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Performance Evaluation of Zigbee and Wimax

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Abstract- The world of wireless communications is quickly progressing. Technologies under research and development promise to deliver more services to more users in less time. Emerging wireless technologies: Wireless Local Area Networks (WiFi-802.11n), Wireless Personal Area Networks (ZigBee) and Wireless Metropolitan Area Networks (WiMAX).. In this paper physical layer parameters are tuned to study the characteristics of ZigBee and WiMAX technologies independently and proposes a study and comparison of two of most advancing communication technologies (Zigbee and WiMax). Both of these technologies are breakthrough in communication and both of them have their own positive and negative points. In some situations, in a near future highly advanced and area specific application of WSN will be required. We will analyze these two technologies, which would be appropriate for those applications & analyse weather, location and terrain conditions are capable for the communication through such networks.

Index Terms- Wireless sensor network (WSN), ZigBee, WiMAX, QOS

I. Introduction

The emerging IEEE 802.15.4 (ZigBee) standard aims to provide low data rate wireless communications with high-precision ranging and localization, for a low-power and low cost solution. WiMAX (Worldwide Interoperability for Microwave Access) is a standard for wireless data transmission covering a range similar to mobile phone towers. With high staging in both range and throughput, WiMAX technology can be a gain to present internet providers seeking to become the leader of next generation wireless internet access. IEEE 802.15.4, ZigBee's name is derived from the bees whirl, that permits them to exchange data, is a low cost and low power consumption Wireless Personal Area Network (WPAN) standard, which can be used in many different wireless sensor network applications such as home/building automation, consumer electronics, industrial controls, medical sensor applications, etc. The IEEE 802.16, the Air Interface for Fixed Broadband Wireless Access Systems, also known as the IEEE Wireless MAN air interface, is an appearing set of standards for fixed, portable and mobile BWA in MAN. These standards are provided by IEEE 802.16 that initially describes the wireless local loop (WLL) technologies in the 10.66 GHz spectrum, which were further enlarged through altered projects to include both licensed and unlicensed spectra from 2 to 11 GHz [7].

II. Related work

In [1] energy consumption optimization in ZIGBEE (IEEE 802.15.4 standard) is done by an algorithm and mathematical formulation. Various parameters of physical layer are tuned depending on various applications. The equation is formulated in which parameters like BER (Bit error rate), SNR (Signal to noise ratio), number of payloads and distance between nodes are optimized. The author focused on physical layer and proposes a model using MATLAB that automatically optimize transmission power, throughput and latency. Various simulations are done to find energy consumption to increase battery lifetime. The results show that the energy consumption depends upon bit rate, payload size and distance.

In [2] author evaluated essential QOS (quality of service) parameters of WIMAX. The parameters are delay, PLR (packet loss ratio), PDR (packet delivery ratio), throughput and jitter. This is found that with increase in number of nodes the optimum value of QOS parameters can be obtained. For QOS there must be guaranteed throughput and less delay, jitter and packet loss.. By using AODV protocol high average value of throughput and packet delivery is obtained. In general QOS is dependent upon type of application and usage. The advantages of WIMAX over LAN are as high data rates, low deployment cost, ease of usage and coverage of large area.

In [3] author measures QOS (quality of service) parameters of ZIGBEE using different protocols OLSR INRIA, OLSRv2 NAGATA, ZRP, AODV and DYMO with star topology and CBR application. QOS parameters studied are end to end delay, throughput, jitter and data packet delivery ratio. In results it is found that highest throughput is of AODV and also receives 25 packets but on overall basis OLSR INRIA protocol is best for CBR application. OLSR INRIA is best in overall performance and also gives less jitter and average end to end delay comparing to other protocols.

III. Physical layer Energy consumption

Energy per bit is defined as average energy consumption to transmit single bit. It is directly proportional to signal to noise ratio, distance and antenna gain and inversely proportional to bit error rate, range and payloads. This is calculated by varying these parameters using the equation:

$$Eb = \frac{1}{(1-pb)^{L+a}}\left[SNR\left(ud^2 - 1\right)\right]\frac{L+a}{RL} \qquad \textbf{(1)}$$

E_b = Average energy consumption per bit.

y= PN*FN

u= $\sqrt{\frac{4\pi}{\lambda G_T G_R}}\cdot(1+{}^{\eta})$

η = The transmit amplifier efficiency
L = Payload size
a = Header size
R = Data rate
$G_{T,R}$= Transmit/receive antenna gain
d= Transmitting distance
PN= Noise power
SNR= Signal-noise power ratio at the receiver
FN= Noise figure
Pb= The bit error rate and is related to SNR
R and a are constants and taken from datasheets of ZigBee and WiMAX, 250kbps and 70Mbps are taken respectively. E_b, now can be computed for particular SNR range.

IV. Quality of Service

Quality of service is overall network performance. It does not refer to single parameter. Quality of Service is an essential parameter to judge performance of any Network [5]. In our work two parameters are taken they are: Throughput and End-to-End delay. Same parameters are taken for both technologies for proper comparison. The word Quality is always termed as the degree to which a set of inherent characteristics fulfils a particular requirement. The term Quality of service refers to the probability of the communication network meeting a given traffic contract. In the field of networking it could be termed as the probability of a packet successfully passing between two points in the network. QOS is the potential of network element to have some level of assurance that its traffic and service requirements would be satisfied.

A. Throughput

Throughput is number of bits passed through a network in a second. It computes how rapidly data can pass through a body. The throughput of a node is sustained by enumerating the total number of data packets successfully delivered at the node and also enumerating the number of bits received, which is divided by the total simulation time [2]. The throughput of the network is defined as the average of the throughput of all nodes involved in data transmission.

$$T_{nn} = \frac{\Sigma T_n}{N_n} \qquad \textbf{(2)}$$

T_{nn}=Network Throughput
ΣT_n= Sum of Throughput of Nodes Involved in Data Transmission
N_n=Number of Nodes

B. End-to-End delay End-to-End delay indicates the length of time taken for a packet to travel from the CBR (Constant Bit Rate) source to the destination. It represents the average data detained, an application encounters during transmission of data. The end-to-end delay is the time acquired for data bytes to reach the end node. The delay for a packet is the time taken by packet to reach the terminal. And the average delay is obtained by considering the average of delays for each data packet transmitted [2]. The parameter is enumerated only if the data transmission has been done successfully.

$$A_D = \frac{\Sigma P_D}{N_r} \qquad \textbf{(3)}$$

A_D =Average Delay
ΣP_D = Sum of all Packet Delays
Nr=Total Number of Received Packets.

V. Simulation Results

Simulations were performed in MATLAB to find the optimal value of 802.15.4 and 802.16, Physical layer energy consumption and how it is affected by the Physical layer parameters such as BER, SNR, Noise power, payloads and distance between nodes. The energy consumption per bit E_b as shown in Eq. (1) is affected by the value of d. First simulation compares E_b at different distances (50,100,200,300 and 400) m and different values of SNR (0.8 to 5) dB at L=10 bytes, as shown in Fig. 1 and Fig.2. E_b Increases with decreasing SNR and increasing d at given L for both technologies, ZigBee consumes much less energy compared to WiMAX. The energy consumption per bit E_b as shown in Eq. (1) is also affected by the value of L. E_b decreases with decreasing L as shown in Fig. 3 and Fig. 4 with different L (50,100,150,200 and 250) bytes, distance d = 400m and different SNR. Also, for each value of L, E_b decreases with increasing SNR for both technologies. The energy consumption per bit E_b is also affected by the value of P_n. E_b Decreases with decreasing L as shown in Fig. 5 and Fig. 6 with different (10, 20, 30, 40 and 50) dB-m, distance d = 400m, L= 10 bytes and different SNR. Also, for each value of P_n, E_b decreases with increasing SNR for both technologies. For all simulations, ZigBee consumes much less energy compared to WiMAX.
Next part is calculation of QOS parameters. Throughput and end-to-end delay are calculated for both technologies using Eq.(2) and Eq.(3). Throughput and end-to-end delay for both technologies have greater value in WiMAX and ZigBee. The graph is drawn between throughput and number of packets as shown in Fig. 7 and end-to-end delay versus number of packets shown in Fig. 8.

VI. Conclusion

In this paper, energy consumption using the 802.15.4 and 802.16 Physical layers at different environmental and interference noise levels is calculated. QOS is also calculated. The simulation results show how the energy consumption (E_b) versus the SNR values were affected by various communication parameters such as payload size, noise power and distance between transmitter and receiver. After delivering certain number of packets QOS parameter are calculated. Overall it is concluded that ZigBee is appropriate technology for sensor networks because main requirement of WSN is less power consumption, in such applications where energy consumption is not severe WiMAX can be implemented as it gives high throughput value as compared to ZigBee. In our future work, we will extend the simulation to include the effects of the MAC and network layers.

We are also exploring the possibility to tune some of these parameters automatically, in order to achieve a required QOS under given performance.

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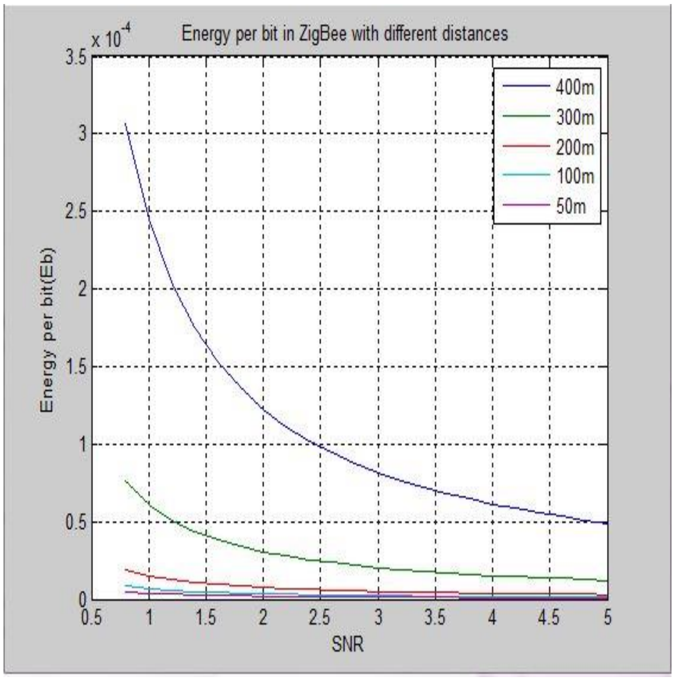

Figure 1: Energy Consumption per bit versus SNR at different distance for ZigBee

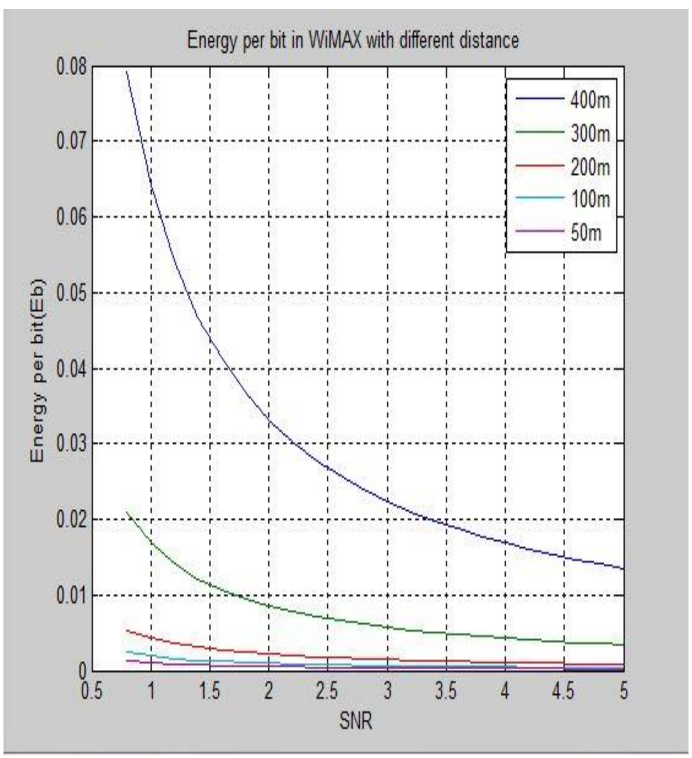

Figure 2: Energy Consumption per bit versus SNR at different distance for WiMAX

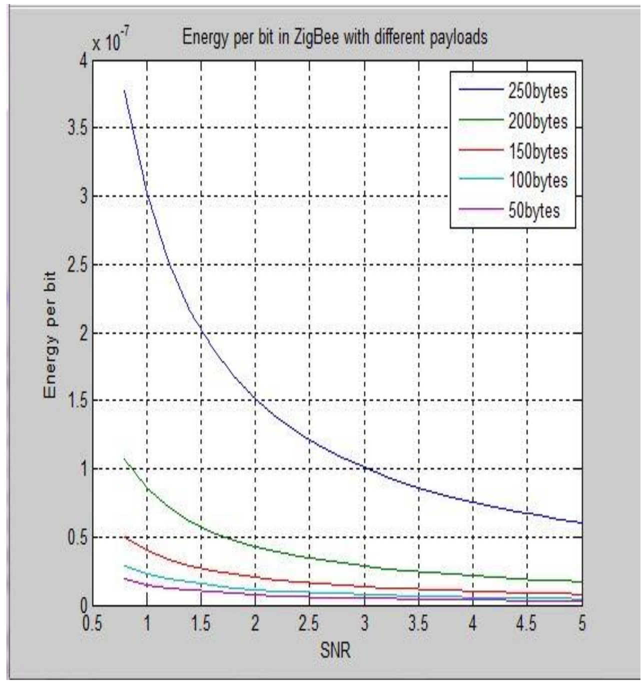

Figure 3: Energy Consumption per bit versus SNR at different payloads for ZigBee

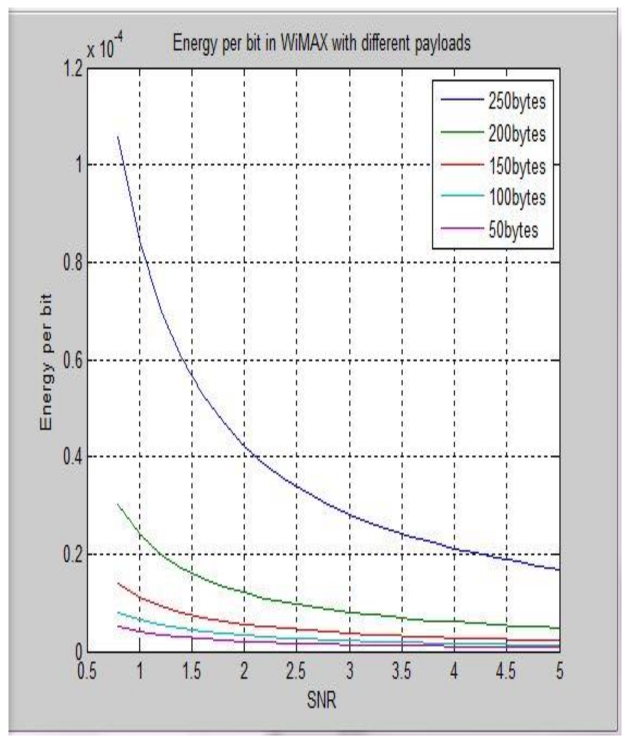

Figure 4: Energy Consumption per bit versus SNR at different payloads for WiMAX

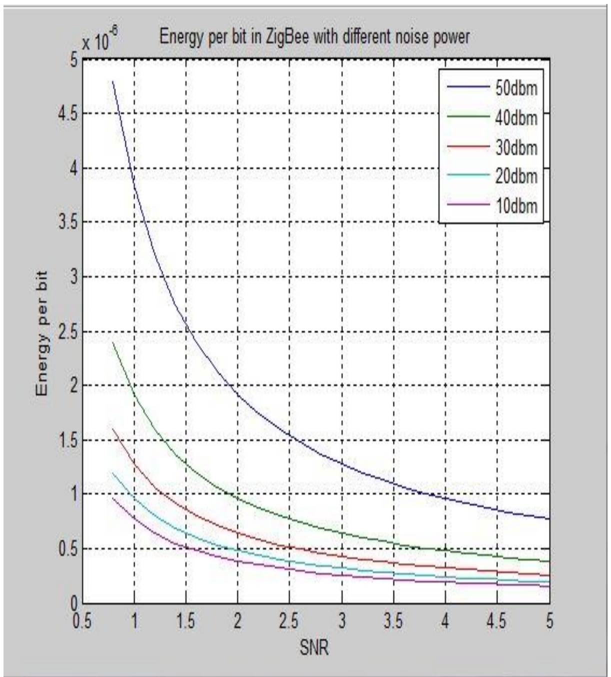

Figure 5: Energy Consumption per bit versus SNR at different noise power for ZigBee

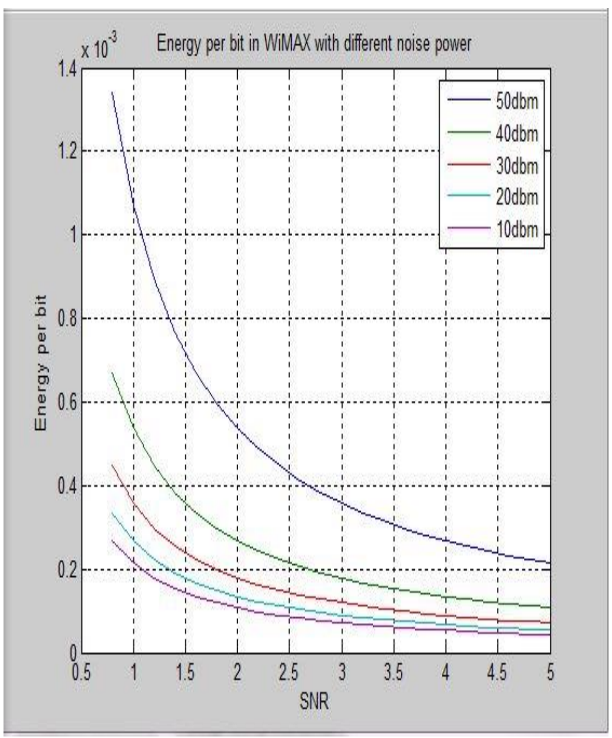

Figure 6: Energy Consumption per bit versus SNR at different payloads for WiMAX

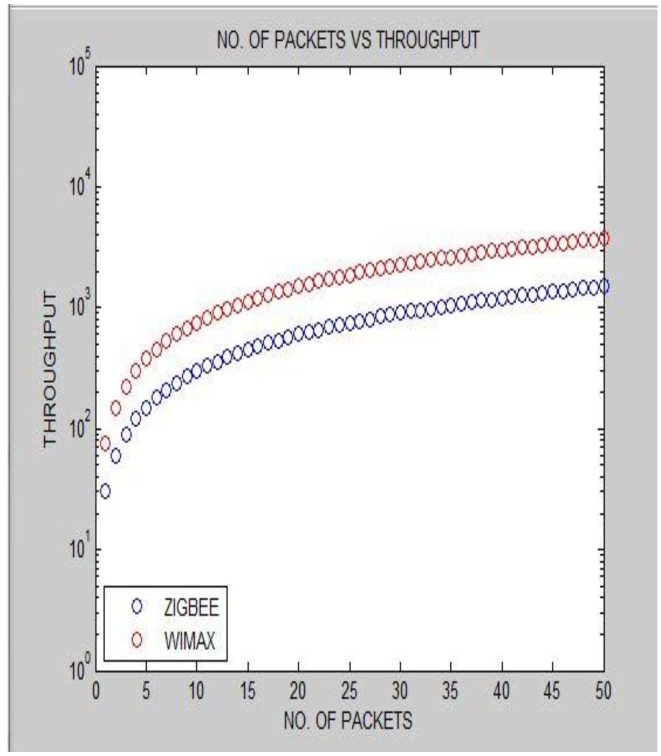

Figure7: Comparison of throughput for ZigBee and WiMAX

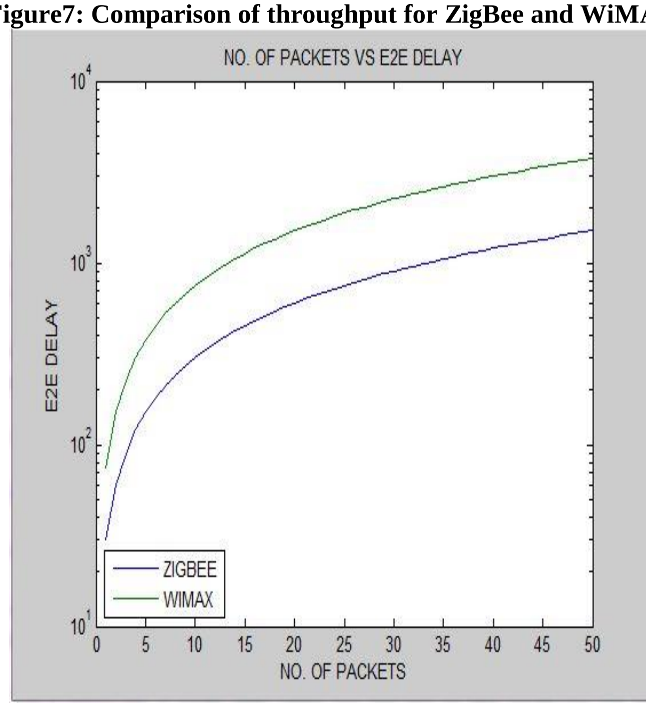

Figure 8: Comparison of End-to-End delay for ZigBee and WiMAX

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