

Performance Comparison of IEEE802.11a, IEEE802.11b, IEEE802.11g and IEEE802.11n in Multiple Routers

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ABSTRACT

Nowadays, WLAN (Wireless Local Area Networks) has evolved into one of the most auspicious and lucrative technology. The most prominent use of the application of wireless network technology is 802.11 WLAN. IEEE 802.11 (Institute of Electrical and Electronics Engineers) standard specified the frequencies of different WLAN standards. The aspiration of this research is to scrutinize and compare the performance of different wireless LAN standards for the increasing number of routers in a predefined area. For evaluating the performance Wireless LAN throughput, wireless LAN load delay, and wireless LAN media access delay metrics are used. For all combinations of the number of routers, IEEE802.11b shows the highest and IEEE802.11n shows the lowest WLAN media access delay and average wireless LAN delay for 64 nodes.

Keywords: WLAN, Mobility, IEEE 802.11, Throughput, Delay, OPNET.

1. Introduction

At present, there has been a dramatic increase in using wireless communication devices that affects an increasing number of aspect of everyday life. WLAN grants an easy way to structure of a computer network using without complex wiring infrastructure. It works using either infrared light (IR) or radio frequency (RF) as medium and is known as Wi-Fi (Wireless Fidelity) or IEEE802.11 [1]. The IEEE 802.11 WLAN standard was freed in 1997 [2] by the IEEE. The inauguration of IEEE 802.11 standard supports the basis for interoperability between different products. IEEE 802.11a [3], IEEE 802.11b [4], IEEE 802.11g [5] and IEEE 802.11n [6] are some popular wireless LAN standards. All standards for wireless LANs use unlicensed bands in USA [7].

There are two approaches to regulate the wireless LAN bands: First approach is used by IEEE 802.11 and HIPERLAN (High Performance Radio LAN) [8] and the WINFORUM (Wireless In-building Network Forum) group uses the second approach. IEEE 802.11 and HIPERLAN [8] standards affect only the first two layers in the OSI (Open Systems Interconnection) model. In the OSI model, The Data Link Layer is subdivided into two parts: Media Access Control (MAC) and Logical Link Control (LLC) in ascending hierarchical order. The WLAN standards apply to the whole Physical Layer and to the MAC of the Data Link Layer. Currently, significant research works have assumed to scrutinize performance of diverse WLAN standards by different parameters and conditions.

Mewara S. and Kumar R., [9] analyzed the performance of IEEE 802.11g WLAN with one access point. They observed the effects of varying data rate on the Delay, Media Access Delay, Queue Size and throughput performance metric. Khanduri R. and Rattan S., [10] analyzed the performance of different extension of IEEE 802.11 (802.11a, 802.11b, 802.11g and 802.11n). On the basis of their spectrum, data rates, modulation techniques used and operating frequency band the conducted results are compared. The effect of the dynamic nodes on the

network performance did not inspect in this work. Fainberg M., [11] analyzed the performance degradation of IEEE 802.11b WLAN due to the presence of Bluetooth piconets. Eisenhofer A., [12] analyzed the performance of the next-generation WLAN protocol IEEE802.11n 2.4 GHz using the OPNET modeler simulation tool. The performances of the protocol were measured by analyzing Media access delay and jitter, traffic, data packet loss, the total throughput of the network and total Network load [12].

This paper analyzes and compares the performance of WLAN standards (IEEE 802.11a, IEEE 802.11b, IEEE 802.11g and IEEE 802.11n) under contrasting network conditions through the simulation. The effects of varying number of routers on network performance are mainly considered. Wireless LAN throughput, wireless LAN load delay and wireless LAN media access delay are the performance metrics used here.

The rest of the paper is formed as follows. Section 2 illustrates wireless LAN standards. In section 3, performance metrics are bestowed. The simulation setup is detailed in section 4. Results are made clear in section 5. Section 6 brings paper closure.

2. An Overview of WLAN Standards

Original IEEE 802.11 standard was freed in 1997 and certified in 1999. It specified two net bit rates of 1 or 2 megabits per second (Mbps), plus forward error correction code also specified 3 contrasting physical layer technologies and diffuse infrared operating at 1 Mbps. IEEE 802.11a operates in 5GHz band with a maximum data rate of 54 Mbps [2]. It uses the identical data link layer protocol and frame format as the authentic standard IEEE802.11, however an OFDM (Orthogonal frequency division multiplexing) based air interface is connected in the physical layer. In ideal conditions, the bit rate of 54 Mbps is achievable [2]. This standard operates the single input, single-output (SISO) antenna technologies and the indoor/outdoor dimension from 35m to 125m for 5GHz operating frequency. The highest data rate of IEEE 802.11b is 11 Mbps and it operates in 2.4 GHz band. This standard also employs the Fig. 4.1. A Simulation Model for Eight Nodes of Eight Star SISO antenna technology similar as IEEE802.11a standard and DSSS (Direct sequence spread spectrum) technology in the physical layer. The indoor range for this standard is 35m and outdoor range is 140m. IEEE 802.11g performs in 2.4 GHz band with the highest data rate of 54 Mbps of forwarding error correction codes, or about 22 Mbps of average throughputs [7]. This standard employs the SISO antenna technologies and OFDM or DSSS modulation schemes. Its indoor/outdoor range is from 38m to 140m respectively. IEEE 802.11n operates in 2.4 GHz or 5GHz band with an utmost data rate of 600 Mbps exclusive of forwarding error correction code. It is comparative with 802.11a/b/g [3]. OFDM modulation technique and Multiple Input Multiple Output (MIMO) antenna technology conducts in IEEE 802.11n standard. The indoor range is 75m and the outdoor range is 250m respectively for this standard.

3. Performance Metrics

The performance metrics that are used in this simulation study are as follows:

3.1 Throughput

Throughput is the entire number of successfully transmitted messages, from the source to the target per unit time, divided by the channel capacity, calculated in number of messages per unit time, between the source and the

destination. This parameter is sometimes referred to as normalized throughput, because its value could never be greater than one [13].

Throughput can be acquired by analyzing the attainable events that may happen on a shared medium in a casually preferred slot time [14]. Let the probabilities that a randomly preferred slot corresponds to an idle slot, a collision, and a successful transmission are P_{idle} , P_{col} and P_{succ} , respectively and the duration of the slot corresponding to an idle slot, a collision, and a successful transmission are denoted by Δ , T_{col} and T_{succ} , respectively [15].

If the average duration is denoted by T_{avg} , then it is obtained as follows:

$$T_{avg} = P_{idle} \Delta + P_{succ} T_{succ} + P_{col} T_{col} \quad (1)$$

The throughput S can be gained as follows:

$$S = E [\text{In a slot time transmitted payload information}] \quad (2)$$

$$S = \frac{P_{succ} + E[p]}{T_{avg}} = \frac{P_{succ} + E[p]}{P_{idle} \Delta + P_{succ} T_{succ} + P_{col} T_{col}} \quad (3)$$

Where, the average payload size (in terms of time unit) is $E [P]$. By dividing the numerator and denominator of equation (3) by $(P_{succ} T_{succ})$, the throughput can be expressed as follows:

$$S = \frac{\frac{E[p]}{T_{succ}}}{1 + \frac{P_{col}}{P_{succ}} + \frac{T_{col}}{T_{succ}} + \frac{P_{idle}}{P_{succ}} + \frac{\Delta}{T_{succ}}} \quad (4)$$

3.2 Delay

Delay is the total number of time units taken by a message from its arrival at the source buffer, until it reaches its destination. This includes the queuing time and the transmission time of the message. In the course of calculating these parameters, some terms and expressions will be used. Two of these terms are very important to be stated here. These two important terms are the offered load G and Little's formula [16]. Mathematically delay can be shown as equation (5).

$$D_{end-end} = N [D_{trans} + D_{prop} + D_{proc}] \quad (5)$$

Where,

- $D_{end-end}$ = End to end delay
- D_{trans} = Transmission delay
- D_{prop} = Propagating delay
- D_{proc} = Processing delay

3.3 Media Access Delay

According to the OPNET documentation, media access delay is the total of queue and contention delays of data packets accepted by WLAN MAC from the higher layer. The delay is recorded for each packet when it is sent to the

physical layer for the first time. Hence, it also involves the season for the lucrative RTS/CTS exchange, if this exchange is used for that packet. In a WLAN Media, access is a basic issue. The station which needs to send data has to access the channel first. If the number of workstations connected to the WLAN increases the possibility of accessing the channel will be decreased hence the media access delay increases. The Simulation result clearly indicates the above phenomenon [12].

4. Simulation Setup for Wireless LAN

For experiments, a star-based IEEE 802.11 standards network is considered and the OPNET Modeler [17] is used for developing for developing our IEEE 802.11 a, b, g, n simulation model. In this research we increased the number of routers and observed the effect of increasing number of routers on fixed number of nodes. A simulation model for a network having 64 nodes and 8 routers with each router connected to equal number of nodes is shown in “FIG 4.1”.

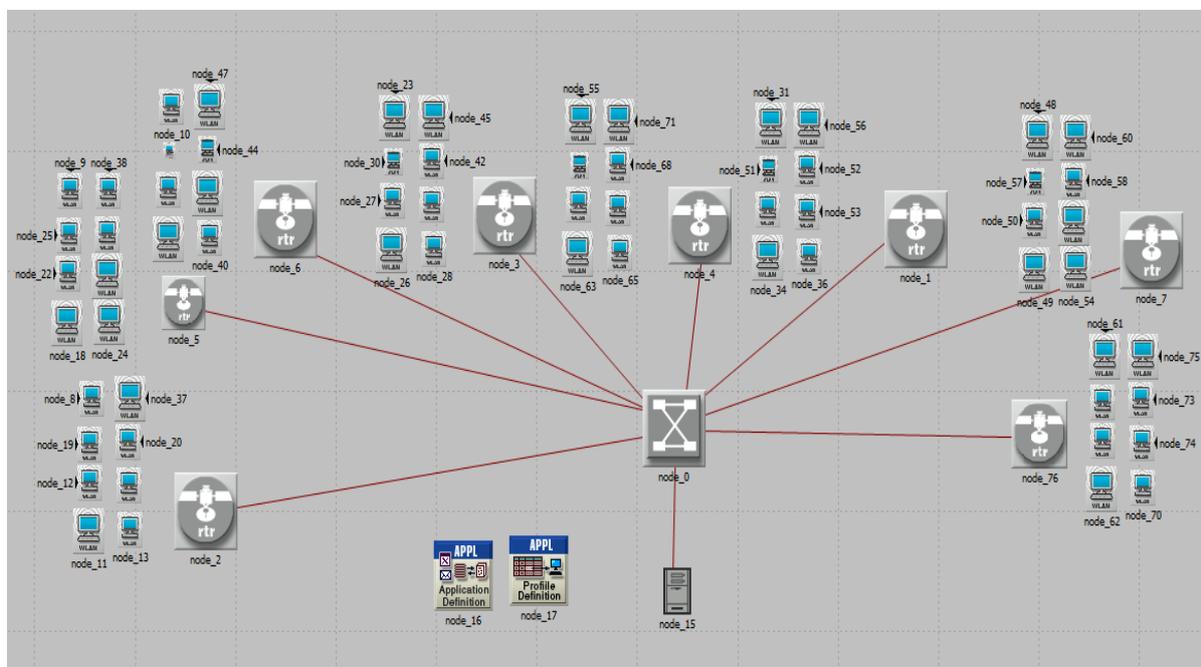


FIG 4.1: A SIMULATION MODEL FOR EIGHT NODES OF EIGHT STAR

5. Result Discussion

The metrics used to evaluate and compare the performance are: wireless LAN throughput, wireless LAN load delay, and wireless LAN media access delay. To compare among all WLAN standards different WLAN scenarios are simulated for the same time duration (1 hour), same value per statistic (100), and approximately similar physical data rate (5.5-6.5Mbps). The results of this simulation study are separately described in this sections.

To analyze the effect of the number of routers on different WLAN standards, network scenarios are created for 64 nodes by using 1, 2, 4 and 8 routers respectively. For example, when 4 routers are used for 64 nodes then each router is connected to 16 nodes. Same DES parameters are used which are used for analyzing the performance of different number of nodes. “FIG 5.1,” shows the effect of routers on WLAN maximum throughput. For 1-star network IEEE802.11a and IEEE802.11b both provides highest throughput and IEEE802.11n and IEEE802.11g

provides lowest throughput. However, the scenario changes with increasing number of routers. It can be concluded that for all combinations of routers IEEE802.11b gives the best performance.

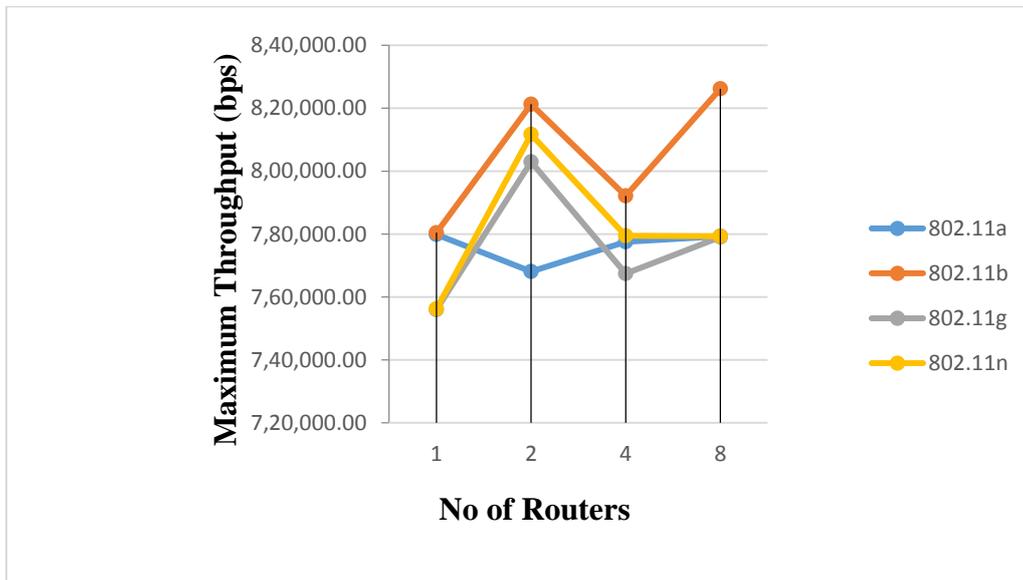


FIG 5.1: WIRELESS LAN MAXIMUM THROUGHPUT FOR WLAN STANDARDS FOR THE VARYING NUMBER OF ROUTERS FOR 64 NODES

“FIG 5.2” shows the effect of routers on WLAN average throughput. For 1 star network IEEE802.11n gives the maximum average throughput. Besides, IEEE802.11a shows the worse performance when average throughput is considered. The result is quite different with increasing number of routers. If 8 star network is considered IEEE802.11a gives best performance. However, the performance of IEEE802.11n degraded remarkably.

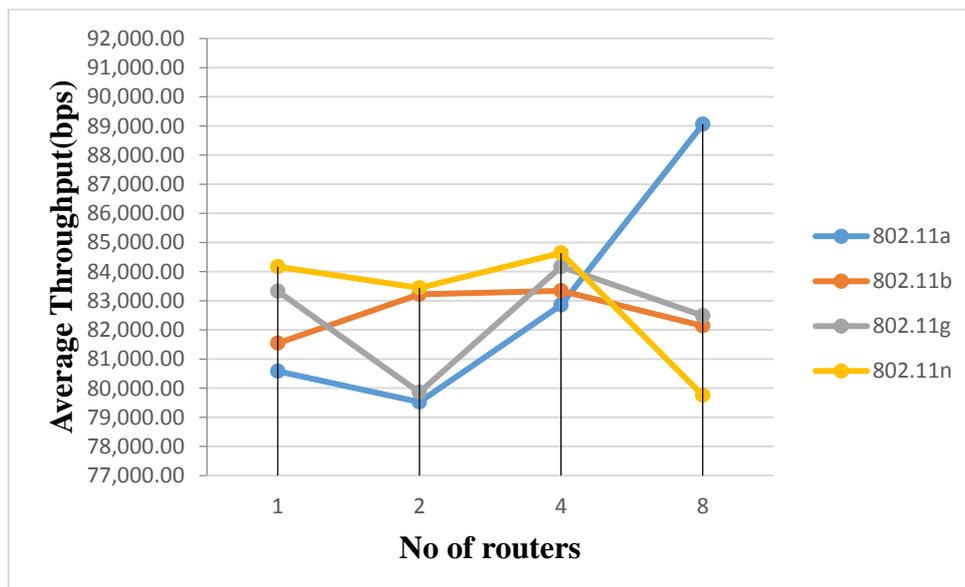


FIG 5.2: AVERAGE WIRELESS LAN THROUGHPUT FOR WLAN STANDARDS FOR THE VARYING NUMBER OF ROUTERS FOR 64 NODES

Due to large coverage area than others, channel noises and interfaces increases with the increasing number of routers for IEEE802.11n. So, when the number of routers is 8 IEEE802.11n shows lower average throughput than other standards. “FIG 5.3,” depicts the effect of routers on average wireless LAN delay. IEEE802.11b provides

maximum average LAN delay than other standards. IEEE802.11a and IEEE802.11g provide approximately same average wireless LAN delay. IEEE802.11n provides lower average throughput than others.

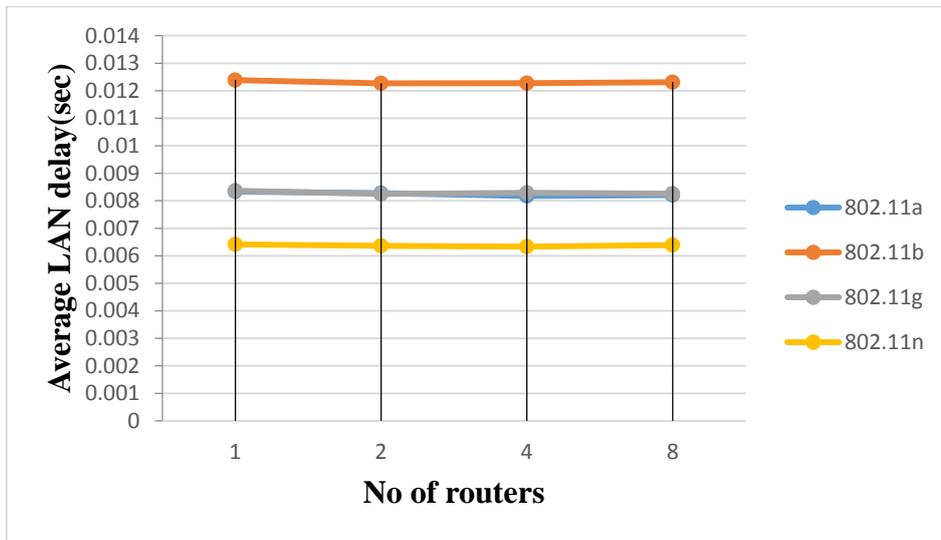


FIG 5.3: AVERAGE WIRELESS LAN DELAY FOR WLAN STANDARDS FOR THE VARYING NUMBER OF ROUTERS FOR 64 NODES

“FIG 5.4,” shows the effect of routers on WLAN average wireless LAN load delay. IEEE802.11a provides maximum average wireless LAN load delay than others only for 8 stars. IEEE802.11b provides medium average wireless LAN load delay than others for all combinations of the routers. For one star, two stars and four stars IEEE802.11n provides maximum average LAN load and IEEE802.11a provides minimum average LAN load delay.

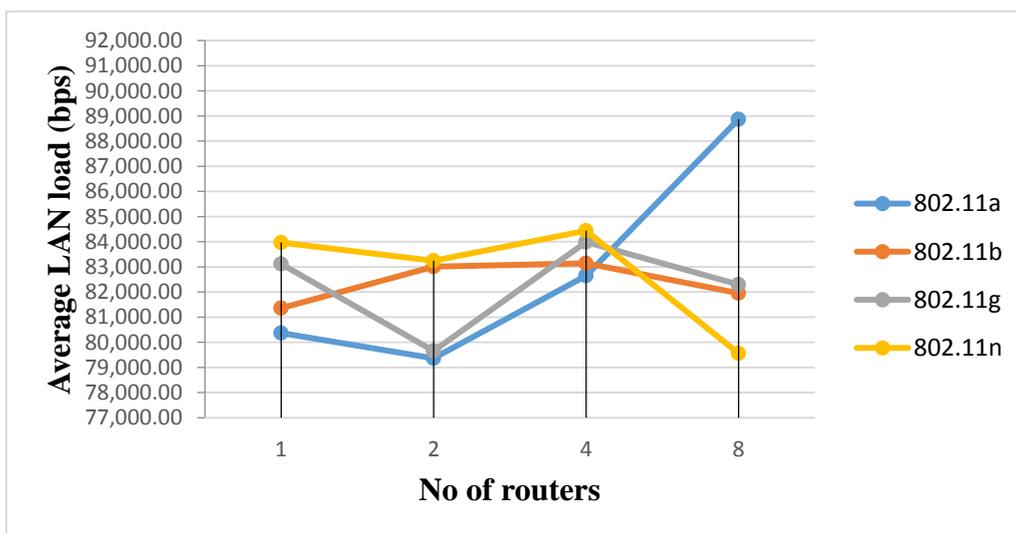


FIG 5.4: AVERAGE WIRELESS LAN LOAD FOR WLAN STANDARDS FOR THE VARYING NUMBER OF ROUTERS FOR 64 NODES

“FIG 5.5,” shows IEEE802.11b provides maximum and IEEE802.11n provides minimum average LAN media access delay than other standards. IEEE802.11a and IEEE802.11g provide approximately same average wireless LAN media access delay.

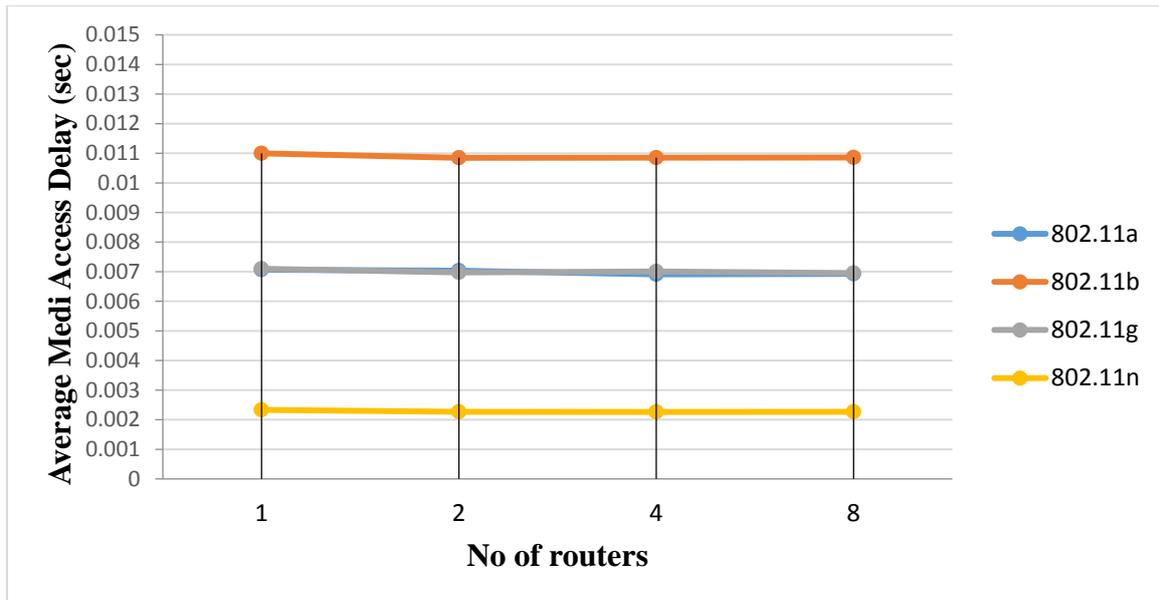


FIG 5.5: AVERAGE WIRELESS LAN MEDIA ACCESS DELAY FOR WLAN STANDARDS FOR THE VARYING NUMBER OF ROUTERS FOR 64 NODES

6. CONCLUSION

In this paper, the performances of various WLAN standards (IEEE802.11a, IEEE802.11b, IEEE802.11g and IEEE802.11n) under different network conditions are analyzed. It is observed that, when multiple routers are used, IEEE802.11b provides maximum throughput for every combination of routers (1, 2, 4 and 8). It is observed that IEEE802.11n provides the highest average throughput for 2, 4 and 6 routers. However, IEEE802.11a provides maximum average throughput for 8 stars network. For all combinations of the number of routers, IEEE802.11b shows the highest and IEEE802.11n shows the lowest WLAN media access delay and average wireless LAN delay for 64 nodes.

References

- 1) AlShourbaji, Ibrahim, "An overview of wireless local area network (WLAN)", arXiv preprint arXiv:1303.1882, 2013.
- 2) Sangeetha J., Kumar S., "A comparative study on WiFi and WiMAX networks", IEEE International Conference on Computational Intelligence and Computing Research, pp. 1-5, 2010.
- 3) Pradeepkumar B., Talukdar K., "Predicting external rogue access point in IEEE 802.11 b/g WLAN using RF signal strength", International Conference on Advances in Computing, Communications and Informatics (ICACCI) (pp. 1981-1986), 2017.
- 4) Li G., Xu M., Liu W., Pang Y., "Analysis and Improvement of Cooperative MAC Based on IEEE 802.11 b in Wireless Networks", pp. 1037-1041, 2019.
- 5) Valadares D., Joseana A., Angelo P., "Performance Evaluation of an IEEE 802.11 g Network in an Industrial Environment", IEEE Latin America Transactions, vol.18, pp. 947-953, 2020.

- 6) Friendly LLC. H., "Wireless Networking in the Developing World: A practical guide to planning and building low-cost telecommunications infrastructure (PDF) (2nd Ed.)" 2007.
- 7) Pahlavan K., Probert, T., "Trends in Local Wireless Networks", IEEE Communication Magazine, pp. (88-95), 1995.
- 8) Doufexi A., Armour A., Butler S., Karlsson, P., "A comparison of the HIPERLAN/2 and IEEE 802.11 a wireless LAN standards.", IEEE Communications magazine, 40(5), pp. 172-180, 2002.
- 9) Mewara HS., Saini MK., Kumar R., "Throughput and Delay Analysis of Access Point in IEEE802.11b Wireless LAN using OPNET Simulator", National Seminar on Recent Advances in Wireless Networks and Communications,, NWNC-2014.
- 10) Khanduri R., Rattan. SS., "Performance Comparison Analysis between IEEE 802.11a/b/g/n Standards", International Journal of Computer Applications (0975 – 8887) Volume78– No.1, September 2013.
- 11) Fainberg M., "A Performance Analysis of the IEEE 802.11b Local Area Network in the Presence of Bluetooth Personal Area Network", Master of Science Thesis, June 2001.
- 12) Eisenhofer A., Yohannes D., "Performance Analysis of the Next generation WLAN Protocol (IEEE802.11n 2.4 GHz) using OPNET Modeller", Channels, vol.36, pp.44.
- 13) Skordoulis D., Ni Q., Chen HH., "IEEE 802.11n MAC frame aggregation mechanisms for next-generation high-throughput WLANs," Wireless Communications, IEEE, vol. 15, pp. 40-47, 2008.
- 14) Achinkole S. O., "Computer Networks", Orient Printers and Communications, Accra, Ghana, 2010.
- 15) Makta M. H., "Basic Computer Communication", Educational Printing & Publishers, Accra, 2008.
- 16) Kulkarni SR, Viswanath P., "A deterministic approach to throughput scaling in wireless networks", IEEE Trans. on Information Theory, vol. 50, pp. 1041- 1049, 2004.
- 17) Dunaytsev R., "Network Simulators: OPNET overview and examples", Department of Communications Engineering, Tampere University of Technology, pp. 2-69, 2010.