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The Development of Personal Portable Wireless Range Extender for IEEE 802.11

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ABSTRACT

In IEEE 802.11 standard, Mobile Station (MS) such as laptop and smartphone are connected to Access Point (AP) to have a wireless connection. However, setting up AP to cover the whole area is costly and complicated. Limitation in signal capacity causes out-of-coverage area, where the MS cannot connect to the AP. In this paper, a portable wireless range extender (PWRE) is developed to assist MS that is located out of coverage area, or at the cell edge area connected to the internet. Development of PWRE involves two processes, which are connecting to existing wireless LAN (WLAN) network, and broadcasting a new WLAN network. The paper discusses development process of PWRE and analysis of its performance. PWRE was developed using a low power consumption microprocessor, known as Raspberry Pi. Performance of the developed PWRE is evaluated by comparing signal strength received by an MS located in the cell edge from an AP using two scenarios; with and without the PWRE. Results showed that the MS signal strength improved significantly with the deployment of PWRE. Other advantages offered by PWRE include being portable and energy efficient as it uses only 5V of power to operate.

Keywords: Access Point, IEEE 802.11, portable, Raspberry Pi, wireless range extender, WLAN

INTRODUCTION

Wireless LANs are widely used for devices that support wireless connection such as smartphone and laptop. Each device requires a better signal capacity to perform a task and get connected to the internet. Mano and James claimed that many cellular customers have increasingly desired to access good wireless signals at their premises (Mano & James, 2006).

Because of limited signal capacity and distance of coverage area from the Access Point (AP), some devices may be restricted to access the connection. For example, James

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and Kenneth (2011) stated that AP to client ranges are generally less than the coverage range required in a typical home, and may be lower than 10 to 15 m. Data rates of devices that operate using standard 802.11 are dependent on signal strength. As a distance in the area of coverage increases, wireless system performance may decrease (James & Kenneth, 2011). Thus, wireless signal strength degrades when Mobile Station (MS) located at the cell edge area and the signal may be too weak to be detected by MS. It also considered as a dead spot area. The service also could be unavailable and the signal could be dropped.

Besides that, John (2008) claimed that when a wireless device is positioned in a cell, the wireless device and Base Station (BS) can communicate with each other in various channels through radio frequency air interfaces. With the growth in the number of MSs that use wireless communication, it can cause problems such as a limitation of signal. The cellular wireless communication can suffer from varying levels of degradation as signals are carried over the air interface between wireless devices and MS (John, 2008). One may think that placing another AP can be a solution, but it is not the best decision because it is expensive and static, and consumes high power.

However, this problem can be solved by using a portable wireless range extender (PWRE). In this paper, a PWRE using Raspberry Pi (Rpi Repeater) is developed to enhance the signal strength and capacity. As mentioned by Severance, Raspberry Pi concepts are based on the series of Broadcom chip and supported as a machine to interact with other hardware (Severance, 2013).

In particular, a PWRE is responsible to increase wireless signal strength at locations with low signal range. As shown in Figure 1, Rpi Repeater also can create its own new signal coverage area for MS. Thus, a PWRE can be deployed easily at the dead spot areas because of the small size of Raspberry Pi. Vladimir and Mirjana (2014) stated that Raspberry Pi is an affordable, flexible, fully customisable and programmable small computer board. The physical size impacts the ease of network deployment because smaller nodes can be placed in more locations (Vladimir & Mirjana, 2014).

On the other hand, the Raspberry Pi also consumes low power to operate, making it suitable to perform as a personal devices for users. Users can just plug the portable wireless range extender to any power source such as power bank or directly from the laptop. The main goal of this study is to develop a PWRE to help MS that is located far from AP to receive a signal and also study if the tool such as Raspberry Pi can perform as a personal portable device than the current AP.

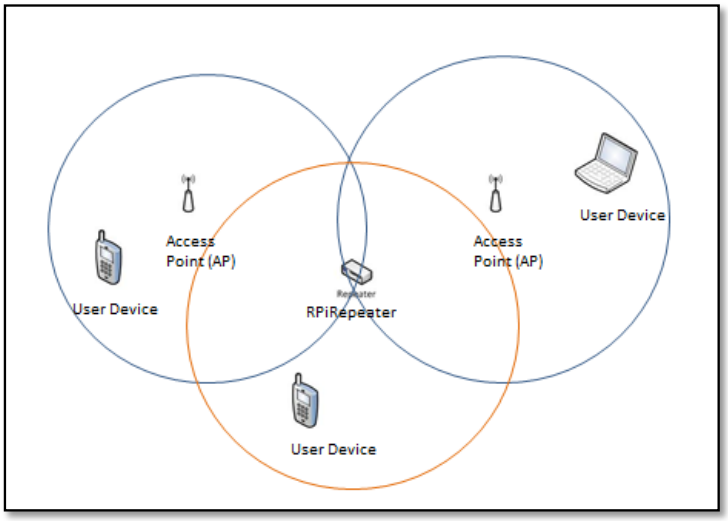

Figure 1. Access Point signal range and Portable Wireless range extender new signal coverage

METHOD

Design and Implementation

The purpose of this research is to build a portable wireless range extender (PWRE) using Raspberry Pi that can help to increase the wireless signal strength. This section describes the designs, lists of components, and procedures required for the research. The network interfaces are configured using two USB WiFi dongles which are known as interface wlan0 and wlan1. The system architecture illustrates the overall research diagram. Logical and physical designs determine all the information related to this research. In this paper, all the requirements to complete this project are explained below.

Software Requirement

Ekahau Heatmapper. Before building the PWRE for this particular project, the data analysis was done to determine the current problem so that the PWRE would be able to solve the problem. Ekahau Heatmapper for windows is used to identify the location with AP signal and the location with a problem to access the signal. Ekahau Heatmapper provides information such as AP list, signal strength, channel, Mobile Access Control (MAC) address, and location of the AP devices.

Hardware Requirement

Raspberry Pi B+. A Raspberry Pi computer looks like a PC motherboard and uses the type of microchips that are usually found in mobile phones. It uses Broadcom SoC (System on Chip) a 700MHz ARM11 processor which can handle basic computations and calculations. These processors combine processing and multimedia capability in a small shell. They do not use

too much power too quickly and keep the computer relatively cool. The model B and B+ has storage capacity for 512MB RAM, 2 USB ports and an Ethernet port (Chris, 2013).

Operating systems are mainly Linux distributions, although there are other non-Linux operating systems such as RiscOS. Linux has low memory overheads, so it is possible to run a fully functional operating system on a simple device with no permanent storage.

There are currently five Raspberry Pi models; Model A, Model B, Model A+, Model B+, and Compute Module (currently only available as part of Compute Module development kit). All the models use the same SoC, BCM2835, but other hardware features are different (*Raspberry Pi Schematics*, 2015). Models A and B use the same PCB, while the A+ and B+ are new designs that are very similar to form factor. Compute Module is an entirely different form factor and cannot be used standalone.

USB WiFi Dongle. In this project two USB WiFi Dongle are used as a network adapter. The purpose of using two WiFi Dongles is because this research needs to configure the PWRE to enable it to increase the strength of existing AP WiFi signal. Two WiFi Dongles are used to create two wlan interfaces, namely interfaces wlan0 and wlan1.

Logical and Physical Design

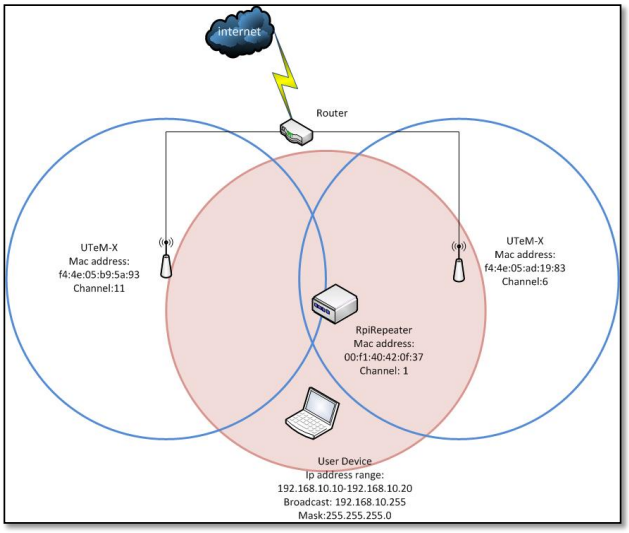

Figure 2. Physical design for product development

Figure 2 shows the physical design of the PWRE using Raspberry Pi. The blue circles represent the coverage of AP signals, and the red circle shows the new coverage signal of the PWRE produced from the existing signals. Detailed information of Figure 2 is as below:

- Access point: SSID, Mac address, channel number, wireless network 802.11n and signal strength.

- Portable wireless range extender: SSID, Mac address, channel number, wireless network 802.11n, signal strength, max speed, password and Key information.
- User Device: IPv4 dhcp address
- Wlan0 and Wlan1 interfaces.

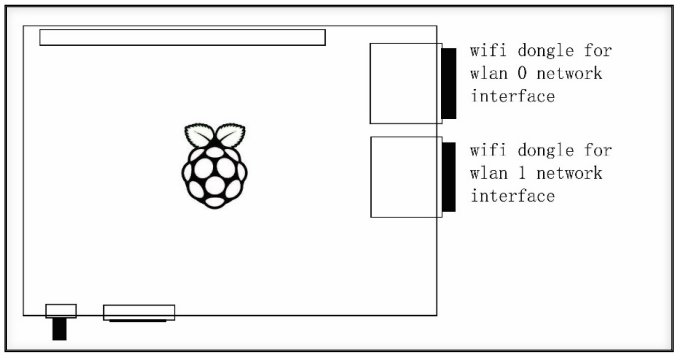

Figure 3. Logical Design for mini board structure to build this research

Implementation

All the network services required in this work are installed using command because Raspberry Pi is a Linux core operating system. The main part of this research is to configure two USB WiFi dongles to act as the network interfaces, wlan0 and wlan1. The wlan0 interface is connected to the existing wlan network, while wlan1 broadcasts a new wlan network using a new SSID, as shown in Figure 3.

RESULTS AND DISCUSSION

In this section, performance of the developed PWRE is discussed. The performance evaluation of signal strength is done by comparing two scenarios; when an MS located in the cell edge of AP coverage connected to AP (without the developed PWRE), and when an MS located in the cell edge of AP coverage connected to the portable wireless range extender. Figure 4 and Figure 5 show the signal strength (coverage) for both scenarios. Table 1 and Table 2 provide details of Figure 4 and Figure 5, respectively.

Scenario 1: An MS Located in the Cell Edge of AP Coverage Connected to AP

MS is connected to AP (without PWRE), as shown in Figure 4 and Table 1. An MS is placed within 30 meters from the AP. The reading for MS signal strength is evaluated and it shows that the signal strength degrades when the MS is placed far from the AP.
-80 dbmMS directly connected to wireless AP from 30 meters.

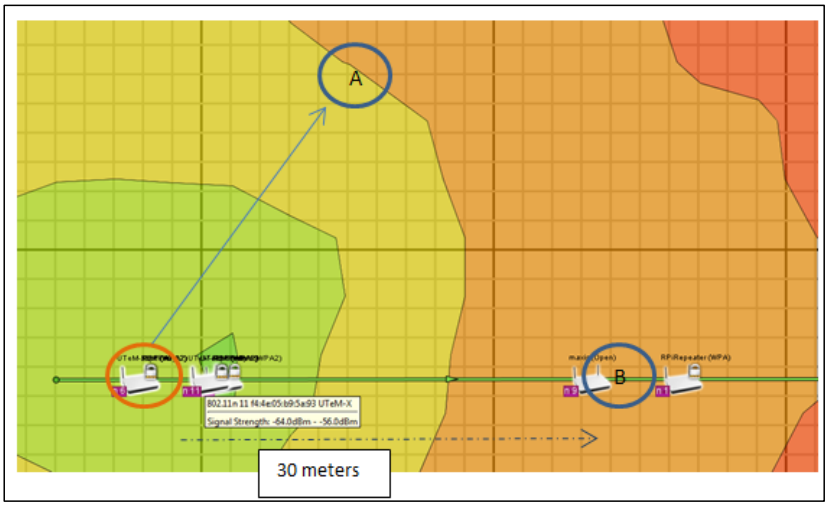

Figure 4. Test Scenario 1 where MS direct connected with AP A (without PWRE)

Table 1
Descriptions for Figure 4

Label	Devices Info	Description
A	SSID: UTeM-X Wireless Standard: 802.11n Signal Strength: -64.0 dbm -> -56.0 dbm	AP coverage area represented with light green (medium signal), yellow (low signal), orange (lowest signal) and red (out of signal).
B	Connected to UTeM-X Signal Strength: -80 dbm	MS directly connected to wireless AP from 30 meters.

Scenario 2: An MS Located in the Cell Edge of AP Coverage Connected to the Portable Wireless Range Extender (PWRE)

MS is connected to the PWRE (RPi Repeater), as shown in Figure 5 and Table 2. The reading for MS signal strength is collected and it shows that the signal strength increases, where the orange area (lowest signal) in Figure 4 changes to dark green area (strongest signal) in Figure 5. The dark green area is detected because the MS is connected to the PWRE. Thus, the PWRE creates its own cell and provides a strong signal to the MS. Figures 4 and 5 show that the MS located in the lowest signal area (Figure 4) can receive a strong signal when connected to the PWRE, as shown in Figure 5.

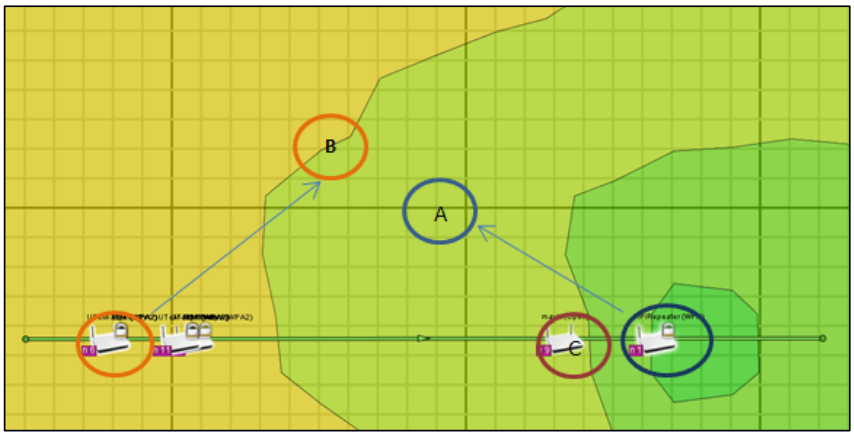

Figure 5. Test Scenario 2 where MS connected to portable wireless range extender (PWRE)

Table 2
Description for Figure 5

Label	Devices Info	Description
A	SSID: RpiRepeater Wireless Standard: 802.11n Signal Strength: -56.0 dbm -> -48.0 dbm	Portable wireless range extender coverage area. It is represent with dark green colour (highest coverage signal), green (medium coverage signal), light green (low signal) and yellow (lowest signal).
B	SSID: UTeM-X Wireless Standard: 802.11n Signal Strength: -64.0 dbm –> -56.0 dbm	AP from the existing network for wlan0 network interface.
C	Connected to portable wireless range extender	MS connected to portable wireless range extender

Figure 6 shows a signal strength received by an MS when connected to various APs. Note that the developed PWRE (RPi Repeater) is placed near to MS during the performance evaluation. It can be seen that the developed RPi Repeater provides the strongest signal (purple line) when the MS is located far away from other APs. The PWRE will receive the signal from the existing wireless network AP and then amplify or boost it. Besides that, the PWRE not only repeats the signal, but also allows MS to connect with it in the new coverage area in case MS is unable to receive a good signal from AP.

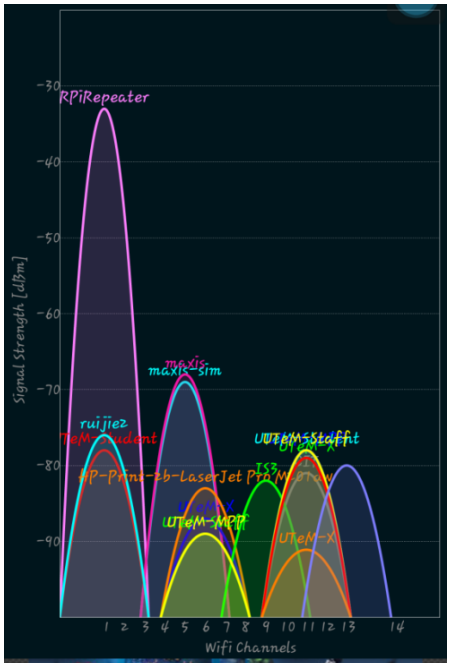

Figure 6. The graph for portable wireless range extender and AP signal strength

CONCLUSION

In this paper, a PWRE is developed to improve signal strength received by an MS that is located at the cell edge or out of AP coverage. Based on the performance evaluation of signal strength, we found that an MS located in the cell edge, or out of the coverage area, can receive a better signal strength when using the developed PWRE known as RPi Repeater. When an MS is located in the cell edge, it can connect to both AP and PWRE in the same point but with a better signal strength when connected to the developed PWRE. From the performance evaluation discussed in the previous section, we found that the PWRE can provide the strongest signal strength compared to the signal strength of other Aps. The developed PWRE can help IEEE802.11 standard users to have wireless connection even in the cell edge and out of coverage area. Since it is operated using a small-sized microprocessor, users can bring it everywhere and have an IEEE 802.11 wireless connection everywhere and anytime. As the microprocessor is embedded in the product, it can also be developed as a multi-tasking repeater in future work since it can be attached with another system or application such as teaching tools. Besides that, the developed PWRE is also an energy efficient product because it uses only 5V to operate.

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