Agenda item:	
Source:	Nokia
Title:	Proposal to add 24 bit CRC polynomial
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Summary:

Currently, according to the Service and Service Capabilities specification (TS 22.105-350) the most stringent QoS requirement of any bearer is BER < 10^{-8}. As the ARQ protocol relies on L1 CRC so low BER is difficult to achieve when using 16 bit CRC. Therefore, a new 24 bits long CRC is proposed to be added to TS 25.212.

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1. INTRODUCTION

In TS 25.212 error detection is based on using Cyclic Redundancy Check (CRC). Three different CRCs of length 0, 8 and 16 bits have been defined. As error detection capability depends on the length of the CRC, 16 bit CRC can not handle easily very low FER/BER.

2. PROPOSAL TO ADD 24 BIT CRC

Currently, according to the Service and Service Capabilities specification (TS 22.105-350) the most stringent QoS requirement of any bearer is BER < 10^{-8} [1]. As the ARQ protocol relies on L1 CRC so low BER is difficult to achieve when using 16 bit CRC. Based on worst case analysis we can expect a probability of undetected error, P_{ue}, of $1.5x10^{-5}$. This is clearly not sufficient if BER of 10^{-8} is needed.

There are ways how to improve the basic CRC detection performance. We could e.g. use some additional side information and get lower P_{ue}. The problem is that it is very difficult to verify that the target quality of BER 10^{-8} is achieved. Moreover, from minimum performance and conformance testing point of view it is very difficult to test if the algorithm and the implementation of it are good enough. Thus, it is preferable to have longer CRC in order to be sure that the QoS of BER 10^{-8} can be achieved.

The requirement of BER 10^{-8} can not easily be translated into P_{ue} requirement because the relation between BER and FER depends on many issues. Yet, if we define CRC of length 24 bits the worst case analysis gives us P_{ue} of $6x10^{-8}$. If we operate at FER of 10 % the FER after CRC detection is guaranteed to be < $6x10^{-9}$. This is sufficient for the QoS target of BER 10^{-8} as specified in TS 22.105-350.

The proposed CRC polynomial defined in chapter 3 is based on distance-4 Hamming code.

3. TEXT PROPOSAL

The chapter 4.2.1 of TS 25.212 v2.0.1 is proposed to be modified as follows:

----------Start text proposal----------

4.2.1 Error detection

Error detection is provided on transport blocks through a Cyclic Redundancy Check. The CRC is 24, 16, 8 or 0 bits and it is signaled from higher layers what CRC length that should be used for each transport channel.

4.2.1.1 CRC calculation

The entire transport block is used to calculate the CRC parity bits for each transport block. The parity bits are generated by one of the following cyclic generator polynomials:

$g_{CRC24}(D) = D^{24} + D^{23} + D^6 + D^5 + D + 1$

$g_{CRC16}(D) = D^{16} + D^{12} + D^5 + 1$

$g_{CRC8}(D) = D^8 + D^7 + D^4 + D^3 + D + 1$

Denote the bits in a transport block delivered to layer 1 by b_1, b_2, b_3, … b_N, and the parity bits by p_1,p_2, … p_L. N is the length of the transport block and L is 24, 16, 8, or 0 depending on what is signaled from higher layers.

The encoding is performed in a systematic form, which means that in GF(2), the polynomial

$b_1D^{N+23} + b_2D^{N+22} + \ldots + b_ND^{24} + p_1D^{23} + p_2D^{22} + \ldots + p_{23}D^1 + p_{24}$

yields a remainder equal to 0 when divided by $g_{CRC24}(D)$, polynomial

$b_1D^{N+15} + b_2D^{N+14} + \ldots + b_ND^{16} + p_1D^{15} + p_2D^{14} + \ldots + p_{15}D^1 + p_{16}$

yields a remainder equal to 0 when divided by $g_{CRC16}(D)$ and polynomial~~. Similarly,~~

$b_1D^{N+7} + b_2D^{N+6} + \ldots + b_ND^8 + p_1D^7 + p_2D^6 + \ldots + p_7D^1 + p_8$

yields a remainder equal to 0 when divided by $g_{CRC8}(D)$.

4.2.1.2 Relation between input and output of the Cyclic Redundancy Check

Bits delivered to layer 1 are denoted b_1, b_2, b_3, … b_N, where N is the length of the transport block. The bits after CRC attachment are denoted by w_1, w_2, w_3, … w_{N+L}, where L is 24, 16, 8, or 0. The relation between b and w is:

$w_k = b_k$ k = 1, 2, 3, ... N

$w_k = p_{(L+1-(k-N))}$ k = N+1, N+2, N+3, ... N+L

----------End text proposal----------

4. CONCLUSIONS

According to the Service and Service Capabilities specification (TS 22.105-350) the most stringent QoS requirement of any bearer is BER < 10^{-8}. As this is difficult to achieve with the currently specified CRCs, a new 24 bits long CRC is proposed to be added to TS 25.212.

REFERENCES

[1] 3GPP. Services and service capabilities. 3GPP specification, TS 22.105 v3.5.0, 37 pp.