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Path-Loss Modeling of Reconfigurable Intelligent Surfaces – Mirror or Diffuser?

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Abstract

In this paper, we will illustrate when a reconfigurable intelligent surfaces behaves as a mirror and as a diffuser

1 Introduction

Future wireless networks will be as pervasive as the air we breathe, not only connecting us but embracing us through a web of systems that support personal and societal well-being. That is, the ubiquity, speed and low latency of such networks will allow currently disparate devices and services to become a distributed intelligent communications, sensing, and computing platform.

Small cells, massive MIMO, millimeter-wave communications are three fundamental technologies that will spearhead the emergence of 5G wireless networks - Their advantages are undeniable. The question is, however, whether these technologies will be sufficient to meet the requirements of future wireless networks that integrate communications, sensing, and computing in a single platform.

Wireless networks, in addition, are rapidly evolving towards a software-defined design paradigm, where every part of the network can be configured and controlled via software. In this optimization process, however, the wireless environment itself - the medium or channel - is generally assumed uncontrollable and often an impediment to be reckoned with. For example, signal attenuation limits the network connectivity, multi-path propagation results in fading phenomena, reflections and refractions from objects are a source of uncontrollable interference.

Recently, a new concept called reconfigurable intelligent surfaces (RISs) has emerged wherein every environmental object is coated with man-made intelligent surfaces of configurable electromagnetic materials. These materials would contain integrated electronic circuits and software that enable control of the wireless medium. Thus, RISs enable telecommunication operators to sculpt the very medium that comprises the network. With the aid of RISs, wireless networks will not be designed anymore to adapt themselves to the environment, but the environment will become part of the optimization space. As such, RISs have the potential to fundamentally change how wireless networks are designed and usher in that hoped-for wireless future. But, RISs are not currently well-understood.

One of the main open and most debated issues in the emerging research field of RISs is the development of a practical, accurate, and tractable path-loss model. In this talk, by using electromagnetic theory, we show when RISs can be modeled as mirrors and diffusers, which directly impacts the path-loss model. Numerical results are illustrated to substantiate the analytical findings. In addition to theory, experimental results by using small-size and large-size RISs will be illustrated.

References

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