International Journal on Recent and Innovation Trends in Computing and Communication ISSN: 2321-8169
Volume: 4 Issue: 3 418 - 420

Experimental Evaluation of Routing Metrics in Wireless Multi-Hop Network

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***Abstract*—** Routing protocols evaluate end-to-end path metrics which is conglomeration of individual link metrics to choose the best route. Routing protocols designed for wireless multi-hop constrained networks must optimally use the scare resources: bandwidth, battery power, memory, computing. Optimal paths are determined based on routing metrics. Analysis of routing metrics and impact of choice of routing metrics plays a major role on Quality of Service (QoS) parameters. This work mainly focus on empirical evaluation of signal strength based metric in indoor and outdoor environments to record Line Of Sight (LOS) and Non Line Of Sight (NLOS) radio characteristics. Analysis and experimentation is carried out using Xbee 802.15.4 modules and XCTU software.

Keywords- Routing,PDR,multi-hop,XCTU,Xbee

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I. INTRODUCTION

The access Point negotiates all wireless traffic as well as any traffic between wireless and wired network. The systems do not communicate direct peer-to-peer way as in Ad-hoc mode.

Wireless Mesh Network (WMN) is a combination of radio nodes arranged in a mesh topology. It comprises of gateways, mesh clients and mesh routers. It offers redundancy and is reliable.

Wireless sensor network (WSN) is a group of specialized transducers with a communications infrastructure for monitoring and recording conditions at diverse locations de-comprises of microcontroller, battery and radio transceiver. It is used for detection of environmental factors such as pressure, temperature etc. Mobile ad-hoc network (MANET) is a self-configuring device, where the network structure changes dynamically due to mobility. The nodes are free to move randomly.

Routing is a process of finding path from source to destination. A metric is a measurement of performance in some product or system, such as a program or a network. A router use metrics to make routing decision. It is based on the parameters such as reliability, path length, load, bandwidth, hop count, delay, Maximum Transmission Unit (MTU), path cost.

Metrics provide a quantitative value to indicate the specific characteristics of the route.

Xbee is a brand name of a family of factor compatible radio module in Digi International. It can operate either in transparent data mode or in packet-based Application Programming Interface (API) mode. Command used for controlling radio's setting is AT.

II. RELATED WORK

The studies in [1] describe received signal strength (RSSI) and the round trip packet delay for different environmental factors such as LOS/NLOS. The Author's main focus is not on information such as battery consumption time, network life time, and measuring the parameters (RSSI and packet delay) in large networks.

Author of [2] discussed about the different routing metrics such as Expected Transmission Count (ETX), Expected Transmission Time (ETT) and Weighted Cumulative Expected Transmission Time (WCETT). Comparison is done for all the routing metrics and inferred that ETT is superior to other metrics because ETT handles parameters such as link quality, intra-flow interference, isotonic etc. compare to other metrics.

The studies in [3] is based on comparison between the different routing metrics based on their performance metrics measured such as throughput, delay, packet loss ratio, delay jitter. Inference has been made that ETX metric gives best result and HOP count metric gives worst result. This work doesn't provide accurate result because environmental condition is not taken into account.

III. EMPIRICAL EVALUATION

A. Received signal strength Indicator

RSSI is the main approach of this work. It helps in determining the link quality. Range test is performed using XCTU software to capture RSSI by varying distance and under different environmental factors.

B. Neighbour Table Management Module

Next hope can be determined using routing metrics with the help of neighbour table formation.

Neighbour table contains information on all other directly connected routers. It is used to collect the related information about its neighbour and maintain a record with the help of routing table. After receiving information other nodes will update their neighbour table based on the information such as packet sent time, packet received time, RSSI and power level. Each entry corresponds to a neighbour with the description of network interface and address.

The work done in this project is based on real time scenario where various environmental factors are considered. Basically range test is performed using XCTU software to achieve high data delivery ratio with best link quality. The main purpose of this work is based on Received Signal Strength Indicator (RSSI) in different scenario such as indoor LOS/NLOS.

This work shows how the packet sent differs in various regions such as connect region, transitional region and disconnect region. The packet can be received in connect region with hundred percent success rate because links are often of good quality, stable, and symmetric whereas in

transitional region we can't predict the packet received because transitional region often quite significant in size, and is generally characterized by high variance in reception rates and asymmetric connectivity. But in disconnected region links have poor quality and are inadequate for communication, hence packet reception rate is almost negligible.

The remaining part of the paper consists of section IV which shows comparison between remote, local and success rate VS varying distance with respect to LOS/NLOS factors, with inferences and section V ends the paper with conclusion.

IV. Simulation Result And Analysis

The range test is conducted for two different transmit Power levels: Highest transmit power level (0dBm) and lowest transmit power level (4dBm), packet sent is around 100.The success rate and RSSI is measured at both the end i.e. at receiver as well at transmitter ends. Radio wave propagates only for certain distance for each power levels. Hence, neither RSSI nor packet success rate can be calculated for distance where there is no propagation of radio wave.

TABLE I. Range Test Specification

Transmit Power Level		
Environmental Condition	***Highest***	***Lowest***
Indoor line of sight	0dBm	4dBm
Outdoor non line of sight	0dBm	4dBm

Many experiments on range test have been performed for Indoor Line Of Sight (LOS) as well as for indoor Non-line of Sight (NLOS). The graphs given below represent the success rate Vs distance for different scenarios.

1. INDOOR LINE OF SIGHT

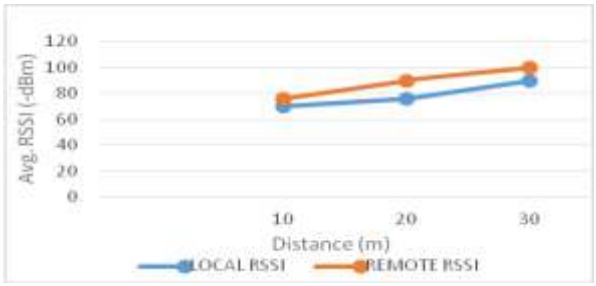

Figure 1. (a) Avgerage RSSI (Local/Remote) Vs Distance (high transmit power level, LOS)

From the above graph we can conclude that for high transmit power level Remote and local RSSI lies between -70 dBm to -100 dBm. It shows that with the increase in distance RSSI decreases.

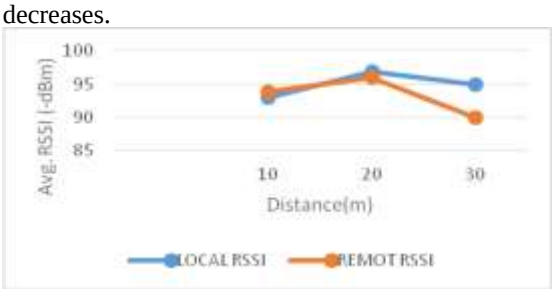

Figure 1. (b) Average RSSI (Local/Remote) Vs Distance (low transmit power level, LOS)

The above graph shows the variation of RSSI range lies between -92dBm to -89dBm with increase in distance, there is sudden fluctuation in the graph which shows the transition region where we can't predict the packet received because of its instability and asymmetric features.

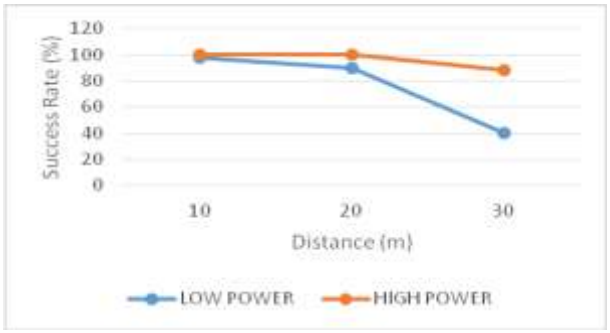

Figure 1. (c) Success Rate Vs Distance(Low/High Transmit Power Level, LOS)

This graph shows the decrease in success rate as the distance increases. Success rate of high transmit power level is better in comparison to low power level. For high power level success rate is hundred percent for 10m and 20m distance.

2. INDOOR NON-LINE OF SIGHT FOR SOFT PARTITION (GLASS)

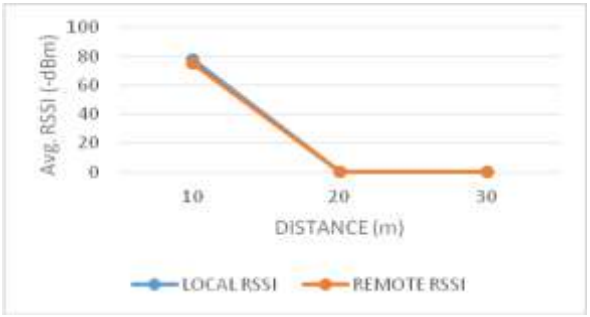

Figure 2. (a) Avrage RSSI (Local/Remote) Vs Distance (low transmit power level)

The above graph shows the RSSI range lies only in the 10m range which lies between -80dBm to -95dBm. We can't predict RSSI after 10m range for NLOS in glass at low power level.

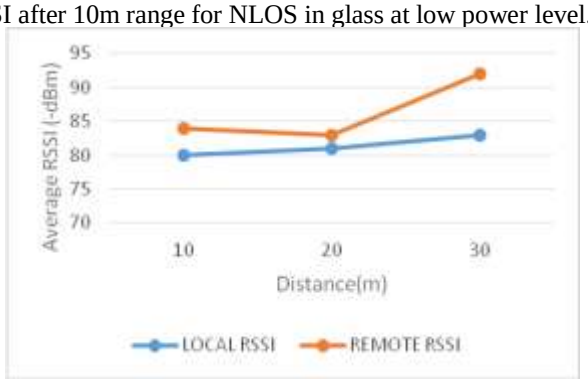

Figure 2. (b) Avrage RSSI (Local/Remote) Vs Distance (high transmit power level)

RSSI range lies between -80dBm to -93dBm with increase in distance, the fluctuation in the graph shows the transition region where RSSI range is unpredictable.

 ISSN: 2321-8169
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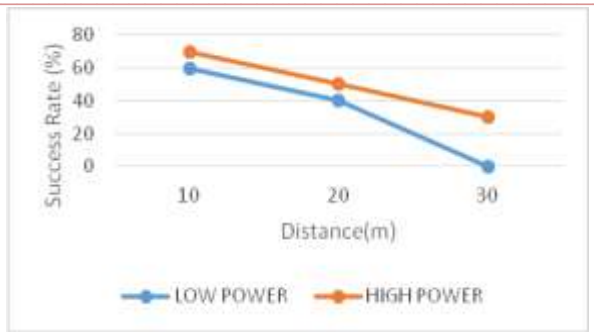

FIGURE 2. (C) SUCCESS RATE VS DISTANCE (HIGH/LOW TRANSMIT POWER LEVEL)

This graph shows the decrease in success rate as the distance increases. Success rate of high power level is better compare to success rate of low power level.

3. INDOOR NON-LINE OF SIGHT FOR HARD PARTITION (WALL)

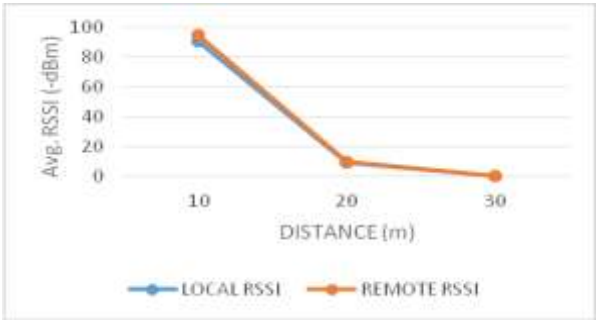

FIGURE 3. (C) AVERAGE RSSI (LOCAL/REMOTE) VS DISTANCE (HIGH TRANSMIT POWER LEVEL)

RSSI range is between -90dBm to -100dBm, it indicates that RSSI range decreases with increase in distance. RSSI range can only be predicted till 20m range after this range radio propagation is not possible for high power level.

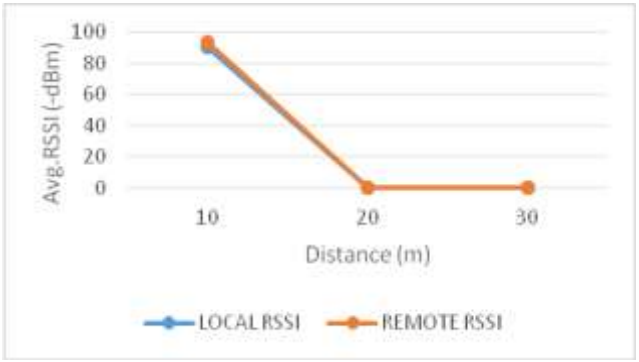

FIGURE 3. (B) AVRAGE RSSI (LOCAL/REMOTE) VS DISTANCE (LOW TRANSMIT POWER LEVEL)

At low power level radio wave do not propagate after 15m range. But RSSI ranges in between -90dBm to -98dBm for 10m range.

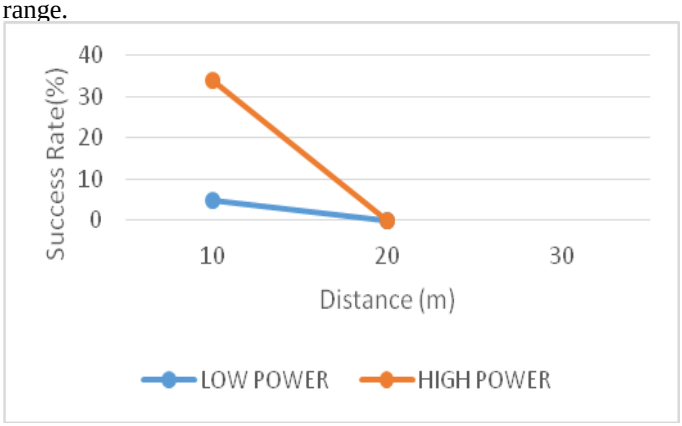

FIGURE 3. (B) SUCCESS RATE VS DISTANCE (HIGH/LOW TRANSMIT POWER LEVEL)

Success rate for indoor NLOS become zero at 20m and 30m, this means beyond 10m-15m range radio wave cannot propagate. Success rate of low transmit power level is very poor compare to high power level.

V. CONCLUSION

We extensively measured RSSI for multiple distances by considering various environmental factors, such as LOS and NLOS. Conclusion have been made that for LOS RSSI region lies up to 30m when high transmit power level is taken into account and for low transmit power level range decreases. Whereas, for NLOS RSSI region lies between 10m and 20m only for soft partition and 10m for hard partition. This means radio propagation range is limited for certain distance for indoor environmental condition.

VI. FUTURE WORK

Future work can be done for multi-hop and for outdoor environmental factors. RSSI can be performing for distance above 30m or more in outdoor environmental factors.

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