Research Paper Engineering

An Efficient Mimo-Ofdm Based Advanced Lte Standard for Next Generation Wireless Networks

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ABSTRACT

Designing very high speed wireless links that provide good quality of service and its range capability in non-line-of- sight (NLOS) environments form a significant research and engineering challenge. This report is intended to provide an analytical overview and performance analysis, on the key issues of an emerging technology known as Multiple-Input Multiple-Output (MIMO) wireless technology with Orthogonal Frequency Division Multiplexing (OFDM) is an attractive air-interface solution for next generation wireless networks and this technology provide significant promise in achieving high data rates over wireless links and which is used to enhance system capacity and robustness of the wireless transmission. In order to meet the strong demand for wireless broadband services advanced Long Term Evolution (LTE) standard supports very high data rate transmissions over wide frequency bandwidths. With the increasing demand for data rate and reliability in Wireless communications and devices, several Issues become very important like bandwidth efficiency, quality of service and radio coverage.

KEYWORDS Adaptive antennas, broadband wireless, multiple-input multiple-output (MIMO), orthogonal frequency division multiplexing (OFDM), LTE advanced, cognitive radio (CR) systems, space–time coding, synchronization. Radio scheduling

INTRODUCTION

OFDM is a Multicarrier modulation technique which is used for data transmission by dividing high bit rate data streams into several parallel low bit rate data streams and these low bit rate data streams are used for modulate several carriers multicarrier transmission as lot of useful properties such as delay spread tolerance and spectrum efficiency that encourage their use in untethered broadband communications that has gained a lot of popularity among the broadband community in the last few years. MIMO technology holds the potential to severely improve the spectral efficiency and link reliability in future wireless networks while the OFDM transmission scheme turns the frequency selective into a set of parallel flat fading channels, which is an attractive way of coping with Inter-Symbol-Interference (ISI).The combination of MIMO and OFDM has been designed to improve the data rate and QoS in wireless communication systems.

The name 'OFDM' is derived from the fact that the digital data is sent using many carriers, each of a different frequency (Frequency Division Multiplexing) and these carriers are orthogonal to each other, hence Orthogonal Frequency Division Multiplexing

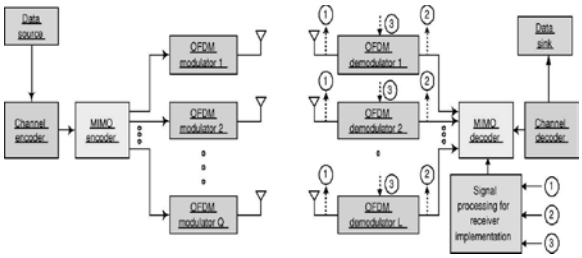
The combination of MIMO and OFDM has been designed to improve the data rate and hence QoS by adopting the multiplexing gain and the diversity gain. In OFDM, usable bandwidth is divided into a large number of smaller bandwidths that are mathematically orthogonal using fast Fourier transforms (FFTs). Reconstruction of the band is performed by the inverse fast Fourier transform (IFFT).

As of the digital wireless revolution made mobile phones available for everyone, the higher speed and packet delivering of 4G Networks will make high quality multimedia available everywhere. The Key to achieving this higher level of Service delivery is a new air interface. OFDM is an alternative wireless modulation technology to CDMA. OFDM has the potential to surpass the capacity of CDMA systems and provide the wireless access method for 4 G systems. Research is going on, on better development of 4th generation (4G) and next generation of mobile communication systems. The commercial rollout of these systems started around 2009 and replaced 3rd generation technology. In addition to high data rates, future systems must support a higher Quality Of Service (QOS) than current cellular systems, which are designed to achieve 90 - 95% coverage i.e. network connection can be obtained over 90 - 95% of the area of the cell. In order to achieve this level of QOS it will require the communication system to be more flexible and adaptive. In many applications it is more important to maintain network connectivity than the actual data rate achieved. Thus providing QoS while optimizing the Long Term Evolution (LTE) network in a cost efficient manner is very challenging. In addition, LTE standards define a new air interface that is based on the concept of OFDM. The radio scheduling is one of the most important functions in mobile broadband networks. The design of a mobile network radio scheduler holds several objectives that need to be satisfied, for example: the scheduler needs to maximize the radio performance by efficiently distributing the limited radio resources, since the operator's revenue depends on it. If the transmission path is very poor, e.g. in a building basement, then the data rate has to drop to maintain the link. Thus the data rate might vary from as low as 1 kbps in extreme conditions, to as high as 20 Mbps for a good transmission path. Alternatively, for applications requiring a fixed data rate, the QoS can be improved by allocating additional resources to users with a poor transmission path. A significant improvement in spectral efficiency will be required in order for 4G systems to provide true broad band access. This will be only achieved by significant advances in multiple aspects of cellular network systems, such as network structure, network management, smart antennas RF modulation, user allocation and general resource allocation.

II.MIMO-OFDM SYSTEM MODEL

Multiple antennas can be used at the transmitter and receiver, that is called a multiple-input multiple-output (MIMO) system. A MIMO system takes advantage of the spatial diversity that is obtained by spatially separated antennas in a dense multipath 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 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.



Broadband MIMO-OFDM systems with bandwidth efficiencies on the order of 10 b/s/Hz are feasible for LAN/MAN environments. The physical (PHY) layer techniques described in this paper are intended to approach 10 b/s/Hz bandwidth efficiency. All MIMO-OFDM receivers must perform time synchronization; frequency offset estimation, and correction and parameter estimation. This is generally carried out using a preamble consisting of one or more training sequences. Once the acquisition phase is over, receiver goes into the tracking mode.

Multiple antenna technologies are emerging to achieve high rate, high reliability, and long range communications. Spatial multiplexing gained importance for its bandwidth conservation and power efficiency. It involves deploying multiple antennas at the transmitter and at the receiver. Recent developments in MIMO techniques promise a significant boost in performance for OFDM systems.

Fig 1. Q×L MIMO-OFDM system, where Q and L are the numbers of inputs and outputs, respectively

This increases the data rate into multiple folds with the number equal to minimum of the number of transmit and receive antennas. This is called MIMO (as a branch of intelligent antenna).

Fig.1 shows a typical MIMO-OFDM implementation.

Let $\mathbf{X}=\{X_0 X_1 \ldots X_{N-1}\}$ denote the length-N

$$\mathbf{X}\mathbf{x}=\{x_0 x_1 \ldots x_{N-1}\} x_n=N\{X_k\}(n).$$

To mitigate the effects of channel delay spread, a guard interval comprised of either a CP or suffix is appended to the sequence $\mathbf{X}$. In case of a CP, the transmitted sequence with guard interval is

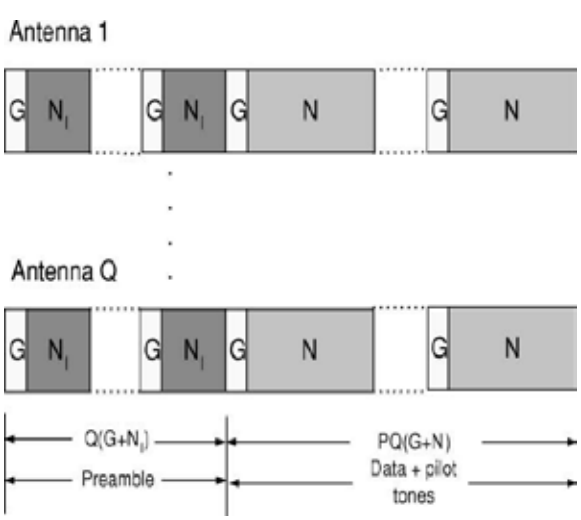


Fig. 2. Frame structure for the **Q 2 L** OFDM system.

$$x$$

$$g_n=x(n)_N n=-G,\ldots,-1,0,1,\ldots,N-1$$

Where G is the guard interval length in samples, and $(n)_N$ is the residue of n modulo N. The OFDM complex envelope is obtained by passing the sequence $\mathbf{x}^g$ through a pair of ADCs (to generate the real and imaginary components) with sample rate $1/T$ s, and the analog I and Q signals are up converted to an RF carrier frequency. To avoid ISI, the CP length G must equal or exceed the length of the discrete-time channel impulse response M. The time required to transmit one OFDM symbol $T_s=NT+GT$ is called the OFDM symbol time. The OFDM signal is transmitted over the pass-band RF channel, received, and down converted to base band. Due to the CP, the discrete linear convolution of the trans-mitted sequence with the channel impulse response becomes a circular convolution. Hence, at the receiver the initial G samples from each received block are removed, followed by an N-point discrete Fourier transform (DFT) on the resulting sequence.

The frame structure of a typical MIMO-OFDM system is shown in Fig. 2. The OFDM preamble consists of Q training symbols of length N_I+G, where $G \le N_I \le N$, $N_I=N/I$ and I an integer that divides N. Often the length of the guard interval in the training period is doubled; for example, in IEEE802.16a [1], to aid in synchronization, frequency offset estimation and equalization for channel shortening in cases where the length of the channel exceeds the length of the guard interval.

First consider the preamble portion of the OFDM frame. The length-N_I+G preamble sequences are obtained by exciting every Ith coefficient of a length-N frequency-do-main vector with a nonzero training symbol from a chosen alphabet (the remainder are set to zero). The frequency-do-main training sequences transmitted from the ith antenna are $\{S(q)\}_N$, where $q=(c-1)Q+i$ and $c=1,2,\ldots,Q$ The individual length-N_I time domain training sequences are obtained by taking an N -point IDFT of the sequence

( )

, keeping the time-domain first coefficients and discarding the rest. A CP is appended to each length-

time-domain sequence.

Let be the vector of $\{S_k^q\}_{k=1}^N$ N_I sub channel N_I

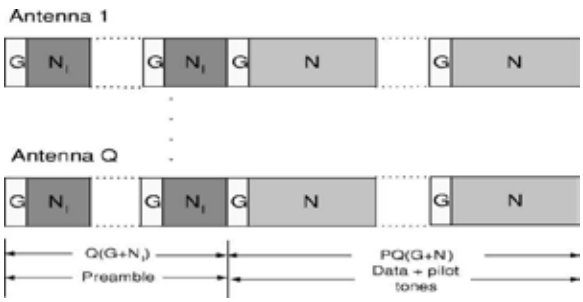
$\mathbf{H}_{ij}$

Coefficients between the ith transmit and the jth receive antenna and let $\{R0\}_{N_I-1}$ be the received sample sequence at the lth receiver antenna.

III .LTE Advanced

In order to achieve up to 1 Gb/s peak data rate in future IMT-Advanced mobile systems, carrier aggregation technology is launched by the 3FPP in order to achieve very high data rate transmissions over wide frequency bandwidths (e.g.up-to 100MHz) in its new LTE Advanced standards. In order to meet the demand for wireless broadband services from fast-growing mobile users, the International Telecommunication Union (ITU)) has initiated the standardization process of the next-generation mobile communication systems, entitled IMT-Advanced or for the next generation mobile systems. According to the performance and technical requirements defined in future IMT-Advanced systems can support very high peak data rates for mobile users, up to 1 Gb/s in static and

pedestrian environments, and up to 100 Mb/s in high-speed mobile environment. Two international standardization organizations, the Third Generation Partnership Project (3GPP) and IEEE 802.16 Working Group (WG), are actively developing new mobile communication standards for achieving the ambitious performance goals of IMT-Advanced mobile systems. In particular, 3GPP has completed its Long Term Evolution (LTE) standards family Release 8 (R8), which defines and specifies new functions, characteristics and key technologies for beyond 3G (B3G) mobile system.



The LTE standards will be further improved to become the LTE-Advanced Standards, which will be submitted to the ITU as candidate technical standards for IMT-Advanced systems. The IEEE 802.16 WG is developing an extension of its fixed broadband wireless access standard, called 802.16m, to meet the technical and performance requirements of IMT-Advanced.

IV. Future Research

Based on the solutions discussed throughout this paper, we demonstrated a number of significant benefits brought about by the GAs for wireless communications. It is worth pointing out that the proposed GAs may be further improved in various ways. For example, the value of the mutation probability can be adapted according to the number of users and/or the GA's generation index. Furthermore, the GA's population-based soft output [can be improved, if the OSs of all meritorious individuals are stored throughout all generations, which may be used for improving the reliability of the GA's soft output. Additionally, the GA individual's symbol chromo-some, which consists of the multiple users' hard-decoded symbol estimates, may also be represented by the soft bit estimates, enabling the GA to benefit from the soft information provided by the channel decoders during the external iterative processing. This is expected to improve the performance of the iterative GAs, such as those used in the IGA MUD of and in the GA-JCE-MUD of , Moreover, the joint channel estimation and symbol detection approach of [can also be further enhanced by introducing a soft-input soft-output mechanism. More specifically, not only the GA-optimized FD-CHTF estimates, but also the GA-optimized symbol estimates can be forwarded to the first-stage MUD for assisting in the initial symbol detection invoked in the next iteration.

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