Performance Enhancement of the V-Blast OFDM System using ZF and Moving Average Filtering

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Abstract - The modern era of wireless communication having many challenges to provide quality of service maintaining the next generation technology needs. The obstacle which are making system performance lower and lower is noises and interferences. In this paper we have analyzed and worked towards to reduce the effect of noises and interferences so that the error rate should be lower. The proposed approach is working on the reduction of bit error rate by utilizing the minimum mean square error - ordered successive interference cancellation (MMSE-OSIC) detection technique with moving average filter and compared with ZF-OSIC and median filtering and achieved $10^{-5.5}$.

Keywords - V-Blast, OFDM, Moving Average Filter, BER, Wireless Communication.

I. INTRODUCTION

Wireless communications is one of the most active areas of technology development of this time. This growth is being driven primarily by the transformation of what has been largely a medium for supporting voice telephony into a medium for supporting other services, for example the transmission of video, text, images, and data. Thus, similar to the developments in wire line capacity in the previous year, the demand for new wireless capacity is growing at a very rapid pace. On the other hand, the traditional resources that have been used to add capacity to wireless systems are radio bandwidth and transmitter power[1]. Unfortunately, these two resources are among the most severely limited in the deployment of modern wireless networks: radio bandwidth because of the very tight situation with regard to useful radio spectrum, and transmitter power since mobile and other portable services require the use of battery power, that is limited. These two resources are simply not growing or improving at rates that can support anticipated demands for wireless capacity.

Wireless communications today covers a very wide array of applications. The telecommunications commerce is one of the largest industries worldwide, with more than $1 trillion in annual revenues for services and equipment [18] [19]. (To put this in perspective, this number is comparable to the gross domestic product of many of the world's richest countries, including Italy, France, and the United Kingdom. The largest and mainly noticeable part of the telecommunications business is telephony. A principal wireless component of telephony is mobile (i.e., cellular) telephony. The worldwide growth rate in cellular telephony is very aggressive, and analyst report that the number of cellular telephony subscriptions worldwide has now surpassed the number of wire line (i.e., fixed) telephony subscriptions. Recently the number of cellular telephony subscriptions worldwide is reportedly by ITU on the order of 5.8 billion. These numbers make cellular telephony a very important driver of wireless technology growth, and in recent years the push to develop new mobile data services, which go collectively under the name *Fourth-Generation* (4G)C*ellular*, has played a key role in motivating research in new signal processing techniques for wireless. Though, cellular telephony is only one of a very wide array of wireless technologies that are being developed very rapidly at the present time.

Multiple-Access Techniques:

We have discussed ways in which a symbol stream associated with a single user can be transmitted. Many wireless channels, particularly in emerging systems, operate as multiple-access system, in which multiple users share the same radio resources.

There are several ways in which radio resources can be shared among multiple users. These can be viewed as ways of allocating regions in frequency, space, and time to different users, as shown in Fig. 1.1. For example, a classic multiple-access technique is *frequency-division multiple access* (FDMA), in which the frequency band available for a given service is divided into subbands that are allocated to individual users who wish to use the service[19][20]. Users are given exclusive use of their subband during their communication session, but they are not allowed to transmit signals within other subbands. FDMA is the principal multiplexing method used in radio and television broadcast and in first-generation (analog voice) cellular telephony systems, such as the Advanced Mobile Phone System (AMPS) and Nordic Mobile Telephone (NMT), developed primarily in the 1970s and 1980s. FDMA is also used in some form in all other current cellular systems, in tandem with other multiple-access techniques that are used to further allocate the subbands to multiple users.

Similarly, users can share the channel on the basis of *time-division multiple access* (TDMA), in which time is divided into equal-length intervals, which are further divided into equal-length subintervals, or time slots. Each user is allowed to transmit throughout the entire allocated frequency band during a given slot in each interval but is not allowed to transmit during other time slots when other users are transmitting. So, whereas FDMA allows each user to use part of the spectrum all of the time, TDMA allows each user to use all of the spectrum part of the time.

This method of channel sharing is widely used in wireless applications, notably in the number of second-generation cellular (i.e., digital voice) system, including the widely used Global System for Mobile (GSM) system and in the IEEE 802.16 wireless MAN standards. A form of TDMA is also used in Bluetooth networks, in which one of the Bluetooth devices in the network acts as a network controller to poll the other devices in time sequence. FDMA and TDMA systems are intended to assign orthogonal channels to all active users by giving each, for their exclusive use, a slice of the available frequency band or transmission time. These channels are said to be *orthogonal* because interference between users may not, in principle, arise in such assignments (although, in practice, there is often such interference, as discussed further below). *Code-division multiple access* assigns channels in a way that allows all users to use all of the available time and frequency resources simultaneously, through the assignment of a pattern or code to each user that specifies the way in which these resources will be used by that user. Typically, CDMA is implemented via spread-spectrum modulation, in which the pattern is the pseudorandom code that determines the spreading sequence in the case of direct sequence, or the hopping pattern in the case of frequency hopping. In these systems, the channel is defined by a particular pseudorandom code, so each user is assigned a channel by being assigned a pseudorandom code. CDMA is used, notably, in the second-generation cellular standard IS-95 (Interim Standard 95), which makes use of direct-sequence to allocate subchannels of larger-bandwidth (1.25 MHz) subchannels of the entire cellular band [20]. It is also used, in the form of frequency hopping, in GSM to provide isolation among users in adjacent cells.

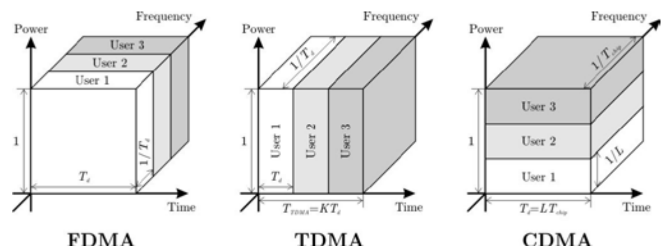

Figure 1.1 Multiple-access schemes.

The spectrum spreading used in wireless LAN systems is also a form of CDMA in that it allows a number of such systems to operate in the same lightly regulated part of the radio spectrum. CDMA is also the foundation for the principal standards being developed and deployed for 3G cellular telephony.

Any of the multiple-access techniques discussed here can be modeled analytically by considering multiple transmitted signals of the form (1.1). In particular, for a system of K users, we can write a transmitted signal for each user as

$$x_k(t) = \sum_{i=0}^{M-1} b_k\,[i]\omega_{i,k}(t), \quad k = 1,2, \ldots \ldots K, \tag{1.1}$$

where $x_k(\cdot)$, $\{b_k[0], b_k[1], ..., b_k[M-1]\}$, and $w_{ik}(\cdot)$ represent the transmitted signal, symbol stream, and ith modulation waveform, correspondingly, of user k. That is, each user in a multiple-access system can be modeled in the same way as in a single-user system, but with (usually) differing modulation waveforms (and symbol streams, of course). If the waveforms $\{w_{i,k}(\cdot)\}$ are of the form (1.2) but with different carrier frequencies $\{\omega_k\}$, say, this is FDMA. If they are of the form (1.1) but with time-slotted amplitude pulses $\{p_k(\cdot)\}$, say, this is TDMA. Finally, if they are spread-spectrum signals of this form but with different pseudorandom spreading codes or hopping patterns, this is CDMA. Details of these multiple-access models will be discussed in the sequel as needed.

II. MIMO System

Wireless communication System was developing continuously and during this advancement procedure it uses various technologies as per the demand and to provide quality of service in Wireless Communication System see figure 2.1. In this there were some earlier technologies which are as follows [8][9]:

SISO – Single Input Single Output System

SIMO – Single Input Multiple Output System

MISO – Multiple Input Single Output System

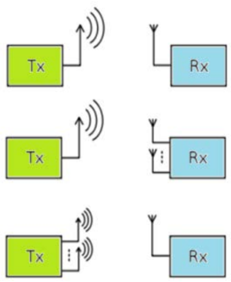

Fig. 2.1: Earlier Technologies of Wireless Communication System

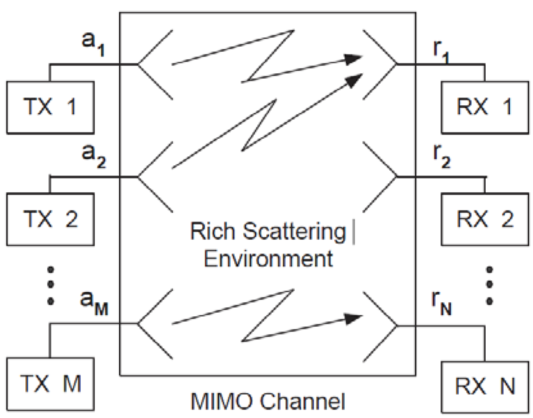

Figure 2.2: Multiple Input Multiple Output (MIMO) channel model. TX and RX stand for transmitter and receiver antennas, correspondingly.

Throughout this thesis, we use the MIMO channel model depicted in Fig. 2.2 with M transmitter and N receiver antennas.

In each use of the MIMO channel, a vector a = ($a_1, a_2, \ldots, a_M)^T$ of complex numbers are sent and a vector r = ($r_1, r_2, \ldots, r_N)^T$ of complex numbers have been received. We assume an input-output relationship of the form

$$r = Ha + v \qquad (1.2)$$

where H is a $N \times M$ matrix representing the scattering effects of the channel and v = ($v_1, v_2, \ldots, v_N)^T$ is the noise vector. Throughout, we assume that H is a random matrix with independent complex Gaussian elements $\{h_{ij}\}$ with mean 0 and unit variance, denoted $h_{ij} \sim CN(0, 1)$. We also assume throughout that v is a complex Gaussian random vector with i.i.d. elements $v_i \sim CN(0, N_0)$. It is assumed that H and v are independent of each other and of the data vector a.

We will assume that the receiver has perfect knowledge of the channel realization H, as the transmitter has no such channel state information (CSI). Receiver's possession of CSI is justified in cases where the channel is a relatively slowly time-varying random process for a discussion of this point.

III. PROPOSED METHODOLOGY

The modern wireless communication with the low bit error rate is proposed in this paper and the block diagram is shown in the figure below. The main blocks are Data generation to evaluate whole system by calculating bit error rate. Next block is modulation of data with QAM modulation after that the serial signal is converted into parallel to apply OFDM modulation and again converted back into serial to transmit over wireless channel. The wireless channel characterization is considered by AWGN with addition of noises. At the receiver side the signal is OFDM demodulated and the detection techniques are applied which are zero forcing with ordered successive interference cancellation(ZF-OSIC) and minimum mean square error ordered successive interference cancellation(MMSE-OSIC) after detection collect respective data and then filtered with median filtering to reduce the noise level and get the data at output.

The above explained proposed system is implemented on simulation tools for simulation of techniques proposed in V-Blast OFDM System. The step by step execution is explained of the system is explained in the below flow chart.

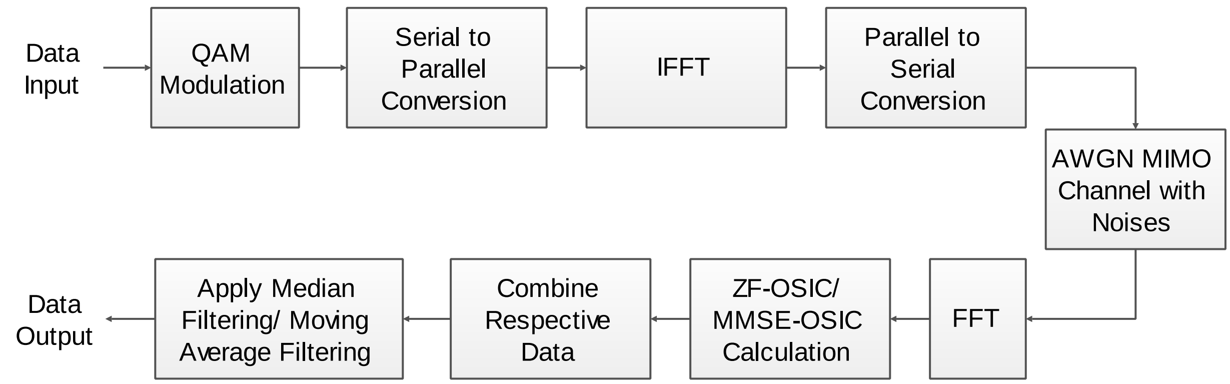

Fig. Block Diagram of Proposed Methodology

The execution of simulation algorithm is as follows:

a. *Start of simulation*
b. *First create simulation environment using system variables*
c. *Generate data to transmit over communication system so that error rate can be analyzed.*
d. *Now modulate data with QAM modulation*
e. *Convert signal from serial to parallel*
f. *Apply OFDM modulation i.e. IFFT operation*
g. *Convert parallel to serial conversion*
h. *Now initialize MIMO channels*
i. *Transmit signal through AWGN channel with addition of noises*
j. *Now apply OFDM demodulation*
k. *Apply MMSE-OSIC and ZF-OSIC Detection*
l. *Apply median filtering on detected signal*
m. *Calculate Bit Error Rates*
n. *Compare BER for ZF-OSIC and MMSE-OSIC with and without Median Filtering and Moving Average Filtering*
o. *Display results*
p. *End of Simulation*

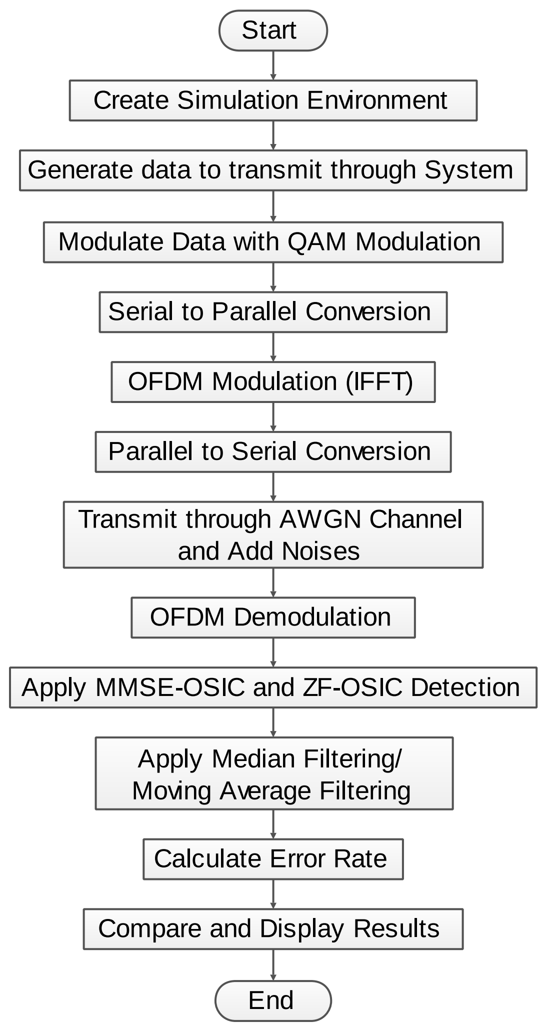

Fig. Flow chart of Proposed System Algorithm

IV. SIMULATION RESULTS

The proposed simulation algorithm mentioned in the previous section is simulated and BER is calculated with different QAM variations. The QAM variations are 8-QAM, 16-QAM, 32-QAM and 64-QAM modulation with 2 transmitters and 2 receivers (MIMO channel) using median filtering and moving average filtering.

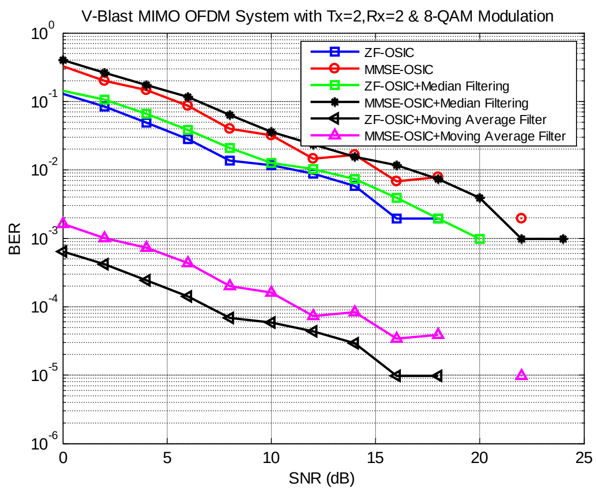

Fig. 4.1 BER vs SNR performance of the proposed V-Blast MIMO system using 8-QAM modulation

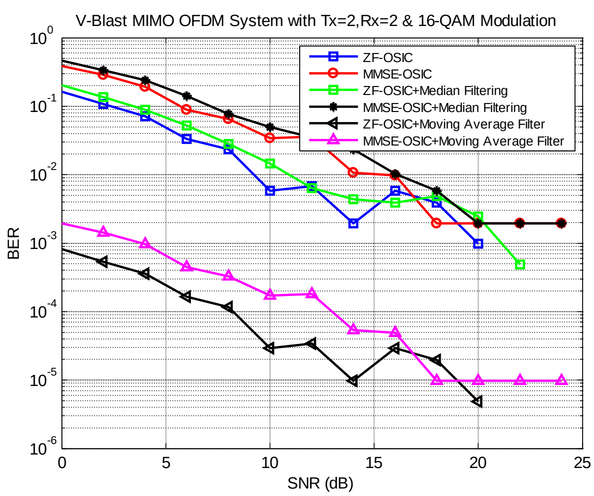

Fig. 4.2 BER vs SNR performance of the proposed V-Blast MIMO system using 16-QAM modulation

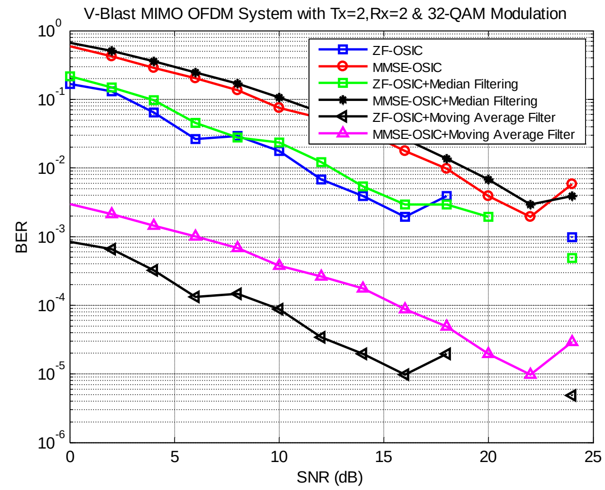

Fig. 4.3 BER vs SNR performance of the proposed V-Blast MIMO system using 32-QAM modulation

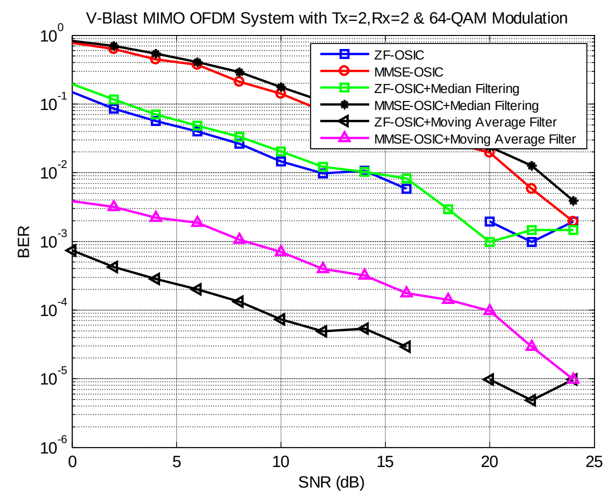

Fig. 4.4 BER vs SNR performance of the proposed V-Blast MIMO system using 64-QAM modulation

In the above results BER is achieved optimum for the ZF-OSIC with moving average filtering using 64-QAM modulation and 2x2 MIMO configurations. BER is achieved about $10^{-5.5}$.

V. CONCLUSION AND FUTURE SCOPE

The simulation of wireless communication tells about the efficiency of the techniques used to reduce the bit error rate of the system. The BER as seen in the previous section is analyzed with different system parameters and filtering techniques. The system with the higher version of QAM modulation gives better results than the lower version of QAM. In this work the optimum BER which is $10^{-5.5}$

achieved with 2x2 MIMO and V-Blast configuration with ZF-OSIC detection and Moving average filtering which is little bit improved than the MMSE-OSIC counterpart. In the future other efficient detection techniques with the 64-QAM and MIMO configuration will gives better results than existing one.

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