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Empirically Approach for Determining the Appropriate of Antenna Heights in Greenhouse Environments

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Abstract: This research shows the best heights of transceivers antenna based on empirical measurements carryout in mango greenhouse environment. In contrast to the theory which states that the path loss decreases with increasing the height of the antennas, real environments containing many of the terrain and objects that impede signal path. Parts of trees have significant effects on the signal strength. Therefore, this study shows the effect of each tree parts (such as trunk, foliage and tree canopy) on the signal to be choosing the appropriate part to put antennas at it.

Key words: Transceivers, antenna, empirical measurements, signal strength, significant effects,trunk

INTRODUCTION

Now a days, the Wireless Sensor Networks (WSNs) applications are applied in all life fields and the precision agriculture at the top of these applications. WSNs are being widely exploited in precision agriculture for example for monitoring and controlling the micro-climate inside the greenhouse. Based on field environment, WSNs are applied in precision agriculture to enhance the monitoring and controlling management process (Dhanavanthan *et al*., 2013). The flexibility is the main feature of WSNs when organizing or updating new systems (Serodio *et al*., 2001).

Recently, ZigBee is the most favorable technology in agriculture, especially in the greenhouse (Mestre *et al*., 2011; Camilli *et al*., 2007). ZigBee provides low power, low data rate and long network life time of several years. ZigBee devices transmit in the range of 10-75 m depending on the transmitted output power and operates with 2.4 GHz unlicensed RF band (Lilo *et al*., 2016).

Modeling of propagation path loss in the agriculture fields is extremely a complex work. There are many parameters influencing the attenuation phenomena. These parameters included, tree type, height, seasonal variation and density of foliage. Furthermore, the height of transceivers antenna regarding the tree height, path length, topography features, frequency and polarization. All these parameters make the path loss prediction is very difficult (Benzair, 1995).

Lamprinos and Charalambides (2015) designed a smart greenhouse based on deploying the wireless sensor nodes for collecting the CO_2, humidity, moisture light and temperature sensors to control the environmental factors. The Received Strength Signal Indicator (RSSI) is the indicator of the wireless signal strength which is depending on the environment type. The group by Yoshimura *et al*. (2016) measured the RSSIs as a function of the distance and the angle between the propagation direction. They achieved an efficient and proper node deployment. While, researchers by Lamprinos *et al*. (2015) distributed of ZigBee sensors in a greenhouse of tomato corps with hydroponic cultivationto assessment of the plant's foliage impact on the network nodes connectivity. A real-time monitoring in a date palm farm is presented by Rao *et al*. (2017), taking into account the variables of the spatial variety that related to data monitoring. The placement and required number of sensor nodes were determined and calculated based on data accuracy requirements.

By Cayli and Mercanli (2017), the impact of environmental conditions of temperature and humidity in a greenhouse on the signal strength performance of Wi-Fi sensor nodes was studied. The experimental results show that the impact of high relative humidity on signal strength is positive while it is negative of high temperature. The same environmental parameters, temperature and humidity was studied by Chen *et al*. 2017), implementing ZigBee wireless technology to control and monitor a small greenhouse while reducing the labour power with zero data packet loss rate and good scalability. A temperature, light intensity and humidity real-time monitoring system in agricultural environment was proposed by Xiao and Guo (2010) which achieved data collection and transmission along with system features of compacted frame, facilitated and relatable in operation.

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Many researchers have studied the influences of foliage on attenuation (Schubert *et al*., 2010; Meng *et al*., 2009; Vougioukas *et al*., 2013) and other researcher's studies the effects of tree canopies and trunks of tree on the RF propagation (Schubert *et al*., 2010; Meng *et al*., 2010). This study investigates the influences of parts of trees on the path loss total in greenhouse environments and shows the important of antenna height on the channel modeling. This research determines the proper heights of antenna that must be placed in greenhouse to achieve fewer amounts of total path losses.

MATERIALS AND METHODS

In order to determine the effects of leaves, twigs, trunks and canopy of trees on the propagation behavior in a greenhouse, different experiments were performed in a mango greenhouse located in Perlis area at the North of Malaysia. In this research, two nodes of Jennic (JN5148) wireless nodes are used. One acts as a coordinator (receiver) and the other one as an end-node (transmitter) as shown in Fig. 1. The nodes setup parameters are shown in Table 1. Table 2 shows the experimental details of greenhouse. The coordinator node was placed in a fixed location and the transmitter (end-node) was strategically placed along the greenhouse. At each experimental point, the coordinator is requesting a Received Signal Strength Indicator (RSSI) packet from the end-node. The collected data are saved into a database for further analysis. Figure 2 shows the geometry of mango trees in the greenhouse.

The experimental was focused to collect LQI information from 576 points classified as 6 positions vertically, 6 position distance and 16 reading points horizontally. The available area for the mango greenhouse is (50×40×5 m). The area was utilized to carry out this scenario is (40×40 m). The scheme based on readings of Received Signal Strength (RSS) for 576 locations as shown in the Fig. 3a,b. The detailed of transmitter movement for RSS collection from different distancesinitially with 2 m and the last point is 20 by 4m step. While, the initial degree is started from zero of the horizontal movement and finished at 360 by 22.5° as shown in Fig. 2a. Finally vertically movement, start with level 0.5 m and finished in 3 by 0.5 m step as shown in Fig. 2 b.

The RSS value is proportional to dBm level. The RSS of the signal is depending on the environment type those signals will transceiver through it. Thus, the researcher focused to measure the RSS of a different environment to check the effect of the environment to signal propagation.

Table 1: Setup of JN5148 wireless nodes

Variables	Values
Channel number	15
Transmit power	0 dBm
Frequency operation	2.245 GHz
Power level	24
Power mode	0 dB
Retries	3
Data rate	250 kbps
Receiver sensitivity	-95 dBm
Antenna type	Omni-directional

Table 2: Greenhouse details

Variables	Values
Dimensions of greenhouse	50×20×5 m
Number of lanes	6
Number of tree in each lane	13
Distance between each tree in same lane	3.20 m
Distance between two lanes	2.20 m
Maximum height of trees	2.5 m
Topology	Star topology
Pattern of nodes deployments	Square grid configuration

Fig. 1: Photography of WSN experimental set-up

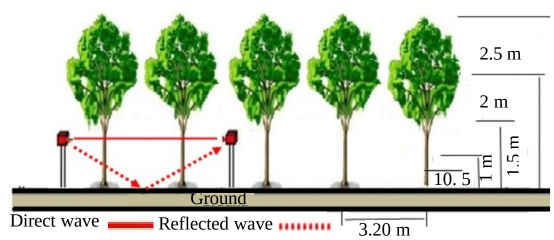

Fig. 2: Average trees geometry

The Link Quality Indicator (LQI) is the indicator for the quality of received signal and can describe it as the error amount for receiving the signal via. wireless sensors. The value of the LQI is inversely proportional to a quality of the received signal or path loss. Thus, the better environment for signal propagation that gives the higher value of RSS with lower value of LQI (Halder and Kim, 2012). The transmitter was utilized data rate 250 kbps and

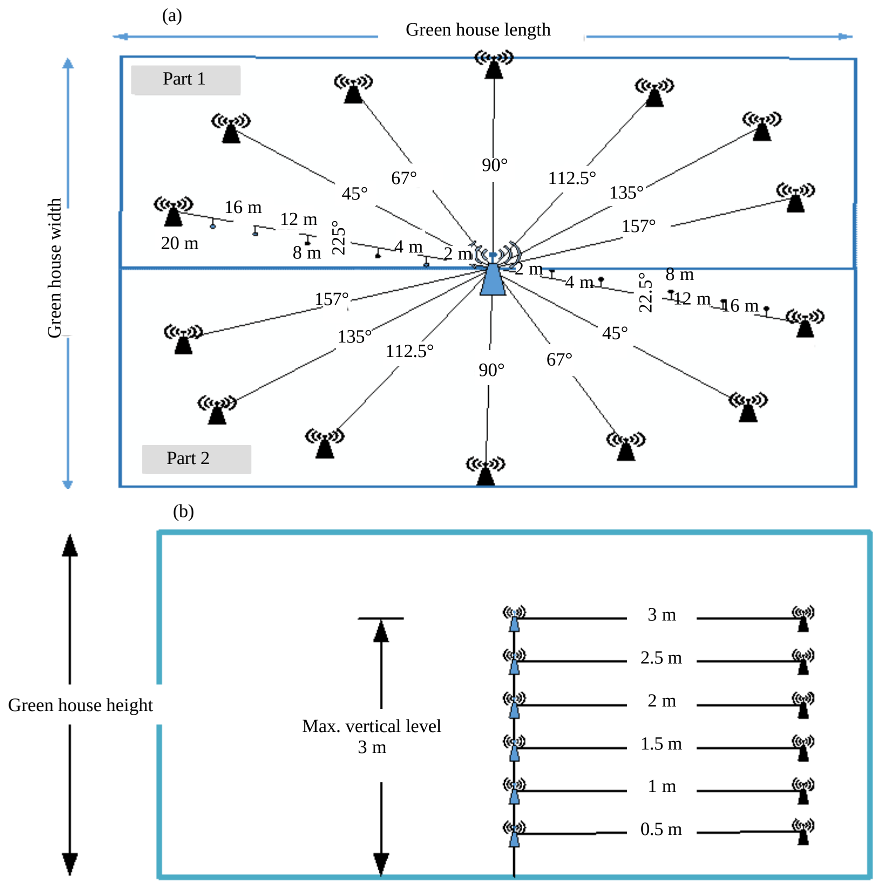

Fig. 3: a) Detail of horizontally and distance movement and b) Vertically movement of the coordinator and end node sensor

transmitted 500 packets for measuring the path loss data. The coordinator connected with the laptop to measure the path loss value (Fig 3a,b)

RESULTS AND DISCUSSION

Table 3 presents the path loss values of the 96 measurement points and Table 4 summarizes its statistical properties when antenna are placed at same heights 1 m for both.

Table 5 shows the empirical path loss at LOS situation for both transmit and receive antenna. Figure 4 shows the plots of the results presented in Table 5.

From Fig. 4, the results show that the total path losses for heights between 0.5-2.5 m are increased in general due to vegetative existence. Contrarily with the height above 2.5 m, the Line of Sight (LOS) situation almost exists and signal propagates with less attenuation. At 2 m height of transceivers shows greatest path loss

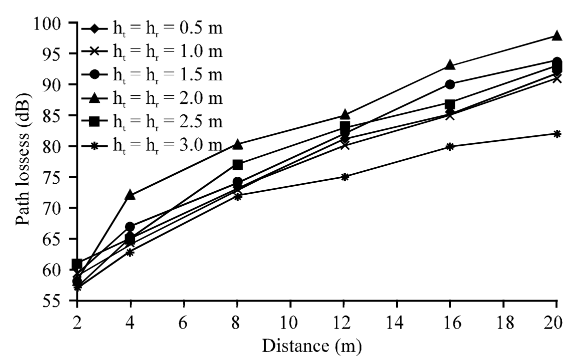

Fig. 4: Empirical path loss measurements at (h_t = H_r)

attenuation due to deepest vegetation depth found. Table 6 summaries the empirical path loss for different transceivers height in decreasing order with explain the reason of loss for each height.

From the empirical results these illustrate in Table 5, the smallest vegetation effects appeared within 1 m for both antenna (R_x and T_x) and this height will be adopted

Table 3: Path loss [dB] at ($h_r = h_t = 1m$)

Radial	Degree	Distance (m) 2	4	8	12	16	20
(Part 1)							
1	00.00	59.8	63.8	72.2	83.4	82.2	87.8
2	22.50	60.2	64.2	73.4	83.4	82.2	95.0
3	45.00	57.8	65.8	83.0	85.4	89.4	93.0
4	67.50	57.8	65.8	79.4	85.4	87.8	91.2
5	90.00	58.2	65.8	79.8	83.5	85.0	92.3
6	112.5	57.8	63.0	83.0	85.1	87.5	91.1
7	135.0	57.8	66.2	77.4	76.2	82.2	89.6
8	157.5	59.0	63.0	87.0	79.8	87.8	91.8
(Part 2)							
1	00.0	61.8	65.0	74.6	75.8	87.0	88.6
2	22.5	61.4	65.0	76.2	76.2	84.2	95.0
3	45.0	57.8	63.0	81.0	79.8	83.8	91.1
4	67.5	57.8	65.4	77.0	78.2	84.0	92.3
5	90.00	61.0	63.4	72.2	76.1	85.0	91.0
6	112.5	61.4	63.8	73.4	79.4	86.0	93.7
7	135.0	61.8	62.6	72.2	79.4	83.0	92.6
8	157.5	59.0	65.0	73.8	77.8	83.0	86.6

Table 4: Path loss results (dB)

Variables	Distance (m) 2	4	8	12	16	20
Average path loss (dB)	59	64	73	80	85	91
Standard deviation (dB)	1.58	1.17	6.11	3.33	2.55	3.04

Table 5: Empirical path loss (dB) at ($h_t = h_r$)

Transceivers height (m)	Distance (m) 2	4	8	12	16	20
0.5	61	65	73	81	85	92
1.0	59	64	73	80	85	91
1.5	59	67	74	82	90	94
2.0	58	72	80	85	93	98
2.5	57	65	77	83	87	93
3.0	57	63	72	75	80	82

Table 6 : Vegetation effect at each height of T_x and R_x

Transceiver heights (m)	Vegetation effects
Path loss	
2.0	The most depth of foliage
1.5	The begin of foliage appearance
2.5	Canopy of trees
0.5	Loss due to trunk of tree only
1.0	Loss due to trunk of tree only
3.0	LOS situation

to deployments the WSN nodes in mango greenhouse and then study, analysis and extract the new vegetation model for this environment.

CONCLUSION

The position of antenna with respect to the tree is the most factors these effects on the prediction by path losses. In this research, the effects mango trees parts in greenhouse environments are analyzed based on Jennic wireless nodes to find a proper height of transceivers antenna. The actual results shows the best heights of antenna are when placed both of receive and transmit antenna at (1, 1m), respectively. At these elevations the attenuation is the lower amount due to the trunk part of tree has the lower effects on the strength of signals between nodes among other parts.

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