An Efficient MIMO-OFDM Based Advanced LTE Standard with QoS for Next Generation Wireless Networks

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Abstract: Multiple-Input Multiple-Output (MIMO) wireless systems using OFDM promise to provide the needed performance for future consumer products. Multiple-input multiple-output (MIMO) techniques have been actively pursued in underwater acoustic communications recently to increase the data rate over the bandwidth-limited channels. In this paper, we present a MIMO system design, where spatial multiplexing is applied with OFDM signals for LTE network. Providing QoS while optimizing the LTE network in a cost efficient manner is very challenging. Thus, radio scheduling is one of the most important functions in mobile broadband networks. In this paper we are implementing MIMO-OFDM systems for LTE standards for mobile communication.
Keywords: MIMO-OFDM, LTE, FFT, QoS.

I. 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 broad band communications that has gained a lot of popularity among the broad band community in the last few years. In this paper, different computerized balance procedures Such as BPSK, QPSK, 8-PSK and 16-PSK are analyzed if there should arise an occurrence of bit mistake rate and usage of data transmission Orthogonal Frequency Division Multiplexing(OFDM) is an option Wireless tweak innovation to CDMA. OFDM can possibly surpass the limit of CDMA frameworks and give the remote access strategy to 4G frameworks. OFDM is a regulation plan that permits advanced information to be proficiently and dependably transmitted over a radio channel, even in bearers. These bearers are frequently separated in recurrence, and framing a square range. The recurrence dispersing and time synchronization of the bearers is picked in such a route, to the point that the transporters are orthogonal, implying that they don't result in obstruction to one another. This is regardless of the transporters covering one another in the recurrence area. 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, henceOrthogonal

Frequency Division Multiplexing. The main reason of using OFDM is because here the symbol detection is easy and also to increase robustness against frequency selective fading and narrow bandinterference.

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). Orthogonal frequency division multiplexing (OFDM) has become a popular technique for transmission of signals over wireless channels. OFDM has been adopted in several wireless standards such as digital audio broadcasting (DAB), digital video broadcasting (DVB-T), the IEEE 802.11a. Local area network (LAN) standard and the IEEE 802.16 a metropolitan area network (MAN) standard. OFDM is also being pursued for dedicated short-range communications (DSRC) for road side to vehicle communications and as a potential candidate for fourth-generation (4G) mobile wireless systems. Manuscript received June 23, 2003; revised November 3, 2003. This work was supported in part by the Yamacraw Mission and in part by the National Science Foundation under Grant CCR-0121565. The authors are with the School of Electrical and Computer Engineering, Georgia Institute of Technology, Atlanta, GA 30332 USA. Digital Object Identifier 10.1109/JPROC.2003.821912 OFDM converts a frequency-selective channel into a parallel collection of frequency flat subchannels. 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. If knowledge of the channel is available at the transmitter, then the OFDM transmitter can adapt its signaling strategy to match the channel. Due to the fact that OFDM uses a large collection of narrowly spaced subchannels, these adaptive strategies can approach the ideal water pouring capacity of a frequency-selective channel. In practice this is achieved by using adaptive bit loading techniques, where different sized signal constellations are transmitted on the subcarriers. In the past few years, fundamental research has demonstrated great potentials of cognitive radio (CR) in increasing the spectrum agility and system capacity of wireless communications systems. With the ability to detect and adapt to the surrounding environment, CR has become one of the widely recognized features for future wireless communication systems. Specifically, CR has been recommended as a key technology to solve the spectrum scarcity problem in the next generation cellar networks. For example, the IEEE 802.16h standard was recently published for the license-exempt operation of WiMAX networks by defining a set of CR capabilities. On the other hand, a lot of efforts are being made to introduce CR features into 3GPP LTE-Advanced.

II. OFDM TRANSMITTER ANDRECEIVER

Fig1 shows the configuration for a basic OFDM transmitter and receiver. The signal generated is at baseband and so to generate an RF signal the signal must be filtered and mixed to the desired transmission frequency.

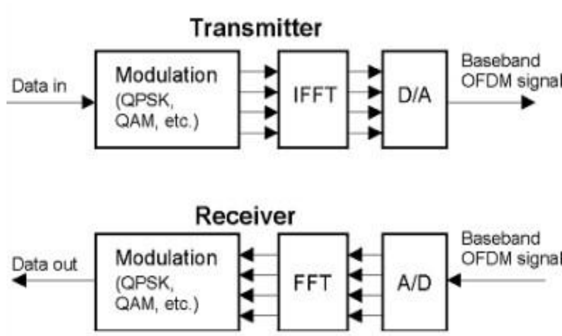

Fig1. Basic FFT, OFDM Transmitter and Receiver. Design of OFDM_Tx:

Input Sampler IQ Gen: This block samples the Serial input and generates 2 bit IQ output.

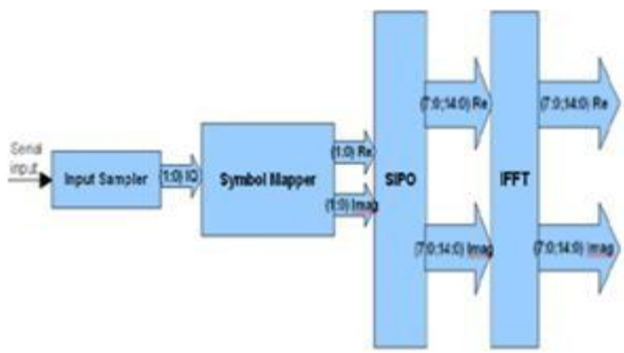

Fig2. Design of OFDM_Tx

Symbol Mapper: This block maps the input I, Q to the corresponding to the real part and imaginary part of the constellation symbols.

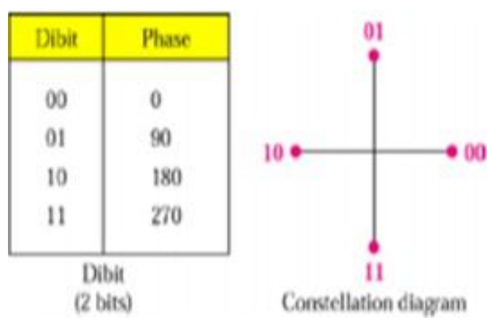

Fig3. SymbolMapper.

SIPO: This block converts the serial input to the parallel output. This block is used in OFDM TX, to convert serial input to parallel output.

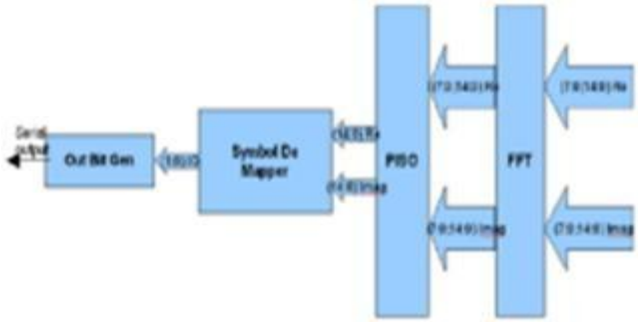

Fig4. OFDM Receiver.

PISO: This block converts the parallel input to the serial output. This block is used in OFDM RX, to convert parallel input to serial output.

Symbol_ de_mapper Symbol_Demapper: This block maps, the Real and imaginary parts of the serial out from PISO, to the IQ corresponding to the real part and imaginary part of the constellation symbols. It extracts the IQ values from the serial out of PISO.

Out_bit_gen: This block takes 2-bit IQs from Symbol_ de_mapper and generates output bits.

Clk distr: This is the clock distributer block, which generates two enable signals en_div_2 and en_div_16. en_div_2 is divided by 2 of input clock. en_div_16 divided by 16 of input clock.

III. MIMO-OFDM SYSTEMMODEL

A multicarrier system can be efficiently implemented in discrete time using an inverse FFT(IFFT)to act as a modulator and an FFT to act as a demodulator. The transmitted data are the “frequency” domain coefficients and the samples at the output of the IFFT stage are “time” domain samples of the

transmitted waveform. Fig. 1 shows a typical MIMO-OFDM implementation.Letx={x_0,x_1, x_{N-1}}denote thelength-
N data symbol block. The IDFT of the date block X yields the time domainsequencex={x_0,x_1, x_{N-1}},i.e.,

$$X_n=IFFT_N\{X_k\}(n) \qquad (1)$$

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

$$X^g_n=x_{(n)N},n=-G,\dots,-1,0,1,\dots N-1 \qquad (2)$$

Where Q and L are the numbers of inputs and outputs, respectively.

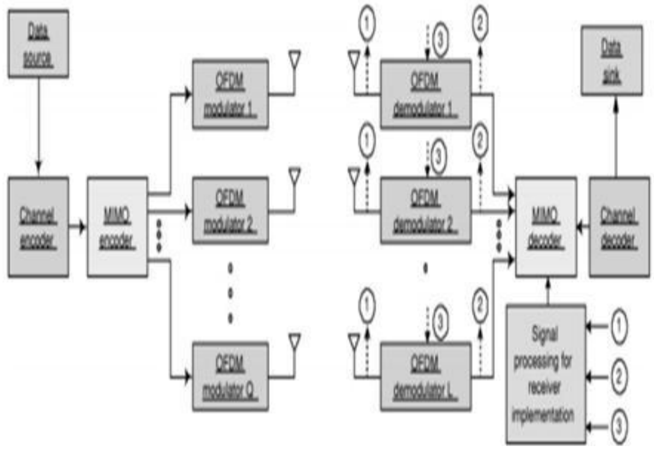

Fig.5.MIMO-OFDM system.

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 X^gthrough a pair of ADCs (to generate the real and imaginary components) with sample rate 1/Ts, and the analog I and Q signals are upconverted to an RF carrier frequency. To avoid ISI, the CP length must equal or exceed the length of the discrete-time channel impulse response of the law impose heavily on the choice of carrier frequency. No such constraints exist for the intermediate frequency however Mathematically however there is no difference in the way we treat the bandpass signals around each of thesefrequencies.

A. Bandwidth

The concept of bandwidth comes from the definition of the Fourier Transform. The Fourier Transform also introduced the concept of negative frequency and we saw that the real part of the FT of a real function of time is even and is therefore a symmetric function for positive and negative frequencies. Similarly the imaginary part of the FT of a real function of time is odd and is therefore an antisymmetric function for positive and negative frequencies. Thus the FT of a baseband signal has positive and negative frequencies Near the origin of frequency and the FT of a bandpass signal consistsof positive and negative frequencies eachindividually centred around the carrier frequency of ±fc. Much of the material to follow will rely on a concept of bandwidth and we will use the following definition. The bandwidth of a signal consists of the total span of positive frequencies in which the energy of the signal is contained. Consider the following figure which shows several spectra. From the above definition, the top baseband spectrum has bandwidth B. The second bandpass spectrum also has spectrum B. Finally the third bandpass spectrum ha bandwidth 2B.

B. OrthogonalFunctions

In digital communications it is important to make every effort we can to transmit pulse shapes representing digital symbols which are as different from each other as possible. This clearly facilitates the decision process at the receiver aimed at distinguishing the signals. There are a number of ways that we can make pulse shapes in the time domain distinguishable. For example, suppose that we only have two symbols in our alphabet (binary signalling), then one technique is to give each pulse shape opposite signs. This is just Binary Phase Shift Keying (BPSK) and we are free to choose any pulse shape we like. The method of altering the sign is also referred to as antipodal signalling. Antipodal signalling is one of the easiest to distinguish at a receiver but it is fairly limited in that there are only two signs to play with! A technique which allows an arbitrary number of symbol shapes to be distinguishable is orthogonal signaling. Orthoginality describes the degree to which a pair of different pulse shapes is independent or unrelated.

Functions φn(t) and φm(t) are orthogonal with respect to each other over the interval a < t <b.

IV. ADVANCED LTE STANDARDWITH MIMO-OFDM

In the past few years, fundamental research has demonstrated great potentials of cognitive radio (CR) in increasing the spectrum agility and system capacity of wireless communications systems. With the ability to detect and adapt to the surrounding environment, CR has become one of the widely recognized features for future wireless communication systems. Specifically, CR has been recommended as a key technology to solve the spectrum scarcity problem in the next generation cellar networks. For example, the IEEE 802.16h standard was recently published for the license-exempt operation of WiMAX networks by defining a set of CR capabilities. On the other hand, a lot of efforts are being made to introduce CR features into 3GPP LTE-Advanced. Evidently, integrating CR technologies into future generation cellular networks is becoming more and more important and will attract significant attention from both academia and industry. However, despite the large amount of research work conducted in recent years, there are still many open problems in developing and deploying large-scale CR-enabled cellular networks, from strategic design to technical implementation. To promote the investigation of CR technologies for next generation cellular networks, we have planned this Feature Topic to help both the industry and academia research communities to better understand the recent progress and

potential research directions. The response to our Call for Papers on this special issue was overwhelming, with a large number of articles submitted from around the globe. During the review process, each article was assigned to and reviewed by at least three experts in the relevant areas, with a rigorous two-round review process. Thanks to the courtesy of the Editor-in-Chief of IEEE Wireless Communications, Dr. Hsaio-Hwa Chen, we were able to accept 12 excellent articles covering various aspects of next generation cognitive cellular networks.

In "Expand LTE Network Spectrum with Cognitive Radios: From Research to Implementation," the authors study how to improve the performance of cellular networks by incorporating CR technology. Specifically, they consider a CR-enabled Long Term Evolution (LTE) system, based on which the authors survey the literature on enabling technologies, standards, and regulations. They also develop a prototype that demonstrates the feasibility of utilizing TV white space in cellular network. To utilize CR technology for cellular networks, spectrum sharing is a key concern of many mobile network operators. In "Simple Rules for Mobile NetworkOperators"StrategicChoicesinFutureCognitive Spectrum Sharing Networks," the authors discuss this issue. They first review the existing spectrum sharing framework from the perspective of regulatory, technology, and business models. They then present a dynamic spectrum sharing framework, so-called Simple Rules, for mobile network operators, including incumbents and challengers. Their study may help network operators adopt CR technology in future cellular network. In "On the Scalability of Cognitive Radio: Assessing the Commercial Viability of Secondary Spectrum Access," the authors present an inspiring report on the commercial applicability of the CR system. Based on their research project, which was funded by European Union FP7, the authors evaluate several application scenarios and argue that some applications, in particular, wide area mobile broadband access, are not feasible from both the business and technique perspectives. On the other hand, indoor and short- range communication scenarios are more attractive because of the lower cost of CR systems and simpler spectrum management.

To exploit CR technology in future cognitive cellular networks, a number of challenges have to be addressed, including the scalability of the system, the complexity of architecture, the heterogeneous of system, and the dynamics of spectrum, etc. Aiming at addressing these issues, the authors of "Self-

Organization Paradigms and Optimization Approaches for Cognitive Radio Technologies. A Survey" suggest that self-organizing shall be taken into consideration in the design of CR systems. Particularly, they present a nice survey on the self-organization aspects of various elements in CR systems. In "Cognitive Femtocell Networks: An Opportunistic Spectrum Access for Future Indoor Wireless Coverage," the authors investigate how to integrate CR technology into fem to cell architecture. In their study, they first identify three interference mitigation schemes, and then propose a joint opportunistic interference avoidance scheme based on interweave CR. Numerical results show that the proposed scheme can achieve considerable gain for indoor applications. To exploit the potential of CR in a cellular network, a key challenge is how to handle the coexistence and self-coexistence issues. To address this challenge, the authors of "Self-Coexistence in Cellular Cognitive Radio Networks Based on the IEEE 802.22 Standard" consider the self- coexistence issue as a channel assignment problem. In particular, assuming IEEE 802.2 as the standard, the authors propose two channel assignment schemes in cognitive cellular network with cooperative and non-cooperative cells, respectively. They also conduct extensive numerical study to investigate the pros and cons of difference schemes in terms of throughput, complexity, and fairness to users. Certainly, to implement cost-effective CR systems, there are a lot of technical challenges to be addressed. In "Design and Implementation of Spatial Interweave LTE-TDD Cognitive Radio Communication on an Experimental Platform," the authors develop an experimentalsystem.

In particular, they use LTE as the physical layer standard, and design and implement a spatial interweave CR, with which the spectrum reuse can be improved because a secondary user can perform null-beam forming in the primary user"sdirection.Intheirexperimentalsystem,theyalsodesign calibration protocol to restore channel reciprocity. In "Overlay Cognitive Radio OFDM System for 4G Cellular Networks," the authors investigate how to integrate an overlay CR system into 4G cellular networks so as to utilize the available TV white space. Specifically, they consider a twolayer OFDM architecture, in which the first layer is dedicated to the digital TV system, and the second one is used to access the cellular network. Based on such a layered model, they develop an overlay CR system using time domain hierarchical transmission or frequency domain hierarchical modulation. The authors demonstrate that with the proposed system, the receiver performance can be substantially enhanced by adaptively cancelling layer1 interference. Spectrum sensing is apparently an important component for any CR system. To fully exploit possible spectrum opportunities, future CR system may be required to sense a wide range of spectrum bands, from a few hundred megahertz to a few gigahertz. To tackle this challenge, many new technologies have been proposed recently. In "Wideband Spectrum Sensing for Cognitive Radio Networks," the authors present a survey of state-of-the-art wideband spectrumsensing.

Specifically, they focus on sub-Nyquist techniques, including compressive sensing and multichannel sub-Nyquist sampling. The authors discuss the pros and cons of different algorithms, and also present important topics for future investigation in wideband spectrum sensing. In "Deploying Cognitive Cellular Networks under Dynamic Resource Management," the authors discuss in general how to manage spectrum resources in CR-enabled cellular systems that provide cellular coverage by both macrocells and small cells.

An Efficient MIMO-OFDM Based Advanced LTE Standard with QoS for Next Generation Wireless Networks

They first survey challenging issues for such systems, including network coordination, interference management, and so on. They then propose a framework for cognitive routing and adaptive spectrum management to maximize the spectrum utilization and mitigate interference between macrocells and small cell users. To achieve efficient power control, a game-theoretical approach is alsointroduced.

In "Spectrum Prediction in Cognitive Radio Networks," the authors generalize the requirements for CR systems into four spectrum-related functions: sensing, decision, sharing, and mobility. To improve the performance of these four functions, the authors emphasize that spectrum prediction is one of the key technologies. In this regard, they present the state-of-the- art research work in the literature, including six prediction techniques and how they can enhance the performance of each of the four functions. Some open issues and future research directions are also discussed. Last but not least, in "Feasibility of CognitiveMachine-toMachine Communication Using Cellular Bands," the authors discuss a possible application for cognitive cellular networks. Specifically, they study the possibility of utilizing cellular bands instead of well-known spectrum bands for CR, such as TV white space, to enable machine-to-machine communications. In their work, they first propose hierarchical network architecture, in which cluster heads collect information from local devices using CR technologies and then forward the data to the cellular network. They then elaborate on the potential of the proposed architecture and investigate its engineering value and, more important, the business model of suchapplications.

V.CONCLUSION

This article gives an overview of CR technology for supporting very-high-data-rate communications in future LTE-Advanced mobile systems. Continuous and non- continuous CR, and two data aggregation schemes are reviewed and compared. Some technical challenges on asymmetric CR, control signaling design, handover control, and guard band setting, as well as possible solutions, for implementing CR technologies in real mobile systems are discussed. Future research topics include interference management for higher frequency bands (e.g., above 3 GHz) and coordinated multipoint CR for resource allocation across multiple cells.

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