ARQ/HARQ inter-working to reduce the ARQ feedback overhead

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Venue:

Re: MAC: User Plane; IEEE 802.16m-08/024, "Call for Comments and Contributions on Project 802.16m System Description Document (SDD)".

Base Contribution:

This is the base contribution.

Purpose:

To be discussed and adopted by TGm for the 802.16m SDD

ARQ and HARQ in IEEE 802.16e

- In current WiMAX system (IEEE 802.16), ARQ and HARQ protocols works independently.
- HARQ provides most of the radio link error detection and correction mechanism but
  - Number of retransmissions are limited therefore user data may still not be delivered correctly.
- ARQ provides residual error correction by scheduling re-transmission.
- ARQ transmitter schedule retransmission when
  - either it receives NAK from the receiver
  - or retransmission timer expires.
- ARQ receiver sends ARQ-feedback when ARQ blocks are lost or received out of order or to let window not stalled.
- When ARQ blocks are received correctly, then it is not necessary to send ARQ feedback so often (however, need to make sure that ARQ window is not stalled).
- When ARQ blocks are received in error, then fast ARQ feedback is required to reduce the retransmission delay.

ARQ and HARQ - Dilemma

- When to send ARQ feedback is implementation dependent.
- If receiver sends ARQ feedback frequently, overhead will increase but if receiver sends ARQ feedback less often, if error happens, latency will increase.
- Sending of ARQ feedback may require contention based Bandwidth request
- ARQ protocol can not rely on HARQ ACK/NAK because of HARQ ACK/NAK decoding errors.
- It is possible to determine when and which ARQ packets are lost if ARQ protocol communicate with HARQ protocol (**locally**).
- This contribution proposed ARQ-HARQ inter-working protocol.

HARQ/ARQ inter-working proposal

- Propose to use Local HARQ-ARQ feedback at both the side. (Implementation detail)
  - HARQ protocol provides ACK/NAK status along with ARQ block sequence number to ARQ protocol.
- Please note that HARQ ACK/NAK discussed throughout this proposal is the final ACK/NAK report after multiple HARQ retransmission.
  - Many HARQ decoding errors can be resolved at HARQ retransmission attempt

HARQ report Local NAK to ARQ

- When HARQ indicate NAK to ARQ Protocol
  - Transmitter and Receiver both must start Timer T1
    - Value of the T1 can be negotiated during Service flow setup or can be fixed parameter known to both transmitter and receiver.
  - Transmitter must schedule retransmission of corresponding ARQ blocks within Timer T1.
  - ARQ feedback messages is not required even though ARQ blocks are lost as long as transmitter can schedule re-transmission within T1.
  - If Receiver does not receive missed ARQ block within T1, receiver will send ARQ-feedback message to explicitly ask for retransmission
    - Does not really increase the latency because transmitter can neglect T1 and still has choice to delay the retransmission. Basically in this case protocol will fall back to legacy operation.
- HARQ Decoding error: ACK turned NAK
  - Cons: Transmitter may unnecessary re-transmit ARQ Blocks.
  - Transmitter believes that receiver does not receive ARQ Blocks and therefore need to re-transmit within Timer T1.
  - If receiver detect unnecessary HARQ retransmission attempt (ACK turned NAK before maximum retransmission) , receiver may transmit HARQ ACK again for unnecessary HARQ retransmission.
  - Therefore, problem happens only when last HARQ NAK turned ACK.

HARQ report Local ACK to ARQ

- When HARQ indicated ACK to ARQ protocol
  - Transmitter/Receiver, both must advance the ARQ window.
  - Transmitter must buffer the ACKed packet for timer T2.
    - This is required in case of HARQ decoding error occur, because if transmitter decodes HARQ NAK as HARQ ACK then it may remove the ARQ blocks.
- Decoding Error: HARQ NAK turned ACK
  - Receiver's ARQ protocol start timer T1 when HARQ indicates NAK. After receiver's timer T1 times out, receiver sends ARQ feedback message to explicitly request retransmission.
  - Therefore buffering of ARQ blocks are required at the transmitter for T2 timer, even though HARQ indicates ACK
- ARQ feedback message is not required if there is no HARQ decoding error.
- As a optimization, If receiver detects that HARQ is pre-maturely terminated by detecting new HARQ packet on that same ACID, receiver may trigger ARQ feedback message to request retransmission instead of waiting for Timer T1 to expire.

Conclusion

- Transmitter buffer ARQ blocks for timer T2 even though ARQ blocks are ACKed by local HARQ protocol.
  - Value of T2 = T1 + ARQ-feedback transmission delay
- Transmitter and receiver both runs timer T1 when local HARQ protocol indicates NAK.
  - Transmitter must re-transmit within Timer T1
  - Receiver if does not receives ARQ blocks within Timer T1, sends ARQ feedback message
- ARQ feedback messages is only required in case of HARQ decoding error therefore ARQ feedback overhead is significantly reduced.
- In case of UL ARQ, if receiver gets local HARQ NAK then it can allocate additional UL bandwidth for ARQ blocks retransmission in order to avoid UL contention based Bandwidth request.
  - BS may indicate type of Bandwidth grant if needed.

Advantages

- Proposed ARQ/HARQ inter-working protocol significantly reduce the ARQ feedback overhead
  - ARQ feedback is only needed if HARQ decoding error happened. However, probability of HARQ decoding error is much low.
- Proposed protocol is immune to HARQ feedback decoding error therefore both transmitter and receiver can rely on local HARQ feedback rather then need for peer ARQ feedback.

SDD Text Proposal

10.2.3 HARQ and ARQ interactions

[Insert following text in section 10.2.3]

In case of ARQ/HARQ interaction, ARQ uses knowledge obtained from the HARQ about the transmission status of a transmit block. With such coupled operations, ARQ feedback is not always required and signaling overhead is significantly reduced.

If a HARQ burst is successfully transmitted, ARQ transmitter marks associated ARQ blocks as transmitted but keep those ARQ blocks in the buffer until Timer T2. Transmitter will re-transmit ARQ blocks if request for re-transmission is received within Timer T2. When Timer T2 is expired, transmitter releases those blocks.

If the HARQ protocol detects a failed delivery of a transmit block due to e.g. maximum retransmission limit is reached, the relevant transmitting ARQ entities are notified and potential retransmissions can be initiated. Transmitter will schedule re-transmission with Timer T1. If receiver does not receives the missed ARQ block within Timer T1, receiver will request re-transmission of ARQ blocks.

Value of T1 and T2 is FFS. (T2 must be greater than T1)