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SINR and Outage Analysis for the Jt Comp Technique based Downlink Lte -A Multi-Cell Cellular Networks with Hexagonal Layout

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Keywords: LTE-A; cellular network; path-loss; SINR; SINRth; CDF; comp; JT comp; outage probability.

I. Introduction

LTE-A is the most popular 4G cellular network standard, which is continuously evolving to meet the expectations of the visionary 5G networks., has been brought the high speed wireless technology for mobile users[1]. It is a major advancement of LTE which targets higher data rate, higher spectral efficiency, less latency, two times higher cell edge user throughput, three times higher average throughput than LTE [2]. Coordinated multipoint (CoMP) is new technique for LTE-A where a User Equipment (UE) receives signal from more than one base station and hereby signal quality and fidelity increases. Joint Transmission (JT) is a special kind of CoMP where a UE receives signals from two base stations and interferences from the others [3]. It potentially eschews co-channel interference due to its implicit feature. In this paper, performance of JT CoMP is simulated and compared in terms of SINR (signal-to-interference-noise ratio), CDF (Cumulative Density Function) and outage probability. In Section II and III, CoMP technique has been discussed in general. In section IV, the proposed technique has been stated. The simulation procedure and the result analysis are in section V.

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II. The Coordinated Multipoint (CoMP Technique)

In case of CoMP technique shown in Fig. 1 when a UE is in the cell-edge region, it may be able to receive signals from multiple base stations and the UE's transmission may be received at multiple base stations regardless of the system load [4]. If the signal transmitted from the multiple base stations is coordinated, the downlink performance can be increased significantly. This coordination can be simple as the techniques that focus on interference avoidance or more complex as in the case where the same data is transmitted from multiple cell sites. For the uplink, since the signal can be received by multiple base stations, if the scheduling is coordinated from the different base stations, the system can take advantage of this multiple reception to significantly improve the link performance [5].

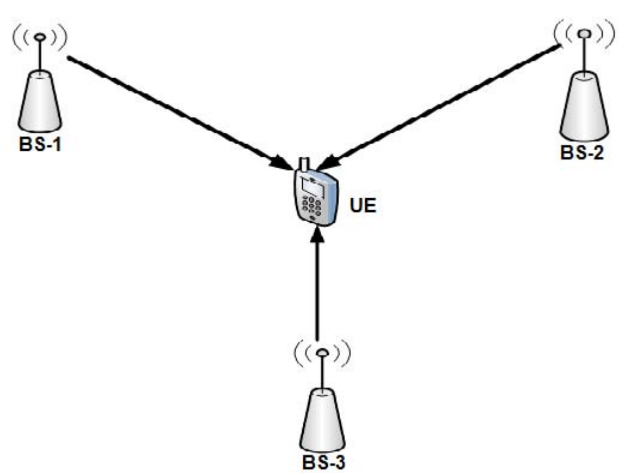

Fig. 1: LTE Advanced Coordinated Multipoint.

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III. The JT CoMP Technique

In Joint Transmission CoMP, a UE receives signal from the cell where it is located and also from the cell closest to it. All other base stations in the adjacent cell are considered as interferences. In order to turn inter-cell interference into a useful signal the JT-CoMP can be used as a MIMO (Multiple Input Multiple Output) approach so that it can transmit the same information to individual UEs located at the cell edge [7] where the received power can be very low. It can improve the spectrum efficiency by avoiding the co-channel interferences and increase the overall throughput [3]. In Fig. 2, base stations (BS-1 and BS-2) coordinate the transmission to user equipments (UE-1 and UE-2).

BS---base station
UE---User Equipment

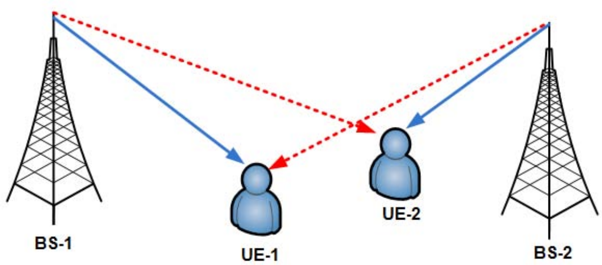

Fig. 2: Joint Transmission CoMP concept.

IV. System Model

A downlink multi-cell cellular network deployed using regular hexagonal cell layout is shown in Fig. 3. Before starting the analysis, some parameters are assumed such as base station, antenna height, transmitted power, channel bandwidth, path-loss model, fading, thermal noise power and interference.

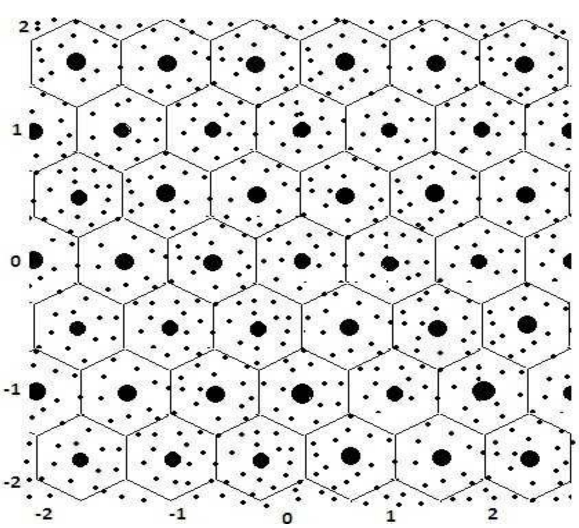

Fig. 3: LTE-A cellular network using regular hexagonal cell.

a) Ue Distribution

100 users are randomly distributed within the cell considering the radius (r) from the center (base station) and the azimuth (θ) as uniform random variable. Here, r is considered as uniform in the interval$[0, radius of\ the\ cell]$ and θ in the interval$[0,2\pi]$. The user distribution is illustrated in Fig. 4.

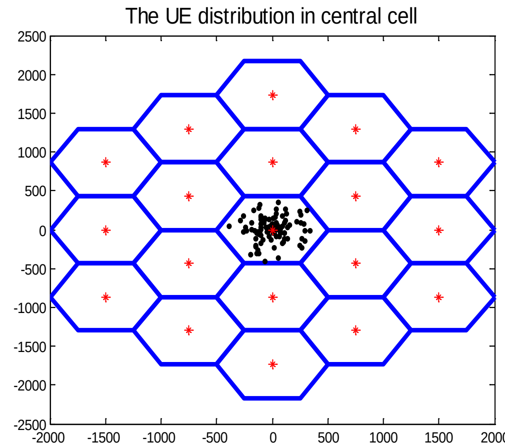

Fig. 4: UE and base station distribution.

b) Base Station Setup

All the base stations are set up at the center of each cell which has also been illustrated in Fig. 4.

V. Simulation and Result

The simulation has been performed on a MATLAB based Monte-Carlo simulation platform. A central cell and 2-tiers of its adjacent cells are implemented. Users' equipment (UE) in only central cell is considered.

a) Path Loss Model

Path loss models describe the signal attenuation between a transmitting and a receiving antenna as a function of the propagation distance and other parameters. It has been calculated using the $WINNER+$ model for urban and rural area. Here, for shadowing (large scale fading) with standard deviation, $\sigma = 8db$ the path loss in urban and rural area is described respectively by the following equations:
For urban area:

$$Path\ loss(in\ dB) = (44.9 - 6.55\log_{10}(h_{BS}))\log_{10}(d) + 5.83\log_{10}(h_{BS}) + 14.78 + 34.97\log_{10}(f_c)$$

For rural area:

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$$Path\ loss\ (in\ dB) = 25.1\log_{10}(d) + 55.4 - 0.13(h_{BS} - 25)\log_{10}\left(\frac{d}{100}\right) - 0.9(h_{MS} - 1.5) + 21.3\log_{10}(f_c/5)$$

Here, d is the distance of a UE from any base station in kilometer, h_{BS} is the base station antenna height in meter and f_c is the carrier frequency in gigahertz.

b) SINR and Outage Probability Calculation

The SINR is the ratio of received power to the sum of interference power and noise power. The Outage probability has been calculated taking different SINR values as threshold. Also, outage probability for various cell radiuses has been computed and plotted to compare with case of non-coordinated multipoint scheme. Instead of simulating 1000 times with 100 UE at the central cell, it has been simulated once with 100000 randomly distributed UEs exploiting the ergodic nature of this random process.

c) Comparison With No-Comp

The SINR for Joint Transmission Coordinated Multipoint (JT-CoMP) scheme is right-shifted than the SINR of No-CoMP scheme. That means higher SINRs are more probable in JT-CoMP which is illustrated in Fig.5 for urban and in Fig.6 for rural area.

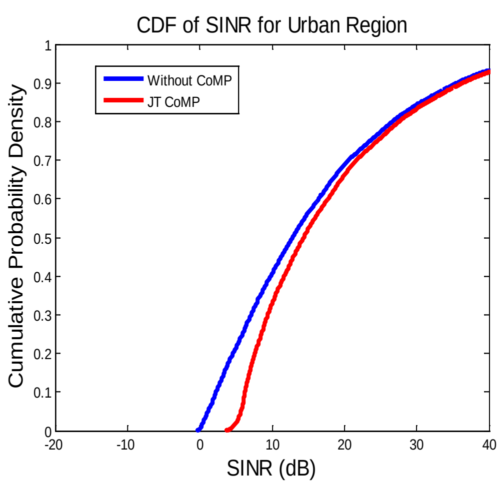

Fig. 5: CDF of SINR for Urban Region.

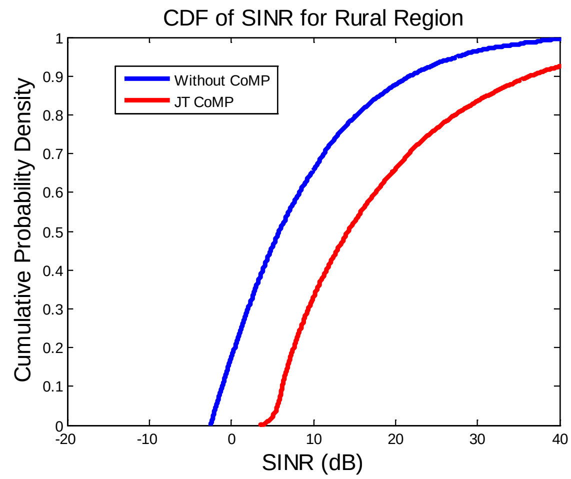

Fig. 6: CDF of SINR for Rural Region.

The improvement can also be seen in the graphs of outage probability. Here, also the curve for JT CoMP is right shifted than the curve for No-CoMP scheme which means compared to the No-CoMP schemes outage (call drop etc.) happens if we consider higher quality signals as threshold statistically which is shown in Fig.7 for urban and in Fig. 8 for rural cases.

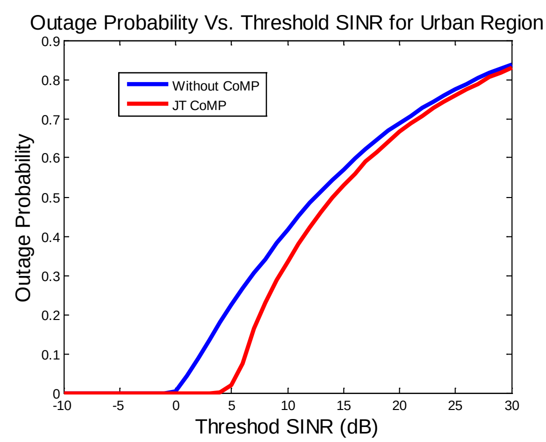

Fig. 7: Outage Probability Vs. threshold SINR for Urban Region.

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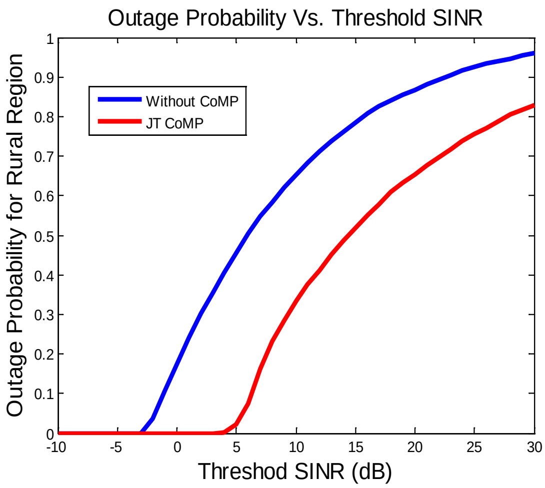

Fig. 8: Outage Probability Vs. threshold SINR for Rural Region.

The difference has also been clear in the outage probability vs radius curve considering fixed threshold $0db$ which is illustrated in Fig.9 for urban and in Fig.10 for rural area.

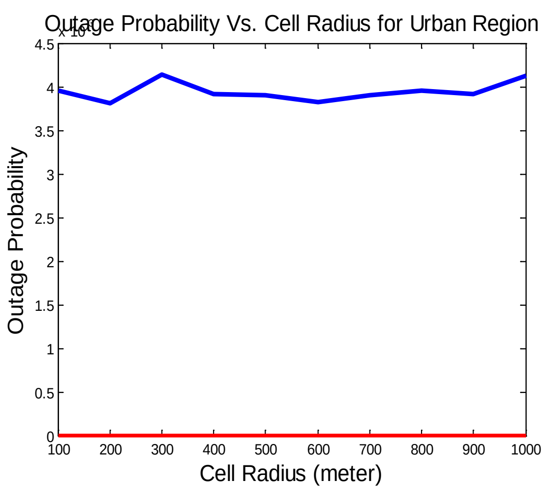

Fig. 9: Outage Probability Vs. cell radius for Urban Region.

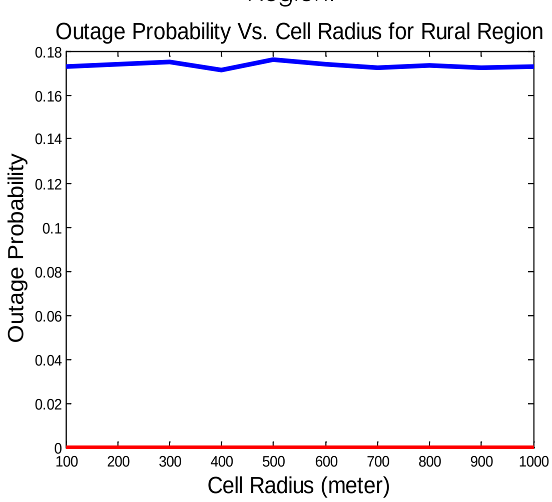

Fig.10: Outage Probability Vs. cell radius for Urban Region.

VI. Conclusion

In this paper, the performance of Joint Transmission Coordinated Multipoint is analyzed using MATLAB and the performance evaluation shows how the CDF and outage probability varies with SINR and cell radius respectively. It also shows that the performance of JT CoMP is obviously better than the traditional techniques in all the aspects analyzed.

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