CHAPTER FOUR

RESULTS AND DISCUSSIONS

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4.1 Introduction:

The system performance was calculated through four scenarios, first one before CRE and other three scenarios after CRE. Where the enhancement percentage (EP) was calculated as shown in (4-1):

$$EP=\frac{\text{the value before CRE} - \text{the value after CRE}}{\text{the value before CRE}} \quad (4\text{-}1)$$

4.2 Simulation Parameters:

List of parameters were used to simulate the network performance before and after the CRE (shown in table 4-1)

Table (4-1): Simulation Parameters

Parameters	Values
System bandwidth	20MHz
Cellular layout	1 macro cell,1 Pico cell
Transmitter antenna height	32 m
Receiver antenna height	1.5 m
Transmitter antenna gain	14dBi
Area gain	10dBi
Receiver antenna gain	0dBi
Macro BS TX power	16dBm
Carrier frequency	150MHz
Noise figure	9 dB
Shadowing	8-9dB
Interference	1-3dB
Penetration loss	20dB

4.3 Simulation Results:

4.3.1 Signal to Interference and Noise Ratio Values:

Figure (4-1): Shows the variation of the signal to interference noise ratio (SINR) for 40 users, from the value 45.21 to the value 9.055.

The further the SINR improve the further the network performances improve through the good use of adaptive modulation and coding.

(Higher modulation and coding rate)

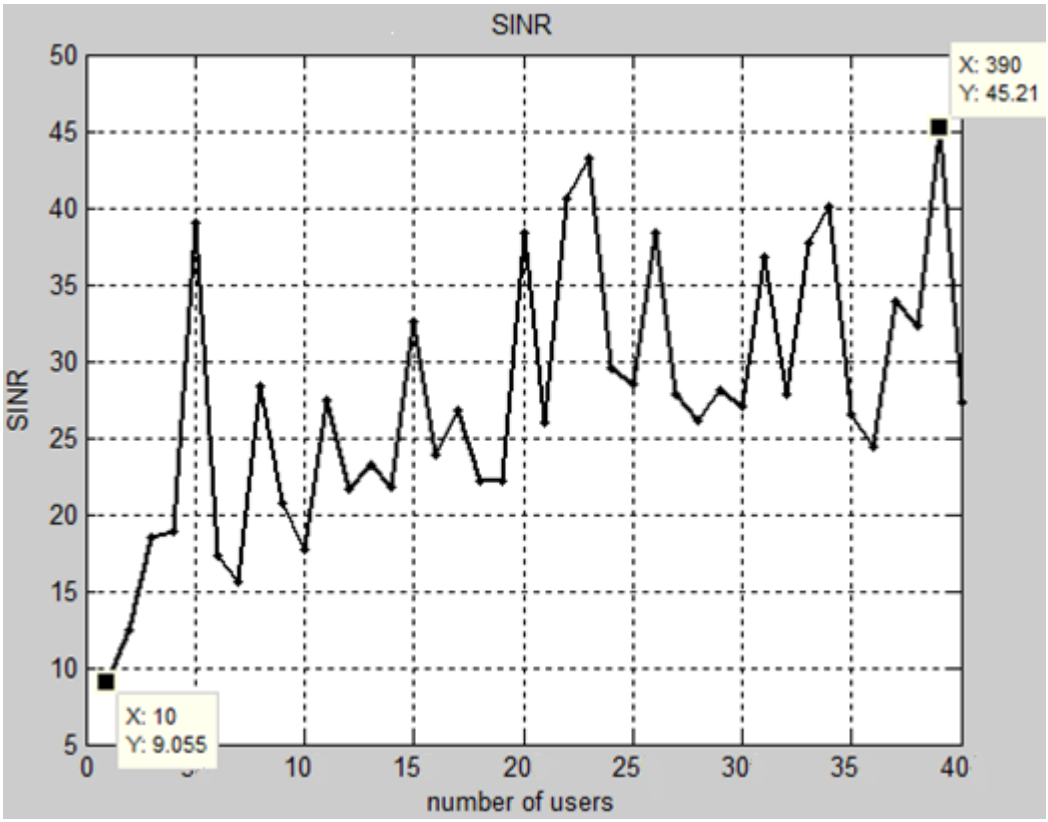

Figure (4-1): SINR Values

4.3.2 Bandwidth per User:

Figure (4-2): Shows the decreasing path for bandwidth per user due to the increasing number of user, the bandwidth per user start to enhance and stabilize afteroffloading users. Varying from maximum 20MHz to

minimum 0.5MHz without rang expansion (black), maximum 20MHz to minimum 0.625MHz for 20% rang expansion (red), maximum 20MHz to minimum 0.8333MHz for 40% rang expansion (pink), maximum 20MHz to minimum 1.25MHz for 60% range expansion (blue).

The bandwidth per user is the key varying performance parameter in our simulation that have the most effect on the other parameters.

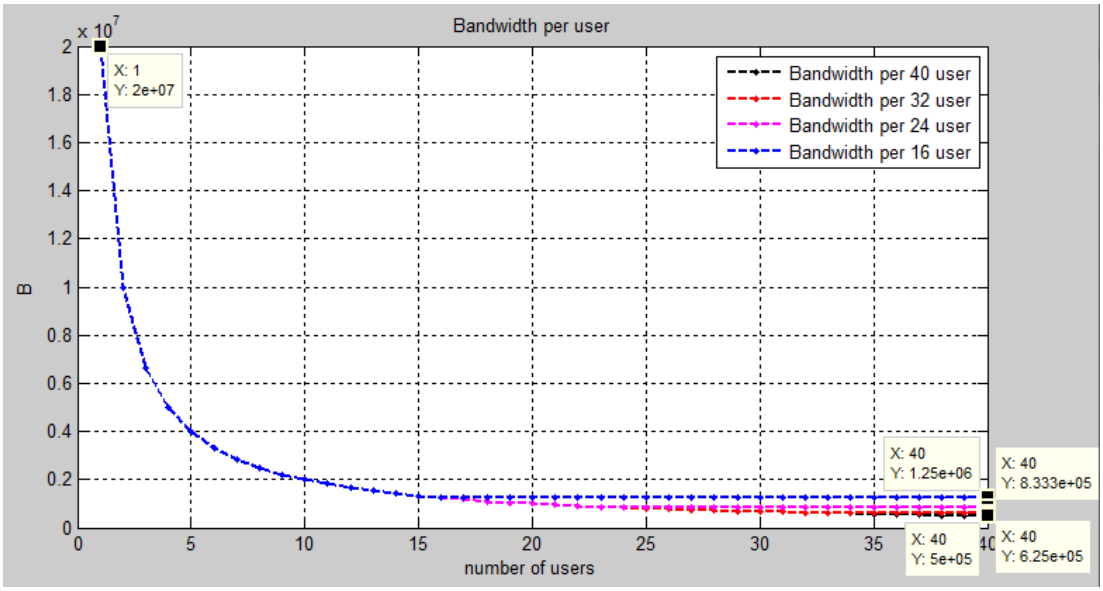

Figure (4-2): Bandwidth per User

4.3.3 Compressionof Data Rate Performance:

- **Compression of Two Scenarios:**

Figure (4-3): Shows the final network data rate performance after 60% Pico range expansion and offloading 24 users from the macro to the Pico the user experience concerning data rate enhanced by 60%.

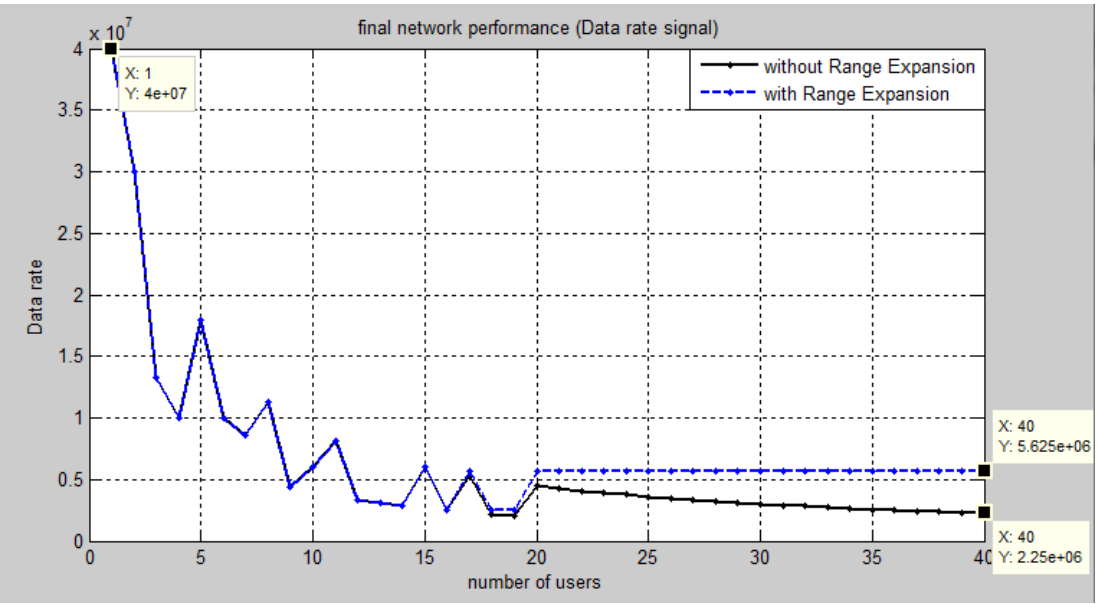

Figure 4-3: Data Rate Values (Two Scenarios)

- **Compression of Four Scenarios:**

Figure (4-4): Shows the data rate gradually enhancement depending on the SINR and the bandwidth per user. The 4 scenarios have the same maximum value of data rate in the beginning due the similarity of SINR values and the bandwidth per user.

The enhancement appears after performing the RE due to the increasing bandwidth per user, varying between the same maximum values 40Mbit/s to minimum 2.813Mbit/s for 20%range expansion, minimum 3.75Mbit/s for 40% range expansion, minimum 5.625Mbit/s for 60% range expansion.

Notice that the variation shape is the same because the SINR values are stable for the 4 scenarios.

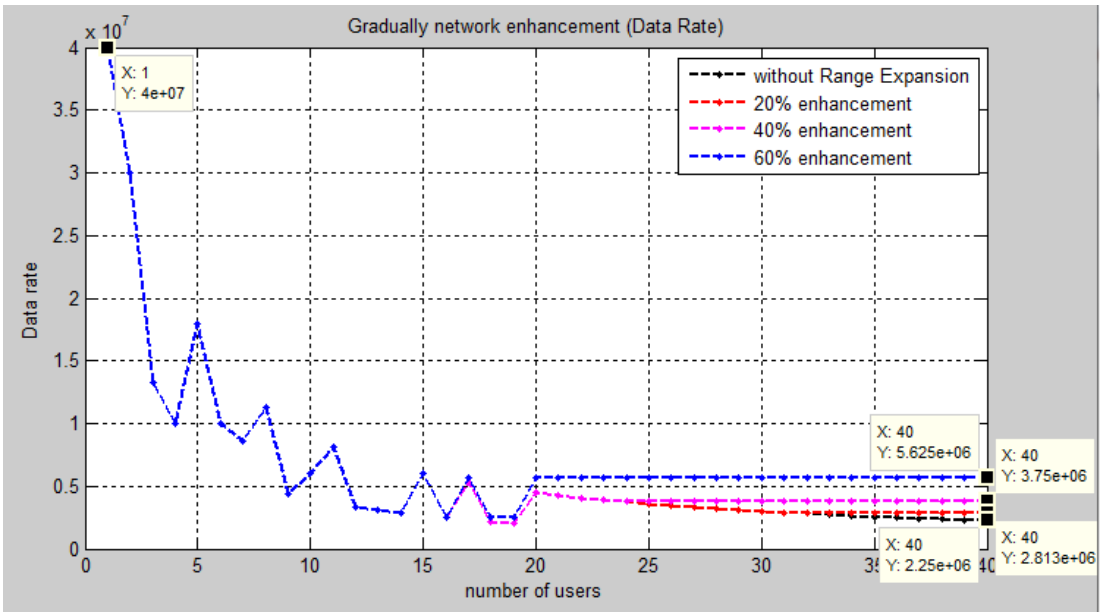

Figure (4-4): Data Rate Values (Four Scenarios)

4.3.4Compression ofSpectral Efficiency Performance:

- **Compression of Two Scenarios:**

Figure (4-5): Shows the final network spectral efficiency performance after 60% Pico cell range expansion, 24 user were offloaded from the macro they experience 2% enhancing concerning the spectral efficiency that's mean more users can be simultaneously supported(more information rate can be transmitted over a given network).

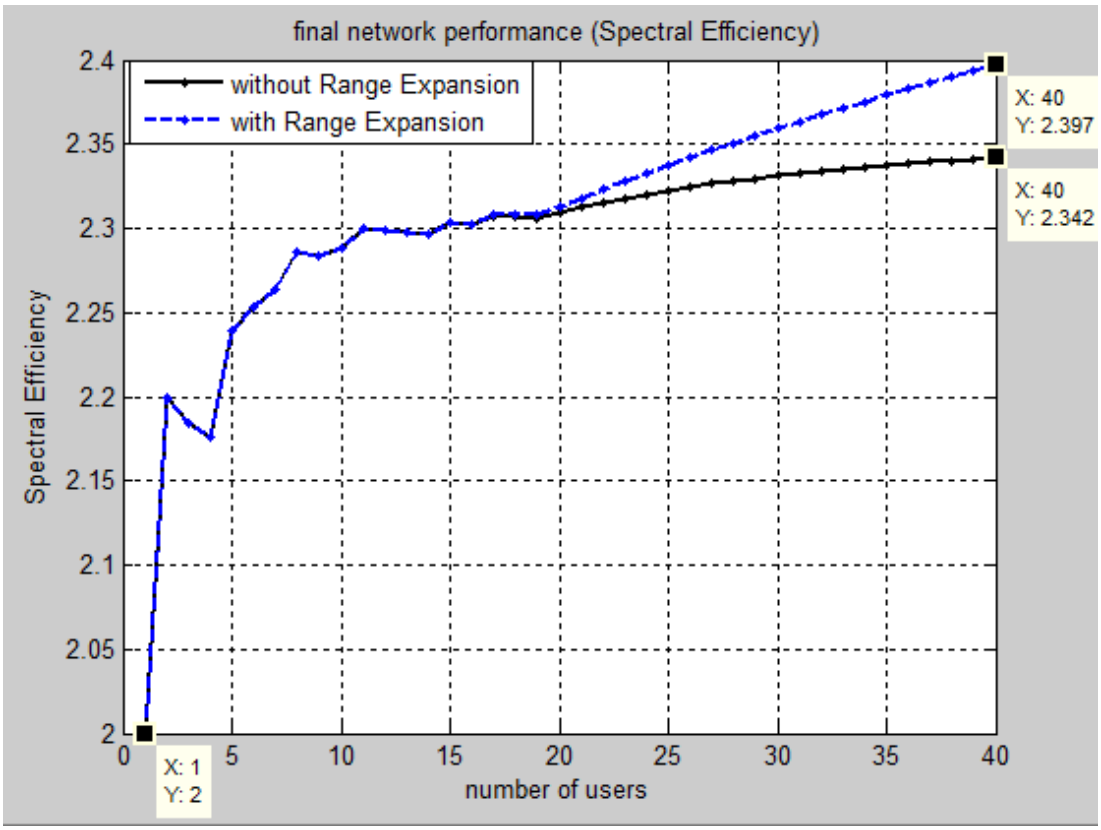

Figure 4-5: Spectral Efficiency Values (Two Scenarios)

- **Compression of Four Scenarios:**

Figure (4-6): Showsthe spectral efficiency variation,the spectral efficiency is mainly depending on the SINR. As mentionedbefore, the 4 scenarios have the same variation shapes due to the stable surrounding conditions (SINR, noise).

The spectral efficiency varied between minimum 2bit/s/Hz for the four scenarios to maximum 2.344bit/s/Hz for 20% range expansion, maximum 2.355bit/s/Hz for 40% range expansion, maximum 2.397bit/s/Hz for 60% Range expansion.

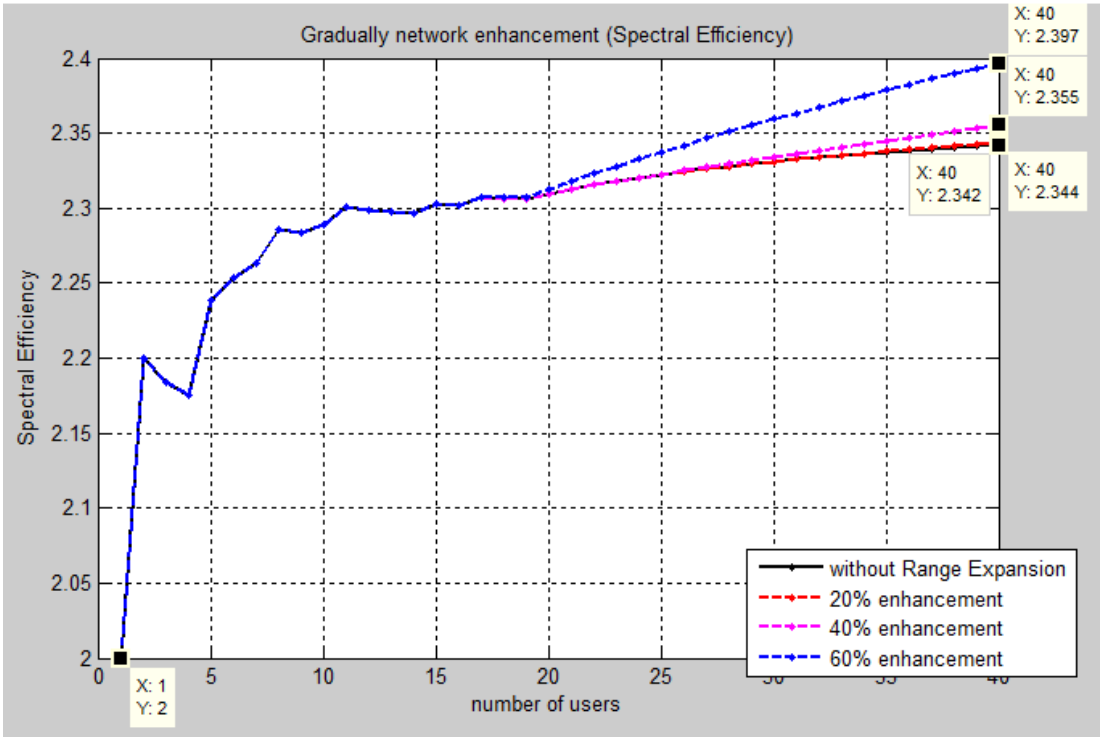

Figure (4-6): Spectral Efficiency Values (Four Scenarios)

4.3.5Compression of Throughput Performance:

- **Compression of Two Scenarios:**

Figure (4-7): Shows the final network throughput performance after 60% Pico cell range expansion the system, due to the data rate 60% enhancement the throughput enhanced by 17% higher network throughput which means large numbers of successful message delivery more data rates are being delivered to terminals and better reliable user experience is achieved.

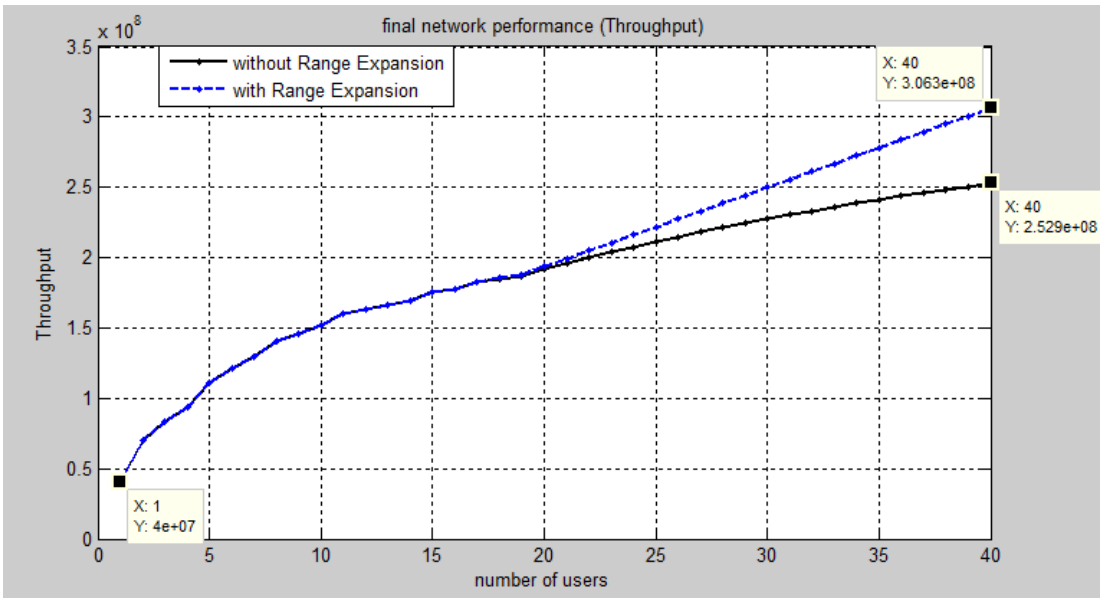

Figure 4-7: Throughput Values (Two Scenarios)

- **Compression of Four Scenarios:**

Figure (4-8): Shows the throughput which is the accumulation of the data rate taking an ascending path; varied between 40Mbit/s minimum and maximum 255.6Mbit/s for 20% range expansion, maximum 267.7Mbit/s for 40% range expansion and maximum 306.3Mbit/s for 60% range expansion.

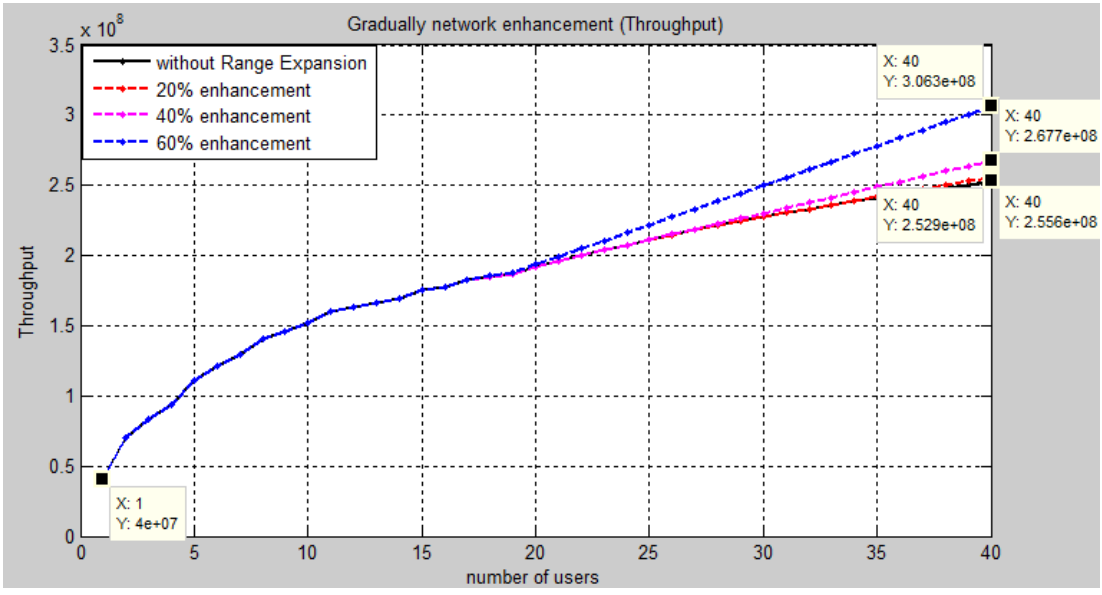

Figure (4-8): Throughput Values (Four Scenarios)

4.3.6 Compression of Bandwidth Utilization Performance:

- **Compression of Two Scenarios:**

Figure (4-9): Shows the final network bandwidth utilization performance after 60% Pico cell range expansion, the bandwidth utilization of the network enhanced by 22%, as mentioned in chapter 3, large values of bandwidth utilization indicate to high performance goals due to the wise used of available bandwidth.

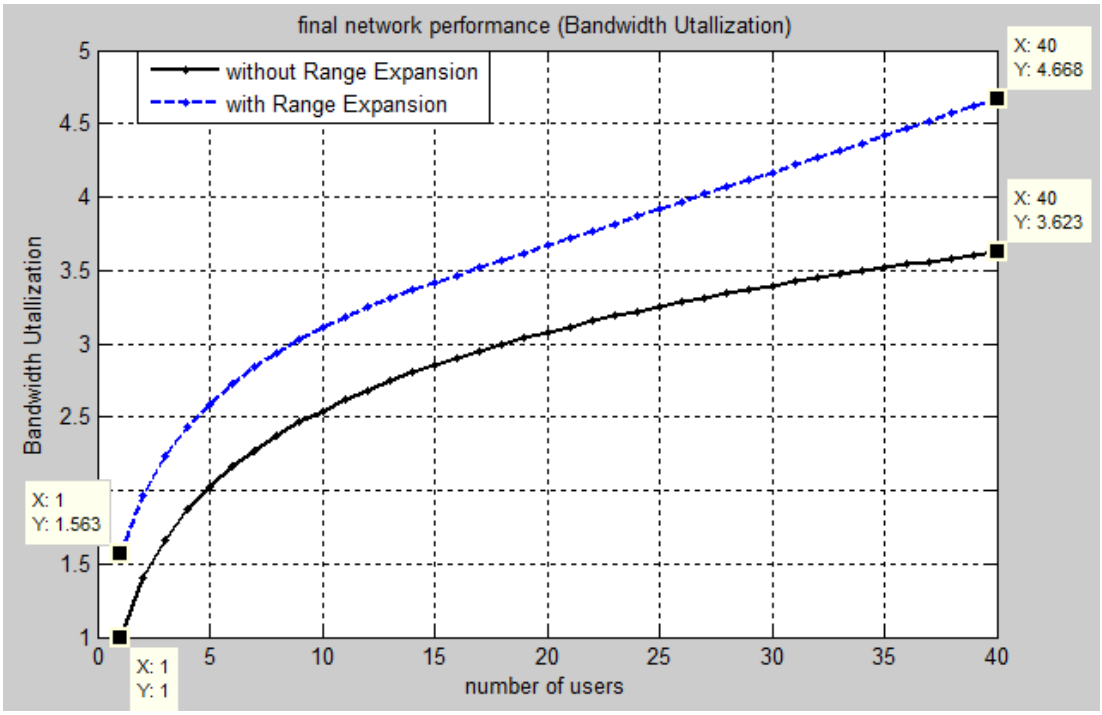

Figure 4-9: Bandwidth Utilization Values (Two Scenarios)

- **Compression of Four Scenarios:**

Figure (4-10): Shows the bandwidth utilization for the system enhancing gradually. Increasing bandwidth per user lead to the increasing in bandwidth utilization, the bandwidth utilization varied between minimum 3.623Hz to maximum 1Hz without range expansion, minimum 4.013Hz to maximum 1.366Hz with 20% range expansion,

minimum 4.242Hz to maximum 1.488Hz with 40% range expansion and minimum 4.668Hz to maximum 1.563Hz with 60% range expansion.

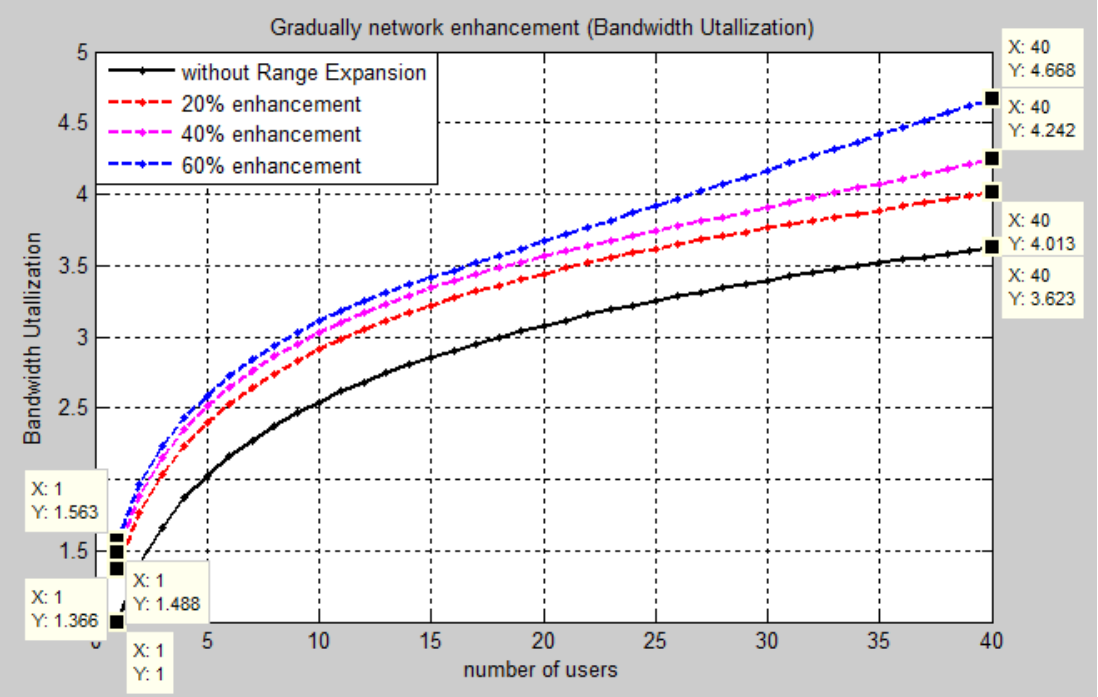

Figure (4-10): Bandwidth Utilization Values (Four Scenarios)