ENTHUSIASTIC
INTERNATIONAL JOURNAL OF APPLIED STATISTICS AND DATA SCIENCE
Volume 3, Issue 2, October 2023, pp. 125-138

Real-Time Wi-Fi Signal Monitoring from a User Perspective in a Wireless Environment Using the Internet of Things

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ARTICLE INFO

Keywords
Internet of things
Wi-Fi
Raspberry Pi
Wireless environment
Access point

ABSTRACT

Mobility issues, such as handover, should be considered in a wireless environment. Real-time Wi-Fi monitoring from a user perspective is important because it is used to keep track of the Wi-Fi performance and status. Thus, improving network efficiency allows users to work more efficiently. The monitoring currently being held on the Wi-Fi is not in a real-time perspective. The monitoring is only focused on the connection between the controller and the Access Point (AP) and the AP to the user devices. We proposed a way to monitor the Wi-Fi from a real-time user perspective in a wireless environment. This project will use the Raspberry Pi as a device (RP). This is because RP has an operating system that can replace personal computers in terms of monitoring the access point from the user's point of view. This device will make monitoring tasks more efficient and faster for the user to identify the problems occurring at the Wi-Fi network. This research will also enable the usage of the existing Internet of Things (IoT) to develop new things. To conclude, monitoring using an IoT device can project the view of the Wi-Fi performance from a user perspective.

1. Introduction

In this modern world, internet is the most required information and communication technology (ICT) that brought a revolutionary change in the information scenario. Malaysia is a country that is being developed, and not to miss paying attention to the field of technology, especially in terms of expanding the use of the internet [1]. The use of internet in universities has increased, and it has become an essential part of student life [2]. Every internet user in Universiti Kebangsaan Malaysia (UKM) needs fast and efficient internet access to perform their daily tasks. As such, every UKM resident needs unlimited fast internet access to contact each other, especially students who are still living in residential colleges, to get faster and more stable internet access than in their hometown. The lack of real-time monitoring of the status of Access Point (AP) available in the vicinity of UKM will cause the problem-solving process will be less efficient. The idea arose to put a computer on each AP with this problem. With this, the Centre for Information Technology (PTM) staff do not have to come to every problem area to bring their personal computer/personal computer (PC) to find out the status of the AP every time a problem occurs. But by placing computers in each AP, this

p-ISSN 2798-253X
e-ISSN 2798-3153

process will require frequent maintenance and appliance security issues, and it will also issue a lot of capital as there are about 3525 APs in UKM.

The Internet of Things (IoT) is one of the most important components of the Fourth Industrial Revolution (4IR) [3]. IoT is emerging as a leading technology for smart object communication [4], and as a powerful domain where embedded devices and sensors can connect and exchange information over the internet [5]. The IoT has an excellent opportunity to deliver more accessibility, availability, and scalability to the world [6]. With the advancement of IoT technology that has already evolved like a mushroom growing after rain, the solution to this computer problem can be curbed using a device called Raspberry Pi (RP), as this RP can act as a PC. The Raspberry Pi is used as a web server to store the information in the database [7]. With the same software as PTM UKM staff, RP can scan the AP status at a remote location. With this, the maintenance cost will be reduced, and it will also use the lower cost for the preparation of programming the RP so that it can function as it is known. The remainder of the paper is organized as follows. In Section 2, we introduce a literature review. Section 3 describes the methodology. Finally, we describe the conclusion in Section 4.

2. Literature Review

Today, wireless technology has become compulsory for an organization. The Centre of Information Technology, Universiti Kebangsaan Malaysia, has also realized this technology through the use of Wi-Fi 6 technology which applies IEEE 802.11AX standard, which is faster and more stable for all its campus citizens. This technology is not only designed for the speed of internet access, but it can address the problem of multi-devices management. UKM has set a single SSID to "MyUKM" for all its citizens, and the system will be able to identify the access from staff, students, or guests. MyUKM can be accessed by students, staff, and other guests in the UKM environment. UKM's Wi-Fi coverage area covers almost 100% of the occupied areas within the UKM campus. UKM students can use these services to access the internet when they are within the vicinity of UKM. This makes it possible for them to use various online technological tools when they are on campus. Studies have shown that the usage of wireless technology can provide new learning opportunities to the learners by increasing their interest in education [8], providing an opportunity for independent learning [9,10], and allowing learners to overcome physical barriers such as distance from the source of information with ease through the use of online libraries and other online sources [11]. Fig. 1 shows the network connection diagram currently in use in UKM. The use of Virtual LAN is to ensure network security.

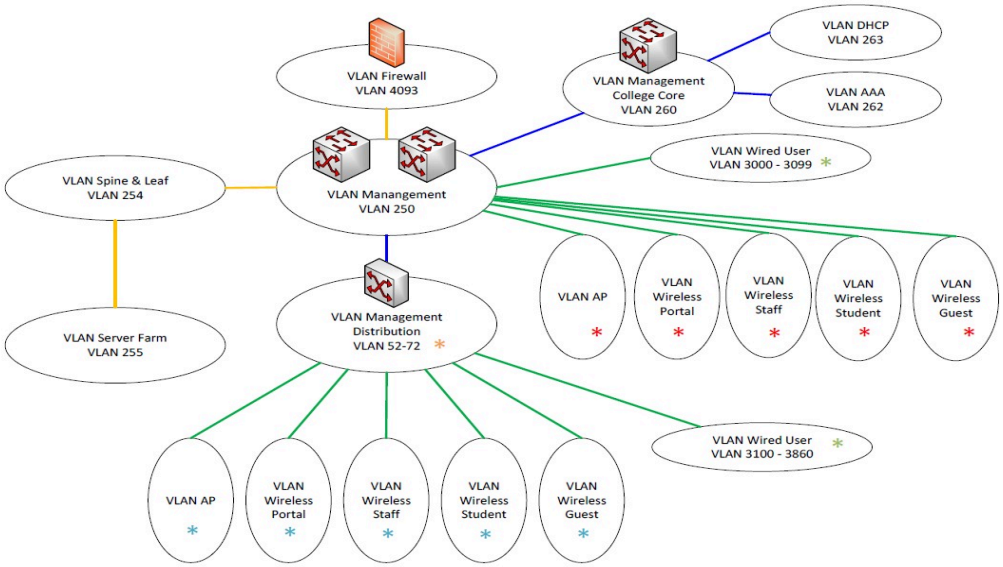

Fig. 1 Existing systems in the UKM area.

p-ISSN 2798-253X
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Fig. 2 shows the AP connection in the UKM environment. There are 3525 APs connected in UKM that covers the student's hostels and administration buildings. This amount also included the AP located in 13 UKM branch campuses.

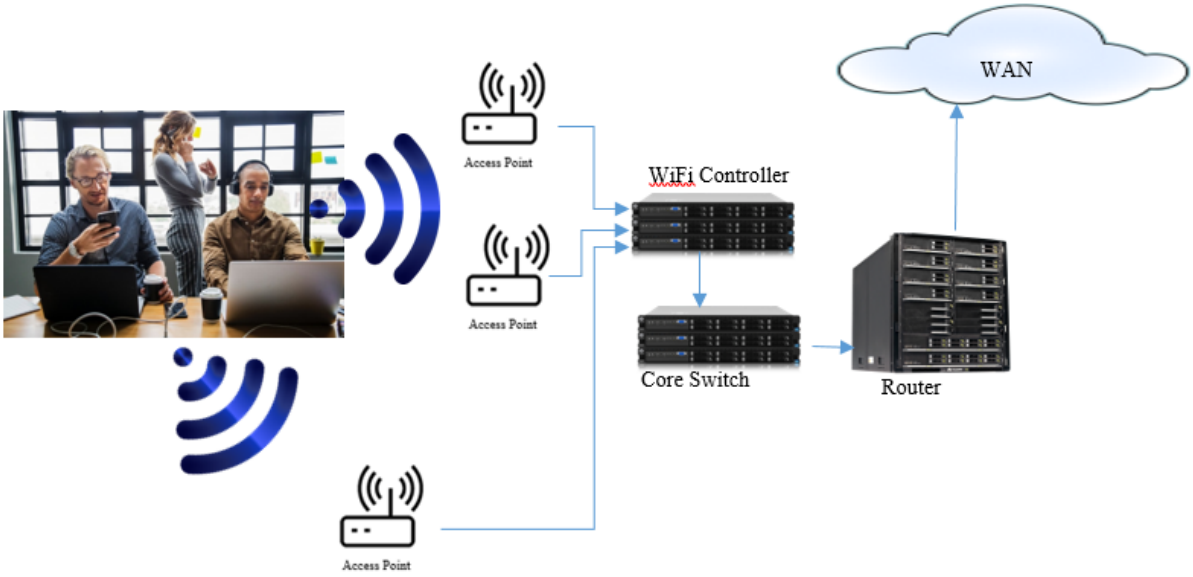

Fig. 2 AP Connections in UKM.

2.1. Comparison and Difference of Access Point Monitoring System

2.1.1. Comparison and Differences of IoT Hardware Systems

Table 1 shows the comparison between the three IoT technologies, namely RP, Arduino, and PC. This study focuses more on developing systems in the IoT RP, specifically RP 3 and RP 4. This is because RP has very similar features as a PC at a much lower price than a PC. The Arduino could provide more uses, but in this study, the addition of such other components will not be used to monitor existing APs.

Table 1. Comparison between RP, Arduino, and PC

Characteristics	Raspberry Pi	Arduino	PC
Construction	A motherboard that contains all the essential components that make up a computer	An appliance that only performs one of the same tasks	Made of components combined to form a computer
Connector	4 USB ports, 1 HDMI port, 1 Audio Port, and 1 Ethernet Port	Components can be added such as Wi-Fi, Ethernet, GPS, touch screen, and others	It has many USB ports, 1 or 2 HDMI ports, 1 audio port, 1 mic port, capable of using HDD/SSD/SATA hard drives, and SD card slots
Memory and storage	Uses micro SD cards of various load sizes	32kb existing storage	Can be added and faster than micro SD
Size	Small as a regular credit card. Size: 3.37in × 2.22in × 0.67in	Small 2.7in x 2.1in	Big Average size: 14in x 7in for small size 24in x 8in for full size
Price	Range RM239.00 - RM350.00	Range RM90.00 – RM200.00	Average Price RM 2500.00

RP is an IoT component that is very easy to use and modify. The cost of owning and buying an RP appliance is cheap compared to other appliances. RP uses the same keyboard and mouse as a normal computer. RP is also a small tool that allows its users to explore new worlds of computers

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e-ISSN 2798-3153

and allows them to learn new programming languages such as Scratch and Python. In addition, RP can also interact with the outside world. This means that RP can allow its users to create new projects in this world.

2.1.2. Comparison of Programming Languages

The system developed in this study is a monitoring system used by PTM UKM staff who use PCs, smartphones, and tablets. Such a system should be installed in all of the following appliances. Therefore, web programming, Hypertext Markup Language (HTML), is the most suitable programming for using this system. By using web programming, developers can build a web server that can interact with users and provide all the information regarding the AP that users want to monitor.

Next, the developer uses the RP tool to access the data from the AP to be monitored. RP appliances will typically use Raspbian OS, which is already included with the Python programming language. This is great because the python programming language is a scripting programming language that can interpret code developers write to machine code.

The Python programming language is a highly advanced, object-oriented, and dynamic programming language [12]. The data structure built by python is at a high level. This Python programming language is connected with dynamic typing and binding, making it easy to develop. Python is also easy to learn because of its straightforward syntax and does not require a lot of things to include in the built-in code.

2.1.3. Database Comparison

A database is a set of structured data housed in a computer, which can be accessed in many different types. The database is also a data repository that will be used in this AP monitoring system that will be developed, so selecting a good database is important to make this AP monitoring effective and run smoothly. Various types of databases can be used to develop this AP monitoring system. Among them are:

a. phpMyAdmin
b. Oracle 12c
c. MySQL
d. MongoDB
e. MariaDB
f. Microsoft SQL Server
g. DB2

The easiest database to build and also easy to maintain is phpMyAdmin. This is because this database can be written in PHP code that can be placed in HTML code for the website construction process of this AP monitoring system [13].

2.1.4. Selection of Hardware and Devices

In the development of this system, the following are a selection of programming languages and databases that will be used to build a real-time Wi-Fi signal monitoring system from the user's perspective in the UKM wireless environment via the IoT:

a. Python
b. HTML
c. PHP
d. phpMyAdmin

This programming language is the best combination for developing a monitoring-based websites. This combination allows different programming languages to interact using the selected database. Website development for this system is very compatible with users who want to monitor the status of AP because users only need a device that has a connection to the internet to monitor the AP available in the UKM wireless environment.

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3. Methodology

This project will use the Agile development process model as a guide to complete this project. This is because this agile methodology is very flexible compared to traditional methods such as a waterfall. This method will be given the distribution of modules according to priority and need. The developer or customer will review the prototype after every new update. This process will continue until all parties have reached a decision. The advantage of using the agile methodology is reducing the waste of energy, time, and money. Fig. 3 shows the project development flowchart according to the Agile method:

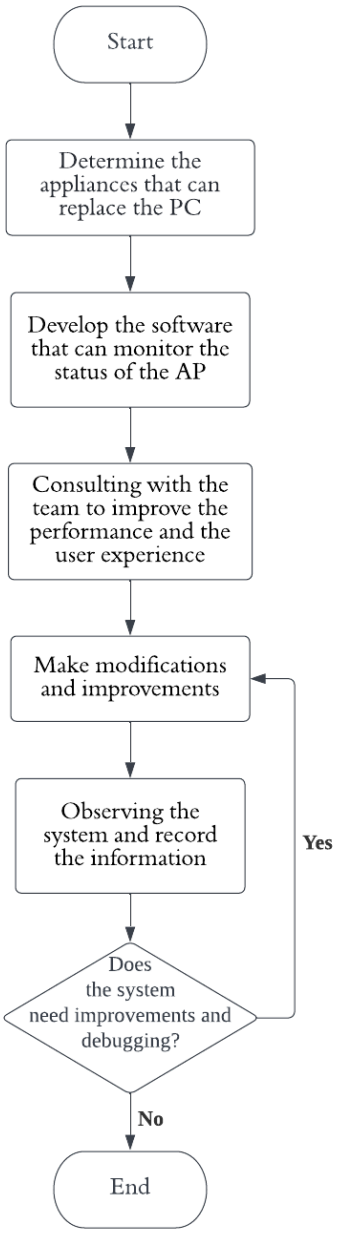

Fig. 3 Flowchart of the development process by using the Agile method.

System design is important when developing a system. In this study, several types of design will be done.

a. Architectural design
b. Database design

c. Interface design
d. Algorithm design

3.1. Architectural Design

The architectural design process is the initial stage of the design process of a system. Based on the study that will be implemented, several types of architecture will be used, namely layered design and simulation design.

3.1.1. Layered Design

Fig. 4 illustrates how the user flow of a real-time Wi-Fi monitoring system from a user's perspective in a wireless environment in UKM. To complete a monitoring process, the user will use a PC connected to a wireless access point that will connect the user to an RP that will be placed close to the AP to be monitored. The RP that is close to the AP will be pinged. After the AP is pinged, the AP will be connected to the internet, and it will try to reach the database that has been established, and it will respond to the ping with a packet that will determine the status of the AP. Upon completion of the process, the existing RP will store the data and send the data to the user's PC via a wireless access point.

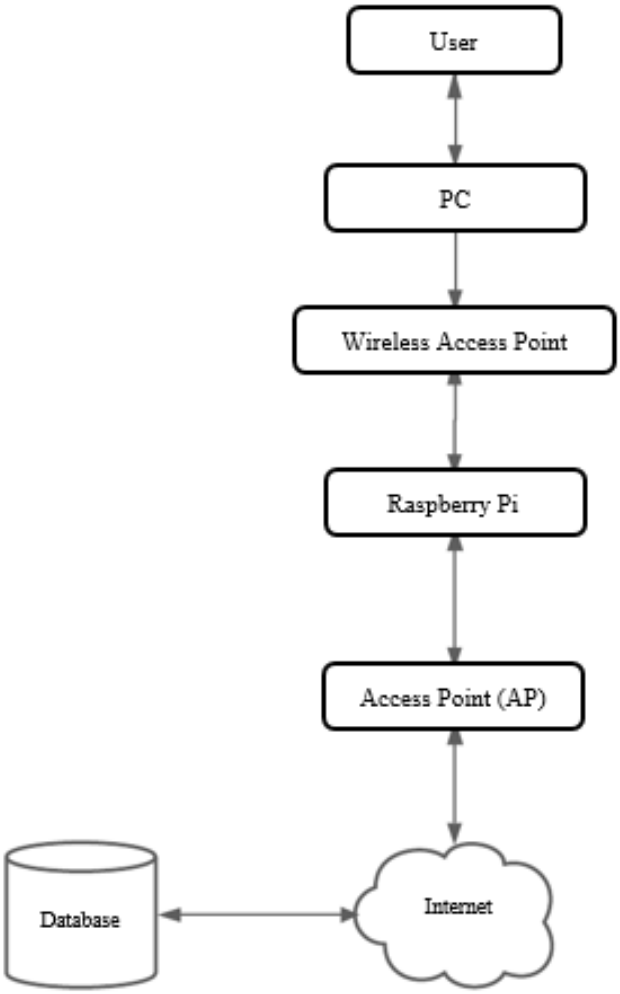

Fig. 4 Layered design for Wi-Fi monitoring technology.

3.1.2. Simulation Design

Fig. 5 shows a simulation of this system working. PCs, APs, and RP appliances will be connected to the internet, and all AP monitoring will be done by the RP assigned to monitor.

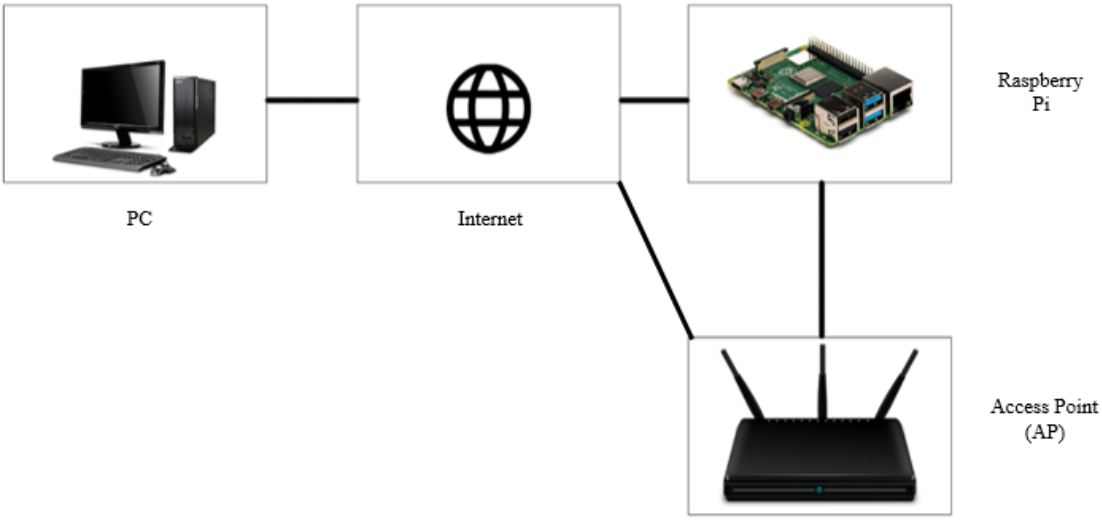

Fig. 5 Architectural design for Wi-Fi monitoring system in UKM wireless environment.

3.2. Database Design

Database design is the process of producing data models in detail. The data model in this design contains all the logical and physical design options that will be used to develop the technology in this project. This data model will associate different entities that have their distinct attributes. There are five (5) different entities, and they have their distinct tasks, namely:

a. User: This entity has four (4) attributes that will differentiate each user who will use this technology. The user's task is to monitor the RP device's data and monitor the AP available around the UKM area.
b. Raspberry Pi: The RP installed will have five (5) attributes with the primary key id RP, which will differentiate each RP installed in the UKM area. The task of this RP is to store, update and channel data on the status of the AP that is being monitored.
c. Access Point: AP entities within the UKM area will be distinguished by the AP id. The AP will monitor this RP, and its status will be updated in the database available in this system.
d. Internet: The internet entity will be used to test the status of the AP. If the AP has a connection to the internet, this means the AP status is ready for use, and if it is not connected, the AP status is interrupted.
e. Database: The database entity will store all data related to the status of the monitored AP.

3.3. Interface Design

User and system interfaces allow users to interact with the operating system. The instructions that have been set in the operating system will tell the computer to act to perform the task of monitoring Wi-Fi in the wireless area in UKM. The software used to create the prototype interface of this system is MockFlow software. Simplicity and user-friendliness are key aspects that need to be considered when designing and creating an interface of a system. This makes the user's task more accessible and efficient in this study.

3.3.1. MockFlow Software

MockFlow is one of the world's well-known software for interface design (UI/UX). MockFlow is often used to visualize user interfaces, create user flows, style documents, and plan designs. It is easy to learn, making it an excellent choice for beginners and non-technical users [14].

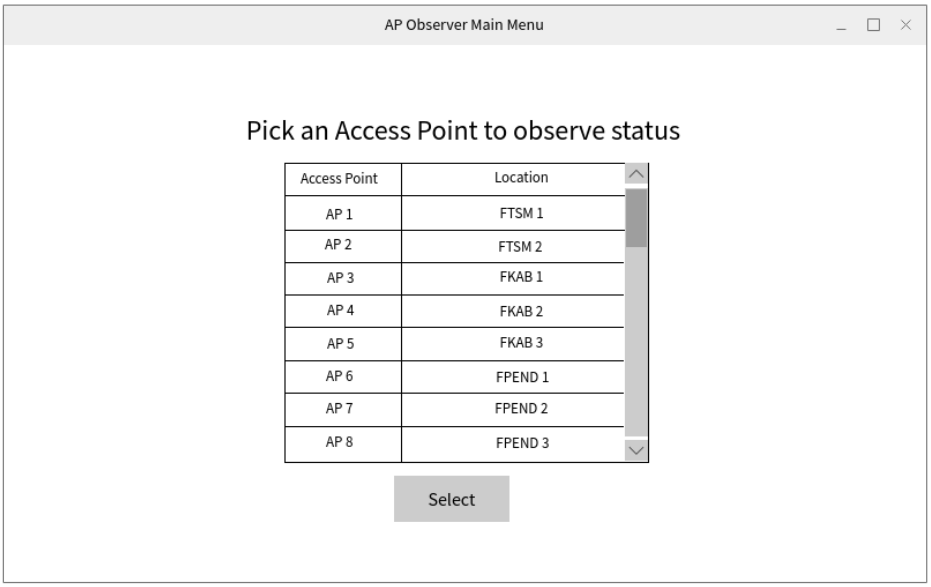

Fig. 6 PC user homepage interface for Wi-Fi monitoring in UKM wireless environment.

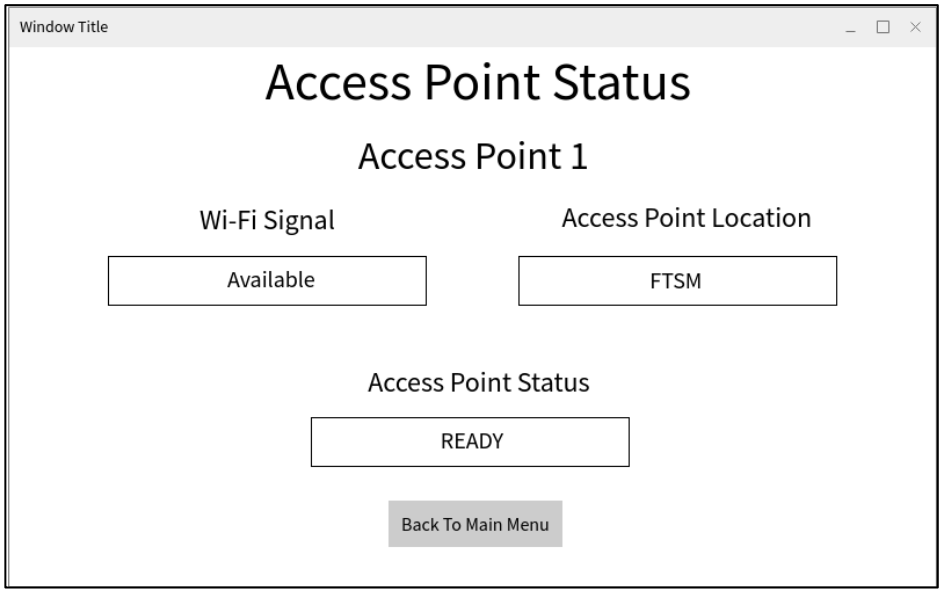

Fig. 7 AP status interface for Wi-Fi monitoring in UKM wireless environment.

In Fig. 6, users can select the AP they want to monitor and press the "select" button, which means select, and it will display the status of the monitored AP, as shown in Fig. 7. In Fig. 7, a button that says "Back to Main Menu", which will bring back users to the main page as in Fig. 6.

3.4. Algorithm Design

Algorithm design is one of the specialized methods for performing calculations or moving variables that are difficult to control in a simulated reality. To facilitate the calculation and transmission of data for the status of AP and Wi-Fi that will be monitored by the user, namely, PTM UKM, an algorithm needs to be established to show the flow to use the system that will be created in this system. This software will use the python programming language found in RP. Fig. 8 is a flow chart used to show the process of monitoring AP by UKM PTM staff while monitoring an AP in the UKM area.

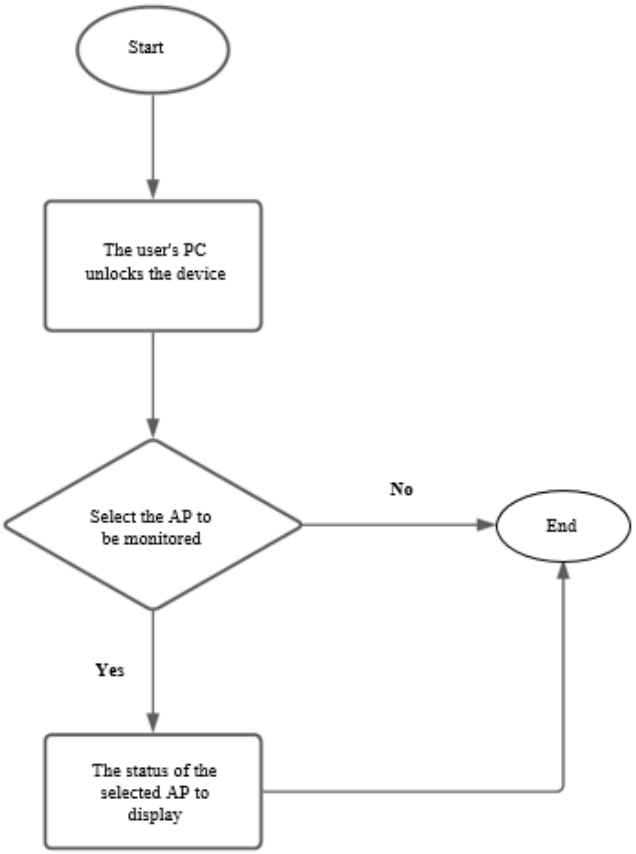

Fig. 8 Flowchart of AP and Wi-Fi monitoring process in a wireless environment.

4. Results and Discussion

The system uses three programming languages, namely Python programming, HTML, and Javascript. This system contains one user, namely PTM UKM staff. This development phase was carried out using the specified software and tested for each build. In this project, the developer uses phpMyAdmin to store the data received by the RP appliance about the monitored AP. PhpMyAdmin uses SQL to receive commands from the appliance and store the data in a database. Fig. 9 shows a database that has been developed using phpMyAdmin.

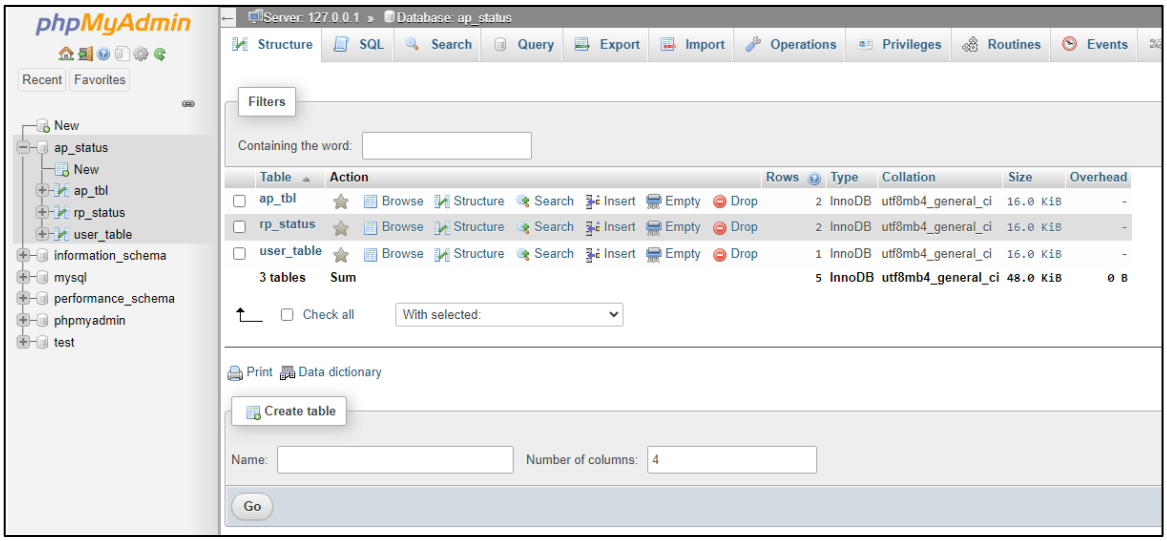

Fig. 9 Main database.

The development of the interface in this system is very important because the objective of this system is to monitor APs in the UKM area. The function of the user interface is to receive input from the user, namely the UKM PTM staff, and complete instructions such as entering the password and username and then wait for the system to provide output to the user. In addition, the interface for this remote real-time Wi-Fi signal monitoring system is on the user login function, which monitors AP status, measures data transmission speed, and monitors RP appliance. Here is the interface that the developer for this monitoring system has developed.

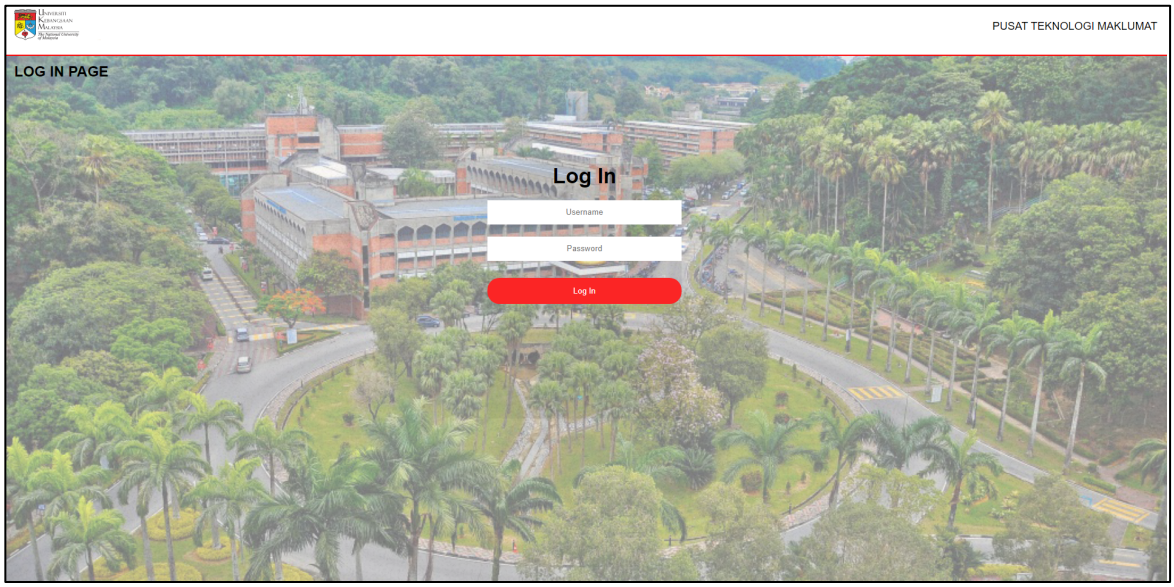

Fig. 10 Login page interface.

Fig. 10 displays the user login interface page in the system. Users will use this page to access the main page, as shown in Fig. 11.

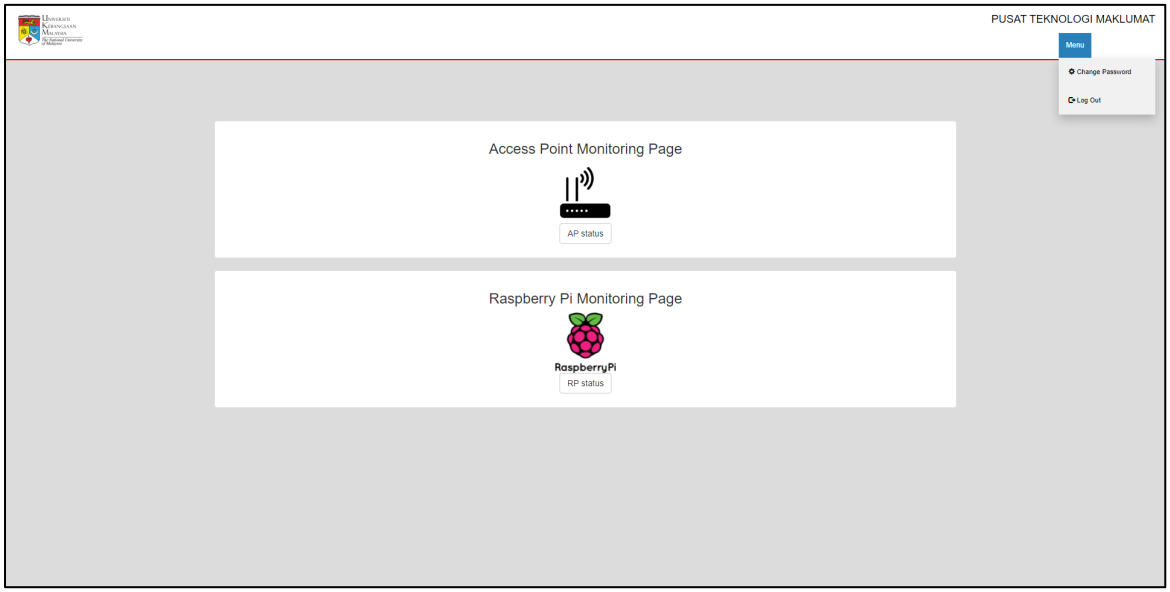

Fig. 11 Homepage interface.

Fig. 11 shows the main page for the Wi-Fi signal monitoring system. On this homepage, users can choose to monitor the status of the AP, monitor the RP used, and select the menu to log out or change the password.

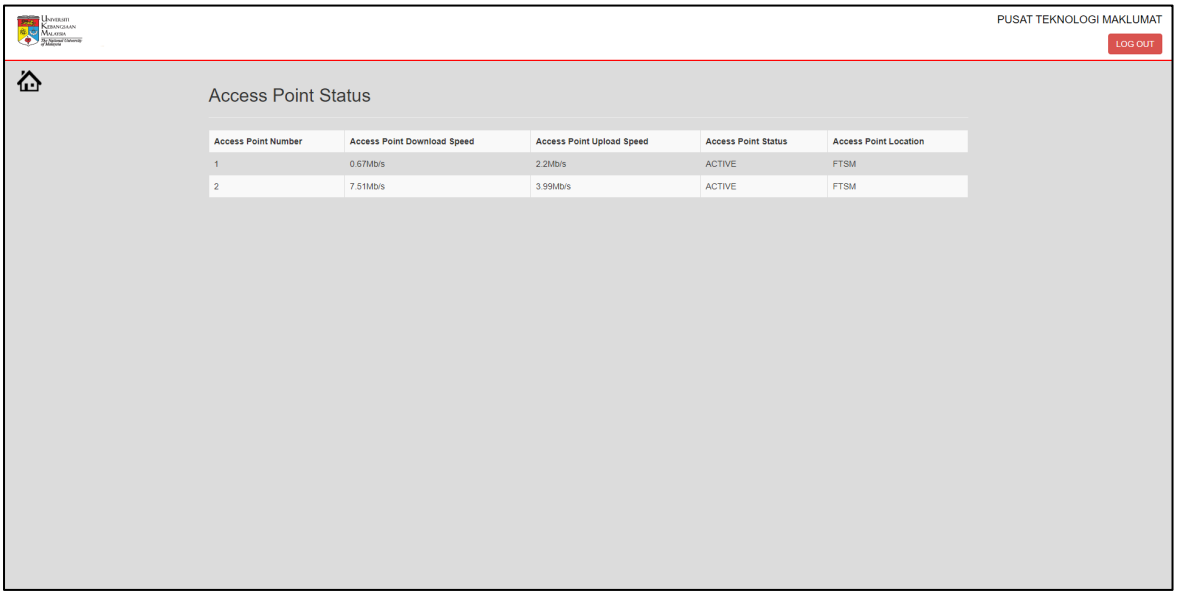

Fig. 12 AP monitoring site interface.

In Fig. 12, there is a site monitoring the status of the AP and the speed of downloading data. Uploading data using the AP is arranged in tabular form. This table is connected to the database to get new data.

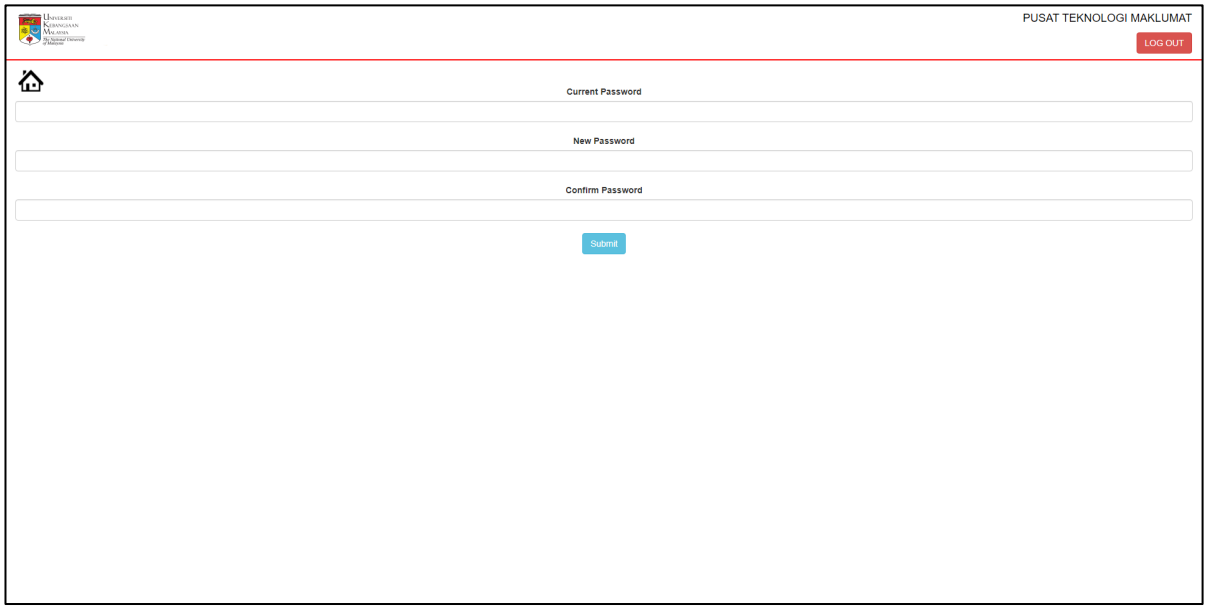

Fig. 13 Password change site interface.

Fig. 13 displays the user password change page. Users use this site to change their passwords. Ssers have to enter their current password and their new password on this website twice. If their passwords are not synchronized, the password change will be canceled, and the user will have to refill all inputs until they are correct.

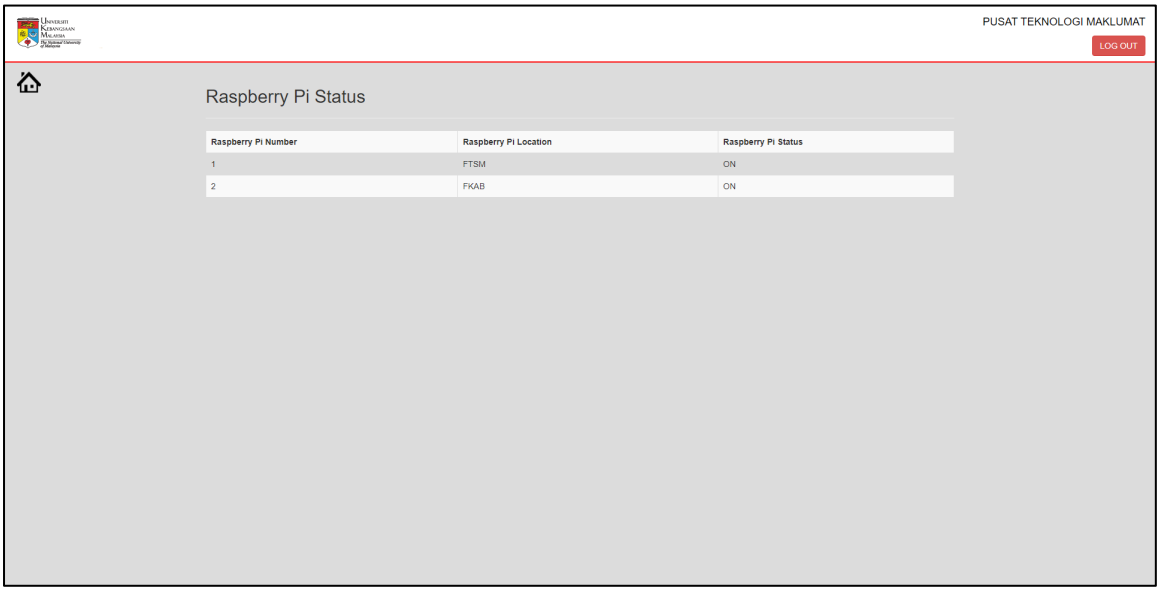

Fig. 14 RP appliance monitoring site interface.

Fig. 14 displays the RP status monitoring page and RP location. This site is connected to a database to get the latest data for RP for user use. Upon developing this system, the developer must ensure that each function performs a well-defined task and meets the specifications and objectives set in the planning and design phase. Testing of this system needs to be carried out to ensure that the system is working correctly. The most critical test in this system is to test the AP monitoring developed. This is to check whether the monitored data is synchronous with the data received in the RP appliance.

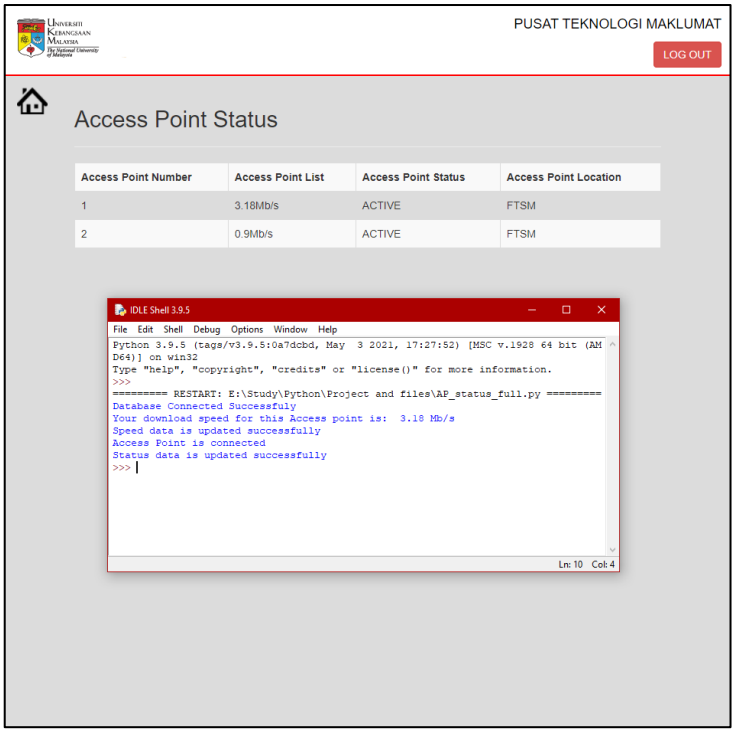

Fig. 15 Process of data retrieval as well as monitoring on the website.

Fig. 15 shows the output generated by the python code successfully synchronized with the output produced on the AP monitoring website.

5. Conclusion

This Wi-Fi signal monitoring system is expected to ease the burden of PTM UKM staff to monitor the status of APs in the UKM wireless environment. The system can monitor the status of APs in UKM from the user's perspective without being in the AP area in real-time. This is because the system has used RP tools to monitor the status of existing APs and upload data to existing databases to communicate with the interface that will display the AP data explicitly. A strength of this system is the AP monitoring that uses python programming in the RP hardware used. This is because the RP appliance is a minimal and compact with multiple uses. This appliance is also cheap compared to a PC. The tools used are also easy to use and easy to care for. In addition, developers can make many improvements in the future by using this python programming, and this system will probably become more than just an AP monitoring system. Next, the website that displays the interface for the use of PTM UKM staff has been equipped with a session that is a number of user interactions found on the website. This session serves as a security function that does not allow users to enter the main page without logging in first. Finally, the interface design of this system is compact and user-friendly. This is because this system does not use too many link buttons that can confuse users. In developing this system, developers have to face various types of challenges. Among the most challenging is using python programming on RP appliances. This is because RP does not use the Windows operating system that developers have commonly used but, it uses the Raspbian operating system which developers and regular users very rarely use. In this system, some improvements can be made in the future. The system can be improved by automatically storing the available data in an excel file that can be used in the future. In addition, an improvement that can be done in this system is a new user registration website that will be used to register more users to monitor this system, along with a detector that can confirm that a person is an employee of PTM UKM. The system can also be improved by having a special site to add APs, change AP configurations and delete APs that have not been used. This special website is reserved for users who want to monitor AP manually. Adding a graphical interface to the python code in the RP tool is also one of the nice improvements to make the user's task more manageable. With this, the developers are confident that the system can grow even more in the long run if it gets a lot of support and workforce.

Acknowledgment

The authors wish to express their sincere appreciation for the assistance received by the Network and Communication Technology (NCT) Research Groups, Faculty of Information Science and Technology, Universiti Kebangsaan Malaysia, throughout this article.

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