PERFORMANCE OF A RANDOM ACCESS PACKET WITH MESSAGE BITS

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Abstract - The performance is investigated for a random access packet containing both a preamble and message. Numerical results show that channel adaptive random access can obtain significant performance gain compared with conventional random access.

Keywords - Random access, Channel adaptive, Wireless network.

I. INTRODUCTION

Random access is one of the essential techniques of a communication system. Channel-adaptive random access has been proposed to reduce transmission power for random access packet in a time division duplex (TDD)-based wireless system [1]-[3].With channel-adaptive random access, a remote station transmits a random access packet, when the uplink channel gain is larger than a certain threshold.

A random access packet is composed of a preamble in wideband code division multiple access (WCDMA) and long term evolution (LTE) systems [4]-[5]. However, it is possible to include message bits in a random access packet to reduce the transmission delay of random access. For example, a random access packet includes short message bits in a cdma2000 systems [6].
With channel adaptive random access, the performance has beenresearched assuming that a random access packetis composed of a preamble only [1]-[3]. However, there have been no previous researches for channel-adaptive random access, when a random access packet is composed of a preamble and message.

In this paper, the performance is investigated for a random access packet containing both a preamble and message. The rest of this paper is organized as follows. Section 2 presents a system model of channel-adaptive random access. Section 3 and 4 present the numerical results and conclusion of the paper, respectively.

II. SYSTEM MODEL

In this section, a system model is presented. A TDD-based wireless system is considered in this paper. In the system model, there are a host station and a remote station. A host station periodically transmits a pilot signal. A remote station can estimate an uplink channel gain using the pilot signal from channel reciprocity [7].

With channel-adaptive random access, a remote station transmits a random access packet, when the estimated uplink channel gain is larger than a predetermined transmission thresholdg_{th}. Otherwise, it postpones the transmission of a random access packet until the estimated uplink channel gain is larger than the transmission thresholdg_{th}.

In this paper, a random access packet is composed of a preamble and message. It is possible to transmit a random access packet with time division multiplexing (TDM) or code division multiplexing (CDM). In this paper, it is assumed that aremote station transmits a random access packet with TDM. Fig. 1 shows the example of a random access packet containing both a preamble and message. In Fig. 1, the lengths of a preamble, message and a random access packet are T_p, T_m and T, respectively.

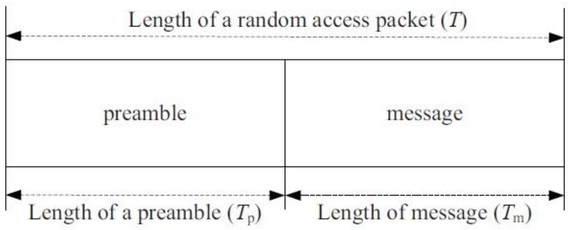

Figure 1. The example of a random access packet

It is assumed that a remote station measures downlink channel gain with discontinuous channel measurement as in [2]. The downlink channel is assumed to be slow time-varying fading such that the channel gain is constant during a random access packet. Without loss of generality, the channel gain is normalized to satisfy $\mathrm{E}(\mathrm{g}) = 1$ as in [1].

By using an energy detector with a search window of size W, a host station detects a preamble as in [1]. When the maximum output of the energy detector is larger than a detection threshold η, a host station decides H_1, which means that a random access packet has been transmitted from a remote station. After the preamble detection, a remote station demodulates message coherently by using the channel estimation obtained from the preamble.

In this paper, two types of power allocation schemes are considered with channel-adaptive random access. First, with constant power allocation, a remote station transmits a random access packet with constant power regardless of channel gain. Second, with channel inversion power allocation, a remote station transmits a random access packet with power inversely proportional to channel gain. Constant and channel inversion power allocations can be expressed as

$$P_1(g) = \begin{cases} P_{R1}, & \text{if } g > g_{th}, \\ 0, & \text{otherwise}, \end{cases} \quad (1)$$

$$P_2(g) = \begin{cases} \frac{P_{R2}}{g}, & \text{if } g > g_{th}, \\ 0, & \text{otherwise}, \end{cases} \quad (2)$$

where P_{R1} and P_{R2} are constants determined by average transmission power constraints. Then, the energies allocated for preamble and message can be expressed as $E_p = PT_p$ and $E_m = PT_m$, respectively.

III. NUMERICAL RESULTS

In this section, simulation results are presented for conventional and channel-adaptive random access schemes. To obtain the results, a random access packet is composed of a preamble and 8 bit message. The length of a random access packet T and window size W are assumed to be 1 ms and 1. The random access packet is transmitted over a Rayleigh fading channel. The detection thresholdη is chosen to satisfy the false alarm probability of 10^{-3}, which is the probability that a host station decides H_1 ,when a random access packet has not been transmitted from a remote station. The message is uncoded and modulated by BPSK.

Fig. 2 shows the block error rate of message for the transmission threshold g_{th} , which satisfies $P_o = \Pr\{g < g_{th}\} = 0.5$. The results are obtained for conventional and channel-adaptive random access schemes. For block error rate of 10^{-2}, compared with conventional random access, channel-adaptive random access can achieve about 14.0 and 15.0 dB performance gain with constant and channel inversion power allocations, respectively.

Fig. 3 shows the error probability of a random access packet for $P_o = 0.5$. The results are obtained for conventional and channel-adaptive random access schemes. In Fig. 3, the energies allocated for a preamble and message are set to same. For error probability of 10^{-2} , compared with conventional random access, channel-adaptive random access can achieve about 15.0 and 16.0 dB performance gain with constant and channel inversion power allocations, respectively.

CONCLUSIONS

In this paper, the performance is investigated for a random access packet containing both a preamble and message. Numerical results show that about 15.0 dB performance gain can be obtained with channel-adaptive random access compared with conventional random access.

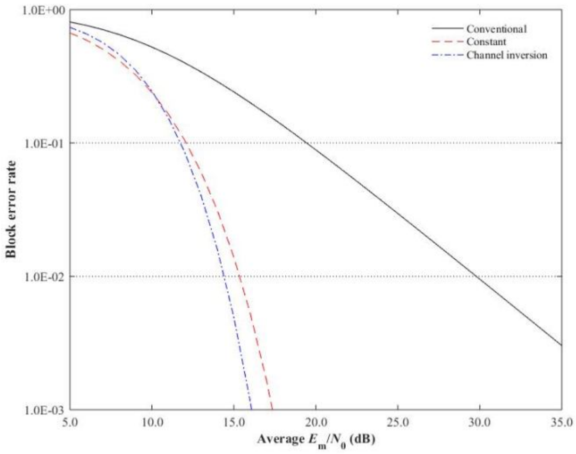

Figure 2. Block error rate of message

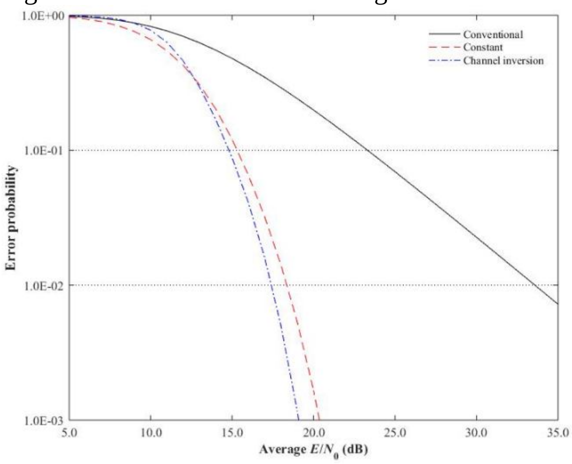

Figure 3. Error probability of a random access packet

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