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Beyond Diagonal Reconfigurable Intelligent Surfaces: The Next Frontier for Smart Radio Environment

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Abstract

Reconfigurable intelligent surface (RIS) is expected to be a key technology in 6G to enhance wireless systems by efficiently and cost-effectively manipulating the propagation environment. In conventional RIS, each RIS element is independently controlled by a tunable load disconnected from the other elements. Thus, conventional RIS results in a diagonal scattering matrix, also known as a phase shift matrix, which has limited passive beamforming capabilities. To enhance the flexibility of RIS, beyond diagonal RIS (BD-RIS) has been introduced as a generalization of conventional RIS, in which the scattering matrix is not restricted to being diagonal. In this lecture, we review the emerging concept of BD-RIS, showing its promising benefits in terms of performance, coverage, deployment, and flexibility in wave manipulation over conventional RIS. We discuss the modelling and architectures of BD-RIS and compare the performance and circuit complexity of BD-RIS architectures with conventional RIS. We discuss potential applications of BD-RIS in various wireless systems and outline the future research directions for BD-RIS.

Bio

Bruno Clerckx is a (Full) Professor, the Head of the Wireless Communications and Signal Processing Lab, and the Deputy Head of the Communications and Signal Processing Group, within the Electrical and Electronic Engineering Department, Imperial College London, London, U.K. He is also the Chief Technology Officer (CTO) of Silicon Austria Labs (SAL). He received the MSc and Ph.D. degrees in Electrical Engineering from Université Catholique de Louvain, Belgium, and the Doctor of Science (DSc) degree from Imperial College London, U.K. Prior to joining Imperial College in 2011, he was with Samsung Electronics, Suwon, South Korea, where he actively contributed to 4G (3GPP LTE/LTE-A and IEEE 802.16m). He has authored two books on "MIMO Wireless Communications" and "MIMO Wireless Networks", 300 peer-reviewed international research papers, and 150 standards contributions, and is the inventor of 80 issued or pending patents among which several have been adopted in the specifications of 4G standards and are used by billions of devices worldwide. His research spans the general area of wireless communications and signal processing for wireless networks. He received the prestigious Blondel Medal 2021 from France for exceptional work contributing to the progress of Science and Electrical and Electronic Industries, the 2021 Adolphe Wetrems Prize in mathematical and physical sciences from Royal Academy of Belgium, multiple awards from Samsung, IEEE best student paper award, and the EURASIP (European Association for Signal Processing) best paper award 2022. He is a Fellow of the IEEE and the IET, and an IEEE Communications Society Distinguished Lecturer.