ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

An Efficient MIMO Periodic Feedback Channels in Wireless Networks

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ABSTRACT:

Advanced wireless technologies such as multiple- input–multiple-output (MIMO) require each mobile station (MS) to send a lot of feedback to the base station. This periodic feedback consumes much of the uplink bandwidth. This expensive bandwidth is very often viewed as a major obstacle to the deployment of MIMO and other advanced closed-loop wireless technologies. This paper is the first to propose a framework for efficient allocation of periodic feedback channels to the nodes of a wireless network. Several relevant optimization problems are defined and efficient algorithms for solving them are presented.
A scheme for deciding when the base station (BS) should invoke each algorithm is also proposed and shown through simulations to perform very well.

Index Terms: Channel state information, wireless networks.

INTRODUCTION:

The idea of TDMA and FDMA gave birth to cellular communications having basic communication standards, and further advanced with higher data rates and increased QoS using emerging technologies. The first generation radio systems named as 1G use analog communications to transmit voice over radio channel. The 2G cellular system is capable of higher data rates use GSM and CDMA technologies. 3G mobile technologies provided users with high data rate mobile access, which developed rapidly during later 90's uses WCDMA air interface. WCDMA is capable of data rates 384 Kbps. UMTS is another 3G air interface supporting data rates up to 14Mbps using WCDMA and HSPA as underlying air interface.

The air interface which were developed so far are based on single carrier modulation and suffers the basic impairments caused by the noisy channel like channel distortions, frequency offset, inter-symbol interference, multipath fading, co-channel interferences etc., Modem design techniques like Pulse Shaping, interpolation, extrapolation at the transmitter and Phase synchronization, carrier recovery, and pulse match demodulation at the receiver helps to reduce the channel distortions and synchronization to some extent but few channel resources like spectrum, high signal power, and additional payload are to be traded.

Empty Guard interval Vs Cyclic Prefixed Guard interval:

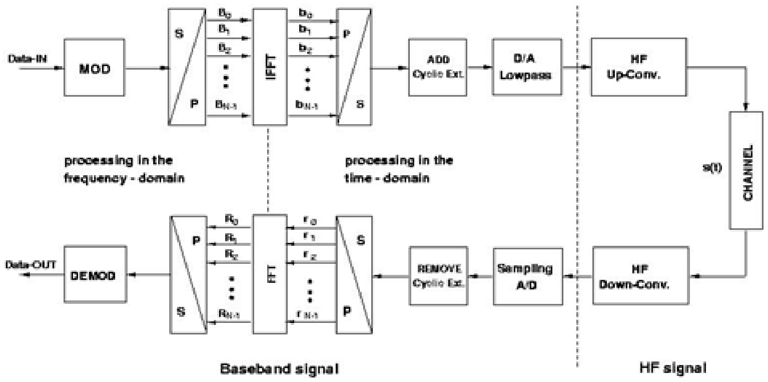
The empty guard interval dose not eliminates Inter Carrier Interference (ICI) aka co-channel interference, ICI resembles the cross talk among different sub carriers in each OFDM symbol. It occurs when ever the sub-carriers sinusoids are no longer an integer number of the cycles, this happens when the sub carriers looses their orthogonality while traveling through the channel. Typically when ever delay occurs, distorted shapes of the subcarriers inside OFDM frames introduce ICI.Cyclic Prefix is used to eliminate the ICI, Cyclic prefix by its nature induces periodicity, and converts the linear convolution to circular between the transmitted symbol and channel impulse response. This periodicity preserves the shape of the sub carriers and only the phase and amplitudes are changed. However this is true when the length of the cyclic prefix is greater than the length of the channel impulse response. The cyclic prefix increases the frame length and this makes the main lobe of sin(x)/x stays for shorter duration and peaks of all the subcarriers are at the same frequency index, thus spectral spacing does not change. As a result each peak of all the sin(x)/x is not at the zero crossing of their adjacent sub-carriers, this introduces ICI, but eventually the cyclic prefix will be removed at the receiver and orthogonality will be preserved. The OFDM signal is constructed by summing a set of delayed complex sinusoids in frequency domain .

$$f(t) = \sum_{k=0}^{N-1} e^{\frac{j2\Pi kt}{Ts}} \quad 2.8$$

The discrete time domain subcarriers are obtained by sampling with t = nT and N = Ts/T.

$$f(n) = \sum_{k=0}^{N-1} e^{\frac{j2\Pi kn}{N}} \quad n = 0,1,2,3\ldots., N-1 \; 2.9$$

The block diagram of the OFDM modem is shown in the figure 2.15. The complex time domain signal can be implemented by applying IFFT and pre pended with the cyclic prefix. The transmitted data signal is demodulated using DFT.



Binary data is mapped to QPSK, QAM symbols and fed into a serial to parallel converter to form a parallel data set as shown in figure 2.14.

$$x(n) = \sum_{k=0}^{N-1} C_k e^{\frac{j2\Pi kn}{N}} \quad n=0,1,2,3,\ldots..N-1 \; 2.10$$

$$C(k) = A(k)e^{j\Phi(k)}$$

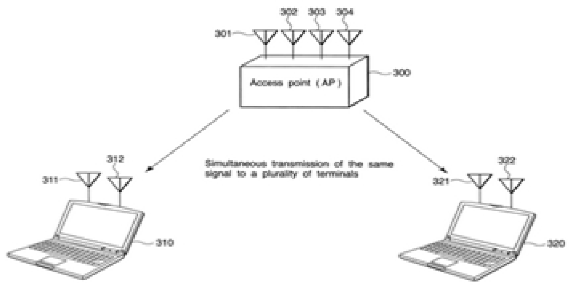
C(k) is the parallel data set which is being modulated using digital modulation techniques such as QPSK, QAM, 64-QAM ect; the parallel data set C(k) is grouped in to frames. The N-point IFFT transforms the frequency domain symbols C(k) into time domain sequence x(n) which is the OFDM frame. The OFDM data along with the cyclic prefix is passed through the parallel-to-serial converter and transmitted through the channel.

The receiver after synchronization and channel estimation and equalization, removes the cyclic prefix and converts the serial data to parallel data. The receiver uses the DFT to undo the effect of IFFT, transforms the time domain signal to frequency domain symbols C(k). The resultant data is demodulated in to binary data.

MIMO:

Multiple Input Multiple Output system has multiple antennas at the transmitter and receiver, is 4G Communication which has high data rates and better QoS. In a MIMO system multiple antennas are spatially separated and create the spectral diversity between them to combat the dense multi-path scattering environment.

A MIMO system can be implemented in many ways, to obtain either diversity gain to combat the signal fading or to obtain capacity gain with increased data rates. Generally, there are three categories of MIMO techniques. The first aims to improve the power efficiency by maximizing spatial diversity; space time block codes (STBC) and space time trellis codes (STTC) are the two techniques used for improving the spatial diversity. The second is the layered approach which improves the capacity of the system, one popular example of such a system is the V-BLAST designed by AT&T where full spatial diversity is not seen. The third type exploits the knowledge of the channel at the transmitter and decomposes the channel co-efficient matrix using singular value decomposition (SVD) and use these decomposed unitary matrix as pre and post filters at the transmitter and receiver.

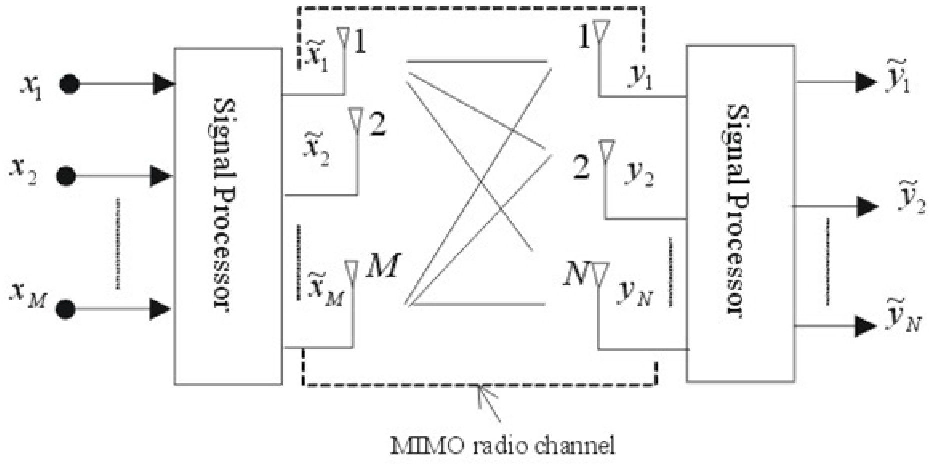


A MIMO System
MIMO system

MIMO systems provide a number of advantages over single antenna communication system.

As shown in figure 3.2 multiple antennas are spatially separated and creates more then one transmit and receive path and increases the spatial diversity. Sensitivity to fading is reduced by the spatial diversity. Under certain environmental conditions, the power requirements associated with high spectral-efficiency communication can be significantly reduced. This is done by distributing energy amongst multiple path modes in the environment.

Spectral efficiency is defined as the total number of total number of bits per second per Hz transmitted from one array to another, which is considerably increased with the space time diversity.



A multiple antenna at transmitter and receiver:

4G is a collection of technologies and standards that will find their way into a range of new ubiquitous computing and communication systems. The key objectives of 4G are to provide reliable transmission with high peak data rates raging from 100 Mbps for high mobility applications to 1Gbps for low mobility applications, high spectrum efficiency up to 10b/s/Hz, and ubiquitous service that can accommodate various radio accesses.

MIMO Channel:

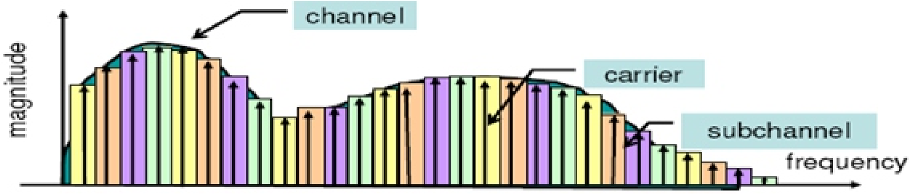
A MIMO channel with nT transmitters and nR receivers is typically represented as a matrix H of dimension nR × nT, where each of the coefficients [H]i,j represents the transfer function from the jth transmitter to the ith receiver. We denote the signal or symbol transmitted from the jth transmitter xj, and collect all such symbols into an nT- dimensional vector x. With this notation, the matrix model of the channel is

y = Hx + w where w is a vector of additive noise 3.1
The MIMO channel is represented in a matrix form

$$H = \begin{bmatrix} h_{11} & \cdots & h_{1N_t} \\ h_{21} & \cdots & h_{2N_t} \\ \vdots & \ddots & \vdots \\ h_{N_R 1} & \cdots & h_{N_r N_t} \end{bmatrix}$$

MIMO-OFDM:

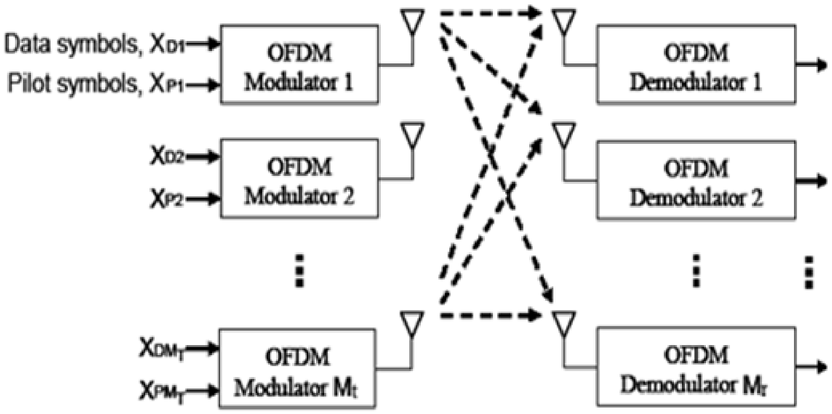
OFDM converts a frequency-selective channel into a parallel collection of frequency flat sub channels as shown in figure 4.1. The subcarriers have the minimum frequency separation required to maintain orthogonality of their corresponding time domain waveforms, yet the signal spectra corresponding to the different subcarriers overlap in frequency. Hence, the available bandwidth is used very efficiently.



Frequency selective fading channel converted to Flat fading channels

OFDM is a block modulation scheme where a block of N information symbols is transmitted in parallel on N subcarriers. The time duration of an OFDM symbol is N times larger than that of a single-carrier system. An OFDM modulator can be implemented as an inverse discrete Fourier transform (IDFT) on a block of information symbols followed by an analog-to-digital converter (ADC). To mitigate the effects of inter symbol interference (ISI) caused by channel time spread, each block of IDFT coefficients is typically preceded by a cyclic prefix (CP) or a guard interval consisting of samples, such that the length of the CP is at least equal to the channel length. Under this condition, a linear convolution of the transmitted sequence and the channel is converted to a circular convolution. As a result, the effects of the ISI are easily and completely eliminated. Moreover, the approach enables the receiver to use fast signal processing transforms such as a fast Fourier transform (FFT) for OFDM implementation.A MIMO system takes advantage of the spatial diversity that is obtained by spatially separated antennas in a dense multi path scattering environment. MIMO systems may be implemented in a number of different ways to obtain either a diversity gain to combat signal fading or to obtain a capacity gain

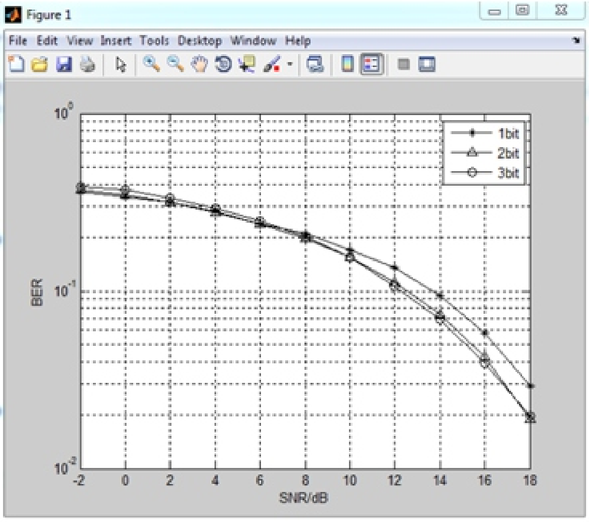
Generally, there are three categories of MIMO techniques. The first aims to improve the power efficiency by maximizing spatial diversity. Such techniques include delay diversity, space–time block codes (STBC) and space–time trellis codes (STTC). The second class uses a layered approach to increase capacity. One popular example of such a system is V-BLAST suggested by Foschini et al. where full spatial diversity is usually not achieved. Finally, the third type exploits the knowledge of channel at the transmitter. It decomposes the channel coefficient matrix using singular value decomposition (SVD) and uses these decomposed unitary matrices as pre- and post-filters at the transmitter and the receiver to achieve near capacity MIMO is known to boost the capacity. For high data rate transmission, the multi path characteristics of the environment cause the MIMO channel to be frequency selective. OFDM can transform such a frequency selective MIMO channel in to a set of parallel frequency flat MIMO channels and therefore decrease the receiver complexity. The combination of the two powerful techniques, MIMO and OFDM, is very attractive and has become a most promising broadband wireless access.

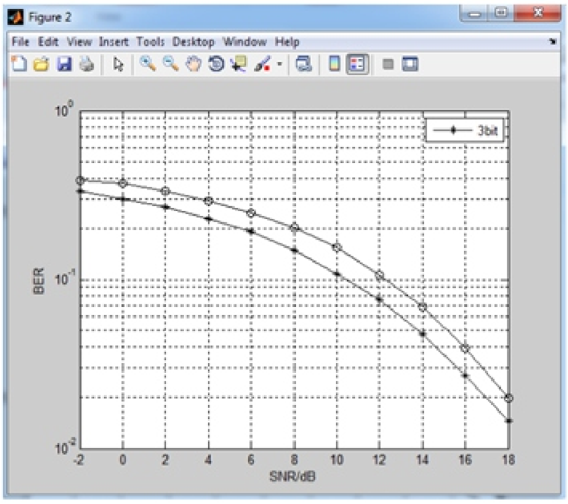


MIMO-OFDM

Similar to the SISO OFDM system, a MIMO OFDM (figure 4.2) is very sensitive to carrier frequency offset (CFO), which introduces inter carrier interference (ICI). Accurate frequency synchronization is essential for reliable reception of the transmitted data symbol. Various carrier synchronization schemes have been proposed for OFDM systems and relay up on the pilot or preamble data.

RESULTS:





CONCLUSION and FUTURE SCOPE:

We presented the Technique called lateration technique by implementing this technique to the OFDM base station the bandwidth can be powerfully obtained. The requirement of the corresponding requested mobile nodes the bandwidth can be allocated and the overall profit of the system can increased. Hence the entire bandwidth allocation can be done by the OFDM base station and its results to the deployment of Multiple input Multiple output (MIMO) is not expensive. In the MIMO technology due to the nodes colliding frequency the delay tolerance, flow rate will affect the system performance. By implementing the maximum-minimum algorithm to the OFDM base station the collision will be eliminated and the maximum throughput can be achieved.

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