Performance Analysis of Soft-Multiple Symbol Differential Sphere Decoding (MSDSD) in MIMO MultiCarrier CDMA System

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Abstract**—**Soft-decision Multiple Symbol Differential Sphere Decoding (S-MSDSD) is proposed for MIMO MC- CDMA based on Differential Space Time Shift Keying (DSTSK) system operating in frequency selective fading channels. DSTSK is capable of achieving both transmitter and receiver diversity gain. DSTSK signal is detected noncoherently by soft-decision MSDSD detector and it spreads the source information in both spatial and time dimensions, DSTSK is otherwise called as noncoherent Space Time Shift Keying. The Soft decision MSDSD for OFDM system reduces the potential performance due to high Doppler frequency in Conventional Differential Detection (CDD) scheme thus, making it more complex. To overcome this drawback, a newly proposed soft-decision MSDSD detector in MIMO MC CDMA is implemented to improve the performance by reducing the BER and Doppler frequency, thereby reducing the computational complexity using Sphere decoding algorithm (SDA) in MIMO MC-CDMA system. Finally, the simulation result shows the performance analysis of MIMO-OFDM based MSDSD scheme and MIMO MC- CDMA based MSDSD scheme.

Keywords**—** *Multiple Symbol Differential Sphere Decoding (MSDSD), Differential Space Time Shift Keying (DSTSK), Conventional Differential Detection (CDD), MIMO Multicarrier CDMA (MIMO MC CDMA).*

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I. INTRODUCTION

MIMO is an about antenna technique for wireless communication systems. MIMO system as the potential of improving both the spectral efficiency and link reliability of wireless communication systems and using multiple antennas is to increase data rates through multiplexing and to improve the performance through diversity and to reduce the BER. Multicarrier CDMA (MC-CDMA) system is the addition of CDMA and OFDM it results in better frequency diversity and higher data rates. The advantages of MC CDMA are low complex receivers, high spectral efficiency and high frequency diversity gain. Multicarrier modulation technique is also called as orthogonal frequency division multiplexing (OFDM). MC CDMA is mainly used in multimedia a service in 3g/4g networks.OFDM is frequency division multiplexing (FDM) scheme used as a digital multi-carrier modulation method. Used for digital audio and video broadcasting, ADSL, WLAN. Here, Multicarrier systems are used because it as the capable to reduces the receiver complexity. Multicarrier CDMA system as frequency domain spread and for multicarrier DS-CDMA it has time domain spread, multidimensional based CDMA.

Differential space time shift keying (DSTSK) is same like space time shift keying both DSTSK & STSK is capable of achieving both transmitter and receiver diversity gains. The STSK perform well in perfect channel state information (CSI) the DSTSK neither the channel nor the statistics of the channel are available [1]. The space modulation (SM) and space shift keying (SSK) is the promising MIMO signaling scheme both SM/SSK has only one active antenna at a time and the source information is assigned to the spatial indices it attain only receive diversity gain. So, to overcome this space time shift keying is introduced because it attains both transmitter and receiver diversity gain and the source information of STSK is in both space-time indices the STSK/DSTSK is a modulation scheme.

II. LITERATURE SURVEY

Differential Space Time Shift Keying employing conventional differential detection (CDD) in dispensing with channel estimate but in the CDD there is major drawback that is it suffers from typical 3 dB performance penalty in low Doppler effects [1]. There is irreducible error floor observed in CDD scheme in high mobility it characterized by high Doppler frequency due to very high Doppler frequency, the performance of CDD severely reduced. So, to overcome this multiple symbol differential detection (MSDD) is proposed with differential phase shift keying (DPSK) the MSDD for multiple input multiple outputs Rayleigh fading channels. It is a power efficient transmission method over the fading channel and with channel state information MSDD uses the fading with noise statistics of the channel it detecting with information symbols from number of consecutively received symbols. In MSDD there is increased complexity and it is the main drawback of multiple symbol differential detection. Adding sphere decoding (SD) in MSDD it become multiple symbol differential sphere decoding (SD+MSDD =MSDSD) [4]. MSDSD is used to reduce the complexity, improve the performance of the system.

Soft decision –MSDSD aided DSTSK in OFDM system it as some draw back in that system that is more complexity and performance degradation due to high bit error rate (BER), high Doppler effects and no of iteration is more in the OFDM system. The space time shift keying technique is used in varies type of systems they are OFDM, OFDMA/SC-FDMA, and MC CDMA. Analysis of multiple symbol differential sphere decoding (MSDSD) in this multiple symbol differential detection (MSDD) is an unsolved problem so MSDSD sphere decoding technique is introduced to find the optimal ML estimate. Coherent and differential space time shift keying a dispersion matrix approach it analyzed the bit

ISSN: 2321-8169
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error rate performance of both CSTSK and DSTSK schemes it as some drawbacks they are coherent STSK has the knowledge about channel state information at the receiver but in differential STSK it does not required any channel state information at the receiver side [2] .Turbo DPSK using soft multiple symbol differential sphere decoding is using the turbo codes the performance is analyzed but it was more complexity. Therefore to overcome the drawback the soft multiple symbol differential sphere decoding aided differential space time shift keying in MIMO MC CDMA system is introduced.

III SYSTEM MODEL

Differential space time shift keying (DSTSK) is same like space time shift keying both DSTSK & STSK is capable of achieving both transmitter and receiver diversity gains. The STSK perform well in perfect channel state information (CSI) the DSTSK neither the channel nor the statistics of the channel are available. The space modulation (SM) and space shift keying (SSK) is the MIMO signaling schemes both SM/SSK has only one active antenna at a time. The source information is the spatial indices it attains only receive diversity gain. To overcome this space time shift keying is introduced because it attains both transmitter and receiver diversity gain and the source information of STSK is in both space-time indices the STSK/DSTSK is a modulation scheme. Differential space time shift keying schemes designed for the single antenna helped system and it has differential phase shift keying (L-DPSK) and the DSTSK does not required any channel state information (CSI) at the receiver side in DSTSK encoder it contains of cayley unitary transform but in further it has some problem that is non linear function produced by that transform so, it is removed and the DSTSK encoder become linear characterize and also the DSTSK is employed in linear dispersion code ,space time code, etc and the differential space time shift keying is also called as non-coherent space time shift keying the DSTSK receiver as a capable of using low-complex in the single stream based ML detection in the system.

DSTSK employ in CDD (Conventional differential detection), multiple symbol differential detection (MSDD) and multiple symbol differential spheres decoding (MSDSD) based multi carrier DSTSK. Also, the MSDSD is designed for DPSK if it is hard decision MSDSD the DSTSK scheme operating in non dispersive channel but here we consider the soft decision MSDSD the DSTSK scheme is operated by dispersive channel. Differential space time shift keying employ in CDD (Conventional Differential Detection), Multiple Symbol Differential Detection (MSDD) and Multiple Symbol Differential Spheres Decoding (MSDSD) based multi carrier DSTSK. CDD suffers from a typical 3-dB performance penalty in low-Doppler shift and irreducible error is observed in high mobility that is characterized by high Doppler frequency due to this problem the performance of CDD is severely reduces. In Multiple Symbol Differential Detection (MSDD) scheme for multiple inputs multiple outputs in Rayleigh channels as high complexity. To overcome this drawback newly proposed MSDSD scheme is introduced [5].

Differential space time shift keying using soft multiple symbol differential sphere decoding in MIMO MC CDMA system to improve the performance by reducing the bit error rates and reducing the complexity of the system, comparing the performance of BER of CDD,MSDD,MSDSD schemes.

The new concept of DSTSK is proposed as a unified differential MIMO scheme, which is capable attaining flexible diversity-versus-multiplexing gains trade off. Similar to coherent STSK, DSTSK is also an ICI-free system model; [2] therefore the proposed DSTSK receiver reduces the complexity of ML detection on the receive side.

To future enhance the performance of DSTSK scheme's is to reduce the effects of Doppler shift, the non coherent detection algorithm based on MSDSD is developed.

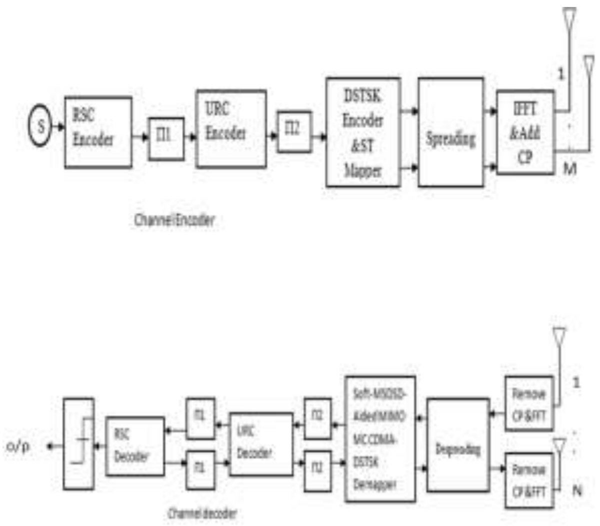

Fig.1 Transceiver blocks for the proposed Differential Space–Time Shift Keying Using Soft Multiple-Symbol Differential Sphere Decoding in MIMO MC CDMA system.

A channel-coded MC CDMA-aided DSTSK transceiver employing *M* transmit and *N* receive antenna elements (AEs), as shown in Fig.1 The encoder/decoder blocks are general channel coding scheme that supports soft-decision decoding at receiver complexity. The coding blocks are interleaved serially by recursive systematic code (RSC) and unity rate code (URC) scheme.

First the source information are encoded by RSC encoder, then the encoded bits are passed to interleaver 1 after interleaved by a random bit is passed to URC encoder further bits are interleaving by 2. Following the encoded bits are coded by DSTSK encoder and the resultant bits are mapped by space-time mapper. The encoded bits are spreads by frequency domain (FD), the DSTSK codes are modulated and passed to IFFT & cyclic prefix block in transmitter side.

In Receiver side the cyclic prefixes is removed and the encoded bits are despreaded and it passed to the soft-MSDSD aided MIMO MC-CDMA system then the bits are demapped and given to interleaver 1&2 then the codes are decoded by (RSC & URC decoder).finally the resultant bits are estimated. The three soft decision components are namely, the DSTSK demapper, the URC decoder, and the RSC decoder.

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The transmitter model of MC-CDMA aided DSTSK scheme. The DSTSK transmitter M generates space time codes from the users that are source information. These codes are further spread by the Frequency Domain (FD) and then mapped to a no of subcarriers, transmitted using M transmit AEs over T time slots.

The system model show about transmitter and receiver block and its working procedures about the DSTSK scheme on the soft-MSDSD in MIMO MC CDMA system and the Encoding principle of the DSTSK's transmitter are explained by, the information bits $B = \log_2(Q, L)$ are input to the DSTSK block in each of the Space-Time (ST) block durations *T*. Then the information bits are Serial-to- Parallel (S/P) converted to $B_1 = \log_2 L$ bits and $B_2 = \log_2 Q$ bits after conversion modulate the complex valued *L*-PSK/QAM symbol. Then calculate the matrices value dispersion matrices $A_1, \ldots\ldots, A_Q \in C^{M \times T}$ and activated matrix $\{A_q; q = 1, \ldots Q\}$, finally the space-time matrix $\boldsymbol{S}$ is generated [1].

A. Sphere Decoding Algorithm (SDA)

Sphere decoding algorithm is the most widely used approach to find the maximum-likelihood (ML) estimate. The sphere decoder provides optimal maximum-likelihood performance in MIMO detection with reduced complexity and it examines those candidate vectors that present inside the sphere of radius R. The sphere decoding algorithm has three main steps they are,

-Sphere Constraint
-Computing partial Euclidean distance
-Tree traversal and radius reduction

Sphere decoder is used to reduce the number of search candidates of the ML detection with the help of pre specified radius distance R. The sphere decoding is also used to find the minimum distance between the given points, using tree search algorithm the sphere decoding finds the ML estimates [4]. Finally, sphere decoding reduces the computational complexity and it is used to overcome the error caused by high Doppler frequency.

STEP 1: Sphere decoder examines that candidate vectors s that lies inside a sphere of radius R.

STEP 2: Let u_{ij} denote the entry of u in row i and column j, $(1 \le i \le \mathrm{N})$ and introduce the squared length.

STEP 3: Then, possible values s_i have to satisfy the length criterion.

STEP 4: If, i =1 is reached, the radius R is dynamically updated by R. And sphere decoding is repeated starting with i =2 and new radius R.

STEP 5: Sphere decoding is finished if no vector is found inside the sphere with radius R. The proposed SDA performs the search for the ML solution.

IV. RESULTS AND DISCUSSION

The performance of the proposed soft-decision-MSDSD-aided MC-CDMA DSTSK scheme is investigated using the parameters listed in Table I. We have the Rayleigh channel model between each transmitter–receiver antenna pair. As given in Table I, we employ an RSC encoder and decoder in half rate and here we taken DSTSK (M, N, T, Q, L) as (2,2,2,2,2) and (2,2,2,4,4) here M and N represent the no of Tx&Rx antenna, T and Q represent the time slots and dispersion Matrices, L represents the modulation order. The spreading code used here is Walsh-Hadamard these are the main parameter used for our proposed systems.

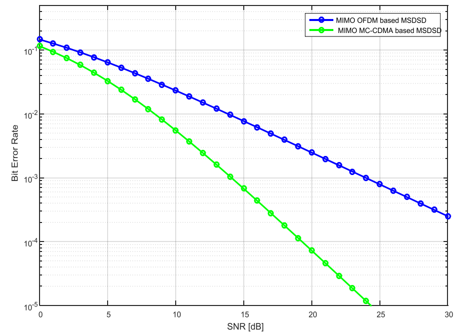

Fig. 2 BER Vs SNR for MIMO MC-CDMA based MSDSD scheme and MIMO OFDM based MSDSD scheme

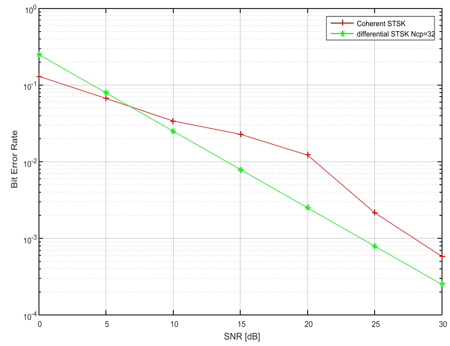

Fig. 3 BER Vs SNR for Coherent Space Time Shift Keying (CSTSK) and Differential Space Time Shift Keing (DSTSK)

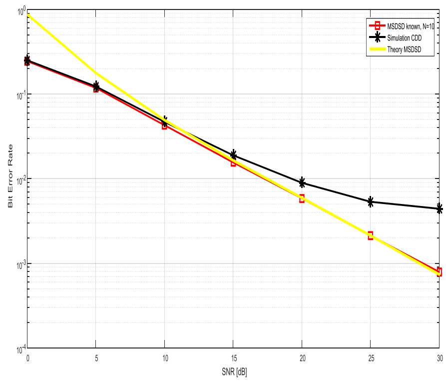

Fig. 4 BER Vs SNR for MSDSD AND CDD scheme in MIMO MC CDMA system

The fig. 2 represents the performance of Bit Error Rate Vs SNR for both MIMO OFDM system and MIMO MC CDMA system based MSDSD for two transmitter and receiver antennas. The result depicts the performance of MC CDMA based MSDSD scheme (proposed system) is better when compared than that of OFDM system based MSDSD scheme (existing system). The fig. 3 represents the performance of Bit

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Error Rate (BER) Vs SNR for Coherent Space Time Shift Keying (CSTSK) and Differential Space Time Shift Keying(DSTSK) and comparing both CSTSK and DSTSK the differential space time shift keying is best in system.Because, it achieves both transmitter as well as receiver diversity gains and in DSTSK the error rate gets reduced.

The fig.4 describes the performance comparison of MSDSD and CDD scheme in MIMO MC CDMA system. The channel used in the system is Rayleigh fading channel. The result implies for MSDSD scheme the error rate gets reduced and hence performance increases. The performance of MSDSD is better when compared than that of CDD scheme. Finally, from the result, the proposed system; Differential Space–Time Shift Keying Using Soft Multiple-Symbol Differential Sphere Decoding in MIMO MC CDMA system is best compared to the existing system.

V .CONCLUSION

A soft decision MSDSD aided DSTSK in OFDM system mitigates the potential performance due to high BER and error caused by high doppler frequency.To overcome this problem, the newly proposed MSDSD scheme is used in MIMO MC CDMA to improve the performance and to reduce the complexity. Differential space time shift keying is used because it attains both transmitter and receiver diversity gain ,and the souce information is both in space-time dimensions.Comparing with other schemes like CDD and MSDD the S-MSDSD scheme is the best. Sphere decoder is an optimal MIMO detector achieves the optimal ML performance with reduced computational complexity. In future the Sphere Decoding (SD) can be used in all communication systems.

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