Project	**IEEE 802.16 Broadband Wireless Access Working Group** <http://ieee802.org/16>
Title	NACK based ARQ Over HARQ in IEEE 802.16m
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Re:	MAC Data Plane
Abstract	Cross-layer design of ARQ and HARQ can result in performance improvements and overhead reduction. The HARQ ACK/NACK mechanism is used to provide internal ACK/NACK information to the ARQ layer facilitating the design of NACK based ARQ mechanism.
Purpose	For discussion and approval by TGm
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NACK Based ARQ over HARQ

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Introduction

A cross-layer design of ARQ and HARQ can result in performance improvements and overhead reduction. We take advantage of the HARQ ACK/NACK mechanism and do not duplicate unnecessarily the same ACK/NACK information at the ARQ layer, thus facilitating the design of a NACK based ARQ in 802.16m.

The NACK based ARQ result in lower overhead compared to the legacy system and ultimately a simpler system, which satisfies the SRD requirements of sections 5.2 and 6.0.

In addition, this ARQ over HARQ mechanism should be extended to MAC management flows to facilitate for a generic framework over which all MAC management state machine retransmissions. In the legacy system, each MAC management state machine, e.g. DSx, HO, etc. has its own retransmission mechanism relying primarily on timers. This results in unnecessary delays since timers must be set sufficiently large to allow the lower layer retransmission schemes to complete first. In addition, the timers must also account for the processing delay at the peer entity.

We propose that in 802.16m the MAC management state machines consider the MAC management connections (basic and primary connections in the legacy system) to be a reliable transport facility with a known and adequate frame error rate performance which meets the MAC management reliability requirements.

Discussion

The following sections describe the DL and UL operation of the ARQ over HARQ mechanism.

DL Operation

The BS relies on HARQ ACK/NACKs to drive MAC level retransmissions (ARQ). The BS keeps keep track of MAC PDUs mapping to HARQ packets and whether several MAC flows are multiplex onto the same HARQ packet. The ARQ state machine is advanced based on HARQ ACK/NACK. This is analogues to the ARQ selective ACK, but without the overhead. The window size of the NACK based ARQ is managed using the Fragmentation Sequence Number (FSN) in a manner similar to the BSN of the legacy system.

If the HARQ packet was ACK'ed by the MS, the BS sends an internal ACK to the ARQ state machine for the associated MAC PDU. If the HARQ process was terminated with and unsuccessful outcome (independent of the maximum HARQ retransmission parameter), the BS sends an internal NACK indication for the associated PDUs. Note that HARQ packets can carry multiple flows. In

this case, the base station needs to send internal ACK/NACK indications to multiple MAC flows state machines.

There are several advantages to this scheme:

- Overhead savings – MS does not send UL ARQ ACK/NACK packets

- Faster retransmission since the combined ARQ and HARQ state machine use explicit indications instead of relaying on timers to expire

- Remove the restriction of ARQ block size; ARQ blocks are used in the Legacy system primarily as a way of reducing ARQ ACK/NACK overhead, by increasing the granularity from one byte to several bytes.

- Simpler design – no need to coordinate timers between two retransmission mechanisms to ensure that they do not overlap.
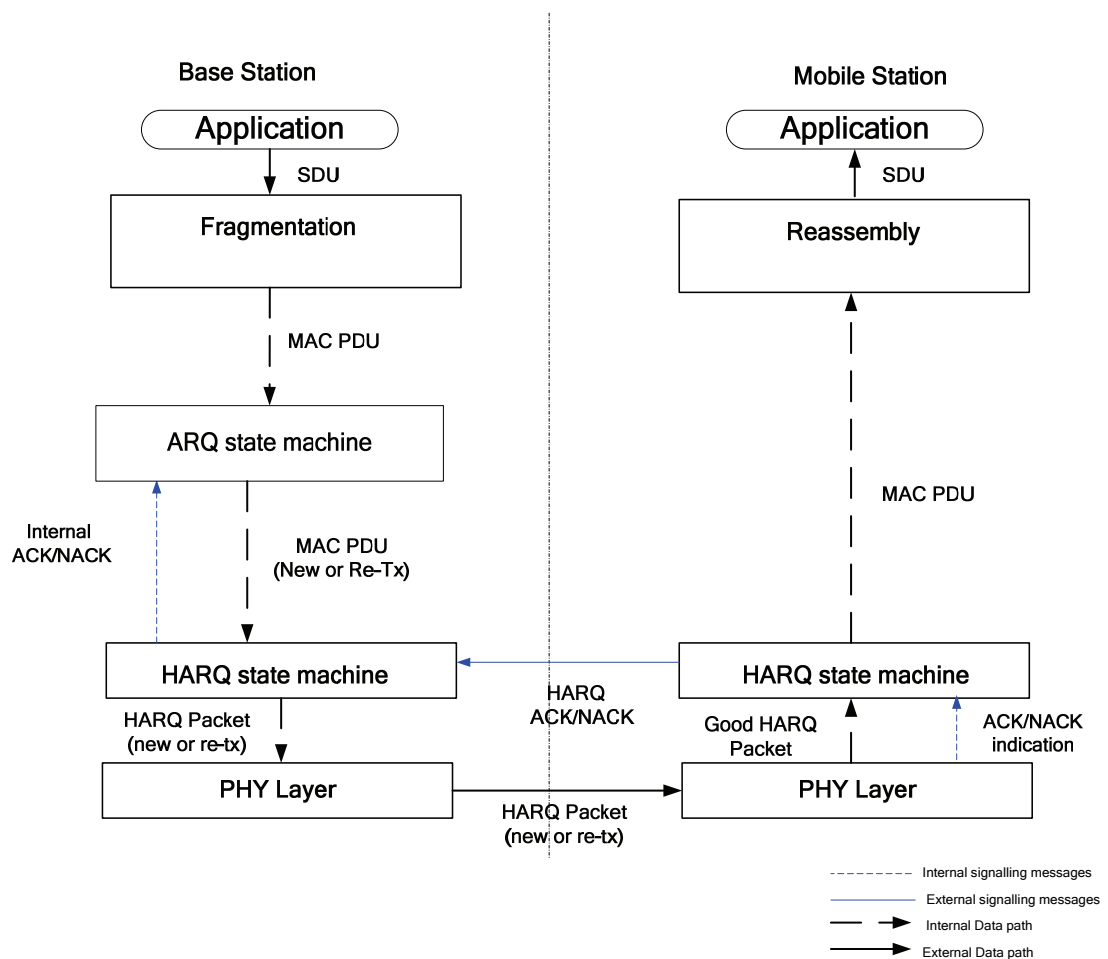

Figure 1: DL ARQ over HARQ operation

UL Operation

The BS controls the HARQ retransmission operation. The MS keeps track of MAC PDUs mapping to HARQ packets. MS assumes that a HARQ packet is implicitly ACKed using the new packet

indication (AI_SN toggle in the legacy system) or after the maximum number of retransmission is reached. The MS sends an internal ACK for the associated PDUs after a predetermined time.

If the BS terminates the HARQ process unsuccessfully, it sends to the MS a MAC level NACK. The BS must send the MAC level NACK before the predetermined time has expired. The MAC level NACK uniquely identifies the HARQ packet so that the MS may trigger ARQ level retransmission for the associated PDUs. For example, the NACK message may contain the HARQ process ID (ACID in the legacy system) and the frame number the HARQ packet was received.
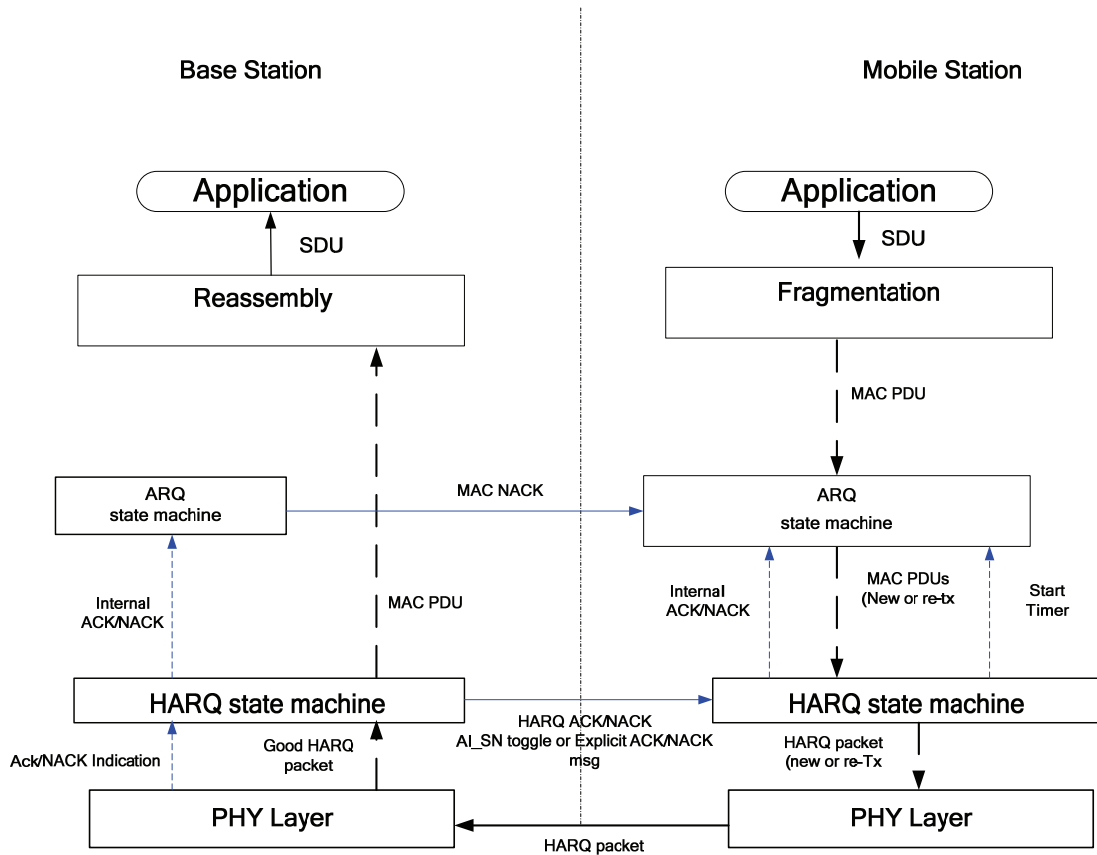
Figure 2: UL ARQ over HARQ operation

Conclusion

This contribution proposes a cross-layer approach from retransmission relaying first on HARQ and potentially completing the retransmission at the MAC level.

Proposed Text

Add the following text to SDD: new Text is shown in blue

10 Medium Access Control

10.x. ARQ

10.x.1 ARQ Over HARQ

ARQ over HARQ mechanism is extended to both MAC management flows and MAC traffic flows. The MAC management state machines consider the MAC management connections (basic and primary connections in the legacy system) to be a reliable transport facility with a known and adequate frame error rate performance which meets the MAC management reliability requirements.

10.x.1.1 DL Operation

The BS relies on HARQ ACK/NACKs to advance the ARQ retransmissions state machine. The BS keeps track of MAC PDUs mapping to HARQ packets and if several MAC flows are multiplexed onto the same HARQ packet.

If the HARQ packet was ACK'ed by the MS, the BS sends an internal ACK to the ARQ state machine for the associated MAC PDU. If the HARQ process was terminated with and unsuccessful outcome (independent of the maximum HARQ retransmission parameter), the BS sends an internal NACK indication for the associated PDUs.
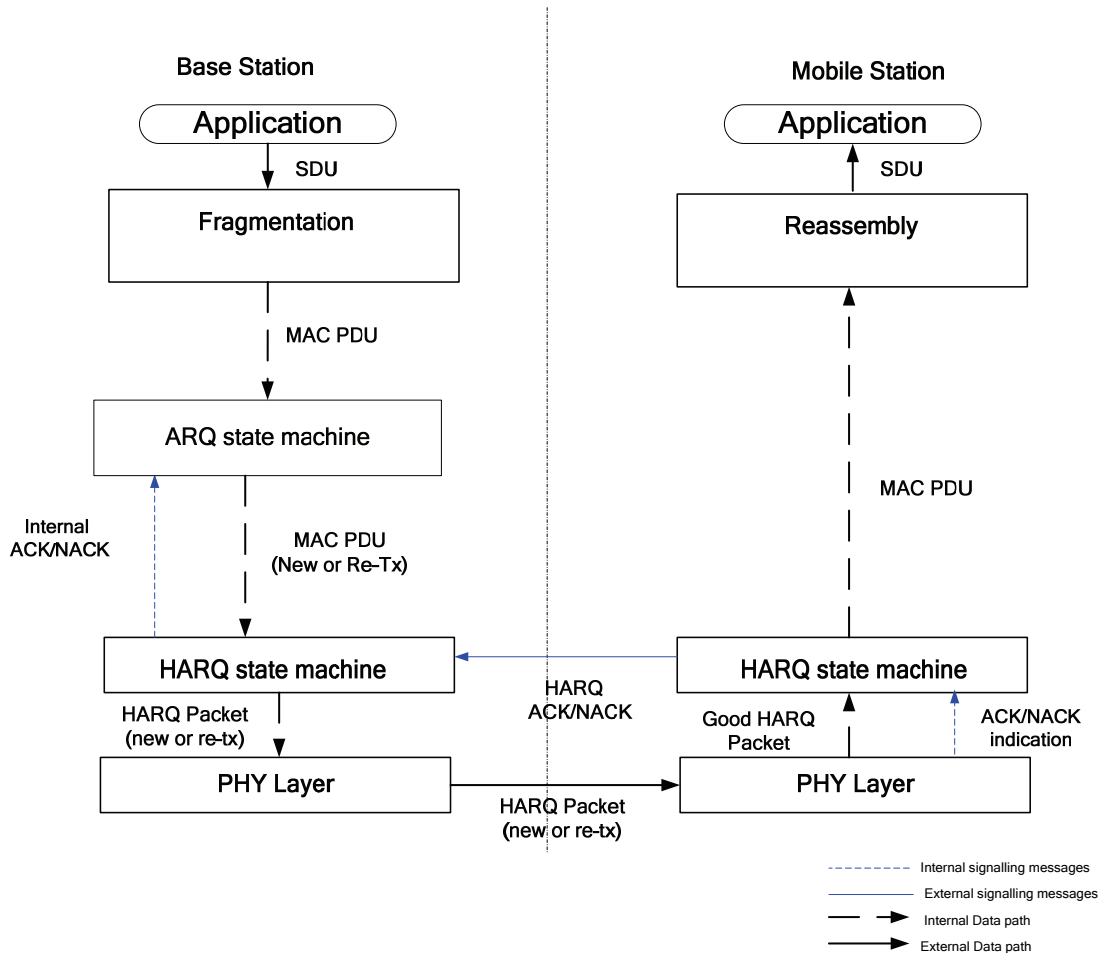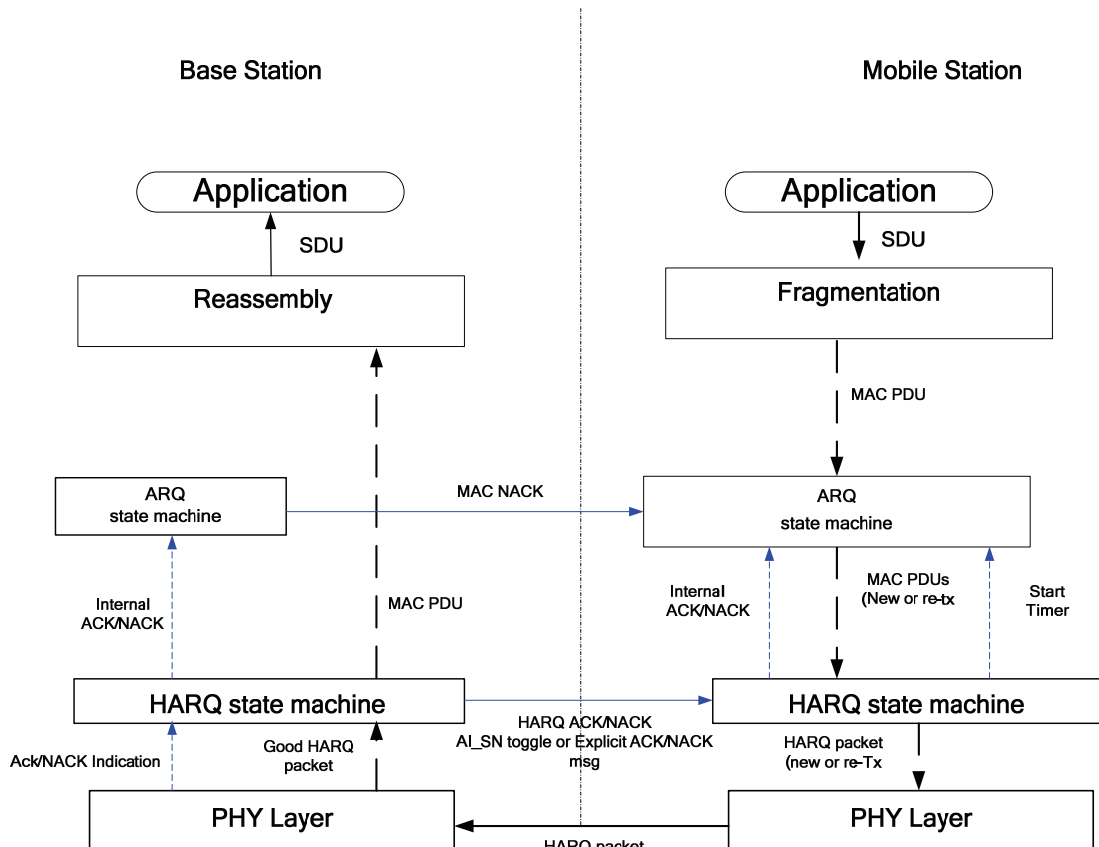
DL ARQ over HARQ operation

10.x.1.2 UL Operation

The MS keeps track of MAC PDUs mapping to HARQ packets. MS assumes that a HARQ packet is implicitly ACKed using the new packet indication (AI_SN toggle in the legacy system) or after the maximum number of retransmission is reached. The MS sends an internal ACK for the associated PDUs after a predetermined time.

If the BS terminates the HARQ process unsuccessfully, it sends to the MS a MAC level NACK. The BS must send the MAC level NACK before the predetermined time has expired. The MAC level NACK uniquely identifies the HARQ packet so that the MS may trigger ARQ level retransmission for the associated PDUs. For example, the NACK message may contain the HARQ process ID (ACID in the legacy system) and the frame number the HARQ packet was received.

UL ARQ over HARQ operation