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Throughput Enhancement of ZigBee, WLAN and Bluetooth System

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***Abstract* – Wireless Communication is the most developing and widely used technology in the world in which ZigBee, WLAN and Bluetooth plays the most crucial role. This paper will help to depict the rate of interference of ZigBee, WLAN and Bluetooth such as BER (Bit Error Rate) and PER (Packet Error Rate). The proposed work is to increase the throughput of ZigBee, WLAN and Bluetooth system by reducing the BER and PER with the help of cross layer design using NS2.**

***Keywords* – ZigBee, Wireless Local Area (WLAN), Bluetooth.**

I. Introduction

Today the world is entering into the network of fourth generation and overcoming 3G wireless networks. Wireless communication system is the main reason behind this and because of its mobility there is a very large demand by end users for integrated applications. But with development the scope of problem and difficulties also comes. Wireless Communication is defined as the flow of information and data between two or more nodes which are not connected to each other. The most well known technologies in wireless communication are ZigBee, WLAN and Bluetooth that makes the user to communicate between two or more users very efficiently.

ZigBee is all about an IEEE 802.15.4 standard with a data rate of 250kbit/s, and is a low-powered application. With the help of intermediate devices ZigBee devices transmits data over long distances by passing data to reach more distant places and thus creating a mesh network. A wireless local area network (WLAN), IEEE 802.11, connects two or more devices by using some wireless distribution method typically spread spectrum or OFDM radio, and usually provides an access point to the wider Internet through connection. This enables the mobile users to be connected in a local coverage area to the network. The standard for switching data over small areas (it uses short-wavelength radio transmissions in the ISM band from 2400–2480 MHz) from fixed and mobile devices, creating personal area networks (PANs) with high levels of security is Bluetooth IEEE 802.15.1. For the improvement of throughput Cross-Layer design method is used.

II. Literature Survey

ZigBee is considered as a big achievement in the development of wireless network, is used for the enhancement of wireless sensor networks. It is developed to fulfill the goals in wireless sensors that utilize low power and low cost.[1] ZigBee is recognized by ZigBee Alliance, 2006 that is based on the IEEE 802.15.4 specification for wireless networks which provide support for co-existence at the OSI layers: Physical layer and the MAC sub-layer. This also includes Application and Network layers above these layers which includes some extra network functionalities to enable the bidirectional wireless communication by means of additional cost efficient and least energy overriding battery devices. ZigBee is extensively engaged in many applications mainly in Wireless sensor Networks. [2]

ZigBee network transmit wireless data in a secure and reliable manner by means of wireless mesh network architectures for Industrial, Commercial, and many other that includes Fitness applications, Health care, wellness and so on. Wireless local-area network (WLAN) is based on IEEE 802.11 a/b/g/n standard and is growing rapidly. WLAN provides the profit of connectivity with no restriction of being attached to a particular location.

Bluetooth is a technology that uses frequency hopping / time division duplex (FH/TDD). It uses master and slave technology in which the slave transmits or receives the data and ACK packets if and only if it is initiated by the master. Thus the master is solely responsible for the transmission [3].

As Bluetooth uses frequency hopping technology so the after some period of time the transmission of packets and ACK packet is assured irrespective of the ongoing transmission in the transmission channel. This is the major cause of interference in the channel but since Bluetooth is used only for short distances so the issue can be overcome. This paper basically focuses the interferences among ZigBee, WLAN and Bluetooth and the proposed solution for the enhancement of the throughput.

A. ZigBee

ZigBee uses Star or Peer-to-Peer network. It is used in applications that need long battery life, low data rate, and protected network access. ZigBee is best matched for periodic or sporadic data or signal broadcast from an input device or sensor. ZigBee uses the application of Personal

Area Network (PAN) which helps to interact with the different users. The applications of ZigBee includes traffic management systems, electrical meters with in-home-displays, wireless light switches, and other consumer and industrial equipment that needs short-range wireless transfer of data at moderately low rates. The technology used by the ZigBee is proposed to be less expensive and relatively less simple than other WPANs, such as Bluetooth or Wi-Fi.

ZigBee networks are secured by 128 bit symmetric encryption keys. In some of the applications such as home automation, the transmission distance ranges from 10 to 100 meters within the confined area, liable on power transmission and other environmental features [3]. Figure 1 shows how the ZigBee devices contact with each other. If device A has to contact to device B then it can do the needful via the intermediate node as shown. Thus, we can see that from moving to one node to another the power consumption may be large but the transmission and reception of data is assured.

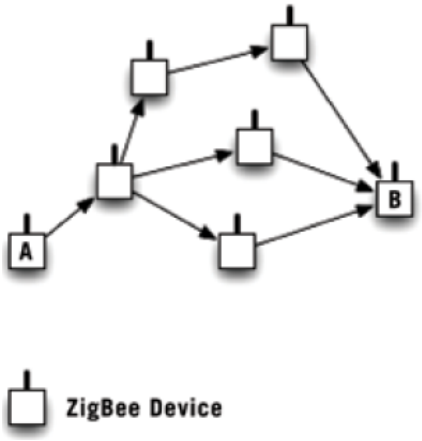

Fig.1. ZigBee Network

B. WLAN

WLAN can links two or more devices, and provides a connection with the help of an access point to the Internet. This gives users the liberty to move around within a confined coverage area and still be associated to the set of connections. Figure 2 shows that with the help of modem different devices can be connected to the internet.

The IEEE 802.11 has two basic modes of operation: ad hoc mode and infrastructure mode. In ad hoc mode, mobile units transmit directly peer-to-peer and in infrastructure mode, mobile units communicate through an access point that serves as a viaduct to other networks such as Internet or LAN. Wireless communication employs a wider medium for communication as compared to wired LANs. Also the 802.11 designers includes encryption or protection mechanisms such as Wi-Fi Protected Access (WPA, WPA2), Wired Equivalent Privacy (WEP, now insecure), to secure wireless networks. Many access points also offer Wi-Fi Protected System. [3]

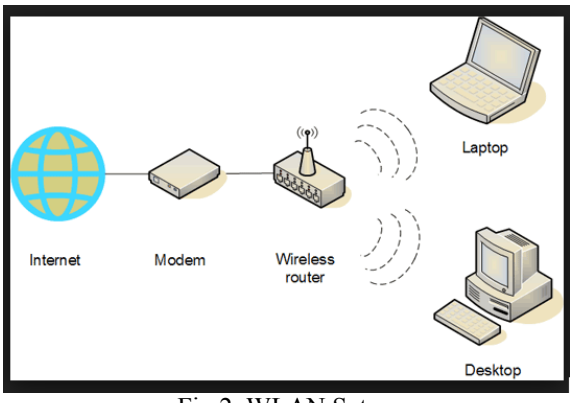

Fig.2. WLAN Setup

C. Bluetooth

Bluetooth is the technology for exchanging the data over short distances using short-wavelength radio transmissions in the ISM band from 2400–2480 MHz Bluetooth operates in the range of 2400–2483.5 MHz (including guard bands). Bluetooth uses a radio technology called frequency-hopping spread spectrum. Transmitted data is separated into packets and each packet is transmitted on one of the 79 nominated Bluetooth channels. Each channel has a bandwidth of 1 MHz. The first channel starts at 2402 MHz and continues up to 2480 MHz in 1 MHz steps. It usually performs 1600 hops per second, with Adaptive Frequency- Hopping (AFH) enabled. [3] Figure 3 shows that the Master is solely responsible for initiation of the transmission of data to the slaves.

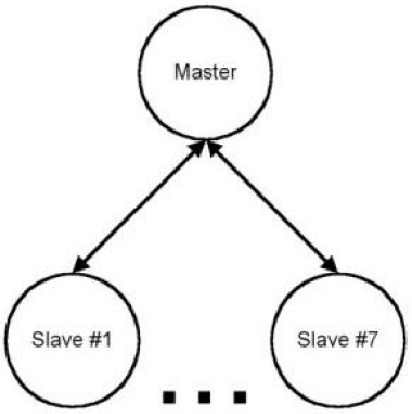

Fig.3. Bluetooth Connection

D. Cross Layer Design

The variation of the layered OSI recommendation architecture is defined as Cross-Layer. Ultimately there are two methods: Dynamic method and Static Method. [4] The designs which react to changing network conditions are Dynamic cross-layer designs. Non-standard boundaries between OSI layers, merge functionality of multiple layers, and jointly standardize layers are all done by Designers. The new interfaces expose internal information which were previously not externally accessible, but are required for cross-layer optimization [4].

In static cross-layer design, known characteristics of the network and layers are utilized, and co-calibrate or co-design a set of layers off-line. By their very nature, all of these modifications destroy most of the benefit that the OSI framework provided. Thus careful decisions should be made as to when, where, and how to implement cross layer designs. [5] Even from a brief survey of existing cross-layer design (CLD) proposals, it is clear that future CLD designs would benefit from a well-defined, widely-adopted framework which results into cross layer framework (CLF). The three different classes of CLF proposals are identified as following. The first involves new interfaces for every layer of the OSI model, and removes the requirement that only adjacent layers communicate. The second class also utilizes an OSI-like stack, except new interfaces are only created between every standard layer and a single new shared layer, which would capture all of the cross-layer functionality. The third set of proposal involves entirely new abstractions for communication systems design. Each different class has potential benefits and downfalls [5].

E. Background of the Survey

Let us assume that ZigBee is hidden to the WLAN user and vice versa. The interference of ZigBee network and WLAN is almost ignorable if the distance between two WLAN nodes is not greater than 3 m.[6] But if there are many WLAN nodes then the traffic in the network increases and collision may occur and which in turn provides the interference to ZigBee devices hence reducing throughput.

Not only the packets that are transferred for communication causes interference but also the ACK packets also sometimes collide with each other and cause collision which results in the interference to the ZigBee and Bluetooth. The next scenario is the study of packet error rate when ZigBee in under the influence of Bluetooth. [6]

Bluetooth employs frequency hopping / time division duplex (FH/TDD) to access the channel, so the Bluetooth packets are transmitted periodically irrespective of Interference of WLAN and ZigBee. Thus the packet and ACK transmission of Bluetooth are very much independent of ZigBee and WLAN. The next scenario is the study of packet error rate when ZigBee in under the influence of WLAN and Bluetooth.

Since for the comparative analysis it has been assumed that the packets of WLAN, Bluetooth and ZigBee are independent of each other but still there are number of parameters over which the interference depends. These parameters are collision of WLAN data and ACK packets with each other, collision of ZigBee data and ACK packets with each other and collision of Bluetooth data and ACK packets with each other. Consider the equation 1 for PER of ZigBee transmission packet under the interference of WLAN and Bluetooth.[6]

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

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]

Thus, according to the previous surveys it has been concluded that the major interference among ZigBee, WLAN and Bluetooth is ZigBee as it occupies major bandwidth and consumes more power comparatively.

III. Reason of Interference between ZigBee, WLAN and Bluetooth System

Since the ISM band is mostly used for the low cost radio campaign such as IEEE 802.11b wireless local area network (WLAN) and Bluetooth, thus an unhindered admission to the ISM band leaks the ZigBee systems to a large obstruction. Although WLAN, Bluetooth and ZigBee have been intended for the diverse purposes, but they might coexist in the close proximity of each other. Thus, the performance of ZigBee under the intrusion of WLAN and Bluetooth and vice versa needs to be evaluated. But when the separation between a WLAN source and WLAN destination is less than 3m, the interference of ZigBee to WLAN is ignorable. [6]

Another powerful interference to ZigBee is that if there are several WLAN nodes, they compete to access channel and collisions may occur. The transmission of packets from their source and the acknowledgement received by their destinations is the main reason behind the collision between the WLAN and ZigBee. WLAN occupies a large bandwidth as compared to ZigBee and Bluetooth it is a major obstacle in the path of transmission of the packets from the source to the destination of Bluetooth and ZigBee.

Thus the Packet Error Rate (PER) and Bit Error Rate (BER) should be reduced with respect to Signal-to-Noise-Ratio (SNR). This helps to increase the throughput of ZigBee, WLAN and Bluetooth System. [6] Bluetooth packets are transmitted occasionally irrespective of restriction of both WLAN and ZigBee packets as it employs frequency hopping / time division duplex (FH/TDD) for the channel access. So, the packet transfer of Bluetooth is autonomous of those of ZigBee and WLAN. To ZigBee user the Bluetooth signal can be modeled as an incomplete band jammer because the bandwidth of the Bluetooth is 1MHz [5]. ZigBee can harmonize under both PHY and MAC layers. Table I shows the comparative study of ZigBee, WLAN and Bluetooth System. It explains that all the three technologies coexist at the frequency of 2.4GHz. Due to

the coexistence the throughput is highly reduced because of reduced data rate and bit rate.

Table I: Comparative study of ZigBee, WLAN and Bluetooth System

Specifications	ZigBee	WLAN	Bluetooth
Data Rate	250 Kbps	1-25 Mbps	1 Mbps
Frequency Range	2.4 GHz	2.4 GHz	2.4 GHz
Coverage Area	10-100 meters	5 Km	1-5 meters
Modulation Technology	DSSS	OFDM	GFSK / FH/TDD

IV. Proposed Work

The proposed work is to enhance the data rate by interaction of MAC and Physical layer using NS2. Thus, the throughput of WLAN, Bluetooth and ZigBee will be greatly improved by using the cross layer design.

V. Conclusion

Thus according to the literature survey, ZigBee, WLAN and Bluetooth are studied such that the interference power of WLAN and Bluetooth is considered as a partial jammer of ZigBee. Whereas, it has been found that when the number of nodes of the WLAN increases, a large interference between ZigBee, WLAN and Bluetooth Devices can be seen. So, to increase the throughput cross layer optimization is used which would result in design and implementation of a network using ZigBee, WLAN, and Bluetooth altogether. Although, different layers of OSI helps in throughput enhancement but physical and MAC Layer plays a major role in it. Also the research is needed to be combined to the particular user inputs with the measureable inputs from the various layers to improve the user satisfaction in wireless networks.

References

[1] 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.

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

[3] 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

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

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

[6] 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.