IEEE P802.11  
Wireless LANs

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| CID3309 ESTTHROUGHPUT SAP enhancements | | | | |
| Date: 2014-08-03 | | | | |
| Author(s): | | | | |
| Name | Affiliation | Address | Phone | email |
| Matthew Fischer | Broadcom | 190 Mathilda Place, Sunnyvale, CA 94086 | +1 408 543 3370 | [mfischer@broadcom.com](mailto:mfischer@broadcom.com) |
| Michael Montemurro | BlackBerry | 4701 Tahoe Blvd., Mississauga, ON. CANADA L4W 0B4 | +1 905 261 4183 | mmontemurro@blackberry.com |
| Vinko Erceg | Broadcom |  |  |  |
| Florin Baboescu | Broadcom |  |  |  |
| Youhan Kim | Qualcomm |  |  |  |
| Srinivas Katar | Qualcomm |  |  |  |
| Oliver Wen | Qualcomm |  |  |  |
| Menzo Wentink | Qualcomm |  |  |  |
|  |  |  |  |  |

Abstract

This document proposes modifications to the ESTTHROUGHPUT SAPs introduced by the resolution of CID 3309 of LB202, specifically, to add an estimate parameter for an estimate of uplink throughput and to include an example algorithm for determining the estimated throughput values.

**REVISION NOTES:**

R0: initial

R1: RSSI IE + ESP IE

R2: ESP IE with RSSI field

R3: changed ave MSDU size values -1=not specified, 0=no MSDUs

Changed “bits per second” to “MSDU bits per second”

Changed uplink to outbound and downlink to inbound

Within 10.44a, in the outbound section, added that if RSSI at the recipient side is not available, that RSSI at the transmitting side is used

Changed AMSDU to A-MSDU, AMPDU to A-MPDU

Changed DATA to Data

Deleted the “name” column of the encoding table for the Data Format bits of the ESP IE

Added Clause 21 (DMG) to the RSSI field description

R4: Updated Equation V.7-aaa, and related parameters.

Replaced RTS Use with Estimated Air Time parameter in the ESP information field.

R5: fix the ESP information field format bit numbering and octet counts

Add CID 3488

Modify the editing instructions to allow replacement of subclauses because after various edits from multiple authors, the editing changes between the baseline text and the proposal were lost

Interpretation of a Motion to Adopt

A motion to approve this submission means that the editing instructions and any changed or added material are actioned in the TGmc Draft. This introduction is not part of the adopted material.

***Editing instructions formatted like this are intended to be copied into the TGmc Draft (i.e. they are instructions to the 802.11 editor on how to merge the text with the baseline documents).***

***TGmc Editor: Editing instructions preceded by “Instruction to Editor” are instructions to the TGmc editor to modify existing material in the TGmc draft. As a result of adopting the changes, the TGmc editor will execute the instructions rather than copy them to the TGmc Draft.***

**CID LIST:**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| 3309 | Matthew Fischer | 143.50 | 6.3 | Sometimes, it is an outside entity that needs to make a decision as to which BSS to choose for association. Those external entities would benefit by knowing the expected throughput of a possible association. Provide a hook for this information to be communicated through the MLME SAP. | Add a SAP called:  MLME-ESTTHROUGHPUT.request  with parameter list:  PeerSTAAddress  with a valid range of "Any valid MAC address" and a description of "Specifies the address of the peer MAC entity with which to estimate throughput."  Add a SAP called:  MLME-ESTTHROUGHPUT.confirm  with parameter list:  PeerSTAAddress  with a valid range of "Any valid MAC address" and a description of "Specifies the address of the peer MAC entity with which an estimate of throughput was calculated."  Estimated Throughput  with a valid range of "either -1, or a floating point value [0,infinite]"  and a description of "Specifies the estimated throughput that is possible between this STA and the peer STA if an association is established." | Revise - TGmc editor to execute proposed changes from 11-14-1246r5 found under all headings which include CID3309 |
| 3488 | Vinko Erceg |  |  | In May 2014 IEEE 802.11 meeting, REVmc worked on a liaison letter from 3GPP. Throughput parameter was proposed to be used for network selection. However, this parameter needs to be defined in REVmc to be useful. | Define Throughput parameter in REVmc. I will bring contribution. | Revise - TGmc editor to execute proposed changes from 11-14-1246r5 found under all headings which include CID3488 |

**Discussion:**

During the July 2014 session, new SAPs for estimated throughput of an existing or potential connection were described within document 11-14-0792 proposing a resolution for CID 3309. As part of the discussion of that document, two major concerns arose about the general nature of the proposal. The first was the question of directionality of the estimate of throughput and the second question was concerning the accuracy of the estimate and the consistency of estimates across implementations.

The question of uplink vs downlink at the July 2014 session prompted the authors to revise the document in a manner so that only the downlink case was described even though the sentiment of the body suggested a preference for including the uplink case as well; The reason that the uplink case was not included at that session was because of a lack of time to sufficiently prepare and review the text that would have been needed to cover that case; Despite the lack of the presence of material to cover the uplink case, the body chose to proceed with the amended material with the promise from the authors that further refinements would be offered at subsequent meetings.

As to the question of the accuracy of the estimates, while it was argued that no estimate could ever promise to accurately predict all possible future conditions and therefore, a measure of accuracy is in some sense, moot, the discussion did converge on the idea that some generalized algorithm for generating an estimate would be useful because it could allow for some consistency which would in turn allow for reasonably accurate heuristics to be developed by centralized connection managers for use in making decisions about potential WLAN connections and traffic steering.

This document is a positive response to both of those issues, meaning that it attempts to provide a solution to both problems by introducing a significant number of refinements to the original proposal. Specifically, it introduces an element containing a set of parameters that can be exchanged between STAs to assist in determining potential uplink traffic throughput estimates and requires the use of an existing element for a similar purpose, proposing to include both of these elements in certain frames. Secondly, it provides a generalized algorithm which shows a simple method that can be used to combine a large set of parameters to produce an estimated throughput value.

**Proposed changes**

**CID 3309, 3488**

***TGmc editor: replace the Estimated Throughput (ESTT) SAP subclauses in draft D3.4 as shown, noting that the subclause numbering is estimated and that the editor shall use the correct subclause numbering as appropriate:***

**6.3.102a Estimated Throughput (EST)**

**6.3.102a.1 General**

The following set of MLME primitives support the transport of an estimate of the throughput for a potential or existing link between the STA and an AP.

**6.3.102a.2 MLME-ESTIMATED-THROUGHPUT.request**

**6.3.102a.2.1 Function**

This primitive is generated by the SME to request that the MLME provide an estimated throughput for a potential or existing link.

**6.3.102a.2.2 Semantics of the service primitive**

The primitive parameters are as follows:

MLME-ESTIMATED-THROUGHPUT.request(

PeerMACAddress,

AverageMSDUSizeDownlink,

AverageMSDUSizeUplink

)

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Type** | **Valid range** | **Description** |
| PeerMACAddress | MACAddress | Any valid individual MAC address | Specifies the MAC address of the AP for which throughput is to be estimated assuming a link with that AP if a link with that AP does not currently exist. |
| AverageMSDUSizeInbound | Set of Integers | -1 - 7920 (for each integer in the set) | A set of integers providing an estimate of the average number of octets per MSDU expected to be delivered to the wireless medium to this STA by the AP corresponding to the PeerMACAddress to this STA, specified per access category. A value of -1 means that the size is unspecified, a value of 0 means that no MSDUs are expected to be delivered for this access category. |
| AverageMSDUSizeOutbound | Set of Integers | -1 - 7920 (for each integer in the set) | A set of integers providing an estimate of the average number of octets per MSDU expected to be delivered to the wireless medium by this STA to the AP corresponding to the PeerMACAddress, specified per access category. A value of -1 means that the size is unspecified, a value of 0 means that no MSDUs are expected to be delivered for this access category. |

**6.3.102a.2.3 When generated**

This primitive is generated by the SME to request that the MLME provide an estimate of throughput for MSDUs sent between this STA and the AP which corresponds to the PeerMACAddress provided in the parameter list.

**6.3.102a.2.4 Effect of receipt**

On receipt of this primitive, the MLME generates a set of estimates of throughput for MSDUs sent between the AP which corresponds to the PeerMACAddress provided in the parameter list and this STA.

**6.3.102a.3 MLME-ESTIMATED-THROUGHPUT.confirm**

**6.3.102a.3.1 Function**

This primitive reports the result of a request to provide a set of estimated throughput values for a potential or existing link.

**6.3.102a.3.2 Semantics of the service primitive**

The primitive uses the following parameters:

MLME-ESTIMATED-THROUGHPUT.confirm(

PeerMACAddress,

EstimatedThroughputDownlink,

EstimatedThroughputUplink

)

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Type** | **Valid range** | **Description** |
| PeerMACAddress | MACAddress | Any valid individual MAC address | Specifies the MAC address of the AP for which throughput is to be estimated assuming a link with that AP if a link with that AP does not currently exist. |
| EstimatedThroughputDownlink | A set of Real Numbers | Non-negative real numbers. | The estimated throughput in the direction from the AP corresponding to the PeerMACAddress to this STA with units of MSDU bits per second, specified per access category. A value of 0 means no estimate is available. |
| EstimatedThroughputUplink | A set of Real Numbers | Non-negative real numbers. | The estimated throughput in the direction from this STA to the AP corresponding to the PeerMACAddress with units of MSDU bits per second, specified per access category. A value of 0 means no estimate is available. |

**6.3.102a.3.3 When generated**

This primitive is generated by the MLME to provide a set of estimates of throughput for MSDUs sent between the AP which corresponds to the PeerMACAddress indicated in the parameter list and this STA.

**6.3.102a.3.4 Effect of receipt**

On receipt of this primitive, the SME may use the reported estimates to make link, association and forwarding decisions.

***TGmc editor: replace the Estimated throughput subclause as shown:***

**10.44a Estimated throughput**

A STA that has a value of true for dot11EstimatedServiceParametersOptionImplemented is an ESP STA.

Entities wishing to control the traffic steering decision of a device will benefit by being able to predict the potential throughput that could be obtained through a link with an AP. Those same entities also need to know what the current expectation for throughput is for network selection purposes. The MLME-ESTIMATED-THROUGHPUT.request and MLME-ESTIMATED-THROUGHPUT.confirm SAPs together provide an interface to allow such entities, operating through the SME, to obtain an estimate of throughput for MSDUs sent between the AP which corresponds to the PeerMACAddress indicated in the parameter list of the MLME-ESTIMATED-THROUGHPUT.request and this STA.

When an MLME-ESTIMATED-THROUGHPUT.request is received at the MLME, the MLME can use the parameters provided in the SAP plus the following information to create estimates of throughput per access category to deliver to the SME in the EstimatedThroughputDownlink parameter of the MLME-ESTIMATED-THROUGHPUT.confirm:

* RSSI measured during receptions of Beacon or Probe Response frames transmitted by the AP that corresponds to the MAC entity with the MAC address equal to the PeerMACAddress in the MLME-ESTIMATED-THROUGHPUT.request to this STA
* Number of spatial streams that is expected to be supported on the link between this STA and the AP
* Channel bandwidth
* Estimated Air Fractional Time
* Block Ack Window size

If the MLME is incapable of determining a value for the EstimatedThroughputDownlink or EstimatedThroughputUplink parameter for any access category, then the MLME shall return the value of 0 for the value of that parameter for that access category in the MLME-ESTIMATED-THROUGHPUT.confirm primitive. If the AverageMSDUSizeDownlink parameter for an access category is equal to -1 in the MLME-ESTIMATED-THROUGHPUT.request, the STA shall include a value of 0 in the EstimatedThroughputDownlink parameter for the corresponding access category in the MLME-ESTIMATED-THROUGHPUT.confirm. If the AverageMSDUSizeDownlink parameter for an access category is equal to 0 in the MLME-ESTIMATED-THROUGHPUT.request, the STA may assume any value for the average MSDU size used in calculating the estimated throughput to be included in the corresponding access category in the EstimatedThroughputDownlink parameter of the MLME-ESTIMATED-THROUGHPUT.confirm, but should use a value of 1500 octets. If the AverageMSDUSizeUplink parameter for an access category is equal to -1 in the MLME-ESTIMATED-THROUGHPUT.request, the STA shall include a value of 0 in the EstimatedThroughputUplink parameter for the corresponding access category in the MLME-ESTIMATED-THROUGHPUT.confirm. If the AverageMSDUSizeUplink parameter for an access category is equal to 0 in the MLME-ESTIMATED-THROUGHPUT.request, the STA may assume any value for the average MSDU size used in calculating the estimated throughput to be included in the corresponding access category in the EstimatedThroughputUplink parameter of the MLME-ESTIMATED-THROUGHPUT.confirm, but should use a value of 1500 octets.

ESP STAs should determine values for EstimatedThroughputDownlink for each AC of a current or potential link with an AP using the equation found in V.7 (Calculating EstimatedThroughput).

An ESP STA may include a Request element that includes the ESP element ID in transmitted Probe Requests.

An ESP STA shall include the ESP element within Probe Response frames transmitted in response to a Probe Request frame which included a Request element that includes the ESP element ID. An ESP STA may include the ESP element within Probe Response frames transmitted in response to a Probe Request frame which did not include a Request element, or included a Request element which did not include the ESP element ID..

An ESP STA shall include the ESP element within Beacon frames.

***TGmc editor: add one row to the table of Beacon frame body components, Table 8-35 Beacon frame body, as shown:***

**8.3.3.2 Beacon frame format**

**Table 8-35—Beacon frame body**

|  |  |  |
| --- | --- | --- |
| Order | Information | Notes |
| <ANA> | Estimated Service Parameters | The Estimated Service Parameters element is present if dot11EstimatedServiceParametersOptionImplemented is true. |

***TGmc editor: add one row to the table of Probe Request frame body components, Table 8-41 Probe Request frame body, as shown:***

**8.3.3.9 Probe Request frame format**

**Table 8-41—Probe Request frame body**

|  |  |  |
| --- | --- | --- |
| Order | Information | Notes |
| <ANA> | Estimated Service Parameters | The Estimated Service Parameters element is optionally present if dot11EstimatedServiceParametersOptionImplemented is true. |

***TGmc editor: replace the row with value 3 in the order column in the table of Probe Request frame body components, Table 8-41 Probe Request frame body, as shown:***

|  |  |  |
| --- | --- | --- |
| Order | Information | Notes |
| 3 | Request information | The Request element is optionally present if dot11MultiDomainCapabilityActivated is true or if dot11EstimatedServiceParametersOptionImplemented is true. |

***TGmc editor: add one row to the table of Probe Request frame body components, Table 8-41 Probe Request frame body, as shown:***

**8.3.3.10 Probe Response frame format**

**Table 8-42—Probe Response frame body**

|  |  |  |
| --- | --- | --- |
| Order | Information | Notes |
| <ANA> | Estimated Service Parameters | The Estimated Service Parameters element is optionally present if dot11EstimatedServiceParametersOptionImplemented is true. |

***TGmc editor: replace the row with value “Last” in the order column in the table of Probe Response frame body components, Table 8-42 Probe Response frame body, as shown:***

|  |  |  |
| --- | --- | --- |
| Order | Information | Notes |
| Last | Requested elements | Elements requested by the Request element of the Probe Request frame are present if dot11MultiDomainCapabilityActivated or dot11EstimatedServiceParametersOptionImplemented is true. See 10.1.4.3.2 (Active scanning procedure for a non-DMG STA) and 10.44a (Estimated throughput). |

***TGmc editor: add one row to the table of elements, Table 8-85 Element IDs as shown:***

**8.4.2.1 General**

**Table 8-85—Element IDs**

|  |  |  |
| --- | --- | --- |
| Element | Element ID | Extensible |
| Estimated service parameters (see 8.4.2.170m Estimated service parameters element) | <ANA> | Yes |

***TGmc editor: add the following new element with appropriate subclause numbering:***

**8.4.2.170m Estimated service parameters (ESP) element**

The Estimated Service Parameters element is used by a STA to provide information to another STA which can then use the information as input to an algorithm to generate an estimate of throughput between the two STAs.

The format of the Estimated Service Parameters element is shown in Figure 8-mmm (Estimated service parameters element format). The value of N in the diagram corresponds to the number of Access Categories for which Estimated Service Parameters information is provided and has a value from 1 to 4.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Element ID | Length | Reserved | ESP Information |
| Octets: | 1 | 1 | 1 | N x 3 |

**Figure 8-mmm Estimated Service Parameters element format**

The Element ID and Length fields are defined in 8.4.2.1 (General).

The format of the ESP Information field is shown in Figure 8-mma (ESP Information field format).

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | B0 B1 | B2 | B3 B4 | B5 B7 | B8 B15 | B16 B23 |
|  | Access Category | Reserved | Data Format | BA Window Size | Estimated Air Time Fraction | Data PPDU Duration Target |
| Bits: | 2 | 1 | 2 | 3 | 8 | 8 |

**Figure 8-mma ESP Information field format**

The Access Category subfield is two bits in length and indicates the Access Category to which the remaining parameters of the ESP Information field apply.The encoding of the Access Category field is given in Table 8-vvv Access Category subfield encoding. When parameters for more than one Access Category are present in an ESP element the ESP Information fields for the Access Categories appear in order of Access Category subfield value, with the ESP Information field with the lowest Access Category subfield value appearing first.

**Table 8-vvv Access Category subfield encoding**

|  |  |
| --- | --- |
| Value | Access Category |
| 00b | AC\_BK |
| 01b | AC\_BE |
| 10b | AC\_VI |
| 11b | AC\_VO |

The Data format subfield is two bits in length and has the meaning indicated in Table 8-www (Data format subfield encoding).

**Table 8-www Data format subfield encoding**

|  |  |
| --- | --- |
| Value | Description |
| 00b | No aggregation is expected to be perfomed for MSDUs or MPDUs of Type Data for the corresponding AC |
| 01b | A-MSDU aggregation is expected to be perfomed for MSDUs for the corresponding AC, but A-MPDU aggregation is not expected to be performed for MPDUs of Type Data for the corresponding AC |
| 10b | A-MPDU aggregation is expected to be perfomed for MPDUs of Type Data for the corresponding AC, but A-MSDU aggregation is not expected to be performed for MSDUs for the corresponding AC |
| 11b | A-MSDU aggregation is expected to be perfomed for MSDUs for the corresponding AC and A-MPDU aggregation is expected to be performed for MPDUs of Type Data for the corresponding AC |

The BA Window Size subfield is three bits in length and indicates the size of the Block Ack window that is expected for the corresponding Access Category as per the encoding indicated in Table 8-yyy (BA Window Size subfield encoding). When the Block Ack window size expected to be used by the transmitter of the element does not match any of the values shown in the table, the transmitter uses the next lower value in the table.

**Table 8-yyy BA Window Size subfield encoding**

|  |  |
| --- | --- |
| Value | Expected BA Window Size |
| 000b | Block Ack not expected to be used |
| 001b | 2 |
| 010b | 4 |
| 011b | 6 |
| 100b | 8 |
| 101b | 16 |
| 110b | 32 |
| 111b | 64 |

The Estimated Air Time Fraction subfield is 8 bits in length and contains an unsigned integer which represents the percentage of time, linearly scaled with 255 representing 100%, that the AP predicts a new STA joining the BSS would be able to be served by the AP.

The Data PPDU Duration Target field is 8 bits in length and is an unsigned integer that indicates the expected target duration of PPDUs that contain at least one MPDU of Type Data for the corresponding Access Category in units of 50 usec.

***TGmc editor: add the following new MIB variable to the dot11StationConfig group and add a corresponding value in the group’s SEQUENCE definition:***

**C.3 MIB Detail**

dot11EstimatedServiceParametersOptionImplemented OBJECT-TYPE

SYNTAX TruthValue

MAX-ACCESS read-only

STATUS current

DESCRIPTION

"This is a capability variable.

Its value is determined by device capabilities.

This attribute, when true, indicates that the IEEE 802.11 Estimated Service Parameters option is implemented."

DEFVAL { false }

::= { dot11StationConfigEntry <ANA> }

***TGmc editor: add the following new subclause to Annex V:***

**V.7 Calculating EstimatedThroughput**

In response to the receipt of MLME-ESTIMATED-THROUGHPUT.request, ESP STAs can determine values for EstimatedThroughputInbound and EstimatedThroughputOutbound for each AC of a current or potential link to another STA using equation V.7-aaa:

Equation V.7-aaa:

EstimatedThroughput = (MPDU\_pPPDU x A\_MSDU\_B x 8) / PPDU\_DUR \* EST\_AIR\_TIME\_FRACTION

Where,

MPDU\_pPPDU = MIN(BA\_WIN\_SIZE, MAX(1,MPDU\_pA\_MPDU))

MIN(x,y) = the minimum of x and y

MAX(x,y) = the maximum of x and y

BA\_WIN\_SIZE = MIN(BA\_WIN\_SIZE\_TX, BA\_WIN\_SIZE\_RX)

BA\_WIN\_SIZE\_TX = the expected BA window size of the transmitter of the PPDUs containing Data Type MPDUs

BA\_WIN\_SIZE\_RX = the expected BA window size of the receiver of the PPDUs containing Data Type MPDUs

MPDU\_pA\_MPDU = MIN(FLOOR(PPDUR/MPDU\_SS),FLOOR(PPDUR/((50+A\_MSDU\_B)\*8))))

FLOOR(R) = the greatest integer that has a value less than or equal to the number R

PPDUR = DPDUR - PHDUR

DPDUR = Data PPDU Duration Target of the transmitter of the PPDUs containing Data Type MPDUs

PHDUR = PHY Header Duration, estimated based on the expected PPDU format of the PPDUs containing Data Type MPDUs

MPDU\_SS = the Minimum MPDU Start Spacing of the receiver of the PPDUs containing Data Type MPDUs

A\_MSDU\_B = MIN(A\_MSDU\_B\_TX, A\_MSDU\_B\_RX)

A\_MSDU\_B\_TX = the maximum A-MSDU size of the transmitter of the PPDUs containing Data Type MPDUs

A\_MSDU\_B\_RX = the maximum A-MSDU size of the receiver of the PPDUs containing Data Type MPDUs

PPDU\_DUR = CEIL((50+A\_MSDU\_B)\*MPDU\_pPPDU\*8 / DataRate / DSYM\_DUR) \* DSYM\_DUR

DSYM\_DUR = the duration of one PPDU Payload symbol for the expected PHY format of the PPDUs containing Data Type MPDUs. If multiple symbol durations are possible, then the shortest symbol duration is assumed.

DataRate is calculated using equation V.7-bbb.

EST\_AIRTIME\_FRACTION = the estimated portion of airtime that is available for downlink transmissions for this link as indicated in the ESP element received from the AP with the MAC address that matches the PeerMACAddress in the MLME-ESTIMATED-THROUGHPUT.request.

Note that some of the parameters of the equation have values which are AC dependent.

Equation V.7-bbb:

DataRate = min( log2( 1 + SNR\_tone ), MaxBitsPerSc ) \* Nss\_max \* Ntone / DSYM\_DUR

Where,

SNR\_tone = 10^( ( RSSI + P\_adjust ) / 10 )

RSSI = RSSI of Beacon or Probe Response frames received from the AP with the MAC address that matches the PeerMACAddress in the MLME-ESTIMATED-THROUGHPUT.request

P\_adjust = implementation specific power adjustment parameter used to convert RSSI into SNR, as well as take into account potential TX power differences between Beacon/Probe Response frames to data frames. The nominal value is 88 if the Beacon or Probe Response frames were received using DSSS or CCK rate, and 86 otherwise.

Nss\_max = Maximum number of spatial streams allowed in the link based on the capabilities of the STA and the AP.

Ntone = N\_SD \* N\_Seg if the expected PPDU format is VHT, and N\_SD otherwise, where N\_SD is defined as Number of subcarriers in Table 18-16 for non-HT format, NSD in Table 20-6 for HT format and NSD in Table 22-5 for VHT format. If multiple PPDU bandwidths are available, the N\_SD of the widest possible PPDU bandwidth allowed between the STA and AP based on capabilities is assumed.

MaxBitsPerSc = 40/6 if 256-QAM 5/6 is allowed in the link, 6 if only up to 256-QAM ¾ is allowed in the link, and 5 otherwise, based on the capabilities of the STA and the AP.

**References:**