Java," International Research Journal of Engineering and Technology (IRJET), vol. 6, no. 5, pp. 6725-6728, 2019.
7. P. G. Mehar, H. Umredkar, D. Vaidya, R. Somkuwar, A. Borkar, A. Pardhi, "Development of Inventory Management Systemin Production Industry," International Research Journal of Modernization in Engineering Technology and Science, vol. 5, no. 4, pp. 2528-2531, 2023.
8. L. Gong, M. Yu, W. Duan, Y. Xujiong, K. Gudmundsson and M. Swainson, "A Novel Camera Based Approach for Automatic Expiry Date Detection and Recognition on Food Packages," IFIP International Federation for Information Processing, pp. 133-142, 2018.
9. S. P. L. Narayan, E. Kavinkartik and E. Prabhu, "IoT Based Food Inventory Tracking System," CCIS, pp. 41-52, 2019.
10. A. S. Shelake, P. V. Sonawane, S. S. Ghumare, P. S. Deshmukh and P. R. Pingale, "IoT Based Food Inventory Tracking System for Domestic and Commercial Kitchens," International Journal of Scientific Research and Engineering Development, vol. 3, no. 1, 2020.
11. S. Bansal, R. Khokar and S. Chandran, "Best Before: An Expiry Date Checker Website to Track the Expiry of Perishable Items," in Proceedings of the International Conference on Innovative Computing & Communication (ICICC) 2022, New Delhi, 2022.

Authors Introduction

Nur Hazwani Ahmad Halil

She is working as a software engineer in a multinational company in Selangor, Malaysia. She graduated with MSc. in Telecommunication & Information Engineering from UiTM Shah Alam and Bachelor (Hons.) Electrical & Electronic Engineering from Universiti Teknologi PETRONAS. Her interests include embedded system, information engineering and software development.

Ir. Ts. Dr Suzi Seroja Sarnin

She is working as a Senior Lecturer at School of Electrical Engineering, College of Engineering, UiTM Shah Alam, Selangor, Malaysia. She received PhD in Wireless Communication UiTM, Master of Science in Microelectronic and Degree in Electrical Engineering UTM. Her interests include Wireless Communication and IoT.

Ir. Ts. Dr Nani Fadzlina Naim

She is working as a Senior Lecturer at School of Electrical Engineering, College of Engineering, UiTM Shah Alam, Selangor, Malaysia. She received PhD in Electrical, Electronic and System Engineering UKM, Bangi. Her interests include Optical sensor, Fiber Bragg Grating (FBG) based sensor, Optical Network.

Prof. Ts Dr Azlina Idris

She is working as a Professor in School of Electrical Engineering, College of Engineering, UiTM Shah Alam, Selangor, Malaysia. She received PhD in Wireless Communication. Her research interest includes Wireless Communications, Signal Processing, Multiple Access, Space Time Coding and Coding Theory, Internet of Things (IoT), 5G systems, Multiple input Multiple output (MIMO).

Ir. Ts. Dr Wan Norsyafizan W Muhamad

She is working as a Senior Lecturer at School of Electrical Engineering, College of Engineering, UiTM Shah Alam, Selangor, Malaysia. Her interests include Wireless Communication.

Assoc. Prof. Ir. Ts. Dr Darmawaty Mohd Ali

She is working as an Associate Professor in School of Electrical Engineering, College of Engineering, UiTM Shah Alam, Selangor, Malaysia. She received her PhD of Wireless Communication, University of Malaya. Her research interest includes Wireless Access Technology, QoS Provisioning in Wireless Network.

Mohd Nor Md Tan

He is working as a Senior Lecturer at School of Electrical Engineering, College of Engineering, UiTM Shah Alam, Selangor, Malaysia. He received Master in Radio Frequency Communication Engineering, Bradford University, Bradford, UK. His research themes include Antenna Design Technology.

Mohd Rizal Dohad

He is working as a lecturer at the School of Electrical Engineering, College of Engineering, UiTM Shah Alam, Selangor, Malaysia. He received a Master of Science in Telecommunication and Information Engineering at UiTM and Bachelor of Engineering (Electrical) with Honors at UTM. Directly engaged in research projects based on the Internet of Things and Electronic Engineering.

Ts. Dr. Hjh Ros Shilawani S. Abdul Kadir

She is working as Senior Lecturer at School of Electrical Engineering, College of Engineering, UiTM Shah Alam, Selangor, Malaysia. Her research interests include Biomedical Engineering, with a particular focus on human body electromagnetic radiation and other human-related studies.

Nur Syahirah Saipul

She holds a Bachelor's degree in Electronic Engineering and a Diploma in Electrical & Electronic Engineering from UiTM. Currently, she is pursuing an MSc in Electrical Engineering at UiTM Shah Alam. Her areas of interest include communication systems and Internet of Things project.

Ts. Zarina Baharudin Zamani

She is working as a Senior Lecturer at Fakulti Kejuruteraan Elektronik dan Kejuruteraan komputer, Universiti Teknikal Melaka, Durian Tunggal, Malaysia. She received Master in Microelectronic, UKM. Her interests include VLSI, IC Design, PCB.