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Efficient Location and Capacity Planning of Node B for 3G Networks

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Abstract

Capacity planning of 3G network unlike 2G is cumbersome. The 3G capacity is multi-fold. It depends on Power Utilization, Code Utilization, Iub (interface between the Radio Network Controller (RNC) and the Node B) and Channel Element (CE). The location of Node B plays a crucial role in 3G Planning. The Radio Frequency planner needs to select the best optimal location for setting up the 3G site in order to a seamless coverage to the customers. In this paper, these topics are explored in a detail manner. For this planning the Node B layout for Airtel in the densely populated Santhome area of Chennai is discussed. The basis issue is the interdependence between coverage and capacity in 3G. In 3G systems, both capacity and quality should be monitored to ensure the best network performance. Planning of new base station has been first treated with an analytical study of the cell coverage range for a specific environment and service. The accomplished results have been checked using ASSET simulation tool and Geographical Information System (GIS) tool.

Keywords: ASSET, Capacity. Coverage Prediction, Pilot Pollution, 3G

1. Introduction

Today's digital world is converging towards data with the evolving of not only entire 3G network but also the 4G network and all this is benefiting data market. Every user is addicted to use data, if Airtel is taken as data market, customers are using around hundreds of Terabytes (TB) per day. With the onset of market towards the smart phone users, data market is really important.

The resource optimization is essential because of expensive equipment and infrastructure. Instead of trying for optimization if RF planner just go and put a new site anywhere, this will lead to more capital expenditure. Because of this it is important to design and manage capacity planning effectively. Because of this there is great need to plan the network. The expenditure which is spent on the Capital Expenditure (Capex) should definitely boost the fortune profit rather than pulling the profit to the service provider. If capacity planning is not done properly then it will harm the profit of service provider. The performance of the network should not deteriorate not only because of competition with the other networks but also because of capacity constraint. It means that if there is no any proper planning then it will lead to the two major problems. First one is it fails to gain the confidence of the customer and the second is the wastage of capacity of the network.

Network should be planned in such a way that the Capital Expenditure (Capex) and Operating Expenditure (Opex) must be in proper control that is capacity planning is utmost important to the operator. It is important to plan the network optimally so that network provider should get profit from competition.

2. Related Works

3G network planning is a multi-objective optimization problem, in which the number of Node B's (Base station for UMTS network) are decided with their configuration such as antennae type, power, azimuth and tilting

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of antenna, tower height and locating Node B's in the geographical area.

By decreasing the overall Node B's transmit power, minimization of interference both in the uplink and the downlink of cellular networks is achieved[1]. As decreasing the access distance[2] between the transmitter and the receiver, will have direct impact on the energy efficiency[3] of the cellular network. Optimal placement for location of Node B has been a significant subject of attention in 3G networks[2,5]. Features of Node B placement in 3G systems are optimizing the location of the Node B for achieving the minimum interference, maximizing the coverage of a 3G network[4] with finding the optimum radius for antenna[5] are optimization in 3G systems. In different words, the capacity will increase (or equally the power saving) if Node B's is largely influenced by locations of Node B.

3. Proposed Methodology

The purpose of this work is to show how the layout of Node B's in a real city scenario is planned and to implement the capacity planning and optimization in order to provide the best coverage to 3G users. Analytical results have been tested in simulation analysis of a single-cell environment.

Multiple cells scenario is analyzed by ASSET tool and the results are presented for the study. Problem of Cell breathing and the capacity requirements are the new problems that are not observed in the single-cell scenario. The impact of the cell breathing is also investigated in[1,6]. This study relies on an analytical study, known as link budget, by which it is possible to estimate the single-cell coverage ranges in different environments for a given system capacity. A first approach to this problem was suggested in[7]. Many issues affect system performance (i.e. user's profile, interference conditions, cell breathing, etc.) making the task quite complex as a result software planning tools can make substantial difference in the study of such complex systems[8]. For the purpose of good coverage the improvisation of the layout by changing the configuration of any Node B's (e.g., tilt, height) is proposed. An optimal planning needs a long process of trial and error from which one has to adjust parameters in order to finally achieve a good provision of service.

4. Modeling and Simulation

Coverage calculations can be made by applying propagation models such as the Okumura-Hata[1] and[9]. With the help of ASSET simulation tool, coverage analysis for set of Node B is done. By using this prediction of coverage area for set of Node B's is done. For Hata's Propagation which is based on Okumura's field test, path loss from Equation 1 for different clutter is calculated with the help of following equations:

$$PL = A + B * \log(d) + C \quad (1)$$

Where A, B and C are factors that depend on frequency and antenna height.

$$A = 69.55 + 26.16 * \log(f_c) - 13.82 * \log(h_b) - a(h_m) \quad (2)$$

$$\mathrm{B} = 44.9 - 6.55 * \log(h_b) \quad (3)$$

Where,

f_c is operating frequency in MHz.
d is distance in km.
h_b is the height base station antenna.
h_m is the mobile station antenna height.

The function a (h_m) and the factor C depend on the environment condition. For metropolitan area value of a (h_m) and C is calculated using following formula.

$$a(h_m) = 3.2 * \log(11.75 * h_m)^2 - 4.97 \textit{ for } f \geq 400 \text{ MHz} \quad (4)$$

$$\mathrm{C} = 0 \quad (5)$$

4.1 Coverage

The propagation model used in the simulator is based on the Okumura-Hata model, specifically tuned for the Santhome area of Chennai. The model computes the power received at each point of the simulation area.

As coverage and capacity are closely related in 3G networks; therefore, both must be treated simultaneously. Once the maximum propagation losses have been estimated, it is necessary to find the equilibrium between coverage (i.e., cell size) and capacity (i.e., maximum number of simultaneous users can be served by the cell)[10,11]. For the light-loaded system, interference generated is less, so the coverage is larger. Since the power emitted by a Mobile Station (MS) is lower compared with the maximum power at Node B, a user far from the Node B probably can listen to the signal, while this communication reaches the Node B with insufficient strength; then that can be called as Uplink (UL) coverage limited. On the other hand, changes in the number of users and services have a strong impact on the cell coverage range and is called as cell breathing effect that is as load increases, the coverage is reduces or decreases. Insufficient power sharing makes it impossible to provide service in the Downlink (DL). Therefore, it is commonly said that the DL is capacity limited[5,12].

4.2 Site Simulation

The site simulations are obtained by utilizing the software named ASSET3G by AIRCOM International.

4.2.1 Coverage Estimation

The radio network planning is based on the estimation of the maximum losses of radio signal that will suffer during its propagation through different environments[9,11,12]. This kind of calculation is known as link budget and it depends on the environment and on the propagation model chosen.

Planning base station is complex task since there are many constraints on the base station layout making it difficult to locate antenna in desired direction. Firstly base station is proposed in Santhome area of Chennai based on link budget analysis and problem of this are analysed and solved. Figure 1 shows simulation of Single Cell coverage in ASSET 9.0 tool around a tri-sectorial antenna, according to the propagation model used in this study.

The different colors representing in Figure 2 are different signal level around the base station. The red color area is dead zone which is out of coverage area. Figure 4 shows the coverage prediction plot for multiple cell layout with good coverage with minimum number of base station, this layout is created with the help of link based

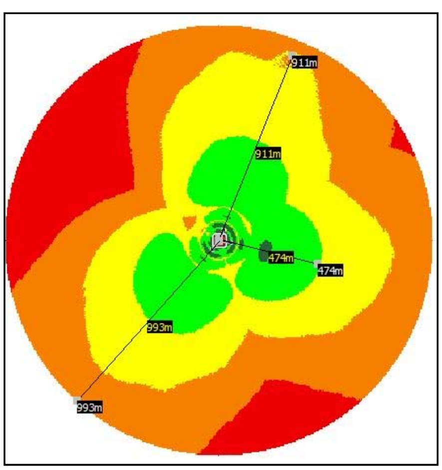

Figure 1. Simulation of single cell coverage in ASSET 9.0 tool.

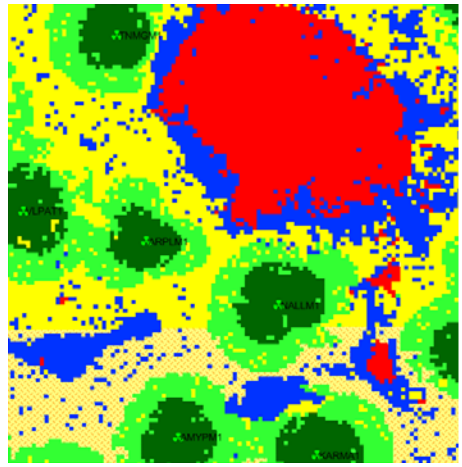

Figure 2. Snapshot of simulation for coverage prediction plot for multiple cells from ASSET tool.

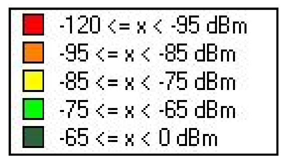

Figure 3. Range of RSCP values for simulation in ASSET 9.0 tool for.

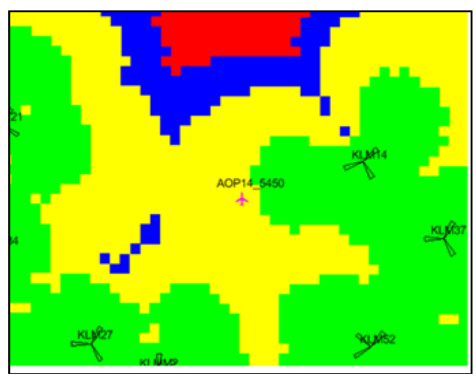

Figure 4. Coverage prediction plotfrom ASSET tool.

analytical calculation which are studied for single cell environment. Figure 2 and Figure 4 displays the coverage map around the Node B, Here Red color represents the signal with RSSI (Received Signal Strength Indicator) values under – 90 dBm corresponding to the out-of-coverage area for this Node B. The area in dark green and light green is shown in the figure represents RSSI signal strength remains between −90 and −80 dBm. Figures 4 and 5 shows the prediction plot and respective Google earth snapshot of new proposed site.

5. Capacity Planning Strategy

This section explains in detail about how capacity planning is done for 3G network.

5.1 Capacity planning and optimization

In 3G the capacity is multi-fold. It depends on following four parameters.

- Power.
- Code Utilisation.
- Channel Element (CE).
- Iub interface.

For 3G network the capacity planning is critical, as it depends on different parameters. Above four parameters are called as capacity parameters for 3G network. When planning for the power is done, Power provided is normally 20 Watts for Node B. When there is problem regarding data rate then there is a need to increase power from 20 Watts to 40 Watts. Power will give the enhancement of HSPA service. In 3G there are two services available for packet access:

- R99 (3GPP Release 99)
- HSPA (High Speed Packet Access).

R99 is a service which can give about 384 Kbps kilobits per second and HSPA has up to 14.4 Mbps. While planning process for sites the enhancement of power is needed to increase the data rate.

The enhancement of the power will give high data rate for those people who use smart phone and tablets to get good experience on the data browsing or data streaming. Other enhancement is code enhancement which is done in sector wise. Each site is normally having 3 sectors. All the Channel Element (CE) cards will be common to the site whereas the power and code are individual and sector wise. Each sector will be serving to different area. If over-loaded for the code or power, then there planning must be done for sector alone. When entire site is in trouble then CE has to be planned.

Suppose for Sector A the code congestion is reported that means more people are trying to brows, to mitigate this problem additional sector is necessary. Extra codes are available when sector addition is done. Card addition in CE is done for whole site while it is beneficial to add sector for power and code congestion.

Iub is an interface between Radio Network Controller (RNC) and Node B, so Iub is backhaul. When traffic pulled by the Node B is passed to RNC, if still the pipe is chocked that results in the congestion at backhaul.

CE is channel element wherein additional physical cards are added like the TRX of 2G. When CE is getting congested that means more user are coming and there will be a problem so there is a need to plan CE cards in proper way so that the problem will be mitigated.

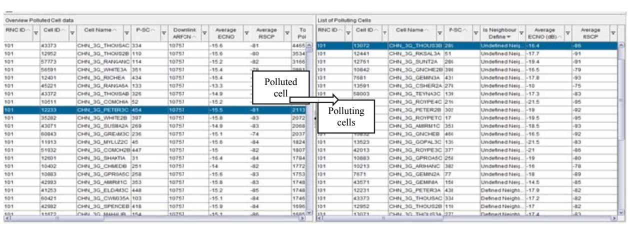

Figure 5. Site location data for above coverage plot from Google earth.

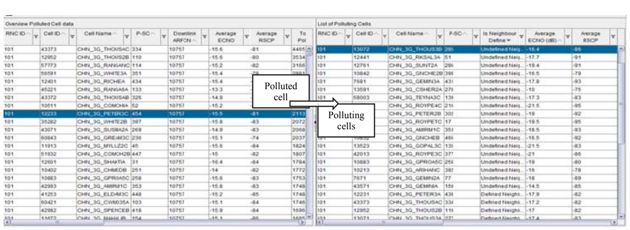

Figure 6. UMTS pilot pollution analysis with polluted and polluter cell data.

6. Results and Discussion

For optimization of the network 3G coverage problems are analyzed such as weak cell coverage and poor service quality. Figures 7 and 8 shows the Chip Energy over Noise (EcNo) and Received Signal Code Power (RSCP) plot's respectively. Here Probability Distribution Function (PDF) and Cumulative Distribution Function (CDF) are analyzed. It is observed that if CDF and PDF are having more value in middle area then there may be interference

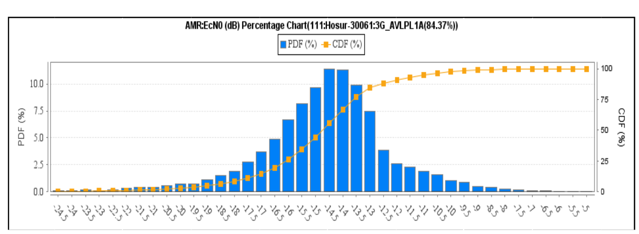

Figure 7. EcNo plot with PDF and CDF.

problem present and because of that call drops are observed.

RSCP plot shows the cumulative value is more above −104 dbm which clearly indicate that there is coverage problem present in the given area. MS (Mobile Station) is always at any location will be served by 3 active set or 3 pilot in 3G. So out of whichever is having higher power or signal strength with that user will be latched and served.

But suppose user is get served by another server because of higher height of the antenna then if it is exceeding above 3. Then these pilot scrambling code are called polluters they are going to pollute the service in that particular area. For more than three pilots are called as pilot pollution. Real time example of pilot polluted cell with the polluter and polluted cell data is shown in Figure 6.

Following step are taken to avoid the pilot pollution. With the help of different optimization technique, by changing tilt of antenna means down tilting of antenna or changing the azimuth of antenna or reducing the height of the antenna so that it does not interfere with the other site.

Figures 9 and 10 show the EcNo and RSCP values for the coverage performance in live network. From Figure 8 it shows that if EcNo value is decreasing less than −14 dBm then there is high interference is observed. And the Figure 10 shows the weak coverage area from that RF planner can observe how many users are served with the weak coverage in live network.

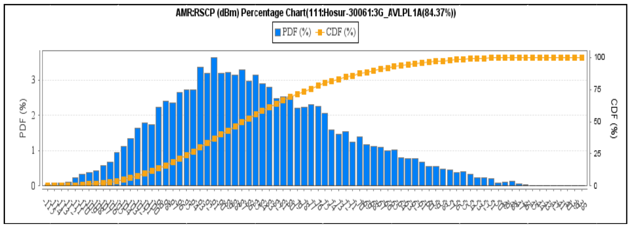

Figure 8. RSCP plot with PDF and CDF.

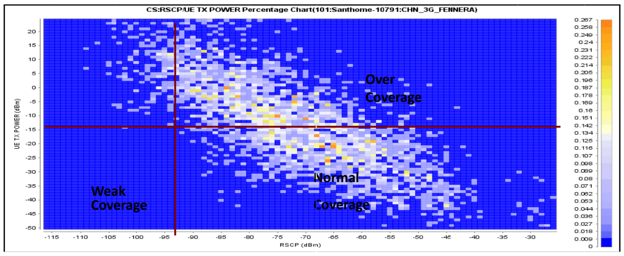

Figure 9. EcNo vs. TX power with coverage performance.

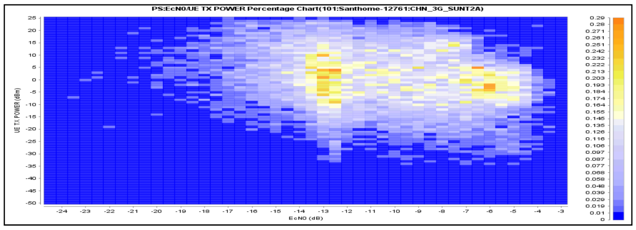

Figure 10. RSCP vs. TX power with coverage performance.

7. Conclusion

This paper has presented a methodology for capacity planning in 3G. Also in this paper location based layout study is done. Results are highlighted with the given coverage prediction model. Better coverage is provided with considering the effect of capacity on the coverage. Also different problems with EcNo, RSCP etc. are observed and to mitigate those problems, optimization is also suggested based on real time scenario. Our future work will be extending the current work in the direction of power optimisation and Quality of Service (QoS).

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