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Title	UMAC RG Harmonized SDD Text Proposal for ARQ Topics		
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	UMAC Rapporteur Group Chairs		
Re:	Result of the UMAC Rapporteur Group Discussions on topics related to ARQ		
Abstract	This document contains UMAC RG harmonized SDD text proposal for topics related to ARQ based on the submissions to the September meeting held in Kobe (16-19 September 2008) and the RG discussions held between September and November 2008 meetings.		
Purpose	For review and discussion in TGm and for the adoption of the harmonized text (See Section 4: SDD Text Proposal) in the TGm SDD.		
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UMAC RG Harmonized SDD Text Proposal

on topics related to ARQ

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UMAC Rapporteur Group Chairs

A Note to the TGm members: This document is based on the latest version of the discussion draft (C80216m-08-UMAC_001r3.doc). The UMAC RG-harmonized text with a very few “opens” is captured in Section 4: SDD Text proposal. Topics where consensus is not reached, is listed as open issues in Section 3.3

Those members who have already read the earlier versions of the UMAC RG drafts (C802.16m-UMAC-08/001 thru 001r2) can skip the earlier sections and go directly to Section 3.3 (No changes have been made until Section 3.3)

This document reflects the resolutions of Session 58 as reported in 802.16m-UMAC-08/002r1.

1 Introduction

The ARQ related topics discussed in this document primarily comprise of two subtopics, namely:

1. HARQ and ARQ Interactions, and
2. ARQ.

This discussion draft will be used as a starting point for developing consensus SDD text related to the aforementioned topics.

There are three more sections in this initial discussion draft. The next section, i.e. the second section of this document provides a further classification and sub categorization of the ARQ related contributions made to the September meeting. As announced earlier (via e-mail) by the UMAC RG chairs, the ARQ related topics include the latest versions of the following contributions:

993, 996, 1038, 1039, 1053, 1068, 1060, 1120, 1122, 1142, 1174, 1177.

The third section discusses the level of consensus for the categories mentioned in Section 2, discusses the order in which topics will be discussed (where applicable), and provides discussion points for the membership on these topics. Comments/opinions are invited on the specific categories where the chairs have determined that there is no consensus at this point.

The fourth section provides the “proposal text” for the IEEE 802.16m SDD and is basically what we need to work and generate consensus on. The section numbers used in the “proposed SDD text” section are based on current version of Draft IEEE 802.16m System Description Document, (IEEE 802.16m-08/003r4¹).

¹ Note that IEEE 802.16m-08/003r4 is the latest version of the 16m SDD available at the time of writing this document (5th Oct 2008). When a new

version, containing the changes/updates from Kobe meeting, is uploaded , we may need to align the section numbers etc.

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2 Summary and sub categorization of ARQ topics

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4 The received contributions can be categorized in to two main areas labeled (1) and (2) below. These can then be
5 further classified in to more focused discussion categories as suggested below:

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1. Contributions related to ARQ mechanisms for 16m

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- A. There is one contribution (1068) suggesting to remove ARQ altogether.
- B. There are several contributions the propose modifications to the 16e ARQ mechanism.
- C. There is one contribution (1038r2) that proposes the use of ARQ for management flows.
- D. There is one contribution (1039r2) that discusses replacing the BW request header with ARQ feedback header (i.e. removing the need for the bandwidth request to send ARQ feedback).

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2. Contributions related to HARQ/ARQ interactions

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- A. Several contributions (993r1, 1038r2, 1053r1, 1120r1, 1142) have proposed the generation of local ACK at the transmitter side in response to a HARQ ACK.²
- B. Several contributions (993r1, 1038r2, 1053r1, 1060, 1120r1, 1142) have proposed the generation of local NAK
 - i. At the transmitter in response to a NAK received after maximum retransmission.
 - ii. There is one contribution (993r1) that proposes the generation of local NAK at the receiver side.
- C. For transmission of ARQ Feedback, the views are quite different:
 - i. Some suggest completely removing ARQ feedback (993r1, 1038r2, 1068)
 - ii. Some suggest having conditional ARQ feedback (i.e. ARQ feedback is sent only under certain conditions). (1053r1, 1060, 1120r1, 1142)
 - iii. Some suggest retaining the ARQ feedback as in 802.16e
- D. Detection of HARQ NACK to ACK errors at the receiver and corresponding recovery mechanisms. (1038r2, 1053r1, 1060, 1142)

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² The word “local” here means that the HARQ entity informs the ARQ entity locally.

3 Consensus level and Open issues

3.1 History: Draft 1

3.1.1 For contributions on ARQ mechanisms,

- The contributions in category 1B (mentioned above) are used for generating the draft SDD text proposed below.
- Views are invited from members (who have different affiliations than the proponents of contribution 1068) who think that ARQ should be removed completely.
- Views are also invited on the contribution in category 1C (1038r2) on the question of whether or not we need ARQ for management flows.
- The contribution in category 1D (1039r2) is deferred until a decision can be made on whether ARQ feedback is needed (look at category 2C) in the first place.

3.1.2 For contributions dealing with HARQ/ARQ interactions

- The “Local ACK” issue discussed in contributions categorized under 2A has proponents as well as opponents, i.e. the view of generating a local ACK is not unanimous. Contributions/opinions are invited on this topic.
- For the Local NAK issue discussed in contributions categorized under 2B, the following was observed:
 - There is no opposition to having a local NAK at the transmitter side. This is therefore adopted in the text provided below.
 - For generating a local NAK in the receiver – there is only 1 contribution (993r1). Views are invited from members (who have different affiliations than the current proponents of 993r1) on the issue of Local NAK generation at the receiver side.
- Category 2C, which deals with ARQ feedback is clearly an issue for discussion. Please express your opinion and put your case forward for ARQ feedback.
- There are several contributions on category 2D which deals with the issue of NAK to ACK error detection and recovery. There is no opposition to this idea but the proposed mechanisms are different. So it is adopted in the proposed text as FFS. Opinions and comments are invited to develop an appropriate mechanism for detection and recovery (or leave it out).

3.2 Updates to Draft 1 for generating Draft 2

The following contributions were submitted: 002r1, 003r1 and 004r1. Additional analysis in support of contribution 003r1 was provided in 007. Furthermore, there was quite an active participation on the email reflector. The contributions and the e-mail discussions were used as a basis for generating the second draft.

3.2.1 For contributions/e-mails on 16m ARQ mechanisms

For the ARQ section, the updates related to ARQ block usage have been made.

1 For the issue regarding the use of ARQ for MAC management message there are strong views in favor as well
 2 as against adoption of ARQ for MAC management messages. More discussion is needed on this topic.

3 On the one hand the rationale for applying ARQ for MAC management messages is:

- 4 (a) Increase the ARQ retransmission speed (same as that for data) for MAC management messages
 5 (Especially some messages have long timers (e.g. DSx messages)).
- 6 (b) Why have two separate ways for handling Data plane and control plane?
- 7 (c) If a single fragment of a large MAC management fails, then the entire MAC management message
 8 has to be retransmitted. Some messages can be quite long (e.g. PKM message).
- 9 (d) More reliability of some MAC management message is needed.

10 On the other hand, those against the adoption of ARQ for MAC management messages have argued:

- 11 (a) HARQ + Message Retry timer is sufficient to provide reliability.
- 12 (b) A large part of the ARQ operations (ARQ window, ARQ timer, ARQ feedback, ARQ sequencing) can
 13 not be applied to MAC management messages. The only part that is common to management plane and
 14 data plane packets is retransmission. Retry timer can quite adequately handle the retransmission
 15 function.
- 16 (c) ARQ handles HARQ residual errors. The reason for data plane and control plane to be different is that
 17 data plane packets go to upper layers and erroneous delivery causes higher layer (e.g. TCP
 18 retransmissions). MAC management message on the other hand terminate at MAC layer.
- 19 (d) Different Retry timers can be applied to the different MAC management messages (according to
 20 importance or urgency). However, ARQ does not provide that level of flexibility and one is forced to
 21 apply the same timer for all management messages.

22 For exact discussions on these topics, please refer to the e-mails exchanged on the reflector (the above examples
 23 merely provide a flavor of the type of arguments raised).

25 **3.2.2 For contributions/e-mails dealing with HARQ/ARQ interaction**

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 27 For issues concerning HARQ-ARQ interaction, there was significant discussion on the e-mail reflector on Local
 28 ACK/NAK on transmitter as well as receiver, ARQ feedback and ACK to NAK error detection/recovery.
 29 There are proponents in favor of, and against, the aforementioned issues.

30
 31 Minor updates have been made to the document based on 003r1. However, most of the aforementioned issues
 32 need further discussion.

34 **3.3 Updates to Draft 2 for generating Draft 3**

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 36 The RG received two contributions in response to the 2nd draft on ARQ. These two contributions are
 37 **C80216m-UMAC-08_029.doc and C80216m-UMAC-08_030.doc**

38
 39 Both of these above contributions represent the views of several members with different affiliations. There was
 40 also discussion on the e-mail reflector. Based on the abovementioned contributions and the e-mail discussion
 41 the RG chairs have updated the proposed text.

42
 43 Besides discussing the points related to the new updates, the RG chairs have also identified topics where there
 44 is no consensus. Harmonization should continue for these topics and the Chairs will make one more attempt to
 45 update the draft before the reply comment deadline (yet to be announced by the TGm chair team).

3.3.1 Updates to the Section on 16m ARQ mechanisms and Open Issues

First of all, please note that the RG chairs will change the Section number from 10.4 → 10.6. This is because Section numbers up to 10.5 are already taken in the current SDD (003r4).

Further changes made to the Proposed Text on the ARQ section are as follows:

The first paragraph for the ARQ section in Draft 2 was as follows:

An ARQ block is generated from one or multiple ~~for more~~ MAC SDU(s) or MAC SDU fragment(s). ~~The ARQ~~ blocks ~~which may~~ can be variable in size. ~~are ARQ blocks are~~ sequentially numbered. ~~and assigned a sequence number.~~ The location of this sequence number in the MAC PDU is FFS.

Both the aforementioned documents, as well as on the email reflector, there was no objection to the above paragraph. **As a result, all the edits in red/blue colors will be removed and clean unbracketed text is provided for the first paragraph.**

The second paragraph for the ARQ section in Draft 2 was as follows:

Retransmission of a failed ARQ block can be performed with or without rearrangement.

Neither of the two documents mentioned above, nor comments on the reflector have suggested any change to the second paragraph. **The second paragraph is therefore retained as it is (Clean and unbracketed text).**

There was a proposal in C80216m-UMAC-08_030r1.doc to add the following sentence:

“As described in section 10.2.3, a NACK based ARQ protocol is used in conjunction with the local NACK/ACK indication from the HARQ entity to the ARQ entity”

Since the proposed change has dependencies on parts/concepts that have not obtained consensus, the proposed sentence is not added to the draft.

Further there is a lot of discussion on whether ARQ should be applied on MAC management messages.

Open issue #1 on ARQ: The RG needs to decide how to capture this in the SDD.

3.3.2 Updates to the Section on HARQ and ARQ interaction and Open Issues

It may be better to move this Section (currently Section 10.2.3) to be a subsection under the Section on ARQ (or perhaps an entirely new section) The reason is that HARQ and ARQ interactions will not change the HARQ behavior – it will only impact the ARQ behavior. Although this change is proposed here as a comment, no section number change has been made in this version of the draft. If there is any objection to this proposed editorial change please let this be known on the reflector. **If there are no objections,** the proposed change (i.e. to move the current Subsection “10.2.3 HARQ and ARQ interactions” to be a subsection under the Section on ARQ) will be made in the next version the discussion draft.

Further changes made to the Proposed Text on the “HARQ And ARQ interactions” section are as follows:

The first paragraph in Section on “HARQ And ARQ interactions” in the 2nd draft was as follows:

1 When both ARQ and HARQ are applied for a flow, HARQ and ARQ interactions described here ~~may be~~ is
 2 applied to the corresponding flow.

3
 4 Document C80216m-UMAC-08_030r1.doc proposed to make HARQ and ARQ interaction an optional feature
 5 by suggesting to remove the word “is” and re-instating the previous wording “may be”. However C80216m-
 6 UMAC-08_029.doc suggested to leave it as it is.

7
 8 As there is no consensus on changing this paragraph, **the original text of the second draft (001r2) is retained.**
 9

10
 11 **Open issue #1 on HARQ and ARQ interactions:** RG needs to make up its mind on the wording for the first
 12 paragraph. Currently we have two proposals from the multi-party harmonized document:

13
 14 Option 1 (HARQ and ARQ interaction is optional): When both ARQ and HARQ are applied for a flow, HARQ
 15 and ARQ interactions described here **may be** applied to the corresponding flow.

16
 17 Option 2 (HARQ and ARQ interaction is mandatory): When both ARQ and HARQ are applied for a flow,
 18 HARQ and ARQ interactions described here **is** applied to the corresponding flow.

19
 20 The second paragraph in Section on “HARQ And ARQ interactions” in the 2nd draft was as follows:

21 If the HARQ entity in the transmitter determines that the HARQ process was terminated with an unsuccessful
 22 outcome, a HARQ burst has failed (e.g. when maximum HARQ retransmission limit is reached), the HARQ
 23 entity in the transmitter informs the ARQ entity in the transmitter about the failure of the HARQ burst. The
 24 ARQ entity in the transmitter can then initiate retransmission and re-segmentation of the appropriate ARQ
 25 blocks ~~in the failed HARQ burst.~~

26
 27 According to documents C80216m-UMAC-08_029.doc and C80216m-UMAC-08_030r1.doc, there is
 28 agreement on the second paragraph except the last sentence. So, the RG chairs have determined **to remove all**
 29 **the edits in the second paragraph except the last sentence.**

30
 31 **Open issue #2 on HARQ and ARQ interactions:** The last sentence needs to be finalized. There are two
 32 proposals:

33 Option 1: The ARQ entity in the transmitter can then initiate retransmission and re-segmentation of the
 34 **appropriate** ARQ blocks.

35
 36 Option 2: The ARQ entity in the transmitter can then initiate retransmission and re-segmentation of the ARQ
 37 blocks **in the failed HARQ burst.**

38
 39 Perhaps the proponents could explain to the RG what their interpretation is, i.e what is the problem that they see
 40 with adopting one sentence over the other.

41
 42 The third paragraph in Section on “HARQ And ARQ interactions” in the 2nd draft was as follows:

43
 44 Detection and fast recovery mechanism of HARQ NAK to ACK error is FFS.

45
 46 In document C80216m-UMAC-08_030r1.doc, it is suggested to remove the third paragraph and rationale has
 47 been provided on why this deserved to be removed. However, C80216m-UMAC-08_029.doc suggests
 48 mechanisms for NAK to ACK error detection and recovery.

1
2 As there is no consensus on changing this paragraph, **the original text of the second draft (001r2) is retained.**

3
4 **Open issue #3 on HARQ and ARQ interactions:** Whether or not NAK-to-ACK error detection and recovery
5 mechanisms are needed:

6
7 Option 1: No mechanisms are needed. Remove 3rd paragraph in this draft. (See document C80216m-UMAC-
8 08_030r1.doc for reasons)

9 Option 2: Adopt the text proposed in C80216m-UMAC-08_029.doc.

10
11 There are suggestions in C80216m-UMAC-08_029.doc to add “Remote NACK” – i.e. a concept similar to
12 Local NAK in the transmitter, be adopted for the receiver. However, C80216m-UMAC-08_030r1.doc counters
13 the adoption of this proposal of Remote NAK (previously referred to in the 001 and 001r2 as Local NAK at the
14 receiver side). Rationale and performance results are provided in the document as to why it should not be
15 adopted. As there is no consensus on this topic, it is not included in the proposed SDD text..

16
17 **Open issue #4 on HARQ and ARQ interactions:** Whether or not “Remote NAK” (previously referred to as
18 Local NAK in the receiver side) should be included.

19 Option 1: Remote NAK should not be included. (See document C80216m-UMAC-08_030r1.doc for reasons)

20 Option 2: Adopt the text proposed in C80216m-UMAC-08_030r1.doc (The proponents of this feature (Remote
21 NAK) are urged to come up with some data (e.g. impact on performance) that supports inclusion of this feature.

22
23 As a last topic on HARQ and ARQ interaction is the topic of Local ACK in the transmitter and receiver side.
24 There is no consensus on this topic either.

25 **Open issue #5 on HARQ and ARQ interactions:** Whether or not Local ACK in the transmitter and receiver
26 should be included in the SDD

27 Option 1: No. There is no need to include Local ACK anywhere. (See document C80216m-UMAC-
28 08_030r1.doc for reasons)

29 Option 2: Yes. Adopt the text proposed in C80216m-UMAC-08_029.doc for Local ACK.

30
31
32 Comments are invited from the membership on all of the open issues mentioned above. During the F2F meeting
33 in Dallas, we will discuss these open issues. If anyone feels that something else should be added to agenda, then
34 please let that be known.

4 SDD Text Proposal

===== *Start of Proposed Text* =====

10. Medium Access Control Sub-Layer

10.2.3 HARQ and ARQ Interactions

When both ARQ and HARQ are applied for a flow, HARQ and ARQ interactions described here ~~may be~~ is applied to the corresponding flow.

If the HARQ entity in the transmitter determines that the HARQ process was terminated with an unsuccessful outcome, the HARQ entity in the transmitter informs the ARQ entity in the transmitter about the failure of the HARQ burst. The ARQ entity in the transmitter can then initiate retransmission and re-segmentation of the appropriate ARQ blocks.

If the HARQ entity in the receiver determines that the HARQ process was terminated with an unsuccessful outcome, the HARQ entity in the receiver informs the ARQ entity in the receiver about the failure of the HARQ process. The ARQ entity in the receiver can then undertake to inform the corresponding ARQ entity in the transmitter of the HARQ process failure. ARQ entity in the receiver can wait for a predetermined time before sending MAC signaling to the ARQ entity in the transmitter. The ARQ entity in the transmitter can then initiate retransmission and re-segmentation of the appropriate ARQ blocks.

10.2.3.1 Local NACK between HARQ and ARQ

A local NACK is sent to the ARQ process in the event that the HARQ process was terminated with an unsuccessful outcome.

10.2.3.2 Local ACK between HARQ and ARQ

A local ACK is sent to the ARQ process in the event that the HARQ process was terminated with a successful outcome.

10.2.3.3 NACK to ACK Errors

To mitigate for NACK to ACK errors, the ARQ transmitter delays the purging of ARQ blocks acknowledged by the local ACK indication. This allows the receiver time to detect the error and take the appropriate action to correct it. The receiver, upon detection of a NACK-to-ACK error event, sends a MAC signalling message to the transmitter. The MAC signalling message identifies the specific HARQ process which incurred the NACK-to-ACK error, e.g. frame/subframe number and HARQ process ID. If the transmitter does not receive a MAC NACK-to-ACK error indication before a predetermined time, it purges the ARQ blocks acknowledged by the local ACK indication.

1 **10.2.3.4 ACK to NACK Errors**

2
3 Recovery from ACK to NACK errors is achieved via duplicate ARQ block detection. Duplicated ARQ blocks
4 are discarded.

5 **10.x ARQ**

6
7 An ARQ block is generated from one or multiple MAC SDU(s) or MAC SDU fragment(s). ARQ blocks can be
8 variable in size. ARQ blocks are sequentially numbered. The location of this sequence number in the MAC
9 PDU is FFS.

10
11 Retransmission of a failed ARQ block can be performed with or without rearrangement.

12
13 As described in section 10.2.3, a NACK based ARQ protocol is used in conjunction with the local NACK/ACK
14 indication from the HARQ entity to the ARQ entity

15
16 ===== *End of Proposed Text* =====
17