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# Intelligent Building Design for Wireless Performance

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The development of wireless communications systems is moving towards the deep integration of hardware and software at an ever-increasing pace. This is essential for the development of 6G and beyond wireless systems. Indeed, communications, localization, and sensing will be tightly interlaced to enable future applications.

In our recent work, we have proposed the novel concept of building wireless performance (BWP) [1, 2, 3]. The BWP has been introduced to quantify the effects of building structures on the in-building indoor wireless network performance. Two main BWP figures of merit have been introduced: (i) the interference gain (IG) and (ii) the power gain (PG). Both parameters incorporate fundamental characteristics of wireless communication links which are of paramount importance to the design and optimization of indoor wireless networks. Indeed, the product of the PG and the IG quantifies the effective change of the experienced signal-to-interference-plus-noise-ratio (SINR) of probing user equipment (UE) at a certain indoor location under the impact of building structures relative to the open-space (i.e., free-space propagation channel) environment. We've proposed a framework that will enable the intelligent design of buildings from the point of view of the offered wireless performance by quantifying the impact of the geometry of rooms, i.e., their size, shape, and disposition, on the BWP. In this approach, we integrate the physical properties of a building that, in addition to geometry, also incorporate the electric properties of building materials because together with the deployed antenna systems they fundamentally contribute to achieving optimal WBP. In our initial work, we have assumed idealized conditions where the spatial distribution and the number of the antennas have been "averaged out". These assumptions define a baseline model that shall be interpreted to correspond to either the extreme deployment of distributed massive multiple-input multiple-output antennas or ultra-dense small-cell networks.

As the final goal is to aid in producing intelligent wireless friendly building designs, new more practical system models integrating the finite nature of the number of realistic antennas and base stations are required. Here, two approaches might be identified: system-specific and system-independent wireless-friendly building design. In the first approach, the BWP ought to satisfy specific application requirements, e.g., 5G distributed antenna system at THz frequencies, while, in the second one, the WBP shall be made as future-proof as possible. Both pose great challenges.

We aim to further develop the theoretical foundations and the practical engineering tools to aid architects and civil engineers in the design process of the buildings of the future based on relevant BWP figures of merit. The ultimate intelligent wireless-friendly building process will require a combination of multidisciplinary and interdisciplinary collaborations among wireless engineers, civil engineers, and architects. At the core of this development, we believe that the application of artificial intelligence and machine learning methods will be indispensable. This is an integral part of the grand picture of *the design and characterization of autonomous intelligent wireless devices, environments, and systems for joint communication, localization, and sensing.*

## References

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