ARQ support for Primary Management connection

IEEE 802.16 Presentation Submission Template (Rev. 9)

Document Number:

IEEE S802.16maint-08/220

Date Submitted:

2008-05-13

Source:

David Comstock E-mail: dcomstock@huawei.com
Jin Lei jinlei60020191@huawei.com
Liu Juejun juejunliu@huawei.com
Huawei Technologies
*<http://standards.ieee.org/faqs/affiliationFAQ.html>

Venue:

IEEE 802.16-08/018, "IEEE 802.16 Working Group Letter Ballot Recirc #26c: Announcement"

Base Contribution:

IEEE C802.16maint-08/220

Purpose:

Review and discuss in support for the adoption of the proposal contained in C80216maint-08/220

Notice:

Release:

Patent Policy:

ARQ support for Primary Management connection

Contents

ARQ support for Primary Management connection

Summary

- MAC layer fragmentation supported for:
  - Basic, primary, secondary management connections
  - Transport connections.
- MAC layer ARQ (retransmissions of fragments) is supported for:
  - Secondary management connection
  - Transport connections
- ARQ is not supported for primary management connections
  - Transmission failure recover only by full message retransmission

ARQ support for Primary Management connection

Summary (cont.)

- In poor radio conditions, such as at the cell edge, multiple factors contribute to an increase in latency
  - More messages will be fragmented due to low modulation order
    - *Message transmission is spread over multiple frames*
  - Transmission errors cause retransmissions of entire MAC messages
  - MAC message retransmission is timer-based
    - *Retransmissions are not triggered at the time of a transmission failure*
    - *Retransmissions triggered after a timer has expired and a response to the message has not been received*
  - If ARQ were supported for primary management connection:
    - *Retransmissions would be triggered at the time of a transmission failure*
    - *Only those blocks of data that fail would be retransmitted*
  - This is particularly relevant for network entry, which often occurs at the cell edge and is time critical
- Avoid using ARQ for every management message
  - ARQ costs overhead for
  - Use ARQ only for fragmented SDUs

Proposal: Add support for ARQ for the primary management connection

ARQ support for Primary Management connection

Fragmentation conditions example

- Assumptions for MS uplink transmissions near cell edge:
  - DL:UL split of 23:24
  - MS limited to no better than QPSK, rate ½ coding
  - The MS is not able to transmit 2 UL subchannels concurrently
  - Allocation sizes would then be limited to 384 bits
  - Each fragment contains a GMH, FSH, 32-bit CRC
- 288 bits are available for payload
- Messages larger than 288 bits would be fragmented

ARQ support for Primary Management connection

Case in point

- Authentication and key exchange during network entry
  - The PKM-REQ/RSP messages are used to encapsulate messages from multiple authentication protocols
  - For device certification, an X.509 certificate is used.
    - *For PKMv1 an X.509 certificate may be sent in the Auth Request message*
    - *For PKMv2, an X.509 certificate may be sent in an EAP Response*
  - The X.509 device certificate is around 1000 bytes
    - *Usually a "certificate chain" will be transmitted*
    - *Includes multiple certificates so the network can trace the MS's authorization to its root certification authority*
  - EAP-TLS supports fragmentation but NWG has set the MTU for EAP-TLS to be 1400 bytes
  - Messages carrying this certificate will be split into multiple fragments, particularly when transmitted near the cell edge

ARQ support for Primary Management connection

Case in point (cont.)

- Retransmission of PKM messages is dependent on the protocol being encapsulating
  - EAP is required by NWG for device authentication using X.509 certificate
  - EAP supports message retransmission but the EAP specification recommends to avoid it, if possible
    - EAP is a "lockstep" protocol
      - *Only one message may be outstanding at any time*
      - *This means a Response to a Request message must be received before a new Request may be sent*
      - *It is inefficient when a message is fragmented above EAP (EAP-TLS)*
    - Receiver must send Response to all retransmitted Requests
      - *If receiver sends a Response but the transmitter's Request timer expires before the transmitter receives it*
      - *Transmitter will retransmit the Request*
      - *The receiver must send a Response to this retransmitted Request also*
- Without ARQ, latency for the authentication and key exchange phase of network entry will be significantly increased

ARQ support for Primary Management connection

HARQ considerations

- HARQ is supported for the primary management connection
- Use ARQ in conjunction with HARQ.

Overview

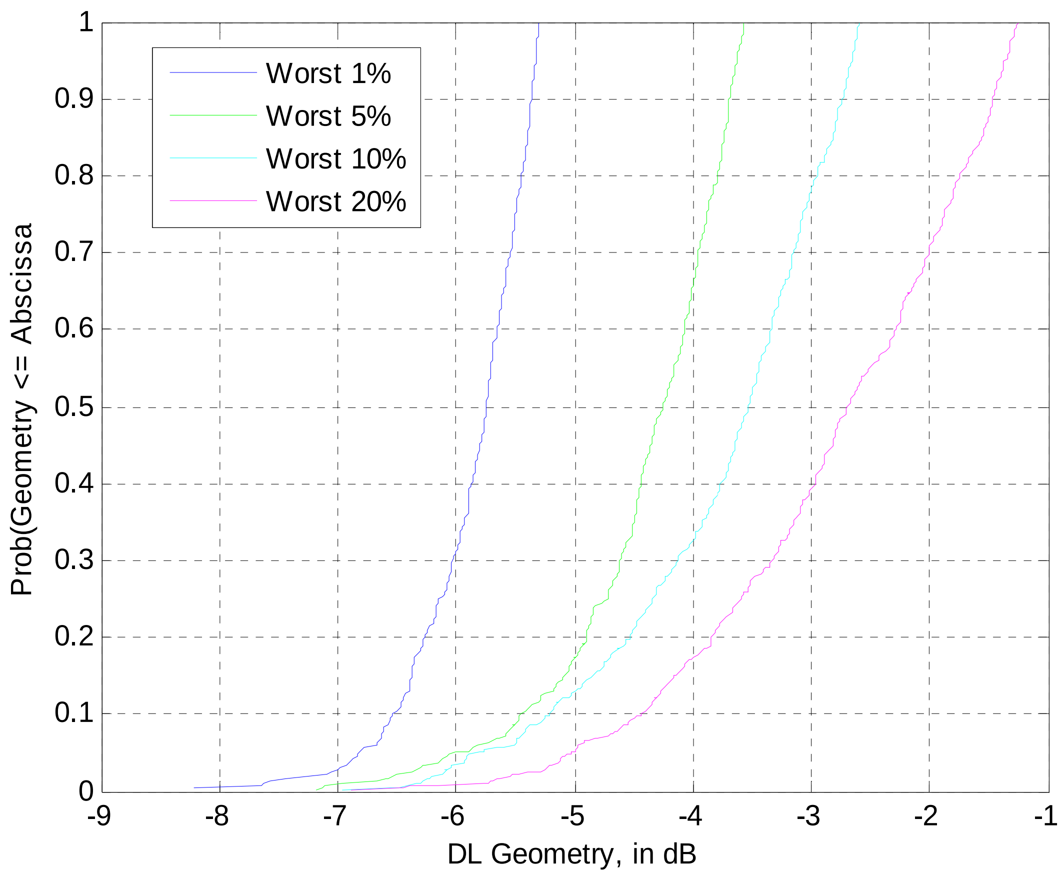
- In order to examine the performance of PKM message delivery with HARQ for cell-edge mobiles, system-level simulations were performed
- The obtained results are:
  - Users in the worst radio conditions (worst 1%)
    - 10% of the time can't deliver a 3000 byte message over the air in less than 3 seconds.
  - Users in worst 5% radio conditions
    - 10% of the time can't deliver a 3000 byte message over the air in less than 1.5 seconds
  - Users in worst 10 and 20% radio conditions,
    - 10% of the time can't deliver a 3000 byte message over the air in less than 750 msecs.

Simulation results

- Figure 1 shows the resulting geometry distributions for each of the four simulations
- Figure 2 shows:
  - Users in the worst radio conditions (worst 1%)
    - 10% of the time can't deliver a 3000 byte message over the air in less than 3 seconds.
  - Users in worst 5% radio conditions
    - 10% of the time can't deliver a 3000 byte message over the air in less than 1.2 seconds
  - Users in worst 10 and 20% radio conditions,
    - 10% of the time can't deliver a 3000 byte message over the air in less than 750 msecs.
- Figure 3 shows the statistics for the number of fragments required for PKM message delivery

Simulation results

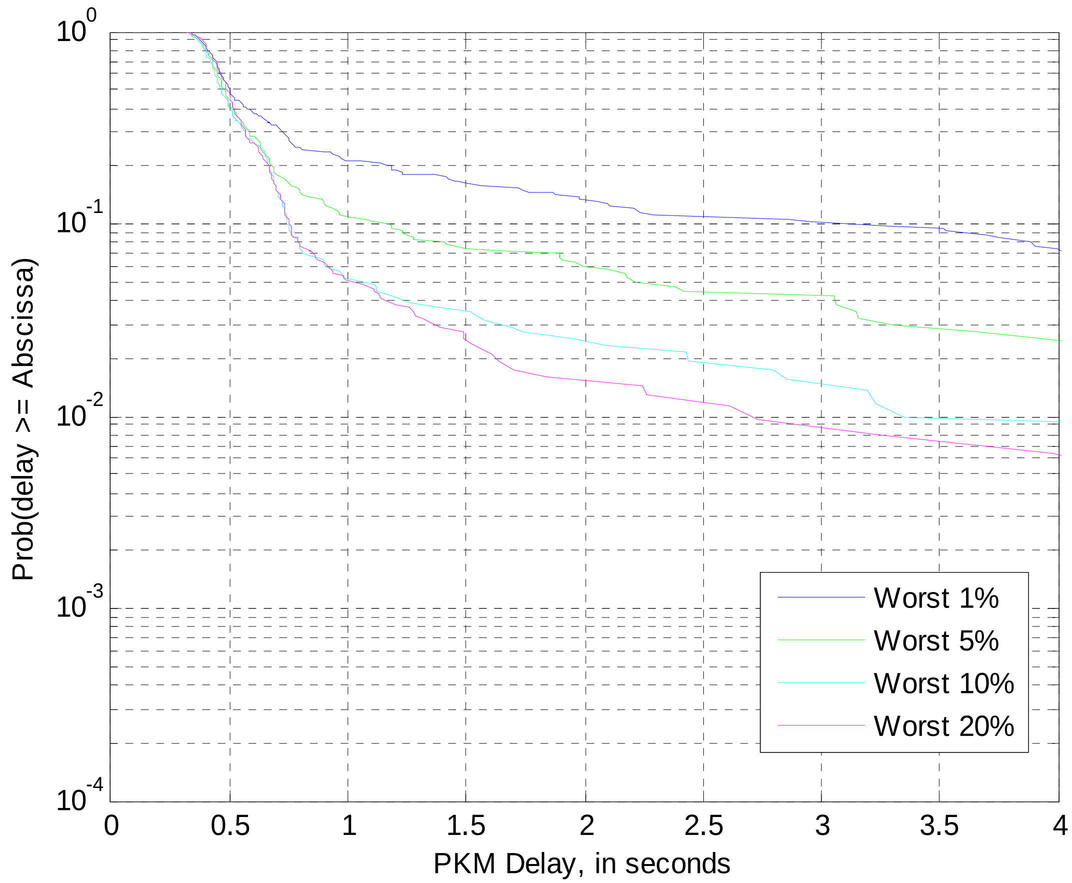
Figure 1: Resulting geometry distributions for each of the four simulations



Worst 1%: -5.3 dB threshold
Worst 5%: -3.563 dB threshold
Worst 10%: -2.589 dB threshold
Worst 20%: -1.24 dB threshold

Simulation results

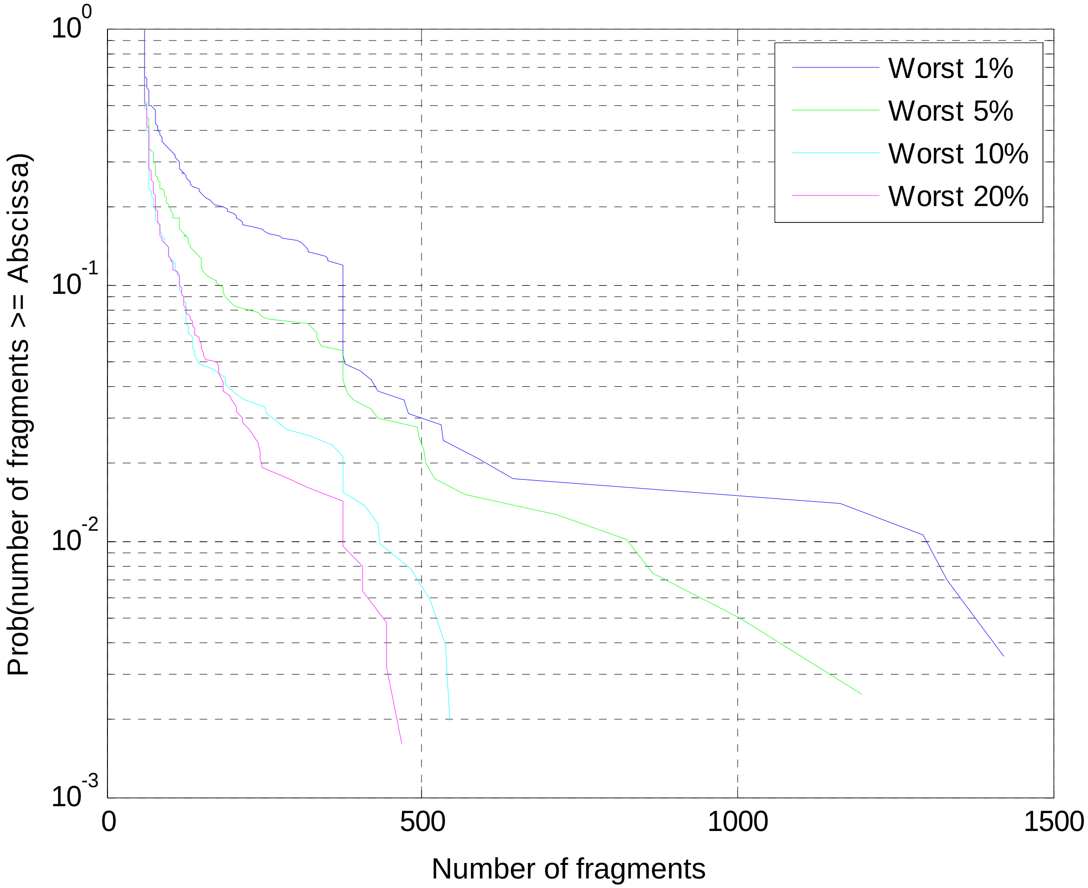
Figure 2: Time required for a PKM packet to be delivered measured in seconds



Worst 1%: -5.3 dB threshold
Worst 5%: -3.563 dB threshold
Worst 10%: -2.589 dB threshold
Worst 20%: -1.24 dB threshold

Simulation results

Figure 3: Number of fragments for delivery of PKM message



Worst 1%: -5.3 dB threshold
Worst 5%: -3.563 dB threshold
Worst 10%: -2.589 dB threshold
Worst 20%: -1.24 dB threshold

ARQ support for Primary Management connection

Limiting use of ARQ

- In 802.16e, if ARQ is enabled for a connection:
  - It is used for every SDU on the connection
  - The fragmentation subheader is added even if the SDU is not fragmented
    - *Includes an 11-bit sequence number*
  - The blocks of every message would require acknowledgement

- It is best to limit the use of ARQ to avoid unnecessary overhead

ARQ support for Primary Management connection

Limiting the scope of ARQ (cont.)

- In order to detect lost blocks, the BSN must be sequential
- It is proposed that:
  - ARQ is used only when a MAC management SDU is fragmented
  - BSNs are only assigned to the blocks of SDUs that use a fragmentation/packing header
  - If the fragmentation/packing header is not included in a MPDU:
    - *The receiver knows that ARQ is not used for the SDU*
  - If the fragmentation/packing header is included but the fragmentation state=00 (no fragmentation):
    - *The receiver knows that ARQ is not used for this SDU*
    - *However, in this case, BSNs are assigned to the blocks of the SDU*
    - *Only the blocks associated with ARQ (fragmented SDUs) are ack/nacked.*

ARQ support for Primary Management connection

Limiting the scope of ARQ (cont.)

- In order to detect lost blocks, the BSN must be sequential
- It is proposed that:
  - ARQ is used only when a MAC management SDU is fragmented
  - BSNs are only assigned to the blocks of SDUs that use a fragmentation/packing header
  - If the fragmentation/packing header is not included in a MPDU:
    - *The receiver knows that ARQ is not used for the SDU*
  - If the fragmentation/packing header is included but the fragmentation state=00 (no fragmentation):
    - *The receiver knows that ARQ is not used for this SDU*
    - *However, in this case, BSNs are assigned to the blocks of the SDU*
    - *Only the blocks associated with ARQ (fragmented SDUs) are ack/nacked*

ARQ support for Primary Management connection

- Alternatively, ARQ for all primary management connection SDUs may be enabled using a new TLV:
  - If *ARQ_ALL_PMC_SDUS* is set to ‘1’:
    - Behavior is the same as for transport connections
    - Blocks of all SDUs are assigned a BSN and the fragmentation or packing header is used for all PDUs

- Backup slides for simulations

Simulation Assumptions

- The simulation assumptions are based on the 802.16m Evaluation Methodology Document (IEEE 80216m-07_037r2). The primary simulation assumptions are summarized in Tables 2-5.

Table 2. System-Level Simulation Layout Assumptions

Layout Model	
Network Topology:	**19cell, 3sectors/cell, wraparound**
BS-BS Distance:	**1.5 km**
Center Frequency:	**2.5 GHz**
Channel Bandwidth:	**10 MHz**
Frequency Reuse:	**1**

Simulation Assumptions

Table 3. System-Level Simulation BS & MS Assumptions

Base Station Model	
Max TX Power Per Sector:	**46 dBm**
BS Height:	**32 m**
Sector Antenna Pattern:	**3 dB beamwidth of 70º; 20 dB F/B Ratio**
Sector Gain:	**17 dBi**
Cable Loss:	**2 dB**
Penetration Loss:	**10 dB**
Number of RX Antennas:	**2**
MS Model	
MS Height:	**1.5 m**
MS Noise Figure:	**7 dB**
MS Antenna Pattern:	**Omni-directional**
MS Antenna Gain:	**0 dBi**
Number of MS TX antennas:	**1**

Simulation Assumptions

Table 4. System-Level Simulation Propagation Assumptions

Propagation Model	
Pathloss Model:	**Loss (dB) = 130.62+37.6*log10(R, km)**
Lognormal Shadow Fading:	**μ=0 dB, σ=8 dB**
Shadow Fading Correlation:	**100% inter-sector, 50% inter-BS, 50 m corr. distance**
Channel Model:	**Modified ITU Ped B, 3 km/hr (60% of users)** **Modified ITU Ped A, 30 km/hr (30% of users)** **Modified ITU Ped A, 120 km/hr (10% of users)**
Temporal Correlation:	**Jakes Spectrum**
Spatial Correlation:	**Correlated antennas at BS (4λ spacing, 3^{o} AS)**

Simulation Assumptions

Table 5. System-Level Simulation Propagation Assumptions

PHY Assumptions	
Frame Duration:	**5 ms**
UL Permutation:	**PUSC, reuse 1**
# of Symbols in UL subframe:	**24 (first 3 reserved for control signaling)**
UL Transmission Scheme:	**1x2 MRC**
PHY Abstraction:	**RBIR**
Channel Estimation:	**Modeled**
HARQ Type:	**Chase Combining (Maximum of 4 TX)**
Primary System Load:	**UL VoIP (100 users/sector)**

Simulation Methodology

- The general simulation methodology was as follows:
  1. Randomly drop 100 users/sector throughout the network and establish UL traffic connections for conducting UL VoIP traffic.
  2. Generate 1 user/cell at 1%, 5%, 10%, 20% worst cell geometry and establish UL primary connections for conducting PKM message delivery.
     - In simulation 1, each test mobile (i.e. PKM message mobile) was re-dropped if their geometry not worse than or equal to the 1% worst cell geometry.
     - In simulation 2, each test mobile (i.e. PKM message mobile) was re-dropped if their geometry not worse than or equal to the 5% worst cell geometry.
     - In simulation 3, each test mobile (i.e. PKM message mobile) was re-dropped if their geometry not worse than or equal to the 10% worst cell geometry.
     - In simulation 4, each test mobile (i.e. PKM message mobile) was re-dropped if their geometry not worse than or equal to the 20% worst cell geometry.
  3. At time t=0 seconds, begin UL VoIP traffic. Allow to warm-up until time t=2 seconds.
  4. At t=2 seconds, a PKM packet is queued for each PKM mobile. The PKM packet size is 3000 bytes.
     - PKM message size determined by 1000 byte X.509 certificate size and includes the certificate chain

Simulation Methodology (continued)

5. Once the PKM packet is queued, the scheduler begins making allocations for its delivery using the following methodology:
    1. Priority is given to UL VoIP traffic. The UL VoIP traffic is allowed to consume all bandwidth at peak demand times.
    2. PKM messages are given secondary priority. The scheduler will make allocations for PKM message delivery only if bandwidth is available to make the allocation.
    3. PKM transmissions are performed using UL open-loop power control.
    4. PKM allocations are scheduled based on the UL available bandwidth, the UL noise+interference measurement, and the estimated average UL propagation loss

Simulation Methodology (continued)

5. The scheduler assumed the following values when making allocations for the PKM messages:
    1. An UL receive antenna gain of 3 dB due to the 2 transmit antennas and MRC
    2. A 3 dB mobile station boost above and beyond the UL open-loop power control table
        - This is the *"Relative Power Offset for UL Burst Containing MAC Management Message".*
    3. A HARQ gain of 6 dB.
        - This is the *"Relative Power Offset For UL HARQ burst"*
6. Because of the associated MAC overhead (48 bits for GMH, 16 bits for FSH, 16 bits for CRC), the minimum allowable allocations was for an Nep of size 96 bits.
7. Delay caused by errors in the downlink, such as DL Ack/Nack errors was not considered
8. Once all PKM messages had been delivered, the statistics related to the PKM messages were appended to an output file, and the simulation trial was repeated for a new set of VoIP/PKM mobiles beginning with step 1 described previously.