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 traffic will 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)
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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 km², but the intended area to be enclosed by the 5G network system, is 1428.8 km², 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 (dBt)           | 7                                 | 4                                 |
| transmitted power of BS (w)        | 5                                 | 1                                 |
| TX antenna for the BS              | Omni                              | Omni                              |
| 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                          | UE Isles                          |                                    |
| Height of UE antenna (metres)      | 1.5                               | 1.5                               |
| Noise Figure of UE (dB)            | 7                                 | 7                                 |
| antenna gain UE (dBt)              | 5                                 | 5                                 |
| scheduler outline of UE            | FIFO                              | FIFO                              |

![Image](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).

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

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

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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).

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

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

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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.

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
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 Mbps |
|----------------|---------------|-----------------|
| VOIP           | 64            | 64              |
| VOIP + data low| 500           | 250             |
| VOIP + data high| 1000         | 500             |

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

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%.

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.

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

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

Figure 13. The ratio of SSs facilities for heavy, moderate, and low traffic burden for, (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 studied 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 reaches (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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