Performance Improvement of a STTD Receiver without the Mutual Interference of Antenna

Byung-Hoon Woo[1] · Seung-Sun Baek[1] · Heau-Jo Kang[2]

Abstract

For mobile multimedia systems that equip transmit diversity for a forward channel, it is well known that the Tx diversity technique is appropriate for high rate mobile multimedia communications. In this paper, we propose a STTD (Space Time Transmit Diversity) receiver, which incorporates the design of the Tx diversity receiver without the mutual interference of antenna by using a CCI cancellation technique. The new STTD receiver is simulated and its performance is analyzed in a DS-CDMA/QPSK. Adopting the proposed STTD receiver at 10^{-2}~10^{-4} in bit error rate, SNR of 0.5 dB~2 dB performance improvement in AWGN and Rayleigh fading environments has been achieved.

Key words : STTD(Space Time Transmit Diversity), CCI Canceller, IMT-2000, MAI(Multi-Access Interference).

Ⅰ. Introduction

The demand for multimedia services using mobile communication is growing rapidly. As such, the next generation systems are expected to provide multimedia services with over 2 Mbps data rate and similar quality as fixed networks. 3rd generation mobile systems (IMT-2000: International Mobile Telecommunication-2000) are required to have high data rate and multimedia services. IMT-2000 is separated into the proposed asynchronous W-CDMA(Wideband-Code Division Multiple Access) by 3GPP(3rd Generation Partnership Project) and the synchronous IS-2000 has evolved from PCS(Personal Communication Service) IS-95A/B. W-CDMA and IS-2000 are based on DS-CDMA(Direct Sequence-Code Division Multiple Access) digital technology[1],[2].

In a DS-CDMA system, many users transmit messages simultaneously over the same wireless communication channel, each using a specific spread spectrum PN(pseudo-random noise) code. At the receiver, a users messages can be extracted using a PN code, which is pre-assigned to each user. The extraction of each user message suffers from MAI(Multi-Access Interference) and multi-path fading. However the problem can be reduced by CCI(Co-Channel Interference) cancellation techniques and rake receiver[3],[4].

For mobile multimedia systems that equip transmit diversity for a forward channel, it is well known that the Tx diversity technique is appropriate high-rate mobile communications, such as personal communication or mobile multimedia communication systems. Using two transmit antennas, performance of the scheme is degraded by mutual interference caused by each antenna. Thus we propose a STTD(Space Time Transmit Diversity) receiver, which incorporates the design of the Tx diversity receiver without antenna mutual interference by using a CCI cancellation technique.

In this paper, a transmitter and receiver system based on the proposed asynchronous IMT-2000 system standard is constructed. The design of a rake receiver using the STTD receiver is proposed and analyzed in mobile environments. Finally, the performance of simulation using proposed new receiver is assessed through a simulation.

Ⅱ. Space Time Transmit Diversity

Fig. 1 shows a baseband representation of the two branch transmit diversity scheme. The scheme uses two transmit antennas and one receive antenna and may be defined by the following three functions[5]

- the encoding and transmission sequence of information symbols at the transmitter;

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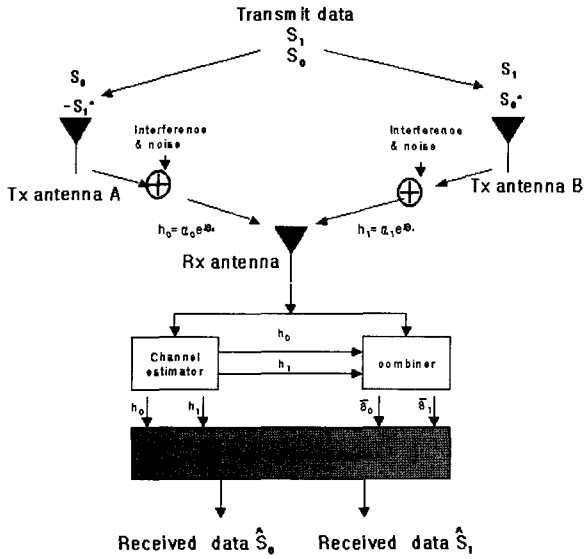

Fig. 1. Space time transmit diversity.

- the combining scheme at the receiver;
- the decision rule for maximum likelihood detection.

A block diagram of a generic STTD encoder by 3 GPP is provided in Fig. 2. Channel coding, rate matching, and interleaving are accomplished as in the non-diversity mode. For QPSK, the STTD encoder operates on 4 symbols b_1, b_2, b_3, and b_4, as shown in Fig. 2. For AICH, AP-AICH and CD/CA-ICH, b_i are real valued signals, and $\overline{b_i}$ is defined as $-b_i$. For channels other than AICH, AP-AICH and CD/CA-ICH, b_i are 3-valued digits, taking the values 0, 1, or "DTX". $\overline{b_i}$ is defined as follows : if b_i=0 then $\overline{b_i}$=1, if b_i=1, then $\overline{b_i}$=0, otherwise $\overline{b_i}=b_i$[6].

Ⅲ. System Model

In this paper, a transmitter and receiver system based on the proposed asynchronous IMT-2000(WCDMA: Wideband CDMA) system standard by 3 GPP is constructed as shown in Fig. 3[6],[7]. For the simulation, we assume that the mobile wireless channel is AWGN, MA and a multi-path fading environment. The transmit data signal is NRZ(Non-return to zero) and system modulation is DS-CDMA/QPSK.

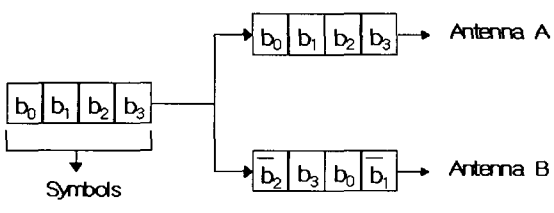

Fig. 2. Transmit structure of STTD.

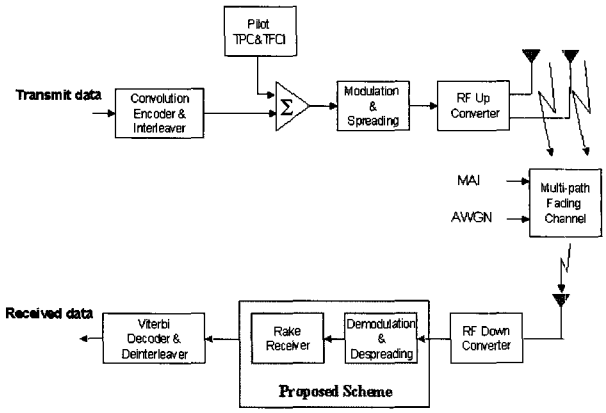

Fig. 3. W-CDMA system model.

3-1 Co-channel Interference(CCI) Cancellation Technique

Here we assume that the cell-site transmits the same power for each user and that interfering signals share the same propagation path. Multi-access interference (MAI) can be modeled as Gaussian random variance. Based on the random sequence assumption, the variance of the interference component at the output of the matched filter, MAI is then given by

$$MAI = \frac{2}{3M} E_b \rho^2. \tag{1}$$

where ρ is the instantaneous amplitude and M is PN code length. MAI of the reference user in the reference cell is given by

$$I_{total} = (K-1)\frac{2}{3M} E_b \rho^2. \tag{2}$$

where K is the number of users in the reference cell.

If we consider the interference from other users, the equivalent $r=SNR_{DS}$(SNR: Signal-to-Noise power Ratio) of DS-CDMA can then be expressed as [8]

$$r = \frac{E_b \rho^2}{\frac{2(K-1)}{3M} E_b \rho^2 + \frac{N_o}{2}}, \tag{3}$$

where $\frac{N_0}{2}$ is the power spectrum density of AWGN.

In order to cancel antenna mutual interference in STTD receiver we use the CCI cancellation technique. Fig. 4 shows a model of reference user's receiver using

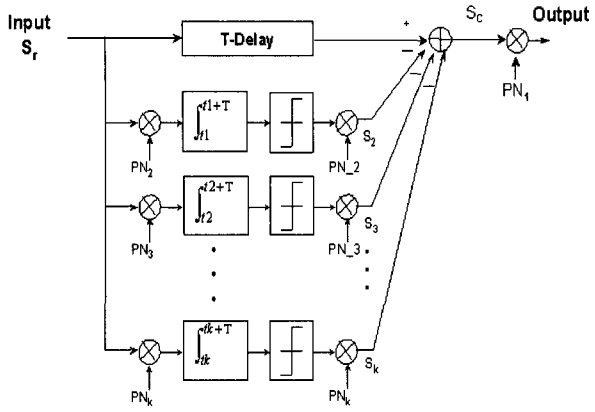

Fig. 4. Structure of co-channel interference canceller.

CCI cancellation techniques in DS-CDMA[4],[9]. Signal to noise ratio r_{CCI} after correlation calculation between Sc and the PN sequence of reference user can be obtained as follows.

$$r_{CCI} = \frac{1}{4P_e + \left(\frac{N_0}{E_b}\right)}. \quad (4)$$

where, P_e is bit error rate after correlation detection at the receiver with CCI non-cancellation.

3-2 Propose STTD Receiver

In this part, we propose a new scheme for a STTD receiver. Using two transmit antennas, the conventional scheme is degraded by a mutual interference side effect caused from each antenna. Therefore we propose a STTD receiver that incorporates the design of a Tx diversity receiver without antenna mutual interference. Fig. 5 shows the design of the STTD receiver using CCI cancellation technique.

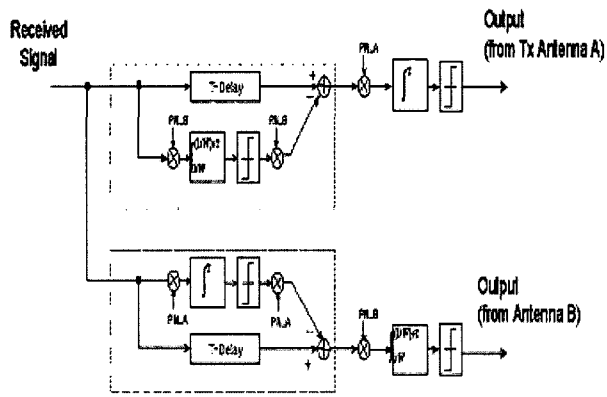

Fig. 5. Proposed STTD receiver.

Ⅳ. Simulation

4-1 Simulation of the Proposed STTD Receiver

In order to analyze the performance of the proposed STTD receiver we should first construct the simulation model shown in Fig. 3. The receiver is constructed using CCI ancellation technique. a block diagram of the simulation for the proposed STTD receiver is shown in Fig. 6. The bit error rate of the proposed scheme is compared with that of transmit signals and received signals in AWGN and Rayleigh fading environments. The simulation parameters are given in Table 1.

4-2 Simulation Results and Discussion

The simulation results of the DS-CDMA/QPSK using the proposed STTD receiver are shown in Fig. 7~Fig. 8. BER curves of the proposed scheme are compared

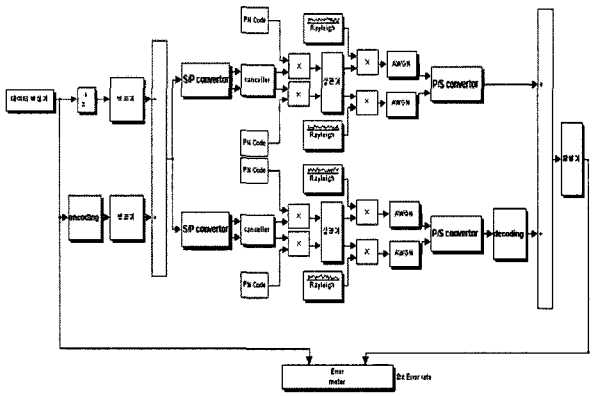

Fig. 6. Block diagram of simulation for the proposed STTD receiver.

Table 1. Simulation parameters of the proposed STTD receiver.

Modulation	QPSK
Transmit antenna	2
PN length	64
PN chip duration	1/64 [sec]
No. of user	1
Channel environment	Multi-path (Rayleigh fading)
Baseband transmission	NRZ(Non-return to zero)
No. of data	10,000~20,000

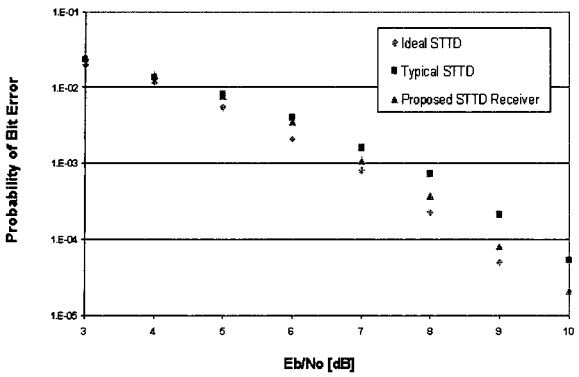

Fig. 7. Performance of the proposed STTD receiver in AWGN environment.

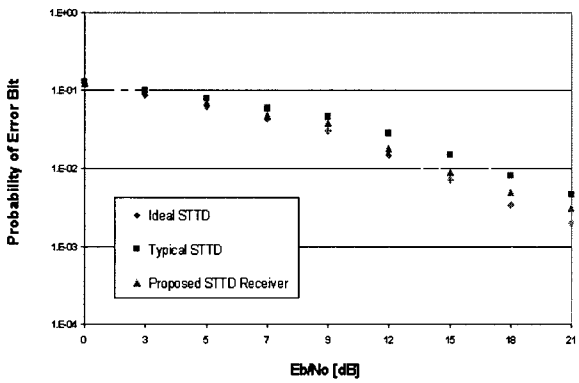

Fig. 8. Performance of the proposed STTD receiver in Rayleigh fading environment.

with those of typical and ideal cases in AWGN and Rayleigh fading environments.

Fig. 7 shows the error performance of DS- CDMA/ QPSK using the proposed STTD receiver in the AWGN environment. We observed that the proposed STTD receiver gained about 0.5 dB and 1 dB when the bit error rate was 10^{-3} and 10^{-4}, respectively. Fig. 8 shows the error performance of DS-CDMA/QPSK adopting the proposed STTD receiver at 10^{-2} in bit error rate. SNR of 2 dB performance improvement in the Rayleigh fading environment has been achieved.

V. Conclusions

In this paper, a new STTD receiver for a mobile multimedia communication system is proposed and its performance is analyzed. For mobile multimedia systems that equip transmit diversity for forward channel, it is well known that the Tx diversity technique is appropriate for high rate mobile communications. We propose a STTD receiver that incorporate the design of a Tx diversity receiver without antenna mutual interference using CCI cancellation technique. From simulation results, the proposed receivers show improved performance of DS-CDMA/QPSK by increasing the total received signal to noise ratio. By adopting the proposed STTD receiver at 10^{-2}~10^{-4} in bit error rate, SNR of 0.5 dB~2 dB performance improvement in AWGN and Rayleigh fading environments has been achieved.

Consequently, the proposed STTD receiver will be a very effective method to improve the performance of mobile multimedia forward channel using transmit diversity.

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