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| Re: | IEEE 802.16j-07/019: "Call for Technical Comments Regarding IEEE Project 802.16j" |
| Abstract | This contribution proposes a forwarding path performance measurement and reporting method. |
| Purpose | To incorporate the proposed text into the P802.16j Baseline Document (IEEE 802.16j-06/026r4) |
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# Forwarding Performance Measurement

*Hang Zhang, Peiying Zhu, Mo-Han Fong, Wen Tong, David Steer, Gamini Senarath, G.Q. Wang,*
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## 1. Introduction

In 802.16j system, in order to optimize the system performance, some data forwarding performance measurement and report shall be performed. Such performances as DL/UL forwarding path delay or throughput for a particular QoS class service or for aggregated flows will enable the followings:

- RS_Zone adjustment by MR-BS or a parent RS
- Path connectivity check
- Source QoS control
- etc

This contribution proposes a forwarding path performance measurement and reporting method.

## 2. Proposal

The forwarding path performance log needs the participation of each of RSs in a path.
The performance logged includes

- forwarding path delay of a particular service flow or a QoS class
- Forwarding path throughput of a particular service or a QoS class
- Data buffer depth of a particular service flow or a QoS class
- etc

The forward path performance measurement procedure includes three processes:

- Measurement trigger
  - For DL, MR-BS sends DL Path performance log request MAC header (refer to contribution "DL MAC control header") downstream along the path of interest to trigger the per-hop performance measurement by RSs in path. This request header explicitly indicates the destination RS identification, type of log and measurement interval
  - For UL, the access RS sends a UL Path performance log request header upstream to trigger per-hop performance log by RSs in the path. This request header explicitly indicates the source RS identification, type of log and measurement interval
- Performance log
  - In DL, each RS in a path which receives a DL path performance log request shall start to record the time interval between the time where a R-MAC PDU (or entire SUD if the SDU is encapsulated in more than on R-MAC PDU) of a particular service flow or QoS class is received (Rx_frame#_RS) and the time when the entire SDU is received by its next hop RS or MS (for an access RS) (Rx_frame#_nexthopRS). For a HARQ enabled QoS class or a service flow, an RS can obtain Rx_frame#_nexthopRS by HARQ ACK/NAK; for a non-HARQ enabled QoS class or service flow, Rx_frame#_nexthopRS is determined by its transmission frame # of the SDU (or the last fragment of the SDU).
    - The per-hop delay of $i$-th hop is denoted as $D\_Hi$ and is measured as
      Rx_fram#_nexthopRS - Rx_frame#

- The per-hop throughput of $i$-th hop is denoted as $T\_Hi$ and is measured as SDU length / $D\_Hi$
- If the above estimations are based on continuous measurement, the log results are a average results
  - o In UL, each RS in a path which receives a UL path performance log request shall start to record the time interval between
    - the time where a R-MAC PDU (or entire SUD encapsulated in more than one R-MAC PDU) of a particular service flow or QoS class is received (Rx_frame#) and
  - o The time when the entire SDU is received by the next hop RS or MS (for an access RS) (Rx_frame#_nexthopRS). For a HARQ enabled QoS class or a service flow, an RS can obtain Rx_frame#_nexthopRS by HARQ ACK/NAK; for a non-HARQ enabled QoS class or service flow, Rx_frame#_nexthopRS is determined by its transmission frame # of the SDU (or the last fragment of the SDU).
    - The per-hop delay of $i$-th hop is denoted as $D\_Hi$ and is measured as Rx_fram#_nexthopRS - Rx_frame#
    - The per-hop throughput of $i$-th hop is denoted as $T\_Hi$ and is measured as SDU length / $D\_Hi$
    - If the above estimations are based on continuous measurement, the log results are a average results
- Performance log report
  - o For DL log, a DL path performance response header can encapsulate measurement results from up to three hops. Such a header is created by the destination RS and may by a third-tier RS (if the number of hops is larger than 3) with its log result included. When this header is relayed upstream to MR-BS, each of RSs in the path (other than the RS which creates such a header) shall add its log result.
  - o For UL log, a UL path performance response header can encapsulate measurement results from up to three hops. Such a header is created by MR-BS and may also by a third-tier RS (if the number of hops is larger than 3) with its log result included. When this header is relayed downstream to the requesting RS, each of RSs in the path (other than the RS which creates such a header) shall add its log result.

After the DL performance measurement procedures, MR-BS and each RS will obtain the performance knowledge of each hop downstream on a path for a particular QoS class. After the UL performance measurement procedure, an access RS and each of RSs in the path will obtain the knowledge of each hop upstream for a particular QoS class.

Figure 1 illustrates the DL path performance measurement log and report procedure.
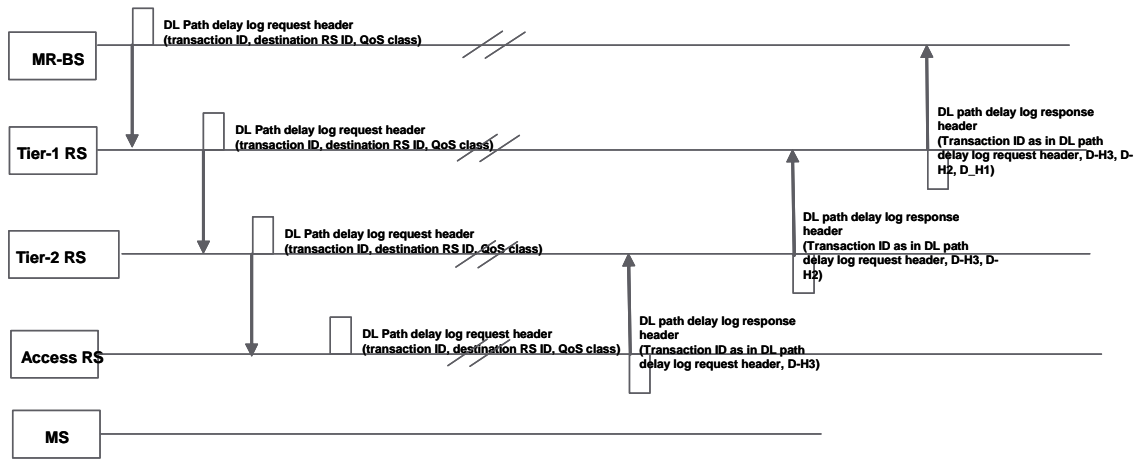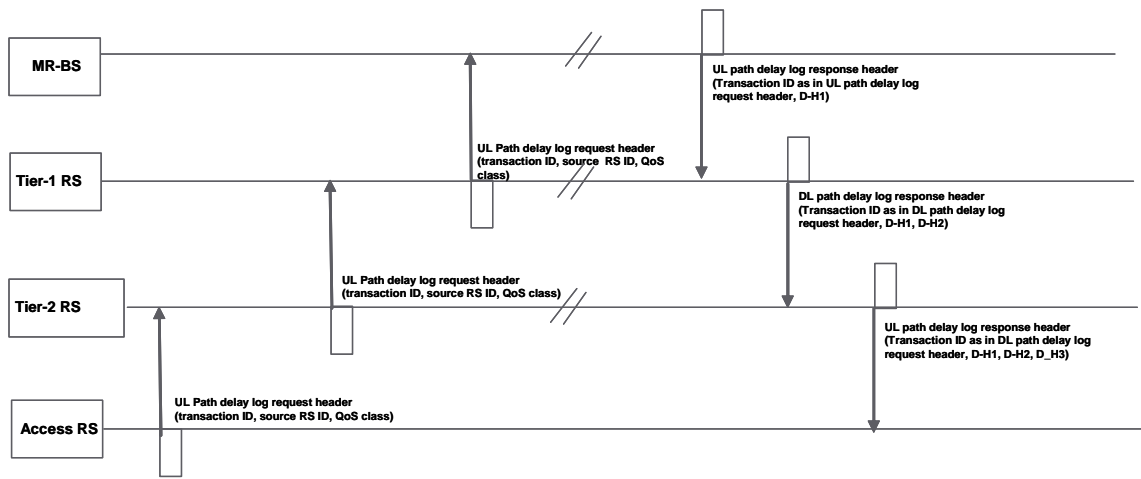
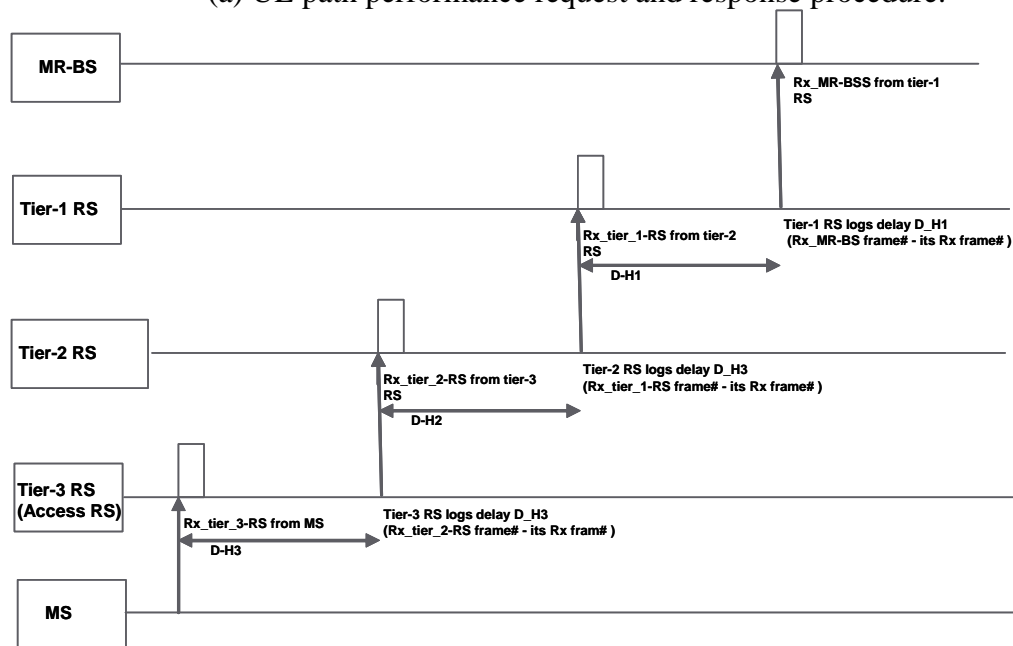(a) DL path performance measurement request and response.
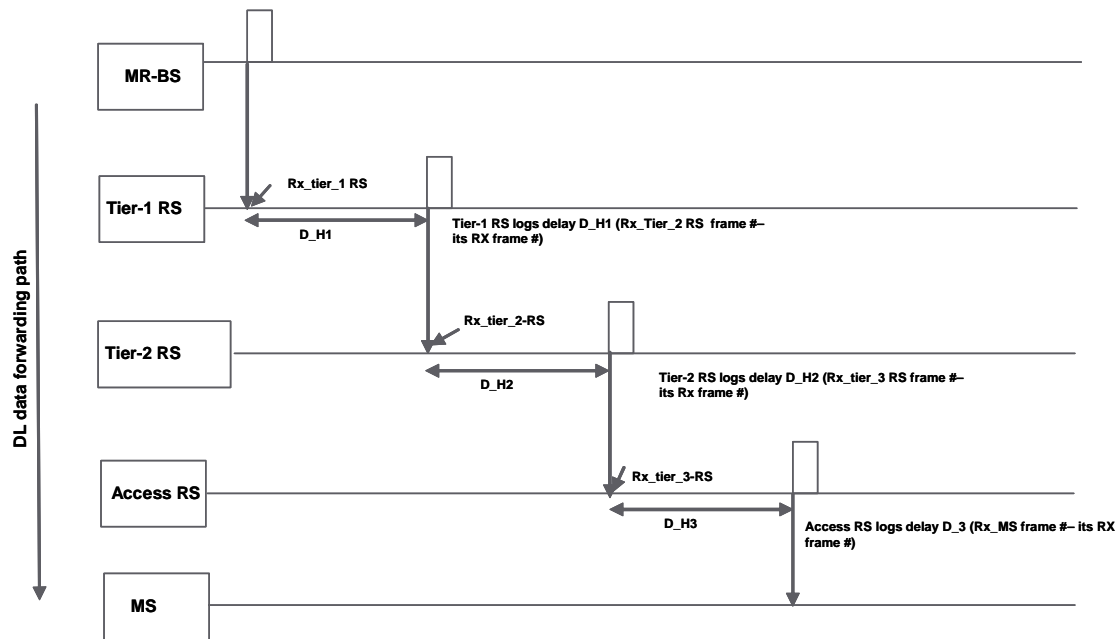


(b) Illustration of DL path erformance measurement by RSs.

Figure 1. DL path performance log.

Figure 2 illustrates the UL path performance measurement log and report procedure.

(a) UL path performance request and response procedure.



(b) Illustration of UL path performance measurement by RSs and MR-BS.

Figure 2. UL path performance log.

To enable the above DL performance log, DL Path performance log request MAC header and DL Path performance log response MAC header are proposed. To enable the UL Path performance log, UL Path performance request MAC header and UL Path performance log response MAC header are proposed.

## 3. Proposed text change

+++++++++++++++++++++ Start Text ++++++++++++++++++++++++++++++++++++++++
3.1 Path performance measurement description

*[Add a new section 6.3.14.12 ]*

6.3.14.12 Forwarding performance measurement for QoS control

5

The forwarding path performance log needs the participation of each of RSs in a path.
The performance logged includes

- forwarding path delay of a particular service flow or a QoS class
- Forwarding path throughput of a particular service or a QoS class
- Data buffer depth of a particular service flow or a QoS class
- etc

The forward path performance measurement procedure includes three processes:

- Measurement trigger
  - For DL, MR-BS sends DL Path performance log request MAC header (refer to contribution "DL MAC control header") downstream along the path of interest to trigger the per-hop performance measurement by RSs in path. This request header explicitly indicates the destination RS identification, type of log and measurement interval
  - For UL, the access RS sends a UL Path performance log request header upstream to trigger per-hop performance log by RSs in the path. This request header explicitly indicates the source RS identification, type of log and measurement interval
- Performance log
  - In DL, each RS in a path which receives a DL path performance log request shall start to record the time interval between the time where a R-MAC PDU (or entire SUD if the SDU is encapsulated in more than on R-MAC PDU) of a particular service flow or QoS class is received (Rx_frame#_RS) and the time when the entire SDU is received by its next hop RS or MS (for an access RS) (Rx_frame#_nexthopRS). For a HARQ enabled QoS class or a service flow, an RS can obtain Rx_frame#_nexthopRS by HARQ ACK/NAK; for a non-HARQ enabled QoS class or service flow, Rx_frame#_nexthopRS is determined by its transmission frame # of the SDU (or the last fragment of the SDU).
    - The per-hop delay of $i$-th hop is denoted as $D\_Hi$ and is measured as Rx_fram#_nexthopRS - Rx_frame#
    - The per-hop throughput of $i$-th hop is denoted as $T\_Hi$ and is measured as SDU length / $D\_Hi$
    - If the above estimations are based on continuous measurement, the log results are a average results
  - In UL, each RS in a path which receives a UL path performance log request shall start to record the time interval between
    - the time where a R-MAC PDU (or entire SUD encapsulated in more than one R-MAC PDU) of a particular service flow or QoS class is received (Rx_frame#) and
  - The time when the entire SDU is received by the next hop RS or MS (for an access RS) (Rx_frame#_nexthopRS). For a HARQ enabled QoS class or a service flow, an RS can obtain Rx_frame#_nexthopRS by HARQ ACK/NAK; for a non-HARQ enabled QoS class or service flow, Rx_frame#_nexthopRS is determined by its transmission frame # of the SDU (or the last fragment of the SDU).
    - The per-hop delay of $i$-th hop is denoted as $D\_Hi$ and is measured as Rx_fram#_nexthopRS - Rx_frame#
    - The per-hop throughput of $i$-th hop is denoted as $T\_Hi$ and is measured as SDU length / $D\_Hi$
    - If the above estimations are based on continuous measurement, the log results are a average results
- Performance log report

o For DL log, a DL path performance response header can encapsulate measurement results from up to three hops. Such a header is created by the destination RS and may by a third-tier RS (if the number of hops is larger than 3) with its log result included. When this header is relayed upstream to MR-BS, each of RSs in the path (other than the RS which creates such a header) shall add its log result.

o For UL log, a UL path performance response header can encapsulate measurement results from up to three hops. Such a header is created by MR-BS and may also by a third-tier RS (if the number of hops is larger than 3) with its log result included. When this header is relayed downstream to the requesting RS, each of RSs in the path (other than the RS which creates such a header) shall add its log result.

After the DL performance measurement procedures, MR-BS and each RS will obtain the performance knowledge of each hop downstream on a path for a particular QoS class. After the UL performance measurement procedure, an access RS and each of RSs in the path will obtain the knowledge of each hop upstream for a particular QoS class.

3.2. DL control headers design supporting path performance log

*[Add the following section 6.3.2.1.3.1]*

6.3.2.1.3.1 DL path perfromacne log request header format.

This header is used by MR-BS to trigger a DL path performance measurement. The format of this MAC header is shown in FigureXXX.

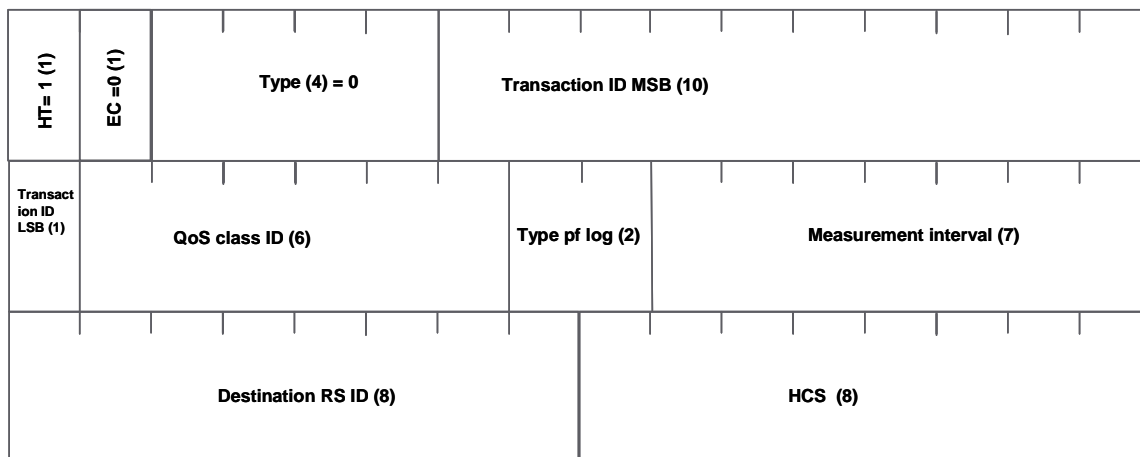| HT= 1 (1) | EC =0 (1) | Type (4) = 0 | Transaction ID MSB (10) | | |
|---|---|---|---|---|---|
| Transaction ID LSB (1) | | QoS class ID (6) | Type pf log (2) | Measurement interval (7) | |
| Destination RS ID (8) | | | HCS (8) | | |

Figure XXX. DL performance log request MAC control header format.

Table XXX shows the DL performance log request MAC header field encodings.

Table xxx. DL MAC control header field encoding.

| Name | Length (bits) | Description |
|---|---|---|
| HT | 1 | Header type. Should be set to 1 |
| EC | 1 | Encryption control. Shall be set to 0 |

| Type | 4 | 0: DL path performance log request |
|---|---|---|
| Transaction ID | 11 | Uniquely identifies a log request created by MR-BS |
| QoS class | 6 | Indication of QoS class need to be logged |
| Type of log | 2 | 0: delay<br>1: throughput<br>2-3: reserved |
| Measurement interval | 7 | Measurement interval in unit of 4 frames. |
| Destination RS ID | 8 | Reduce destination RS CID |
| HCS | 8 | Header check sequence |

*[Add the following section 6.3.2.1.3.2]*

6.3.2.1.3.2 DL path performance log response header format.

This DL control header is used by MR-BS and RSs in responding to a UL performance request control header sent by an access RS for the purpose of UL path performance log of a particular QoS class.

The header format is shown in Figure XXX.
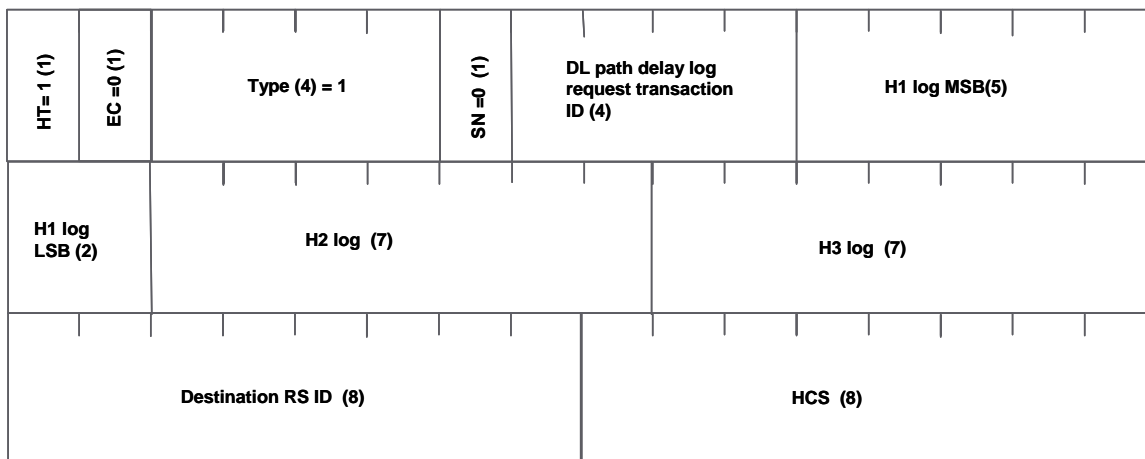
| HT= 1 (1) | EC =0 (1) | Type (4) = 1 | SN =0 (1) | DL path delay log request transaction ID (4) | H1 log MSB(5) |
|---|---|---|---|---|---|
| H1 log LSB (2) | | H2 log (7) | | H3 log (7) | |
| Destination RS ID (8) | | | | HCS (8) | |

The Table XXX shows the UL path performance log response MAC control header field encodings.

Table XXX. Path performance log response MAC control header field encodings.

| Name | Length (bits) | Description |
|---|---|---|
| HT | 1 | Header type. Should be set to 1 |
| EC | 1 | Encryption control. Shall be set to 0 |
| Type | 4 | 1: UL path performance log response |
| Transaction ID | 4 | The same transaction ID as in the request header to which this response header is responding |
| H1 log | 7 | Hop 1 perfromance report (by a RS one-hop away from MR-BS)<br>For delay report: in unit frame<br>For throughput report: in unit 4kb/s |

8

| | | |
|---|---|---|
| H2 log | 7 | Hop 2 performance report (by RS two-hop away from MR-BS)<br>For delay report: in unit frame<br>For throughput report: in unit 4kb/s |
| H3 log | 7 | Hop 3 performance report (by RS three-hop away from MR-BS)<br>For delay report: in unit frame<br>For throughput report: in unit 4kb/s |
| Destination RS ID | 8 | Reduce destination RS basic CID that is corresponding to the source RS ID in the UP path performance request header to which this header is responding |
| HCS | 8 | Header check sequence |

3.3 UL control header design to support path performance measurement

*[Pleas change the last line of Table 19a by as indicated]*

| | | | |
|---|---|---|---|
| 4 7 | ~~Reserved~~ DL path performance log response | | |
| 5 | UL path performance log request | | |
| 6-7 | Reserved | | |

*[Add the following section 6.3.2.1.2.2.2.5]*

6.3.2.1.2.2.2.5 DL path performance log response

This header is sent by an access RS and all intermediate RS (if any) to MR-BS as response to DL path performance request sent by MR-BS.

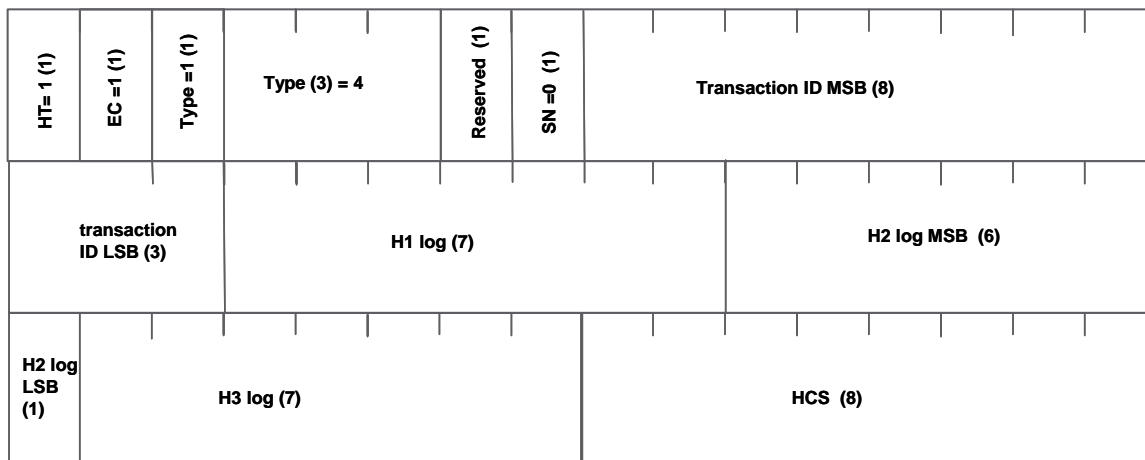The format of this control header is shown in Figure XXX.



Figure XXX. DL path performance log response MAC control header (SN = 0 case).

The Table XXX shows the UL path performance log response MAC control header field encodings.

Table xxx. DL MAC control header field encoding.

| Name | Length (bits) | Description |
|---|---|---|
| Type | 3 | Type = 4. UL path performance log response. |
| SN | 1 | 0: the first response header associated with an UL path performance log request. Used to carry hop 1,2,3 performance report (hop 1 is defined as hop from MR-BS)<br>1: the second response header associated with an UL path performance log request used for scenarion where the number of hops is larger than 3. Used to carry hop 4,5,6 performance report |
| Transaction ID | 4 | The same transaction ID as in the request header to which this response header is responding |
| H1 log | 7 | Hop 1 perfromance report (by a RS one-hop away from MR-BS)<br>For delay report: in unit frame<br>For throughput report: in unit 4kb/s |
| H2 log | 7 | Hop 2 performance report (by RS two-hop away from MR-BS)<br>For delay report: in unit frame<br>For throughput report: in unit 4kb/s |
| H3 log | 7 | Hop 3 performance report (by RS three-hop away from MR-BS)<br>For delay report: in unit frame<br>For throughput report: in unit 4kb/s |
| HCS | 8 | Header check sequence |

*[Add the following section 6.3.2.1.2.2.2.6]*

6.3.2.1.2.2.2.6 UL path performance log request

This header is sent by an access RS upstream for the purpose of path performance log of a particular QoS class. The format of this control header is shown in Figure XXX.

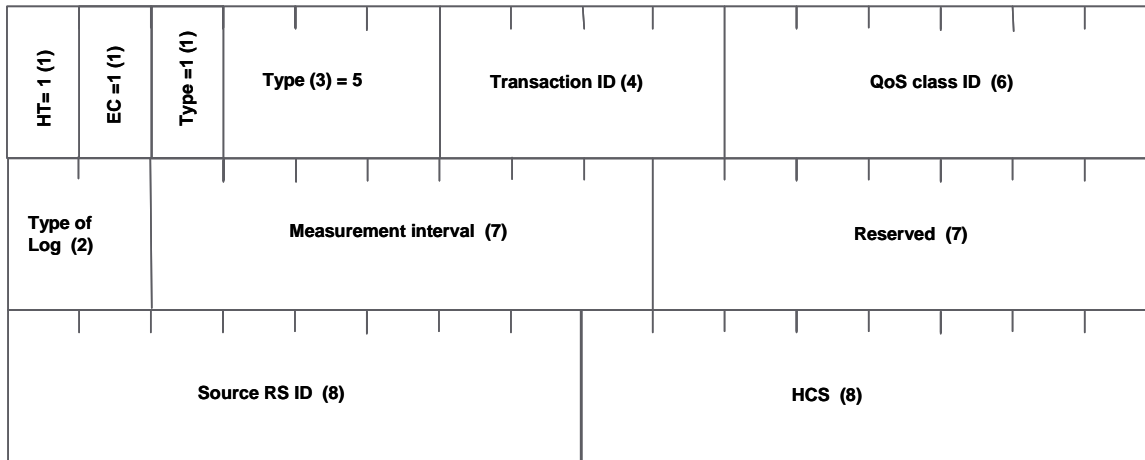| HT= 1 (1) | EC =1 (1) | Type =1 (1) | Type (3) = 5 | Transaction ID (4) | QoS class ID (6) |
|---|---|---|---|---|---|
| Type of Log (2) | | | Measurement interval (7) | | Reserved (7) |
| Source RS ID (8) | | | | HCS (8) | |

Figure XXX. Format of UL path performance log request MAC control header.

The encodings of the UL path performance log request MAC control header fields are shown in Table XXX.

Table XXX. UL path performance log request MAC control header fields encodings.

| Name | Length (bits) | Description |
|---|---|---|
| Type | 3 | Should be set to 5 |
| Transaction ID | 4 | Uniquely identifies a log request created by one access |
| QoS class | 6 | Indication of QoS class need to be logged |
| Type of log | 2 | 0: delay<br>1: throughput<br>2-3: reserved |
| Measurement interval | 7 | Measurement interval in unit of 4 frames. |
| Source RS ID | 8 | Reduce access RS basic CID |
| HCS | 8 | Header check sequence |

+++++++++++++++++++++ Start Text ++++++++++++++++++++++++++++++++++