



International Journal of Engineering, Business and Enterprise Applications (IJEBA)

www.iasir.net

Review on 2G, 3G and 4G Radio Network Planning

*Tushar Saxena, ** J.S. Jadon

*Student, M.Tech., ** Associate Professor

Amity University,

Noida, India

Abstract- Telecommunication sector is growing tremendously. The evolution of mobile services are taking place with considerable faster rate from second generation GSM services, third generation UMTS services to fourth generation LTE technology. But with this pace the operators always have a concern of planning the network. Network planning is a never ending task, planning network with limited number of user is not the issue but the issue is to plan a network that also allows future growth and expansion. The planning ensures the customers to use the network services wherever they are. This is an ongoing process. This paper highlights the process for 2g, 3g and 4g radio network planning.

Index- GSM, UMTS, WCDMA, BTS, Node B, LTE, eNode B

I. INTRODUCTION

Wireless mobile operators are on tough competition with each other to provide the best they can offer to their subscribers. Here in this paper we will be talking about 2G that includes both gsm and gprs, 3g that consists of wcdma, umts and 4g which is LTE. There are references that says GPRS as 2.5G but being technical n precise, we will count it in 2G by default working with GSM as now. For any kind of network, network planning is one very fundamental task so that the coverage and capacity can me maintained. This is not just to be done for the costumers present but also for the customers which are yet to be added to the network[1]. Radio network planning is described by the flow chart as shown in the figure 1 can be summarized into three main steps[2]:-

- Network dimensioning
- Capacity and Coverage Planning
- Network optimization

1. Network Dimensioning

Network dimensioning is the very task to start the network planning of a given cellular network[3]. The main outcome of this step are firstly the generation of power budget, coverage analysis and capacity estimation and secondly estimation of the number of sites required.

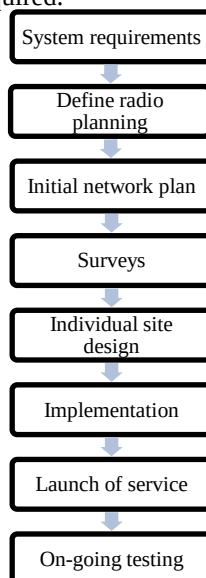


Figure 1

With the network planning overall picture of the network is visible and this can be taken as the base for all further planning activities. Network Dimensioning determines the area which is supposed to be work out with the computation of number of sites required to provide cover the target areas while satisfying the coverage and capacity requirements.

II. Coverage and Capacity Planning

The capacity of any given network can be measured in terms of the traffic load of the subscribers it can handle. Following are the steps to calculate network capacity [4]:

- Determine the maximum no of carriers per cell which can reach different region according to the frequency reuse scheme and available spectrum.
- Determine the capacity of a given cell using the number of carriers and the blocking probability.
- Now the sum of all the individual cell capacities gives the network capacity.

The propagation curve formulas determines the possibilities for rough coverage calculations but these average values are not sufficient enough for making the detailed network plan hence many computer-aided tools which are based on digital maps have been developed to improve the prediction quality.

III. Network optimization

Network optimization is step in which the efficiency of the network is increased. The output of the planned network is optimized for better results. It is the continuous process that keeps on improving the overall network quality. Network quality can be seen two different perspectives, one is the subscriber point of view and other is the operator point of view. Subscriber can never be interested in site leasing or any maintenance issues[5]. As long as he is getting proper services and his service is not affected issues like spectrum efficiency, network traffic etc are of no interest to him but from the operators point of view, these things are of great importance.

IV. GSM NETWORK PLANNING

The GSM radio network planning process can be shown by the figure 2:-

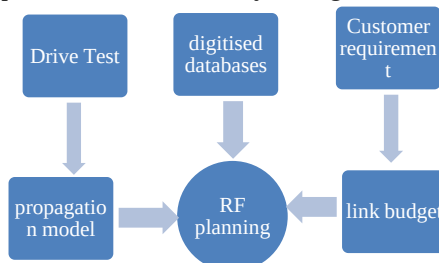


Figure 2

A. Drive Test

Drive test can be used for the Propagation model tuning and assessing the site with respect to the coverage and interference. The process starts by initiating a file to record the measurement, maintain the drive test vehicle speed accordingly. Drive through the pre plan route as close as possible, mark the spots to indicate special readings like perceived hot spot, potential interferer etc. consistently monitor the GPS and signal strength level throughout the test[6]. Drive test can be used for the Propagation model tuning and assessing the site with respect to the coverage and interference. The process starts by initiating a file to record the measurement, maintain the drive test vehicle speed accordingly. Drive through the pre plan route as close as possible, mark the spots to indicate special readings like perceived hot spot, potential interferer etc. consistently monitor the GPS and signal strength level throughout the test.

B. Propagation Model

Standard Macrocell Model for Asset

$$L_p \text{ (dB)} = K1 + K2 \log(d) + K3 H_m + K4 \log(H_m) + K5 \log(H_{eff}) + K6 \log(H_{eff}) \log(d) + K7 \text{ Diffraction} + \text{Clutter factor}$$

where L_p , Diffraction, Clutter factor are in dB and d , H_m , H_{eff} are in m. This propagation model is based on the Okumura-Hata empirical model, with a number of additional features that enhance its flexibility. It works for the frequencies ranging from 150MHz to 2GHz[7].

The given propagation model can be apply in condition:-

- Base station height : 30 - 200 m
- Mobile height : 1 - 10 m
- Distance : 1 - 20 km

There is an optional second intercept and slope ($K1$, $K2$) mentioned to create a two-piece model.

C. LINK Power Budget

The table 1 and table 2 respectively showing the Power budget for transmitting and receiving end respectively. The assumptions value are taken for the convenience and understanding of the concept[8].

Table 1 transmitting end

Transmitting end	
Tx RF output power	dBm
Combiner loss	dB

Feeder loss	dB
Tx antenna gain	dB
EIRP	dBm

Table 2 Receiving end

Receiving end	
Rx sensitivity	dBm
Rx antenna gain	dB
Diversity gain	dB
Feeder loss	dB
Rx power	dBm
Required isotropic Rx power	dBm
Maximum permissible path loss	dB

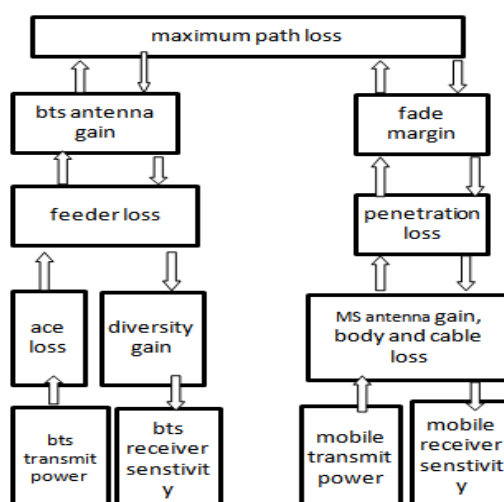


Figure 3

V. UMTS PLANNING

The process of UMTS radio planning can be summed into the following steps as shown in the figure 4.

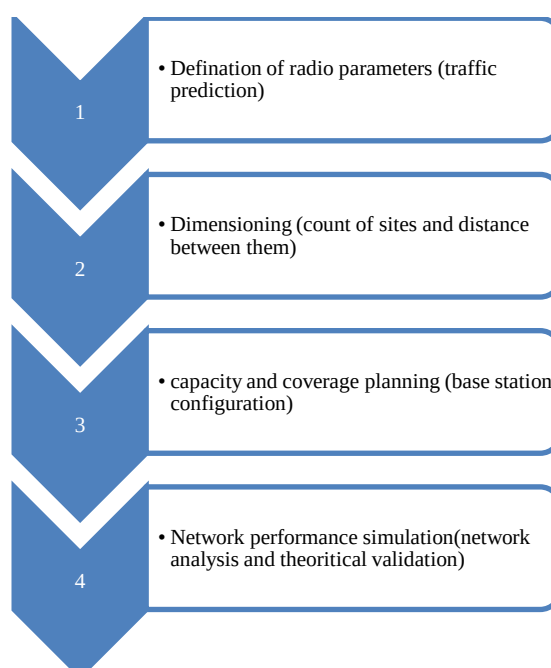


Figure 4

1. Link budget

After the output of dimensioning process, next step is the link budget planning that ensures the coverage and the capacity for a particular area. The link budget for the receiving and the transmitting ends can be seen in the table 3 and table 4 respectively.

TABLE 3 At receiving end

A	Thermal Noise Density	dBm/Hz
B	BTS Receiver Noise Figure	dB
C	BTS Receiver Noise Density	dBm/Hz
D	BTS Noise Power [NoW]	dBm
E	Required Eb/No	dB
F	Soft handover MDC gain	dB
G	Processing gain	dB
H	Interference margin (NR)	dB
I	Required BTS Ec/Io [q]	dB
J	Required Signal Power [S]	dBm
K	Cable loss	dB
L	Body loss	dB
M	Antenna gain RX	dB
N	Soft handover gain	dB
O	Power control headroom	dB
P	Sensitivity	dBm

TABLE 4 At transmitting end

A	Power per connection	dBm
B	Maximum Power per connection	dBm
C	Cable loss	dB
D	Body loss	dB
E	Antenna gain TX	dB
F	Peak EIRP	dBm
G	Maximum Isotropic path loss	dB
H	Isotropic path loss to the cell border	

In UMTS networks, there is slightly more complexity than in GSM. Here every user is generating interference for the other user because all of those users are sharing a common frequency band hence cell radius depends on the traffic load at any given time and it should be estimated in an iterative way in both Uplink and Downlink, analyzing each one separately. The uplink and downlink both will output a cell range value but the smaller one in the two should be taken[9].

Cell Range

Cell range can be calculated by defining the sensitivity for the receiver for a reference user i of each service k :

$$\text{Required_Level [dBm]} = NF + 10 \log (N_o) + 10 \log (i_o i) + 10 \log [E_b/N_o k] + 10 \log R_k$$

Where:

- NF = Node B noise Figure [dB]
- N_o = thermal noise density, normally assumed to be -174 dBm/Hz
- $E_b/N_o k$ = E_b/N_o for the service k (linear Figure)
- R_k : Service k bit rate (bps)
- $i_o i$ = Noise Rise due to interference (linear Figure)

To calculate the **Maximum path loss**, the following equation is used

$$L_{\max, i} = PUL_k - \text{Required_Level} - \sum \text{losses} - \sum \text{margins} + \sum \text{gains}$$

Where PUL_k is the mobile power valid for service k [dBm].

In the above equation all the Losses, margins and gains are given in dBs. Once this is determined, the smallest $L_{\max}$ is chosen as the limiting maximum path loss. This when applied to propagation model, it will give the cell range.

VI. LTE PLANNING

4g or the LTE is long term evolution is high speed internet providing network. The technology supports only data traffic and no voice traffic. According to various telecom professionals the Voice over LTE is still under research and is expected to be in the market in the coming two to three years. LTE Network dimensioning outputs the following results.

- Site count and their locations
- Cell ranges and cell areas
- Site and sector throughput

This result helps in estimation of core network, backhaul requirement and the initial implementation cost. The very next step after this is to make power link budget which estimate the path loss between the base station and the mobile antenna. Using a suitable propagation model like Okumara-Hata, the maximum cell range can be determined by considering the maximum path loss[10]. This maximum cell range outputs the count of base station sites or the eNode B(in case of LTE) to cover the given area or location.

A. Link budget

Link budget for LTE can be seen in two tables as shown in table 5 and table 6 for uplink and downlink respectively.

Table 5 Uplink Budget

<i>Transmitter – UE</i>	
a	Max. TX power (dBm)
b	TX antenna gain (dBi)
c	Body loss (dB)
d	EIRP (dBm)
<i>Receiver – eNode B</i>	
e	Node B noise figure (dB)
f	Thermal noise (dBm)
g	Receiver noise floor (dBm)
h	SINR (dB)
i	Receiver sensitivity (dBm)
j	Interference Margin (dB)
k	Cable Loss (dB)
l	RX antenna gain (dBi)
m	MHA gain (dB)

Table 6 Downlink Budget

<i>Transmitter – eNode B</i>	
a	HS-DSCH power (dBm)
b	TX antenna gain (dBi)
c	Cable loss (dB)
d	EIRP (dBm)
<i>Receiver – UE</i>	
e	UE noise figure (dB)
f	Thermal noise (dBm)
g	Receiver noise floor (dBm)
h	SINR (dB)
i	Receiver sensitivity (dBm)
j	Interference Margin (dB)
k	Control Channel Overhead (dB)
l	RX antenna gain (dBi)
m	Body Loss (dB)

B. Propagation (Path Loss) Models

A propagation model describes the average signal propagation, and it provides the maximum cell range with respect to the maximum propagation loss[11]. It depends on the following:

- Environment : urban, sea, rural, forest, dense urban, etc...
- Distance
- Frequency
- atmospheric conditions
- Indoor/outdoor

We will consider the Okumara –HATA model as it is the one mostly used in urban environments and is described below:

- For Urban Areas:

$$L_u = 69.55 + 26.16 * \log(f) - 13.82 * \log(h_B) - C_H + [44.9 - 6.55 * \log(h_B)] * \log(d)$$

- For Small and Medium-sized cities:

$$C_h = 0.8 + (1.1 * \log(f) - 0.7 * h_M - 1.56 * \log(f))$$

- For Large cities:

$$C_H = \begin{cases} 8.29 * (\log(1.54 * h_M))^2 - 1.1, & 150 \leq f \leq 200 \\ 3.2 * (\log(11.75 * h_M))^2 - 4.97, & 200 < f \leq 1500 \end{cases}$$

Where,

L_u = path loss in urban areas (dB)

h_B and h_M = height of base station antenna and mobile station antenna respectively (m)

F = frequency of transmission (MHz)

C_h = antenna height correction factor (dB)

d = Distance between base station and MS (KM)

VII. TECHNOLOGICAL COMPARISON

Some of the basic technological differences in the above mentioned technologies are listed below in Table 7. This will give an outline for the three technologies we have mentioned here. There are many more differences which can be read in the references mentioned.

Table 7 basic comparison

2G	3G	4G
based on digital voice	based on high capacity broadband data	based on Internet Protocol.
Advance mobility	Seamless roaming	IP based mobility
Data presence	Service concepts and models	Very high data rates
Download 114 kbps	Download 2mbps	Download 100 mbps
Upload 20kbps	Upload 153 kbps	Upload 50 mbps
Carrier bandwidth is 200khz	Carrier bandwidth is 5MHz	Carrier bandwidth is 5Mhz
Supports both voice and data	Supports both voice and data	Supports data only
Circuit and packet switched	Circuit and packet switched	Packet switched only
End node to user is BTS	End node to user is Node B	End node to user is eNode B

VIII. CONCLUSION

The review for different kind of radio network planning has been presented. There are several steps for network planning. The main logic stays the same behind planning for any of these radio networks but the way of measuring network parameters changes due to different frequencies of operation., different characteristic of network etc. the task of network planning is never ending because it always focus to meet the customer requirement with optimum use of resources.

References

- [1]. T. Norman, "The Road to LTE for GSM and UMTS Operators", Analysis Mason Ltd. White Paper, Jan. 2009
- [2]. K.W.Sung, L. Shi and J. Zander "Coexistence of LTE Femtocells with GSM CellularNetwork".
- [3]. A. Mishra, Fundamentals of cellular network planning and optimisation: 2G / 2.5G / 3G... Evolution to 4G. Wiley-Interscience, 2004.
- [4]. Hannes Ekström, Anders Furuskär, Jonas Karlsson, Michael Meyer, Stefan Parkvall, Johan Torsner and Mattias Wahlqvist. "Technical Solution for the 3G Long-Term Evolution". IEEE Communications Magazine, March 2006.
- [5]. Mogensen P., Wei Na., Kovacs I.Z., Frederiksen F., Pokhariyal A., Pedersen K.I., Kolding T., Hugi K., Kuusela M.. "LTE Capacity Compared to the Shannon Bound". IEEE 65th Vehicular Technology Conference 2007, pages 1234–1238, April 2007.
- [6]. Purnima K. Sharma, R. K. Singh, "Cell Coverage Area and Link Budget Calculations in GSM System", International Journal of Modern Engineering Research (IJMER) Vol.2, Issue.2, Mar-Apr 2012 pp-170-176.
- [7]. Dinesh Sharma, Purnima K. Sharma, Vishal Gupta, R.K.Singh, "A Survey on Path Loss Models used in Wireless Communication System Design" in IJRTE Vol. 3, No. 2 in 2010.
- [8]. Dr. S. A. Mawjoud, "Evaluation of Power Budget and Cell Coverage Range in Cellular GSM System" Al-Rafidain Engineering vol.16 no.1, page no.37-47 in 2008.
- [9]. Amaldi, A. Capone, and F. Malucelli, "Radio planning and coverage optimization of 3G cellular networks," Journal of Wireless Networks, vol. 14, no. 4, pp. 435–447, August 2008.
- [10]. Hosein, P. "Resource Allocation for the LTE Physical Downlink Control Channel"-GLOBECOM Workshops, 2009, IEEE.
- [11]. Shipra Gupta*, Supriya Shakya "The 4G Technology V/S other G Technologies", International Journal of Advanced Research in Computer Science and Software Engineering, Volume 3, Issue 3, March - 2013, pp. 737-740.