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Investigation on Rate Matching and Soft Buffer Splitting for LTE-Advanced Carrier Aggregation

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Abstract

- In the LTE-Advanced downlink, carrier aggregation (CA) employing multiple component carriers (CCs) is an essential technique to achieve a target peak data rate of 1 Gbps.

- 3GPP RAN WG1 meeting decided to adopt one transport block (TB) per CC, where the TB is the unit of channel coding and hybrid automatic repeat request (HARQ).

- We propose a rate-matching scheme for CA and a new receiver suited to this rate matching scheme.

Introduction (1/4)

- The 3rd Generation Partnership Project (3GPP) finalized the radio interface specifications for the next generation mobile system called Long-Term Evolution (LTE) as LTE Release 8 in 2008.

- In LTE-Advanced, eight user equipment (UE) categories are specified according to the maximum downlink and uplink data rates.

Introduction (2/4)

TABLE I. UE CATEGORIES

UE category	DL data rate	Soft buffer size	Maximum number of transmission layers
Category 1	10 Mbps	250368 bit	1
Category 2	50 Mbps	1237248 bit	2
Category 3	100 Mbps	1237248 bit	2
Category 4	150 Mbps	1827072 bit	2
Category 5	300 Mbps	3667200 bit	4
*Category 6	300 Mbps	3654144 bit	2 or 4
*Category 7	300 Mbps	3654144 bit	2 or 4
Category 8	3 Gbps	35982720 bit	8

* Categories 6 and 7 support different UL data rates

Introduction (3/4)

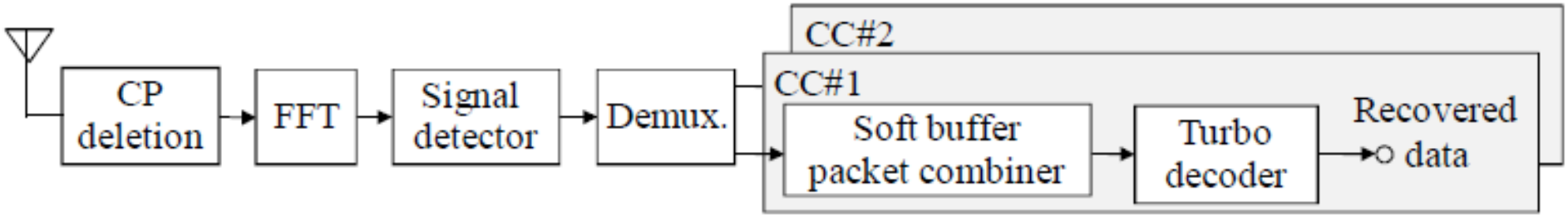


Figure 1. Receiver Structure for CA.

Introduction (4/4)

- We consider that the soft buffer of each UE is equally divided by the number of CCs.
- We propose a rate-matching scheme for CA and the optimum receiver for HARQ packet combining and decoding.
- In this scheme, rate matching is performed at the eNbodeB always assuming a single CC and does not depend on the number of CCs.

REL-8 LTE Rate-Matching Scheme

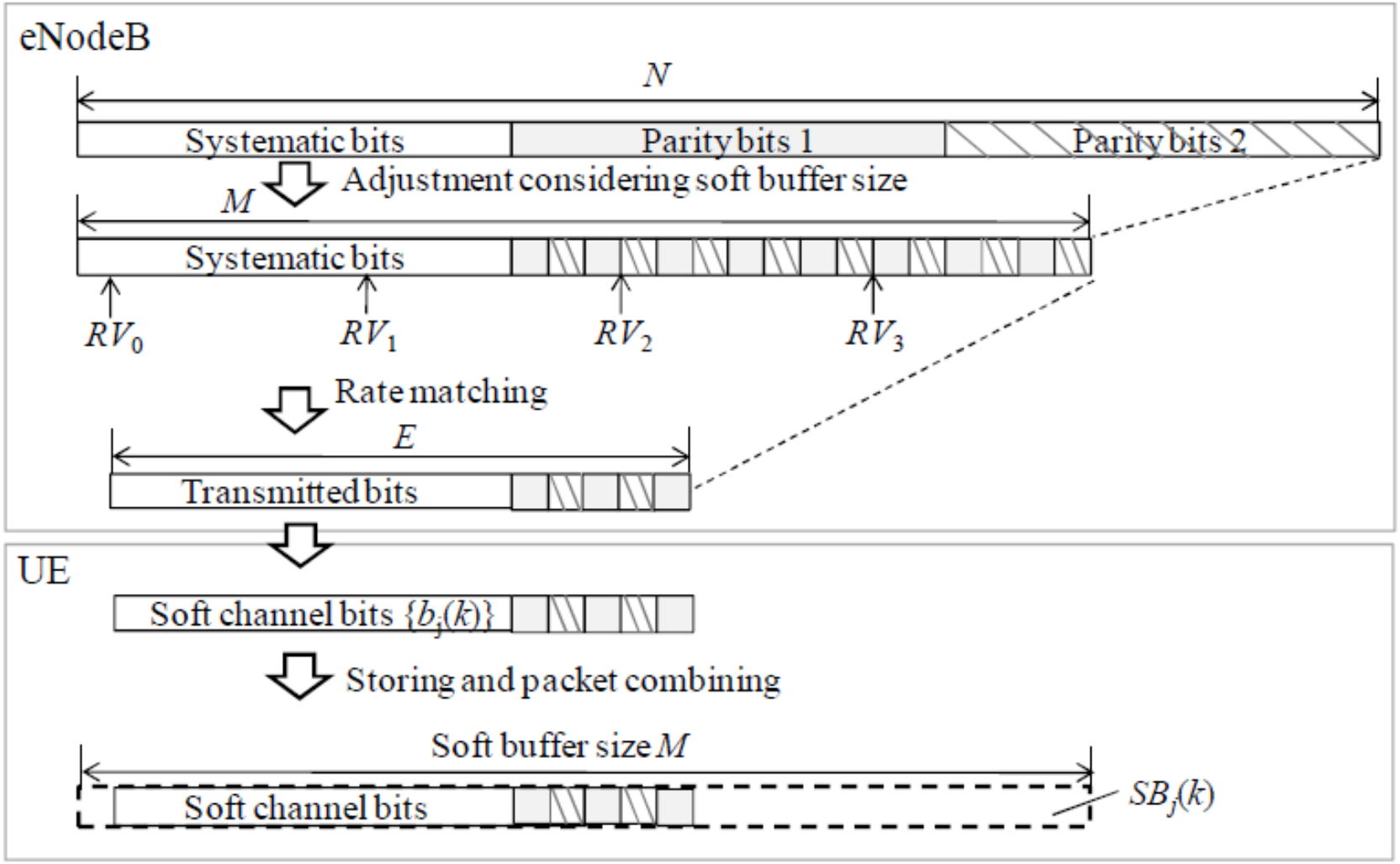


Figure 2. Rel-8 LTE rate matching procedure.

REL-8 LTE Rate-Matching Scheme (Cont.)

- At the UE receiver, after deletion of the CP, IFFT and equalization are performed.
- The soft channel bits, $\{b_j(k)\}$, are stored in a soft buffer with the size of M, and soft channel bits $\{SB_j(k); k=0\sim M-1\}$ after storing and packet combining are given by

$$SB_j(k) = SB_{j-1}(k) + b_j(k + k'_j), \qquad (2)$$

  where $\{SB_{-1}(k)=0; k=0\sim M-1\}$ and $k'_j \in RV_i$.
- Turbo decoding is performed for $\{SB_j(k)\}$ to recover the information bits.

Equal Eplitting Rate-Matching Scheme

- When CA is configured, the soft buffer with the size of M needs to be split between CCs. In this section, we assume that the soft buffer is equally divided by the number of CCs as

$$M_C = M / C \,, \qquad (3)$$

- Where M_C is the soft buffer size after splitting and C is the number of configured CCs.
- In this scheme, the first-step rate matching is performed if

$$N > M_C \,. \qquad (4)$$

Equal Eplitting Rate-Matching Scheme (Cont.)

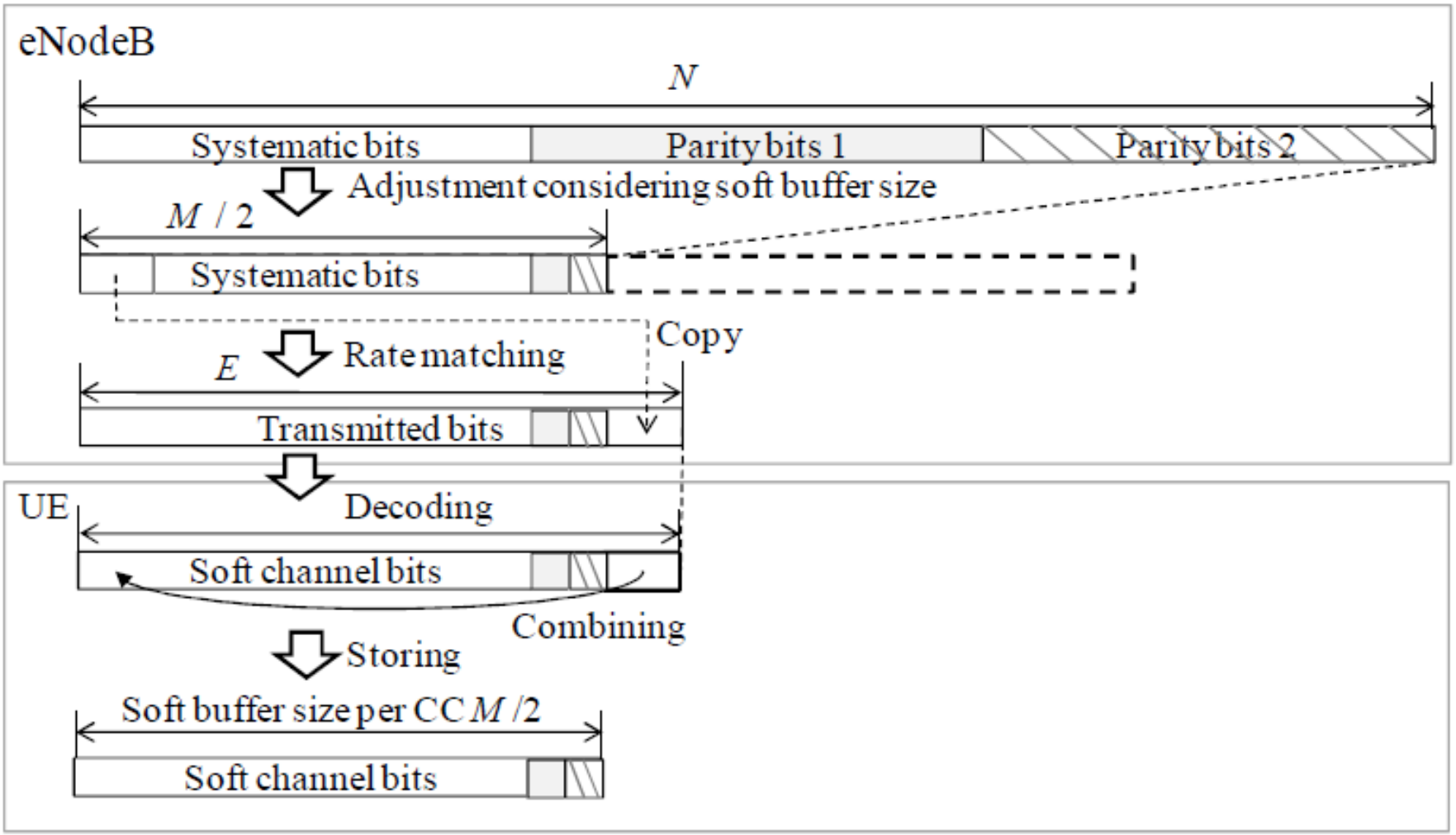


Figure 3. Equal splitting rate-matching procedure.

Proposed Rate-Matching Scheme

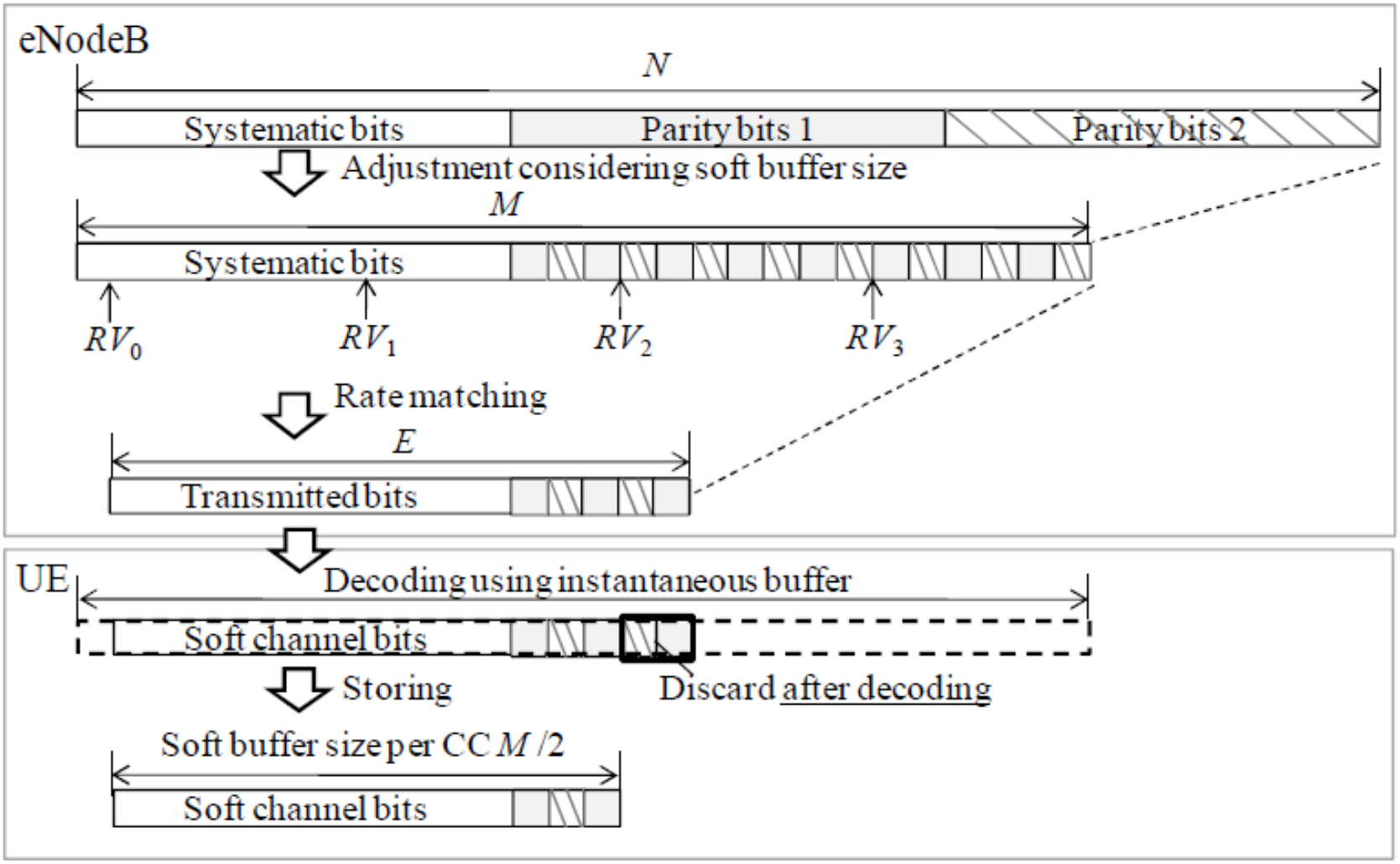


Figure 4. Proposed rate-matching procedure.

Proposed Rate-Matching Scheme (Cont.)

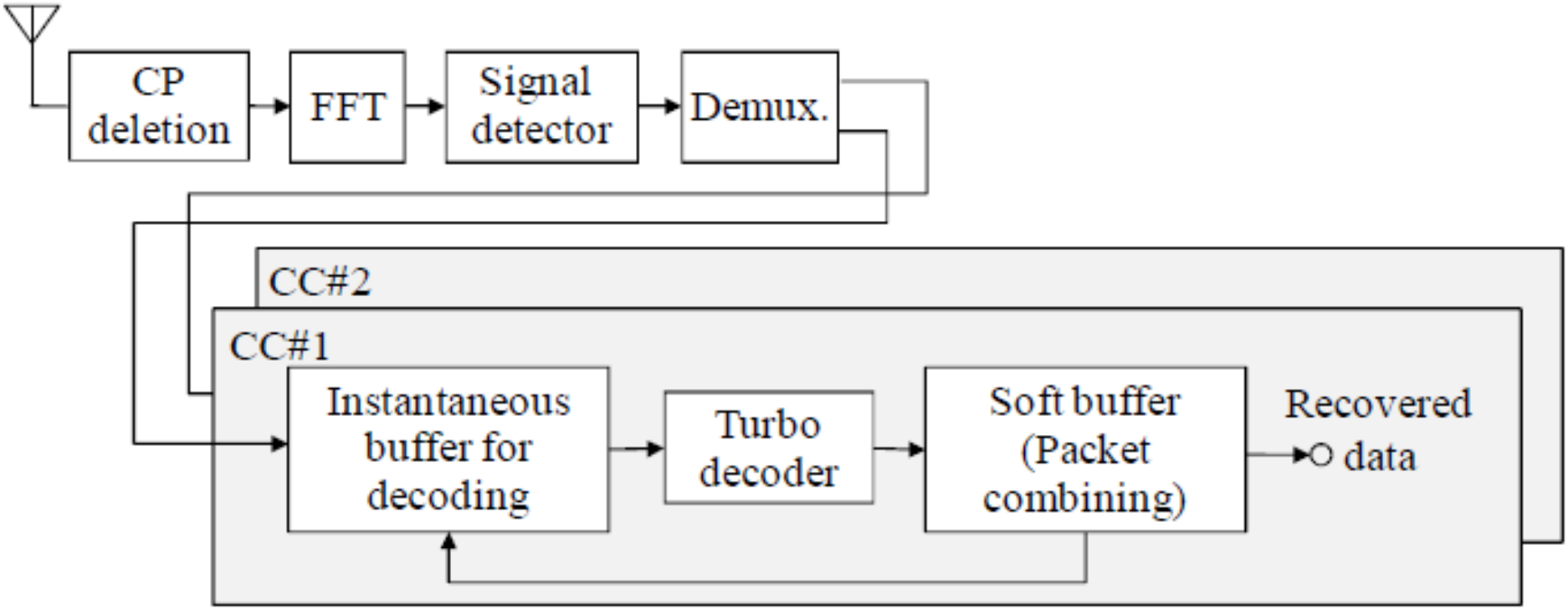


Figure 5. Proposed receiver structure.

Receiver For Proposed Rate Matching

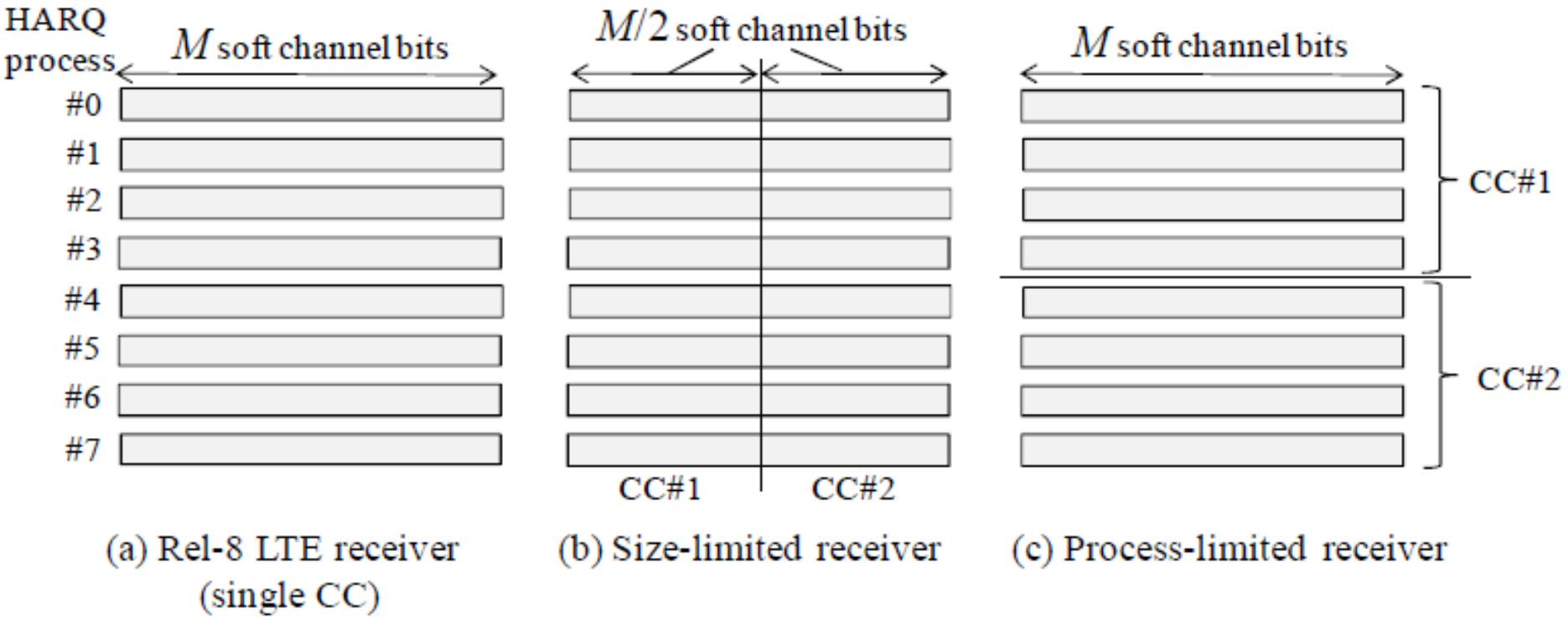


Figure 6. Comparison of receiver types.

Comparison of Receivers Types

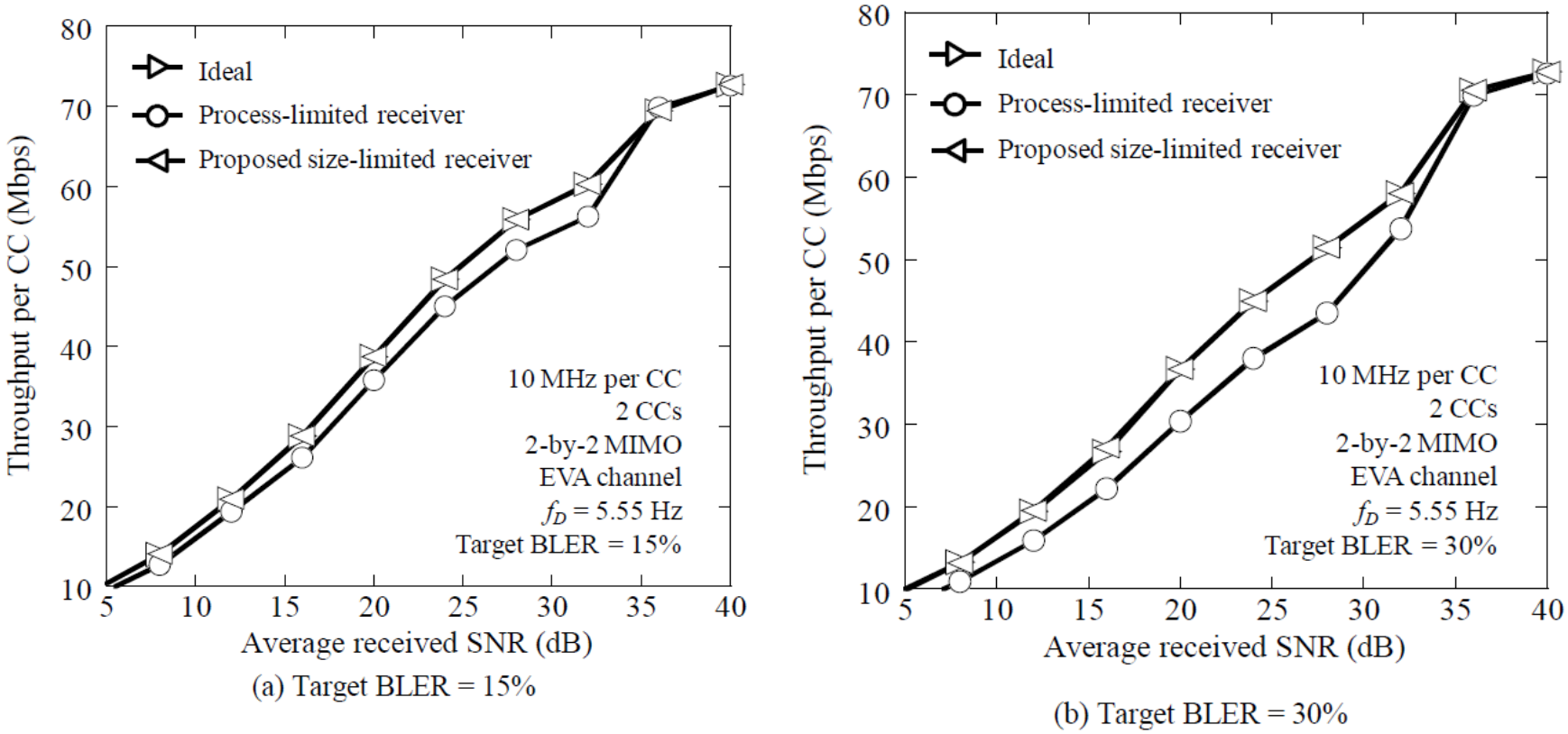
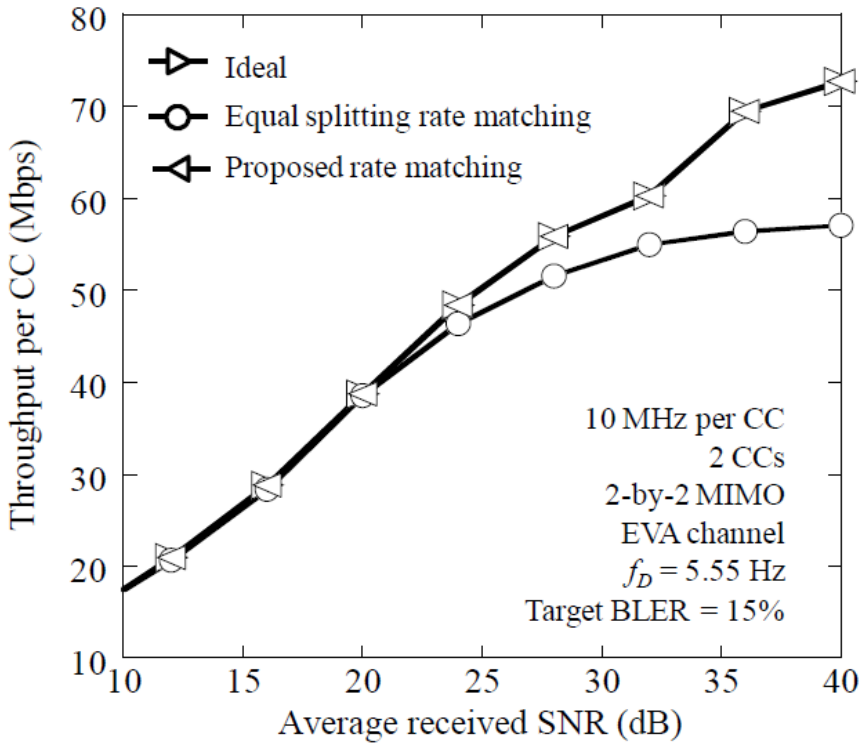
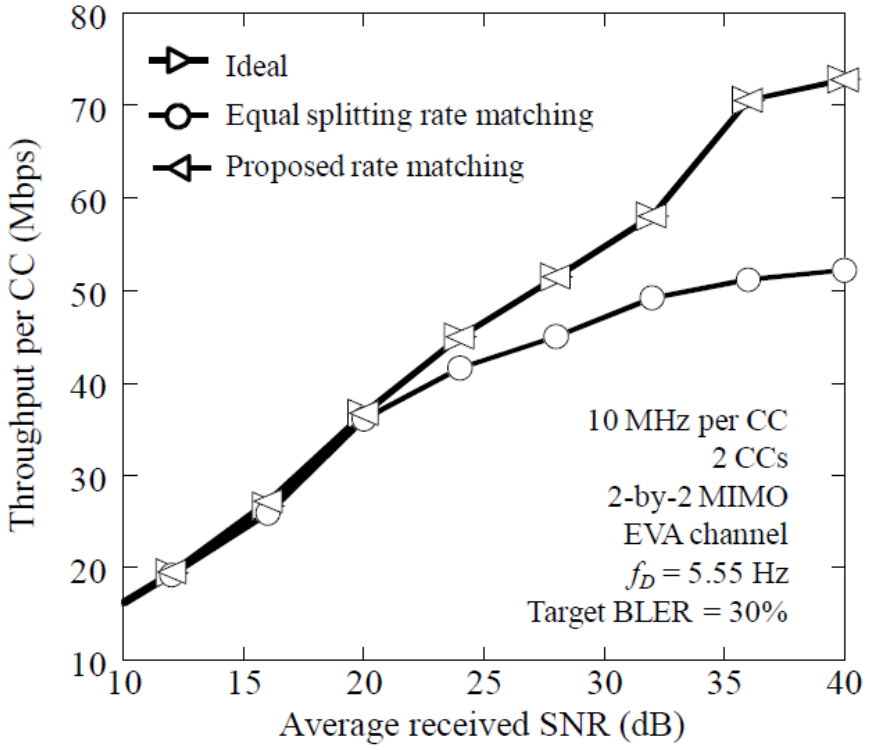


Figure 7. Performance comparison of receiver types.

Comparison of Rate-Matching Schemes



(a) Target BLER = 15%



(b) Target BLER = 30%

Figure 8. Performance comparison of rate-matching schemes.

Conclusion

- The soft buffer size per CC may not be sufficient and the performance of the HARQ packet combining is not ensured when soft buffer splitting is applied to a UE in a lower UE category.
- We proposed a rate matching scheme for CA and the optimum receiver for efficient HARQ packet combining and decoding.
- As a consequence of standardization in the 3GPP RAN WG, the proposed rate-matching scheme with the size-limited receiver is adopted for CA in LTE-Advanced.

The End

Thank you for your attention