ADAPTIVE CHANNEL CODING SCHEME FOR QOS GUARANTEES

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ABSTRACT

Due to the advent of software defined radio, the availability of flexible and reconfigurable transceivers has renewed interest in adaptive techniques. This includes adaptive modulation and coding, adaptive antennas and adaptive equalization techniques. This paper focuses on an adaptive channel coding scheme that can change code rates and error correcting capabilities. This is to adapt to AWGN (Additive White Gaussian Noise) channel environments. This paper proposes a channel quality metric using soft decision input to apply to adaptive channel coding. Proposed channel quality metric makes use of soft decision input as sample data at channel decoder and performs statistical analysis for this sample. So that statistical distribution gives the channel quality information. Channel coding scheme adopting the proposed channel quality metric is adaptive to select the code parameter on the condition that the desired BER(Bit Error Rate) does not vary with channel environments. The decision is used as feedback information to the other side of terminal.

1. INTRODUCTION

To maximize the use of wireless channel resources, it is important that the design of wireless multimedia communication systems has to consider the variation in channel condition fluctuation and QoS (Quality of Service) requirements of applications such as voice, data, video and etc . One of the methods fully utilizing the channel capacity is an adaptation technique. To adopt this adaptation technique, the method of changing parameters such as transmission power, symbol rate, constellation size, and code rate/scheme in response to time-varying channel conditions is needed. This paper focuses on an adaptive channel coding scheme and proposes new channel quality metric.

The potential of adaptive transmission was recognized 30 years ago by Cavers[1] but it did not receive much interest at that time because of hardware constraints, lack of good channel estimation techniques and the adoption of systems with point-to-point links using no transmitter feedback[2]. In order to the advent of software defined radio, the availability of flexible and reconfigurable transceivers has renewed interest in adaptive techniques.

This paper is organized as follows. Section 2 provides system and wireless channel model. Section 3 proposes new channel quality metric using soft decision input at channel decoder. Section 4 describes adaptive channel coding scheme with proposed channel quality metric and sections are divided to maintain the desired BER as one of QoS parameters. In Section 5, Simulation results present to illustrate the performance that adaptive channel coding scheme with proposed channel quality metric over varying AWGN maintains the desired BER.

2. SYSTEM MODEL

Let us assume a simple communication system. The transmitter system is composed of a source, switch, channel encoders, and modulator. The receiver system is composed of a soft-output demodulator, buffer, switch, channel decoders, re-encoders, and channel quality metric.

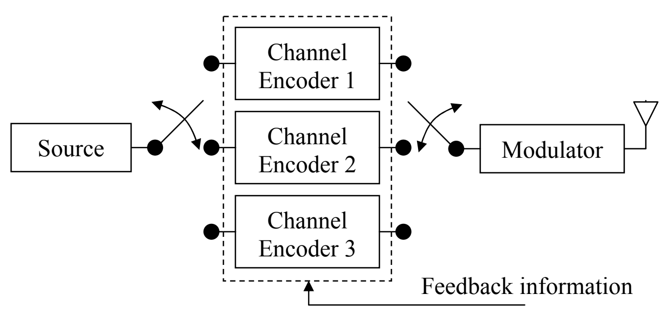

Figure 1. System model of transmitter

Figure 1 shows a schematic of the transmitter, source generates binary random data, channel encoders are composed of 3 convolutional encoders, code rates, R=1/2, 2/3, and 3/4 and the industry-standard generator polynomials, g0=133 (oct), g1=171 (oct). The puncturing patterns of R=2/3 and 3/4 are 1110 and 111001 respectively. The channel encoder is selected by feedback information and the modulator uses BPSK (Binary Phase Shift Keying).

The channel is assumed varying AWGN channel that is uniform in the frame and changes 3dB to 6dB according to Eb/No.

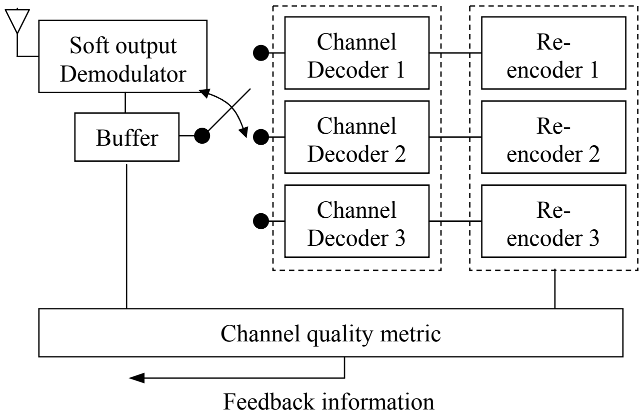

Figure 2. System model of receiver

Figure 2 shows a schematic of the receiver, Signals through AWGN channel arrive at soft output demodulator and then are determined on binary signals as 4bits quantized output. The buffer stores the binary signals. The channel decoders are composed of 3 Viterbi decoders that are inserted zeros according to each puncturing pattern. Channel quality metric compares soft decision input with re-encoded bit, collects it according to re-encoded bit 1 or 0, and calculates the distribution so that it generates the feedback information.

3. CHANNEL QUALITY METRIC USING SOFT DECISION INPUT

3.1. Overview of channel quality metric

Wireless channel resources change according to the variation of time, frequency and space. For the use of effective channel resources, it is important to measure the channel condition. If channel prediction is accurate, wireless communication system will use channel resources more efficiently.

The points to be considered, when designing the channel quality metric, are a variety of wireless channel, measurement period, complexity, particular signal for measurement and etc. So far, there have been some methods such as measuring average SNR (Signal to Noise Ratio) and Euclidean distance at demodulator, counting PER (Packet Error Rate) at link layer, SINR (Signal to Interference and Noise Ratio) at equalizer's output, and etc.

This paper proposes simple method to measure the channel condition. This method has not particular signal and can control the measurement period with number of sample. This is suitable to apply to channel coding.

3.2. Design of channel quality metric

When designing wireless communication system, there are several mitigating techniques for combating the effects of both signal distortion and loss in SNR. Adaptive equalization, OFDM (Orthogonal Frequency Division Multiplexing) and etc are used in order to reduce or remove any distortion degradation. Diversity techniques are used to compensate for the loss of SNR. One of diversity techniques is channel coding. This is suitable to use to compensate for the effects of AWGN [3].

Demodulated signals represent points on the signal constellation. These are distorted by channel noises and represent a channel condition. So far, channel quality metric was measured by using this point. When quantization is performed for making the input of channel decoder, it produces the degradation such as (1) the increase in variance, which is proportional to the square of the quantum interval, (2) a threshold, proportional to the quantum interval, caused by the ambiguity, (3) limiting at the ends of the quantizing range [4]. However quantized symbols are easy to handle. Therefore this is used to measure the channel.

Demodulated signals are soft decision input for channel decoder and have a specific statistical distribution because they have gone through AWGN channel. The pdf (probability density function) of noise n_0 is given by

$$p(n_0) = \frac{1}{\sigma_0\sqrt{2\pi}}\exp\left[-\frac{n_0^2}{2\sigma_0^2}\right] \qquad (1)$$

where noise n_0 is assumed to be an independent Gaussian random variable and variance σ_0^2. The assignment of soft decision input is an unsigned 4bits quantization. This has 16 states from 0000 to 1111.

Figure 3 shows the bit assignment for channel quality metric design. This has the most confident 0 as 0100 and the most confident 1 as 1011. In other words, the mean of distribution is 0100 and 1011. When soft decision inputs are below the limit 0000, they map to 0000. When soft decision inputs are above the limit 1111, they map to 1111.

When varying AWGN channel, variance σ_0^2 and mean change. Both of them can be metric for measuring channel quality. However mean has a small change because it is revised at demodulator. Therefore primary channel quality metric is variance σ_0^2. If channel condition is good (Eb/No

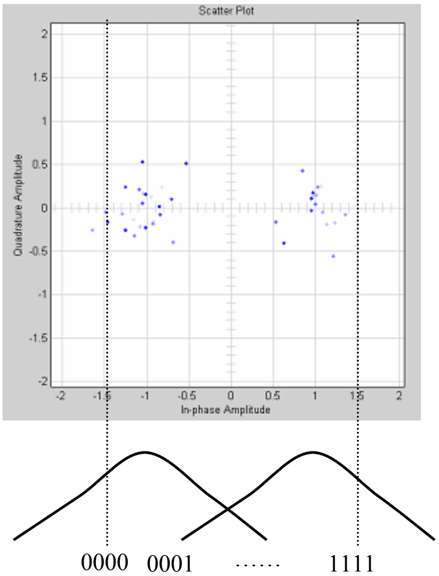

Figure 3. Soft decision input of channel decoder

is high), it increases. If channel condition is bad (Eb/No is low), it decreases. Therefore Look-up table of channel quality metric is made by simulation results that channel condition (Eb/No) correlates to variance σ_0^2.

3.3. Procedure of channel quality metric

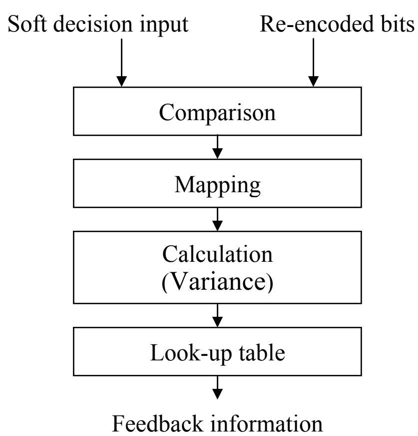

Figure 4. Procedure of channel quality metric

Figure 4 shows a procedure of channel quality metric and is described as follows

First of all, Channel quality metric receives two inputs that are re-encoded bits and soft decision inputs. Re-encoded bits are composed of 1 bit sequences for example 1 0 1 0 and soft decision inputs are composed of 4 bits sequences for example 1011 1000 1001 1011 0110. Two sequences are compared orderly. Next, for re-encoded bit 1 or 0, Mapping block collects soft decision input for example if two inputs come in above, Mapping block collects 1011 1000 1011. Then, Calculation block makes variance σ_0^2 for collected sequences. Finally, in Look-up table, variance σ_0^2 is compared with Look-up table value. Channel quality metric decides the channel condition that is good or not and then generates the feedback information to send to the other side of terminal. In that case, channel quality metric can measure varying AWGN channel.

4. ADAPTIVE CHANNEL CODING SCHEME

The threshold of channel quality metric was decided through the simulation results that store at Look-up table. This threshold can change for the communication system configuration such as a modulation scheme, power control, channel code rate, and etc. This paper assumed specific configuration and simple system model. This configuration is BPSK modulation, convolution encoder, code rate R=1/2, 2/3, and 3/4, and AWGN.

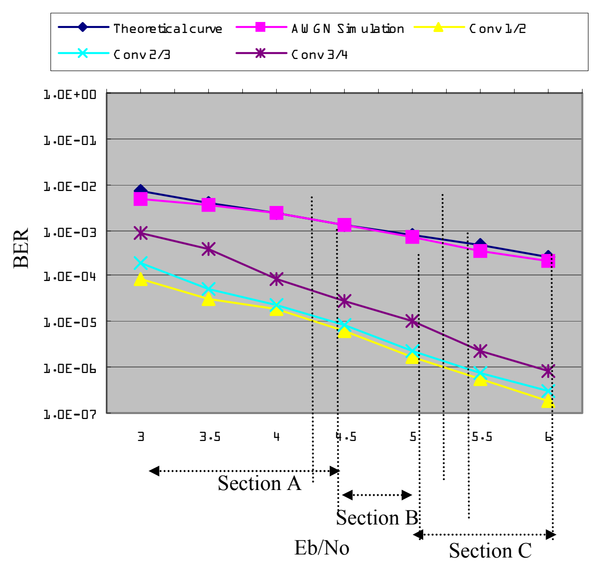

Figure 5. BER of convolution codes

Figure 5 shows the capability of each channel coding. For maintaining the required BER ~ 1e-6, section is divided as follows. Section A (3 ~ 4.5dB) means bad channel condition to use convolution code R=1/2, Section B (4.5 ~ 5 dB) means not bad channel condition to use convolution code R=2/3, and Section C (5 ~ 6dB) means good channel condition to use convolution code R=3/4.

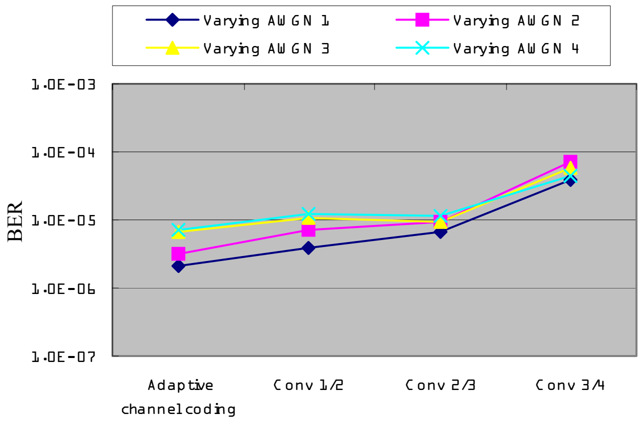

Figure 6. BER for each channel coding scheme at varying AWGN

5. SIMULATION RESULT

Figure 6 shows the simulation result of adaptive channel coding for varying AWGN. Varying AWGN 1, 2, 3, and 4 change Eb/No from 4.5dB to 6dB, 4dB to 6dB, 3.5dB to 6dB, and 3dB to 6dB respectively. Adaptive channel coding scheme with proposed channel quality metric can maintain the desired BER~1e-6.

6. CONCLUSIONS

According to the variation of frequency, time, and space, wireless channel environment changes severely. If communication system know the state of wireless channel, it can be more efficient to use channel resources. In that case, it is important to know the channel condition precisely. This paper proposes the simple method to know the channel condition and performs a simulation. Through the proposed channel quality metric, adaptive channel coding can maintain the desired BER over varying AWGN channel.

7. FUTURE WORKS

This paper showed the results of adaptive channel coding scheme with proposed channel quality metric over AWGN environment. However real channel environment is close to Rayleigh and Rician multi-path fading channel. Therefore we are planning to apply it over multi-path fading channel at more complicated wireless system.

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