Performance Analysis of Vertical BLAST Multiplexing with Selection Transmit Diversity

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Abstract *—Adaptive Modulation and Coding (AMC) is combined with Multiple Input Multiple Output (MIMO) multiplexing to improve the throughput performance of AMC. In addition, Selection Transmit Diversity (STD) is considered in MIMO multiplexing to achieve higher diversity gain. AMC-STD-MIMO multiplexing system is proposed. STD in our simulation selects 2 transmission antennas from 4 antennas and AMC-MIMO multiplexing process operates with the selected antennas in Vertical BLAST (V-BLAST).*

Keywords: AMC, MIMO, STD, V-BLAST

I. INTRODUCTION

The Bell-lab Layered Space-Time (BLAST) is representative of the MIMO multiplexing scheme [1]. Also, in order to improve throughput performance, together with MIMO multiplexing system, Adaptive Modulation and Coding (AMC) has drawn much attention [2], [3]. The AMC scheme adapts coding rate and modulation scheme to channel condition, resulting in improved throughput and guarantees transmission quality.

II. PRELIMINARIES

2.1 AMC-MIMO Multiplexing System

The combination of MIMO multiplexing system and AMC could be one of the solutions for improved throughput performance. This paper aims at Transmit Diversity (TD) technique that could be a useful application for improving throughput of AMC-MIMO system. TD technique brings on a higher SNR and allows a usage of Modulation and Coding Scheme (MCS) level that supports higher data rate with a satisfactory throughput.

In the AMC-MIMO multiplexing scheme, the previous V-BLAST structure has been changed [4]. Fig. 1 and Fig. 2 show the transmitter structure and decoding algorithm of V-BLAST, respectively. This is because Turbo decoding procedure in Fig. 3 considered in combining AMC with V-BLAST. Namely, soft decision value instead of hard decision value of V-BLAST is inputted to decoder for Turbo decoding.

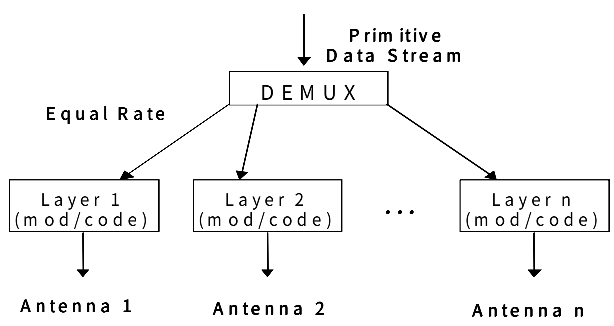

Fig. 1 Transmitter of V-BLAST.

We can consider using Turbo decoded data, such as the hard decision value used for V-BLAST canceling procedure, using Turbo decoded data. But this scheme increases delay in signal processing procedure and increases receiver complexity because the decoded data is used for cancellation after encoding, interleaving and modulating process.

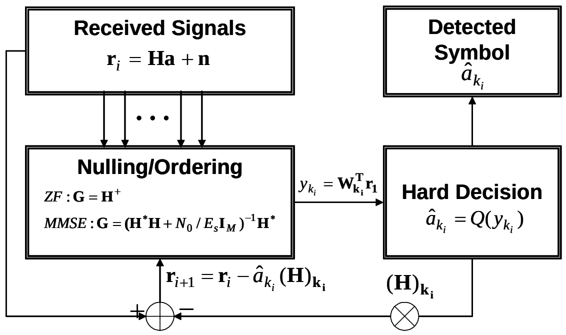

Fig. 2 Decoding algorithm of V-BLAST.

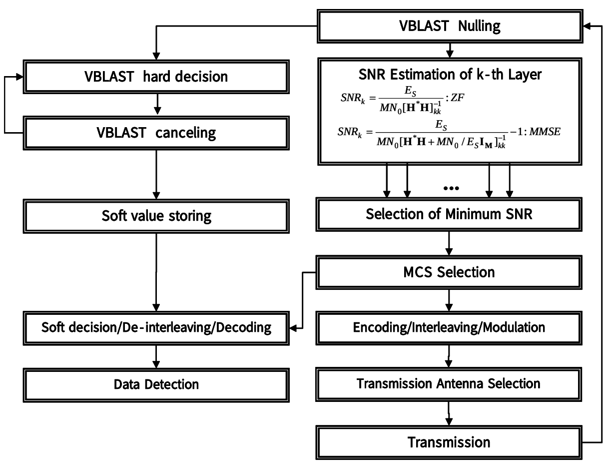

Fig. 3 Turbo decoding procedure
in AMC-MIMO multiplexing system.

2.2 The proposed V-BLAST STD multiplexing system

The AMC-MIMO multiplexing system attains an improved throughput compared to a conventional AMC system. Moreover, the throughput can be greatly increased by adopting transmit diversity. In the simulation, STD is applied. The reason of the selecting STD from the other TD techniques is as follows. First, closed-loop TD is considered since the AMC system basically contains feedback information. Second, instead of open-loop TD like Space-Time Block Coding (STBC), higher diversity gain is achievable [5], [6].

Finally, the feedback information of STD is simpler than that of the other closed-loop TD like Transmit Adaptive Array (TxAA). Fig. 4 shows the transmitter and receiver structure of the proposed system. Fig. 5 shows the transmit antenna selection algorithm when STD is applied to AMC-MIMO multiplexing system where M_t is the number of transmit antenna which is possible to select and M is the number of selected transmit antenna for MIMO multiplexing.

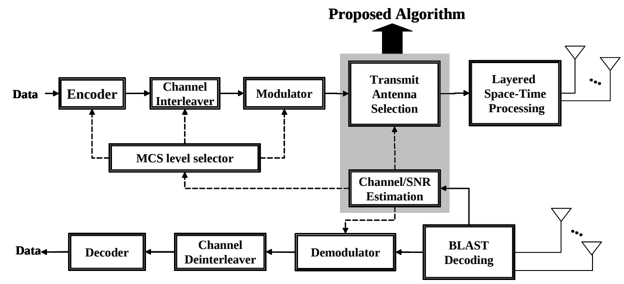

Fig. 4 Transmitter and receiver structure of the proposed AMC-STD-MIMO multiplexing system.

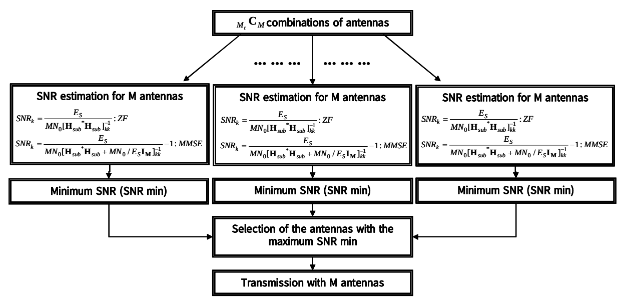

Fig. 5 The transmit antenna selection algorithm in AMC-STD-MIMO multiplexing system.

The SNR of each layer is obtained as a result of nulling. When we select M antennas among M_t candidate antennas for MIMO multiplexing, the possible combination of the antenna selection is $_{M_t}\mathbf{C}_M$. For each possible combination, SNR for each of the M selected transmit antennas can be obtained.

The selected set of antennas is one that has the maximum value among the compared minimum SNRs. As an example, if 2 antennas from 4 candidate antennas are used, six possible combinations of antennas exist.

Then minimum SNR from each combination, SNRmin in Fig. 5, can be obtained and only one combination that has the maximum SNRmin is chosen. Finally, the data is transmitted on the antennas which belong to the combination.

III. SIMULATION RESULTS

Simulation results are presented and discussion of the throughput performance of AMC-STD, AMC-

MIMO multiplexing system, and the proposed system is made.

Table 1 and Table 2 show the MCS level selection and the simulation parameters in this paper, respectively.

In addition, since we put emphasis on data transmission rate, we select the threshold that maximizes throughput. Accordingly, each MCS level selection threshold is based on the throughput performance cross point in Fig. 6. MCS level selection thresholds decided by the cross points are 3.25dB, 7.25dB, and 9.25dB, respectively.

We investigate the performance of proposed system in MIMO channel modeling in Fig. 7 through the computer simulation.

Table 1 MCS levels.

MCS level	Data rate (kbps)	Bits/frame	Code rate	Modulation
1	614.4	1024	1/3	QPSK
2	1228.8	2048	2/3	QPSK
3	1843.2	3072	2/3	8PSK
4	2457.6	4096	2/3	16QAM

Table 2 Simulation parameters.

Parameter	Value
Bandwidth	1.2288MHz
Slot length	1.67msec
Modulation	QPSK, 8PSK, 16QAM
Code rate	1/2, 2/3
Channel coding	Turbo coding (Number of iterative decoding: 4)
Number of Tx. antennas	1, 2, 4
Channel	Flat Rayleigh fading

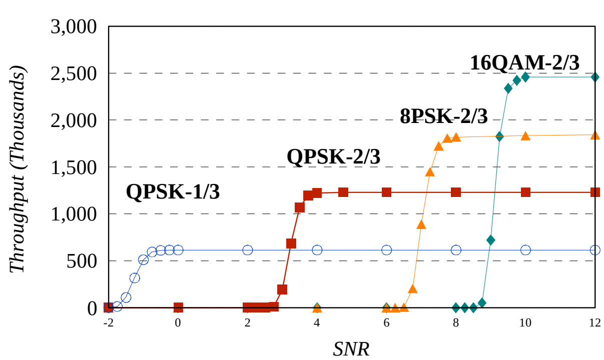

Fig. 6 The throughputs (kbps) of each MCS level.

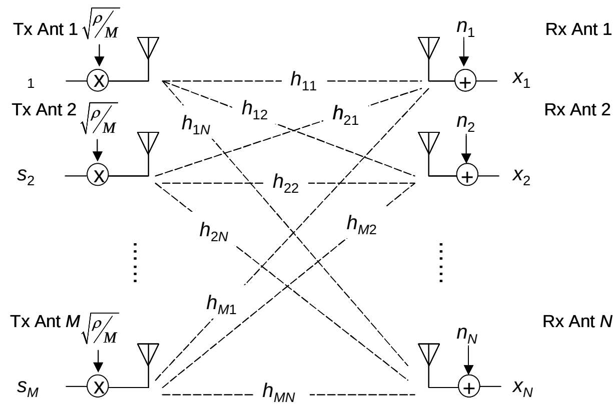

Fig. 7 MIMO Channel Modeling.

Fig. 8 shows throughput performance of AMC-MIMO multiplexing system. We can see that maximum throughput which we can obtain by increasing the number of transmit antenna is higher than that of only one transmitter and receiver system combined with AMC scheme.

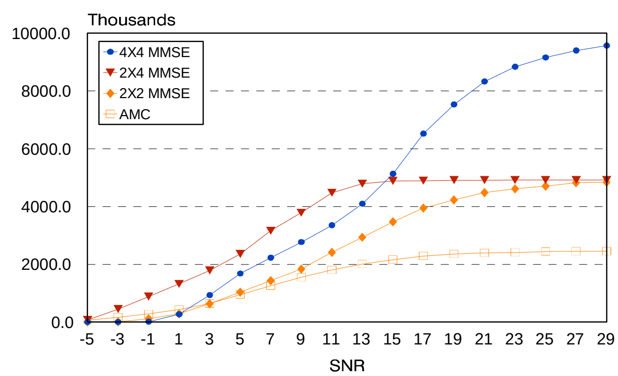

Fig. 8 The throughputs (kbps) of AMC-MIMO multiplexing system.

Fig. 9 shows the throughput performance of the AMC-MIMO multiplexing system with STD. As a simulation result, Performance of the AMC-MIMO multiplexing system using 2 transmit antennas and 4 receiver antennas is superior in all SNR environment. Because of the decreased error occurrence by receiver diversity, we can obtain fine throughput performance of V-BLAST scheme. On the other hand using 2 by 2 Minimum Mean Square Error (MMSE) V-BLAST scheme in a low SNR environment, throughput increases very little [4]. That is, in low SNR environment, throughput-increasing effect of MIMO multiplexing scheme is limited by error occurrence. On the other side, maximum throughput values of the AMC system combined with STD using only one transmit and receiver antenna is lower than that of AMC-MIMO multiplexing system. However, in low SNR environment, throughput value of the AMC system combined with STD using only one transmit and receiver antenna increases with stable and is higher than throughput value of the general AMC system. Because of diversity gain in antenna selection, its performance is superior to general AMC system. From these results, we can see that maximum throughput improvement of the AMC-MIMO multiplexing system and stable throughput increase characteristics of the AMC system combined with diversity scheme.

Fig. 10 depicts the throughput improvement for the proposed AMC-STD-MIMO multiplexing system. The same experiment environment of the Table 1 and 2 is applied and the STD that selects 2 transmit antennas from 4 antennas is used. The results show the proposed system (AMC-STD-MIMO multiplexing system) achieves better throughput performance than the AMC-MIMO multiplexing system in the total SNR range. In case of applying the MMSE method, the AMC-STD-MIMO multiplexing system achieves the gain of 4.5dB SNR compared to the AMC-MIMO multiplexing system at 3Mbps throughput. The result demonstrates that the performance of the proposed scheme approaches that of AMC-MIMO 2X4 MMSE multiplexing system up to 2dB for the same throughput.

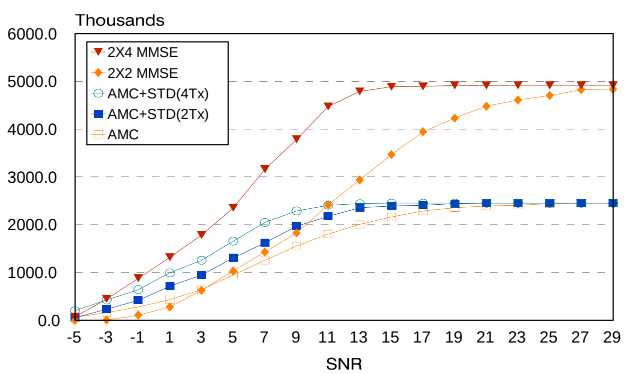

Fig. 9 The throughputs (kbps) of AMC-MIMO multiplexing system and AMC-STD system.

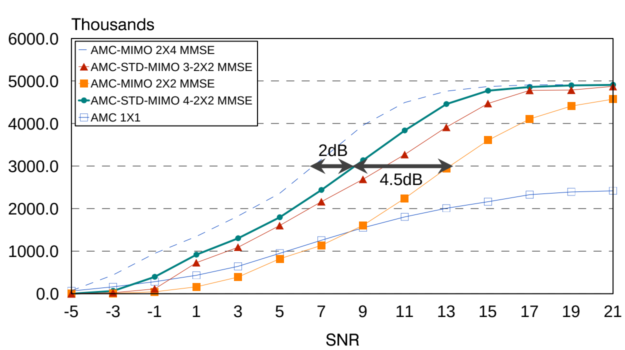

Fig. 10 The throughputs (kbps) of the proposed system.

IV. Conclusions

In this paper, the AMC-MIMO multiplexing system is implemented and its performance is shown. The results prove that the AMC-MIMO multiplexing system contributes to the throughput enhancement. On the other hand, it hardly improves the performance in a low SNR range. To mitigate this problem, the AMC-STD-MIMO multiplexing system is proposed. As a result of simulation, the proposed system provided the maximum throughput improvement and stable throughput increase in the whole SNR range.

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