Feedback Rate Adaptation in Transmit Power Control for Closed-loop V-BLAST Systems

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Abstract: In this paper, we propose an efficient feedback rate adapdation scheme in transmit power control for closed-loop V-BLAST systems in time-varying channel. In the proposed scheme, according to the time variation of channel, the feedback rate is adaptively decided to reduce redundant feedback overhead which is a major concern for the closed-loop systems. The simulation results demonstrate that the proposed scheme can reduce the feedback overhead significantly without the system performance loss.

1. Introduction

V-BLAST (Vertical Bell Labs Layered Space-Time) system has received remarkable attention due to its simple system structure and high throughput performance [1]. There have been some attempts to improve system performance by employing the feedback mechanism [2], [3]. Among various studies, the power control techniques have noticeable merit for its relative simplicity and remarkable capability. In this regard, a transmit power allocation for the OSIC (Ordered Successive Interference Cancellation) based V-BLAST systems has been introduced to improve the system error performance [2]. In such a closed-loop system, feedback overhead is a major concern for implementation aspect. In respect of practical implementation, some researches are needed to reduce feedback overhead and system complexity for closed-loop V-BLAST systems.

2. System Model

We consider a transmit power allocation scheme employed SQRD based V-BLAST system with M transmit antennas and N ($\geq M$) receive antennas as shown in Fig. 1.

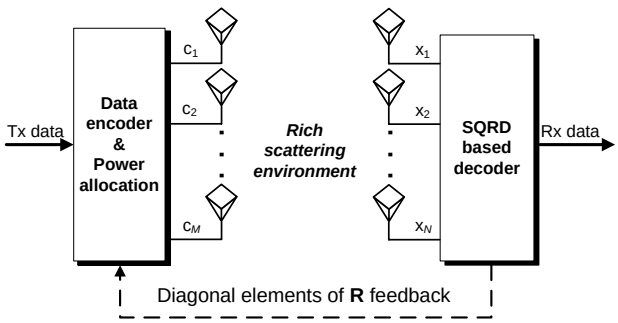

Fig. 1 System Block Diagram

In the system, the real valued diagonal elements of **R** matrix obtained from the SQRD of the channel matrix are forwarded to the transmitter. Using the limited feedback information, the transmitter allocates the optimum transmit power to minimize bit error rate (BER) of the system. Thus, the receiver does not need any effort for power allocation, and simple transmit power control calculation of each antenna is only needed at the transmitter. The object of the power allocation is to make equal received signal power for every layers based on [3].

3. Proposed Scheme

In this paper, we propose an adaptive feedback rate control scheme in transmit power allocation with partial feedback for sorted QR decomposition (SQRD) based V-BLAST systems. In time-varying channel environment, according to the variation rate of the channel, the system could adapt proper feedback rate to reduce feedback overhead while maintaining the system performance. Fig. 2 describes the flowchart of the proposed feedback rate control algorithm.

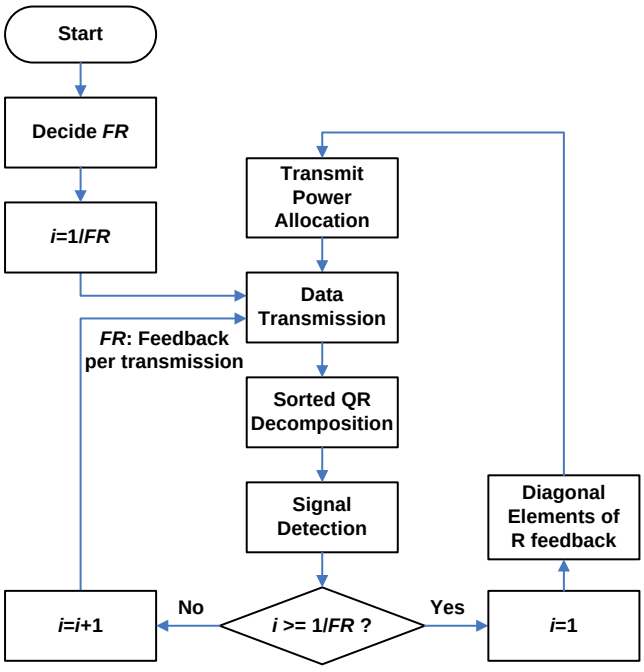

Fig. 2 Flowchart of the Proposed Scheme

As a measurement for channel variation, normalized Doppler frequency $f_m T$ is considered, where f_m is the maximum Doppler frequency and T is the symbol period. Based on $f_m T$ values, the receiver decide proper value of feedback per transmission rate (FR). According to the

corresponding feedback rate, the receiver execute feedback, and the transmitter employing the transmit power allocation. With the proposed adaptive feedback control scheme, the feedback overhead of the system can be reduced efficiently.

3. Performance Analysis

The performance of the proposed scheme is evaluated with Monte-Calro simulation. The proposed scheme is applied to MMSE-SQRD based V-BLAST system with 4 transmit antennas and 4 receive antennas. Power Normalized QPSK modulation is employed and perfect channel information availiability at the receiver and error-free feedback is assumed in uncorrelated Rayleigh flat fading channel. The BER performance of the proposed scheme is shown in Fig. 3.

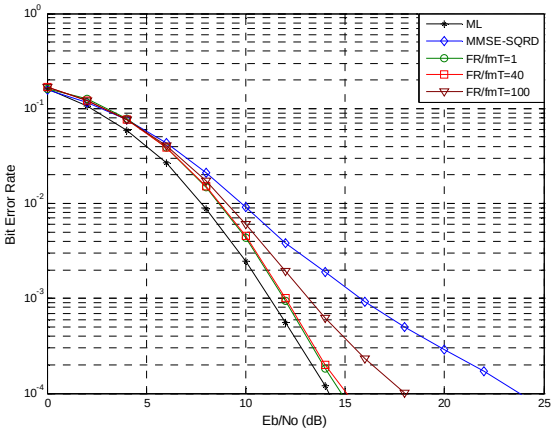

Fig. 3 BER Performance of the Proposed Scheme

It is observable that the transmit power control improves the system performance significantly. In addition, by employing adaptive feedback rate control, we can also reduce feedback overhead. For time-varying channel environment with $f_m T = 10^{-2}$, we can reduce about 60% of feedback overhead without the system performance loss compare to the case with every transmission employing feedback process. More generally, we can conclude that if the ratio of feedback rate and normalized Doppler frequency is larger than 40, we can reduce feedback overhead while maintaining system performance. The advantage of the scheme will be enormous when the time variation of the channel is slow.

Acknowledgment

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References

[1] P. W. Wolniansky, G. J. Foschini, G. D. Golden, and R. A. Valenzuela, ``V-BLAST: An architecture for realizaing very high data rates over the rich-scattering wireless channel," in Proc. IEEE ISSE, pp. 295-300, Sept. 1998.

[2] S. H. Nam, O. S. Shin, and K. B. Lee, ``Transmit power allocation for a modified V-BLAST system," IEEE Trans. Commun., vol. 52, pp. 1074-1079, July 2004.

[3] J. K. Zhang, A. Kavcic, and K. M. Wong, ``Equal-diagonal QR decomposition and its application to precoder design for successive-cancellation detection," IEEE Trans. Inf. Theory., vol. 51, no. 1, pp. 154-172, Jan. 2005.

[4] D. Wubben, J. Rinas, R. Bohnke, V. Kuhn, and K. D. Kammeyer, ``Efficient algorithm for decoding layered space-time codes," IEE Electronic Letter, vol. 37, no. 22, pp. 1348-1350, Oct. 2001.