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Effect of propagation path loss in designing two–tier 5G Het-Nets for coverage and rate

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This paper aims to provide the effect of two important large scale propagation path loss models, namely, the alpha-beta-gamma (ABG) model and the close –in (CI) free space reference distance model for the analysis of achieved coverage and rate in designing two-tier 5G heterogeneous network (Het-Net). 5G communication system is expected to evolve both in architectural (heterogeneous) and new spectral domain (mm-wave frequencies). At first, we have designed a two-tier Het-Net using non-homogeneous poison point process [1, 2] consisting one macro base station (MeNB) and several small base stations (SeNBs) as shown in fig 1. The important parameter such as the ratio of MeNB and SeNB is varied in accordance to density of the users and base stations transmit power to observe the coverage and rate of the designed network.

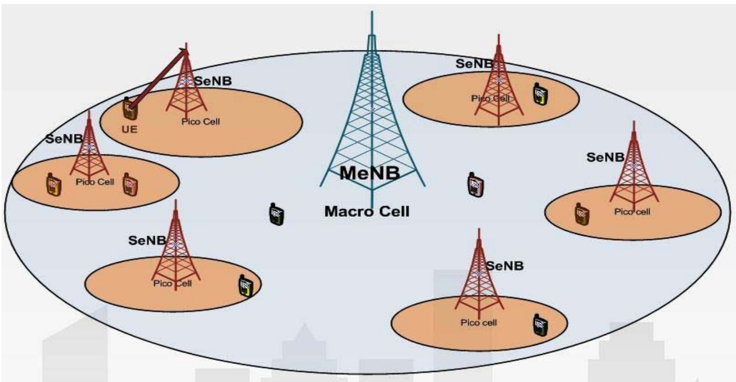


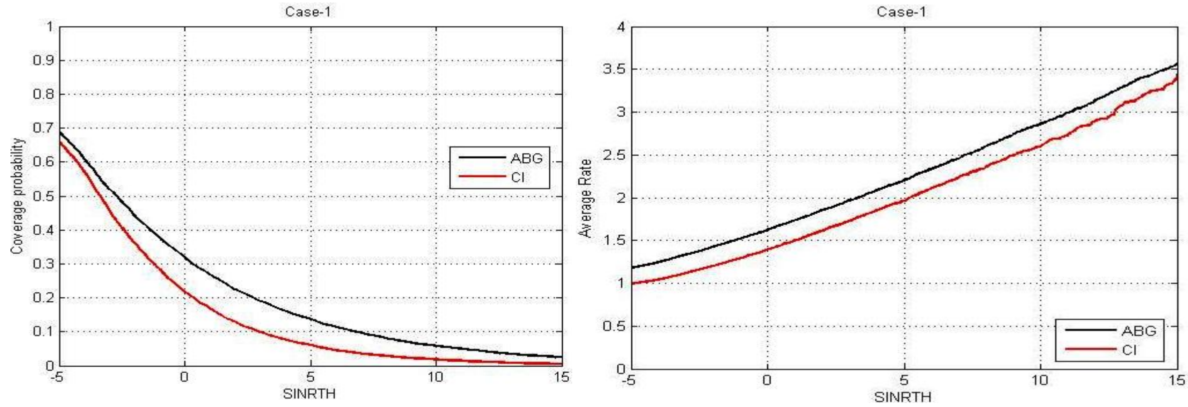
Fig.1 Illustration of a two-tier Het-Net utilizing a combination of macro, pico and femto cell base stations, only a single macro-cell is shown for the sake of simplicity

The propagation models considered in this work has followed the most recent significant work of Rappaport et al. [3] covering the frequency range of 2 GHz to 73.5 GHz. The analysis is based on line of sight (LoS) and non-line of sight (nLoS) propagation environments across varied user's locations. Both the ABG and CI models are generic all frequency models for large scale propagation path loss [3] which are function of distance and frequencies. Moreover, case studies have been performed considering 5G Het-Nets operating in only mm-wave frequencies (Case-1) and combination of terrestrial 4G cellular network frequency and mm-wave frequency (Case-2). The scenario considerations and simulation parameters are included in Table-I.

Table I Scenario considerations and Simulation parameters

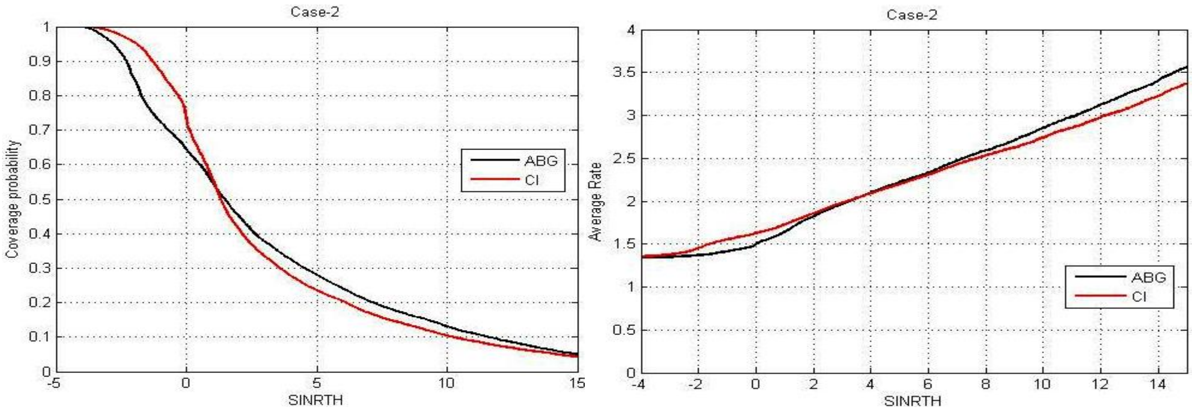
Ratio of density of MeNB to SeNB	$\lambda_{MeNB} : \lambda_{SeNB}$=1:5	
Transmit power (watt) ratio of MeNB and SeNB	$P_{MeNB} : P_{SeNB}$=40:1	
Sub-urban scenario Tele-density	90% approx. (in Indian context)	
Case 1	MeNB	nLoS
	SeNB	LoS
	MeNB operating Freq.	73.5 GHz
	SeNB operating Freq.	60 GHz
Case 2	MeNB	nLoS
	SeNB	LoS
	MeNB operating Freq.	2 GHz
	SeNB operating Freq.	60 GHz

It is very interesting to observe that for mm-waves frequencies used in MeNB and SeNBs, ABG model performs better than CI model as CI model has its inherent frequency dependence path loss in the first one meter of propagation. So for mm-wave frequencies the loss effect is more when both MeNB and SeNB operate in mm-wave rather than MeNB in 2 GHz and SeNB in 60 GHz.



a. b.

Fig.2 Comparison between (a) Coverage and (b) Rate for ABG and CI propagation path loss models for **case 1**



a. b.

Fig.3. Comparison between (a) Coverage and (b) Rate for ABG and CI propagation path loss models for **case 2**

In conclusion it can be said that with a known tele-density (urban/sub-urban) the choices of frequencies for MeNB and SeNB become important in the aspect of propagation path loss to achieve a desired coverage and rate. Further, ABG model provides better results in both of the cases when receiver SINR threshold is kept above 0 dB.

References

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