

Holistic Evaluation for Ceiling-Mounted MIMO Indoor Base Stations Based on Power-Related Multiplexing Efficiency

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Multiple-input multiple-output (MIMO) antenna systems for indoor base stations (BSs) needs to consider various requirements to maximize the performance in complicated environments. In this study, the evaluation of an $M \times M$ MIMO antenna system is conducted from a holistic perspective using a modified multiplexing efficiency:

$$\bar{\eta}_{\text{MUX}} = \frac{P_{\text{max,tc}}}{P_{\text{max,d}}} \det(\mathbf{R}_t)^{1/M}, \quad (1)$$

where $P_{\text{max,d}}$ is the desired maximum transmitted power level of the MIMO antenna system, $P_{\text{max,tc}}$ is the reduced power level due to electromagnetic field (EMF) exposure compliance, and $\mathbf{R}_t$ is the correlation matrix of the transmitters. $\bar{\eta}_{\text{MUX}}$ is derived from channel capacity and holistically considers antenna performance, deployment scenario, and power constraints.

The calculation of $\bar{\eta}_{\text{MUX}}$ requires the channel properties, in terms of the angular power spectrum $P(\theta, \phi)$ and its polarization ratio $\chi(\theta, \phi)$. For ceiling-mounted indoor BSs shown in Fig. 1, these channel conditions of the BS and a randomly placed user equipment (UE) are specified in 3GPP TR 38.901, which can be used for the evaluation of $\bar{\eta}_{\text{MUX}}$. Using Monte Carlo simulations with a large number of UE positions for a given size of a room, a cumulative distribution function (CDF) of $\bar{\eta}_{\text{MUX}}$ can be obtained. This is an efficient way to evaluate the overall MIMO performance that only needs simple scripts. The resultant $\bar{\eta}_{\text{MUX}}$ CDFs for different antenna designs can indicate their average performance in a given deployment scenario.

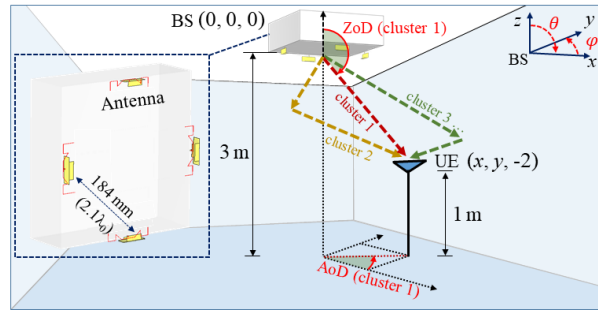


Figure 1: Scheme of the indoor scenario with the ceiling-mounted base station and a single UE. The BS is equipped with four monopole antennas as an example.

The proposed evaluation process can be used as a framework that can easily characterize the overall antenna system performance in realistic deployment scenarios while avoiding the use of complicated link-level or system-level simulations. More importantly, the analytical expression of $\bar{\eta}_{\text{MUX}}$ and its Monte Carlo quantification process can be practically applied to evaluate any MIMO antenna system that requires compliance with EMF exposure limits in specific deployment scenarios. Thus, this study is helpful in cases when the MIMO antenna design needs to be rapidly improved or identify a better design considering EMF power constraints and deployment scenarios.