Implementation of LTE Networks in Indian Terrain: Practicality and Throughput Evaluation

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Abstract: ***Long Term Evolution is the upcoming mobile technology that is going to serve 862M subscribers in India with its ultrafast data speed. Indian vendors already invested almost 100000 crore so as to develop the infrastructure to serve this exploding subscribers in India. This paper checks the maximum data that can be delivered with the infrastructure with an eye towards the Indian terrain and vegetation with some propagation models and the noise and interference effects. Monte Carlo Analysis Methods are adopted and Prediction tools and a Monte Carlo Analysis tool for Communication system is used for the simulation. An RF planning approach for LTE network in India especially in Kerala using Atoll software.***

Keywords: LTE, Terrain, Propagation Model, Monte Carlo Analysis, Cell, e Node B.

1. Introduction

While 3G gradually expands its wings in India, the LTE is seeing a rapid growth over the past one year and is likely to impact the Indian telecom market significantly. According to a recent report by the industry LTE connections across the world is forecast to pass one billion by 2017 of which the Asian market will account for over 47% of all 4G connections - driven mainly by India and China. LTE is expected to herald a new age of productivity for remote business users. Greater capacity, lower cost of deployment, support for high mobility, spectrum flexibility and superior quality of services are some of the factors that make LTE ideal for high-speed, high-quality mobile broadband services. LTE will also boost the demand for data intensive services like mobile TV and mobile videoconferencing. This, in turn, is expected to increase telecom operators' revenues, while enriching the overall end-user experience. With increasing adoption of smartphones and high demand for data intensive applications, the mobile operators today are burdened with immediate need to upgrade their network infrastructure to be able to offer high-speed data services to the consumers. The mobile operators are planning to move to 4G technologies to accommodate the surge in data traffic.

Figure 1: Indian Mobile Users

Natural vegetation are gifts of nature. They grow naturally. They follow the climatic variables. Due to a variety of climates, a wide range of natural vegetation grows in India. Types of natural vegetation vary according to climate, soil and altitude. A study of the distribution of the forests in India reveals that there is a marked relation between the rainfall zones and their belts of natural vegetation.

Kerala (38,863 km²; 1.18% of India's landmass) is situated between the Arabian Sea to the west and the Western Ghats to the east. Kerala's coast runs some 580 km in length, while the state itself varies between 35–120 km in width. Geographically, Kerala roughly divides into three climatically distinct regions. These include the eastern highlands (rugged and cool mountainous terrain), the central midlands (rolling hills), and the western lowlands (coastal plains). The topography consists of a hot and wet coastal plain gradually rising in elevation to the high hills and mountains of the Western Ghats. Kerala lies between north latitudes 8°.17'.30" N and 12°. 47'.40" N and east longitudes 74°.27'47" E and 77°.37'.12" E.

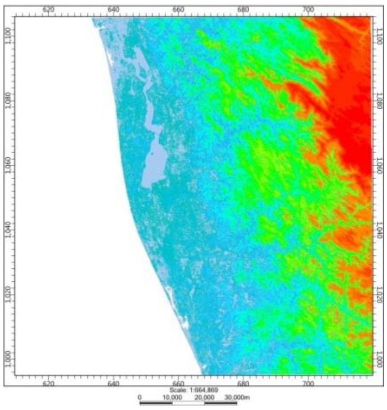

Figure 2: Kerala Vegetation and clutter height

We consider Kerala as the LTE deploying area since it have wide verity of vegetation. Though the state is small in size with comparatively small area under forest cover, Kerala is the medley of a variety of vegetations and forest types. Much of the forest cover of Kerala is spread over the Western Ghats the chain of mountains running north to south. 51% of the total forest cover is in the southern districts and the remaining 49 percent is in the central and northern regions. Idukki and Pathanamthitta districts have the largest area under forest cover. Alappuzha is the only district without any area under forest cover. Propagation in land mobile service at frequencies from 300 to 1800MHz is affected in varying degrees by topography, morphography, ground constants and atmospheric conditions.

2. LTE Network Parameters

One of the key parameters associated with the use of OFDM within LTE is the choice of bandwidth. The available bandwidth influences a variety of decisions including the number of carriers that can be accommodated in the OFDM signal and in turn this influences elements including the symbol length and so forth. LTE defines a number of channel bandwidths. Obviouslyfor greater bandwidth, the channel capacity will be greater. In this section an e Node B parameters are have to be considered since they play key role in LTE downlink. e Node B is the hardware that is connected to the mobile phone network that communicates directly with mobile handsets (UEs), like a base transceiver station (BTS) in GSM networks.

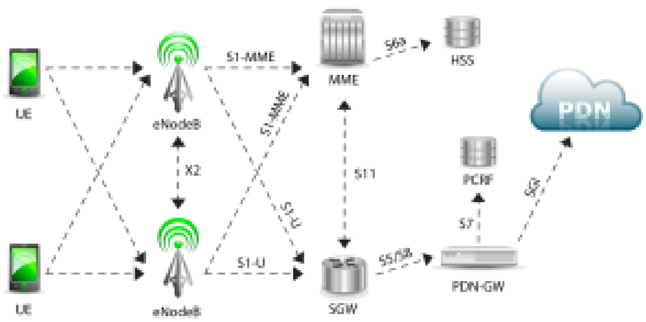

Figure 3: LTE Architecture

This paper introduces LTE from the perspective of radio network planning. The paper is mainly targeted for readers with earlier experience in radio planning and mobile communications. Some prior knowledge of radio engineering and LTE is assumed as principles of OFDMA and SC-FDMA, as described in 3GPP LTE specifications, will not be reviewed in this paper. The most important LTE radio interface parameters are summarized in Table 1 for the convenience of the reader. Our focus is on the FDD variant of LTE, although most of the discussion is also applicable to TDD

Achieving maximum capacity while maintaining an acceptable grade of service and good speech quality is the main issue for the network planning. Planning an immature network with a limited number of subscribers is not the real problem. The difficulty is to plan a network that allows future growth and expansion. Wise re-use of site location in the future network structure will save money for the operator.

3. Prediction Parameters and Conditions

A 1 tier 3 sector system with reuse-3 scheme is considered. OFDMA environment is considered with the channel bandwidths that have been chosen for LTE is 10 MHz. In addition to this the subcarriers spacing is 15 kHz, i.e. the LTE subcarriers are spaced 15 kHz apart from each other. To maintain orthogonality, this gives a symbol rate of 1 / 15 kHz = of 66.7 μs. The carrier frequency is considered as 2100MHz or 2.1 GHz, which is simply the working condition for LTE downlink.

Base Station maximum transmission power. A typical value for macro cell base station is 20-69 W at the antenna connector, Commonly 43 dBm. Base Station Antenna Gain which depends on manufacturers and here we consider it as 18dBi antenna is considered . The antenna is simply a 65° 18dBi 4 Tilt 2100MHz antenna. The maximum height of antenna from ground is 30m. Tower Mounted Amplifier with feeder cables are considered. The mechanical and electrical Azimuth can be adjusted so as to effectively adjust the range. Almost 600m radius cell is considered with 3GPP TR 36.942 parameters.

Cable loss between the base station antenna connector and the antenna. The cable loss value depends on the cable length, cable thickness and frequency band. Many installations today use RF heads where the power amplifiers are close to the antenna making the cable loss very small. The noise figure is considered as 6dB. The effective EIRP is then 55dBm as secondary antenna. Propagation in land mobile service at frequencies from 1800 to 2100MHz is affected in varying degrees by topography, morphography, ground constants and atmospheric conditions. A very common way of propagation loss presentation is the usage of so called propagation curves, normally derived from some measurement formulae is Okumura – Hata modal.

4. Results

Here we consider 7 cell (1-tier) structures with 3 sectors. Considering 3GPP TR 25.942 we make the separation of e Node Bs as 1800m approximate. We evaluate this placement scenario of e Node B is applicable with the terrain taken. Thus according to the vegetation, altitude difference and other geographical and environmental factors, it is clear that the vegetation have to be considered while placing e Node Bs.

Figure 4 shows the placement of 7 e Node Bs with 3 sectors in the geographical area us considering. There are 7 e Node Bs numbered from 1 to 7 which is coloured with 7 different colours. The altitude levels and vegetation can be seen in the figure with shades.

In this figure we calculate the effective coverage area. The 7 e Node Bs coverage are calculated. The cluster region seems to be an infinite coverage region since there is no other e Node B shares the outer e Node Bs region.

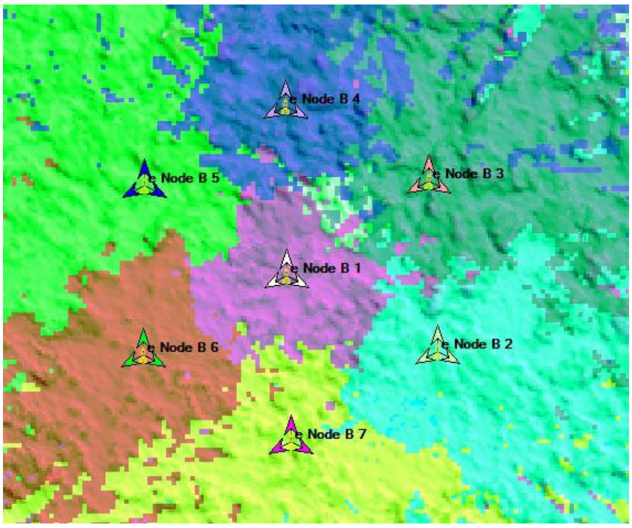

Figure 4: e Node B Coverage

In figure 4 it can be seen that the region between e Node B 1, 3 and 4 there is a region which is not covered by any of the e Node Bs. So in the practical scenario it is quite difficult have wide area coverage with proposed system since the geographic as well as environmental factors including vegetation have great influence in the signal level. Hence comes the relevance of HetNet system. So a heterogeneous network with femtocells can deliver signals at that location. So by placing such a HetNetfemtocell or picocell at the location where e Node B signal level is very low and we can improve the system. Effective use of resources with femtocell network can improve the throughput as well as capacity. Thus the low signal level ranges can be improved by femtocells which are proposed by 3GPP in its technical specifications. Tower mounted amplifier (TMA) and e Node Bs e Node B generated femto access points can also be placed at those locations. These two can improve the communication facility at wireless domain in low signal level or coverage free locations in practical scenario.

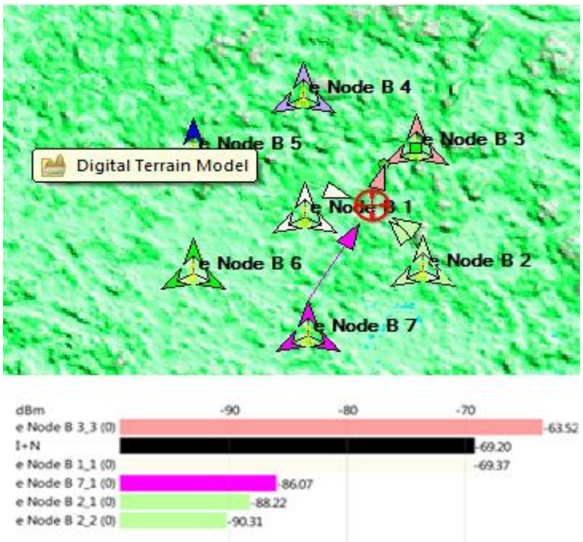

Figure 5: Point analysis for signal strength & I+N

In figure 5 we take point analysis in a particular location so as to calculate the signal level and interference level at that point. In point analysis we take point in the 1-tier trisector system in between e Node B 1, 3 and 2. While calculating the signal level it can be seen that the third sector of e Node B 3 serves that location with it coverage. So all users in that location will be served by that e Node B. So the signal level at that point is -63.52 dB.

The same location will be covered by many other e Node Bs. In this scenario the first sector of e Node B 1, first sector of e Node B 7, first and second sector of e Node B 2 have signals with dominant power at that location. So this e Node Bs makes interference at that point we considered. The total interference added u with noise at that location will be -69.20 dBm. From this point it is clear that we can calculate, operate, and make observation as well as function calculation in a mobile communication with great precision as well as good statistics the mobile signal level strength as well as interference added u with noise. So practically the Shannon-Hartley law can be implemented by the calculation of SINR. Thus throughput evaluation in practical sense can be implemented and evaluated. Using this calculation we can implement a better system with interference calculation. The signal levels for other e Node Bs -80 to -95 dBm except e Node 1.

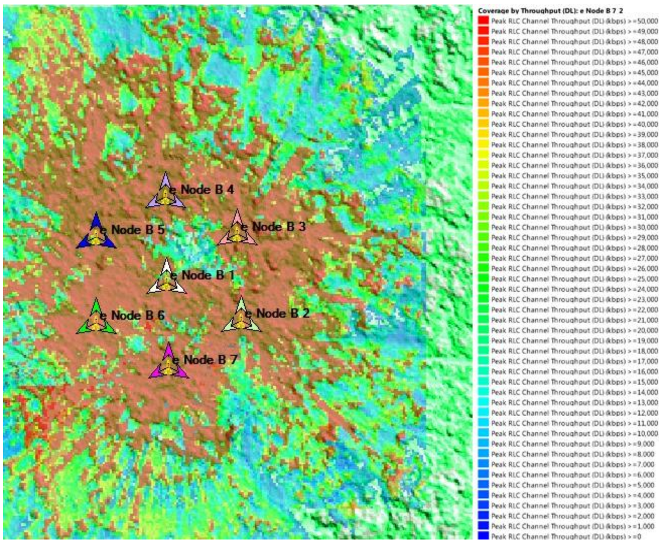

Figure 6: LTE Throughput analysis in terms of DL data rate

In fig: we calculate the throughput in terms of uplink (UL) and downlink (DL) data rates. Here we only consider the downlink only since it is based on OFDM systems. Thus the calculations of downlink throughput have great importance since in LTE implementation in practical sense we have to ensure the terrain based systems to optimize the calculation of capacity of each cell in a 1 tier, trisector cluster of LTE cells.

The maximum capacity that can be ensured is 50 Mbps around an e Node B and is getting down as per the distance increases and that can be seen in fig. . From the fig, it is clear that as per the distance increases the capacity is getting down. It is due to the fact that, as per the distance from e Node B increases the path loss gets increased which will make limitations in bit rate. Here the minimum data rate offered at the cell centre region is 50 Mbps (overall) and at the cell edge region is at most 7 Mbps.

Using the prediction tool, we worked as an RF engineer assigned to design cell structure for mobile communication networks with great responsibilities. RF planning is the most important process in developing the mobile communication infrastructure for each vender in thus emerging era of wirelesses. The 5G technology proposes a worldwide wireless web (wwww) and LTE can be considered as the milestone for this explosion of wireless world

5. Conclusion

Kerala terrain is considered with Kollam, Pathamnathitta, Kottayam, Alappuzha and Idukki districts in prior. Since till 2015 august no vendor provide the LTE technology here in Kerala. Gods own country is of with Western Ghats as well as Arabian sea surrounded lad as a result here the altitude dramatically changes with clutter. In this high and low as well as lads with a altitude almost sae as that of Western Ghats. The RF planner have to look these changes while place a e Node B at a particular position

Each e Node B and each sector in that is configured and allocation of physical resource blocks PRBs are done in such a way that it can provide maximum capacity with the existing systems. The expansion of existing infrastructure will lead to increase in capital expenditure. Thus the optimum implementation in practical sense and with an eye towards the Kerala terrain must be one with lesser CAPEX (Capital Expenditure).The Kerala terrain with specific clutter and vegetation with drastic altitude changes we can ensure the LTE technology can provide better data rates. In the present scenario, the LTE implemented. Vendors like BharatiAirtel can provide a minimum of 3 Mbps speed with limited infrastructure in Indian cities Bangalore, Chennai, Delhi etc. So as an emerging mobile technology LTE has a bright future in Indian terrain.

Since some geographic areas with lower altitudes, it's difficult to serve the users at that locations which is already see in results of the prediction tool. So while making an RF plan we have to consider the terrain regardless of technical specifications.

References

[1] V. Chandrasekhar and J. G. Andrews, "Femtocell Networks: A Survey", IEEE Commun. Mag., vol. 46, no. 9, pp. S9-67, Sept. 2008.
[2] G. Mansfield, "Femtocells in the us market -business drivers and consumer propositions," in Femtocells Europe 2008. ATT.
[3] 3GPP TR 36.921 V 10.0.0, "Evolved Universal Terrestrial Radio Access (E-UTRA); (Release 10)"
[4] Jie Zhang, Guillaume de la Roche, "Femtocells Technologies and Deployment," John Wiley & Sons Ltd, Publication, 2010.
[5] H. Claussen, "Performance of Macro- and co-channel Femtocells in a hierarchical cell structure," IEEE 18th International Symposium on Personal, Indoor and Mobile Radio Communications (PIMRC 2007, September 2007.
[6] K. Cho, W. Lee, D. Yoon, K. Hyun, and Yun-Sung Choi, "Resource alloation for orthogonal and co-channel Femtocells in a hierarchical cell structure," 13th IEEE (lSCE2009), May 2009.
[7] L. T. W. Ho and H. Claussen, "Effects of user-deployed, cochannelFemtocells on the call drop probability in a residential scenario," IEEE 18th IntI. Symposium on Mobile Radio Communications(PIMRC), Sep. 2007.

Author Profile

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