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Outage Probability Analysis of Multi-Tier Wireless Network

Nishi Shree[1], Saif Jahangir[2], Shuvabrata Bandopadhaya[3]
School of Engineering & Technology, BML Munjal University, Gurgaon, Haryana, India

ABSTRACT

This paper focuses onthe outage probability analysis of multi-tier wireless network.The classical approach to handle ever-increasing traffic is to increase the density of the network with smaller cells. The recent approach implemented for network densification is multi-tier network where more than one class of transmission nodes are being deployed in same area. The user choses most suitable node based on the received signal strength as its service node and signals from all other nodes are treated as interference. If the signal-to-interference ratio (SIR) at the user end goes below the preset value called threshold, then it goes out of coverage. Complimentary of coverage is called as outage. In this paper, Monte-Carlo simulation is carried out for outage probability of three tier network with different propagation conditions.

Keywords

Multi-tier network, Poison point process, pico-cell, femto-cell, interference-limited network, outage probability

INTRODUCTION

To incorporate the ever increasing wireless internet traffic is major challenge for next generation network. Total wireless internet traffic is accounted as 3 Exabyte in 2010 and expected to reach to over 190 Exabyte by 2018, may exceed 500 Exabyte by 2020 [1]. The classical approach to handle ever-increasing traffic is to increase the density of the network with smaller cells. Within last two decades, the cell size has being reduces to hundreds of square kilometers to fraction of square kilometers [2-3]. The recent approach implemented for network densification is multi-tier network where more than one class of transmission nodes are being deployed in same area. In multi-tier network several lower power tiers like picocell (few hundreds of meter range) and femetocell (few tens of meter range) co-exists along with long range traditional macro base stations [4-5].

The most important benefit of multi-tier network is extreme reuse of spectrum across a geographic area that increases bits/sec/area metric. It has been proved that there is no adverse effect of network densification on signal-to-interference ratio (SIR), thanks to power-law path loss model. The major goal multi-tier network is to offload majority of traffic to lower tiers from macro-tier to achieve maximum throughput. To achieve optimum spectral efficiency, the multi-tier network goes for universal frequency use with simultaneous use of total available spectrum by all co-existing tiers.In such type of network, single base station qualifies as service base stationthe user equipment depending on maximum received signal strength. The signal received from the service base station is the intended signal and rest signals are treated as interference. In multitier network the interference are both co-tier and cross-tier type [6-7].

Due to the non-uniform user density in practical scenario, the spatial locations of transmission nodes are stochastic and each tier is modeled with anindependent Poisson point process (PPP) with specified intensity [8]. Though, theoretically SIR which is the function of distance, fixed for a given location, it changes every instant due to shadowing and small-scale fading. In some instances, the SIR goes far below the acceptable value which is referred as outage. As during outage, there is significant performance degradation as well as occasional call drop may occur, outage probability is an important quality of service (QoS) index for a network.

In this paper,Monte-Carlo simulation for outage probability of three tier network with different propagation conditionsis being carried out.The organization of the paper is as given: multi-tier network system model is presented in section 2, the simulation results and analysis are present in section3 and section 4 concludes the paper.

SYSTEM MODEL

Consider a *k*-tire multi-tier wireless network is being deployed on a torus of $\Re^2$. Let, Γ is the set of all transmitting node and $\Gamma_i \subset \Gamma$ is the set for all nodes of *i*th tier, *i*=1,2,..,*k*. The spatial locations of the transmission nodes of each tier is considered as stochastic and modeled with independent homogeneous Poisson point processes (PPP) where λ_i is the intensity of *i*th tier.Let $P_T^{(i)}$ is the transmitted power for *i*th tier. Let, $X_j^{(i)}$ is spatial location of *j*th node of *i*th tier, the power received at the mobile user with spatial location X_U is given by [6],

$$P_R\left(X_j^{(i)}\right) = AP_T^{(i)} S_{X_j^{(i)}} h_{jU}^{(i)} \left\| X_j^{(i)} - X_U \right\|^{-\beta} \tag{1}$$

where, A is the propagation constant, β is the path loss exponent (PLE), $S_{X_j^{(i)}} \in S_{X^{(i)}}$ which is a set of random variables following a zero mean log-normal distribution representing shadowing experienced between the transmitting nodes of *i*th tier and user mobile and $h_{jU}^{(i)}$ is the random fading variable between node at $X_j^{(i)}$ and the user mobile, $E[h_{jU}^{(i)}] = 1$.

The user terminal selects one transmitting node as servicing node irrespective of tier based on average received signal strength (RSS). Let the spatial location of the servicing node is X_0 .Hence the signal power is given by

$$S = P_R(X_0) \tag{2}$$

Signals from all other nodes are treated as interfering signals. Hence the interference power experienced by the user mobile at the downlink is given by

$$I = \sum_{X_j^{(i)} \in \Gamma} P_R\left(X_j\right) - S\,. \tag{3}$$

Hence the signal to interference ratio (SIR) is given as

$$SIR = \frac{S}{I} = \frac{P_R(X_0)}{\sum_{X_j^{(i)} \in \Gamma} P_R\left(X_j\right) - P_R(X_0)}\,. \tag{4}$$

The outage probability for the user in the network with a given SIR threshold (*Th*) is given as

$$Po(Th) = \Pr[SIR < Th] \tag{5}$$

It is equivalent to the cumulative distribution function (CDF) of received SIR.

SIMULATION RESULTS AND ANALYSIS

In this section, three tier network is simulated. Each tier is simulated with independent PPP having intensities $\lambda_1 = 0.5\lambda_2 = 0.25\lambda_3$. The user terminal is put at origin. Figure 1 shows spatial location user terminals of the network. The transmitted powers of tier 1, tier 2 and tier 3 respectively are 50W, 2W and 0.2W.

Monte-Carlo simulation is carried out by configuring the network 10^4 times using three independent PPP. For each network, servicing base station is assigned based on average maximum received signal strength. SIR is evaluated for 10^4 time by transmitting that many data samples incorporating shadowing and small-scale fading. The shadowing is quantified with standard deviation (σ) of log-normal distribution. Figure 2 and figure 3 show SNR Threshold (dB) vs Outage Probability (i.e. PR(SNR < SNR Threshold (dB)) with no shadowing (σ = 0dB) and large shadowing (σ = 12dB).

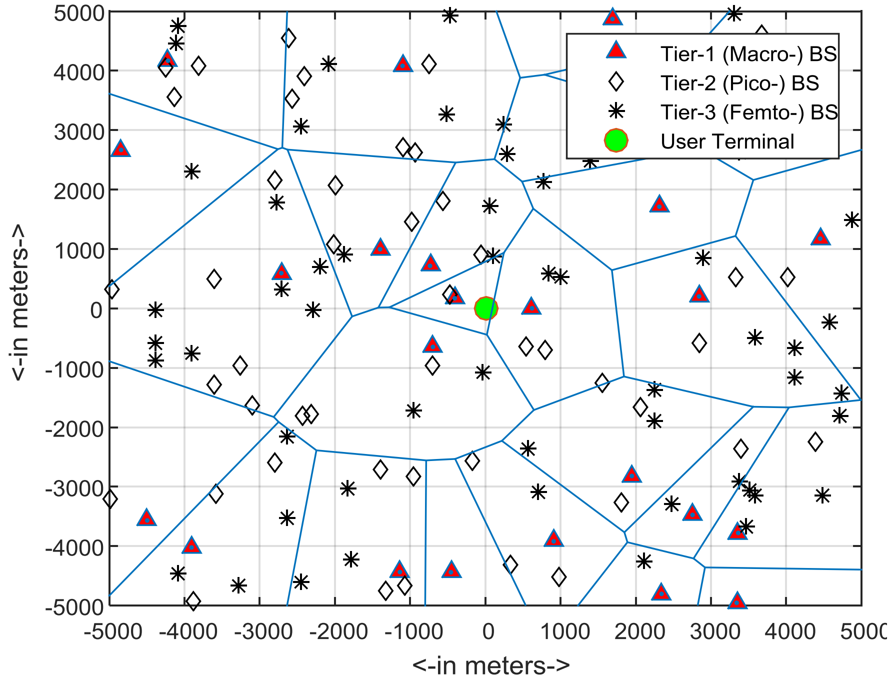

Figure 1. 3-tier Network: Tier 1 (Macro), Tier 2 (Pico), Tier 3 (Femto)

Path loss exponent (PLE) is considered as 2.2 and 8.6 representing quasi-open and urban terrain respectively. In all cases, it has been observed that the outage performance of three tier network tightly matches with that of single tier network. Hence, by suitably offloading the traffic to the lower tier significant gain in throughput can be achieve. It is also observed that the outage performance improves in urban areas where the interference signals die down rapidly due to high value of PLE.

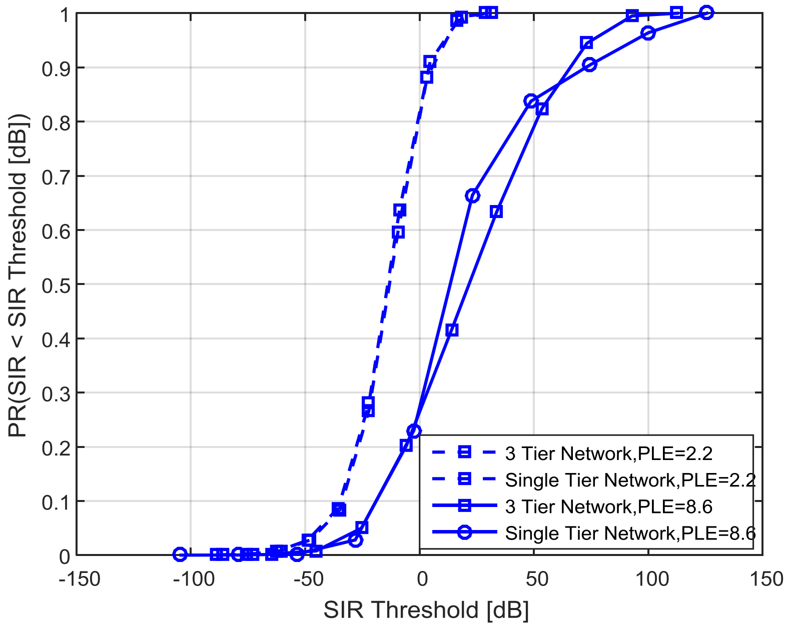

Figure 2. SNR Threshold (dB) vs Outage Probability (i.e. PR(SNR<SNR Threshold(dB)) with no shadowing (σ = 0dB)

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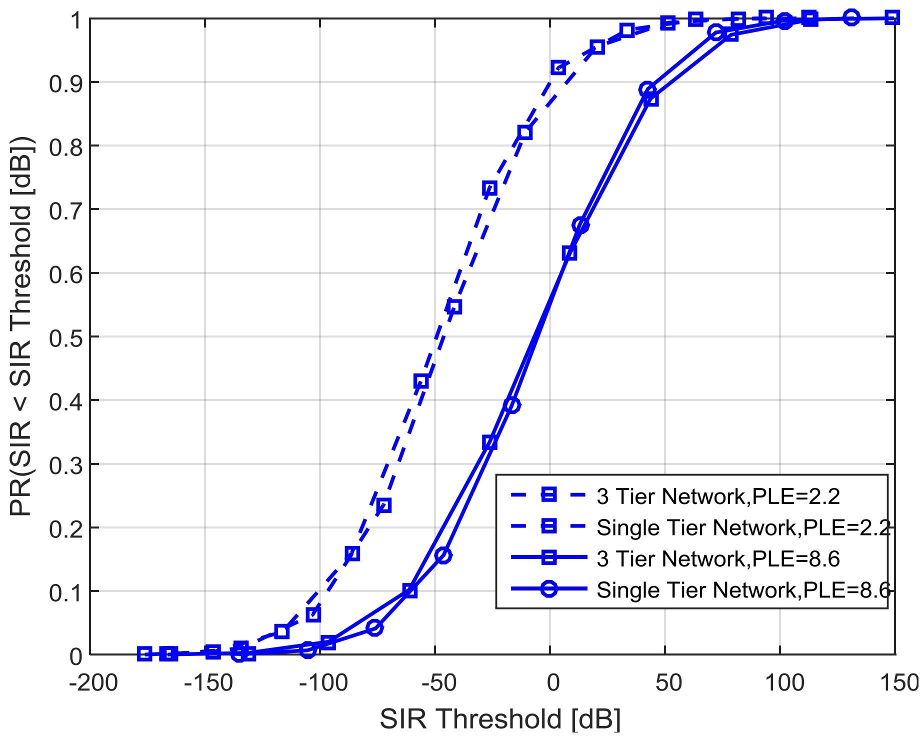

Figure 2. SNR Threshold (dB) vs Outage Probability (i.e. PR(SNR < SNR Threshold (dB)) with large shadowing (σ = 12dB)

CONCLUSION

In this paper,outage probability analysis of multi-tier wireless network is being carried out using Monte-Carlo simulation. The number of tiers considered is three. Various propagation conditions are implemented. It has been observed that the outage performance of three tier network tightly matches with that of single tier network in all cases that encourages network densification through installing multi-tier network. Analysis of suitable offloading technique can be considered as future direction of research.

REFERENCES

[1] Cisco. 2014. Visual networking index, white paper at Cisco.com.
[2] Chandrasekhar, V., Andrews, J., Gatherer, A.2008. Femtocell networks: a survey. IEEE Communications Magazine, vol. 46, no. 9, 59–67.
[3] Dohler, M., Heath, R., Lozano, A., Papadias, C., Valenzuela, R. 2011. Is the PHY layer dead? IEEE Communications Magazine, vol. 49, no. 4, 159–165.
[4] Andrews, J. 2013. Seven ways that HetNets are a cellular paradigm shift. IEEE Communications Magazine, vol. 51, no. 3, 136–144.
[5] Andrews, J., Claussen, H., Dohler, M., Rangan, S., Reed, M. 2012. Femtocells: Past, present, and future. IEEE Journal on Sel. Areas in Comm., vol. 30, no. 3, 497–508.
[6] Dhillon, H., Ganti, R., Baccelli, F., Andrews, J. 2012. Modeling and analysis of K-tier downlink heterogeneous cellular networks. IEEE Journal on Sel. Areas in Comm., vol. 30, no. 3, 550–560.
[7] Ramasamy, D.,Ganti, R.,Madhow, U. 2013. On the capacity of picocellular networks.in Proc., IEEE Intl. Symposium on Information Theory, 241–245.
[8] Błaszczyszyn, B., Keeler, H.,2015. Studying the SINR process of the typical user in Poisson networks by using its factorial moment measures. IEEE Transaction on information theory, vol.61 no.12, 6774-6794.
[9] Ghosh, A., Zhang, J.,Andrews, J., Muhamed, R. 2010. Fundamentals of LTE. Prentice-Hall.