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EXPERIMENTAL CALCULATION OF RSSI FOR JENNIC WIRELESS SENSOR NETWORK PLATFORM

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ABSTRACT

Wireless Sensor Network received signal strength and link quality Indicators, RSSI and LQI respectively, of Wireless Sensor Network are considered as a crucial indication for channel characterization and thus network communication success. Most of researcher used LQI as an estimation of RSS, although it is not accurate since it depend on approximation estimation. This research introduces an experimental method to calculate the RSS value of Jennic wireless network transceiver in dBm. The work has done indoor and outdoor environments to validate the results. The results can be used by researchers who adopt this platform based propagation and network communication prospective.

Keyword: RSSI, LQI, wireless sensor network, ZigBee, propagation path loss.

INTRODUCTION

The emerging and advancing of nowadays significant technologies that encompass the facility to modernize the exploitation of physical environment data, enabling Wireless Sensor Networks (WSNs) to be used with various applications that were difficult or impossible to be conducted [1-3]. Applications WSNs for both Indoor and Outdoor, currently, are widely adopted within civilian, military, industry and space fields.

The extensive observing of the earth's environment, animal habitats, industrial sensing and analytics, civil structures, significant infrastructure safety, health monitoring and collecting of monitored data in hospitable locations counting biochemical hazard detection and tracking, as well as precision agriculture applications in agriculture fields beside military applications uses [1, 4, 5, 6].

Figure-1 shows the structure of WSN. It depicts the composing elements of the network which composed of plentiful end nodes that equipped with sensors and transceiver unit. These nodes are communicated for a coordinator node directly in single hope strategy or using multi-hope techniques. WSNs may use one of many communication technologies as a communication medium [7].

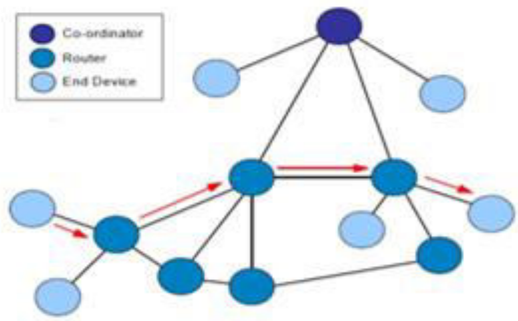

Figure-1. The structure of JN5148 wireless sensor nodes.

One of popular technology used with WSN is ZigBee. It's a 2400 MHz with 250 Kbps and less power consumption wireless platform technology. The radio unit of ZigBee is adopting signal quality gauges represented by the strength of the received wave indicator (RSSI) and quality of the communication link indicator (LQI). The received signal energy is considered as a worth indication of the wireless channel connection quality where the energy received within the radio unit is used as a computation factor. On the other hand, the link quality indicator is computed with reference to the ratio of the signal to the noise of the channel operating frequency, thus it offers for each received packet a mean correlation value [8]. Practically, it is difficult to compute the RSSI value since no instructions anywhere as how to compute it in dBm [9] even though, hardware manufacturing are not so clearly in providing a way to measure the received energy value within their manufactured chips and kits. The author in [10] uses the datasheet with the aids of protocol stack to specify the RSS value. They found that RSSI value is attached as the last byte within the internal data packet, following the LQI byte [9-10]. They are successfully read

RSSI and LQI values easily, but when comparing the RSSI value to real RSS value (dBm); it became complicated due to mismatching. RSSI value is defined in datasheets but never explained as to how to calculate real RSS value in dBm. Although that, for Jennic WSN processor equipped in wireless sensor nodes [11], the signal strength (above the receiver sensitivity level) is displayed on the Master board using LEDs D1, D2, D3 and D4, as follows:

- When all 4 LEDs are on; Very strong signal (greater than 60 dB).
- When 3 LEDs are on; Good signal (greater than 40 dB).
- When 2 LEDs are on; Acceptable signal (greater than 20 dB).
- When 1 LEDs is on; Weak signal (less than 20 dB).
- When 0 LEDs on; No packets are being received.

The Link Quality Indication (LQI) value is output to the serial port to be read by a host computer. Figure-2 shows the record of serial data captured. This research, introduce an experimental method to calculate the (RSS - LQI) of Jennic Wireless Sensor Network processor and clear the ambiguity for other researchers that used same hardware.

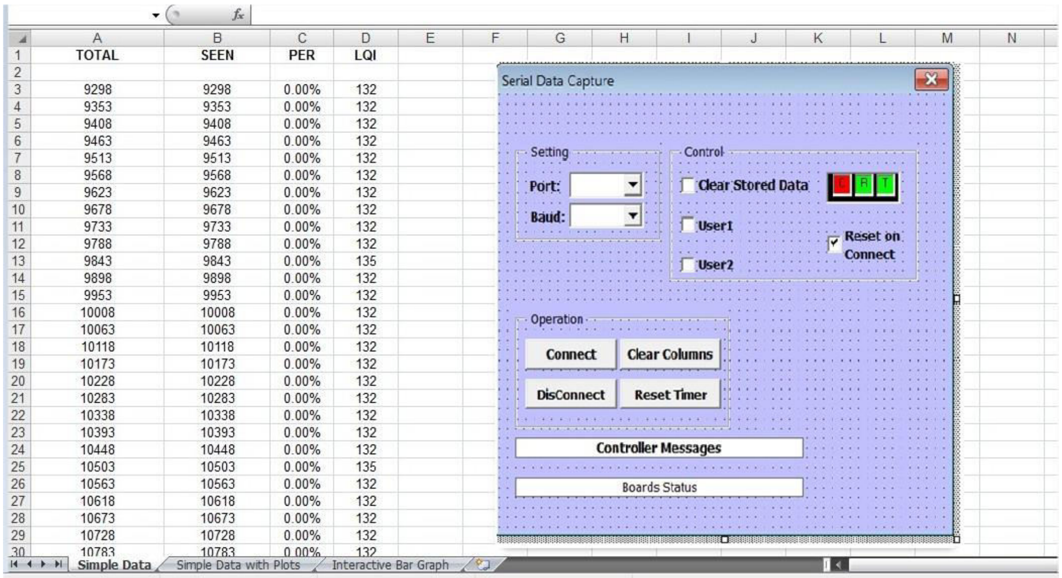

Figure-2. Jennic wireless network node serial data captured.

RSSI AND LQI INDICATORS

There are two popular practical approaches are used to define the energy of wireless received packets; the received-power and the estimated received link-quality indicator, RSSI and LQI respectively. The calculated power of a received broadcasting signal is defined as RSSI. RSSI is applied and extensively used in 802.11 standards while received power can be calculated from RSSI. On the other hand, the estimation of how simply the received signal can be modulated when considering noise existing in the communication channel is defined by LQI [12].

RECEIVED SIGNAL ENERGY STRENGTH (RSS)

The idea behind RSS is that the configured transmission power at the transmitting device (P_t) directly affects the receiving power at the receiving device (P_r). According to Friis' free space transmission equation [12], the detected signal strength decreases quadratically with the distance to the sender [12].

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

Where:

P_t, P_r : The Power of the Transmission and Receive signals.

G_t, G_r : Transmitter and Receiver gains.

λ : Signal wave length.

d : Separation distance (sender and receiver).

The received signal strength indicator (RSSI) is derived from the received signal strength, equation 2, and thus, within embedded devices, it is defined as a ratio of the received power to the reference power (P_{ref}). Typically, the reference power represents an absolute value of P_{Ref} =1mWatt [12].

$$RSSI[dBm] = 10 \cdot log_{10}\left(\frac{P_r}{P_{Ref}}\right) \quad (2)$$

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Hence, increasing of RSSI value indicating of an increasing of received power. In practical scenarios, the ideal distribution of P_r is not applicable, because the propagation of the radio signal is interfered with a lot of influencing effects such as reflections on metallic objects, superposition of electromagnetic fields, diffraction at edges, and refraction by media with different propagation velocity, polarizations of electromagnetic fields and etc. These effects degrade the quality of the determined RSSI significantly [12-13].

Link quality indicator

The abovementioned affects during broadcasting packets will lower the quality of RSSI tremendously. The definition of LQI in the 802.15.4 standard is presented but its context of use is not specified in this standard. Some works on the LQI, few of which are field experiments, have shown that the LQI decreases as the distance increases. The differentiation between RSSI and LQI is shown in Table-1 [12]:

Table-1: RSSI and LQI

Strength	Signal	Noise	RSSI Value	LQI Value
Weak	√	√	Low	Low
Weak	√	Absence	Low	High
Strong	√	√	High	Low
Strong	√	Absence	High	High
Strong	-	√	High	Low

With jennic WSN transceiver, the LQI is computed based on RSSI of successful reception of packets within Zigbee protocol standard.

EXPERIMENT SETUP

The experiments have been conducted in indoor environment as shown in Figure-3 and outdoor environment as shown in Figure-4 to validate the results of computing of RSSI and LQI.

Figure-3. Indoor environment.

Figure-4. Outdoor environment.

EXPERIMENTAL HARDWARE SETUP

The JN5148 module

The JN5148 wireless nodes used to acquire data are efficient performance surface mounted modules with low-power consumption, targeted at low-power wireless networking applications and facilitating users to implement applications with shorter time and cheapest cost. They use Jennic wireless network module to offer a complete solution with highly features such as bigger memory and high performance of CPU and radio transceiver. This foundation will allow easily developing an efficient and cost effective tremendously wireless network sensing and controlling applications [11].

The experimental uses two of Jennic boards, ones the coordinator to sink all data sent from the end node. Packets (frames) are sent between the boards and the PER results are collected serially within aids of a PC. Figure-3 and Figure-4 show the experiment setup in indoor and outdoor environments.

Power analysis manager

The Agilent Power Analysis Manager is adopted which is of model N1918A. It is combined with GUI package of many functions such as power display, plotting, archiving of time based readily [14]. Figure-5 shows the photography of power sensor that used in our experiments.

Figure-5. Photography of hardware experiments.

METHODOLOGY

In order to obtain the RSS values in dBm, experiments were done in two scenarios, one in the indoor environment and the other for outdoor environment:

Scenario 1- Indoor environment

This scenario is carried out in laboratory. The setup shown in Figure-3 is deployed in indoor environment with two JN5148 wireless nodes and N1918A Agilent Power Analysis Manager. The Jennic board is set to use a transmission power of 0dBm and a receiver sensitivity of -95dBm, and 2.425 GHz is the operation frequency. It uses a Omni-directional antenna, the heights of transmission and receive antenna were at 20cm from the ground, channel 15 is chosen for this experiment thus, the frequency of N1918A power meter has been as 2425MHZ. Both Power Analysis Manager and coordinator node are connected to PC and fixed in position, contrary the end-device node is moved in predefined spatial distances. At each point, the coordinator requests a RSS packet for the end-device. The received power is read by power sensor and Jennic node and thus to compute the value of RSS in dBm. Table-2 shows the readout of various distances with LQI and Power Analysis Manager Values.

Scenario 2-Outdoor environment

This scenario is carried out on the natural grass in a football stadium in Perlis. Figure-4 shows the photography of outdoor environment scenario and Table-3 illustrates the readout of wireless node and power meter values.

Table-2. Indoor results.

Distance meter	LQI	Power sensor (dBm)
1	180	-23
2	168	-27
3	162	-30.2
4	150	-35
5	144	-37.4
6	138	-39.8
7	135	-41
8	132	-42.2
9	126	-44.6
10	130	-42.2

Table-3. Outdoor result.

Distance meter	LQI	Power sensor (dBm)
1	183	-21.8
2	168	-27.8
3	159	-31.4
4	138	-39.8
5	135	-41
6	135	-41
7	132	-42.2
8	117	-48.2
9	130	-43
10	126	-44.6

RESULT AND DISCUSSIONS

Table-2 and Table-3 indicate that the values of LQI approximately equal to 2.5dB. The value of RSS computed based LQI values can be deduced as equation (3) and (4) which is matched the values read out by the Power Analysis Manager.

$$RSS\ (dBm) = \left(\frac{LQI}{2.5} - R_{sen}\right) \quad (3)$$

$$RSS\ (dB) = \left(\frac{LQI}{2.5} - R_{sen} - 30\right) \quad (4)$$

where R_{sen} is the receiver sensitivity and its equal to -95 dBm in our experiment.

CONCLUSIONS

Receive Signal Strength Indicator (RSSI) value is defined in datasheets but never explained as to how to calculate real RSS value in dBm. This work, introduce an experimental method to calculate the RSS of Jennic JN5148 wireless sensor nodes. The work has done indoor and outdoor environments to validate the results.

The value of Jennic JN5148 wireless sensor nodes can be extracted based equations (3) and (4) which feasible to be used for various environment either indoor such laboratories and building and outdoor like farm.

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ARPN Journal of Engineering and Applied Sciences

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