3GPP TSG RAN1 #50bis R1-074478
Shanghai, China
October 8 - 12, 2007

Agenda Item:	**6.3**
Source:	**Broadcom**
Title:	**One generator polynomial for both transport block CRC and code block CRC**
Document for:	**Discussion and Decision**

1. Introduction

Let L be the size of CRC and $G_{TB}(D)$ be the CRC generator polynomial for transport blocks (TB), and let $G_{CB}(D)$ be the CRC generator polynomial for code blocks (CB). Let i-th CB turbo code block size be k_i (>L) and suppose one TB has N CBs. Furthermore, we define

$$P(TBE) = \Pr(\text{TB in error})$$
$$P(TBE \wedge Miss) = \Pr(\text{TB in error but not detected})$$

In this document, we show that

$$P(TBE \wedge Miss) = 2^{-L}$$

whether $G_{TB}(D) = G_{CB}(D)$ or $G_{TB}(D) \neq G_{CB}(D)$. Therefore, we suggest keeping the 36.212 v200 CRC specification for UL and DL SCH turbo coding, i.e. take one generator polynomial for both TB CRC and CB CRC.

2. Proof

Let L be the size of CRC and $G_{TB}(D)$ be the CRC generator polynomial for transport blocks (TB), and let $G_{CB}(D)$ be the CRC generator polynomial for code blocks (CB). Let i-th CB turbo code block size be k_i (>L) and one TB has N CBs.

To simplify the proof, w.l.o.g. we give the proof for N=2.

Let $X_i(D), i = 1,2$ be two CB information blocks. Then $\deg X_i(D) = k_i$, $i = 1,2$. Let $CRC_T(D)$ be the CRC of TB, then

$$G_T(D) \mid [X_1(D)D^{k_2+L} + X_2(D)D^L + CRC_T(D)] \qquad \text{(EQ-1)}$$

Let $CRC_i(D), i = 1,2$ be two CRC for CB 1 and CB 2, respectively. Then after turbo decoding the output will be

$$E(D)+[X_1(D)D^L+CRC_1(D)]D^{(k_2+2L)}+\{[X_2(D)D^L+CRC_T(D)]D^L+CRC_2(D)\} \qquad \text{(EQ-2)}$$

where $E(D)$ is possible error after turbo decoding with no restriction and

$$\deg E(D) \le k_1+k_2+3L \qquad \text{(EQ-3)}$$

Let us denote

$E(D)=E_1(D)D^{k_2+2L}+E_2(D)$ with $\deg E_1(D) \le k_1+L$ and $\deg E_2(D) < k_2+2L$. Then (EQ-2) becomes

$$[E_1(D)+X_1(D)D^L+CRC_1(D)]D^{(k_2+2L)}+\{E_2(D)+[X_2(D)D^L+CRC_T(D)]D^L+CRC_2(D)\}$$

Furthermore, we denote

$E_1(D)=E_{11}(D)D^L+E_{12}(D)$ and $E_2(D)=E_{21}(D)D^L+E_{22}(D)$ such that

$$\deg E_{11}(D) \le k_1, \deg E_{21}(D) \le k_2+L-1 \text{ and } \deg E_{i2}(D) < L, i=1,2 \qquad \text{(EQ-4)}$$

Then the output after CB CRC detecting is

$$[E_{11}(D)+X_1(D)]D^{k_2+L}+E_{21}(D)+X_2(D)D^L+CRC_T(D)$$

If TB CRC made a miss-detection, we have

$$G_T(D) \mid \{[E_{11}(D)+X_1(D)]D^{k_2+L}+E_{21}(D)+X_2(D)D^L+CRC_T(D)\}$$

Combine this with (EQ-1), we have

$$E_{11}(D)D^{k_2+L}+E_{21}(D)=G_T(D)U(D) \text{ with a polynomial } U(D) \qquad \text{(EQ-5)}$$

Combining this conclusion with EQ-3 and EQ-4, we can conclude that there are $2^{k_1+k_2+3L-L}$ error polynomials

$$E(D)=[E_{11}(D)D^L+E_{12}(D)]D^{k_2+2L}+E_{21}(D)D^L+E_{22}(D)$$

such that $E_{11}(D)D^{k_2+L}+E_{21}(D)$ satisfying (EQ-5) .

Thus

$$P(TBE \wedge Miss) = \frac{\left\| \{E(D) \mid \deg E(D) \le k_1 + k_2 + 3L, E_{11}(D), E_{21}(D) \text{ satisfy (EQ - 5)}\} \right\|}{\left\| \{E(D) \mid \deg E(D) \le k_1 + k_2 + 3L\} \right\|}$$

$$= \frac{2^{k_1 + k_2 + 2L}}{2^{k_1 + k_2 + 3L}} = 2^{-L}$$

3 Conclusion

Therefore, we suggest keeping the 36.212 v200 CRC specification for UL and DL SCH turbo coding, i.e. take one generator polynomial for both TB CRC and CB CRC.