Performance Evaluation and Comparisons of IEEE 802.11 Releases a, b, g and n using OPNET Simulator

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Abstract

Wireless Communication is an application of science and technology that has come to be vital for modern existence. From the early radio and telephone to current devices such as mobile phones and laptops, accessing the global network has become the most essential and indispensable part of our lifestyle. Wireless Local Area Network is a data transmission system considered to provide location independent network access between computing devices by using radio waves rather than a cable infrastructure. In the business venture, wireless LANs are frequently employed as the final link between the existing wired network and a group of client computers, giving these users wireless access to the full resources and services of the corporate network across a building or campus setting. The 802.11 is a family of specifications developed by the IEEE for WLANs. The IEEE 802.11 standard supports radio transmission within the 2.4 GHz band. New release IEEE802.11ac has been appeared. In this paper, different WLAN standards were concerned and their IEEE 802.11 standards a/b/g/n have been studied and compared, their performance were evaluated based on Throughput, Delay and packet drop. Key Performance Indicators (KPI), which help WLAN user’s, student and researcher’s for selection the better type of WLAN standard. Keywords: IEEE 802.11a,b,g,n, throughput, delay, packet loss and opnet.

1. Introduction

Background:

WLAN technologies were first available in late 1990, when vendors initiated introducing products that operated within the 900 MHz frequency band. These solutions, which used non-standard, proprietary designs, provided data transfer rates of approximately 1Mbps. It was considerably slower than the 10 Mbps speed provided by most wired LANs at that time. In 1992, sellers began selling WLAN products that used the 2.4GHz band. Even if these products provided higher data transfer rates than 900 MHz band products they were expensive provided comparatively low data rates, were prone to radio interference and were often designed to use proprietary radio frequency technologies. The Institute of Electrical and Electronic Engineers started the IEEE 802.11 project in 1990 with the objective to develop a MAC and PHY layer specification for wireless connectivity for fixed, portable and moving stations within an area. Wireless LAN (WLAN, also known as Wi-Fi) is a set of low tier, terrestrial, network technologies for data communication. The WLAN standard operates on the 2.4 GHz and 5 GHz Industrial, Science and Medical (ISM) frequency bands. It is specified by the IEEE 802.11 standard and it comes in many different variations like IEEE 802.11a/b/g/n. The application of WLAN has been most visible in the consumer market where most portable computers support at least one of the variations. In the present study, we overview on different standard in table-1 and four WLAN standards were preferred for comparison that are IEEE 802.11a, IEEE 802.11b, IEEE 802.11g and IEEE 802.11n because these standards are very much popular among the users. It is noted that all 802.11 standards used Ethernet protocol and Carrier Sense Multiple Access / Collision Avoidance (CSMA/CA) for path sharing. Standards are a set of specifications that all manufacturers must follow in order for their products to be compatible. This is important to insure interoperability between devices in the market. Standards may provide some optional requirements that individual manufacturers may or may not implement in their products.

A. IEEE 802.11a

Ratification of 802.11a took place in 1999. The 802.11a standard uses the 5 GHz spectrum and has a maximum theoretical 54 Mbps data rate. Like in 802.11g, as signal strength weakens due to increased distance, attenuation (signal loss) through obstacles or high noise in the frequency band, the data rate automatically adjusts to lower rates
(54/48/36/24/12/9/6 Mbps) to maintain the connection. The 5 GHz spectrum has higher attenuation (more signal loss) than lower frequencies, such as 2.4 GHz used in 802.11b/g standards. Penetrating walls provides poorer performance than with 2.4 GHz. Products with 802.11a are typically found in larger corporate networks or with wireless Internet service providers in outdoor backbone networks.

B. IEEE 802.11b
In 1995, the Federal Communications Commission had allocated several bands of wireless spectrum for use without a license. The FCC stipulated that the use of spread spectrum technology would be required in any devices. In 1990, the IEEE began exploring a standard. In 1997 the 802.11 standard was ratified and is now obsolete. Then in July 1999 the 802.11b standard was ratified. The 802.11 standard provides a maximum theoretical 11 Megabits per second (Mbps) data rate in the 2.4 GHz Industrial, Scientific and Medical (ISM) band. In 2003, the IEEE ratified the 802.11g standard.

C. IEEE 802.11g
It has maximum theoretical data rate of 54 megabits per second (Mbps) in the 2.4 GHz ISM band. As signal strength weakens due to increased distance, attenuation (signal loss) through obstacles or high noise in the frequency band, the data rate automatically adjusts to lower rates (54/48/36/24/12/9/6 Mbps) to maintain the connection. When both 802.11b and 802.11g clients are connected to an 802.11g router, the 802.11g clients will have a lower data rate. Many routers provide the option of allowing mixed 802.11b/g clients or they may be set to either 802.11b or 802.11g clients only. To illustrate 54 Mbps, if you have DSL or cable modem service, the data rate offered typically falls from 768 Kbps (less than 1 Mbps) to 6 Mbps. Thus 802.11g offers an attractive data rate for the majority of users. The 802.11g standard is backwards compatible with the 802.11b standard. Today 802.11g is the most commonly deployed standard.

D. IEEE 802.11n
In January, 2004 the IEEE 802.11 task group initiated work. There have been numerous draft specifications, delays and lack of agreement among committee members. Yes, even in the process of standards development, politics are involved. The Proposed amendment has now been pushed back to early 2010. It should be noted it has been delayed many times already. Thus 802.11n is only in draft status. Therefore, it is possible that changes could be made to the specifications prior to final ratification. The goal of 802.11n is to significantly increase the data throughput rate. While there are a number of technical changes, one important change is the addition of multiple-input multiple-output (MIMO) and spatial multiplexing. Multiple antennas are used in MIMO, which use multiple radios and thus more electrical power. 802.11n will operate on both 2.4 GHz (802.11b/b) and 5 GHz (802.11a) bands. This will require significant site planning when installing 802.11n devices. The 802.11n specifications provide both 20 MHz and 40 MHz channel options versus 20 MHz channels in 802.11a and 802.11b/g standards. By bonding two adjacent 20 MHz channels, 802.11n can provide double the data rate in utilization of 40 MHz channels. However, 40 MHz in the 2.4 GHz band will result in interference and is not recommended nor likely which inhibits data throughput in the 2.4 GHz band. It is recommended to use 20 MHz channels in the 2.4 GHz spectrum like 802.11b/g utilizes. For best results of 802.11n, the 5 GHz spectrum will be the best option. Deployment of 802.11n will take some planning effort in frequency and channel selection. Some 5 GHz channels must have dynamic frequency selection (DFS) technology implemented in order to utilize those particular channels.

Comparison overview of WLAN /Wi-Fi IEEE Standard 802.11 a/ b/ g /n

Table1 below explain the main features of each IEEE802.11 release:

<table>
<thead>
<tr>
<th>Standard</th>
<th>Maximum Data Rate (Mbps)</th>
<th>Typical Throughput (Mbps)</th>
<th>Operating Frequency Band</th>
<th>Maximum Non-Overlapping Channels (North America)</th>
</tr>
</thead>
<tbody>
<tr>
<td>802.11b</td>
<td>11</td>
<td>6.5</td>
<td>2.4 GHz</td>
<td>3</td>
</tr>
<tr>
<td>802.11g</td>
<td>54</td>
<td>8 ( Mixed b/g )</td>
<td>25 ( Only 802.11g )</td>
<td>2</td>
</tr>
<tr>
<td>802.11a</td>
<td>54</td>
<td>23</td>
<td>5 GHz</td>
<td>24 (20MHz channels)</td>
</tr>
<tr>
<td>802.11n</td>
<td>248</td>
<td>74</td>
<td>2.4 GHz &amp; 5 GHz</td>
<td>6</td>
</tr>
</tbody>
</table>

802.11ac
802.11ac, the emerging standard from the IEEE, is like the movie The Godfather Part II. It takes something great and makes it even better. 802.11ac is a faster and more scalable version of 802.11n. It couples the freedom of wireless with the capabilities of Gigabit Ethernet accommodating high-bandwidth applications for numerous users.
2. Methodology

OPNET 17.5 is used to simulate four different methods from IEEE 802.11a, b, g & n. for analysis of the traffic between source and destination. Three parameters (delay, Packet loss, and throughput) were considered to evaluate the network performance for each transition releases.

3. Network Components

This section discusses the network components used in the suggested network models running on OPNET 17.5 device used in the network at 44 WLAN station. These are Ethernet server, switch Ethernet 16, Firewall, router, and IP backbone. The Application_Config includes a name and a description table that specifies various parameters for the different applications (i.e. web browser HTTP Heavy and FTP heavy applications). The specified application name is used while creating user profiles on "Profile_Config" object. The Profile_Config is used to create user profiles. These user profiles can be specified on different nodes in

4. Results and Analysis

The simulation run for 3min (180 sec): this time had been considered enough to gain an overview of the proposed network behaviour.

4.1 Throughput

The comparison between Wi-Fi releases recorded in figure below represents the throughput of Wi-Fi release a, b, g and n. From the graph shown, Wi-Fi release n has the greatest throughput (close to 2700 bps) compared to other releases, which mean it has better performance in case of high traffic volume. On the other hand, the graph shows Wi-Fi release a have the lowest throughput (2500bps) compared to other releases, and it indicates that the performance in heavy traffic conditions will be degraded more and more when the traffic volume increases. While the releases b and g of Wi-Fi products have the medium throughputs, it indicate that it can work well in the middle traffic conditions loads with acceptable performance As shown in fig 1 below.

4.2 Delay

Fig 4 shows that Wi-Fi g and b releases have more delay in the packet than the rest of the others i.e. release a, n. So, from the previous comparison of throughput for release a and n, it is found that they have the same measurement or they are closed to each other’s. They has a great throughput in addition to that they have a little amount of packet delay, so, it is better to use product n in real time applications which require more bandwidth such as ;Voice over IP, and gaming, since these applications need small delay over the network, because in case of any delay, the quality of services for the application will be affected directly.
4.3 Packet Drop

Fig. 4 represent the packet loss of the Wi-Fi releases. As mentioned above, if the system has high packet loss, this will affect the system performance directly, especially for the critical system that deal with the critical applications. According to fig.3, Wi-Fi release n has the little amount of packet loss compared to the other release, while release a has the highest packet loss during the traffic. So, Wi-Fi release n is more suitable for critical applications, like the banking transfer, because it needs accurate system with low pack loss operation.

5. Conclusion

Simulation is run by using OPNET17.5 tool, and three types of key performance indicators (Throughput, Delay and Packet Loss) have been considered. Release n has the greatest throughput and at the same time it has less delay to the packet, so, it can be used in applications that require high bandwidth, and it is also suitable for real time applications. From the simulation results, release n is found to be suitable for critical applications, and it is also acceptable for real time applications since it has little amount of delay compared with the other releases.

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