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Performance Analysis of Wi-Fi Network

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Abstract: *Recently, the wireless connection has become a preferred technology, due to its ease in use and for its mobility, therefore , a rapid development has emerged in the wireless technologies. Wi-Fi is the most common technology used today. This paper discusses the Performance of Wi-Fi network in three cases: No fading, flat fading and dispersive fading by measuring the bit rate and packet error rate ratio (PER). IEEE 802.11a WLAN Physical Layer model is taken to simulate these three cases using Matlab simulation.*
Keywords: *Wi-Fi, Wireless, Performance, fading.*

I. Introduction:

In the last years the mobility in computing and communications became more and more essential, especially for business usage. Mobility implies smaller sizes and more power considerations. It also, does not fit with fixed wired connections. The only suitable communication for mobile applications is wireless communication. The implication of mobility on computers appeared in the evolution of Notebook personal computers. On the other hand, the effect of mobility on computer networks appeared in the evolution of Wireless Computer Networks of which Wireless Local Area Networks are one kind. [1]

Wi-Fi becomes the most common used wireless technology today. Wi-Fi was originally created to meet the requirements of relatively high bit rate and large bandwidth. Currently Wi-Fi is the primary wireless communication technology which is extensively utilized in the internet services because of its excellent capability and transparency to internet protocols.

This paper describes the Performance of Wi-Fi network for three cases: No fading, flat fading and dispersive fading. The paper first gives a technical overview of the Wi-Fi wireless technology (IEEE 802.11). Then the paper Explain the methodology used and the model by using Matlab simulation Program. The paper then provides a comparative analysis of the three cases of fading and shows the results in tables and graphs. Lastly we conclude our paper.

II. Overview of Wi-Fi:

2.1 Wi-Fi network components:

Wi-Fi stands for “Wireless Fidelity”. Referring to Institute of Electrical and Electronic Engineers stand as WLAN-IEEE 802.11.
An 802.11 LAN is based on a cellular architecture where the system is subdivided into cells, where each cell (called Basic Service Set or BSS) is controlled by a Base station (called Access Point or AP).

2.1.1. Access Point (AP):

An AP operates within a specific frequency spectrum and uses an 802.11 standard specified modulation technique. It also informs the wireless clients of its availability and authenticates and associates wireless clients to the wireless network. An AP also coordinates the wireless clients’ use of wired resources.
The APs generally have two main tasks:

1. They act as a base station to the users.
2. They act as a bridge between wireless and wired networks.

It’s a Physical/Data link layer device, it supports 1, 2, 5.5, or 11Mbps connectivity depending on standard implemented. The coverage area of AP can be up to 375ft (114 m) .the number of user and AP supports varies but is generally 60-200 users.
A single access point should also be placed as closed as possible to the center of the planned coverage area. [14]

2.1.2. Network interface card (NIC)/client adapter:

A PC or workstation uses a wireless NIC to connect to the wireless network. The NIC scans the available frequency spectrum for connectivity and associates it to an access point or another wireless client.
The NIC is coupled to the PC/workstation operating system using a software driver.
Wireless NICs do same as standard NICs:

1. Change data from parallel to serial.

2. Framing and make packets ready for sending.
3. Determine the time to send or receive it.
4. Transmitting and receiving.

2.1.3. Bridge:

Wireless bridges are used to connect multiple LANs (both wired and wireless) at the Media Access Control (MAC) layer level. It's used in building-to building wireless connections; wireless bridges can cover longer distance than AP's. The coverage range can be up to 25 miles (40 Km) [14].

2.2. Architecture:

The fundamental building block of the IEEE 802.11 architecture is what is called the Basic Service Set (BSS). It is defined as a group of stations that are under the direct control of a single coordination function whether this coordination function is a centralized scheme, or a distributed scheme. The geographical area covered by a BSS is called the Basic Service Area (BSA). All stations within the same BSS can communicate directly to each other if the channel is assumed to be idea. IEEE 802.11 standard supports both of the two WLANs connections; these connections are the ad-hoc connection and the infrastructure network connection.

2.2.1. Ad-Hoc Mode connection (peer to peer): In Ad-Hoc mode connection AP is not requiring, the wireless station is connecting to each other directly without using an AP or any other connection. The topology is very useful to set up a wireless networks quickly and easily. Ad-Hoc mode is also called peer to peer mode or (IBSS) Independent Basic Service Set.

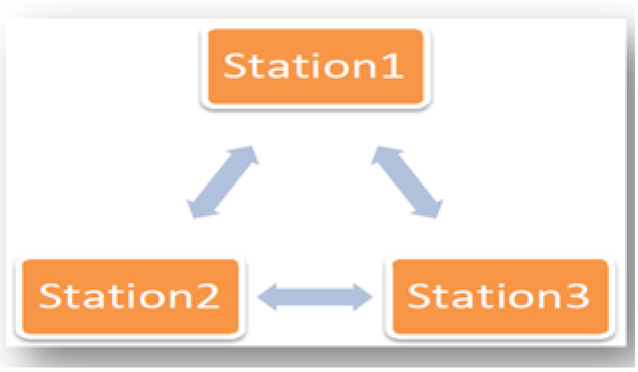

Figure 1: Ad-Hoc connection.

2.2.2. Infrastructure Mode connection (client/server): In the infrastructure mode connection, the wireless network consists of at least one AP (access point) connected to the wired infrastructure. All the wireless stations are connected to the AP. An AP controls encryption on the network and also can router the wireless traffic to a wired network (same as a router). We can think an AP as the base station used in cellular networks.

Figure 2: infrastructure connection

2.3 Wi-Fi Physical layer:

The Wi-Fi PHY layer is divided into two sub layer:

1. The Physical Medium Dependent (PMD) sub layer: It includes the standards for characteristics of the wireless medium (FHSS, DSSS, or IR). It defines the methods for transmitting and receiving data through the medium.

2. The Physical Layer Convergence Procedure (PLCP) sub layer: It reformats the data received from the MAC layer into packets (frame) that the PMD sub layer can transmit. It listens to the medium to determine when the data can be sent [14].

2.4 Wi-Fi Data link layer:

An 802.11 data link layer is divided in two sub layers: Logical Link Control: (LLC) and Media Access Control (MAC).

1. LLC is the same as in 802 LANs allowing for very simple bridging from wireless to wire networks.
2. MAC is different to WLANs. The first method in MAC is CSMA (Carrier Sense Medium Access) with collision avoidance protocol. This protocol is to ask each station to listen before action. If the channel is idle, the station is allowed to transmit. If the channel is busy, the station has to wait until channel is free [15].

2.5. Wi-Fi Modulation:

The Wi-Fi technology used many modulation techniques, the most popular techniques are: Direct Sequence Spread Spectrum (DSSS) and Frequency Hopping Spread Spectrum (FHSS). In both techniques the spreading of the signal is performed using a pseudo-random code called Pseudo-random Noise PN.

I. Direct Sequence Spread Spectrum (DSSS):

Uses a PN code, which has a bit rate very much higher than the bit rate of the transmitted signal. This PN code is binary multiplied with the transmitted signal before modulation. This causes the resulting signal to have a bandwidth approximately equal to that of the PN code. Hence the transmitted signal is effectively spread over the bandwidth of the PN code. Taking the bandwidth of the PN code to be equal to the bandwidth of the allowable channel, the transmitted signal will be spread over the bandwidth of the allowable channel [12].

II. Frequency Hopping Spread Spectrum (FHSS):

Uses the PN code to change the frequency of the carrier between different frequencies covering the range of the allowable bandwidth, or most of it. This means that the PN code controls the frequency of the modulator causing it to hop pseudo-randomly between different frequencies in the allowable bandwidth [12].

2.6 Wi-Fi Standards:

The IEEE 802.11 task group issued the first set of specifications in 1997 for Wi-Fi working at a frequency of 2.4 GHz. The IEEE 802.11 task group comprised several task force named a, b, g, e, h, I, n to address the user needs, regarding security, speed, Quality of Service (QoS) and throughput. [16]

802.11a, b, and g standards are most commonly used; these standards define the Physical (PHY) Layer and the Media Access Control (MAC) Layer. In these three IEEE 802.11 standards the MAC layer is the same, but the PHY layer differs between them. The table below shows the details of each standard:

Wi-Fi standard	Frequency (GHz)	Modulation	Channel BW (MHz)	Data rate (Mbps)	Max range (m)
802.11 a	5.15-5.25	OFDMA	20	6-54	50
802.11b	2.4-2.485	CCk DSSS/FHSS	25	11	100
802.11g	2.4	Code keying OFDM	20	5.5-54	100
802.11n	2.4-5.5	MIMO	40	320	200

Table 1: standards of Wi-Fi

III. Model of Wi-Fi PHY layer:

The results presented in the paper are based on Matlab simulation by using IEEE 802.11a WLAN Physical Layer model. The Model represented an end-to-end baseband model of the physical layer of a wireless local area network (WLAN) according to the IEEE 802.11a standard. The model supported all mandatory and optional data rates: 6, 9, 12, 18, 24, 36, 48, and 54 Mb/s.

Three cases are used in this model to analyze the performance of the network; when there is no fading in multipath channel, then when there is flat fading, and last when there is dispersive fading.

In each cases the SNR graded from (0 to 40) dB and equivalent values of packet error rate (PER) and bit rate are calculated. Also the maximum Doppler shift is changed from 200 Hz to 100Hz and 300 Hz.

The results are taken from the simulation model and represented in tables and then represented in graphs by using Excel office.

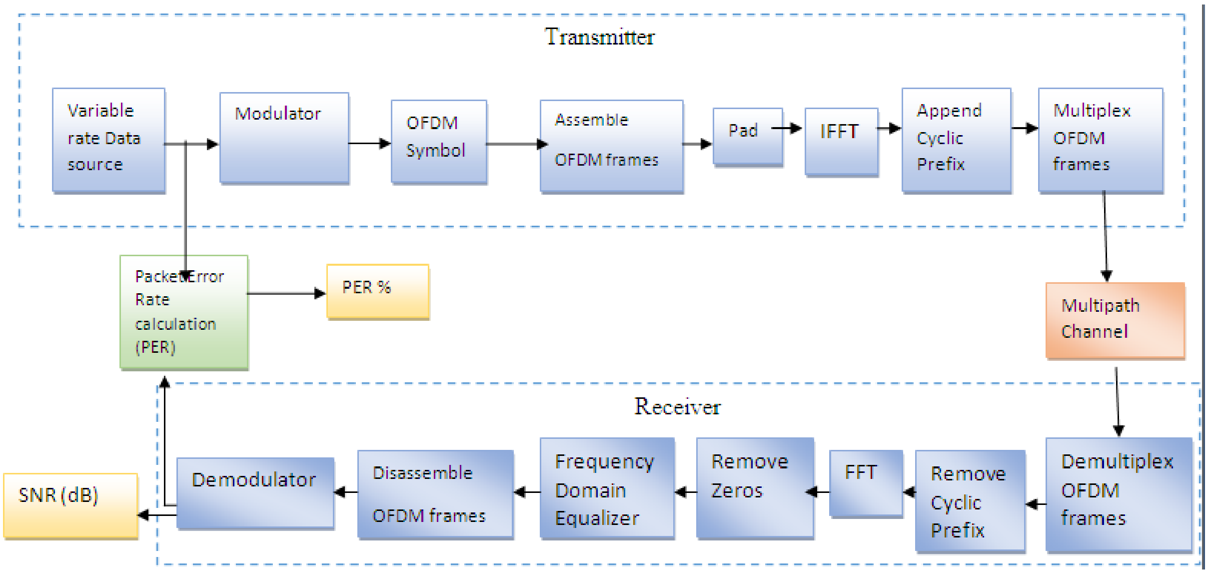

Figure 3: 802.11a WLAN Physical Layer Model

IV. Results and Discussions:

The results were divided into 3 cases:

4.1. No fading:

Table 2 and Figure 4 shows the result of PER and bit rate when the maximum Doppler shift is 200 Hz. Table 3 and Figure 5 shows the result of PER and bit rate when the maximum Doppler shift is 100 Hz. Table 4 and Figure 6 shows the result of PER and bit rate when the maximum Doppler shift is 300 Hz.

There is no PER when SNR equal (5-40) dB and bit rate increases from (6 to 54) MB/S.

SNR(dB)	PER %	Bit Rate (Mb/s)
0	76	6
5	0	6
10	0	6
15	0	12
20	0	18
25	0	36
30	0	48
35	0	54
40	0	54

Table 2: PER percentage when there is no fading and max Doppler shift is 200 Hz.

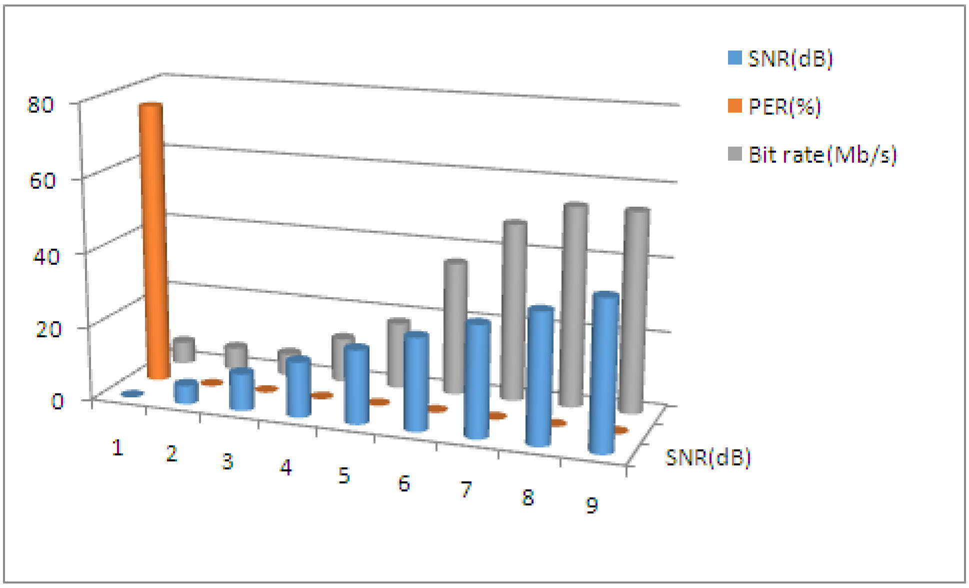

Figure 4: SNR (dB) Vs PER (%) and Bit rate (Mb/s) when max Doppler shift is 200 Hz.

SNR(dB)	PER %	Bit Rate (Mb/s)
0	76	6
5	0	6
10	0	6
15	0	12
20	0	18
25	0	36
30	0	48
35	0	54
40	0	54

Table 3: PER percentage when there is no fading and max Doppler shift is 100 Hz.

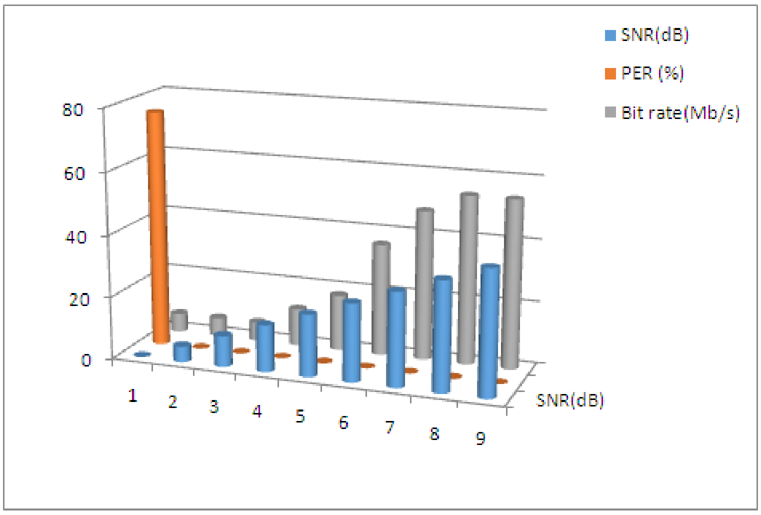

Figure 5: SNR (dB) Vs PER (%) and Bit rate (Mb/s) when max Doppler shift is 100 Hz.

SNR(dB)	PER %	Bit Rate (Mb/s)
0	76	6
5	0	6
10	0	6
15	0	12
20	0	18
25	0	36
30	0	48
35	0	54
40	0	54

Table 4: PER percentage when there is no fading and max Doppler shift is 300 Hz.

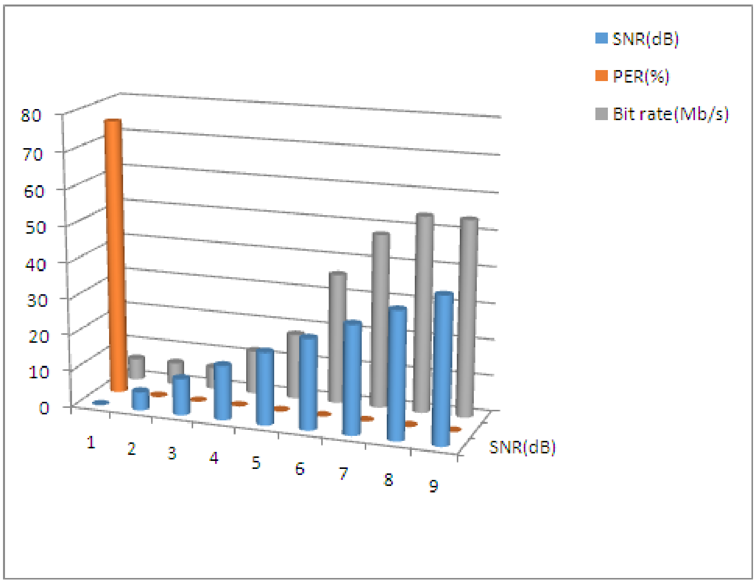

Figure 6: SNR (dB) Vs PER (%) and Bit rate (Mb/s) when max Doppler shift is 300 Hz.

4.2. Flat fading:

Table 5 and Figure 7 shows the result of PER and bit rate when the maximum Doppler shift is 200 Hz. Table 6 and Figure 8 shows the result of PER and bit rate when the maximum Doppler shift is 100 Hz. Table 7 and Figure 9 shows the result of PER and bit rate when the maximum Doppler shift is 300 Hz.

When comparing the three results with other, we find that the best result when maximum Doppler shift is 100 Hz.

SNR(dB)	PER %	Bit Rate (Mb/s)
0	60	6
5	28	6
10	16	6
15	4	6
20	4	9
25	2	12
30	2	18
35	4	18
40	8	18

Table 5: PER percentage when there is Flat fading and max Doppler shift is 200 Hz.

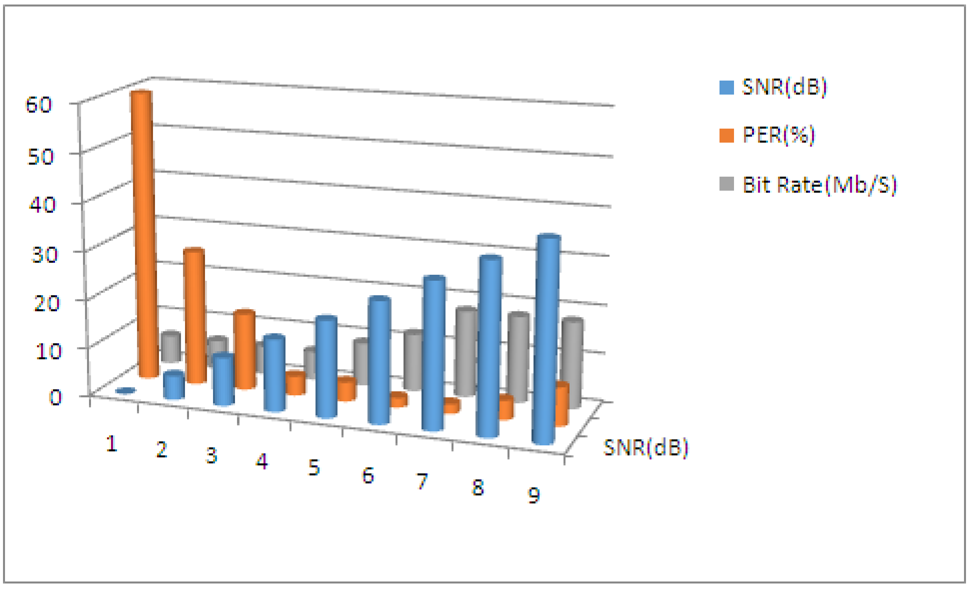

Figure 7: SNR (dB) Vs PER (%) and Bit rate (Mb/s) when max Doppler shift is 200 Hz.

SNR(dB)	PER %	Bit Rate (Mb/s)
0	18	6
5	0	6
10	0	12
15	0	24
20	0	36
25	0	36
30	0	54
35	0	54
40	0	54

Table 6: PER percentage when there is Flat fading and max Doppler shift is 100 Hz.

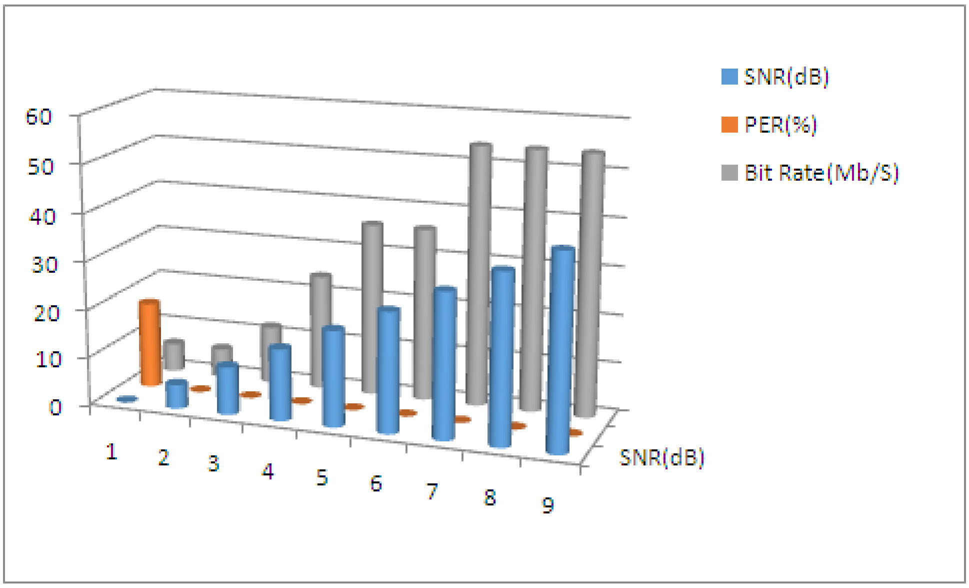

Figure 8: SNR (dB) Vs PER (%) and Bit rate (Mb/s) when max Doppler shift is 100 Hz.

SNR(dB)	PER %	Bit Rate (Mb/s)
0	70	6
5	18	6
10	4	9
15	0	18
20	4	24
25	0	36
30	2	54
35	4	54
40	4	54

Table 7: PER percentage when there is Flat fading and max Doppler shift is 300 Hz.

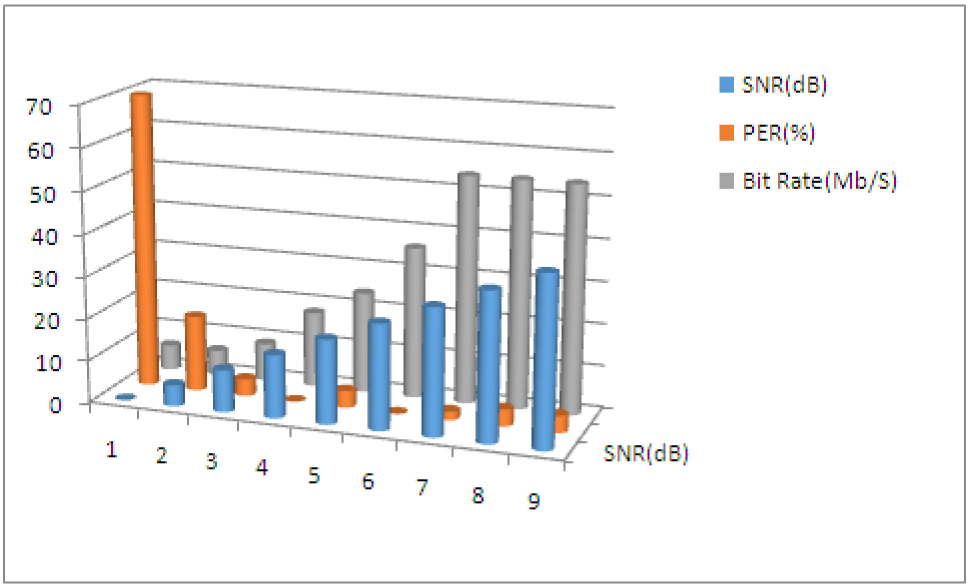

Figure 9: SNR (dB) Vs PER (%) and Bit rate (Mb/s) when max Doppler shift is 300 Hz.

4.3. Dispersive Fading:

Table 8 and Figure 10 shows the result of PER and bit rate when the maximum Doppler shift is 200 Hz. Table 9 and Figure 11 shows the result of PER and bit rate when the maximum Doppler shift is 100 Hz. Table 10 and Figure 12 shows the result of PER and bit rate when the maximum Doppler shift is 300 Hz.

SNR(dB)	PER %	Bit Rate (Mb/s)
0	100	6
5	80	6
10	44	6
15	20	6
20	8	12
25	8	18
30	6	24
35	8	36
40	10	36

Table 8: PER percentage when there is Dispersive fading and max Doppler shift is 200 Hz.

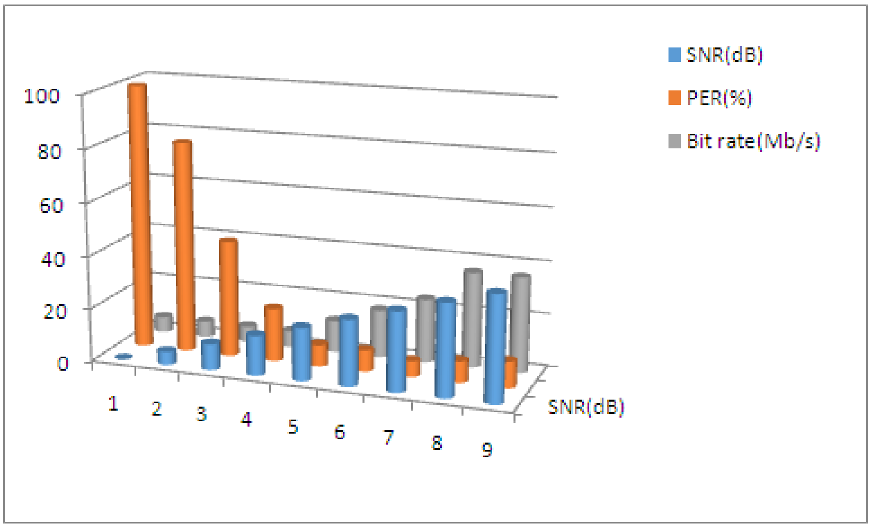

Figure 10: SNR (dB) Vs PER (%) and Bit rate (Mb/s) when max Doppler shift is 200 Hz.

SNR(dB)	PER %	Bit Rate (Mb/s)
0	100	6
5	96	6
10	58	6
15	22	6
20	4	12
25	10	18
30	0	24
35	0	36
40	12	36

Table 9: PER percentage when there is Dispersive fading and max Doppler shift is 100 Hz.

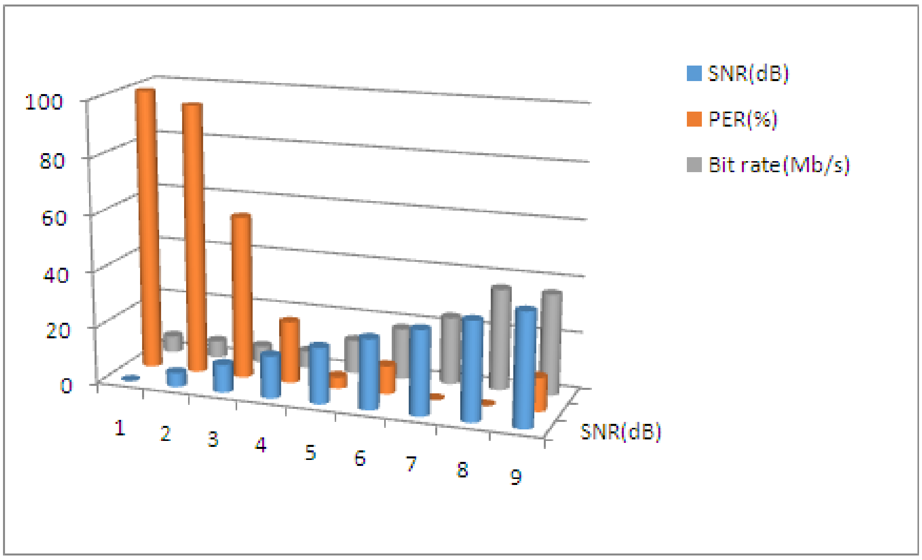

Figure 11: SNR (dB) Vs PER (%) and Bit rate (Mb/s) when max Doppler shift is 100 Hz.

SNR(dB)	PER %	Bit Rate (Mb/s)
0	84	6
5	46	6
10	30	6
15	14	12
20	20	18
25	16	18
30	16	24
35	14	24
40	16	24

Table 10: PER percentage when there is Dispersive fading and max Doppler shift is 300 Hz.

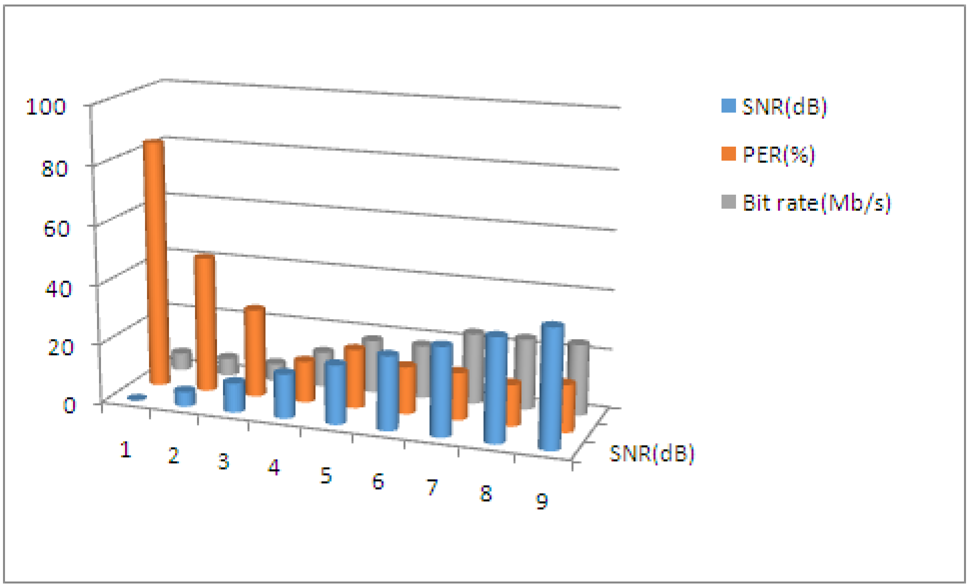

Figure 12: SNR (dB) Vs PER (%) and Bit rate (Mb/s) when max Doppler shift is 300 Hz.

V. Conclusion:

This paper discussed the Performance of Wi-Fi network for three cases: No fading, flat fading and dispersive fading by measuring bit rate and packet error rate ratio (PER) .we conclude that when there is no fading the performance of Wi-Fi is perfect. In case of flat fading and /or dispersive fading; maximum Doppler shift less than 200 Hz reduces the degradation performance of the Wi-Fi network.

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