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Re:	OFDM preamble Ad Hoc
Abstract	This document presents and motivates a formula for the number of symbols necessary to accurately estimate a channel impulse response from multiple transmitting antennas
Purpose	OFDM preamble design for MIMO
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Preamble design in (MIMO) Multiple Input/ Multiple Output antenna systems for OFDM/OFDMA systems

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Formula for number of symbols in preamble for channel estimation

Multiple antenna (MIMO) systems will require an extension of the preamble design of single antenna systems in order to perform channel estimation. In particular, the number of symbols used to determine the channel estimate should be given by

$$N_{sym} = 2 * N_{DOF} / N_{FFT}$$

where N_{FFT} is the number of samples in each symbol and N_{DOF} is given by

$$N_{DOF} = N_{chan} * M$$

where N_{chan} is the length of the channel (in samples) and M is the number of antennas. This formula is based on an extension of the general MMSE channel estimation approach presented in [2].

Motivation for preamble length formula

The argument for using multiple symbols when doing channel estimation with multiple antennas goes as follows. The signal received at a CPE antenna from multiple transmit antennas is a linear combination of delayed and attenuated signals received from each transmit antenna. The effect of the channel can be written as

$$s = Xh = [x_{11} x_{12} x_{1N_{chan}} x_{21} \ldots x_{2N_{chan}} \ldots x_{M1} \ldots x_{MN_{chan}}]h$$

where s is the received signal, x_{mn} is the column of samples starting at time n on antenna m, and h is the vector of channel coefficients from each transmit antenna to the receive antenna. The vector h has dimension $M*N_{chan}$ x 1. The MMSE solution for the channel coefficients is the same as the equation for channel estimation given by [2]:

$$h = \left(X^H X\right)^{-1} X^H s$$

where X has dimension K x (N*M), where K is the number of samples. The number of samples K must be greater than MN in order for the matrix ($X^H X$) to be invertible (i.e. nonsingular). Therefore, to estimate the channel impulse response for a MISO system requires at least N*M samples. To obtain an accurate estimate of the channel, we extend this to 2*M*N samples.

The formula for the number of symbols to do channel estimation approximately follows the recommendation for the number of symbols given by [3] for two antennas. In [3], the length of the channel is assumed to be N_{chan}=64 and the number of antennas is 2 (on the transmit side). This implies N_{DOF}=64*2=128 and the number of symbols should be N_{sym}=1. The actual number of symbols used in [3] is 2 because the first half of the first symbol is used for acquisition. The number of samples used for channel estimation is 256 as predicted by the above formula.

Our motivation for using the above formula is that more than two antennas may be used on the transmit side. The preamble structure proposed in [3] is for two antennas. If more than two antennas are used (for increased diversity or beamforming), this formula indicates how many symbols should be used in the preamble for channel estimation.

Conclusion

We proposed that the general formula for the number of symbols in the channel estimation part of the preamble be given by $N_{sym}=2*N_{chan}*M/N_{FFT}$ where the terms are as defined above. This formula allows for accurate measurement of the channel impulse response between multiple transmit antennas and each receive antenna.

References:

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