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Performance Analysis of 802.lln MIMO OFDM Transceiver

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ABSTRACT
The increasing demand on real time application to achieve high throughput, reliable wireless system and network capacity for fourth generation wireless local area networks is to combine MIMO wireless technology with OFDM. Orthogonal Frequency Division Multiplexing (OFDM), which offers reliable high bit rate wireless system with reasonable low complexity. OFDM does provide large data rates with sufficient robustness to radio channel impairments. OFDM is a combination of modulation and multiplexing and are able to maximize spectral efficiency without causing adjacent channel interference.
This paper first focuses on 802.11n standard, MIMO-OFDM system. This paper further reviews different work done on implementation of MIMO-OFDM transceiver for 802.11n standard.

Index Terms—, Multiple Input Multiple Output, Orthogonal Frequency Division Multiplexing, Spatial Multiplexing, Space Time Block Code, Field Programmable Gate Array, Matlab Simulink, System Generator and Xilinx.

I. INTRODUCTION

The most important character of the standard is MIMO-OFDM, which not only improves the throughput but also the spectrum efficiency and channel capacity[1] One of the techniques being Orthogonal Frequency Division Multiplexing (OFDM), which offers reliable high bit rate wireless system with reasonable low complexity. The new 802.11n standard is predicted to be capable of supporting data rates up to 600 Mbps [1] by deploying the latest communication method such as "MIMO" (Multiple Input Multiple Output). The MIMO operations are based on STBC (Space Time Block Code) and SM (Spatial Multiplexing). The STBC method helps in enhancing Quality of Service (QoS) of the system whereas SM method leads to result in higher capacity in the system. There are several methods to implement the OFDM system like ASIC, microprocessors and microcontrollers and FPGA. The implementation on FPGA is better than on a general purpose MPU in terms of speed and on ASIC in terms of cost. The goal of this article is to provide a high-level review of the basics of MIMO-OFDM wireless systems with a focus on 4X4 MIMO-OFDM transceiver. The remainder of this article is organized as follows. Following this introduction, part II provides the detail 802.11n standard. Part III will provide information about MIMO-OFDM System. Part IV provides review of work done in the area of implementation of MIMO-OFDM transceiver for 802.11standard . Part V highlights track for future work. Finally part VI provides the concluding remarks.

II. IEEE802.11n STANDARD

There are three renowned standards in WLAN literature: IEEE 802.11a,b and g. the first standard was 802.11b standard which had a simple structure and supported up to 11Mbps. However, the next two standards supported higher data rates and had a more promising performance. These two standards 802.11a and g take advantage of orthogonal frequency Division Multiplexing (OFDM) method for enhancing the data rate.

In January 2002, IEEE set up a new workgroup to establish higher rate standard, which is IEEE 802.11n. After 7 years amendment, the final version 802.11n-2009 was published. MIMO-OFDM is the core technology of the physical layer. It operates at 2.4GHz or 5GHz band, and can offer OFDM 40MHz [2] channel bandwidth. At most it supports up to 4*4 configuration antennas. The highest transmission rate is 600Mbps [2].

IEEE 802.11n standard utilizes MIMO-OFDM as modulation technique. MIMO OFDM system comprises of transmitter and receiver sections. An 802.11 n system has various different parts. Figure 2 illustrates these parts. The data bits are encoded using a convolutional encoder at a specific rate like ½ or 2/3. Next, according to the mode of operation, the data bits are punctured and mapped using one of the constellations mentioned such as BPSK/ QPSK/QAM [1] [4] and then sent to the MIMO parser. This parser can perform different operations on the data bits which enter it. These operations can be Space Time Coding (STC) or Spatial Multiplexing (SM). These methods have different complexities and give different error correcting or capacity gains. The first group is methods which help enhancing QoS in these systems. The second group, are methods which cause higher capacity in the system.

The next block is the interleaver. This block interleaves data bits in order to change burst errors of the channel into separated errors which can be detected easily. The next block inserts zeros to prevent Inter Carrier Interference (lCI). Furthermore, this block places pilots to the corresponding subcarriers for channel estimation. The next block is the IFFT which transforms the signals into time domain. Inserting the guard interval (GI) is the last part in the transmitter. This interval is inserted in order to avoid Inter Symbol Interference (lSI).

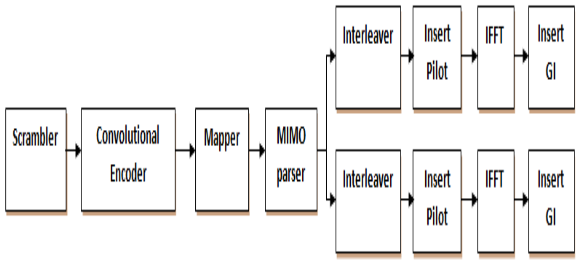

Fig.2.1. 802.11n System Transmitter block diagram.

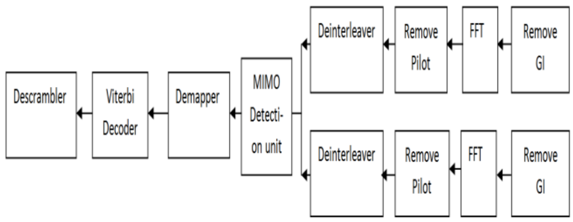

Fig.2.2. 802.11n System Receiver block diagram.

The operations of receiver blocks are opposite to that of transmitter to receive the actual signal.[4] At the receiver, the signal should first be detected. The guard interval is then omitted and the signal is sent to the FFT block. After calculating FFT, the signals are deinterleaved and sent to the MIMO detection unit. This block detects the signals using the channel estimation. The block's operation depends on the method used to code the signals in the transmitter. After signal detection, the received signals are demapped into corresponding numbers. The detected signals are then decoded using a decoder and finally descrambled. At this point the data are ready for sending to the higher level.

III. MIMO-OFDM SYSTEM

Multiple-input multiple-output (MIMO) wireless technology in combination with orthogonal frequency division multiplexing (MIMO-OFDM) is an attractive air-interface solution for next-generation wireless local area networks (WLANs), wireless metropolitan area networks (WMANs), and fourth-generation mobile cellu-lar wireless systems.

3.1 Orthogonal Frequency Division Multiplexing:
Orthogonal Frequency Division Multiplexing (OFDM) is a combination of modulation and multiplexing. In this technique, the given bandwidth is shared among individual modulated data sources. Normal modulation techniques like AM, PM, FM, BPSK, QPSK, etc... are single carrier modulation techniques, in which the incoming information is modulated over a single carrier [1].

OFDM is a multicarrier modulation technique, which employs several carriers, within the allocated bandwidth, to convey the information from source to destination. Each carrier may employ one of the several available digital modulation techniques like BPSK, QPSK, and QAM.

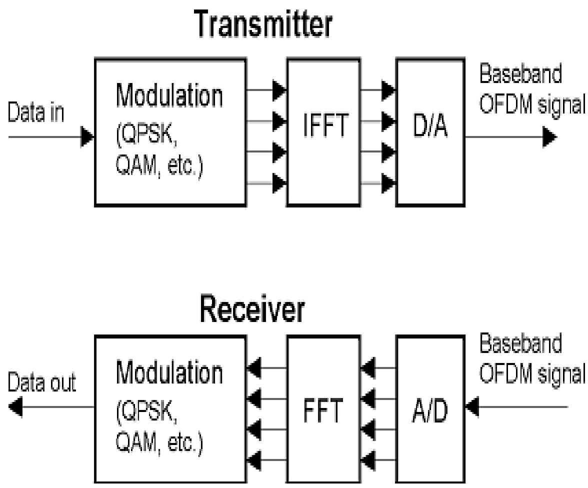

Fig.3.1 OFDM Transmitter and Receiver.

A communications data stream is effectively split into N parallel low bandwidth modulated data streams. Each sub-carrier overlaps, but they are all orthogonal to each other, such that they do not interfere with one another. Each of the sub-carriers has a low symbol rate. But the combination of sub-carriers carrying information in parallel allows for high data rates. The other advantage of a low symbol rate is that inter-symbol interference (ISI) can be reduced dramatically since the symbol time represents a very small proportion of the typical multipath delay [1].

3.2 MIMO-OFDM System:

In MIMO, the system exploits the fact that the received signal from one transmit antenna can be quite different than the received signal from a second antenna. This is most common in indoor or dense metropolitan areas where there are many reflections and multipath between transmitter and receiver [9]. In this case, a different signal can be transmitted from each antenna at the same frequency and still be recovered at the receiver by signal processing.

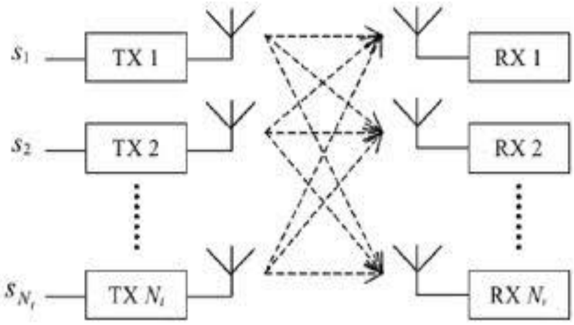

Fig..3.2 Transmit 2 Receive (2x2) MIMO channel

3.2.1 Spatial Multiplexing (SM)

In Fig. 3.2, a high-rate bit stream (left) is decomposed into three independent 1/3-rate bit sequences which are then transmitted simultaneously using multiple antennas, thus consuming one third of the nominal spectrum. The signals are launched and naturally mix together in the wireless channel as they use the same frequency spectrum [4][10].

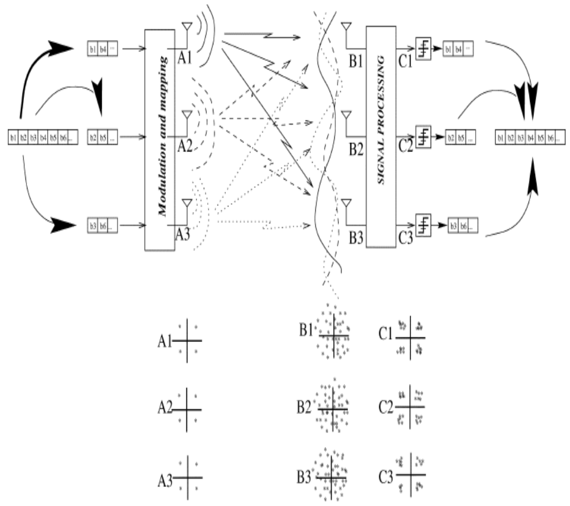

Fig.3.2.1 (a) Basic spatial multiplexing scheme with three Transmitter and three Receiver antennas

Fig.3.2.1 (b) Basic spatial multiplexing scheme with three Transmitter and three Receiver antennas

At the receiver, after having identified the mixing channel matrix through training symbols, the individual bit streams are separated and estimated [9]. This occurs in the same way as three unknowns are resolved from a linear system of three equations. This assumes that each pair of transmit receive antennas yields a single scalar channel coefficient, hence flat fading conditions.

The separation is possible only if the equations are independent which can be interpreted by each antenna "seeing" a sufficiently different channel in which case the bit streams can be detected and merged together to yield the original high rate signal.

IV. MIMO OFDM TRANSCEIVER FOR 802.11n

The best approach for real time application to achieve high throughput and network capacity for fourth generation wireless local area networks is to combine MIMO wireless technology with OFDM. This section provides a survey on the various aspects of MIMO OFDM Transceiver for 802.11n.

In [1] a 802.11n transceiver was designed and simulated. First the system-level model was developed in Simulink environment and design alternatives such as the Viterbi depth were considered and optimized. After completing the system level design, the calculations in each section was changed into fixed point calculations. This model was used to implement hardware design model by using system generator [Sysgen] for DSP. The I/FFT block is modified to take better from all of the used bits.

[2] focuses on the physical layer IEEE802.11n model. By utilizing an existing Simulink based IEEE802.11n system, functionalities like MIMO (up to 4*4), OFDM, STBC, Beam forming, and MMSE detector were simulated and tested. In [2] an existing Simulink based IEEE802.11n system was simulated through both TGn channel and AWGN channel. From the simulation results it was investigated that with the application of SDM and STBC, special diversity as well as throughput was increased dramatically. And beam forming can improve the transmission quality, since both BER and PER were improved.

In [3] A real-time MIMO-OFDM physical layer transmitting at a peak data rate of 216 Mbit/s over 20 MHz bandwidth was prototyped and characterized through measurements. Real-time operation of the system on an FPGA was achieved by diligent selection and optimization of the employed transceiver algorithms for the FPGA implementation and by careful design of the corresponding transceiver hardware architecture. This architectural optimization allows to reduce the resource utilization compared to straightforward replication of the corresponding hardware. One of the most critical parts in the system is the MIMO detector. For this prototype a linear detector was chosen to en-able a real-time FPGA implementation of soft-output MIMO detection with reasonable resource utilization., it was found that the preprocessing of the channel matrices in the MIMO detector is one of the main complexity bottlenecks which can incur considerable detection latency and thus requires large FIFO buffers in the receiver.

Compared to legacy single-antenna IEEE 802.11a WLAN systems, which transmit over the same bandwidth but are limited to a peak data rate of 54 Mbit/s, the measured average data rates are clearly higher. It was observed that the system performance is affected by channels with increasing delay spread and by high antenna correlation. As expected, the MIMO gain is reduced when the antenna spacing is not sufficient.

[4] focuses on high level Matlab Simulink 4 x 4 spatially multi-plexed (SM) MIMO OFDM transceiver encoded at ½ rate using 64 size FFT which is designed and implemented on Spartan Virtex 6 FPGA board with help of Matlab Simulink, Xilinx and System generator.. The hardware co-simulation, RTL Schematics, Test Bench and VHDL codes for all the blocks and for the complete 4 X 4 MIMO OFDM model were obtained to verify its functionality. Thus the MIMO transmit Four or more times the data rate per channel without additional band width. Data rate of 216Mbps is achieved.

In [5] An overview was given of the new IEEE 802.11n standard. This is the first wireless LAN standard based on MIMO-OFDM, a technique pioneered by Airgo Networks to give a significant performance increase in both range and rate relative to conventional wireless LAN. Performance results show that net user throughputs over 100 Mbps were achievable, which is about four times larger than the maximum achievable throughput using IEEE 802.11a/g. For the same throughput, MIMO-OFDM achieves a range that is about 3 times larger than non-MIMO systems. This significant improvement in range-rate performance makes MIMO-OFDM the ideal solution not only for wireless LAN, but also for home entertainment networks and 4G networks.

[6] focuses on review of the basics of MIMO-OFDM wireless systems with a focus on transceiver design, multiuser systems and hardware implementation aspects. Author reviewed A four-stream (four transmit and four receive antennas) MIMO-OFDM WLAN physical layer test bed developed in a collaboration between the Integrated Systems Laboratory (IIS) and the Communication Technology Laboratory (CTL) at ETH Zurich. MIMO-OFDM baseband signal processing ASIC manufactured in 0.25 □m 1P/5M 2.5 V CMOS technology was also studied in this article and investigated that Com-pared to a SISO transceiver, the 4 x 4 MIMO transceiver requires the four-fold replication of most functional blocks and, in addition, a channel-matrix preprocessor for MIMO detection The main bottleneck in implementing the 4 x 4 MIMO system was found to be the latency incurred by preprocessing the channel matrices for MIMO-OFDM detection.

V. Future Work

An 8 X 8 spatially multiplexed MIMO OFDM based hardware system can be implemented using FPGA based on similar methodology. Different modulation techniques such as QPSK or QAM accommodating number of subcarriers as 1024 or up to 4096 can be experimentally tried to achieve data rates in multiple of 100 Mbps or more.

VI. CONCLUSION

Multiple-input multiple-output (MIMO) technology combined with orthogonal frequency-division multi-plexing (OFDM) has recently attracted significant attention. MIMO offers high spectral efficiency through spatial multiplexing, OFDM provides resilience against interference caused by multipath propagation. This article provide a high-level review of the basics of MIMO-OFDM wireless systems with a focus on transceiver design. From literature survey, it is observed that, significant improvement in MIMO-OFDM is the ideal solution not only for wireless LAN, but also for home entertainment networks and 4G networks.

REFERENCES

[1] Zoha Pajoudi, et. al., "Hardware Implementation of a 802.11n MIMO OFDM Transceiver,*" in IEEE Jour. 978-1-4244-2750-5. (2008), 414-419*.

[2] Xin Xu, *"IEEE 802.11n MIMO Modeling and Channel Estimation Implementation"* Tekniska Högskolan Linköpings Universitet, 2012. NO. 6, (2008),877-889.

[3] Richard Van Nee, et. al., "*The 802.11n MIMO-OFDM Standard for Wireless LAN and Beyond"*, Wireless Personal Communications (2006) 37: 445–453.

[4] Helmut Bölcskei, Eth Zurich, "MIMO-OFDM Wireless Systems:Basics, Perspectives, And Challenges MIMO-OFDM Wireless Systems:Basics, Perspectives, And Challenges", *IEEE Wireless Communications,(August 2006)), 31-37.*

[5] Perahia, E. , "IEEE 802.11n Development: History, Process, and Technology", *Communications Magazine, IEEE, pp. 48-55, July 2008*

[6]] V. Tarokh, et. al., "Space-time block coding for wireless communications: performance results," *IEEE Jour. On Sel. Areas in Commun, vol. 17, no. 3, pp. 451-460, 1999.*

[7] Parvathi C, et. al., "Fading, Coding And Mimo-Ofdm: A Short Review", *International Journal of Recent Advances in Engineering & Technology (IJRAET), ISSN (Online): 2347 - 2812, Vol.-1, Issue - 1, pp. 69-72, 2013*

[8] The University of Adelaide, WLAN Background, available: http://www.eleceng.adelaide.edu.au/research/undergrad-projects/archive/WLAN-optimisation/ProjectOverview/WLANBackground.htm.

[9] K. F. Lee, et. al., "A space-frequency transmitter diversity technique for OFDM systems," *in Proc. Globecom 03, San Francisco, USA, vol.3, pp.24-28, 2003.*

[10] D. Getsberg, et. al., " From theory to practice: An overview of MIMO space-time coded wireless systems," *in IEEE Jour. Sel. Areas in Commun.,vo1.21, no. 38 pp. 281-301, 2003.*

[11] Yu Wei Lin Chen Yi Lin, "Design of FFT/IFFT Processor for MIMO OFDM Systems," *IEEE Transaction on circuit and system, Vo1.54, no. 4 pp. 807-815, 2007.*

[12] Yin, Hujun of Intel Corporation, "OFDMA : A Broadband Wireless Access Technology," *in IEEE Sarnoff Symposium 2006.*

[13] V.R Balaji, et. al., "Design and Implementation of MIMO-OFDM for 4G Mobile Communications", *Journal of Global Reserch in Computer Science, Vol.4, no.1 pp.18-21, 2013.*