

Performance Extension of Wireless Mesh Sensor Network Communication Applied in Grape Farm

Wasana Boonsong¹, Tanakorn Inthasuth², Umapathy Kannan³

¹Department of Electrical Education
Faculty of Industrial Education and Technology
Rajamangala University of Technology Srivijaya
Songkhla, 90000 Thailand

²Department of Electrical Engineering
Faculty of Engineering
Rajamangala University of Technology Srivijaya
Songkhla, 90000 Thailand

Department of Electronics and Communication Engineering
Sri Chandrasekharendra Sarawathi Visma Mahavidyalaya
Kanchipuram 631561, India

¹wasana.b@rmutsv.ac.th, ²tanakorn.i@rmutsv.ac.th, ³umapathykannan@gmail.com

Abstract

The effectiveness of data communication links in a wireless communication network is an essential factor to be considered. Many applications in an agricultural farm need technology to facilitate significantly and increase productivity in planting. This paper presents the performance extension of wireless mesh sensor network communication in a grape farm. The performance of distance extension for data communication in an agriculture farm is a central topic to be designed. Therefore, the received signal strength indicator (RSSI) demonstrates the strength of the communication link in an outdoor condition. This article adopts a wireless module of XCTU, a free multi-platform application designed to enable developers to interact with Digi RF modules through a simple-to-use graphical interface embedded with a microcontroller device to process data transmission tests. The results found that the XBee-S2 and XBee-Pro tags have an RSSI tested for -71.6 dBm and -25.9 dBm, respectively. However, the Xbee-Pro still had a higher RSSI test compared to XBee-S2 by 63.83%. However, in the application, the entrepreneur needs to consider which technology is a match to be used in their business correctly.

Keywords: RSSI, XCTU, Digi, RF, ZigBee

1. Introduction

An organic farm is central to the certification process. The farm plan describes production, handling, and record-keeping systems and demonstrates an understanding of organic practice for a specific crop. Developing the program can be precious in anticipating potential issues and challenges and fosters thinking of the farm as a whole system. Namely, the soil, nutrient, pest, and weed management are all interrelated on organic farms and must be managed in concept for success. Certifying organizations may provide a template for the farm plan [1]. Farmers must plant what the arena's weather, climate, and soil allow. The species or range selected for cultivation should be native to the ground. The plating material and seeds need to be procured from a reliable supply licensed organic with the aid of the authorizing frame. If 'organic' ones are unavailable, chemically untreated planting material should be used. Pollen, tissue culture seeds, transgenic plants, and genetically engineered seeds are strictly prohibited. The soil fertility must be maintained through leguminous crops, green manure plants, and different biodegradable materials that need to be used as manures. Those substances must be of animal or plant origin. Crop and animal residues must be recycled and returned to the soil immediately or indirectly. Various vermicomposting, sheep penning, farm yard manure, compost, etc., are regularly used. The soil requirements for mineral-primarily based manuring for an organic field then: Mulches, slurry farm backyard manure, crop residues from the farm itself, Chalk,

gypsum, salt, excelsior, and sawdust from untreated timber, not unusual salt, bacterial-based completely bio-fertilizers, Magnesium rocks, Vermicompost, plant extracts and plant preparations like neem cakes and specific biodynamic arrangements are frequency used. It is also endorsed to touch the certifying agency from the different farms before using urine, straw, slurry, etc. [2].

The tropics are an area of land and sea mass in the world surrounding the equator and are generally defined by the tropical of Cancer to the north and the tropic of Capricorn to the south. In tropical regions, the sun reaches a point directly overhead at least once in the solar year, and these regions are hotter because they are closer to the sun. In addition, the earth's axial tilt means a much more significant variation in the sun's axis relative to the land, leading to the extreme divergence between where the sun rises and sets throughout the year [3]. In the tropical regions, most vineyards are for table grape production, but there are also increasing vineyard areas for the growth of quality wine grapes [4, 5]. From measuring environmental conditions that influence crop production to tracking livestock health indicators, Internet of Things (IoT) technology for agriculture enables efficiencies that reduce environmental impact, maximize yield and minimize expenses.



(a) Grape farm environment

(b) Top view from satellite

Figure.1 Environment in a grape farm located in South Thailand

The basic principle of ZigBee and Bluetooth wireless communication technology is not different, both of which take RSSI positioning technology as the core. After the application of this technique, the actual loss is determined by analyzing the signal strength, and then the actual loss is transformed to make sure the specific distance. Finally, the specific position of the node is analyzed [6]. Numerous studies often hypothesize that all sensor nodes in WSNs are homogeneous [7, 8], but such networks do not exist. Even industrial-designed homogeneous sensors have many different capacities regarding initial energy level and energy degradation rate [9, 10]. Furthermore, large WSNs often deploy several sensors and protocols to work together, forming heterogeneous WSNs. Hence, the assurance of Quality of Service (QoS) and resource optimization in heterogeneous WSNs brings several challenges [11, 12]. Solutions focus on synchronously designing hardware and software systems in WSNs using techniques such as clustering, radio optimization, data reduction, sleep or wake-up methods, energy-efficient routing protocols, and energy harvesting [13]. Many communication protocols for WSNs have been developed, such as Bluetooth, WiFi, BLE, Zigbee, LoRa, NB-IoT, and LTE-M [14].

2. Proposed Wireless Mesh Sensor Network Extension Test

A wireless mesh sensor network (WMSN) is a communication network of radio nodes organized in a mesh topology where no central node should flow through all the traffic. All end device nodes can transmit directly to communicate with each other. This experiment is to prove the achievement of performance extension of WMSN communication using in a grape farm (south of Songkhla, Thailand). The WMSN has several redundant links and paths to a destination node; therefore, in case one of these end nodes fails, then other nodes can still be continued to reroute the data communication until it reaches the destination sink node. Namely, WMSN can adapt to network changes and self-heal from failures. It can be implemented with various wireless technologies such as 802.11, 802.15, 802.16, and cellular technologies, and need not be restricted to any one technology or protocol [15, 16].

2.1 Hardware

ZigBee is a wireless communication module manufactured by Digi Inc. ZigBee can be set-up to create a WMSN communication in our area. It can run either ZigBee or DigiMesh protocols depending on its type, and by utilizing the appropriate firmware. The advantages of the ZigBee application are low power consumption and low-cost applications. This experiment is to compare the performances of the XBee-Pro module and XBee-S2. XBee-Pro is for higher power and longer-range applications. Both series are configured by XCTU software provided by Digi.

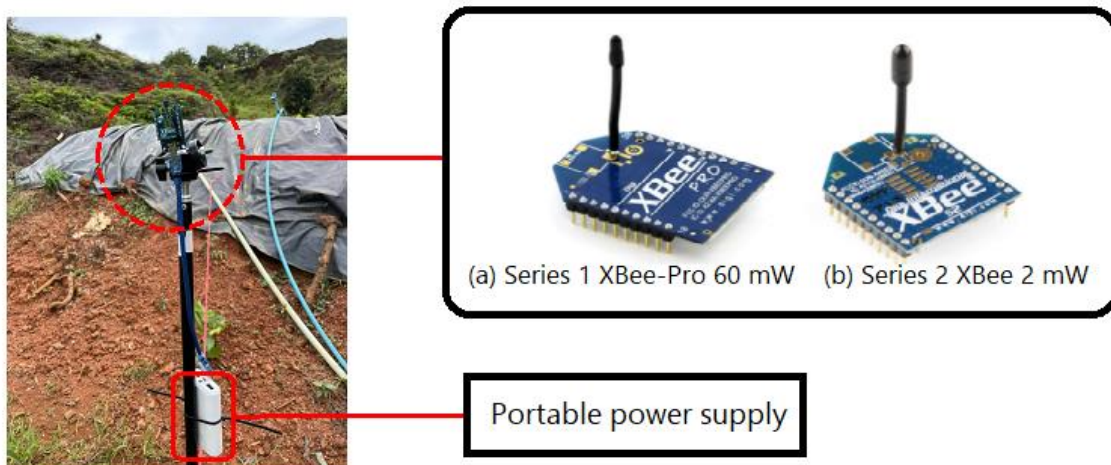


Figure.2 ZigBee module test in two types of test: XBee-Pro, and XBee-S2

2.2 Wireless Mesh Sensor Network (WMSN) Configuration

There are three interaction devices with XBee modules, which are AT commands, transparent, and API. These modes apply only to interactions via the XBee's serial connection, such as the UART. A wireless XBee can communicate with each other independently of the chosen interaction mode. Therefore, a radio configured to operate in transparent mode may communicate wirelessly with another radio configured in API mode.

2.3 Performance Evaluation of Communication Extension

In this section, a performance extension evaluation of the DigiMesh and ZigBee WMSN is presented to analyze the deep performances of XBee-Pro and XBee-S2. They have a standard communication mesh topology of 2.4 GHz for 60 mW, and 2 mW, respectively. The performance metric used is the Received Signal Strength Indicator (RSSI). This study's results are essential for considering the performance of the wireless mesh sensor network when applied in a real grape farm. The experiment is designed to verify the RSSI values according to the distance condition between nodes, which is greater than a point-to-point communication link, and hence communication requires multi-hop transmissions.

RSSI is the signal strength level of a wireless device of the last good packet received and is measured in dBm units. In free space, the Received Signal Strength (RSS) decays with the distance traveled away from the sender. The ratio of the received power (P_r) to the transmission power can be expressed as follows using the Friis transmission equation [1]:

$$P_r = P_t \times G_t \times G_r \left(\frac{\lambda}{4\pi d} \right)^2 \quad (1)$$

Where G_t and G_r are the gains of the transmitter and the receiver antennas, respectively. Moreover, d is the distance between the sender and the receiver. Equation 1 above shows that the power received decreases when the distance increases. Namely, the RSSI value can be defined as the ratio of the received power P_r to the reference power P_{ref} as shown in equation (2).

$$RSSI = 10 \log \frac{P_r}{P_{ref}} \quad (2)$$

3. Experimental Results and Discussions

This section compares the two types of ZigBee active RFID family modules: ZigBee-Series and ZigBee-Pro. This evaluation presents the performance of active RFID tags used in outdoor environments. More details are demonstrated as follows.

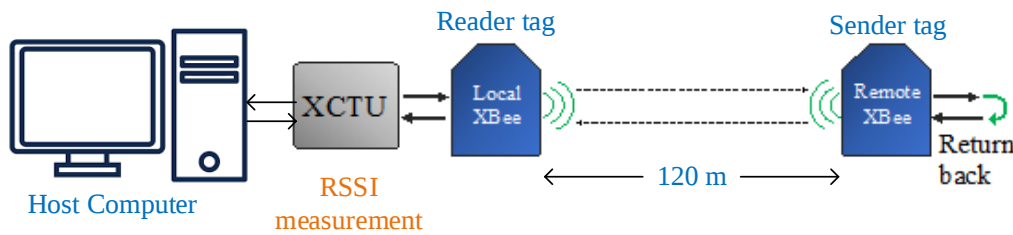


Figure.3 Experiment test of RSSI measurement by XCTU

Figure 3 demonstrates the wireless sensor with single-hop communication. The experiment was designed to attempt a maximum of 120 m regard to the limitation of XBee-S2 specification. More details are presented in the following sub-sections.

3.1 The RSSI measurement according to the number of hops

The wireless sensor with single-hop communication. The experiment was designed to attempt a maximum of 120 m regard to the limitation of XBee-S2 specification. On the other hand, ZigBee-Pro is able to cover a maximum read range of 90 m in indoor applications and 1,500 m in outdoor conditions [17].

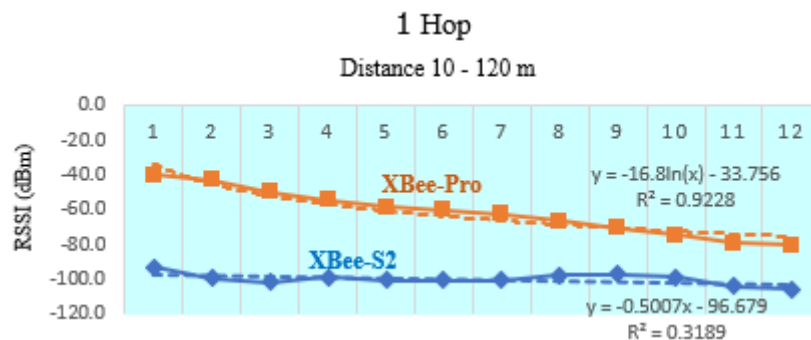


Figure.4 RSSI test with point-to-point communication

Figure 4 shows that the two types of Zigbee modules were placed away at a distance of 120 m. According to the received RSSI data, which was compared between XBee-S2, and XBee-Pro, it was found that they are different, with XBee-Pro achieving a higher performance of RSS than XBee-S2 of 38.24%. Namely, the XBee-S2 has an RSSI test lower than XBee-Pro by -99.9 dBm and -61.7 dBm, respectively.

Next experiment, the authors designed to test using double-hop communication between the end device tag, router tag, and coordinator tag. Three of them communicate at a distance away of 60 m (at the center between the end device tag and coordinator tag). The results are obtained according to Figure 5 below.

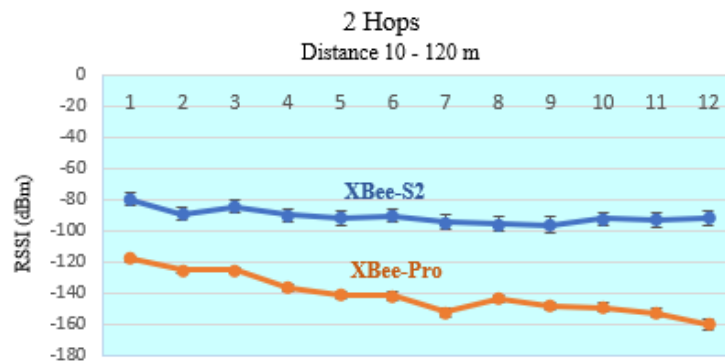


Figure. 5 RSSI test with 2 hops communication (1 router)

Figure 5 demonstrates the RSSI test with two hops communication, which is also tested with the exact condition of max distances of 120 m, and the router tag was placed at the distance of 60 m (between sender and reader tags). The results found that the RSSI tests of XBee-S2 and XBee-Pro are 90.9 dBm and 50.6 dBm, respectively. According to the obtained result of the single hop, and double hop, it was found that the double hops communication has better performance referring by the RSSI test with showed better performance of both systems by 9.0% and 11.10%, respectively. Moreover, the more profound information of double-hop communication between both systems differs by 44.3% (the XBee-Pro is a performance).

The last test of the RSSI performance of both systems is set up with three hops communication testing a maximum distance of 120 m. Therefore, two router tags are set up and placed between the position of the sender tag and reader tag 40 m away from each other. The results are graphed in Figure 6.

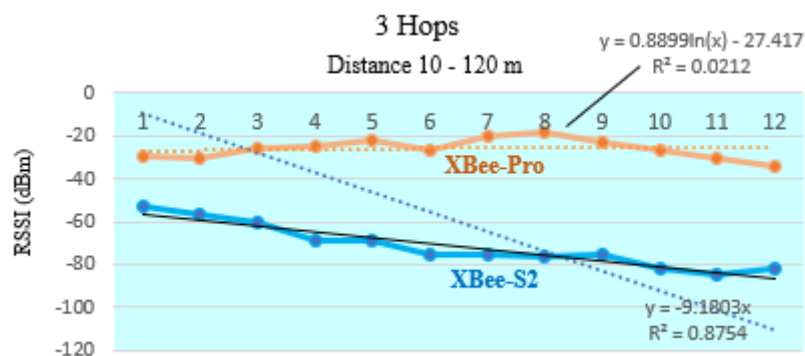


Figure. 6 RSSI test with 3 hops communication (2 routers)

The results concluded that the XBee-S2 and XBee-Pro tags have an RSSI tested for -71.6 dBm and -25.9 dBm, respectively. However, the Xbee-Pro still had a higher RSSI test compared to XBee-S2 by 63.83%. Based on the experiment of both systems are not to compare the different types of ZigBee only. The test's purpose is to show the performance of the wireless ZigBee module, which can be used as a network communication that is both suited to use in indoor or outdoor conditions, and whether they are a match to use in any environment. Thus, the wireless sensor network device can be used for the appropriate function according to the worksite and fulfill the user's requirements.

Conclusions and Future Works

This paper presents the performance extension of wireless mesh sensor network communication in the grape farm. The purpose of the study is to analyze the received strength signal while data transmitting in an outdoor condition, according to the different factors used in indoor and outdoor environments based on lost affecting factors. The wireless sensor ZigBee modules are tested, and the performance used in a grape farm to analyzed in an actual place. However, this information may be useful to the system analyzer, trader, and investor for deciding which one is proper for their business. Regarding farming businesses, the entrepreneur needs to realize and consider efficiency and invested cost for the equipment cost differently. Thus, the future works authors would like to study and present helpful information regarding throughput and package delay to fulfill the technical term, which is applied in a business section as well.

References

- [1] Cornell University, "Production Guide for Organic Grapes," NYS IPM Publication No. 224, vol. 2, 2011.
- [2] S. M. Krishnan, and G. Barani, "Organic Grape Farming-Practices and Problems," *Alochana Chakra Journal*, pp. 1400-1407, 2020.
- [3] T. Commings, S. Asavasanti, and A. Deloie, "What is tropical wine and what defines it? Thailand as a case study. *As J. Food Ag-Ind.* vol. 5(2), pp. 79-95, 2012.
- [4] J. Tonietto, G. E. Pereira, "A concept for the viticulture of "tropical wines", *IXe International Terroirs Congress, Dijon/Reims, Burgundy/Champagne, France*, pp. 2-34/2-37, 2012.
- [5] B. Guesmi, T. Serra, and M. Gil Roig, "The productive efficiency of organic farming: the case of grape sector in Catalonia," *Spanish Journal of Agricultural Research*, pp. 552-566, 2012.
- [6] F. Adelantado, X. Vilajosana, P. Tuset-Peiro, and B. Melia-Segui, "Understanding the Limits of LoRaWAN. *IEEE Commun. Mag.*, vol. 55, pp. 34-40, 2017.
- [7] M. Farsi, M. A. Elhosseini, M. Badawy, H. A. Ali, and H. Z. Eldin, "Deployment techniques in wireless sensor networks, coverage and connectivity: A survey," *IEEE Access*, vol. 7, pp. 28940-28954, 2019.
- [8] M. Jouhari, K. Ibrahim, H. Tembine, and J. Ben-Othman, "Underwater wireless sensor networks: A survey on enabling technologies, localization protocols, and internet of underwater things," *IEEE Access*, vol. 7, pp. 96879-96899, 2019.
- [9] T. Rault, A. Bouabdallah, and Y. Challal, "Energy efficiency in wireless sensor networks: A top-down survey," *Computer Networks*, vol. 67, no. 12, pp. 104-122, 2014.
- [10] X. Feng, F. Yan, and X. Liu, "Study of wireless communication technologies on internet of things for precision agriculture," *Wireless Personal Communications*, vol. 108, no. 3, pp. 1785-1802, 2019.
- [11] S. Abraham, and X. Li, "A cost-effective wireless sensor network system for indoor air quality monitoring applications," *FNC/MobiSPC*, vol. 34, pp. 165-171, 2014.
- [12] W. Ma, Y. Wei, F. Sun, and Y. Li, "Design and implementation of water-saving irrigation system based on Zigbee sensor network," *IOP Conf. Series: Earth and Environment Science*, vol. 252, no. 5, pp. 52086, 2019.
- [13] G. Sahitya, N. Balaji, C. D. Naidu, and S. Abinaya, "Designing a wireless sensor network for precision agriculture using Zigbee," in *IEEE 7th Int., Advance Computing Conf., New York, US. IEEE*, pp. 287-291. 2017.

- [14] V. Bianchi, P. Ciampolini, and I. De Munari, "RSSI-based indoor localization and identification for Zigbee wireless sensor networks in smart homes, *IEEE Transactions on Instrumentation and Measurement*, vol. 68, no. 2, pp. 566-575, 2018.
- [15] A. Khalifeh, H. Salah, S. Alouneh, A. Al-Assaf, and K. Darabkh, "Performance Evaluation of DigiMesh and ZigBee Wireless Mesh Networks," *2018 International Conference on Wireless Communication, Signal Processing and Networking (WiSPNET)*, Chennai, India, pp. 1-6, 2018.
- [16] R. Faludi, Building Wireless Sensor Networks: With ZigBee, XBee, Arduino, and Processing," *O' Reilly Media*, Inc., Dec 14. 2010.
- [17] Digi International. INC. (2012) XBee®/ XBee-PRO® RF modules. 11001 Bren Road Inc. Minnetonka, MN 55343: 877 912-3444, <http://www.digi.com>