Performance Analysis of the Next generation WLAN Protocol (IEEE802.11n 2.4 GHz) using OPNET Modeler

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ABSTRACT

In this paper we analyzed the performance of the next generation WLAN protocol IEEE802.11n 2.4 GHz using OPNET modeler simulation tool. The performance of the protocol were measured by setting up four scenarios. Media access delay and jitter, traffic received by all receiving stations, data packet loss, total throughput of the network, total Network load and other WLAN parameters were measured for each scenarios and the results were compared. The Signal to interference ratio and signal receiving power for a mobile workstation were also analyzed by setting up an appropriate scenario.

The educational version of OPNET Modeler 17.1 were installed on Windows7, 64 bits operating system to model and simulate the IEEE802.11n 2.4 GHz WLAN protocol.

Key Words:- Protocol, OPNET, Performance, Scenario, Throughput, Delay, Jitter

1. INTRODUCTION

In recent years, most Wireless Local Area Networks (WLAN) are based on the IEEE 802.11b, 802.11a, 802.11g or 802.11n standards. These standards define how to wirelessly connect computers or devices to a network. Wireless enabled devices can send and receive data anywhere within the range of a wireless access point. The choice of the Wireless LAN protocol depends on the requirements of the individuals or a company who aims to implement the WLAN infrastructure. Some of the parameters that should be considered in selecting an appropriate WLAN working protocol includes: data communications speed and range, the level of security, noise and interference concerns, compatibility issues and cost.

The latest upgrade to the family of IEEE 802.11 standards is identified as IEEE 802.11n. Users of this new process will find that significantly greater speeds and ranges can be achieved over the existing standards.

The achievable range of IEEE802.11n is harder to quantify because it is affected by many variables, such as physical barriers that could block the signal. However, testing shows that 802.11n equipment typically delivers more than twice the range of 802.11g equipment at any given throughput speed.

The new 802.11n technology is expected to solve the throughput problem for business users, opening the way to the more effective use of far more applications such as wireless voice over IP, and more effective video conferencing sessions.

The 802.11n standard uses some new technology and updates some of the existing technologies to give wireless LANs more speed and range. The most notable new technology is called multiple input, multiple output (MIMO). MIMO uses several antennas to move multiple data streams from one place to another. Instead of sending and receiving a single stream of data, MIMO can simultaneously transmit three streams of data and receive two. This allows more data to be transmitted in the same period of time. This technique can also increase range, or the distance over which data can be transmitted.

Although the total acceptance of the IEEE 802.1n standards is still a work in progress, most of the provisions are now being implemented in both private and business networks.

Table 1.1. Comparison between different protocols

<table>
<thead>
<tr>
<th>Parameters</th>
<th>IEEE802.11 Protocols</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>IEEE 802.11a</td>
</tr>
<tr>
<td>Operating frequency</td>
<td>5.3 and 5.8 GHz</td>
</tr>
<tr>
<td>Average signal range</td>
<td>30–35 m</td>
</tr>
<tr>
<td>Bandwidth/channel</td>
<td>20–22 MHz</td>
</tr>
<tr>
<td>Max. Data rate</td>
<td>54 Mbps</td>
</tr>
<tr>
<td>Modulation Technique</td>
<td>OFDM</td>
</tr>
</tbody>
</table>
| Channels            | 36, 40, 44, 48, 52, 56, 60, 64, 149, 153, 157, 161 | 1 - 11 | 1 - 11 | 3 or 12 non overlapping chnl.

2. WHY OPNET MODELER?

In recent days there are lot’s of commercial and free ware Network simulation software tools in the market, some of the...
common once are Ns2, OMNET++, OPNET, ANYLOGIC, SIMULINK and etc. We stipulated different criteria’s to choose an appropriate modelling and simulation tool, some of the criteria’s were: User friendliness, flexibility, portability, performance, hardware and software compatibility and etc…..

More than 20 research articles were reviewed and Experts on the filed were consulted to select the appropriate WLAN simulator software. We have also installed some of the tools and evaluated their performance. Based on the results of the above analysis OPNET Modeller were selected to model and simulate the WLAN protocol.

3. INSTALLATION & RUNNING OF OPNET MODELER

OPNET Modeller 17.1 educational version were installed on the Windows7, 64 bits Toshiba laptop. The three packages (modeler_171A_PLL_11034_win, modeler_docs_10-Oct-2011_win, and models_171A_PLL_06Oct11_win) of the software were necessary and installed in the same directory for running the OPNET. Many thanks to the OPNET group for the provision of the license key for 6 months.

In addition with the above packages, Microsoft Visual Studio 10, Microsoft.NET and Microsoft SDKs were installed and some environment and system variables were created and the values were inserted into the system so that compilation and running of the stipulated scenarios were possible.

Environment variables created and added to the Windows7, 64 bits operating system

PATH

C:\Program Files (x86)\Microsoft Visual Studio 10.0\VC\BIN\amd64;
C:\WINDOWS\Microsoft.NET\Framework\v4.0.3.5;
C:\WINDOWS\Microsoft.NET\Framework\v2.0.50727;
C:\Program Files (x86)\Microsoft Visual Studio 10.0\VC\VCPackages;
C:\Program Files (x86)\Microsoft Visual Studio 10.0\Common7\IDE;
C:\Program Files (x86)\Microsoft Visual Studio 10.0\Common7\Tools;
C:\Program Files\Microsoft SDKs\Windows\v7.1\bin\x64;
C:\Program Files\Microsoft SDKs\Windows\v7.1\bin

LIB

C:\Program Files (x86)\Microsoft Visual Studio 10.0\VC\ATLMFC\LIB\amd64;
C:\Program Files (x86)\Microsoft Visual Studio 10.0\VC\LIB\amd64;
C:\Program Files\Microsoft SDKs\Windows\v7.1\lib\x64;

LIBPATH

C:\WINDOWS\Microsoft.NET\Framework\v4.0.3.5;
C:\WINDOWS\Microsoft.NET\Framework\v2.0.50727;
C:\Program Files (x86)\Microsoft Visual Studio 10.0\VC\ATLMFC\LIB\amd64;
C:\Program Files (x86)\Microsoft Visual Studio 10.0\VC\LIB\amd64;

INCLUDE

C:\Program Files (x86)\Microsoft Visual Studio 10.0\VC\ATLMFC\INCLUDE;
C:\Program Files (x86)\Microsoft Visual Studio 10.0\VC\INCLUDE;
C:\Program Files\Microsoft SDKs\Windows\v7.1\include;

FrameworkDir = C:\WINDOWS\Microsoft.NET\Framework64
FrameworkVersion = v2.0.50727
Framework35Version = v3.5
VCINSTALLDIR = C:\Program Files (x86)\Microsoft Visual Studio 10.0\VC
VSINSTALLDIR = C:\Program Files (x86)\Microsoft Visual Studio 10.0
WindowsSdkDir = C:\Program Files\Microsoft SDKs\Windows\v7.1\v
5. RESULTS & ANALYSIS

5.1 Total & Average Throughput of the WLAN

This parameter of a WLAN network is a measure of the actual data packets which are received by all receiving workstations in one second. The figure below easily depicts the total amount of data received in one second (Throughput) at three different scenarios. From this simulation result one can conclude that the total Throughput of WLAN network is increasing when the number of workstations which are connected to the network is increasing. Fig.3

5.2 Media Access Delay

According to the OPNET documentation, media access delay is a total of queue and contention delays of data packets received by WLAN MAC from higher layer. For each packet, the delay is recorded when the packet is sent to the physical layer for the first time. Hence, it also includes the period for the successful RTS/CTS exchange, if this exchange is used for that packet.

In a Wireless Local Area Network 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. Much Media Access delay were observed at Scenario 3 than Scenario 2 and 1. Fig.4

5.3 Total Data Packet Received

WLAN data traffic successfully received by the MAC from the physical layer in bits/sec. This statistic includes all data traffic received regardless of the destination of the received frames. While computing the size of the received packets for this statistic, the physical layer and MAC headers of the packet are also included.

This statistic also includes Data-Null, CF-Ack, CF-Poll and CF-Poll+CF-Ack frames, which are specified as data frames in the IEEE 802.11 standard, received during the contention free periods, if PCF operation was enabled for the BSS of this MAC. From the simulation result one can easily see that the total data packet received by all the workstations at scenario 3 is maximum or larger than at the scenarios 1 and 2. And this clearly indicates the possibilities of data flow and communication will be higher if the number of workstations connected to the WLAN is increased. And hence for the increment of the total traffic received by each workstations. Fig.5
5.4 Total Data Dropped (Buffer overflow)

This parameter is a measure of the total size of higher layer data packets (in bits/sec) dropped by all the WLAN MACs in the network due to: full higher layer data buffer, or the size of the higher layer packet, which is greater than the maximum allowed data size defined in the IEEE 802.11 standard.

If small numbers of workstations are connected to WLAN network, collisions, congestions and buffer overflow problems will be reduced and hence lower rate of data drop will be experienced by the network. The simulation result shown bellow verifies this concept. Fig.6

![Fig.6. Total Data Dropped (Buffer Overflow) (bits/sec) for Scenarios 1, 2 & 3](image)

5.5 Signal to Noise ratio (SNR) and Mobile Workstation received power

This statistic represents the ratio of the average power of a packet segment being received at a receiver channel and the combined average power of all relevant interference sources.

The Last Scenario i.e. Scenario4 (Fig. 2) were used to measure the moving Workstation received power and the signal/noise ratio. A mobile workstation with a ground speed of 1m/s were configured to move closer and away from the access point within the signal coverage area. The scenario were simulated for 40min and the following result were obtained. As it is expected the power received by the moving workstation is lowest at the beginning and end of the simulation time because the workstation is far from the AP, so it receives very little power. As the workstation moves close to the AP, the highest power was received and the signal to Interference ratio was the lowest. Fig.7

![A. Mobile Workstation received power (W) B. Mobile Workstation Signal/noise ratio (dB)](image)

Fig.7. Mobile Workstation received power (W) and Signal/noise ratio (dB)

6. SUMMERY AND CONCLUSION

In this paper, an infrastructure based WLAN Network with a working protocol of IEEE 802.11n 2.4GHz was simulated using OPNET simulator. The main focus of the research was to analyze the performance of the next generation WLAN and to see how the performance of the network is affected when the number of workstations connected to the WLAN is increasing.

From the simulation result we can conclude that, when number of workstations connected to WLAN increases, a degradation of network performance will occur. The possibility of data packet collisions, buffer overflow, congestion, dropping of data packets, end to end and media access delay will be higher when the workstations connected to the WLAN is increasing and hence affects the performance of a WLAN negatively.

Signal to Interference Ratio and power receiving ability of a moving workstation were also measured by setting an appropriate Scenario. As it is expected the power received by the moving workstation is lowest at the beginning and end of the simulation time because the workstation is far from the AP, so it receives very little power. As the workstation moves close to the AP, the highest power was received and the signal to Interference ratio was the lowest.

Finally, showing the performance of the IEEE802.11n 2.4GHz protocol for various connected workstations, procedures to install OPNET modeler on Windows7 64 bits machine and stipulating a concise guide to add an appropriate environment and system variables to Windows7 operating system so that compilation and running of scenarios will be possible using OPNET are some of the contributions of this research article.

7. REFERENCES