URSI GASS 2023, Sapporo, Japan, 19 – 26 August 2023

A Study of Multiplexing Efficiency of Small Base Station with Different MIMO Antenna Placements

Wenfu Fu*(1), Bo Xu(2), Sailing He(1)
(1) KTH Royal Institute of Technology, Stockholm, Sweden; e-mail: wenfu@kth.se; sailing@kth.se
(2) Ericsson Research, Ericsson AB, Stockholm, Sweden; e-mail: bo.xu@ericsson.com

The multiplexing efficiency η_{mux} is a simple and intuitive evaluation metric of the multiple-input multiple-output (MIMO) antenna performance [1, 2]. In this study, we apply the multiplexing efficiency to a small cell base station antenna placement scenario. For an $M \times M$ MIMO system, η_{mux} can be calculated by [1, 2]

$$\eta_{\mathrm{mux}} = \det(\mathbf{R})^{1/M}, \tag{1}$$

where the elements r_{ij} in $\mathbf{R}$ is the correlation coefficient of the ith and jth antenna, and can be expressed as

$$r_{ij} = \frac{1}{4\pi}\int \chi E_{\theta,i}(\Omega)E^*_{\theta,j}(\Omega)P_\theta(\Omega) + E_{\phi,i}(\Omega)E^*_{\phi,j}(\Omega)P_\phi(\Omega)\mathrm{d}\Omega. \tag{2}$$

where χ denotes cross-polarization ratio (XPR), $E_{\theta,i}$, $E_{\theta,j}$, $E_{\phi,i}$, $E_{\phi,j}$ are the θ and ϕ components of the radiation pattern for the ith or jth antenna normalized to the realized gain, and Ω is solid angle. Traditionally, P is the probability density function (pdf) of the incident wave that can describe the propagation scenario, and the integral of P over the sphere is 1. While in this study, P is treated as a spatial filter presenting the overall MIMO performance considering many incident-wave scenarios. $P(\Omega_0) = 1$ represents that the environment has an ideal response for the wave incident from Ω_0.

In this study, a four-antenna system with two antenna placements is designed at 3.5 GHz for a small cell base station on the indoor ceiling. The base station is modeled as a perfect electrical conductor (PEC) box of 200 mm $\times$ 200 mm $\times$ 70 mm, as shown in Figure 1. The four patch antennas are placed on the front surface or four sides. For the independent and identically distributed (i.i.d.) environment (dashed line), η_{mux} of two placements is the same. For comparison, when the environment has a better response for the wave incident from the center of the room, P is assumed to follow the normal distribution on the zenith angle θ, i.e., $P \propto \exp(-\frac{1}{2}(\frac{\theta}{\sigma})^2)$, and σ varies from $\pi/6$ to π. The calculation results in Figure 1 show that the antennas placed on the front surface have a higher η_{mux} for the given P since the radiation is towards the center of the room.

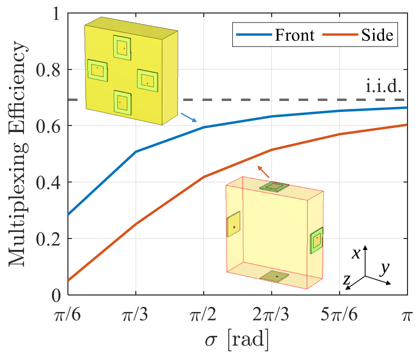

Figure 1. The calculation results of η_{mux} of the four-antenna system with two different placements, comparing with the results for the i.i.d.

References

[1] R. Tian, B. K. Lau and Z. Ying, “Multiplexing Efficiency of MIMO Antennas,” *IEEE Antennas and Wireless Propagation Letters*, vol. 10, 2011, pp. 183–186, doi: 10.1109/LAWP.2011.2125773.

[2] R. Tian, B. K. Lau and Z. Ying, “Multiplexing efficiency of MIMO antennas in arbitrary propagation scenarios,” *2012 6th European conference on antennas and propagation (EUCAP)*, 2012, pp. 373–377, doi: 10.1109/EuCAP.2012.6205897.