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Title	**Success Rate Gray Scale Feedback Mechanism for HARQ**
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Re:	Comments on the HARQ Rapporteurs report: Initial Draft, SDD Text Proposed by Rapporteur Group Chairs for HARQ, Contribution number: C802.16m-HARQ-08_001r3.doc
Abstract	This contribution proposes a multi-level HARQ feedback mechanism to enable the HARQ transmitter to reduce its retransmission rate of subsequent retransmissions
Purpose	Discussion and approval by TGm for the 802.16m SDD
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Success Rate Gray Scale Feedback Mechanism for HARQ

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Introduction

In general HARQ operates with an all or nothing signaling mechanism from the receiver saying that the full packet was successfully received or that a full retransmission is required. With a Success Rate Gray Scale (SRGS) feedback, a mechanism would be provided where a receiver can describe the level of successful decoding of the HARQ packet and, thus, indicate to the Base station the rate of retransmission that should be required to successfully complete a HARQ transmission.

The SRGS return signal can be generated locally by a receiver based on metrics generated by the decoders that were performing Forward Error Correction (FEC) on the receiver information. In particular while decoding Convolution Turbo Coded (CTC) FEC blocks, quality metrics from the internal operation of the decoder can be extracted. Anther metric might be the instantaneous SNR measured while receiving the HARQ packet and the accumulated CINR so far for the HARQ packet.

The benefits of the SRGS feedback signalling come from the reduced retransmission rate and come at the cost of increased signalling overhead. However, there is an overall net throughput gain of about 10%-20%.

SRGS feedback mechanism is more suitable for Asynchronous/adaptive HARQ mechanism. The discussion regarding the choice of HARQ mechanism should take into account the overhead reduction afforded by using fractional rate retransmission.

The UL control channel for HARQ should be designed to support multi-level HARQ feedback signalling.

Success Rate Gary Scale HARQ Operation

A full HARQ channel of information contains a user data portion and a CRC checksum. The CRC checksum values for a HARQ channel must pass for an “ACK” to be signaled back to the transmitter. An ACK’d channel can be considered to be closed and the channel can now be used by the transmitter for new information.

If the checksums do not pass, a “NACK” is signaled back to the transmitter requesting a retransmission of the information for that HARQ channel. Each subsequent retransmission is summed with the stored result for that HARQ channel at the receiver and the same checksum pass/fail condition is applied resulting in another ACK/NACK signal back to the transmitter. The operation of a non-SRGS HARQ channel is shown in Figure 1; specifically in this case DL reception and UL feedback transmission are depicted.

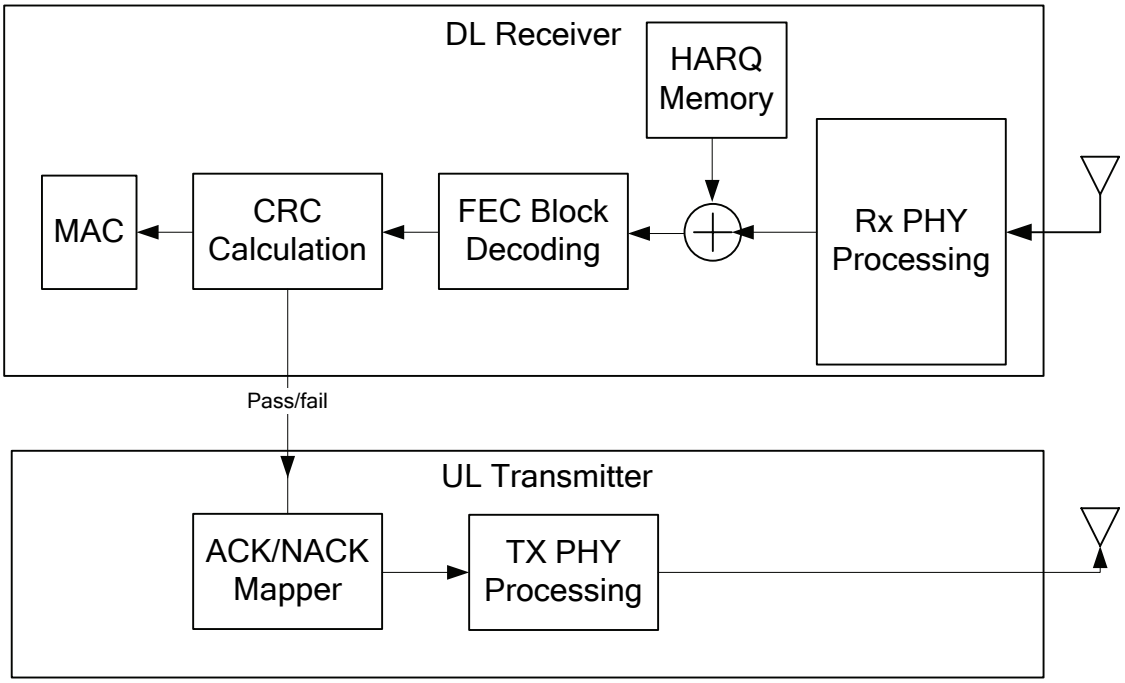

Figure 1 Non-SRGS HARQ Operation

In SRGS HARQ operation, a receiver can signal a multi-level ACK/NACK signal instead of a single bit. One setting within the multi-level mapping is used to signal successful reception (an ACK) and another setting is used to signal that a full retransmission is required (a NACK), the other settings within the overall mapping are used to signal that only a partial retransmission is required to successfully close the currently operating channel. In other words, the NACK feedback signal indicates to the base station the decoding success level of the HARQ packet.

A variety of different information sources can be used to determine the correct adaptive ACK/NACK signal such as the following:

1. Accumulated CINR values. As each retransmission is received an accumulated CINR value can be computed.

2. Partial CRC completion flags in the case that one or several FEC blocks in a HARQ channel are successful.

3. Qualitative Decoder Feedback. For many classes of decoders such as Turbo codes or LDPC codes a variety of metrics can be determined from the internal operation of the decoder. Such feedback can include success/failure determination or qualitative values signaling the perceived performance of the decoding.

The overall operation of a SRGS HARQ system is shown in Figure 2.

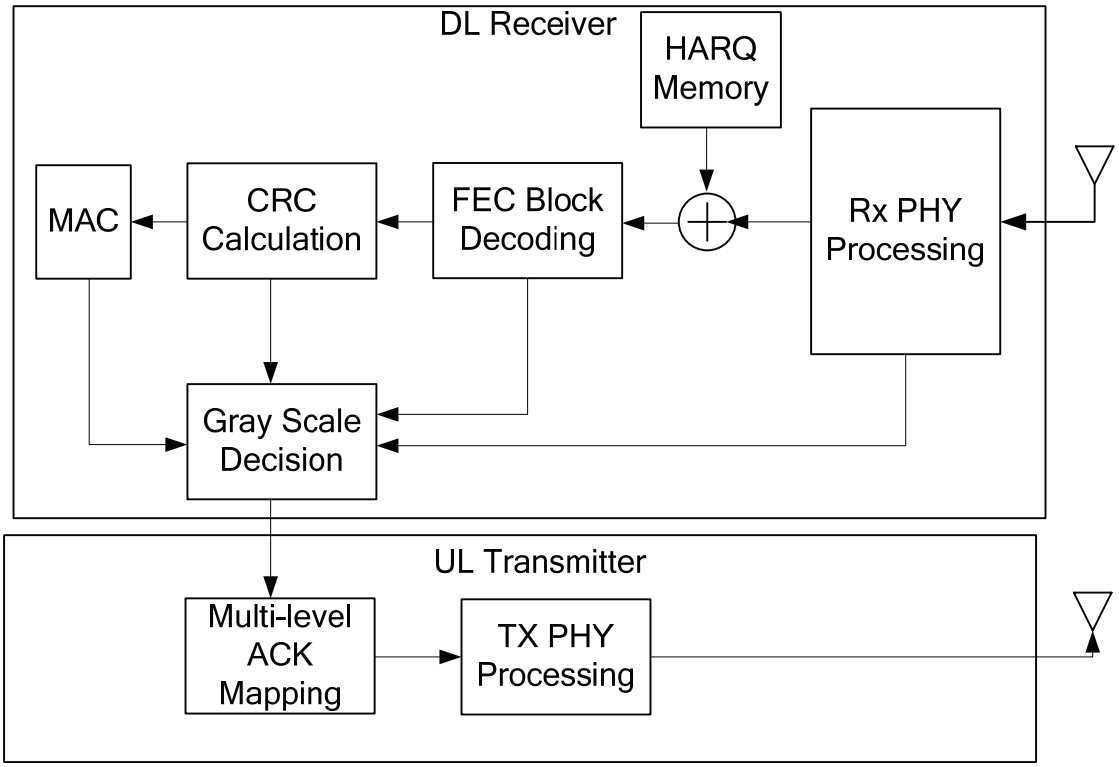

Figure 2 SRGS HARQ Operation

UL HARQ

For UL reception the situation is very similar to the DL case except that the UL receiver is generally in charge of scheduling grants for the UL transmitter. As such, the result of advanced HARQ operation can be included within the control information for the next scheduling grant for each UL HARQ channel.

SRGS HARQ Signalling

We can define a variety of different multi-level ACK/NACK formats. Some possible formats are shown in Table 1 below.

Table 1 – Fraction ACK/NACK Signal Formats

Number of Levels	Level Interpretations
3	0 NACK, Transmit Full amount of data 1 SRGS_ACK1, ½ decode success rate; indicating to the BS that possibly only ½ of the normal amount of data on the next TX will be sufficient. 2 SRGS_ACK2, Transmit success
4	0 NACK – Transmit Full amount of data 1 SRGS_ACK1 – Success Rate of ¼ of normal 2 SRGS_ACK2 – Success Rate of ½ of normal

	3 ACK – transmit success
4	0 NACK – Transmit Full amount of data 1 SRGSl_ACK1 –Success Rate of 1/3 of normal 2 SRGS_ACK2–Success Rate of 2/3 of normal 3 ACK – transmit success

Conclusion

Success Rate Gray Scale (SRGS) feedback mechanism improves system throughput by reducing the amount of retransmission information based on explicit feedback from the receiver.

Proposed SDD Text

Add to the following text to the SDD within the section 10.x.1 DL HARQ:

10.x.1.y DL Success Rate Gray Scale (SRGS) HARQ Feedback

The HARQ feedback information supports multi-levels of HARQ feedback. The multi-level feedback information indicates the decoding success rate of the HARQ packet. This information can be used by the base station scheduler for selecting the modulation and coding (MCS) of subsequent retransmissions.