Recent Advances in Reconfigurable Antennas and Spatially-Fed Arrays

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Advances in microwave and millimeter-wave technologies and materials have allowed low-cost reconfigurable antennas and spatially-fed arrays to become reality in recent years. Continual advances in these architectures promise to bring compelling new capabilities to radio systems, including high-gain beam-steering for communications and remote-sensing, payload reconfiguration for satellites, and adaptive capabilities for MIMO systems, among others. Prof. Julien Perruisseau-Carrier was a creative and productive researcher in the area of reconfigurable antennas and spatially-fed arrays, and investigated a range of antennas architectures for these applications throughout his brief but prolific research life.

This presentation focuses primarily on recent advances in fixed and reconfigurable space-fed arrays, such as reflectarrays and array lenses, where Prof. Perruisseau-Carrier and the author had shared interests (S. V. Hum and J. Perruisseau-Carrier, IEEE Trans. Ant. Propag., vol. 62, no. 1, pp. 183-198). In the past decade, a range of devices, materials and techniques have emerged that make the design and implementation of spatially fed arrays, particularly those with reconfigurable characteristics, much easier, cost-effective, and compelling. New devices and materials, such as liquid crystals, MEMS, transparent conducting oxides, and graphene have found applications in engineering these antennas. On the techniques side, recently developed analysis methods have allowed reconfigurable reflectarrays and array lenses to be designed at ease with these devices and materials without the need for massive full-wave simulations of the entire array. The recent evolution in interpretation of spatially-fed arrays from an array perspective to a meta-surface / impedance surface perspective has also allowed the performance and capabilities of the architecture to be extended in terms of bandwidth, behavior at oblique angles of incidence, and efficiency. Together these advancements provide spatially-fed arrays with competitive advantages that may enable them to displace conventional array and reflector antennas in certain applications.

Parallel research advances have opened up opportunities for single-antenna reconfigurable antennas. Reconfigurable antennas improve the degrees of freedom in MIMO systems and offer a compelling adaptive handset antenna solution. Work by Prof. Perruisseau-Carrier also demonstrated that reconfigurable antennas can be used to devise efficient MIMO transmission schemes using a single RF chain using so-called beam-space MIMO. Collectively, these examples demonstrate the evolution of the antenna from a simple transducer to a sophisticated active element in the feed chain. Continued progress in reconfigurable antennas promises to reshape future front-ends and space-fed arrays.