History of Adaptive Array Antenna

The adaptive array antennas appeared as the array antenna systems that flexibly receive the desired wave while rejecting the unwanted waves. The term, “adaptive” is used to describe the ability of the systems to change the characteristics by radio environments under which the systems are operating for communications and radars. The adaptive array antennas are composed of array antennas that detect the incident signals and real-time signal processor which automatically adjusts the array pattern. The advent of highly compact, inexpensive and high-speed digital computers has made it possible to employ the adaptive array antennas in wider applications such as mobile communications and advanced driver assistant systems. The functions of the adaptive array antennas are classified into adaptive beamforming and adaptive null steering. The former is to automatically form the mainbeam of the array antenna in the desired direction. The latter is to produce the pattern nulls in the directions of unwanted waves (interference).

In 1964, the first “special issue on active and adaptive antennas” was published by IEEE Transactions on Antennas and Propagation. At that time, it was a fledgling field and characterized by retrodirective and self-steering or self-focusing array systems. It can be said that many researchers focused on automatic mainbeam steering. In 1976, we had the second publication of “special issue on adaptive antennas” by the same IEEE Transactions. It included the adaptive interference nulling as the key capability. After another decade, we reached the third special issue on adaptive antennas in 1986. Just as the difference between the first and second special issues, the third issue differs markedly from the second one due to the inclusion of the key capability for high-resolution spatial spectrum estimation or DOA estimation.

The high-resolution algorithms for DOA estimation have been developed by Pisarenko, Capon, and Schmidt, et al. Among them, Schmidt presented a much-referenced algorithm named MUSIC (Multiple Signal Classification), which provides DOS estimates of multiple signals with high resolution or super-resolution. Currently, MUSIC and other high-resolution algorithms are used in radar systems to detect targets.

Nowadays, the most effective and most attractive technology for a high transmission rate is thought to be multiple-input multiple-output (MIMO). MIMO uses multiple antennas at the transmitter and the receiver both, and enables us to send and receive more than one data signal simultaneously over the same radio channel by exploiting multipath propagation. In MIMO transmission, adaptive array techniques are utilized for signal separation. Moreover, multi-user MIMO (MU-MIMO) systems have recently attracted much attention as a technology that enhances the total system capacity between a base station and multiple user terminals. In MU-MIMO, adaptive array techniques also are used for suppressing inter-user interference. In this way, we can find that adaptive array antennas continue to live in modern wireless systems, and therefore a history of adaptive array antennas changing their performance arenas will be presented in this talk.