

Graphical User Interface for Capacity Planning in Long Term Evolution

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Abstract: Getting the most out of the network, meeting subscriber demands and developing new revenue growth plans, is business critical and one of the key drivers in the uptake of LTE as a new technology, so radio network planning is an essential process for operators who are looking to make the most of their networks. In order to achieve the radio network planning, there are a number of stages that are typically performed, these includes: Initial planning, detailed planning and optimization. The initial phase of network planning is known as dimensioning .The purpose of dimensioning is to estimate the required number of radio base stations needed to support a specified traffic load in an area. Dimensioning has two phases: coverage planning phase and capacity planning phase. This paper focuses on the capacity planning phase. A GUI tool was designed and simulated using MATLAB program to perform it. The tool provides the number of sites required in the capacity planning phase.

Keywords: LTE, Dimensioning, Capacity Planning, GUI, Number of Sites .

1. Introduction

Long Term Evolution (LTE) has engaged the attention of wireless operators, investors, and industry watchers around the world in the late years. LTE was initiated by 3GPP, to maintain its competitive edge in the world of mobile networks in the future; it represents the first generation of cellular networks to be based on a flat IP architecture.

The essential part of any system to be deployed is the planning operation, because the existence of all activities is related to its existence. The radio network planning process is designed to maximize the network coverage, whilst at the same time providing the desired capacity [1].

Dimensioning is the initial phase of network planning. It provides the first estimate of the radio network element count as well as the capacity of those elements. Dimensioning tool should be accurate enough to provide results with an acceptable level of accuracy, when loaded with expected traffic profile and subscriber base [2][3]. Dimensioning has two phases; coverage planning phase and capacity planning phase. In this paper a GUI was designed using MATLAB to provide the number of sites required in the capacity planning phase.

2. Dimensioning Process in LTE

LTE network dimensioning process shown in Figure 1 consists of the following steps;

- Information collection.
- Network deployment requirement.
- Coverage design.
- Capacity design.

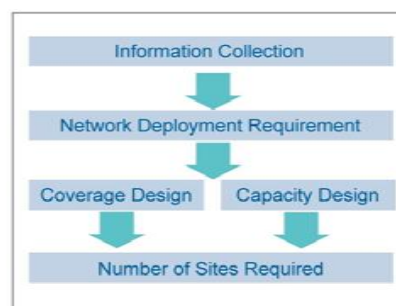


Figure 1: LTE Network Dimensioning Process

Collecting information regarding the geographical distribution of the area to be deployed and the expected capacity needed

(that is, how many subscribers will join the system and how much traffic will be generated) is the first step in dimensioning. This is followed by the requirements needed to deploy a network. Each wireless network has its own set of parameters. The operator's network selects its main parameters to be used in dimensioning its initial network. Table 1 provides the LTE network deployment parameters.

Table 1: LTE Network Deployment Parameters

<i>LTE Parameter</i>	<i>Description</i>
Frequency bands	Different choices of frequency Bands in LTE standard
Preferred channel bandwidth	There are six choices in LTE Standard
Throughput	Throughput is the spectral Efficiency of a modulation scheme
Overbooking factor (OBF)	OBF is the average number of users sharing a given channel or Capacity at the same time.

After choosing the network deployment parameters, dimensioning has two phases capacity planning and coverage planning to estimate the number of sites needed, the two phases are independent from each other. This paper focuses on capacity planning phase. A simple GUI was designed using MATLAB to simulate this phase.

3. Capacity Design Stages

Capacity planning gives an estimate of the resources needed for supporting a specified offered traffic with a certain level of QoS (e.g. throughput or blocking probability). Theoretically the capacity of the network is limited by the number of eNodeB's installed in the network.

The capacity of a network is evaluated by the following parameters:

- **Throughput Estimation:** Cell peak throughputs for different bandwidths and other conditions can be calculated based on 3GPP specification and the recommendation values which are shown in Table (2) [4][5].
- **Traffic Demand Estimation:** Since the given bandwidth can only deliver a certain amount of capacity, then the traffic demand needs to be understood. The complex part is the analysis of the peak hours of different subscriber types and traffic profiles. The required result is the overbooking factor (OBF) that describes the level of multiplexing or number of users sharing a given channel or capacity. It is an experience-based value and usually set to 20 or lower. The lower the contention ratio the higher the quality of service is [2].

If the requirements corresponding to the peak hour traffic (the hour during a 24-hour time frame that has the greatest number of calls) is used, then it would lead to over dimensioning. Precious

resources will be wasted in other hours of the day and network cost will go significantly higher. For this reason it is important to define the overbooking factor. The channel unit used in dimensioning is the peak data rate. Assume that a 100 percent channel loading, then the OBF is simply equal to the ratio between the peak and the average rates (PAR). However, it is not safe to dimension the network with 100 percent loading. Hence, the parameter utilization factor is introduced. In most of data networks, the utilization factor is less than 85 percent in order to guarantee Quality of Service (QoS). So the higher this parameter, the longer will be the average waiting time for users accessing the channel. Thus, the overbooking factor is assumed to be equal or lower than 20 to achieve appropriate and fair percentage of channel loading.

Table 2: Cell Peak Throughputs for Different Bandwidths

<i>eNodeB Bandwidth (MHz)</i>	<i>1.4</i>	<i>3</i>	<i>5</i>	<i>10</i>	<i>15</i>	<i>20</i>
DL (SISO)	4.392 Mbps	11.064 Mbps	18.336 Mbps	36.696 Mbps	55.056 Mbps	75.376 Mbps
DL (MIMO2*2)	8.784 Mbps	22.128 Mbps	36.672 Mbps	73.392 Mbps	110.11 Mbps	150.75 Mbps
DL (MIMO4*4)	17.52 Mbps	44.304 Mbps	73.392 Mbps	150.75 Mbps	220.27 Mbps	299.55 Mbps
UL(SIMO MCS=23) Category4 (16QAM)	2.984 Mbps	7.48 Mbps	12.576 Mbps	25.456 Mbps	37.888 Mbps	51.024 Mbps
UL(SIMO) Category5 (64QAM)	4.392 Mbps	11.064 Mbps	18.336 Mbps	36.696 Mbps	55.056 Mbps	75.376 Mbps

The overall data rate is calculated by using equation 1

$$\text{Overall Data Rate} = \text{Number of Users} * \text{Peak Data Rate} * \text{Overbooking Factor} \dots\dots(1)$$

Where:

- Overall data rate: is total capacity of the network.
- Number of users: is total number of users in the coverage area.
- Peak data rate: is peak data rate of the operator's traffic profile.
- Overbooking Factor: is the ratio between the peak and the average rates (PAR).

The number of sites necessary to support the overall data rate is simply:

$$\text{Number Of Sites (cells)} = \frac{\text{Overall Data Rate}}{\text{Site (Cell)Capacity}} \dots\dots\dots(2)$$

Where

The Site Capacity is a multiple of the Cell Throughput (depending on the channel bandwidth), not considering any hardware limitation.

In real networks, capacity based site count is smaller in the earlier years of network operation, when the number of users is quite less. But as the demand increases and more users are added to the service, the capacity based site count takes the lead and smaller cells are required.

4. Graphical User Interface Design

A Graphical User Interface (GUI) was designed using MATLAB, to calculate the number of sites based on the traffic forecast, the operator must start the capacity planning phase by entering several parameters as shown in Figure (2).

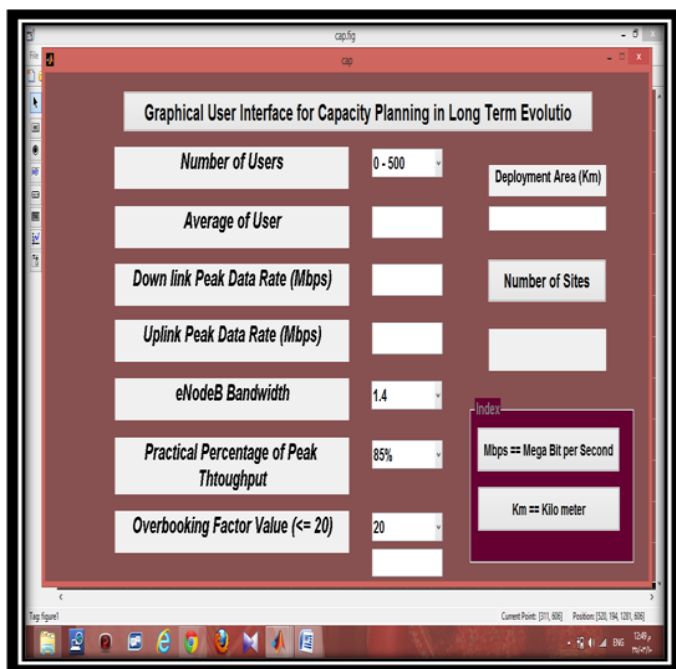


Figure 2: Capacity Planning Parameters GUI

The Capacity planning parameters are as follow:

- Number of users: is total number of users in the covered area, it is optional to the operator to select an average number from a popup menu of four values or enter his own value.
- Downlink Peak Data Rate: The operator enters the downlink peak data rate value according to their explanations of the traffic load profile.
- Uplink Peak Data Rate: The operator enters the uplink peak data rate value according to their explanations of the traffic load profile
- Practical Percentage of Peak Throughput: it is the percentage of the peak throughput (ideal condition). The operator selects a percentage from the popup menu.
- Over Booking Factor Value (OBF): the operator enters his preferred value of OBF or selects the default value 20.

After calculating the capacity, the number of sites required is then provided to the user in a graphical shape.

5. Results and Discussions

After designing the GUI, four different scenarios were carried out to test the effect of varying different parameters such as total number of users, downlink peak data rate, the percentage of the peak throughput and the OBF value when calculating the number of sites.

A. Scenario 1: Number of Users Varied

This scenario tests the effect of varying the number of users when calculating the number of sites. Table 3 shows the different users used. The following parameters were fixed during the simulation:-

- Area covered is 800 km, and it is a large city area.
- Deployed frequency is 1500MHz, and channel bandwidth is 20MHz.
- Downlink peak data rate is 1 Mbps, and the uplink peak data rate is 0.75 Mbps.
- The Percentage of Peak Throughput is 95%.
- The OBF value is 5.

Table 3: Number of Users Varied

	Case 1	Case 2	Case 3	Case 4
Average of Users	500	750	1000	1250
Number of Sites Based on Capacity	9	13	18	22

The number of sites based on capacity for each case is shown in Figure 3. The figure shows that as the number of subscribers in the network increases, the number of sites increases

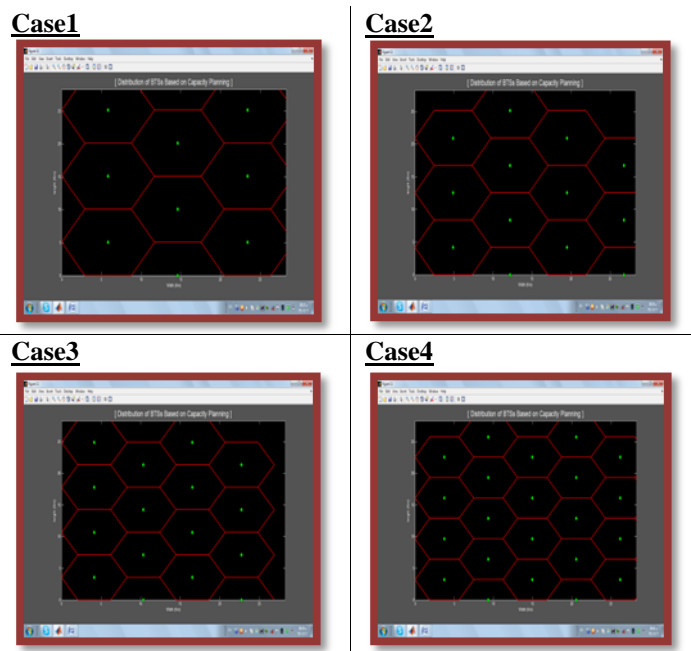


Figure 3: Result of Varying Number of Users

B. Scenario 2: Downlink Peak Data Rate Varied

This scenario tests the effect of varying the downlink peak data rate when calculating the number of sites. Table 4 shows the

different peak data rates used. The following parameters were fixed during the simulation:-

- Area covered is 400 km, and it is a small city area.
- Deployed frequency is 900 MHz, and channel bandwidth is 15MHz.
- Total number of users 1000.
- The uplink peak data rate is 0.5 Mbps.
- The Percentage of Peak Throughput is 95%.
- The OBF value is 7.

Table 4: Downlink Peak Data Rate Varied

	Case 1	Case 2	Case 3	Case 4
<i>The Downlink Peak Data Rate (Mbps)</i>	0.4	0.6	0.8	1
<i>Number of Sites Based on Capacity</i>	13	20	27	33

The number of sites based on capacity for each case is shown in Figure 4. The figure shows that increasing the downlink peak data rate increases the number of sites required to be deployed.

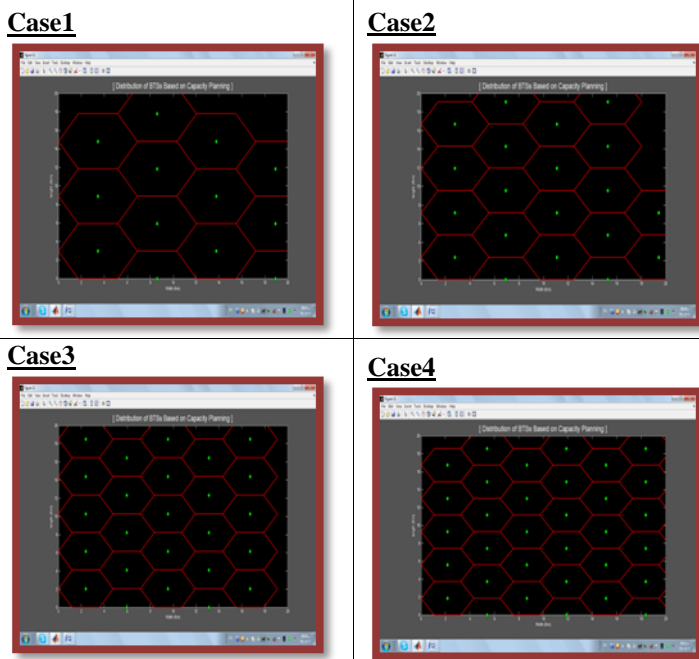


Figure 4: Result of Varying Downlink Peak Data Rate

C. Scenario 3: Peak Throughput Percentage Varied

This scenario tests the effect of varying the peak throughput percentage when calculating the number of sites. Table 5 shows the different percentages used. The following parameters were fixed during the simulation:-

- Area covered is 250 km, and it is a suburban area.
- Deployed frequency is 1500 MHz, and channel bandwidth is 20 MHz.
- Total number of users 750.
- Downlink peak data rate is 0.5 Mbps, and the uplink peak data rate is 0.3 Mbps.

- The OBF value is 10.

Table 5: Peak Throughput Percentage Varied

	Case 1	Case 2	Case 3	Case 4
<i>The Practical Percentage of Peak Throughput</i>	85 %	88%	95%	97%
<i>Number of Sites Based on Capacity</i>	15	14	13	13

Figure 5 shows the number of sites required based on capacity when varying the peak throughput. The figure shows that increasing the percentage of peak throughput decreases the number of sites required to be deployed.

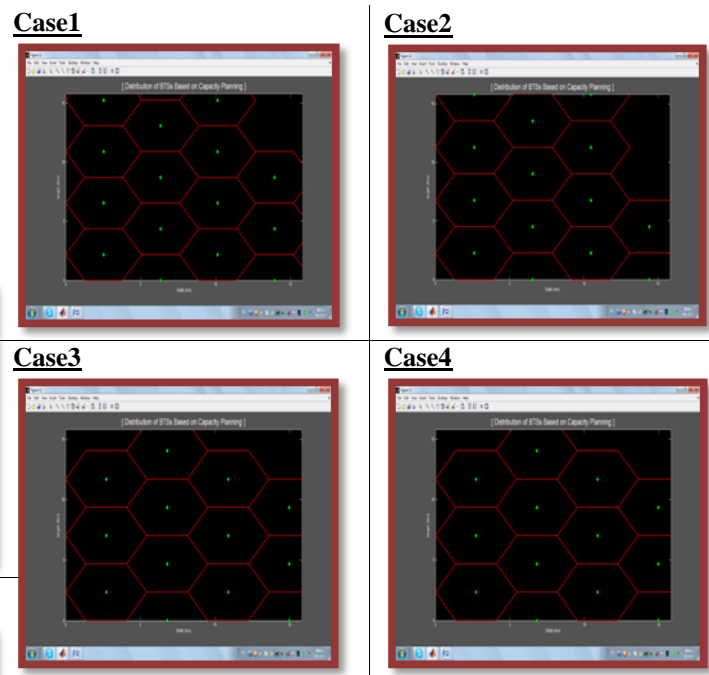


Figure 5: Result of Varying the Peak Throughput Percentage

D. Scenario 4: OBF Value Varied

This scenario tests the effect of varying the OBF value when calculating the number of sites. Table 6 shows the different OBF values used. The following parameters were fixed during the simulation:-

- Covered area is 50 km, and it is an open area.
- Deployed frequency is 800 MHz, and channel bandwidth is 20 MHz.
- Total number of users 250.
- The downlink peak data rate is 0.6 Mbps, and the uplink peak data rate is 0.4 Mbps.
- Percentage of peak throughput value is 95%.

Table 6: OBF Value Varied

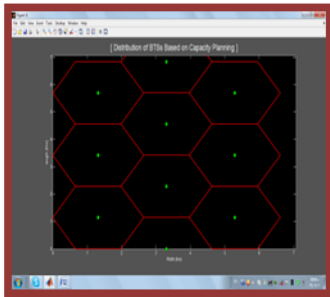
Case 1	Case 2	Case 3	Case 4
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<i>The OBF</i>	20	13	10	5
<i>Number of Sites Based on Capacity</i>	11	7	4	3

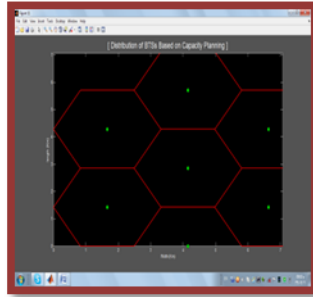
The capacity planning phase was investigated using different factors; Subscriber geographical spread, traffic forecast, over booking factor and the Cell throughput (site capacity) for system's channel bandwidth. The number of sites resulting in this phase increases when the number of subscribers and/or the traffic load increases, it also increases when the over booking factor value increases and it decreases when the cell throughput (channel bandwidth) increases.

Figure 6 shows the number of sites required based on capacity when varying the overbooking factor. The figure shows that the number of sites required decreases when the OBF decreases from 20

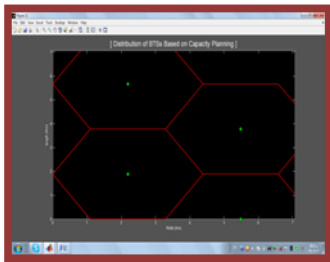
Case1



Case2



Case3



Case4

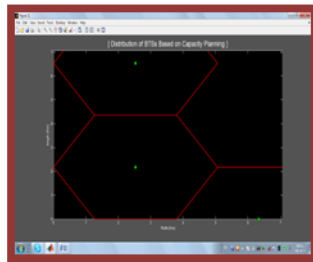


Figure 6: Result of Varying the OBF Value

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6. Conclusion

In this paper capacity planning phase in the dimensioning stage of LTE network is presented, its main objective is to provide the number of sites (cells) needed in order to support a certain subscriber population with a given capacity.

Capacity planning phase has been simulated using a GUI tool based on MATLAB software programming. The tool provides the number of sites required depending on this phase.