Chapter 9
Direction of Arrival (DOA) and Channel Estimation

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ABSTRACT

Future fit demand combined with a flexible technical solution that is by latest wireless technology stands for. Estimating of the user’s location is going to be an integral system with the upcoming mobile technology. This chapter shows some techniques for estimating the direction of arrival (DOA) with mathematical elaboration and simulation results as well. Estimating the DOA in this chapter is regarded to the purpose of using Smart antenna system. It is possible to estimate the location of a user by considering the uplink transmission system of the mobile communication system. Estimating the channel and accurate path delay is also an important task which might be done by using 1D Uniform Linear Array (ULA) or 2D Uniform Rectangular (URA) array antenna system. In this chapter, 1D ULA is considered in order to utilize some popular techniques. The performance of a communication system between two ends is substantially determined by the behaviors of the channel characteristics. It determines signal transformation while propagating through the channel between receivers and transmitters. Accurate channel information is crucial for both the transmitter and receiver ends to perform their best services. The ultimate focus of this chapter is to estimate the channel based on 2D parameter estimation. Uniform Rectangular Array (URA) is used to perform the 2D parameter estimation. It is possible to estimate Azimuth and Elevation of a source by using URA model.

INTRODUCTION

During the last few decades, wireless communication technology was improved enormously. However, the technology did not only perform the communication between two ends. The cutting-edge technologies are not able to meet all the demands required by the people. An interest of recent researchers is to efficiently design a model to estimate the distance, direction, path delay and location of a signal source which might be a mobile user. A proper estimation model technique is very important to identify and
perform those tasks efficiently. Therefore, problem of proper channel estimation arises in a large variety of important applications for the researchers.

In order to meet the demand with the increasing data rate, Third Generation Partnership Project (3GPP) standardized the Long Term Evolution (LTE) and LTE-Advance. It is also one of the most usable technologies nowadays because of its higher spectrum efficiency, low latency, and seamless mobility. MIMO (Multiple Input Multiple Output (MIMO) and Orthogonal Frequency Division Multiple Access (OFDM), the two latest technologies in wireless communication system are adopted in LTE system so that it executes better than any other technologies. Lam et al. (2015) discussed about the frequency reused algorithm for LTE-A system to increase the data rates.

In this chapter, techniques for estimating direction of arrival (DOA) have been just investigated. It is expected for the upcoming mobile generation like 5G that direction of arrival will play a vital role to track the user’s location exactly. The need for DOA estimation increases enormously to keep pace with the technology advances like finding the geographical location of the User Equipment (UE). Positioning has many applications such as emergency services, location-based billing, hostage rescue, etc. In that case, beam pattern of the antenna array can, therefore, be changed without physically changing the antenna pattern. In order to estimate DOA, channel estimation should be measured exactly.

Propagation signals transmitted from arbitrary sources contain a lot of information about the sources which produce them. This information includes the location of the sources, path delays, angular elevation, etc. Using smart antenna technologies, it is possible to estimate that information as well as the channel between two ends.

The antenna array receives spatial samples of propagating wavefield, which are then processed for DOA estimation. DOA estimation technique performs spatial filtering to separate signals from different spatial locations that have overlapping frequency contents (Van et al., 1988). But there are many other techniques also available and some of them will be discussed in this chapter.

A ULA antenna configuration is considered at the receiver where all the antennas are placed in a line and the distance between two adjacent antennas are same. Other array configuration options are also possible, e.g., Uniform Circular Array (UCA), Uniform Rectangular Array (URA). The purposes of using smart antenna system, i.e., MIMO is regarded with the respect of

- Direction of Arrival (DOA) estimation,
- Path delays estimation, and
- Accurate Channel Estimation.

Only estimation of DOA is considered in this chapter.

1. SIGNAL MODEL FOR DOA ESTIMATION

Consider a ULA that consists of $L$ elements and the distance between two adjacent antennas is $d$ according to the Figure 1. It is assumed that total number of sources is $P$. Sources are placed at a distance where near field effect of the receiving antenna array is avoided. Consider a wavefront of a source at an angle $\theta$ from the far field region impinges first on the left most antenna element of the receiving antenna array. Each antenna receives the signal from the same source with a time delay and an amount of phase shift. The fact is that the wavefront of the source signal takes extra time to reach the each antenna element relative to the first element. The Figure 2 exactly shows the geometry of how the signal wavefront arrives.