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Title: Softest Hand-over with Rate Matching

Document for: Discussion

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1. Introduction

At the TSG RAN WG1 4th meeting in Shin-Yokohama, Japan, a contribution paper from Nortel Netwoks [1], which improves the radio link performance based on the CPC (Complementary Punctured Convolutional) codes [2] when a UE is in soft hand-over mode was presented. There were some discussions about the proposal, and the conclusion was that this item could be studied in release 2000. And then LGIC presented the similar improved soft hand-over scheme at the 12th meeting in Seoul as release 2000 study item, which uses the concept of 'coding diversity' of Turbo code and by using concept some performance gain was obtained in soft hand-over mode [3].

The current assumption of soft hand-over is that the UE receives the same encoded data bits for each DCH from the different Node Bs in its active set. The corresponding CCTrCH is spread and scrambled by different set of channelisation and scrambling codes.

This document proposes two enhanced soft hand-over schemes to maximise the radio link performance enhancement. We optimised the rate matching so that the puncturing pattern by each Node B should be different. In the current specification, the puncturing is performed in the rate matching. The proposed schemes are based on the modification of rate matching not to loose the coding gain of Turbo code.

2. Proposed Schemes

Currently when a UE is in hand-over, same data stream is transmitted from each base station in the downlink. At the receiver the UE combines signals in the way of maximum ratio combining after descrambling and despreading. This document proposes two enhanced soft hand-over schemes. A couple of proposed schemes are based on the modification of rate matching not to loose the coding gain of Turbo code. We considered the two cases, one is 1/3 rate Turbo decoding and the other is 1/5 rate Turbo decoding case

2.1 Proposal 1 (1/3 rate decoding case)

In the case of turbo coding, only 1/3 coding rate is included in the specification. Generally speaking a higher rate code can be obtained by deleting some bits of the lower rate code. This proposed softest hand-over scheme enables us not to loose the original coding rate 1/3 of turbo code by introducing the complementary rate matching for each Node B. Each node B has same coded data and different rate matching parameters. This can be shown as figure 1, figure 2. Figure 1 shows the coding scheme, and figure 2 shows the rate matching for each node B.

In current specification, to make a higher coding rate code, puncturing is performed not in the coding block but in the rate matching block. Therefore, to make different puncturing patterns, the parameters in the rate matching have to be changed to be complement. In this proposal, we consider two Node B case. For one Node B, the parameter in current specification is used. And for the other Node B, different parameter is used. Changing parameter e_{ini} in the rate matching pattern generation algorithm, we can make a complementary puncturing pattern. By the way, the rate matching for turbo coding should observe the following conditions.

- Puncturing of systematic bits is excluded and the puncturing is only imposed on the parity sequence.
- Equal amount of puncturing over RSC encoder output is performed.
- Punctured bit positions should be uniformly distributed among parity bits.
- Different Node Bs should have different puncturing positions for each parity sequence. And when the puncturing from both Node B is considered simultaneously, Punctured bit positions should be uniformly distributed among parity bits.

The first three conditions are for current specification. And the last condition is only for softest hand over. In this proposal we use the parameters as follows to fulfil the last condition. Here we consider fixed position transport channel case.

- Parameter type 1(For one node B, current rate matching parameter)

a=2 for the 1st parity bit sequence

a=1 for the 2nd parity bit sequence

$$\Delta N_i = \begin{cases} \lfloor \Delta N_{il}^{TTI} / 2 \rfloor & :\text{1st parity sequence} \\ \lceil \Delta N_{il}^{TTI} / 2 \rceil & :\text{2nd parity sequence} \end{cases}$$

$X_i = N_{il}^{TTI} / 3$,

$e_{ini} = X_i$,

$e_{plus} = a \cdot X_i$

$e_{minus} = a \cdot |\Delta N_i|$

- Parameter type 2(For the other node B)

$$e_{ini} = X_i - (D/2) \times e_{\text{minus}}$$

$$D = \lfloor e_{plus} / e_{\text{minus}} \rfloor$$

Same for other parameter

The e_{ini} values for the first parity sequence and for the second parity sequence are different from each other.

At receiver, the coded bits are combined after derate matching block, and decoded. By using different puncturing pattern for each Node B, the loss from puncturing can be compensated. Here the decoding block is not changed. The receiver is shown in figure 3.

2.2 Proposal 2 (1/5 rate decoding case)

The 1/5 coding rate Turbo code generates one systematic sequence, and four parity sequences. At each Node B, the different 1/3 coding rate Turbo code is transmitted with rate matching. Coding scheme and rate matching for 1/5 is described in figure 4. Here we consider two Node B case. The sequences x_k, y_k, y'_k are transmitted from one Node B. And x_k, z_k, z'_k sequences are transmitted from the other Node B. The transfer function is as follows.

$$G(D) = \left[1, \frac{g_1(D)}{g_0(D)}, \frac{g_2(D)}{g_0(D)}\right],$$

where

$g_0(D) = 1 + D^2 + D^3$,

$g_1(D) = 1 + D + D^3$.

$g_2(D) = 1 + D + D^2 + D^3$

The rate matching conditions and method for 1/3 rate decoding of proposal 1 is also consistent in this 1/5 rate decoding case. We note that the puncturing position should be as apart as possible for each constituent code word, y_k, z_k, y_k', z_k'. Considering the rate matching conditions, we can set the rate matching parameters of (y_k, y_k') and (z_k, z_k') so as to satisfy the rate matching condition for 1/3 coding rate, respectively. However, (y_k, y_k') and (z_k, z_k') have the different rate matching parameters so that there is no puncturing loss after derate matching in the receiver side.

3. Simulation Results

We evaluate the performance of the proposed schemes over AWGN and 1-path fading channel, and compare with the current one. The simulation parameters are as follows :

- Puncturing ratio : 30 %, 20 %, 10 %, 5 %
- Number of base stations : 2
- No power control
- Perfect channel estimation
- Carrier frequency : 2 GHz
- AWGN and 1-path fading channel with vehicle speed = 100 Km/h
- Equal average received power from both base stations
- Turbo decoding : MAP, 8 iterations

3.1 AWGN.

We show the simulation results over AWGN in Figure 6 and Figure 7. In Figure 6, the Proposal 1 with different rate matching parameter outperforms over current one by 0.1 dB to 0.4 dB at a BER of 10^{-4}. Since the punctured bits of one base station are compensated with the non-punctured bits of the other base station, those gain can be obtained. In Figure 7, the performance of the Proposal 2 is evaluated. In this case, we obtain a gain of 0.3 dB to 0.5 dB at a BER of 10^{-4}. In addition to the gain of the Proposal 1, we can achieve more gain by using 1/5 decoding.

3.2 One path Fading.

We also show the simulation results over 1-path fading channel in Figure 8 and Figure 9. In Figure 8, the performance of the Proposal 1 is compared with the current one. The Proposal 1 has gain of up to 0.5 dB at a BER of 10^{-3}. The performance gain is resulted from the puncturing gain as in AWGN case. In Figure 9, the performance of the Proposal 2 is evaluated. The performance gain is up to 0.7 dB at a BER of 10^{-3}. Likewise in AWGN case, the performance gain is resulted from the puncturing diversity and 1/5 decoding.

4. Conclusion

This document proposed two enhanced soft hand-over schemes to maximise the radio link performance enhancement. One is the simple modification of rate matching not to loose the coding gain of Turbo code rate 1/3. And the other scheme is based on the modification of rate matching based on the Turbo code of rate 1/5. We found that the first proposed scheme shows about 0.2dB performance gain and the second one shows the 0.5dB performance gain in AWGN and Fading. The performance gain of 0.5dB is substantial gain considering the importance of soft hand-over. Recent measurement of a CDMA cellular system indicates that the system is in hand-over about 50% of an average call period. Thus we propose that at least one of two schemes should be considered as promising method to improve the radio performance enhancement.

5. Reference

[1] TSGR1 #4 (99) 512, Nortel Networks.

[2] Samir Kallel, "Complementary Punctured Convolutional (CPC) Codes and Their Applications," *IEEE Trans. Commun.*, vol 43, no 6, June 1995.

[2] TSGR1 #12 (00) 574, The softest hand over design using iterative decoding(Turbo coding).

[3] TS 25.212v 3.1.0, Multiplexing and channel coding(FDD).

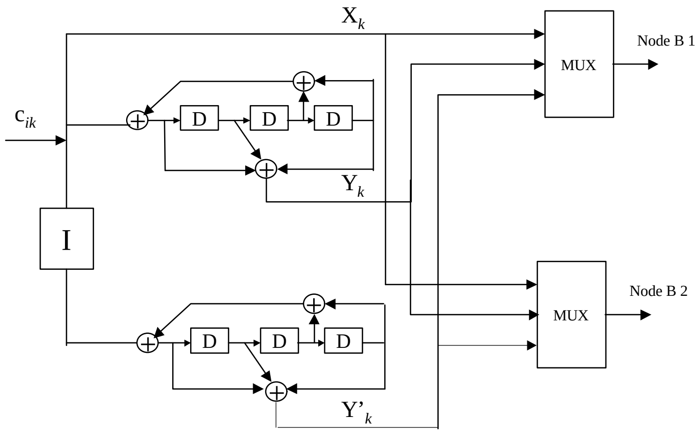

Figure 1. Coding scheme for rate 1/3 case.

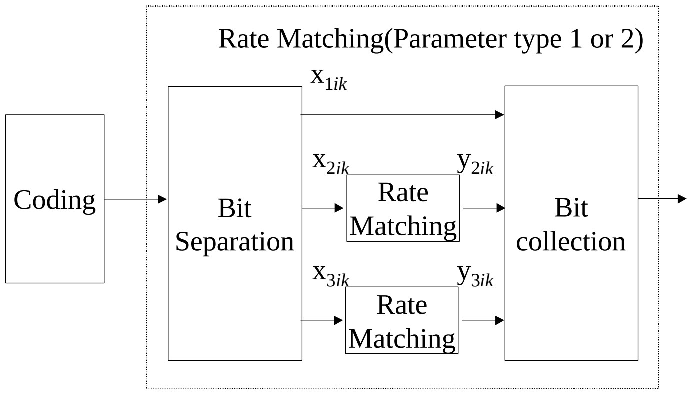

Figure 2. Rate matching for rate 1/3 case.

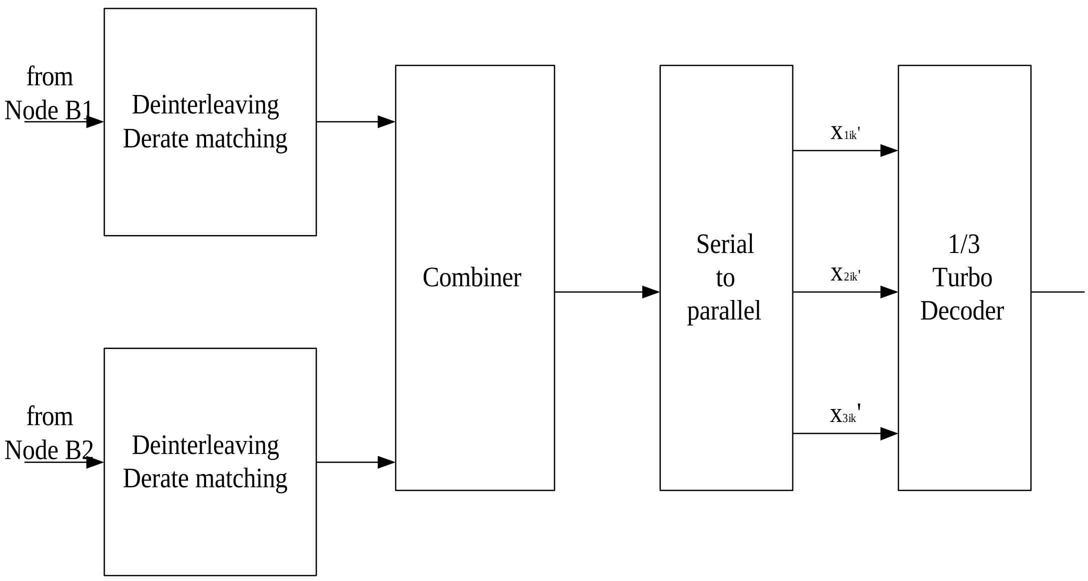

Figure 3. Decoding block for rate 1/3 softest hand-over.

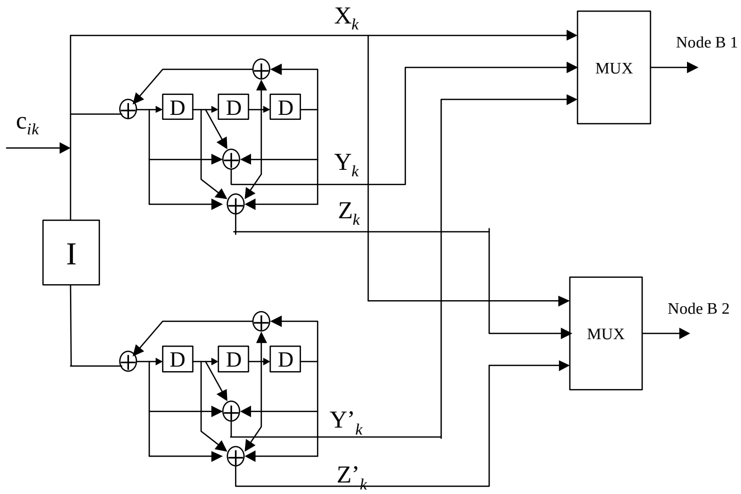

Figure 4. Coding scheme for rate 1/5 case.

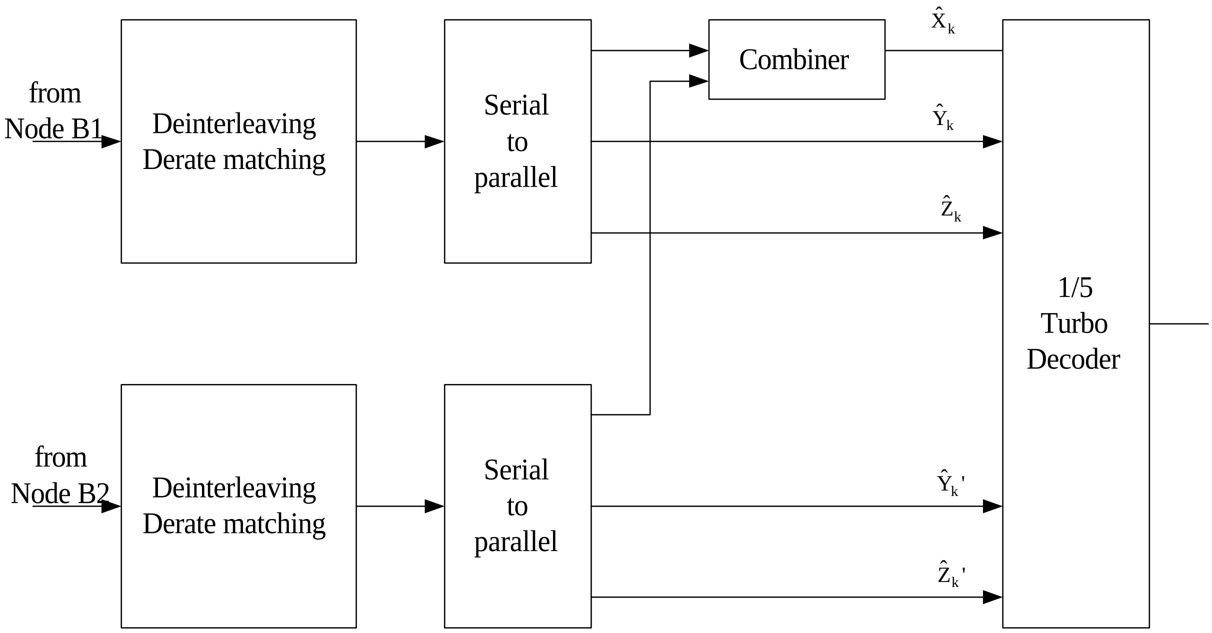

Figure 5. Decoding block for rate 1/5 softest hand-over.

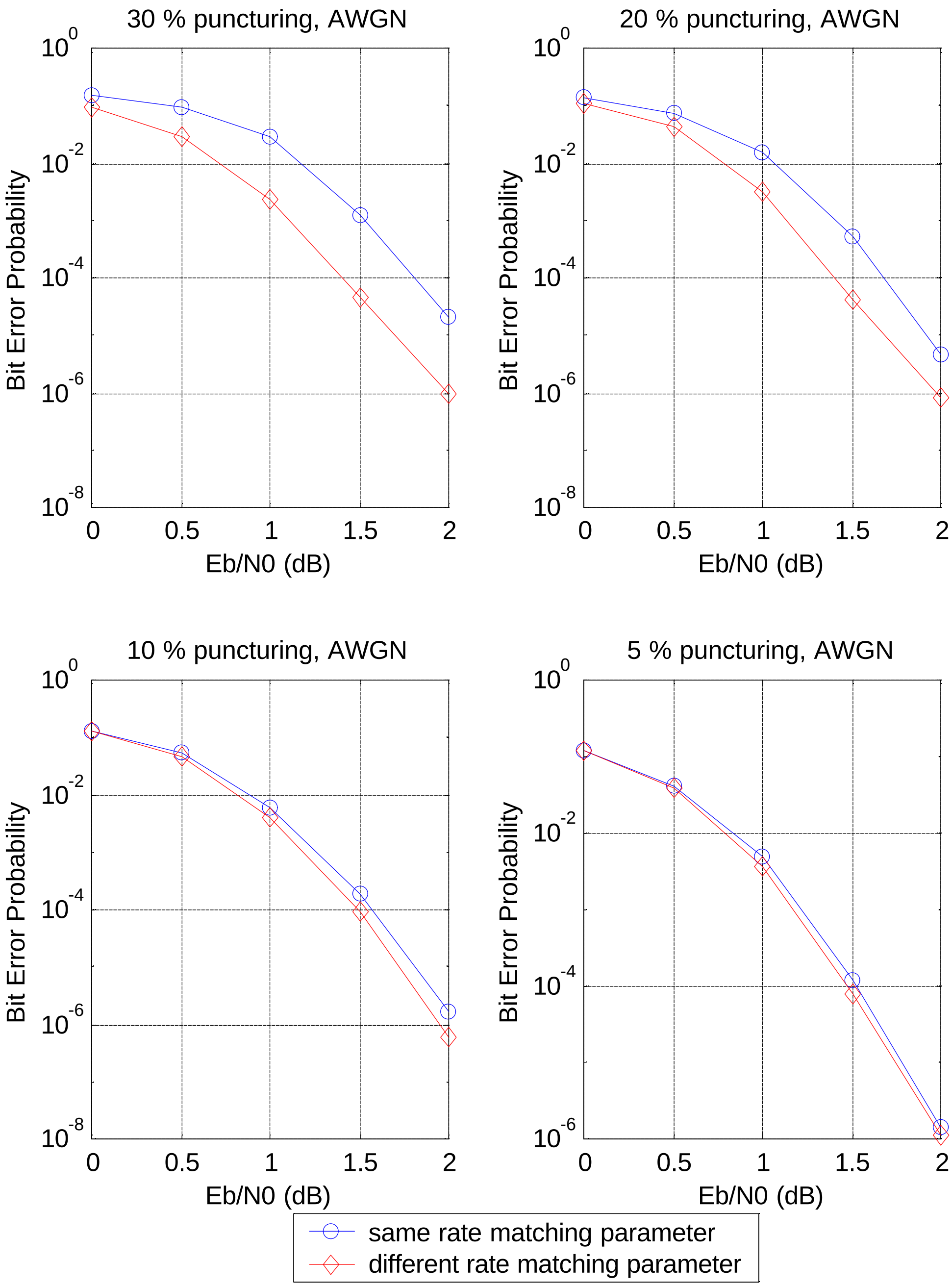

Figure 6. Performance evaluation over AWGN rate 1/3 decoding case.

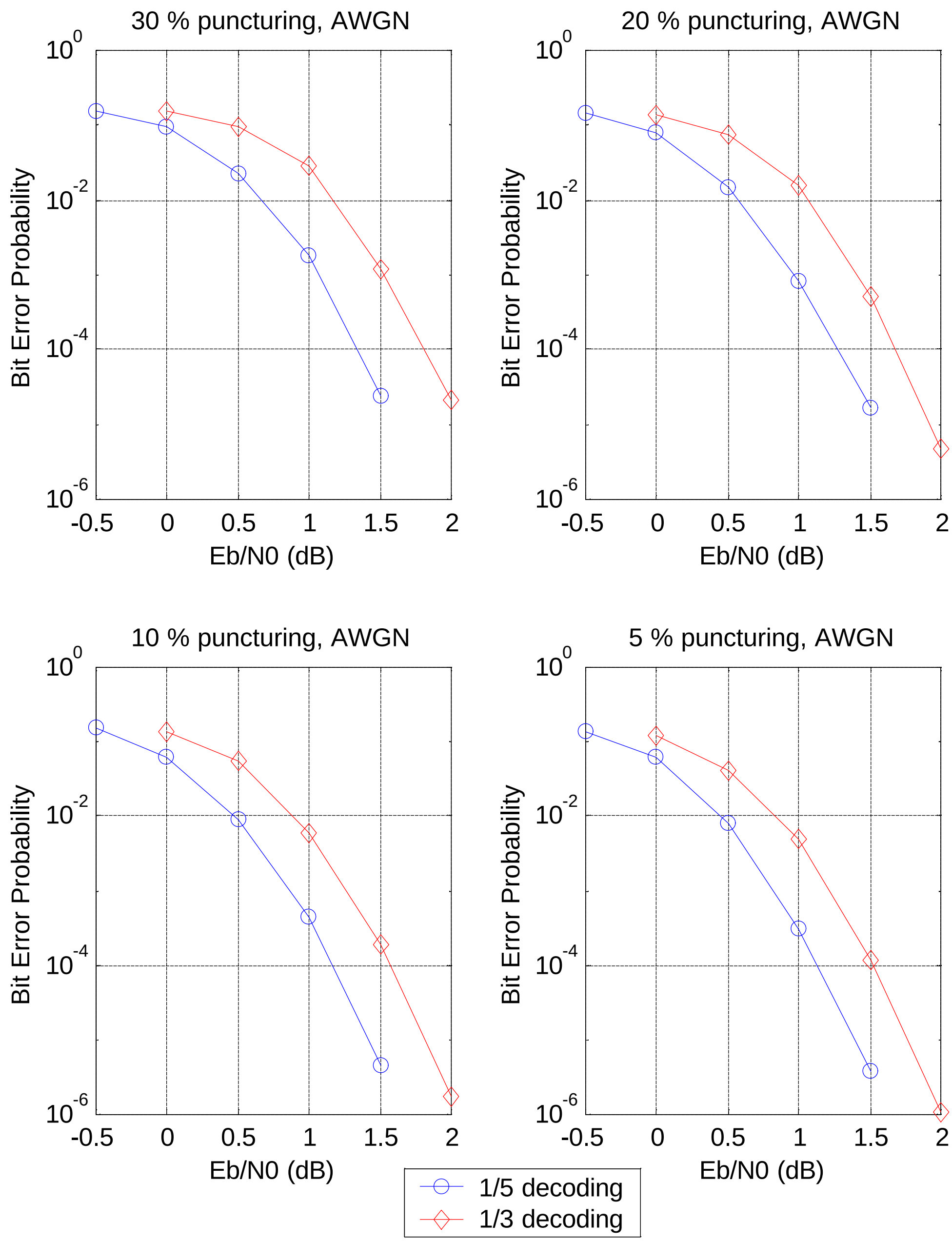

Figure 7. Performance evaluation over AWGN for rate 1/5 decoding case.

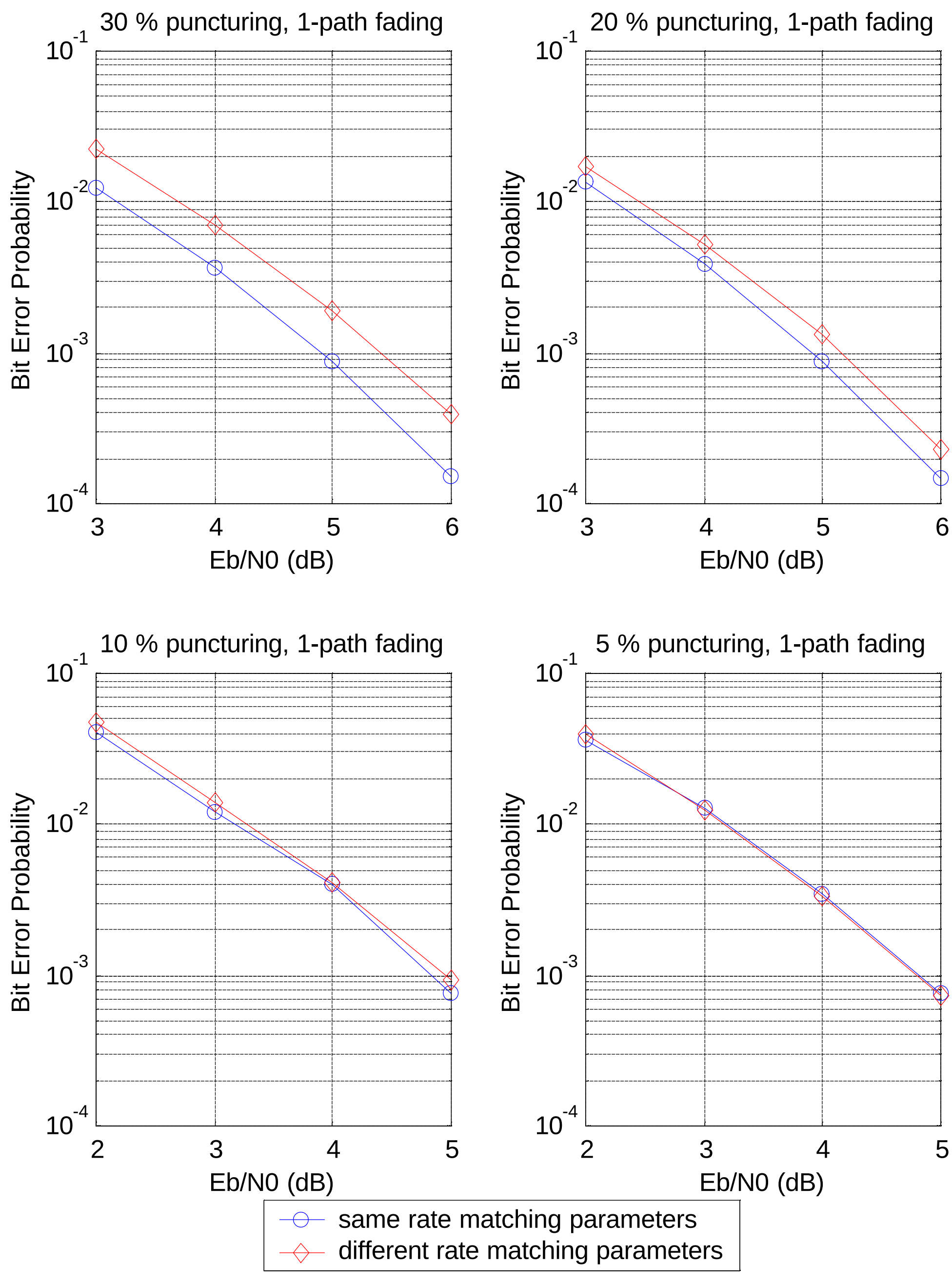

Figure 8. Performance evaluation over 1-path fading channel for rate 1/3 decoding case.

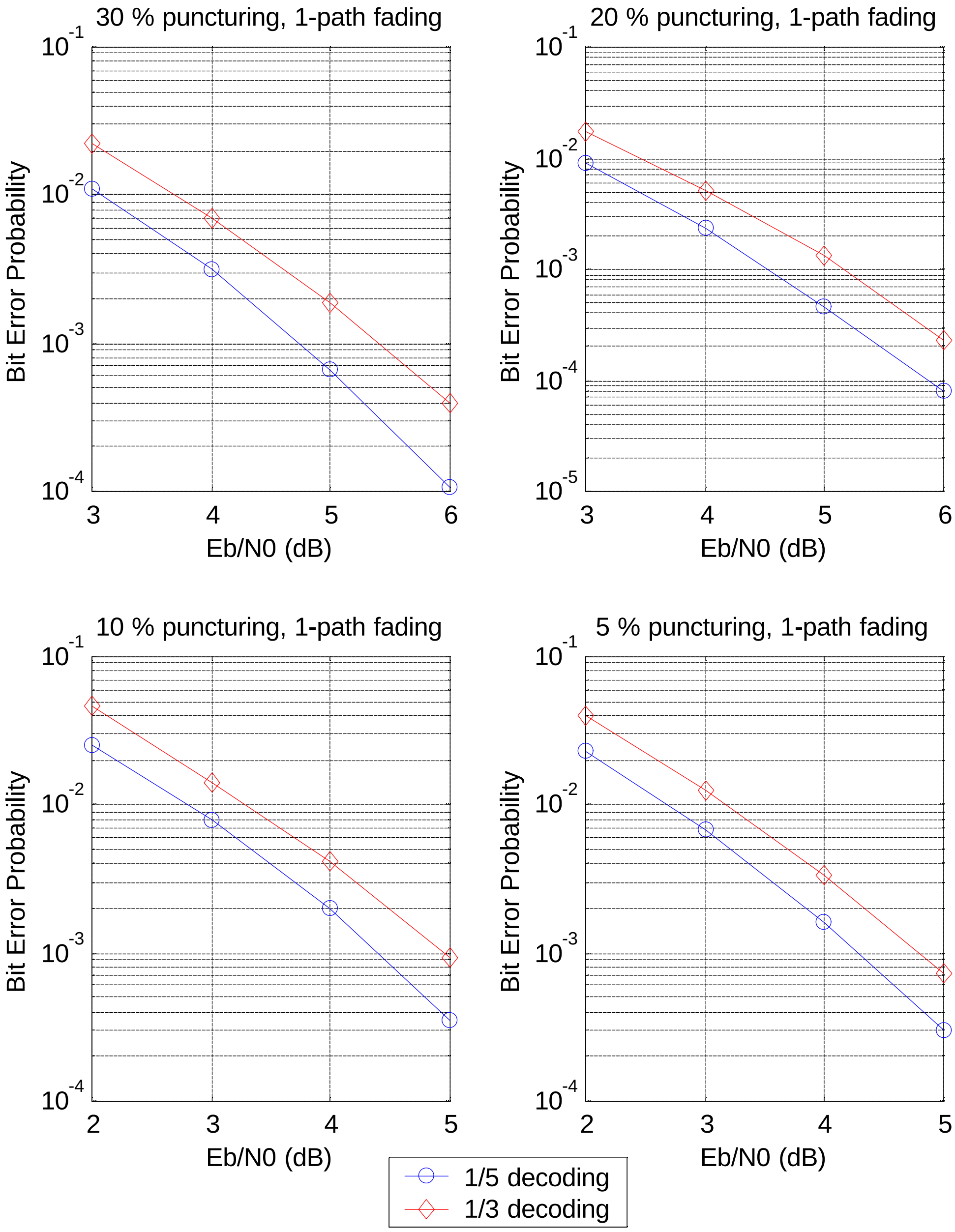

Figure 9. Performance evaluation over 1-path fading channel for rate 1/5 decoding case.