DESIGN AND INVESTIGATIONOF CDMA TRANSCEIVER BASED WAVELET TRANSFORMS WITH ADAPTIVE ANTENNA SYSTEM +

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Abstract:

Suppression of Multiuser Interference (MUI) and mitigation of multipath effectssignals constitute major challenges in the design of third-generation wireless mobile systems. The objective of this paper is to find the most suitable technique for implementation in Fourth Generation (4G) communication systems. An Adaptive Antenna System (AAS) has been distributed at the receiver module to decrease the fading effectssignal caused by proposed Stanford University Interim (SUI) Channel Models. AAS uses beamforming system to focus the wireless beam between the base station and the subscriber station. The Least Mean Square (LMS) system is used at the receiver to direct the main beam towards the wanted Line of Sight (LOS) signal and nulls to the multipath signals. It has been verified through this thought byMATLAB simulations that the performance of the system important advances by AAS approximately 3dB, where beamforming is employed in the direction of preferred user. The performance of the scheme can be more developed by increasing the number of antennas at receiver.

Keyword: **CDMA, AAS, DWT, LMS.**

تصميم واختبار جهاز الارسال والاستقبال المتعدد الوصول باستخدام تقسيم الشفرة (CDMA) المبني على تحولات الويفلتمع نظام الهوائي المتكيف

محمد عبود كاظم

المستخلص:

قمع التداخلات لعدة مستخدمين والتخفيف من الاثار الناجمة عن تعدد المسارات للاشارات تشكل تحديات كبرى في تصميم الجيل الثالث من الانظمة اللاسلكلية المتنقلة الغرض من هذا البحث هو العثور على افضل تقنية مناسبة لتنفيذ الجيل الرابع من الانظمة اللاسلكية في نظم الاتصالات. نظام الهوائي المتكيف (AAS) تم نشره في جزء الاستقبال للحد من الاثار الناجمة من تلاشي الاشارات في نموذج قنوات التلاشي المقترحة في قنوات جامعة ستانفورد المؤقتة (SUI). نظام الهوائي المتكيف يستخدم تقنية التشكيل الحزمي لتوجيه شعاع اللاسلكي بين المحطة الاساسية وبين المحطة المشتركة. نظرية مربع اقل معدل (LMS) استخدمت في المستقبل لتوجيه الشعاع الرئيسي باتجاه خط الافق المرغوب ويلغي اشارات المتعددة المسار. لقد تم اثبات هذه الفكرة بواسطة استعمال نظام المحاكاة (MATLAB) وان تحسن كبير حدث بواسطة استعمال نظام الهوائي المتكيف (AAS) بحيث ان التشكيل الحزمي نفذ باتجاه المستخدم المرغوب. اداء النظام يمكن ان يتحسن اكثر بواسطة زيادة عدد الهوائيات في المستقبل.

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Introduction:

Code Division Multiple Access (CDMA) is a channel access technique used by different radio communication technologies. CDMA is an example of multiple accesses, which is where some transmitters can send information at once over a single communication channel. This allows a number of users to share a band of frequencies. To permit this to be achieved without unnecessary interference between the users CDMA employments spread-spectrum technology and a special coding scheme (where each transmitter is assigned a code). CDMA is used as the access method in many mobile phone standards for example CDMA One, CDMA2000 , and WCDMA the 3G standard used by Global System for Mobile Communications (GSM) carriers, which are often mentioned to as simply CDMA. Most proficient solutions at the physical layer are verified in cellular schemes using spread spectrum code division multiplex access (CDMA), and indoor wireless Local Area Networks (WLAN) using orthogonal frequency division multiplexing (OFDM). Both methods use temporal signal processing to mitigate the Inter-symbol Interference (ISI) introduced by wideband frequency selective fading channel. Current research on Multiple Input Multiple-Output (MIMO) systems [1]. The spectral efficiency can be enhanced by combining temporal processing with spatial processing that profiteers spatial dimension of the wireless channel. Such space-time processing operates with multiple transmit/receive (Tx/Rx) antennas and improve the link capacity by diversity and multiplexing gain [2]. It also reduce the Co-Channel Interference (CCI) and more mitigates the ISI by spatial filtering. Foschini has presented that capacity produces linearly with the number of antennas in narrow-band flat-fading channels [3]. This gain is assign to spatial multiplexing. Though, in wideband systems, the capacity gain due to combined time and spatial processing depends not only on the frequency selectivity of wideband MIMO channel, but too on the relationship, sequence, and execution of signal processing schemes used for space-time processing. The wireless Metropolitan Area Network MAN-OFDM interface can be exceedingly restricted by the existence of fading caused by multipath propagation and as result the reflected signals arriving at the receiver are multiplied with diverse delays, which reason Inter-Symbol Interference (ISI). OFDM chiefly is designed to overcome this problem and for states where high data rate is to be transmitted over a channel with a relatively large maximum delay. If the linger of the received signals is larger than the guard interval, ISI may cause severe dishonor in scheme performance. To resolve this subject multiple antenna array can be used at the receiver, which offers spectral efficiency and interference suppression [4]. Adaptive Antenna System (AAS) is an optional feature in CDMA standard but to improve the coverage, capacity and spectral efficiency, it should be essential for an OFDM air interface. It has an benefit of having single antenna system at the subscriber station and all the burden is on base station [3]. An array of antenna is installed at the base station to decrease inter-cell interference and fading effects by providing either beamforming or diversity gains. When small spacing is approved, the fading is highly correlated and beamforming methods can be working for interference elimination as compared to Diversity-oriented systems [5]. As a result receiver can separate the favorite LOS signal from the multipath signals and nulls are formed at the interfering signals. The objective of this paper is to develop the physical layer of CDMA standard by uses adaptive antenna array at the receiver to combat multi-path channel. In past recent years considerable amount of research work has been conducted to improve the performance of the system in terms of increasing the capacity and range. One such technology that is proving to be very useful to cater these issues is “Smart Antenna Systems” (SAS) [6, 7].Smart Antenna System uses advanced signal processing techniques to construct the model of the channel. Using the knowledge of the channel, SAS uses beamforming methods in order to steer or direct a radio beam towards wanted users and null steering towards the interferers [8]. It works by adjusting the angles and width of the antenna radiation pattern. SAS consist of set or radiating elements accomplished of sending and receiving signals in such a technique that radiated signals combine together to form a switch able and movable beam in the way of the user. Though it may be noted that the hardware of the smart antenna does not make them “smart”, the signal processing method that is used to motivation the beam of the radiated signals in the preferred direction. This procedure of combining the signal and then focusing the signal in particular direction is named beamforming [8]. On the other hand Adaptive Array System acts in a diverse manner as compared to switched beam Antenna system. It works by keep a constant track of the mobile user by directing a main beam towards the user and at the same time jamming the interfering signals by forming nulls in direction towards them. A brief comparison of these two approaches can be best observed from [8] which show beamforming lobes and nulls. It can be seen that for the Adaptive Array the main beam is towards users and nulls to interferer [8]. A BS can serve multiple subscriber stations with higher throughput by using AAS. For that space Division multiplex is used to separate (in space) multiple SSs that are transmitting and receiving at the same time over the same sub-channel. By using AAS, Interference can be severely reduced that is originated from the other Subscriber Stations or the multipath signals from the same SS by steering the nulls towards the preferred interference [9]. An adaptive antenna system achieves the next functions. In principal it computes the direction of arrival of all incoming signals counting the multipath signal and the interferers using the Direction of Arrival (DOA) algorithms with for model MUSIC and ESPIRIT [10]. This is just two of numerous used processes. DOA information is then fed into the weight upgrade system to calculate the corresponding complex weights. The least-mean-square (LMS) is a search procedure in which an explanation of the gradient vector calculation is made probable by properly adapting the objective function. The LMS algorithm, as well as others related to it, is extensively used in many applications of adaptive filtering due to its computational simplicity. The convergence features of the LMS procedure are examined in order to establish a range for the convergence factor that will guarantee stability. The convergence speed of the LMS is shown to be dependent on the eigen value spread of the input signal correlation matrix .The LMS procedure is by far the most extensively used process in adaptive filtering for several reasons. The key advantage that fascinated the use of the LMS process are low computational complexity further information about LMS algorithm in [6, 11].

Stanford University Interim (SUI) Channel Models:

This is a set of six channel models representing three terrain types and a variety of Doppler spreads, delay spread and line-of-sight/non-line-of-site conditions that are typical of the continental US. The terrain type A, B,C are same as those defined earlier for Erceg model. The multipath fading is modeled as a tapped delay line with 3 taps with non-uniform delays. The gain related with each tap is considered by a Rician Distribution and the maximum Doppler frequency.This model can be used for simulations, design, and evolvement and testing of technologies agreeable for broadband wireless performances [12].

The Proposed Modified Block Diagram Structure:

The new proposed structures for the CDMA-OFDM system based on Discrete Wavelet Transform (DWT) with AAS will be implementing in this paper. The Block diagram in Figure 1 characterizes the whole system model or signal chain at the base band. The CDMA-OFDM based wavelet signals system is used for multicarrier modulation.

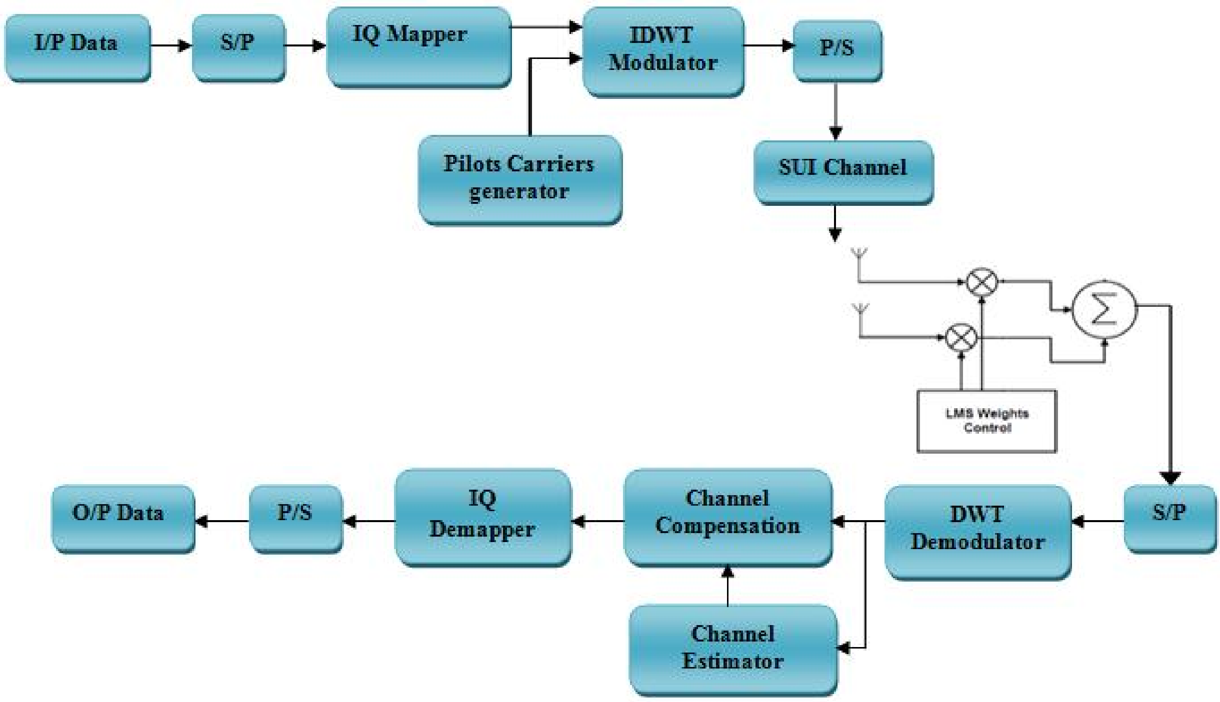

Figure (1): Proposed Modified Block Diagram Structure

The block diagram structure is divided into four main sections: transmitter, receiver, adaptive antenna array algorithm and SUI channel. The transmitter receives data, and converts it into lower rate sequences via serial to parallel conversion, these lower rate sequences are mapped to give sequences of channel symbols. This method will convert data to conforming value of Mary constellation which is complex word, i.e. real and imaginary part. The bandwidth (B =(1/T_s)) is separated into Nsimilarly spaced subcarriers at frequencies (kΔf), k=0,1,2,...,N-1 with Δf=B/Nand,T_s , the sampling interval. At the transmitter, information bits are collected and mapped into complex symbols. In this scheme, quadrature amplitude modulation (16-QAM) with constellation C_{QAM} is assumed for the symbol mapping. $N_c$is the number of sub-carriers carrying data. *N* is the multicarrier size. So, the number of virtual carriers is N-N_c. We accept that half of the virtual carriers are on both ends ofthe spectral band [1]. Which consists of the OFDM modulator and demodulator. The training frame (pilot sub-carriers frame) are inserted and sent prior to the information frame. This pilot frame is used to offer channel estimation, which is used to compensate for the channel effects on the signal. The spread data symbol is modulate on the orthogonal carriers, an N-point Inverse Discrete Wavelet Transform (IDWT) is used, as in conventional OFDM. Zeros are injected in some bins of the IDWT to compress the transmitted spectrum and decrease the adjacent carriers' interference. The appended zeros to some sub-carriers limit the bandwidth of the system, while the system without the zeros pad has a spectrum that is spread in frequency. The earlier case is unacceptable in communication structures, since one restriction of communication schemes is the width of bandwidth. The adding of zeros to some sub-carriers means not all the sub-carriers are used; only the subset (N_c) of total subcarriers (N_F) is used. So, the number of bits in OFDM symbol is equal to $\log_2$ (M)*N_c. Orthogonality between carriers is generally destroyed when the transmitted signal is passed through a dispersive channel. When this occurs, the inverse transformation at the receiver cannot recover the data that was transmitted perfectly. Energy from one sub-channel leaks into others, leading to interference. However, it is probable to rescue orthogonality by presenting a Cyclic Prefix (CP). This CP contains of the last *v* samples of the original *K* samples to be transmitted, prefixed to the transmitted symbol. The length *v* is determined by the channel's impulse response and is selected to minimalizeISI. If the impulse response of the channel has a length of less than or equivalent to *v*, the CP is satisfactory to remove ISI and inter-carrier interference (ICI). The Fourier based OFDM utilize the complex exponential bases functions. If the number of sub-channels is necessarily large, the channel power spectral density can be supposed virtually flat within each sub-channel. In these kinds of channels, multicarrier modulation has long been familiar to be optimum when the number of sub-channels is large. The size of sub-channels needed *t*approximate optimum performance depends on how quickly the channel transfer function varies with frequency. The efficiency of the transceiver is reduced by a factor of $\frac{K}{K+V}$so it is necessary to make *v* as small or *K* as large as possible. So the disadvantages of the CP are the loss of data throughput as precious bandwidth is wasted on repeated data. For this goal it is necessary to find another construction for OFDM to mitigate these problems. If the number of sub-channels is suitably large, the channel power spectral density can be supposed virtually flat within each sub channel. In these kinds of channels, multicarrier modulation has long been identified to be optimum when number of sub-channels is large. The size of sub-channels required to approximate optimum performance depends on how rapidly the channel transfer function varies with frequency. The calculation of Discrete Wavelet Transform (DWT) and IDWT for 256 point. After which, the data changed from parallel to serial are fed to the channel CDMA model. In This section will introduce the system model of an NsubcarrierOFDM system with transmit antenna and *MR* receive antennas in the presence of transmit antenna and path correlations. The worst performance of the SUI channel is due to multipath effect, delay spread and Doppler effects. Although the impact of the delay spread and the Doppler Effect is low so the major degradation in the performance is due to the multipath effects. There are various methods to reduce the multipath effect. However in this model it is done by implementing AAS. For that adaptive beamforming algorithm such as (LMS), be used. The calculated weight is then multiplied by the signal from the antenna array and required radiation pattern is formed. So a beam is steered in the direction of the desired signal and the user is tracked as it moves while placing nulls at interfering signal directions by constantly updating the complex weights by using any of the beamforming algorithms. AS has the feature that requires only multiple antennas at theBase Station (BS) and thus putting whole burden on the BS. As AAS is known to reduce inter-cell interference and multipath fading by providing beamforming. So multiple antennas are installed at the receiver and performance is investigated in the presence of receiver antennas. The receiver achieves the same operations as the transmitter, but in a reverse order. In addition, wavelet OFDM comprises processes for synchronization and compensation for the damaging SUI channels.

Simulation Results:

In this section the simulation of the proposed adaptive antenna array system in CDMA and comparing without adaptive antenna array system is executed, beside the BER performance of the system regarded in SUI channel models, the system parameters shown in Table (1).

Table (1):System parameters

Number of transmitter antenna	1
Number of receiver antenna	2
Spacing between receiver antennas	λ/2
Fading correlations	ρ_R=0.5
Channels	SUI
Number of sub-carriers	256
Number of DWT points	256
Number of data bits transmitted	10^6
Modulation type	16 QAM

1. Performance of proposed modified model in SUI-1 channel:

In this situation, the results obtained were encouraging. With AAS and without AAS it can be seen that for BER=10^{-3} the SNR required for AAS is about 9.9 dB while in without AAS the SNR about 11.5dB .From Figure 2 it is found that using AAS outperforms significantly better than other systems for this channel model.

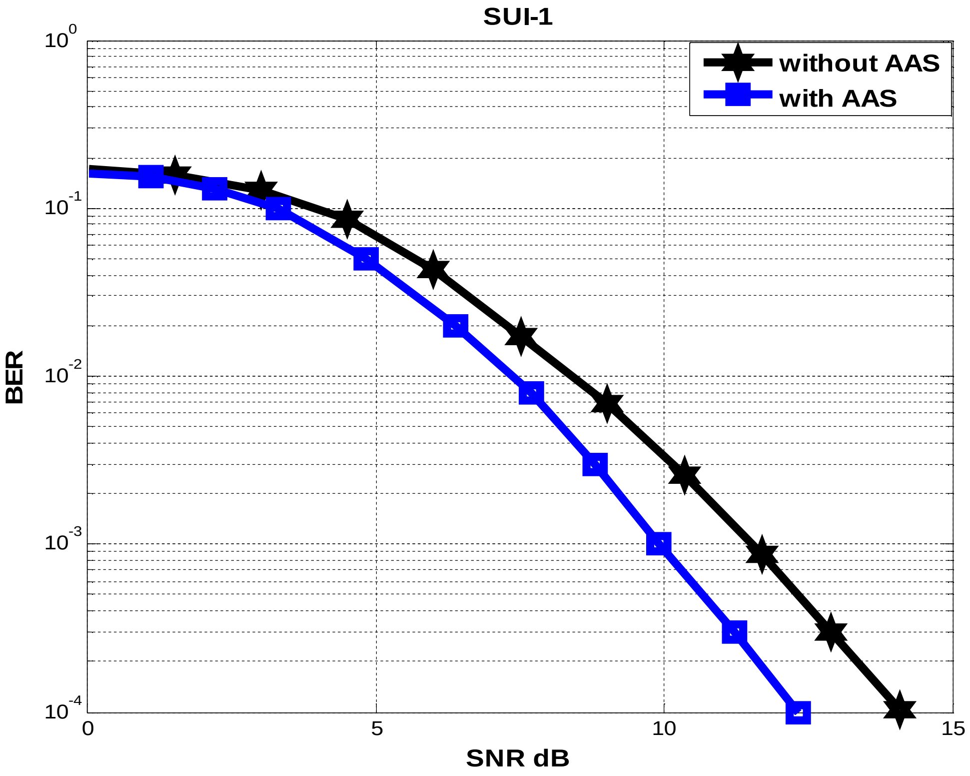

Figure (2): BER performance of proposed modified model in SUI-1 channel

2. Performance of proposed modified model in SUI-2 channel:

In this simulation profile some influential results were obtained. it can be seen that for BER=10^{-3} the SNR required for the system with AAS is about 11.25dB while in without AAS the SNR about 14.03dB from Figure 3 it is found that the system with AAS outperforms significantly better than other system for this channel model.

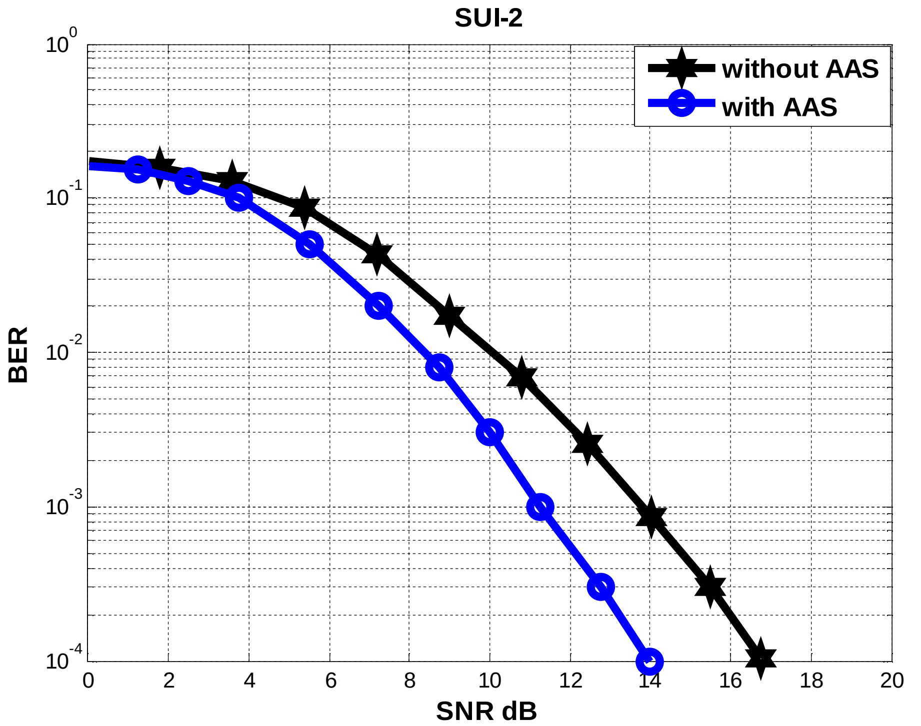

Figure (3); BER performance of proposed modified model in SUI-2 channel

3. Performance ofproposed modified model in SUI-3 channel:

In the SUI-3 channel, the results are depicted in Figure 4 it can be seen that for BER=10^{-3} the SNR required for the CDMA model with AAS is about 14.85 dB, while in without AAS the SNR about 17.92dB, From Figure 4 it is found that the CDMA with AAS outperforms significantly than other systems for this channel model.

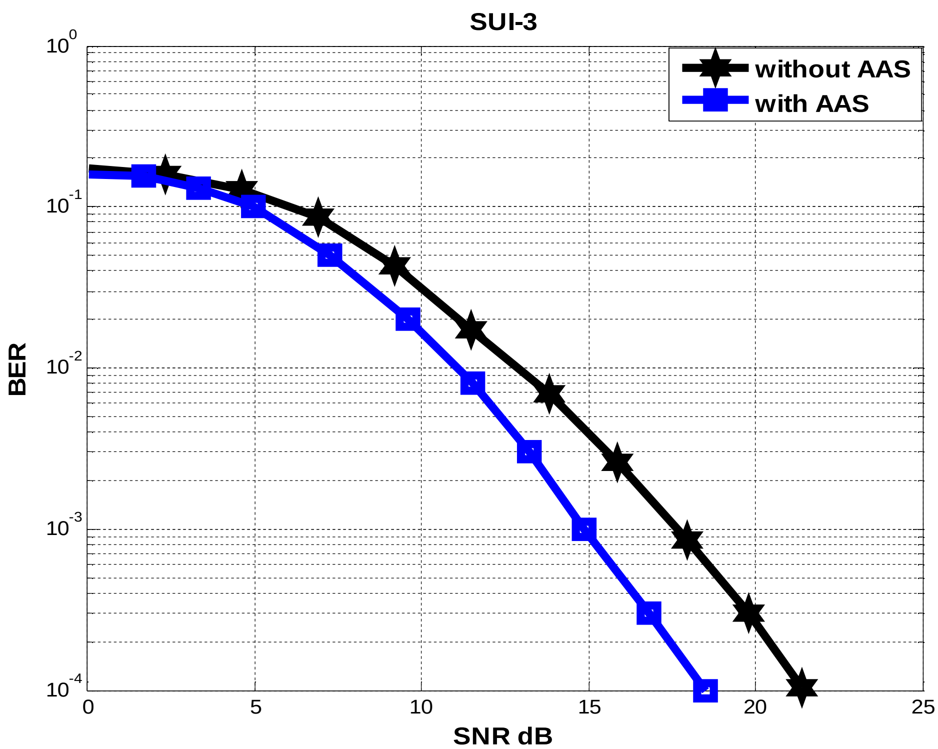

Figure (4): BER performance of proposed modified model in SUI-3channel

4. Performance of proposed modified model in SUI-4 channel:

Using similar procedure as in the previous section, simulations for SUI-4 channel The result depicted in Figure 5 it can be seen that for BER=10^{-3} the SNR required for the system with AAS is about 18.9dB, while in without AAS the SNR about 22.1dB. Also from Figure 5 it is found that the CDMA with AAS outperforms significantly than other systems for this channel model.

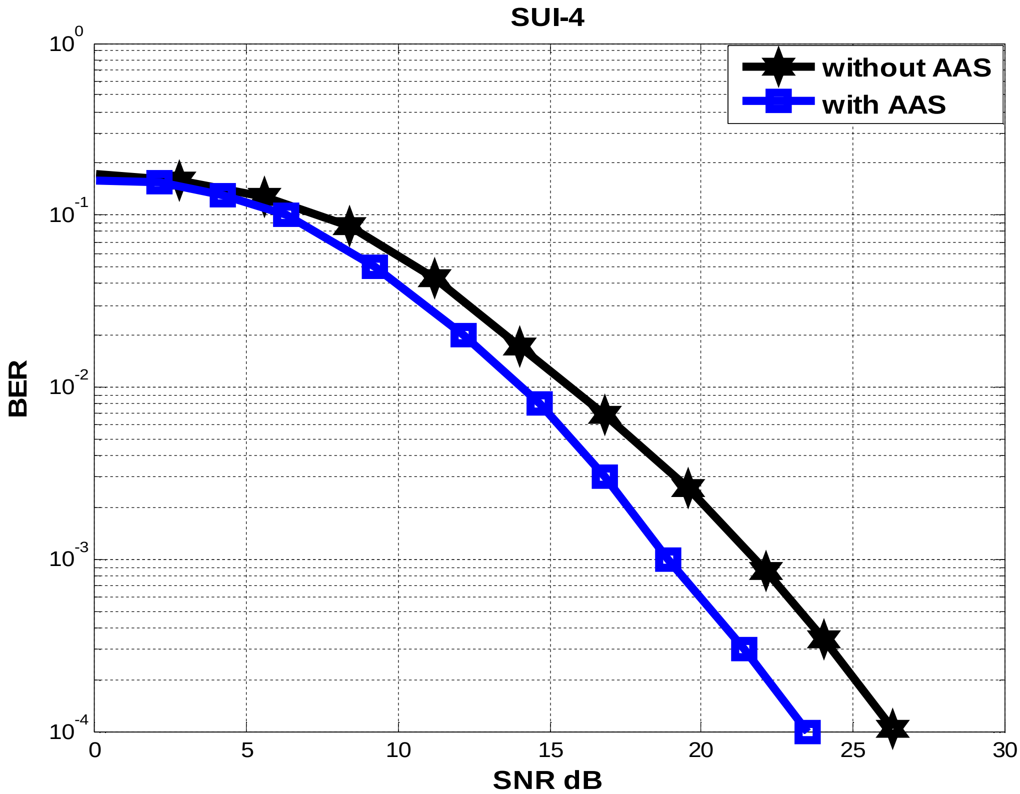

Figure (5): BER performance of proposed modified model in SUI-4channel

5. Performance of proposed modified model in SUI-5 channel:

The structure with AAS and without AAS it can be seen that for BER=10^{-3} the SNR necessary for with AAS is about 22.96 dB while in without AAS the SNR about 26.5dB from Figure 6, it is found that the CDMA with AAS is best than other scheme for this channel model.

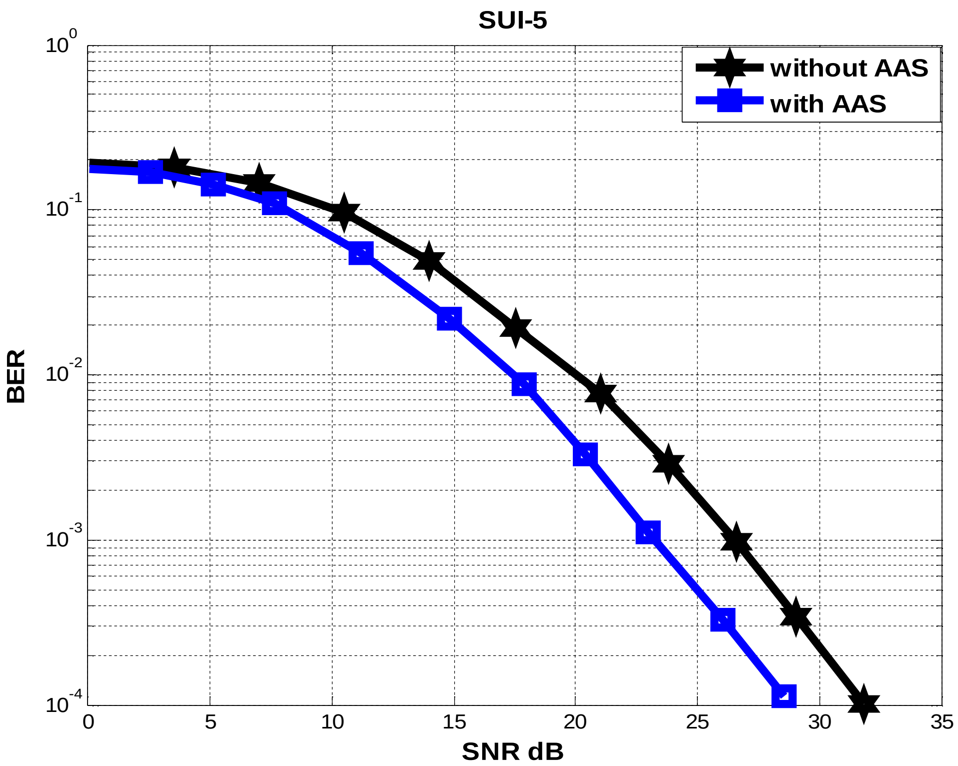

Figure (6): BER performance of proposed modified model in SUI-5channel

6. Performance of proposed modified model in SUI-6 channel:

In this state, the results obtained were hopeful. With AAS and without AAS it can be seen that for BER=10^{-3} the SNR necessary for the system with AAS is about 31.1 dB while in without AAS the SNR about 34.96dB from Figure 7 it is found that the CDMA with AAS is better than other system for this channel model.

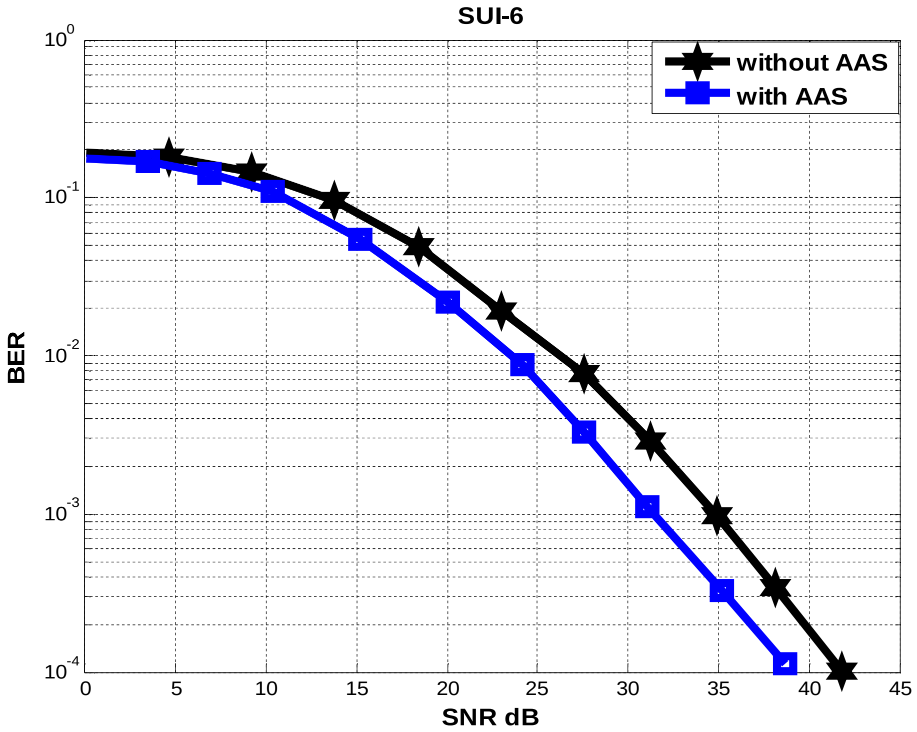

Figure (7): BER performance of proposed modified model in SUI-6 channel

From previous results it has been shown that the AAS can be applied to processing the output of the individual elements in a receiving antenna array. This processing results in reduced sensitivity of the array to interfering noise sources whose characteristics may be unknown a priori. The combination of array and processor has been shown to act as an automatically tunable filter in both space and frequency. In most scenarios, the CDMA system with AAS was better than the CDMA system without AAS , user-channel characteristics under which wireless communications is tested or used have important impact on the systems overall performance. It became clear that SUI channels with larger delay spread are a bigger challenge to any system. The AAS system proved its effectiveness in combating the multipath effect on the SUI fading channels.

Table (2):Comparison between results

Channel for BER= 10^{-3}	SUI-1 dB	SUI-2 dB	SUI-3 dB	SUI-4 dB	SUI-5 dB	SUI-6 dB
Without AAS	11.5	14.03	17.92	22.1	26.5	34.96
With AAS	9.9	11.25	14.85	18.9	22.96	31.1

Conclusion:

In this paper, the CDMA with AAS structure was proposed and tested. These tests were carried out to confirm its successful operation and its possibility of implementation. It can be concluded that this construction accomplishes much lower bit error rates. In all SUI channels the CDMA with AAS outperform than without using AAS therefore, this structure can be considered as an alternative to the conventional CDMA structure. It can be concluded from the results obtained, that S/N measure can be successfully increased using the proposed AAS designed method. The key contribution of this paper was the execution of the CDMA PHY layerbased the AAS structure. Simulations provided proved that proposed design accomplishes much lower and it can be used at high transmission rates.

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