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PERFORMANCE EVALUATION OF VARIOUS IEEE 802.11 STANDARDS USING QUALNET

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ABSTRACT This paper, evaluates the performance of various IEEE standards such as 802.11a, 802.11b, 802.11n and 802.11ad. Various performance factors like throughput, average jitter, and Average End-to-End delay are evaluated using QualNet. The next frontier in the WLAN and WPAN technologies are Multi-Gigabit communication, will set the basis for new applications such as high speed device synchronization, wireless display and for real time multimedia applications, wireless home entertainment. In this paper scenarios have been designed for various 802.11 standards using the QualNet simulator and their performance metrics is compared.

KEYWORDS : Average End-to-End delay, Average Jitter, IEEE 802.11a, 802.11b, 802.11n, 802.11ad, QualNet 7.4, Throughput.

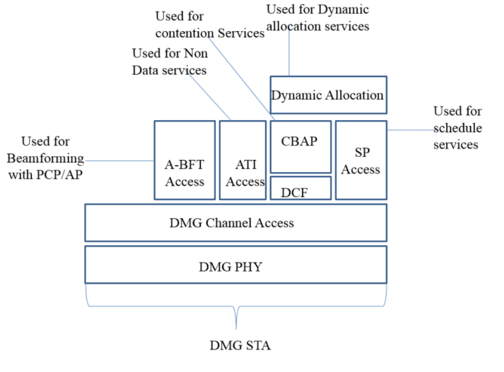
INTRODUCTION

IEEE 802.11 WLAN, also recognized as Wi-Fi, took more than 15 years for development and standardization. Early form of IEEE 802.11 standard was realized using Ethernet technology in the year 1997 as an extension or wireless alternative to existing wired LANs. With progress in time, several amendments were made and new technologies and functionalities were added to this existing standard [1]. Various IEEE 802.11 standards function in the 2.4 and 5 GHz unlicensed frequency band. IEEE 802.11ad functions in 60 GHz unlicensed frequency band. These frequency bands are available globally [1]. Throughput enhancement is considered as one of the fundamental importance in the development of IEEE 802.11 technology. Enhanced physical layer and MAC layer techniques are adopted to achieve higher throughput in WLAN. OFDM is one of the technology which is employed in the physical layer in the 5 GHz frequency band to achieve data rate of up to 54 Mbps in IEEE 802.11a [2]. Direct Sequence spread spectrum (DSSS) and Complementary Code Keying (CCK) are the technologies which are employed in the physical layer in the 2.4 GHz ISM band to achieve data rates of up to 11 Mbps in IEEE 802.11b [2]. IEEE 802.11 group introduced IEEE 802.11n WLAN standard by improvising on the features of both Physical and MAC layers of previous 802.11 WLAN standards. IEEE 802.11n functions in 2.4/5 GHz band, it guarantees the data rate, of at least 108 Mbps and of 50 meters coverage distance, with a maximum data of 600 Mbps over short distances [3]. Discussions for operation in 60 GHz band began in November 2007, the reasons for this discussion was that the millimeter wave might offer broader bandwidth to channels than in the Microwave band, which enables the throughputs of single link more than 1 Gbps. Manufacturing floor, backhaul, auditorium, outdoor campus, wireless display, rapid upload or download and distribution of high definition TV are the general categories of usage model. Users will be able to rapidly sync movies and images between mobile devices such as phone, laptop, or a tablet with rapid sync-and-go. A video file of size 1 GB would take fewer seconds to get transferred between the devices, with a one Gbps radio link [4]. Due to this rapid growth in Wi-Fi technology, the demand for speed is also becoming a critical issue, and the ever-growing number of user applications have created heavy data traffic and calls for a need to reduce this data transfer time. The reason for today's WLAN technologies becoming increasingly overloaded and congested is because of increase in mobile devices and data hungry applications. The pre-requisite basis for new applications like, high-speed device synchronization, wireless display, and to attain advancement in Wi-Fi technology is offered by the multi-Gbps communication [5]. Uncompressed HDMI replaced the HDMI cable and it was one of the initial application of 60 GHz technology. Devices of standard IEEE 802.11ad, while functioning in the 60 GHz can switch back to 2.4/5 GHz band, which is one of the special feature of IEEE 802.11ad and is known as Multi-band operation [5]. The channel bandwidth defined for IEEE 802.11ad is 2160 MHz.. 7 Gbps is the maximum achievable throughput in IEEE 802.11ad, but the coverage is limited up to 10 meters [6]. In this paper comparison of performance metric parameters of IEEE 802.11a, 802.11b, 802.11n and 802.11ad is carried out using QualNet 7.4

RELATED

Performance evaluation and comparison of various IEEE 802.11 standards has been done using various network simulators like NS-2, NS-3, OPNET, QualNet so on. The author of [7] has compared the performance metrics of IEEE 802.11n and 802.11 ac protocols. Aim of the authors was to compare the throughput of IEEE 802.11n and 802.11ac using variety of Spatial Streams (SS), number of clients and data rates. Simulator made used by the author of [7] was NS-3.

Uppal et.al., in their paper [8] have evaluated the performance using QualNet 5.0 network simulator for IEEE



802.11e. The work indicates that throughput, jitter, end-to-end delay are significantly affected by the number of nodes present in the network and the traffic sources for constant bit rate transmission.

In this work, performance evaluation of IEEE 802.11a, 802.11b, 802.11n is carried out and compared with the performance metrics of IEEE 802.11ad using QualNet 7.4 network simulator. It has been shown that the throughput of IEEE 802.11ad is higher than the other IEEE 802.11 standards at the application layer, which operates with a bandwidth of 2160 MHz in the 60 GHz band.

IEEE 802.11ad MAC LAYER

In a DMG (Directional Multi Gigabyte) STA, DMG channel access mechanisms are utilized to provide MAC services. To access the channel during scheduled periods some specific rules apply, which include Association Beamforming Training (A-BFT) period, Announcement Transmission Interval (ATI), Service period (SP), and contention base access period (CBAP). Contention base access period are utilized by the DCF. Service period and contention base access periods are utilized by the dynamic allocation [8].

DMG CHANNEL ACCESS

A beacon interval is an interval during which the channel is accessed by the DMG STA and it is coordinated using a schedule. A PCP/AP are the one who generates the schedule, and this generated schedule is communicated to STAs using Announce frame and DMG Beacon, and the PCP/AP does all these things operating as a DMG STA. Within a DMG BSS the medium time is divided into beacon intervals. Beacon interval is divided further, and these subdivisions are called as access periods. Within a schedule, access periods are described, within this schedule PCP/AP communicates with non-PCP/non-AP [8].

Figure 1: DMG MAC Architecture

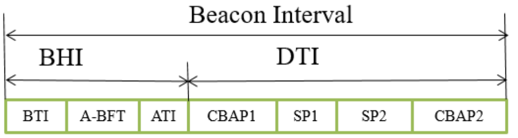


Figure 2: Access Period within a Beacon Interval

Name of IEEE 802.11 Standards	Throughput in Mbps	Average End-to-End delay(Sec)	Average Jitter (Sec)
IEEE 802.11a	24.978	0.0469311	0.00006127
IEEE 802.11b	5.06522	0.226832	0.000460123
IEEE 802.11n	110.206	0.0192234	0.000888712
IEEE 802.11ad	717.07	0.021393	0.000214471

Table 1. SIMULATION SETUP

SIMULATION RESULTS

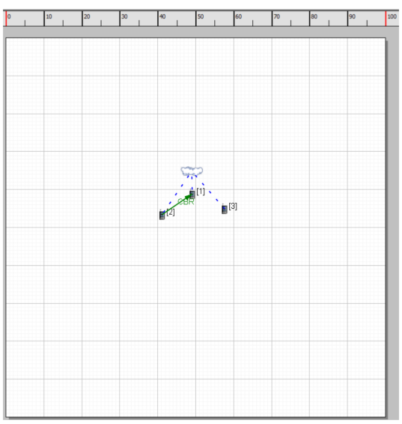


Figure 3: Scenario Created in QualNet 7.4 Simulator

SIMULATION SETUP

A parameter which is directly proportional to the capacity/bandwidth and is expressed in bits per second and amount of data transmitted in a specified amount of time is known as throughput. In a network, number of nodes, frame size, number of frames sent etc. are the factors which affect the throughput. The total delay for a packet to reach destination from the source is known as average end-to-end delay or one way delay. Average end-to-end delay is a crucial parameter, because lot of applications depend on this performance metric, and a few applications which depends on this performance metric are virtual reality (VR) environments, multiplayer network games, and real time multimedia applications like video conferencing, internet telephony etc. Another performance metric related to delays only is the jitter, which is nothing but the variations in delay encountered during the packet inter-arrival time [8].

In QualNet 7.4, a scenario with 3 nodes and 1 wireless network was created. The wireless network was given the configurations of Physical layer and MAC layer as shown in the Table 1. Traffic source of type constant bit rate (CBR) was given from node 2 to node 1. The Performance metrics were evaluated for different IEEE 802.11 standards. For IEEE 802.11a, packet size of 1536 bytes was considered and the maximum throughput of 24.978 Mbps was achieved. For IEEE 802.11b, 1536 bytes was the size of the packet considered and the corresponding maximum throughput of 5.06522 Mbps was achieved. For IEEE 802.11n, 6144 bytes was the size of the packet considered and the corresponding throughput of 110.206 Mbps was achieved. Finally, for IEEE 802.11ad packet size of 9728 bytes was considered and the corresponding throughput of 717.07 Mbps was achieved.

Table - 2 SIMULATION RESULTS VALUES

Table 2 shows the values obtained by performing the simulation in QualNet 7.4, corresponding graphs are plotted.

Parameters	Value
Scenario Dimensions(meters)	100x100m2
Physical layer (Protocols)	802.11a,802.11b, 802.11n and 802.11ad
MAC Layer (Protocols)	802.11, 802.11, 802.11e
Path Loss Model	Two Ray
Routing Protocol	Bellman Ford
Traffic Source	Constant Bit Rate (CBR)
Simulation Time	200 Seconds
Packet Size (Bytes)	1536, 1536, 6144, 9728

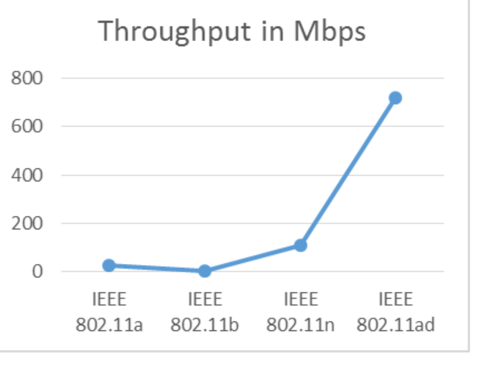


Figure 4: Graph between various IEEE 802.11 standards and their throughputs

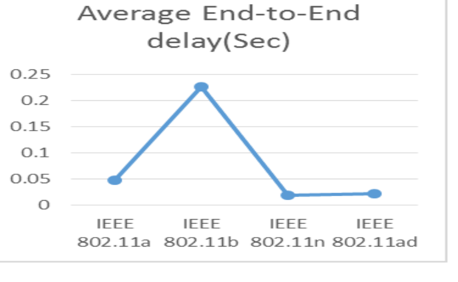


Figure 5: Graph between various IEEE 802.11 standards and their Average End-to-End delay

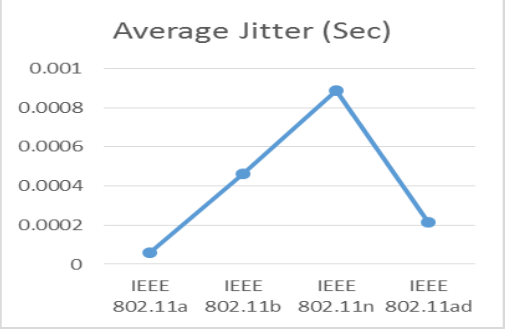


Fig 6: Graph between various IEEE 802.11 standards and Average Jitter.

CONCLUSION

In this work, performance evaluation of various IEEE 802.11 standards were carried out using QualNet 7.4. Throughput, average end-to-end delay and average jitter were evaluated using QualNet 7.4 for a scenario consisting of 3 nodes and one wireless network. A performance comparison for IEEE 802.11a, 802.11b, 802.11n and 802.11ad for their performance metric is shown in figures 4, 5 and 6. Figure 4 shows the graph of various IEEE 802.11 standards with respect to their throughputs, and the throughput of IEEE 802.11ad was the best, compared to other standards. The main aim of this work was to show that IEEE 802.11ad has a good throughput compared to other standards and it will support emerging applications such as high quality uncompressed video transmission and fast large file transmission at short distances, that is IEEE 802.11ad devices will be mainly used in wireless home networking.

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