Chapter 10

Spectral Efficiency in Wireless Networks through MIMO–OFDM System

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ABSTRACT

The traffic in Wireless Sensor Network (WSN) is brusty in nature; when any incident takes place, the data load on the channel increases suddenly demanding large channel spectrum. The scarcity of spectrum is the major technical obstacle for high data rate transmission along with better quality of service in any kind of wireless network. Hence it is very essential to enhance the spectrum efficiency of wireless channel. The major technical advancement in the physical layer which brings feasibility of broadband data transmission without increasing the transmission bandwidth or transmitting power are implementation of Multiple Input Multiple Output (MIMO) communication system with Orthogonal Frequency Division Multiplexing (OFDM) as modulation schemes. This chapter includes the fundamental concept of MIMO-OFDM system along with the channel estimation methods and the spectrum utilization issues therein.

INTRODUCTION

The physical channel established between transmitting and receiving nodes in wireless sensor network are established through wireless link as shown in Figure 1. The information generated at each node being transmitted by the antenna in form of electromagnetic waves.

The traffic generated by nodes is brusty in nature. The nodes remain ideal for most of the time. But they have to transmit large amount of data when any incident takes place. Hence the data load on the channel in WSN system increases suddenly demanding large channel spectrum. The scarcity of spectrum is the major technical obstacle for high data rate transmission along with better quality of service in any kind of wireless network. Hence it is very essential to enhance the spectrum efficiency of wireless channel.

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Generally, the sensor nodes are deployed in such places that the probability of existence of line-of-sight path is very less which introduces frequency-selective nature in the channel. The frequency-selective nature is another major technical bottleneck for wireless broadband transmission.

The major technical advancement in the physical layer which brings feasibility of wireless broadband data transmission without increasing the transmission bandwidth or transmitting power are implementation of multiple input multiple output (MIMO) communication system with orthogonal frequency division multiplexing (OFDM) as modulation scheme. The high rate data transmission through a frequency selective channel using OFDM is possible as the time dispersive effect of the channel is combated by dividing the channel into narrow band, frequency-flat, orthogonal sub-channels and using cyclic prefix of duration much smaller than the OFDM symbol duration. A significant improvement in capacity limit is achieved by using MIMO systems with multiple antennas at transmitting as well as receiving end. The MIMO provides spatial degree of freedom to the system by transmitting multiple data stream through single channel.

The knowledge of channel state information (CSI) is very essential for channel effect compensation and coherent detection of the signal; the system performance is very much dependent on the quality of estimation. The spectral utilization of MIMO-OFDM wireless system is limited in practical scenario as the estimation of channel state information (CSI) in wireless channel is made using a known reference sequence called pilot sequence or training sequence which introduces spectral overhead. The spectral utilization is further decreases to estimate the channel with transmit diversity as the amount of time-frequency resources needed increases linearly with the number of transmitting antenna. The optimum number of pilots to be used is a trade-off between quality of the estimation and the spectral utilization.

This chapter deals with spectral efficiency improvement in wireless networks through MIMO-OFDM system. OFDM provides significant robustness against the frequency-selective nature which is essential for broadband data transmission. MIMO provides parallel transmission path to support high-rate data transmission. It also discusses the channel estimation methods and the spectrum utilization issues therein.