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Abstract

IEEE 802.11 based Wireless Local Area Networks (WLANs) are becoming popular in home, enterprise and public access areas primarily due to their low cost, simplicity of installation and high data rates. While WLANs continue to be predominantly data centric, there is growing interest in using WLANs for voice and text data especially in enterprise markets. In this paper, a comprehensive analysis comparison to measure the delay, throughput packet loss and retransmission attempts was done to different scenarios using different trending wireless protocols such as 802.11n (2.4GHz, 5GHz), 802.11g, 802.11b, 802.11a while transferring low and high data load in FANET, with two major routing protocols AODV, and OLSR. As concluded in the result, recent wireless technology 802.11n with frequency band such of 2.4GHz can give better performance as they transfer higher data rates with longer distances and frequency band of 5GHz with higher data rate and less distance than 2.4GHz.

Keywords

FANET, Data Rate, Wireless Protocols, Routing Protocols, 802.11, Bandwidth

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RESEARCH ARTICLE

A Comparative Study of Different FANET 802.11 Wireless Protocols with Different Data Loads

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ABSTRACT

IEEE 802.11 based Wireless Local Area Networks (WLANs) are becoming popular in home, enterprise and public access areas primarily due to their low cost, simplicity of installation and high data rates. While WLANs continue to be predominantly data centric, there is growing interest in using WLANs for voice and text data especially in enterprise markets. In this paper, a comprehensive analysis comparison to measure the delay, throughput packet loss and retransmission attempts was done to different scenarios using different trending wireless protocols such as 802.11n (2.4GHz, 5GHz), 802.11g, 802.11b, 802.11a while transferring low and high data load in FANET, with two major routing protocols AODV, and OLSR. As concluded in the result, recent wireless technology 802.11n with frequency band such of 2.4GHz can give better performance as they transfer higher data rates with longer distances and frequency band of 5GHz with higher data rate and less distance than 2.4GHz.

Keywords FANET, Data Rate, Wireless Protocols, Routing Protocols, 802.11, Bandwidth

1.INTRODUCTION

In recent years wireless technology allowed to sharing and transfer of different types of information between different devices without any need for wireless infrastructure. This gives the devices full freedom to move while transferring the information. Still, devices movement was restricted by the range of the wireless signal reaching capability. These devices are connected and shares data using different 802.11 wireless protocols with a radio signal frequency of 2.4 GHz or 5 GHz while using different bandwidths and ranges to transmit the data between the devices [Ketshabetswe, L.K., et al. 2019].

In Flying ad-hoc network FANET, a group of flying Unmanned Aerial Vehicles (UAV's) are formed in the air to record and transmit data between them while they are moving and changing their topology consistently. Therefore, the biggest challenge of FANET is the data communication between the UAVs, as they communicate together with the support of different 802.11 wireless protocols as shown in figure 1 [QasMarrogy, G.A., 2021].

Supporting long-distance in FANET can enhance latency performance and reduce hop count, therefore higher gain antennas are required for each node to achieve that. But unfortunately, the small size and restricted battery problem can limit the distance transmission of these antennas.

FANET can communicate with each other with the help of different types of routing protocols that support the changing topology, these protocols namely Proactive, reactive and hybrid routing protocols [QasMarrogy, G.A., 2021].

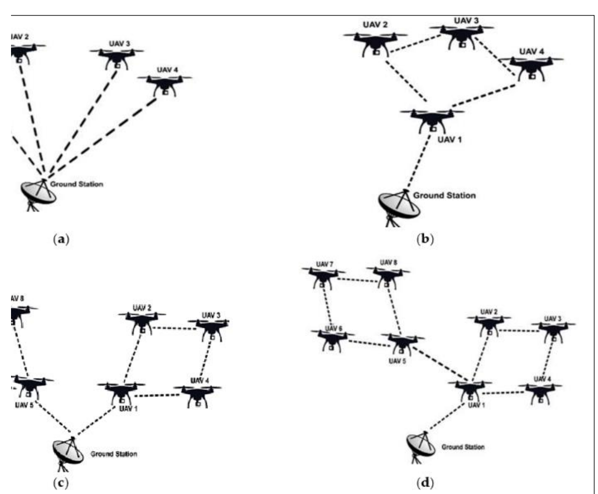

Figure 1: Different Movement Of FANET [QasMarrogy, G.A., 2021].

Unfortunately, not all moving devices are equipped with the same versions of 802.11 wireless protocols, therefore it's very important to know and simulate different types of wireless protocols while transmitting data between FANET devices to enhance the network performance and discover the different problems that can affect the throughput and delay of the transmission while suggesting a different type of solutions. The major importance of this paper is to find which wireless protocol standards can be used better for different purposes in FANET with the lowest delay possible while finding the gaps of each protocol to find better solutions for upgrading to newer standards.

The rest of the paper will be organized as follows, in section 2 related work will be discussed to show the similar simulations and solutions proposed to different problems for transmission. Sections 3 will show a summary background of the wireless and routing protocols used for this research, sections 4 will demonstrate and result and analyses used. And finally, section 5 will conclude the paper with some future work suggestions.

1. Related work

Different researchers analyzed the performance of different types of wireless signals and protocols through the recent years to enhance and solve the different problems that they may face during upgrading and issues with new wireless protocols and types, where different problems such as battery life, video transmission quality, speed and height effect on the transmission can be shown. In [Rochim, A.F., et al. 2020] the author focuses on comparing and analyzing the data rate of IEEE 802.11ac and 802.11ax with fixed load size and devices, and the result shows that 802.11ax has better performance in data rate than 802.11ac with a higher device number. In [Kaewkiriya, T., 2017] new research was simulated to compare 802.11ax and 802.11n by measuring the delay and throughput of different scenarios with high data rates. The result shows that in specific scenarios 802.11n gives better performance while in other scenarios 802.11ac gives better throughput. In [QasMarrogy, G., 2021] a full analysis was done on FANET to enhance and evaluate different video traffic types, IEEE 802.11n standards, and mobility models by measuring the delay and the throughput, the results show that in close range 802.11n 5GHz gives better performance while in longer-range 802.11n 2.4GHz gives higher throughput. Also, in [QasMarrogy, G.A., 2021] the author improves and calculate the low traffic VOIP services under 802.11n 5GHz MANET by comparing different type of routing protocols and metrics to show the perfect metric design for data transmission, the result shows that during specific metric the data rate can be enhanced. Finally, the author [Nourildean, S.W., Salih, A.M. and Othman, K.M., 2021] simulates wireless network VLAN to reduce WLAN traffic by comparing two main routing protocols OLSR and AODV, while measuring rate, latency, and traffic sent/received. The result shows that using VLANs in WLAN can give better results while using both AODV and OLSR routing protocols.

2.IEEE 802.11 Wireless and Routing protocols

The creating of IEEE 802.11 wireless protocol standards to be implemented in each moving device, gives the market a huge boost to upgrade its needs for data transmission without any cables. Today, most devices use different types of IEEE 802.11 wireless protocols technologies. As they support higher data rates and lower cost, they can be used in all moving devices it becomes a universal solution for different applications demands. As a result, these wireless protocols are developing all the time to fix technical issues and to become more flexible for all future applications [Elhabyan, R., Shi, W. and St-Hilaire, M., 2019].

The 802.11 networking wireless protocols family is the official and default for all devices to be applied these days, these protocols were upgraded through the years as shown in table 1 with their data rates speed and their distance capability [Khorov, E., et al. 2018].

Table 1: IEEE 802.11 Wireless Protocols Data Rate and Wireless Range [Khorov, E., et al. 2018].

Wireless Protocol	Frequency used	Data Range Mbps	Wireless Range (ft)
802.11 a	5 GHz	54	120
802.11 b	2.4 GHz	11	140
802.11 g	2.4 GHz	54	140
802.11 n	2.4 GHz	300	250
802.11 n	5 GHz	600	150

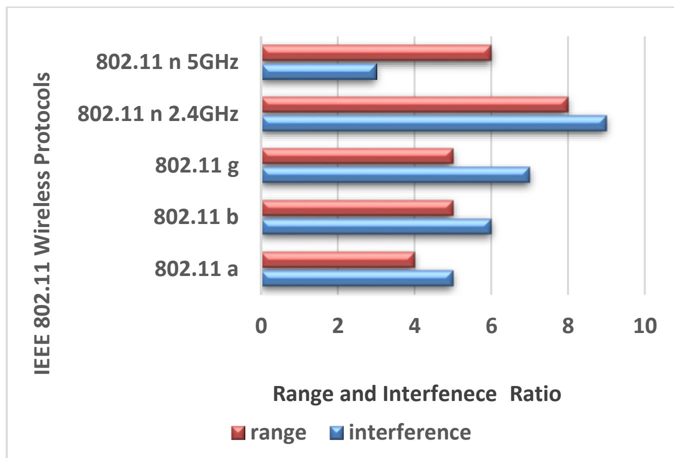

Figure 2: IEEE 802.11 wireless protocols interference ratio [Katila, C.J., et al. 2017].

As they get faster through the years, still they are unable to transmit through multi walls and they are non-immune to interference as shown in figure 2 [Katila, C.J., et al. 2017].

1.1. IEEE 802.11 Wireless protocols

a) 802.11a: this wireless protocol uses the frequency band of 5 GHz, to achieve a higher speed data rate but with a lower wireless range. This protocol was the first one used (orthogonal frequency division multiplexing) OFDM technology, which is a digital modulation technique used to work on encoding the data on multiple frequencies and converting it to an OFDM coding scheme, thus increasing the data rate of the signal transmitted [de Carvalho, J.P., et al. 2021].

b) 802.11b: this wireless protocol uses (Direct-Sequence Spread Spectrum) DSSS modulation technique to decrease signal interference while transmitting for longer distances and penetrating walls by using the frequency band of 2.4GHz. Still, as many devices use these protocols types, interference may be increased [Antonioli, D., Siby, S. and Tippenhauer, N.O., 2017].

c) 802.11g: this wireless protocol also uses a 2.4GHz frequency band to decrease the signal interference, while transmitting for longer distances and penetrating walls. The only difference between 802.11g and 802.11b is the first one has a faster data transfer rate than the second one [Antonioli, D., Siby, S. and Tippenhauer, N.O., 2017].

d) 802.11n: to improve speed this wireless protocol uses two frequency bands 2.4 GHz and 5GHz. This can lead to an increase in the transmission rate while increasing the coverage range. This happened as its uses MIMO technology (Multiple-Input Multiple-Output), also this protocol is considered to be a big upgrade from other wireless protocols [Mourad, A., et al. H., 2017].

To summarize the main differences between the mentioned wireless protocols table 2 will show all the advantages and disadvantages.

Table 2: IEEE Wireless Protocol Advantages and Disadvantages.

IEEE 802.11 Types	Advantages	Disadvantages
802.11a	Normal speed, normal signal interference	Higher cost, short signal range
802.11b	Lowest cost, normal signal range	Slow speed, higher interference
802.11g	Faster speed, normal signal range	Higher cost, normal interference
802.11n	Faster speed, higher signal range	Higher cost, higher interference

1.2. FANET Routing Protocols

To transmit the data in FANET, routing protocols must be used to guide the data from the sender to the receiver with the lowest delay and data drop possible. Also due to the moving nature of FANET topology, it's very difficult to transmit the data between the same nodes after the topology changes, therefore the main duty of FANET routing protocols is to preserve the connections between the source and destinations to transmit the data while the devices are moving. There are three main types of FANET routing protocols namely, reactive, proactive, and hybrid routing protocols as shown in figure 3 [QasMarrogy, G.A., 2020].

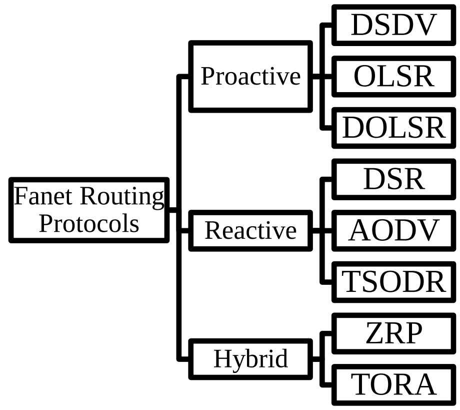

Figure 3: FANET Routing Protocols Types [QasMarrogy, G.A., 2020].

For this paper, two main routing protocols were chosen as they are the top of their analysis for FANET data transmission, AODV, and OLSR

a. Ad-Hoc On-Demand Vector (AODV): AODV in general uses routing tables and sequence numbers to store the old routes to become available all the time during transmission, thus can leads to lower delay to find the best routes during transmission. Finally, it can reduce the total network overhead traffic caused by management messages to establish and find new routes. Newer routs will replace the old ones after the topology changes and the old routes are no longer useful [QasMarrogy, G.A., and Almashhadani, Y.S., 2019].

b. Optimized Link State Routing Protocol (OLSR): this protocol maintains its routing table and stores the routes information periodically, but after topology changes, it starts a new search for better routes. Unfortunately, this can cause a huge amount of control data transmitted between the devices to find newer routes, which can cause overhead, lower bandwidth for data packets, and more energy consumption. But on the positive side, this also can give faster data transmission with lower packet dropping when the topology of the network changes very fast [Jain, R. and Kashyap, I., 2019].

2. Simulation's Parameters and Result Analysis

Data transmission is one of the most topics in wireless networks, as most of the data are transmitted between source and destination all the time without any cables. In this paper, different IEEE 802.11 wireless protocols 802.11(a, b, g, n) will be compared and analyzed during FANET realistic devices movement of random waypoint model in an area of 1500 x 1500 square meters with a flying speed of 10 to 15 m/s as it's the normal speed of capturing a video, with 40 flying drones in height of 20m while transmitting two types of traffic-heavy and light, with the support of two types of routing protocols, AODV and OLSR, as shown in table 3 the simulation parameters were explained. Also, all simulation scenarios will be repeated 10 rounds while calculating the average to get the optimal values for the throughput, delay, packet loss, and retransmission attempts metrics, by using the NS3 simulator, which is the top of network simulators.

Table 3: Simulation Parameters

Parameters	Values

IEEE Wireless Protocols	802.11a, b, g, n
Scenario's Area	1500 × 1500 m^2
Scenario's time	10 min
Number of FANET Drones	40 Drone
Mobility models	Random Waypoint Model
Node speed, height	Varying 10 -15m/s, 20 m
FANET routing protocols	AODV, OLSR
Heavy Traffic Load	Video streaming 15 - 20 MB
Light Traffic Load	HTTP Traffic 5 - 8 MB

As shown in figure 4, the highest throughput can be demonstrated in IEEE 802.11n 2.4GHz as it has the highest data rate and longer-range coverage, while OLSR protocol can show higher throughput as it transmits frequently control messages to keep the fresh routes alive. High traffic is always giving higher throughput as more packets are transmitted and received from the source to the destination.

Other protocols show lower throughputs as they have very low or limited coverage range or data rate compared to both IEEE 802.11n 2.4GHz and 5GHz

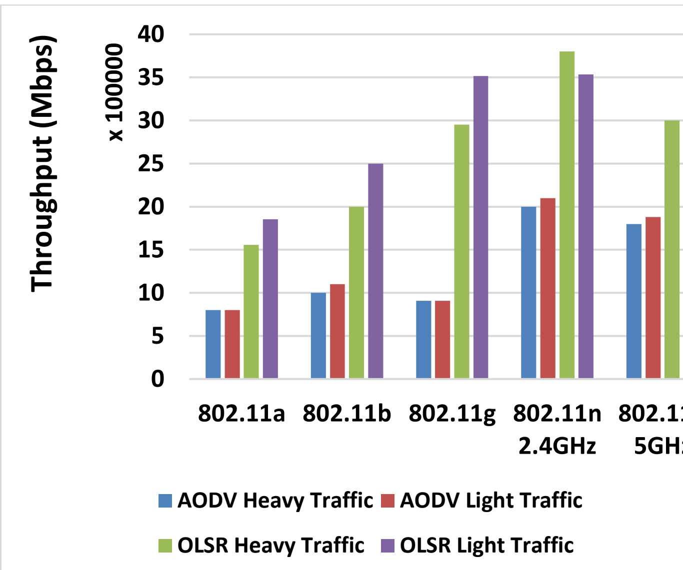

Figure 4: Throughput for IEEE 802.11a, b, g, n 2.4GHz, n 5GHz, routing protocols, and heavy and light load

Figure 5 demonstrates the delay of IEEE 802.11 wireless protocols, showing the highest delay is when IEEE 802.11b is used, as it has the lowest data rate and coverage range compared to all others. While the lowest delay can be shown using IEEE 802.11n 2.4GHz and 5GHz with OLSR routing protocol, as it uses fresh routs to transmit the data all the time.

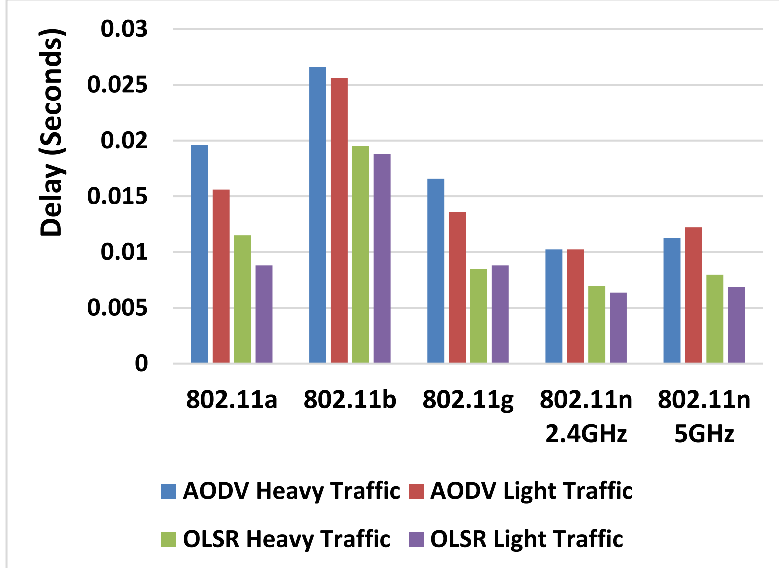

Figure 5: Delay for IEEE 802.11a, b, g, n 2.4GHz, n 5GHz, routing protocols, and heavy and light load

Retransmission attempts are measured to calculate how many packets were not received and retransmitted. Figure 6 shows the highest retransmission attempt was for IEEE 802.11b, a, g as they have a very low data rate and coverage range, while the highest is shown for IEEE 802.11n with OLSR routing protocol.

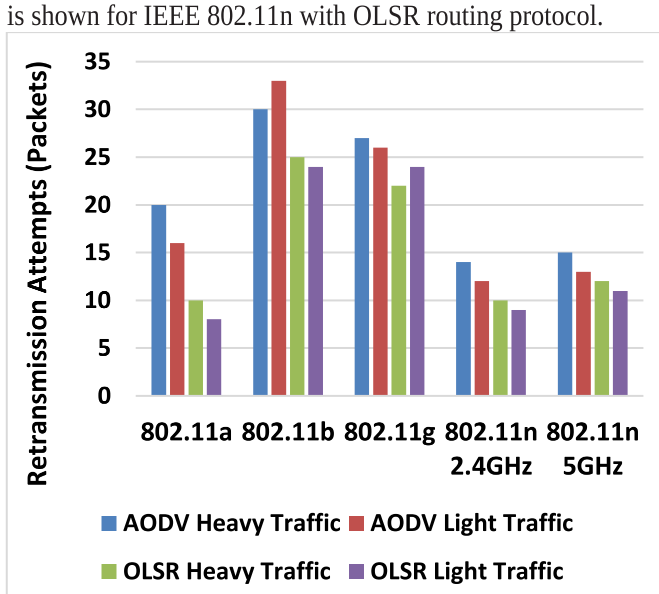

Figure 6: Retransmission Attempts for IEEE 802.11a, b, g, n 2.4GHz, n 5GHz, routing protocols, and heavy and light load

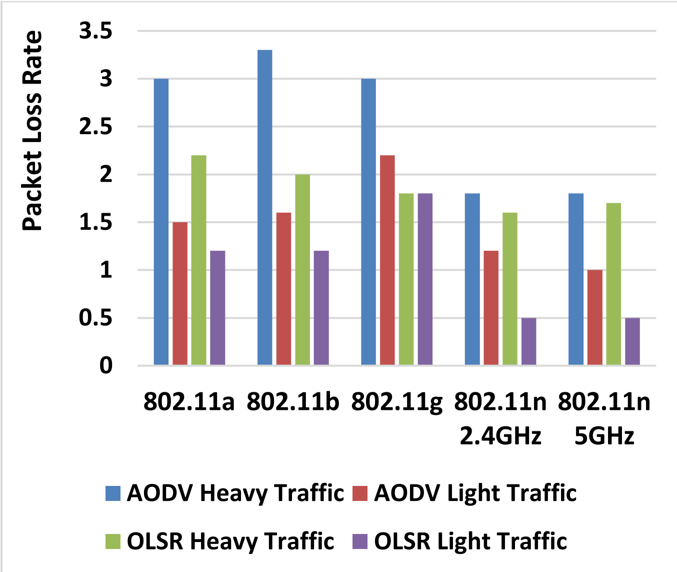

Figure 7: Packet Loss Ratio for IEEE 802.11a, b, g, n 2.4GHz, n 5GHz, routing protocols, and heavy and light load

Finally, packet loss are measured to calculate how many packets were not received and dropped. Figure 7 shows the highest packet loss was for IEEE 802.11b, a, g as they have a very low data rate and coverage range, therefore too many received packet will fill the buffer until there is no buffer memory to store the incoming packets and they will be dropped, while the highest is shown for IEEE 802.11n with AODV routing protocol.

3.Conclusion

Data transmission is very important to transfer different types of data between the sender and receivers, these data is very important to be transmitted wirelessly and for longer distances without using any type of cables. FANET is one network that uses wireless data transmission while flying and changing its topology continuously. In this paper, five types of IEEE 802.11 wireless protocols were compared and analyzed in FANET while using two types of routing protocols, AODV and OLSR with high and low data load.

The result shows the random movement of the drones with varying speeds between 10 to 15 m/s causes the links to break between the drones, therefore AODV and OLSR routing protocols are updating all the fresh routes to the destination. This movement needs more data rates and a longer coverage range between the drones to ensure the delivery of data. IEEE 802.11a, b, g uses lower data rates with shorter ranges which is not compatible with the highest movement and random directions of the drones, causing them to give very poor performance. Also, in terms of packet loss OLSR shows little better results as the connections between the nodes are always available therefore the packet will not wait for in buffer for long time after the network changes.

While IEEE 802.11n 2.4GHz and 5GHz can give better performance as they give more data rate and longer coverage range. It can also conclude that the 802.11n 2.4GHz can give higher range with lower transfer data rate than the 802.11n 5GHz. For future work, it is recommended to use more mobility models and more recent IEEE wireless protocols to be tested as there are much more to be compared and analyzed.

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