Evaluation: Theoretical vs Practical

Standard of the 802.11n

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Abstract

This paper makes a study of verification about certain specific data provided by the 802.11n protocol standard at the speed level, taking into account the kind of use that the protocol makes out of the communication channels. To perform the verification process, it was necessary to define a methodology, which is based on sending packets of information in the context of a LAN network at a residential level; by sending packets amongst the same network we were able to estimate and evaluate through the use of specialized programs (IPREF and INSSID) attributes and features discussed in the 802.11n protocol, such as: shipping time, distance between the sender and receiver, operating frequency, delivery speed and channel usage done by the device using this protocol. While performing the verification it was found as main conclusion that compared to the theoretical values, the practical values always lag behind, this means the actual data remains between the averages of the theoretical data, having this average as its top. However this may be caused
because the verification processes were conducted under conditions that do not fit the minimal requirements of an ideal in terms of the environment; since the workstation is a daily environment; it means, the environment is a home under standard conditions provided by the internet service provider.

**Keywords**: Network, LAN, Internet, Protocols, Bandwidth, last mile, wiring, internetworking, control flow, software, 802.3, 802.11, ip and mac address, segmentation, backbone, algorithm

### 1 Background

The engineers Ricardo Águila and Jimmy Sánchez in [1], provide a study for 802.11e and 802.11n standards stating that "in 802.11e each type of traffic should receive a differentiated treatment by the network to ensure the quality of service. And like the previous case by the 802.11n standard we can achieve faster speed", it should be noted that in this work only reached the maximum distance of 15 km. This last reference goes in accordance with what is stated in this document, given the fact that not in any scenario the protocol 802.11n reaches its maximum speed. As indicated there, it must be in special conditions in terms of noise (in the channel), traffic, the number of used channels, distance (between the transmitter and the receiver) and other variables involved in the performance of the Protocol.

It should be remarked that this Protocol was only used to handle maximum distances of 15 km, which shows a large gap in terms of usability and applicability in more extensive environments; and therefore a difficulty when it comes to overcrowd this service outside the residential environments [2-5].

The engineer, Patricia Ludeña in [6], States that "Based on tests with low noise levels and distances shorter than 100 cm, the streaming values are quite high. The values for 802.11n using the bandwidth of 40 MHz, obtained a better performance than with 20 MHz bandwidth".

In the present practice it is only taken into account the performance of the Protocol with a bandwidth of 20 MHz, however it is shown in tests that are made in the following methodology, that while using that bandwidth, there are more networks that may cause interference with the signal of the device, but if this protocol operates in less used bandwidths its performance may be better.

This work also analyzes the 802.11n, proposes its applicability in rural environments specifically in Latin America, which combined with 802.11n protocol, carries certain advantages such as an increased bandwidth and resistance to the Multi-pathing for these environments.


2 Description of the Working Environment

The entire verification process was carried out under a 892.11n, network environment, as a router an RCA model DCW725, a network card Usb Encore N300 with Wi-Fi card 300mbps.

The workstation is located within a WLAN at home, using as standard the 802.11n protocol, which has the following settings displayed by using the command ipconfigall in the cmd of the Computer.

The information which at the moment is taken as relevant information, is shown by the indicators:

- Physical address: 4C-0F-6E-0F-B6-F5
- IPv4 Address: 192.168.0.20
- Subnet mask: 255.255.255.0

These first three indicators show how it is identifying the computer from which all tests be carried out in terms of speed of 802.11n Protocol. They are important since these characterize the equipment, and these data will be necessary to carry out the proposed methodology.

- Default gateway: 192.168.0.1
- DHCP server: 192.168.0.1

These two recent indicators show the connection between the computer and the network gateway, these data will be useful in the methodology, since when the process of configuring the default gateway is done it will be what informs the machines that they are in the same LAN, which corresponds to the limit of this practice.

Given the configuration that is available from the console, you can create a Physical - logical architecture in which it is more didactically demonstrated the distribution of equipment involved in the network, as well as the connections that exist between them.

The following is the layout of the home network, in accordance with the directions that appear in the box above
In the Figure 1, the Physical–Logical architecture is basically composed of:

- A computer with IPv4 address: 192.168.0.20.
- A computer with subnet mask: 255.255.255.0
- A router with gateway: 192.168.0.1

The architecture is shown as the main part for the realization of the present tests, however there are many more elements that make up the workstation, items that do not necessarily belong to the same LAN where the practice is being done, since they are external factors that alter the conditions at the transmission medium level. This under the basis of the protocol 802.11n that shows the medium for communicating as a wireless medium, which has a radius of action on certain channels; but this does not guarantee that it is the only acting within that radius, as it does not guarantee either that it is the only one that uses certain channels; all of this is given by the fact of being in a residential environment where comparing the radius of action of each of them, there is very little space, also at the level of channels may always be that the networks overlap each other, because of the limiting factor in terms of the number of channels, since many of the protocols currently used handle up to 4 channels simultaneously in 20 MHz band.

The previous architecture design allows a flow of data from the computer through the router to the same computer or another computer that is on the same LAN; advantage that is used to perform the following methodology.

### 3 Methodology

Currently we can see that there are many technologies from different eras that
coexist simultaneously, they are therefore of different formats, however under the rules of a well-functioning and matching technologies, developed technologies as the 802.11n, which without leaving aside its own technological advancement, strives to be compatible with technologies already implemented in the world. Given that the purpose of this paper is to check the information presented by the protocol 802.11n, is necessary to carry out the tests to assess the competence of the Protocol:

3.1 Verification of Channels

The standard 802.11n uses both options, a channel width of 20 MHz as mandatory and of 40 MHz as optional. As in proprietary products, the 40 MHz channel bandwidth in 802.11n are actually two adjacent 20 MHz channels together. When using a channel of 40 MHz, the 802.11n takes an additional advantage because each 20 MHz channel has a small amount of the bandwidth of the channel that is reserved at the beginning and at the end to reduce interference between these adjacent channels; and with a channel of 40 MHz, the end of the lower channel and the beginning of the superior channel should not be booked. These small parts of the channel can be used to convey information; and, therefore, 802.11n reaches slightly more than twice the speed.

![Diagram of channels](https://upcommons.upc.edu/fcbитстроим2099.1/78341memoria.PDF)

In the Figure 2, there is evidence that the overlap between the networks on the use of the channels is very common since the amount of channels is very limited compared to the number of networks that can act and make use of them.

Depending on the bandwidth a different number of channels are used, it means, for the range of the 20 MHz bandwidth up to 4 channels are used, while for the bandwidth of 40 MHz only 2 channels are used given capacity of the channel itself. However for the next experiment it is used only the range of 20 MHz bandwidth.
There it is shown that actually in a 2.4 GHz band, the 78802980 network occupies 4 adjacent 20 MHz channel, even with a very low power or signal level. However there is also evidence that in the same channel in which the network operates, there act other five signals, which occupy from 1 up to 4 channels simultaneously. As a result it gives noise and increase in the traffic level for the use of channels 9, 10, 11 and 12. The use of these channels, it means how they are chosen, is performed by the router immediately when it is turned on, it looks for the 4 continuous channels that are with least amount of traffic. However it may be that after starting the router, other signs adhere to one or several of those channels previously chosen.

3.2 Speed Check
The speed check, is divided into two parts, the first has to do with the calculations of the average theoretical speed, for this, we make a query in which expected values at the level of the speed are obtained by taking into account the protocol used and the number of channels used. The second part of the verification corresponds with a practice developed with a program called ipref, which performs a process of validation of the speed within the same LAN network, taking into account basic parameters such as:

- Sent Packet size [Mbytes].
- Shipping Time [Seconds].
- Distance between transmitter and receiver. [Meters]

Step 1: Validation of Average Theoretical speed.

In which the values of each of the protocols will be found in channels of 20 MHz and of 40 MHz; In addition, it specifies ranges of speed that each of the protocols can take, depending on the number of channels that it uses to make the connections and data transmissions. In the proposed methodology, it is expressed that the network with which the 802.11n Protocol is working, makes use of 4 channels simultaneously and given the fact that in the table it specifies the minimum values and maximum values of each protocol, it is deduced that the average theoretical speed of to the protocol 802.11n using 4 channel is given by:

\[
\text{average theoretical speed} = \frac{\sum_{1}^{n} v}{n}
\]

Where:
- \( n \): Number of theoretical speeds.
- \( v \): Values of the theoretical speeds.
average theoretical speed \(= \frac{1242.3}{8}\) 
average theoretical speed \(= 155.2875 \text{ Mbits/seg}\)

**Results:**

- Average Theoretical Speed: 155.2875. Mbits/seg.

**Step 2: Validation of Average Practical Speed (real).**

To find the speed from practical exercises, we proceed to use the *iperf* program, a program that allows the evaluation of a network in terms of the speed at which it serves itself. All of this starting from the size of the package that will be sent and the time that takes sending the packet.

For this practice two computers are used, one that will act as a client and another that will act as a server.

**Server Configuration:**

The following steps are performed on the server:

1. By means of the console we access to the directory of the already downloaded *iperf*.
2. We execute the *iperf* –s command, with which you start the server from that computer, it remains activated and awaiting for client requests.

**Client Configuration:**

For the configuration of the client, we proceed to activate the interface which allows its communication by means of the following steps:

1. By means of the console access to the directory of the already downloaded *iperf*.
2. Enter the command *iperf* -c 192.168.1.51, by means of which the connection to the server is made and automatically the speed test starts.

By taking the data information of distance, time, and size of submitted file data, it delivers the speed:

Given the fact that a package of 113 Mbytes is sent in the time interval of 9.56 (closer to 10) seconds, an estimated speed of 94.5 Mbits/sec is calculated.

1. We changed 113Mbytes to Mbits: 113 Mbytes \(= 904 \text{ Mbits}\).
2. Then this is divided into the time that was need to transfer all the information: \((904 \text{ Mbits}) / (9.56 \text{ sec}) = 94.5 \text{ Mbits/sec}\).

It is found that the calculated theoretical speed is 94.5. Mbits/sec.

**4 Analysis of results**

Given the results obtained both at the theoretical and practical level, it demonstrates
that the velocities obtained are slower than those it should have with regard to the theoretical values. There is a percentage of the difference between the values obtained with the practice and those obtained with the query made at the theoretical level; to express this, we come the following analysis:

There is a simple rule of three, in which 100% will be represented by the average theoretical speed calculated in the methodology. It also relates the X parameter that will be the one which makes up the percentage that represents the actual speed (Practical) with respect to the theoretical:

\[
\begin{align*}
100 \% & \quad \rightarrow \quad 155.2875 \frac{\text{Mbits}}{\text{seg}} \\
X \% & \quad \rightarrow \quad 94.5 \frac{\text{Mbits}}{\text{seg}} \\
X & = \frac{(94.5 \times 100)}{155.2875} \\
& = \frac{9450}{155.2875} \\
& = 60.85 \%
\end{align*}
\]

This shows that Practical Speed carried out under the conditions described in the methodology, it only reaches to 60.85% average theoretical speed which expresses the 802.11n standard. There is a difference between the current work and the related work of approximately a 14%, this is due to the fact that there is no evidence of the existence of large changes, because of the similarity of the work environment, regarding the bandwidth used in channels, protocol used, and distance between the equipment and the router.

5 Conclusions

The average theoretical value to which it should have come was 116.125 Mbits/sec, however the result at the level of the practical evaluation was lower, with a speed of 94.5 Mbits/sec. The theory shows that the protocol 802.11n implements 20 MHz and 40 MHz bands. The channels used by the protocol 802.11n are 4 for the band of 20 MHz and 2 for 40 MHz band; but this amount can only be possible when the channels are continuous with each other; for this practice we used the 9, 10, 11 and 12 channels in the band of 20 MHz. The workstation develops a fundamental role in the process of validation of the results, given that in a moment of time, the standard that is undergoing the evaluation shares the work channel with various networks, which can be used; which would limit the use of the network that the Protocol has at its disposal and therefore it would directly affect its performance.
References


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