Turbo Approach for Signal Detection for Intelligent Transportation Systems

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목 차

Ⅰ. INTRODUCTION

The existing transport system is occasionally pointed out to induce traffic congestion. To ease traffic jams, many countries are trying to develop a new traffic control system. In addition, the future transport systems are demanded for various kinds of useful services such as advanced incident management, electronic toll collection, traveler information service, route guidance service, heavy vehicle monitoring and so on. For the time being, however, the established transport systems have a limitation to operate these service. To support these advanced traffic service, the existing facilities are needed for combination with advanced mobile communication technologies. Since the vehicles are moving with high speed, the signals will be affected by a harmful noise. For example, the signals from moving vehicle will be received at the traffic control center with frequency distortion due to Doppler effect. This situation would be possible to make error signal. Both every vehicle and traffic control centers transmit and receive informational signals simultaneously. Therefore, to support multiple vehicle users, multiuser detection (MUD) scheme can be a promising candidate to enhance detection performance of the traffic signals.

The concept of multiuser detection is proposed by S. Verdu in 1986 to relieve 'near-far problem' in CDMA channels [3]. This multiuser detector has a serious problem in terms of computational complexity [4]. To reduce this complexity, X. Wang had proposed turbo multiuser detector in 1999.

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In addition, the future transport system is anticipated to support not only traffic information service but also various kind of useful service. These multiform data have a different data transmit rate which leads to multirate transmission strategy with multiuser detection. The conventional turbo multiuser detector takes into account only single data rate. To satisfy a new traffic control system, both multiple user and multiple rate system must be considered.

The rest of the paper is organized as follows:

In Section Ⅱ, the concept of Turbo Multiuser Detector is described. In Section Ⅲ, the multirate strategy is analyzed. In Section Ⅳ, the conclusions are drawn.

Ⅱ. TURBO MULTIUSER DETECTOR

1. Turbo Encoder

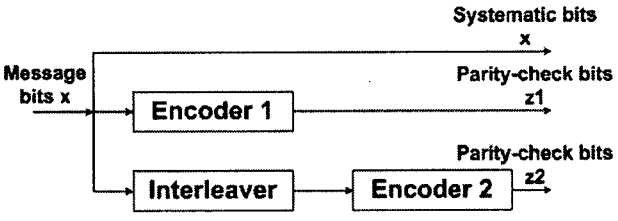

Fig. 1. Turbo Encoder.

Figure 1. represent a basic turbo encoder structure. Generally, turbo encoder composed of two RSC(Recursive Systematic Convolutional) encoder and one interleaver [1]. An interleaver is a kind of input-output mapping device

that permutes the sequence of input signal, thereby the probable burst error in receiver could be reduced [10]. It is a feature of turbo coding that the larger interleaver length the better error performance [5].

The binary message bits are encoded with multi code rate R_k. The output of the encoder will be modulated by symbol mapper such as BPSK and then, spreaded to transmit. These transmitted signal is then undergo the multipath channel.

The transmitted signal of kth user is given by

$$x_k(t) = A_k \sum_{i=0}^{M-1} b_k(i) s_k(t - iT), \quad (1)$$

where M is the number of data symbols per user per frame, and A_k and s_k is the amplitude and normalized signaling waveform of the kth user, respectively. A multipath channel with impulse response is given as

$$g_k(t) = \sum_{l=0}^{L_k-1} g_{kl}\delta(t - \tau_{kl}), \quad (2)$$

where L_k is the number of paths ,and g_{kl} and τ_{kl} are the complex gain and delay of the lth path of the kth user's signal.

2. Turbo Decoder

At the receiver, the received signal of the kth user is then given by

$$y_k(t) = x_k(t) \bigstar g_k(t), \quad (3)$$

where ★ denotes convolution operator.

The K users' signal at the receiver consists of the additive white Gaussian noise. Therefore,

$$r(t) = \sum_{k=1}^{K} y_k(t) + \sigma n(t). \quad (4)$$

Turbo Receiver structure is shown in the Figure 2. It consists of two stages, that is, a SISO multiuser detector and K parallel single user SISO channel decoders. Similarly to the encoder, there are deinterleaver and interleaver. Each stages are compute the a posteriori log-likelihood ratio (LLR). From the received signal, the SISO multiuser detector delivers the following LLR for every code bit of every user,

$$\Lambda_1[b_k(i)] \equiv log\frac{P[b_k(i) = +1 \mid r(t)]}{P[b_k(i) = -1 \mid r(t)]}, \quad (5)$$

$$k = 1, \ldots, K; \quad i = 0, \ldots, M-1.$$

Using Bayes' rule, eq.(5) could be written as

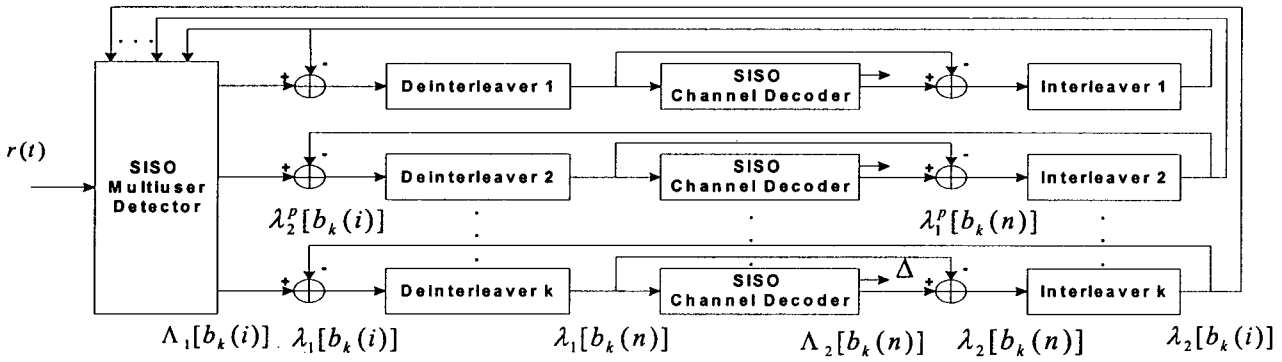

Fig. 2. Turbo Detector structure.

$$\Lambda_1[b_k(i)] = \quad (6)$$

$$\log\frac{p[r(t) \mid b_k(i) = +1]}{p[r(t) \mid b_k(i) = -1]} + log\frac{P[b_k(i) = +1]}{P[b_k(i) = -1]}$$

, where the first and the second term of eq.(6) are referred as extrinsic information and a priori LLR, respectively.

The SISO channel decoder also computes the a posteriori LLR of every information bit. In the last iteration of the decoding, the value of a posteriori LLR of the SISO channel decoder is used to make decision on the decoded bit. The performance of the turbo decoding is improved by increasing the number of iteration [2].

III. MULTIRATE TRANSMISSION STRATEGY

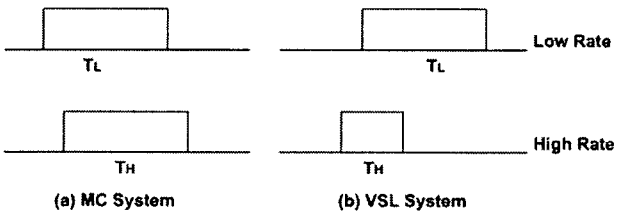

Fig. 3. Multirate Strategy.

There are two widely used multirate system strategies such as multicode access, variable spreading length (VSL) access [10]. Fig.3 represent the concept of these scheme. In multicode access scheme, it employs several spreading codes to distinguish each user with constant chip rate. In VSL access scheme, on the other hand, it assigns different spreading factors according to data rate.

Although VSL access scheme has shown to outperform multicode scheme, in view of practical environments, multicode access scheme is better than VSL scheme for implementation.

IV. CONCLUSIONS

The proposed turbo multirate multiuser detector can be a promising solution to enhance signal detection performance for ITS applications.

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