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Design and analysis 5G mobile network model to enhancement high-density subscribers

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ABSTRACT

To obtain a high data rate that is commensurate with the growing demand for internet services, the fifth generation (5G) cellular networks will use the bandwidth beyond 6 GHz, called millimeters waves (mm-waves), to obtain a higher. The first phase (phase I) of the 5G network design for high user density, where the optimized microcells are deployed at carrier frequency 700 MHz with 20 MHz bandwidth. The second phase (phase II) of the design consists of the deployment of microcells which are operating at 3.6 GHz with 100 MHz bandwidth; this phase is planned to cover 200000 users within the province. The third phase (phase III) of the design is represented by the deployment of picocells, which are planned to operate at 26 GHz frequency and bandwidth 500 MHz; this phase is planned to cover 3,500,000 users within the province. Two types of modulation are adopted for the network (orthogonal frequency division multiplexing (OFDM) and 256 quadrature amplitude modulation (QAM)); the overall performance of the network is studied with regards to the percentage of coverage, power overlapping ratio, frequency interference, and quality of service (QoS).

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1. INTRODUCTION

The recent developments in mobile communications systems a significant extension in worldwide subscriptions and the enormous demands of new facilities, which are data, voice, image, or online video. The universal mobile telecommunications system (UMTS) forecasts the mobile data traffics can exceed 800 Mbps/subcarrier via 2020 [1]. Ericsson expects that by the end of 2020, data possibly will exceed 1000 times the data currently obtainable [2]-[7]. Fifth generation (5G) is nevertheless under large development and the primary standard specification for the fifth generation is estimated to be provided by the end of 2020 by third-generation partnership project (3GPP) [8]-[14]. The number of subscriptions to global cellular communications is expected to rise to 8.2 billion by 2018 according to information coefficient (IC) statistics [15]. Data services such as multi-media will play a modest role and dominate the movement of cellular data rather than voice services in the future. In such a situation, the currently accessible systems will be overloaded and there may be no space for future requirements. Operators and investigators around the world are researching different communication systems to integrate the demands of expected data rates in the various studies. Some 5G allowed tools consist of advanced system technology, multi-access radio technological innovation, mm-wave frequency, multi-inputs multi-outputs (MIMO), multiple access (MA) technologies, advanced device to device (D2D), and smaller cell skill [16]-[19]. The requirement to improve the data rate to increase the bandwidth demands and is making operators transfer towards the higher frequency bands of future 5G cellular communications [20], [21]. Low-frequency bands are simpler and cost-effective but are unable to afford greater data charge, which is the main request for future generation communications specifications. On the other hand, the band of mm waves will offer lesser handling space, nonetheless it run compact antenna and data charges to qualify internet of things (IoT) for the future network [22]-[26].

The first phase of the 5G network of high-density users in the cities of Iraq. At this phase, three microcells are deployed at optimized government sites which are operating at 700 MHz frequency and bandwidth 20 MHz and planned to covered and serviced 100,000 visitors. The second and third phases of the 5G network of the high-density users in the cities of Iraq are completed design and evaluation. The small cells which are operated at a frequency (3.6 GHz) were deployed the macrocells at 200000 number of subscribers under the second phase (phase II). The network performance was analyzed in terms of percentage of coverage, power overlapping ratio, frequency interference, and the quality of service provided at each base station. The third phase (phase III) of the design was started with deploying the picocells which are operated at a frequency (26 GHz) at the number of users 3.5 million. The overall network (phases I, II, and III) was tested and evaluated in terms of performance and coverage ratio, and QoS of the network.

2. PROPOSED 5G NETWORK (PHASES I, II, AND III) FOR HIGH-DENSITY SUBSCRIBERS

In this work, we will complete the design of the network in its phases I, II, and III. The first phase of the network, which operates on 700 MHz frequency and bandwidth of 20 MHz for macrocells-type cells, is designed to cover the city during normal days (free days of events), which is 100,000 visitors according to statistics of the Iraqi Ministry of Tourism and the Civil Government Governorate. Phase II of network design is the deployment of microcells that are intended to work at carrier frequency 3.6 GHz. Phase II is planned to cover the number of visitors 200000, which represents the number of visitors during the normal events. Phase III of the network design is the deployment of picocells that operate at a frequency 26 GHz, which is supposed to serve 3.5 million visitors who come to the governorate during special events. In this paper, phases (I, II, and III) of the 5G network design methodology as shown in Figure 1 and will be contained.

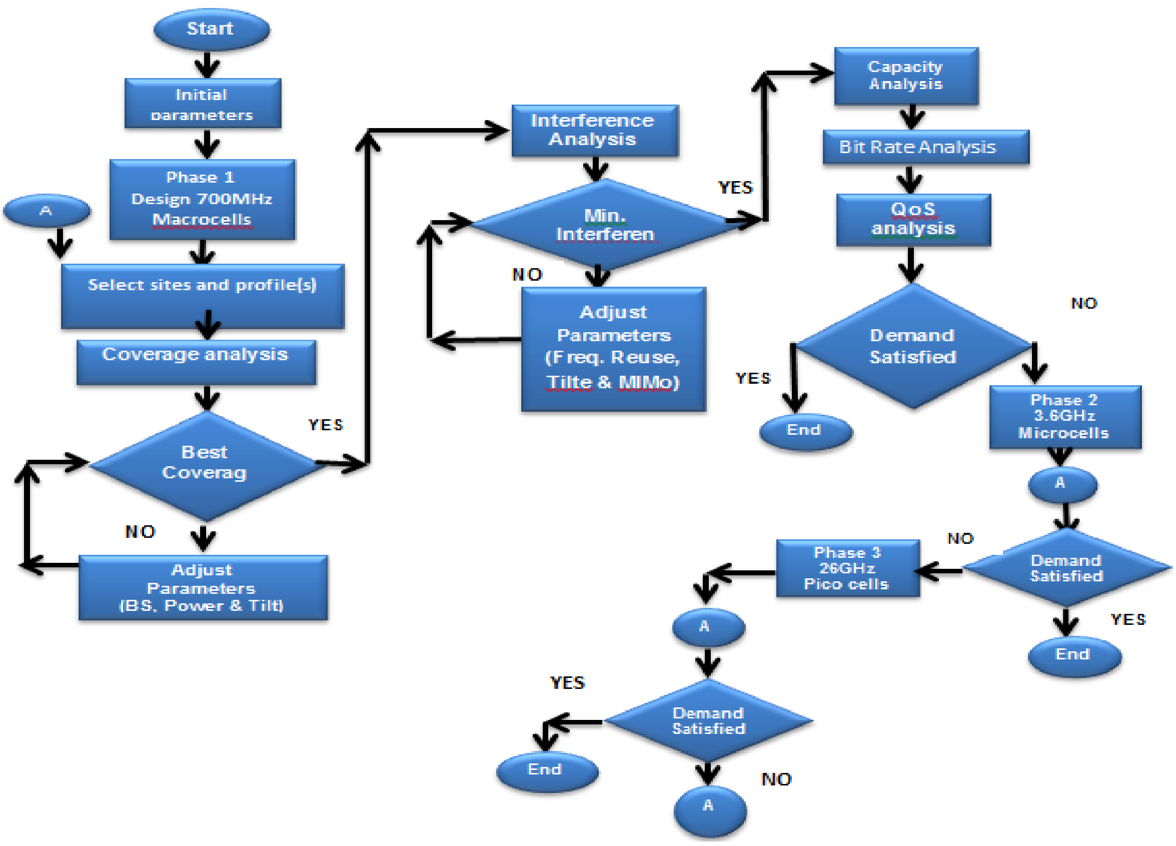


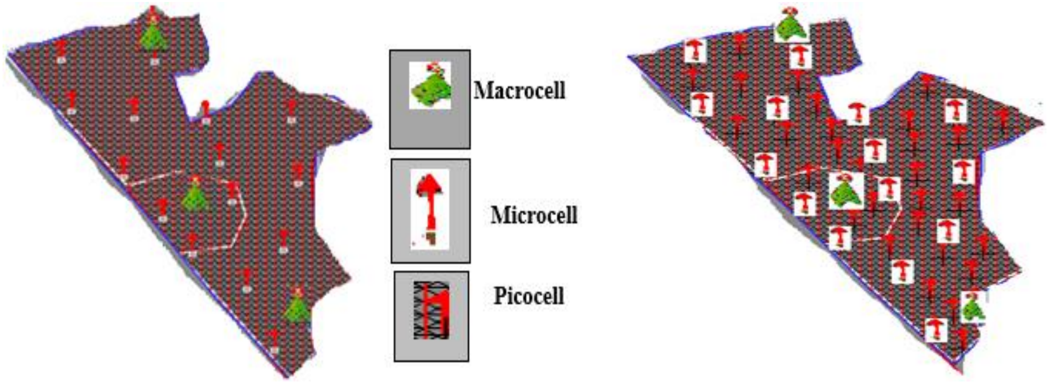
Figure 1. 5G network design methodology

a. Deploying the small cells (macrocells) at the three selected positions that represent the optimized government sites which are operating at frequency 700 MHz. study and evaluate the coverage and the performance of these cells and optimizing the percentage of the power overlapped.
b. Deploying the small cells (microcells) at the fifteen selected positions that represent the optimized government sites which are operating at frequency 3.6 GHz. Then studying and evaluating the coverage and the performance of these stations and optimizing the percentage of the power overlapped.
c. Evaluating the capacity, throughput, received power, and signal to noise ratio (SNR) of the network at the various number of visitors for different types of subscribers traffic (low, moderate, and heavy).
d. Deploying the picocells at the twenty-nine selected positions which represent the optimized government sites that are operating at frequency 26 GHz. study and evaluate the coverage and the performance of these cells and optimizing the percentage of the power overlapped.

In phase (II) of the network system policy, the aim zone is shown in Figure 2(a), which denotes the governorate of one high-density user in the cities of Iraq that takes space of 28824 km^2, but the intended area to be enclosed by the 5G network system, is 1428.8 km^2, which is the center of high-density user in the cities of the Iraq urban city. The designed network has a carrier frequency (f_c) at 3.6 GHz and bandwidth (BW) of 100 MHz, the city's guests are expected to be 200000; 50% of the subscribers (SSs) were arbitrarily spread the planned area. In phase III, 47 adopted sites (3 macrocells+15 microcells+29 Picocells) in high-density user in the cities of the Iraq governorate in Figure 2(b). The minimal features of the base station subsystem (BSs) card are assumed in Table 1.

Table 1. 5G adopted parameters

Parameter	Nominal value (Phase II) Microcell	Nominal value (Phase III) Picocell
height antenna of BS (meters)	20	6
gain of BS antenna (dBi)	7	4
transmitted power of BS (w)	5	1
TX antenna for the BS	Omni 3 sectors, 4 sectors	Omni 3 sectors, 4 sectors
BW of the Channel (MHz)	100	500
Carrier frequency (GHz)	3.6	26
Losses of the Tx cable (dB)	1	1
Losses of the Rx cable (dB)	1	1
Noise Figure of the BS (dB)	4	4
Vital cell edge SNR (dB)	8	8
Parameter	UEs	
Height of UE antenna (metres)	1.5	1.5
Noise Figure of UE (dB)	7	7
antenna gain UE (dBi)	5	5
scheduler outline of UE	FIFO	FIFO



(a) (b)

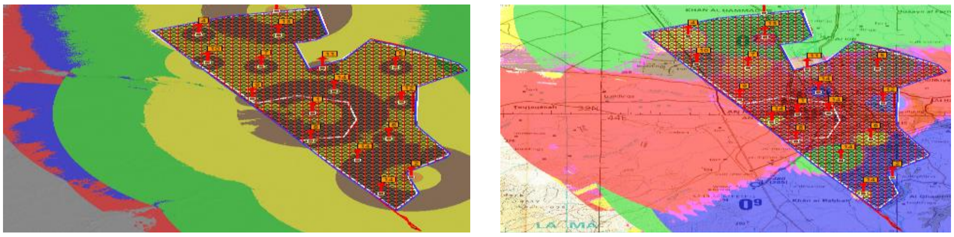
Figure 2. Candidate planned area at, (a) Phase II, (b) Phase III

3. NETWORK PERFORMANCE ANALYSIS AND EVALUATION

3.1. Coverage dimensioning

Case 1: Phase II coverage

In the first, deploying the microcells are based on the 15 candidate optimized government locations at the high-density user in the cities of Iraq after applying the particle swarm optimization (PSO) algorithm with the three microcell sites which are deployed in phase I. After the test, the network coverage, the power overlapping is improved to be condensed to (6.3252%) for Omni-directional of the antenna, while compact to (8.3254 %) for three segments antenna and to (10.4870%) for four segment antenna as shown in Figure 3(a, b & c). The ratio of the handling area for each location showed in Figure 4(a, b & c).

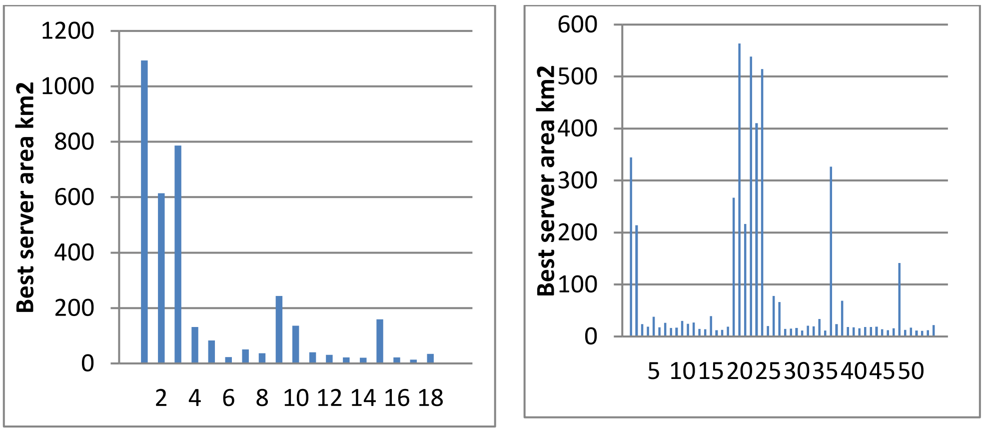


(a)

(b)

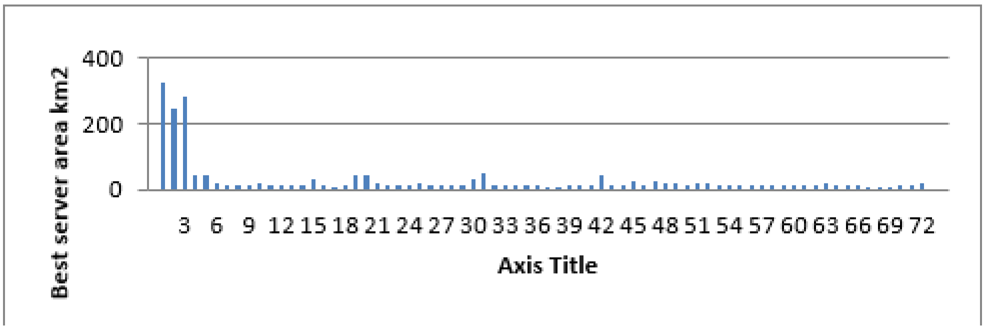
(c)

Figure 3. Exposure measurement with, (a) Antenna of Omni-direction scheme, (b) Three sectors antenna scheme, (c) Four sectors antenna scheme



(a) (b)

Figure 4. The coverage area ratio for each location, (a) Omni-direction antenna scheme, (b) 3-segments antenna scheme

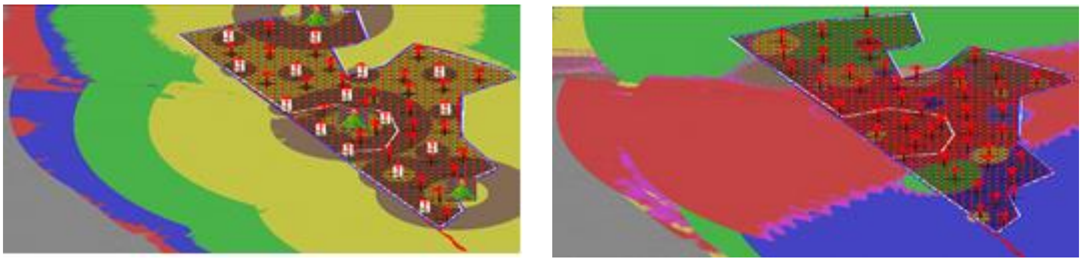


(c)

Figure 4. The coverage area ratio for each location, (c) 4-segments antenna scheme (*continue*)

Case 2: Phase III coverage

In this case, 29 Picocells are deployed at the network. The network, in this case, also designed and inspected for the three antenna molds; these are Omni-directional antennas, three sectioned antennas, and four sectioned antennas. The power overlapping, in this case, is adjusted to reduced to (7.0580%) for Omni-directional of the antenna, while compact to (9.1210 %) for three segments antenna and to (11.4619%) for four segment antenna as presented in Figure 5(a, b & c). The ratio of the handling area for each location is showed in Figure 6(a, b & c).

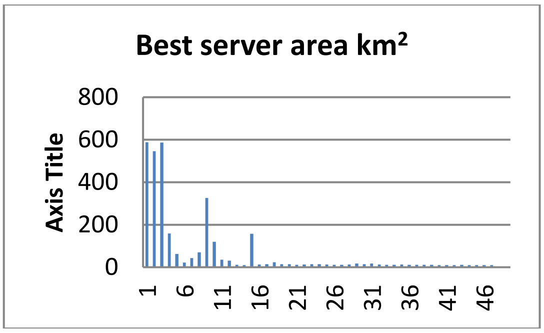


(a)

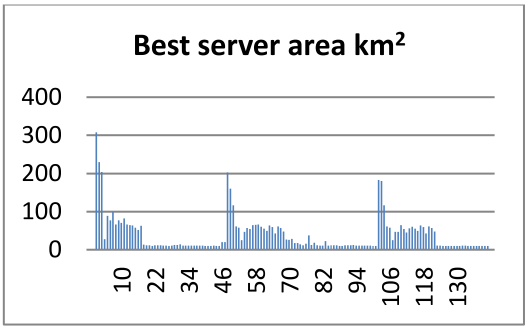
(b)

(c)

Figure 5. Exposure measurement for, (a) Omni-directionl antenna, (b) Three segments antenna, (c) Four segments antenna



(a)



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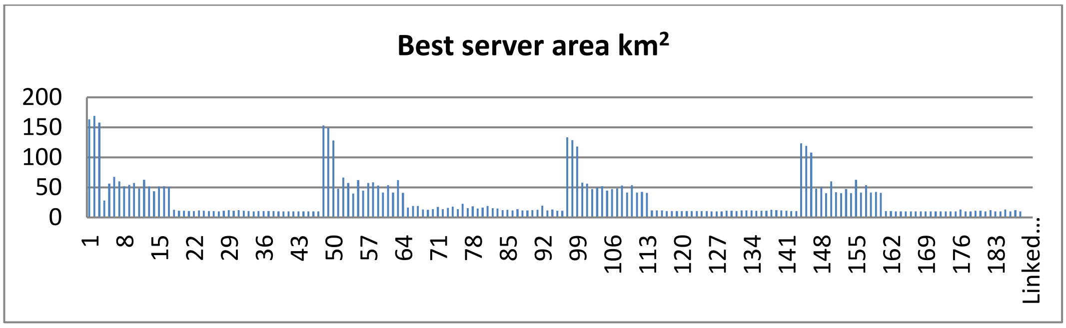
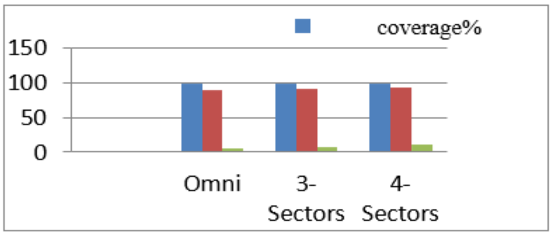


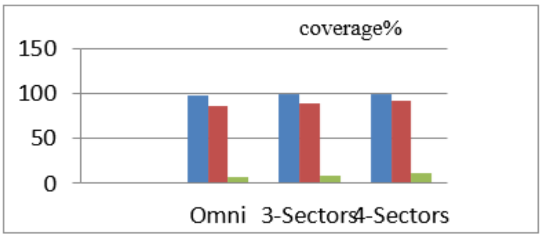
(c)

Figure 6. The ratio of the exposure area for each location, (a) Omni-direction antenna scheme, (b) 3-segments antenna, (c) 4-segments antenna

Figure 7(a and b) relating several antenna arrangements in terms of exposure area ratio, intersecting and associated sectors-sectors (SS), from field strength point of view is offered for two phases in. It is obvious that the network design with 100 MHz bandwidth, and four sectors per cell, has the highest coverage area with a minimum overlapping area for phase II; same that, for phase III it is obvious that the network design with 500 MHz bandwidth, and four segments per cell, has the uppermost exposure zone with the lowest intersecting area. The exposure measurement with BS fixed at (20 m) for the microcells and (6 m) for picocells with (1.5 m) antenna height for SS.



(a)



(b)

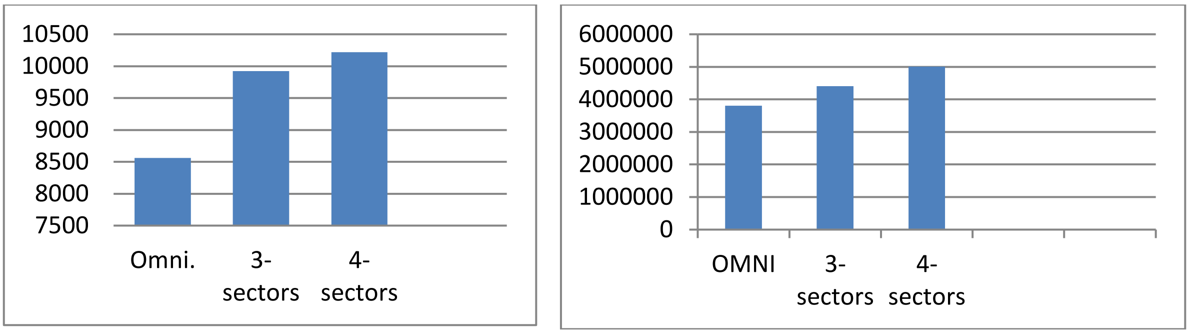
Figure 7. These figures are, (a) Evaluation of assumed antenna arrangements for several design models, (b) Improved 3-locations, studied for many antenna arrangements in terms of exposure area ratio and linked SS and interfered area

3.2. Measurement of capacity

To study the demanded SSs size will be satisfied by the suggested design, the design system is examined depending on linked SSs ratio, in terms of the bit-rate and QoS desires. The proposed setting is simulated for a 200000 SSs for phase II and 3.5 million SSs for phase III. The facilities are categorized into three modules demonstrating the main applications of the internet. Table 2 shows these uses with their desirable bit-rate for both uplink and downlink. Figure 8(a) and (b) illustrates the required bit-rate to each base station in (phase II & III) network, while Figure 9(a) and (b) show the stream levels of QoS facility of the linked SS same as in (phase II & III) system.

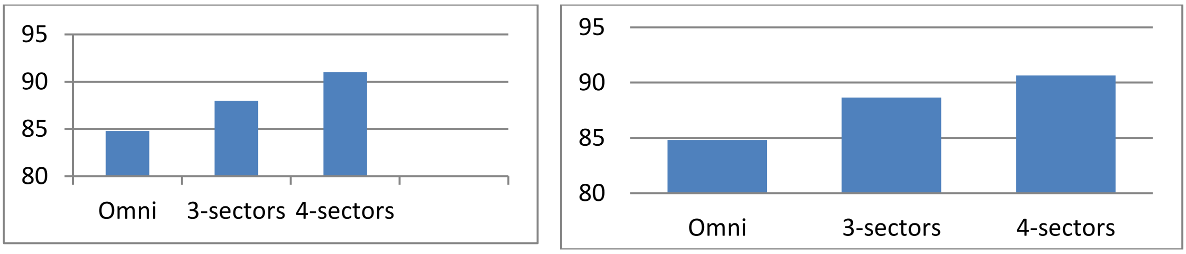
Table 2. The key internet service

Services Class	claim DL Mbps	request UL Mpbs
VOIP	64	64
VOIP + data low	500	250
VOIP + data high	1000	500



(a) (b)

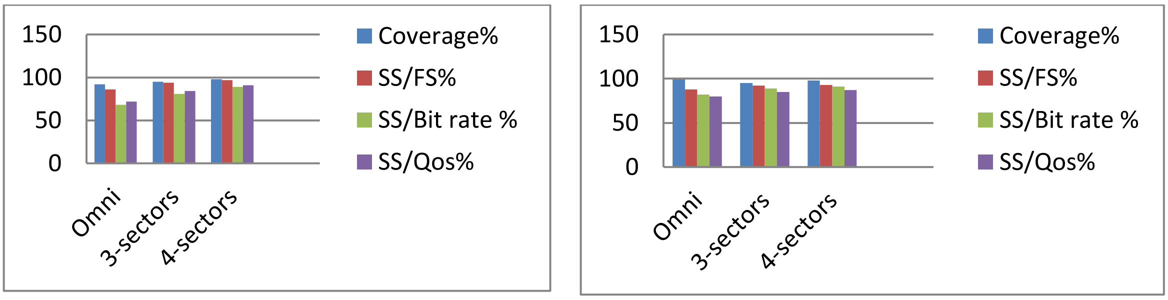
Figure 8. Average downlink bit rate (Mbps), (a) Phase II, (b) Phase III



(a) (b)

Figure 9. QoS%, (a) Phase II, (b) Phase III

The performance of the system of these arrangement stages is studied as presented in Figures 10 (a) and (b) for phase II and phase III respectively. For phase II, it is clear that the system with (B.W=100 MHz), four segment antenna has the uppermost performance. It has a exposure area=98.02% of the total area from one big city in Iraq. The connected SS's FS=97.6%, while the bit-rate demands=89.2%, and QoS=87.1%. For phase III, it is clear that the system with (B.W=500 MHz), four segment antenna has the uppermost working performance. It has a exposure area=97.01% of the total area from one big city in Iraq. The connected SS's FS=96.54%, while the bit-rate needed=86.7%, and QoS=83.41%.

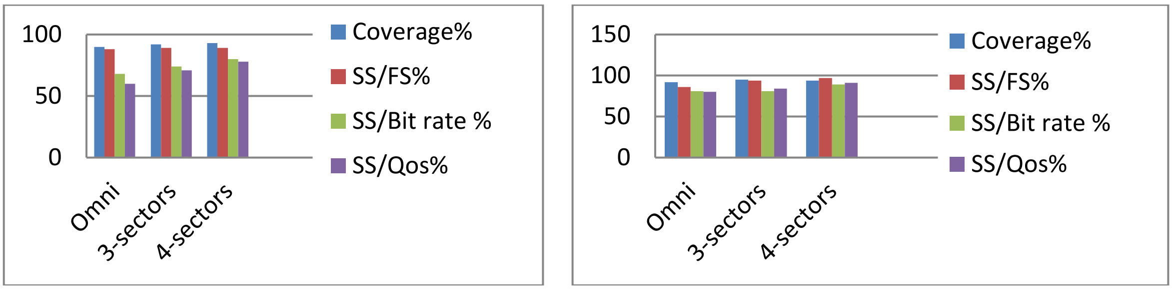


(a) (b)

Figure 10. Overall network performance, (a) Phase II, (b) Phase III

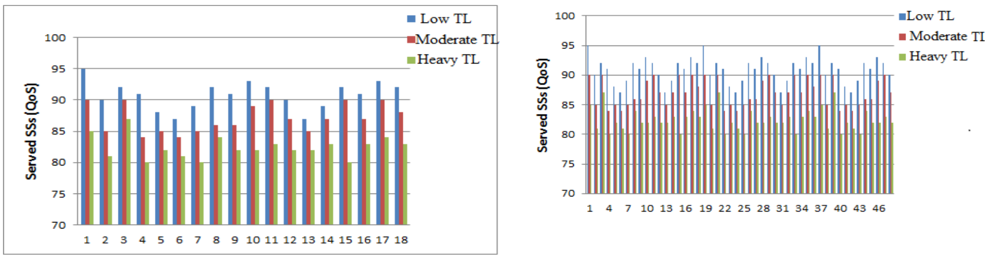
3.3. Analysis of suggested modulation system

Figure 11(a) and (b) displays the system performance by using the 256-QAM modulation. The performance of the system at the OFDM-modulation presented in Figure 10(a) and (b) is better than the system performance at the 256-QAM in exposure area, field strength for the subscriber, required bit-rate, and in terms of QoS. Figure 12(a) and (b) reviews the served SSs% at each segment for 3-segments antenna direction of the system at various traffic burden states (low TL, Moderate TL & Heavy TL) for both phase II and phase III respectively. Also, Figure 13(a) and (b) displays the ratio of SSs facilities for heavy, moderate, and low traffic burden for the network for both phase II and phase III. Figure 14(a) and (b) display a traffic test simulates during full day operation for phase II and phase III respectively.



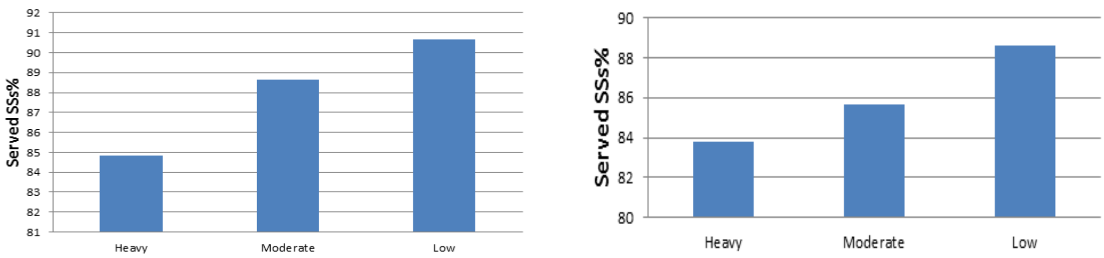
(a) (b)

Figure 11. Network routine at 256-QAM, (a) Phase II, (b) Phase III



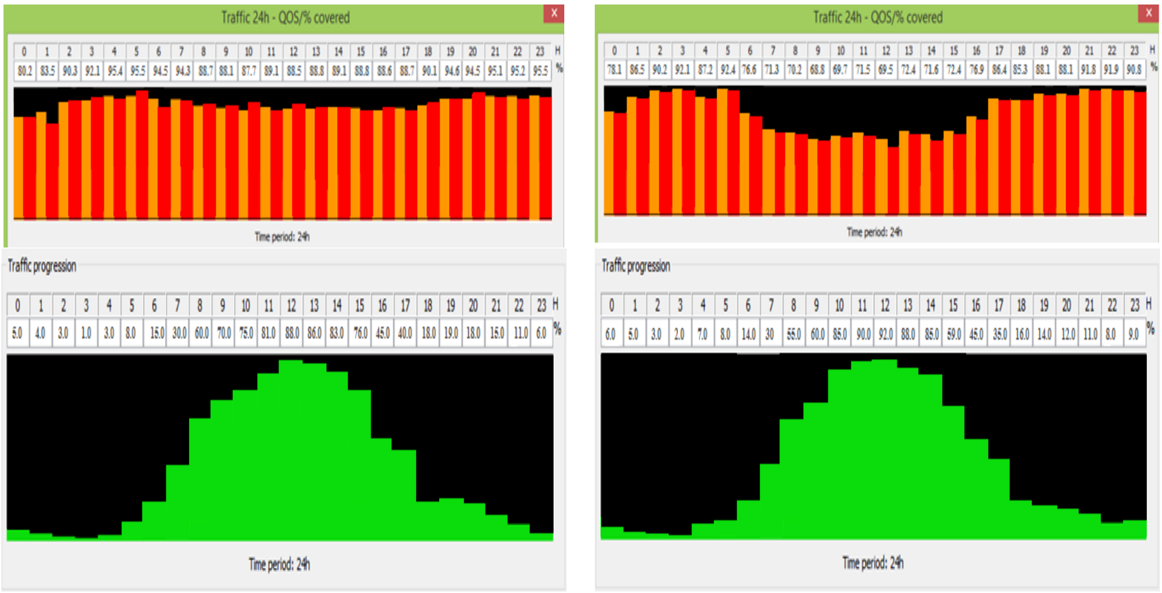
(a) (b)

Figure 12. The served SSs% for each B.S for, (a) Phase II, (b) Phase III



(a) (b)

Figure 13. The ratio of SSs facilities for heavy, moderate, and low traffic burden for, (a) Phase II, (b) Phase III



(a) (b)

Figure 14. Analysis of full day traffic, (a) Phase II, (b) Phase III

4. CONCLUSION

The first phase of the design of the fifth-generation network to the one big cities from Iraq was studied in the previous work. Phase II and III of the network were completed in this work. The second phase of the design consists of the deployment of small cells operating at an average frequency 3.6 GHz with 100 MHz bandwidth; this phase is planned to cover 200000 users within the province. The third phase of the design is represented by the deployment of Picocells, which are planned to operate at 26 GHz frequency and bandwidth 500 MHz and cover 3.5 million users. Network performance is tested for both phases in terms of overlapping coverage, load rate request, and quality of service for subscribers. The system is studed with three antenna alignments (Omni-directional, 3 segments, and 4 segments). The proposed network performance at 4 segments antenna scenario is performed better than the other two antenna types. The exposure of the network system for the Omni-directional antenna reches (95.9%) with the coverage overlay (6.3252%) but reached (98.2%) for the situation 4-overlapping sectors with coverage (10.4870%) for the second phase; (97.1%) with coverage (9.1210%), but it touched (98.3%) in terms of case 4. The segments covered (11.4619%); the subscribers, 4-segment antenna QoS (94.73%), (92.1%) for 3-segments antenna, and (90.02%) for the Omni-directional. Two types of modulation are adopted for the base stations (OFDM and 256 QAM); After the test the routine of the system at each modulation type in terms of percentage of coverage, power overlapping ratio, frequency interference, and the quality of service provided at each base station that is found OFDM modulation gives better performance than 256 QAM modulation for the overall network (phase I, II, &III).

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