ISSN: 2278 – 909X
International Journal of Advanced Research in Electronics and Communication Engineering (IJARECE)
Volume 4, Issue 6, June 2015

Throughput Enhancement of ZigBee and WLAN under the Influence of Bluetooth

Ms. Hina Dhiman
Dept. of Electronics and Telecommunication
Sinhgad College of Engineering
Pune, India

Prof. Mrs. S.A. Shirsat
Dept. of Electronics and Telecommunication
Sinhgad College of Engineering
Pune, India

***Abstract*— ZigBee, WLAN and Bluetooth play a very important role in Wireless Communication. But on the other hand the throughput of these three technologies decreases due to the fact that they co-exist in the frequency band of 2.4GHz. This paper will show the comparative study of ZigBee, WLAN and Bluetooth and also the method to improve the throughput using Power Control Technique using NS-2.**

***Index Terms*—Wireless Local Area (WLAN), Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA), Direct Sequence Spread Spectrum (DSSS), Orthogonal Frequency Division Multiplexing (OFDM), Packet Delivery Ratio (PDR)**

I. INTRODUCTION

The use of short range wireless standards has increased today. But the wireless standards used in the environment are not very efficient in the areas of power consumption, survivability, dynamic information technology capabilities, and energy efficiency. On the other hand mobility also results in the need of ad hoc networks that require low maintenance. The introduction of cross-layer design helps in the throughput enhancement due to the optimization of data across the different OSI layers [1].

The sharing of the spectrum is even though a solution for a number of wireless networks but it has also emerged with a problem of coexistence, that is sharing of a common band in the spectrum. This results in the degradation of throughput and increase in packet drop ratio. Although most of the systems induce interference avoidance mechanism such as RTS/CTS.

Thus the interaction between the physical and MAC layer (MAC/PHY) in the OSI layer somehow helps to cope up the issue of coexistence.

WLAN is a type of technology in which the user can access and leave the network depending upon the need, Bluetooth is the type of technology in which the users may interact for the need of data and video transmission for a short distance range, also ZigBee is generally used for the Military and other secure services.

These three technology exists in the frequency band of 2.4GHz, and if comes in the range of each other all together then give rise to interference and coexistence that results in decrease in throughput and packet drop ratio.

This paper has the analysis of throughput of WLAN and ZigBee under the influence of Bluetooth. The performance of ZigBee is observed when Bluetooth acts as interferer and similar it is observed for WLAN.

II. SPECIFICATIONS OF ZIGBEE, WLAN AND BLUETOOTH SYSTEM

As per the study, it has been observed that ZigBee is a partial jammer for WLAN and Bluetooth System. Thus, if the plane has all the three systems together, a significant reduction in the throughput is observed due to collision of data packets.

TABLE I. Specifications of ZigBee, WLAN and Bluetooth System

Specifications	ZigBee	WLAN	Bluetooth
Data Rate	250 Kbps	1-25 Mbps	1 Mbps
Frequency Range	780/868/915MHz, 2.4 GHz	2.4 GHz	2.4-2.8 GHz
Coverage Area	10-100 meters	5 Km	1-5 meters
Modulation Technology	DSSS	OFDM	FHSS
Transmission Power	-25 to 0 dB	15 to 20 dB	0 to 10 dB
Channel Bandwidth	2 MHz	22 MHz	1 MHz

Table I shows the specifications of ZigBee, WLAN and Bluetooth System. It is observed that all the three technologies coexist at the frequency of 2.4GHz. It can also be observed that the transmission power of Bluetooth system is less as compared to ZigBee and WLAN but the rate of transmission of data packets that is Data rate of Bluetooth is high compressively.

III. COEXISTENCE ANALYSIS

Coexistence means that if two or more systems or technologies coexist at the same frequency. Here ZigBee, WLAN and Bluetooth coexist at 2.4GHz. Coexistence impacts the performance of the technology which results in the poor throughput.

Coexistence can be avoided from the following ways:

Modulation Technique : The modulation technique can help to reduce the interferences. The modulation technique can use the type of technique which allows the effective use of bandwidth with as minimal as possible interferences. For an instance OFDM can be considered in which the carrier frequencies are orthogonal to each other which reduces the large usage of bandwidth.

Clear Channel Assessment (CCA): It detects if the channel is free and can be accessed. CCA reports the channel busy if any energy above the threshold is detected. In this method if the carrier can sense a busy medium and can thus put a halt if the energy is above the Energy threshold.

Dynamic Channel Selection: This feature explains the method in which based upon certain criterion if a channel is busy then the other channel in the same bandwidth will be selected and thus the transmission will proceed. For an instance consider Bluetooth, it has 79 channels onto which one of the channel is busy then the carrier frequency can hop to the different for the smooth transmission of data packets. As and when the channel seems to be busy the best channel can be selected and the transmission can be proceeded with respect to the particular channel.

Acknowledged Transmission: It refers to the method in which if the transmission of data packets is done then acknowledgement is awaited. As soon as the acknowledgement is received then the next data packet is transmitted. This will reduce the interference due to the loss and thus retransmission of data packets. Also it will result in the less number of false retries of packets, the way it's been done in Bluetooth.

Non-overlapping Channel Selection: The overlapping channels can use the offset of center frequency to be of 5-7MHz which will result in the easy transmission of channels that will also result in the secure transmission without any collision. Also it would result in the non-overlapping channels.

Physical Separation and Safe Distance: If the two technologies having ZigBee or WLAN or Bluetooth are physically separated such that a minimum distance can be maintained which may prove to be better than in the collocated device.

IV. INTERFERENCE BETWEEN ZIGBEE AND WLAN

The IEEE 802.11 Wireless LAN (WLAN) standard adopts OFDM and operates in a total of 14 channels available in the 2.4GHz band, numbered 1 to 14, each channel with a bandwidth of 22MHz and a separation of 5MHz.

The IEEE 802.15.4 is also based on DSSS. A total of 16 channels are available in the 2.4GHz band, numbered 11 to 26, each with a bandwidth of 2MHz and a channel separation of 5MHz. The signal is spread over a larger bandwidth, so narrow-band interferers block a smaller overall duty of the signal, allowing the receiver to receive the signal correctly. Because both are in 2.4GHz band, so co-channel interference should be taken into account.

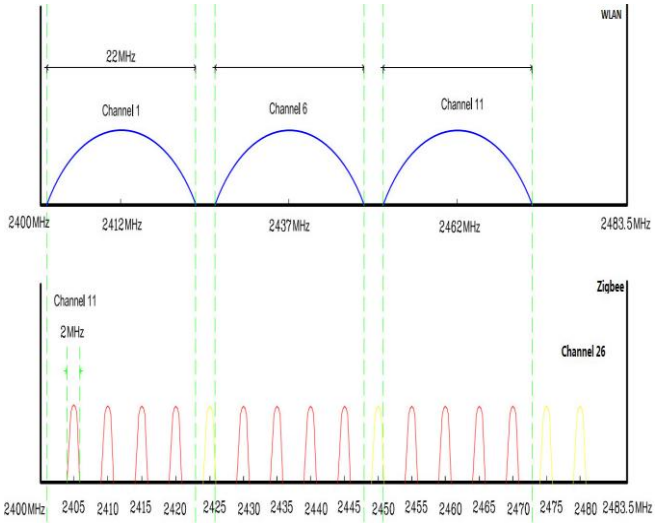

Fig. 1.1. WLAN and ZigBee overlapping channels in 2.4 GHz [1]

The overlapping channels between WLAN and ZigBee are shown in fig. 1.1., which shows channel 15, 20, 25, and 26 are not overlapped with Wi-Fi channels, these channels are of negligible interference. For each Wi-Fi channel, there are four overlapping ZigBee channels, two channels of them are at the edges and another two are close to the center frequency of the Wi-Fi channel. In fact, the interference level on the two channels close to the center is higher than those on the edges. Packet error rate(PER) has close relationship with distance between interference source and receiver and differences of center frequencies between interference source and receiver. They can even coexist within very short range of 2 meters even when difference of center frequencies is considerable, however, when their center frequencies are very close, they can coexist only if the distance is long. It shows that, if the interference source is more far from receiver, they can coexist better. Channel occupancy detection and dynamic channel selection are very important to keep good coexistence.

V. INTERFERENCE BETWEEN ZIGBEE AND BLUETOOTH

Bluetooth adopts FHSS technology, which supports 79 channels with each 1MHz bandwidth. Its frequency quickly hops 1600 times per second. Even if there are several kinds of 2.4GHz RF systems, the hopping system only interferes with other RF systems for a little time period, other RF systems can operate without any influence most of the times. ZigBee is a DSSS system, not a kind of frequency hopping system, so there is only one time channel overlap in 79 times. If a Bluetooth device transmits in a frequency that overlaps with the ZigBee

channel, then the ZigBee device randomly backs off while the Bluetooth quickly hops to another frequency, so Bluetooth does not disturb ZigBee products in most instances, they can coexist very well. But ideally this case is not achieved since the data packets of Bluetooth are sent randomly before the prior permission of the channel being busy or free. This in turn results in the collision of data packets.

VI. PROPOSED WORK AND RESULTS

Since ZigBee, WLAN and Bluetooth coexist at the frequency of 2.4GHz, so the collision can't be avoided completely. Even though ZigBee and WLAN employ CSMA/CA but Bluetooth transmits its data packets periodically irrespective of the ongoing transmission in the channel.

Consider the equation 1 for PER of ZigBee transmission packet under the interference of WLAN and Bluetooth.[2]

$$P_E = 1 - P_S^{W} . P_S^{BD} . P_S^{BA} \quad \ldots\ldots\ldots\ldots\ldots .. 1.$$

P_S^{W} : Probability that ZigBee packet is successfully received under the influence of WLAN and Bluetooth packets.

P_S^{BD} : Probability that ZigBee packet is successfully received under the influence of Bluetooth data packets.

P_S^{BA} : Probability that ZigBee packet is successfully received under the influence of Bluetooth ACK packets.[1]

Table II, lists all the parameters used for the simulation purpose using NS-2.

TABLE II: SIMULATION PARAMETERS OF ZIGBEE, WLAN AND BLUETOOTH

SR. NO.	PARAMETERS	VALUE
1.	ZigBee packets arrival time	Varying
2.	Duration of ZigBee data packets	4128µs
3.	Turn-around time	192-512µs
4.	CCA time	640µs
5.	Duration of ZigBee ACK packets	352µs
6.	Average back-off time of ZigBee	1120µs
7.	Minimum contention window size of ZigBee	7
8.	Transmission power of ZigBee	1mW
9.	Center frequency of ZigBee	2410MHz
10.	WLAN packets arrival time	Varying
11.	Duration of WLAN data packets	1303µs
12.	Duration of WLAN ACK packet	304µs
13.	Average Back-off time of WLAN	310µs
14.	Minimum contention window size of WLAN	31
15.	Transmission power of WLAN	30mW
16.	Center frequency of WLAN	2412MHz
17.	Duration of Bluetooth ACK packet	126µs
18.	Slot time of Bluetooth	625µs
19.	Transmission power of Bluetooth	1mW
20.	Center frequency of Bluetooth	2402+k MHz k = 0,……..,78

When ZigBee and Bluetooth exists in the same plane, both ZigBee and WLAN continues to transmits its data packets without considering any transmission need of Bluetooth. Bluetooth hops within the different channels (among 79 frequency bands) and also transmits the data but acknowledgement is not received by Bluetooth. Thus, because of this periodic transmission of Bluetooth's data and acknowledgement packets the collision is observed among ZigBee and WLAN systems when they co-exists.

Throughput is defined as number of packets transmitted per unit time. If the throughput is high then the performance is also increased.

Figure 4 depicts the throughput of ZigBee under the influence of Bluetooth. Result shows that if the distance between ZigBee receiver and Bluetooth transmitter is more and both coexists in the same plane, then throughput of ZigBee is 67.27kbps and it decreases to 2.8kbps with decrease in distance of nodes of ZigBee receiver and Bluetooth transmitter. In this scenario as discussed in Table II, the transmission power of ZigBee and Bluetooth nodes is 1mW each.

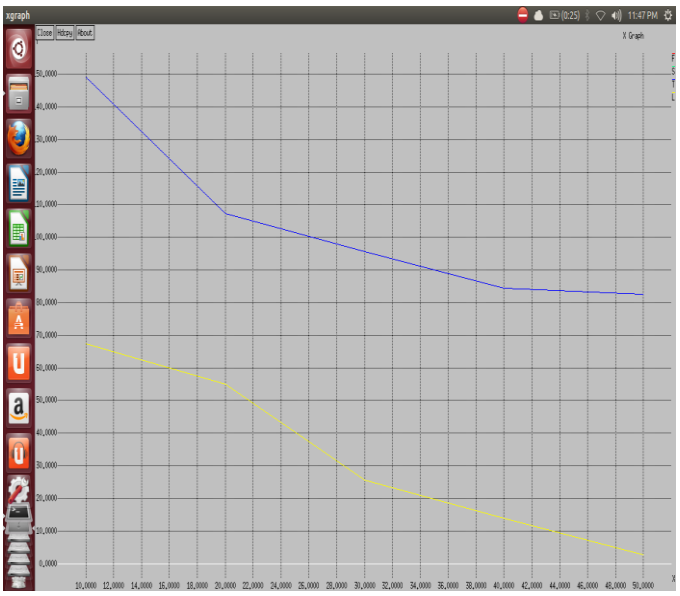

Figure 4. Throughput of ZigBee under Bluetooth transmission

When the power control mechanism is deployed the throughput of ZigBee increases upto 149kpbs as seen in Figure

4. The throughput decreases till 82.6kpbs when distance of ZigBee receiver and Bluetooth transmitter nodes increases.

Thus, when power control mechanism is used for transmission of data packets of the two systems the increase in throughput can be considerably increased.

Figure 5 depicts the throughput of WLAN under the influence of Bluetooth. Result shows that if the distance between WLAN receiver and Bluetooth transmitter is more and both coexists in the same plane, then throughput of WLAN is 5.5Mbps and it decreases to 4.633Mbps with decrease in distance of nodes of WLAN receiver and Bluetooth transmitter. In this scenario as discussed in Table II, the transmission power of WLAN and Bluetooth nodes is 30mW and 1mW respectively.

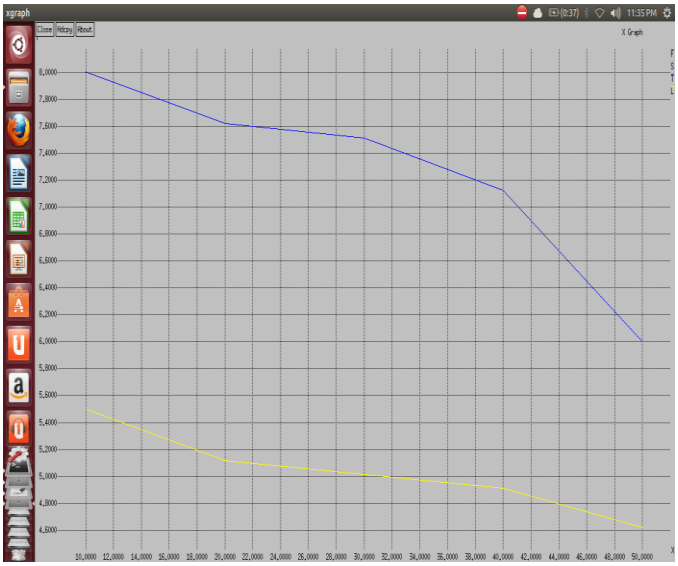

Figure 5. Throughput of WLAN under Bluetooth transmission

When the power control mechanism is deployed the throughput of WLAN increases upto 8Mpbs as seen in Figure 5. The throughput decreases till 6Mpbs when distance of WLAN receiver and Bluetooth transmitter nodes increases.

VIII. CONCLUSION

According to the simulation it has been concluded that when Bluetooth and WLAN or ZigBee and WLAN exists in the close proximity of each other, collision is observed which results in the decrease in throughput. The coexistence at 2.4GHz frequency causes collision among the data packets. If time scheduled transmission of data packets are considered then the collision is observed to be reduced. In this work, the data packets are adjusted and channel is sensed before the transmission of packets and its acknowledgement. If the channel is found free then the transmission continues otherwise the transmission is ceased with the help of power control mechanism. If the bandwidth of transmission is properly sensed and utilized, then the collision rate is highly reduced. Thus, according to the simulation results and experimentation the transmission occurs with very less collision using Power Control Mechanism.

IX. FUTURE SCOPE

The future scope can be that if the transmission of these three systems can be time dependent and the power control mechanism should be automatically switched with respect to transmission need. When the systems will be present in the same plane the transmission will be done sequentially. Thus the coexistence issue will be considerably resolved and collision free transmission will be seen. Scheduling of the data packets transmission automatically can be the solution for the coexistence issue and also responsible for smooth transmission. Also, cross-layer method can also improvise the transmission methodology which will increase the throughput.

REFERENCES

[1] C. Hager, D. J. Shyy, and J. Ma, “Cooperative Cross-Layer Design for Wireless Networks,” JOURNAL OF COMMUNICATIONS, VOL. 3, NO. 4, SEPTEMBER 2008.

[2] D. K. Yoon, S. Y. Shin, and W. H. Kwon, “Packet error rate analysis of IEEE 802.11b under IEEE 802.15.4 interference,” IEEE VTC -Spring, 2006, pp. 1186–1190.

[3] R. E. Ziemer, R. L. Peterson, and D. E. Borth, Introduction to Spread Spectrum Communications. Upper Saddle River, NJ: Prentice Hall, 1995.

[4] D. K. Yoon, S. Y. Shin, and W. H. Kwon, “Packet error rate analysis of IEEE 802.11b under IEEE 802.15.4 interference,” IEEE VTC – Spring 2006, pp. 1186–1190

[5] Jeffrey Mehlman, “Cross-Layer Design: A Case for Standardization”.

[6] Vijay T. Raisinghani, Sridhar Iyer “Cross-layer design optimizations in wireless protocol stacks”, October 2012.

[7] Soo Young Shin, Hong Seong Park, Sunghyun Choi, Wook Hyun Kwon “Packet Error Rate Analysis of ZigBee Under WLAN and Bluetooth Interferences” IEEE TRANSACTIONS ON WIRELESS COMMUNICATIONS, VOL. 6, NO. 8, AUGUST 2007

[8] Sandeep Sharma, Rajesh Mishra, Karan Singh, “A Survey on Cross Layer Security” National Conference on Innovative Paradigms in Engineering & Technology (NCIPET-2012) Proceedings published by International Journal of Computer Applications® (IJCA)