IEEE P802.11  
Wireless LANs

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Minor Revisions to FTM Protocol | | | | |
| Date: 2015-11-10 | | | | |
| Author: | | | | |
| Name | Affiliation | Address | Phone | Email |
| Carlos Aldana | Qualcomm Corporation |  |  | [caldana@qca.qualcomm.com](mailto:caldana@qca.qualcomm.com) |

Abstract

This contribution addresses some minor revisions to FTM protocol. The motivation behind these changes stem from:

1. some audio applications having clock synchronization errors as large as 1ms
2. ps changes to FTM timestamps that lead to 1/4096m ranging errors can also be applied to Z
3. exponential ranging error replacing linear ranging error in FTM Range report

It uses Draft 4.3 as a baseline.

***Revision history:***

***v0 :*** Initial submission

***NOTE TO EDITOR* : *Please make the changes shown in red.***

**8.4.2.20.19 Fine Timing Measurement Range request**

The Measurement Request field corresponding to a Fine Timing Measurement Range request is shown in Figure 8-185 (Measurement Request field for a Fine Timing Measurement Range request(#2403)).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Randomization Interval | Minimum AP Count | ~~Neighbor Report Subelements~~ | ~~Optional Subelements~~  FTM Range  Subelements |
| Octets: | 2 | 1 | variable | variable |
| * Measurement Request field for a Fine Timing Measurement Range request(#2403) | | | | |

The Randomization Interval field specifies the upper bound of the random delay to be used prior to making the measurement, expressed in units of TUs. See 10.11.3 (Measurement start time).

The Minimum AP Count field specifies the minimum number of fine timing measurement ranges between the requested STA and the APs listed in the Neighbor Report Subelements field that are requested. The value 0 and values above 15 are(M55) reserved.

(#3074)The ~~Optional~~ FTM Range Subelements field contains ~~zero~~ one or more subelements. The subelement format and ordering of subelements are defined in 8.4.3 ((#2041)Subelements).(#6707). The ~~optional~~ FTM Range subelements are listed in Table 8-104 (~~Optional~~ FTM Range subelement IDs for Fine Timing Measurement Range request(M55)).

The Subelement IDs for subelements in the Fine Timing Measurement Range request are defined in Table 8-104 (~~Optional~~ FTM Range subelement IDs for Fine Timing Measurement Range request(M55)).(#3074)

|  |  |  |
| --- | --- | --- |
| * ~~Optional~~ FTM Range subelement IDs for Fine Timing Measurement Range request(M55) | | |
| Subelement ID | Name | Extensible |
| 0–3 | Reserved |  |
| 4 | Maximum Age | Yes |
| 5-51(#3074) | Reserved |  |
| 52(#3074) | Neighbor Report | Subelements |
| 53–220 | Reserved |  |
| 221 | Vendor Specific |  |
| 222–255 | Reserved |  |

The FTM Range Subelements field shall include a concatenation of at least Minimum AP Count Neighbor Report subelements. ~~(#3074)The Neighbor Report Subelements field is a concatenation of at least Minimum AP Count Neighbor Report subelements.~~ Each Neighbor Report subelement has the same format as the Neighbor Report element and contains the Wide Bandwidth Channel subelement. See Table 8-104 (Optional subelement IDs for Fine Timing Measurement Range request(M55)) and Table 8.4.2.36 (Neighbor Report element). The Neighbor Report Subelements field specifies a superset of nearby APs with which the requested STA is requested to perform the Fine Timing Measurement procedure (see 10.11.9.11 (Fine Timing Measurement Range report(#2403))).

~~(#3074)The Optional Subelements field contains zero or more subelements. The subelement format and ordering of subelements are defined in 8.4.3 ((#2041)Subelements).(#6707). The optional subelements are listed in Table 8-104 (Optional subelement IDs for Fine Timing Measurement Range request(M55)).~~

The Maximum Age subelement indicates the maximum age of the requested (#3637)fine timing measurement ranges. The format of the Maximum Age subelement is defined in Figure 8-186 (Format of Maximum Age subelement(M55)). The absence of a Maximum Age subelement indicates that (#3637)fine timing measurement ranges determined at or after the Fine Timing Measurement (#3637)Range request is received are requested.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Subelement ID | Length | Maximum Age |
| Octets: | 1 | 1 | 2 |
| * Format of Maximum Age subelement(M55) | | | |

(M99)The Subelement ID field is defined(MDR) in Table 8-104 (Optional subelement IDs for Fine Timing Measurement Range request(M55)).(M55)(#3073)

The Length field is defined in 8.4.3 ((#2041)Subelements).(M55)

The Maximum Age field of the Maximum Age subelement indicates the maximum elapsed time between when (#3637)fine timing measurement ranges are determined and when a Fine Timing Measurement (#3637)Range request is received, within which the (#3637)fine timing measurement ranges satisfy the Fine Timing Measurement (#3637)Range request. The Maximum Age field is encoded as an unsigned integer with units of 0.1 s.(Ed) The value 0 is reserved. The value 65 535 indicates that (#3637)fine timing measurement ranges determined at any time are acceptable. (M55)

The Vendor Specific subelement has the same format as the corresponding element (see 8.4.2.25 (Vendor Specific element)). Multiple Vendor Specific subelements can be included in the Optional Subelements field.(Ed)(M55)(#3074)

**8.4.2.21.10 LCI report (Location Configuration information report)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Subelement ID | Length | STA Floor  Information | STA Height Above Floor | STA Height Above Floor Uncertainty |
| Octets: | 1 | 1 | 2 | ~~2~~ 3 | 1 |
| * Z subelement format(#2403) | | | | | |

The STA Height Above Floor field indicates the height of the STA above the floor. The field is coded as a 2s complement integer with units of 1/4096 m.(M56)(Ed) The value –8388608 indicates an unknown STA height above floor. The value –8388607 indicates the height of the STA above the floor is –8388607/4096(#6238)(M56) meters or less. The value 8388607 indicates the height of the STA above the floor is 8388607/4096(#6238)(M56) meters or more.(#2403)

An STA Height Above Floor Uncertainty value of 0 indicates an unknown STA height above floor uncertainty. Values ~~19~~ 25 or higher are reserved. A value from 1 to ~~18~~ 24 indicates that the actual STA height above floor, *a*, is bounded according to:(#2403)

(M56)

where

*h* is the value in units of ~~1/64~~ 1/4096 m of the STA Height Above Floor field

*u* is the value of the STA Height Above Floor Uncertainty field

If the STA Height Above Floor field indicates an unknown STA height above floor, the STA Height Above Floor Uncertainty field is set to 0. (#2403)

* Location Civic (#1294)report

The Location Civic (#1294)report includes the location information defined in civic(#3) format for the location subject provided in the Location Civic (#1294)request, as shown in Figure 8-225 (Location Civic (#3637)report field format).

|  |  |  |  |
| --- | --- | --- | --- |
|  | Civic Location Type | Location Civic Subelement | Optional  Subelements |
| Octets: | 1 | variable(#2403) | variable |
| * Location Civic (#3637)report field format | | | |

The Civic Location Type field contains the format of location information in the Civic Location field, as indicated in Table 8-98 (Civic Location Type field values(#3638)).

The subelement IDs of the Location Civic (#3637)report are defined in Table 8-119 (Subelement(#2403) IDs for Location Civic report(#1294)(#1429)).

|  |  |  |
| --- | --- | --- |
| * Subelement(#2403) IDs for Location Civic report(#1294)(#1429) | | |
| Subelement ID | Name | Extensible |
| 0 | Location Civic(#2403) | No |
| 1 | Originator Requesting STA MAC Address | No |
| 2 | Target MAC Address | No |
| 3 | Location Reference |  |
| 4 | Location Shape |  |
| 5 | Map Image |  |
| 6–220 | Reserved |  |
| <ANA> | Co-Located BSSID | Yes |
| 221 | Vendor Specific |  |
| 222–255 | Reserved |  |

***(#2403)***

The Location Civic Subelement field contains a Location Civic subelement.(Ed) The Location Civic subelement of the Location Civic (#3637)report (see Figure 8-225 (Location Civic (#3637)report field format)) is formatted according to Figure 8-226 (Location Civic subelement format(#2403)).

|  |  |  |  |
| --- | --- | --- | --- |
|  | Subelement ID | Length | Location Civic |
| Octets: | 1 | 1 | variable |
| * Location Civic subelement format(#2403) | | | |

(#2403)

The Subelement ID is equal to Location Civic as defined in Table 8-119 (Subelement(#2403) IDs for Location Civic report(#1294)(#1429)).(#2403)

The Location Civic field contains the location information in the format as indicated in the Civic Location Type field. When the Civic Location Type field(#5338) is IETF RFC 4776(#6005):(#2403)

* Location Civic field is formatted according to IETF RFC 4776(#6005) starting at the country code field (i.e., excluding the GEOCONF\_CIVIC/ OPTION\_GEOCONF\_CIVIC, N/option-len and what fields)
* An unknown civic location is indicated by a subelement Length of 0 and a zero-length Location Civic field
* The Civic Location field follows the little-endian octet ordering

When the Civic Location Type field(#5338) is IETF RFC (#6212)4776(#6006), the Optional Subelements field optionally(#1677) includes the Location Reference, Location Shape, Map Image, and Vendor Specific subelements as defined in Table 8-119 (Subelement(#2403) IDs for Location Civic report(#1294)(#1429)).

When the Civic Location Type field(#5338) value is Vendor Specific, a Vendor Specific subelement is included in the Optional Subelements field that identifies the Organization Identifier corresponding to the Civic Location Type field(#5338).

The Optional Subelements field contains zero or more subelements with subelement ID greater than or equal to 1 as listed in Table 8-119 (Subelement(#2403) IDs for Location Civic report(#1294)(#1429)). The subelement format and ordering of subelements are defined in 8.4.3 ((#2041)Subelements).(#6707)

The Originator Requesting STA MAC Address subelement contains the MAC address of the STA that requested the Location Information and it is present whenever the Location Subject(#3202) field in the corresponding Location Civic (#1294)request was set to 2. The format of the Originator Requesting STA MAC Address subelement is shown in Figure 8-165 (Originator Requesting STA MAC Address subelement format).

The Target MAC Address subelement contains the MAC address of the STA whose Location Information was requested and it is present whenever the Location Subject(#3202) field in the corresponding Location Civic (#1294)request was set to 2. The format of the Target MAC Address subelement is shown in Figure 8-166 (Target MAC Address subelement format).

The format of the Location Reference subelement is shown in Figure 8-227 (Location Reference subelement format).

|  |  |  |  |
| --- | --- | --- | --- |
|  | Subelement ID | Length | Location Reference |
| Octets: | 1 | 1 | variable |
| * Location Reference subelement format | | | |

The Location Reference is an ASCII string that defines a position on a floor from which the relative location contained in the Location Shape subelement is offset. A Location Reference value of 0 length indicates that the position of the Location Shape is top north west corner (i.e., 0,0) of the floor plan (#6067)on which the Location Shape is defined.

The format of the Location Shape subelement is shown in Figure 8-228 (Location Shape subelement format).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Subelement ID | Length | Location Shape ID | Location Shape Value |
| Octets: | 1 | 1 | 1 | variable |
| * Location Shape subelement format | | | | |

The Location Shape subelement defines the position in meters, including uncertainty, of the entity being located. A Shape is specified with respect to either a 2-Dimensional or 3-Dimensional Coordinate Reference System where each point in the shape defines the direction from the Location Reference starting point. A positive X-axis value corresponds to an easterly direction relative to the Location Reference; a negative X-axis value corresponds to a westerly direction relative to the Location Reference; a positive Y-axis value corresponds to a northerly direction relative to the Location Reference; a negative Y-axis value corresponds to a southerly direction relative to the Location Reference and the Z-axis value corresponds to the altitude above the horizontal plane at the Location Reference.

The Location Shape ID field contains a one-octet identifier that defines the shape contained in the subelement and is one of the values defined in Table 8-120 (Location Shape IDs(#1429)).

|  |  |
| --- | --- |
| * Location Shape IDs(#1429) | |
| Location Shape ID | Name |
| 0 | Reserved |
| 1 | 2-Dimension Point |
| 2 | 3-Dimension Point |
| 3 | Circle |
| 4 | Sphere |
| 5 | Polygon |
| 6 | Prism |
| 7 | Ellipse |
| 8 | Ellipsoid |
| 9 | Arcband |
| 10–255 | Reserved |

The Location Shape Value field contains the location shape value for each corresponding Location Shape ID. The formats of Location Shape Values are described in the following text.

All shape field value units that are 4-octet single precision floating point values are in meters and are represented by binary32 floating point values as defined in IEEE Std 754-2008, with the least significant bit of the fraction occurring in bit 0 of the field.

The format of the 2-Dimension Point Location Shape Value is defined in Figure 8-229 (2-Dimension Point Location Shape Value format).

|  |  |  |
| --- | --- | --- |
|  | X-coordinate | Y-coordinate |
| Octets: | 4 | 4 |
| * 2-Dimension Point Location Shape Value format | | |

The X-coordinate field contains a 4-octet single precision floating point value.

The Y-coordinate field contains a 4-octet single precision floating point value.

The format of the 3-Dimension Point Location Shape Value is defined in Figure 8-230 (3-Dimension Point Location Shape Value format).

|  |  |  |  |
| --- | --- | --- | --- |
|  | X-coordinate | Y-coordinate | Z-coordinate |
| Octets: | 4 | 4 | 4 |
| * 3-Dimension Point Location Shape Value format | | | |

The X-coordinate field contains a 4-octet single precision floating point value.

The Y-coordinate field contains a 4-octet single precision floating point value.

The Z-coordinate field contains a 4-octet single precision floating point value.

The format of the Circle Location Shape Value is defined in Figure 8-231 (Circle Location Shape Value format).

|  |  |  |  |
| --- | --- | --- | --- |
|  | X-coordinate | Y-coordinate | Radius |
| Octets: | 4 | 4 | 4 |
| * Circle Location Shape Value format | | | |

The X-coordinate field contains a 4-octet single precision floating point value.

The Y-coordinate field contains a 4-octet single precision floating point value.

The Radius field contains a 4-octet single precision floating point value.

The format of the Sphere Location Shape Value is defined in Figure 8-232 (Sphere Location Shape Value format).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | X-coordinate | Y-coordinate | Z-coordinate | Radius |
| Octets: | 4 | 4 | 4 | 4 |
| * Sphere Location Shape Value format | | | | |

The X-coordinate field contains a 4-octet single precision floating point value.

The Y-coordinate field contains a 4-octet single precision floating point value.

The Z-coordinate field contains a 4-octet single precision floating point value.

The Radius field contains a 4-octet single precision floating point value.

The format of the Polygon Location Shape Value is defined in Figure 8-233 (Polygon Location Shape Value format).

|  |  |  |
| --- | --- | --- |
|  | Number of Points | List of 2-Dimension Points |
| Octets: | 1 | variable |
| * Polygon Location Shape Value format | | |

The Number of Points field is a 1 octet unsigned integer that specifies the number of points defined in the polygon. The value 0 is reserved.

The List of 2-Dimension Points is a sequence of 2D Point field values that define the closed polygon.

The format of the Prism Location Shape Value is defined in Figure 8-234 (Prism Location Shape Value format).

|  |  |  |
| --- | --- | --- |
|  | Number of Points | List of 3-Dimension Points |
| Octets: | 1 | variable |
| * Prism Location Shape Value format | | |

The Number of Points field is a 1 octet unsigned integer that specifies the number of points defined in the prism. The value 0 is reserved.

The List of 3-Dimension Points is a sequence of 3-Dimension Point field values that define the closed prism.

The format of the Ellipse Location Shape Value is defined in Figure 8-235 (Ellipse Location Shape Value format).

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | X-coordinate | Y-coordinate | Angle | Semi-Major Axis | Semi-Minor Axis |
| Octets: | 4 | 4 | 2 | 4 | 4 |
| * Ellipse Location Shape Value format | | | | | |

The X-coordinate field contains a 4-octet single precision floating point value.

The Y-coordinate field contains a 4-octet single precision floating point value.

The Angle field contains a 2-octet unsigned integer between 0 and 359°(#3380)(#1491).

The Semi-Major Axis field contains a 4-octet single precision floating point value.

The Semi-Minor Axis field contains a 4-octet single precision floating point value.

The format of the Ellipsoid Location Shape Value is defined in Figure 8-236 (Ellipsoid Location Shape Value format).

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | X-coordinate | Y-coordinate | Z-coordinate | Angle | Semi-Major Axis | Semi-Minor Axis | Semi-Vertical Axis |
| Octets: | 4 | 4 | 4 | 2 | 4 | 4 | 4 |
| * Ellipsoid Location Shape Value format | | | | | | | |

The X-coordinate field contains a 4-octet single precision floating point value.

The Y-coordinate field contains a 4-octet single precision floating point value.

The Z-coordinate field contains a 4-octet single precision floating point value.(#12)

The Angle field contains a 2-octet unsigned integer between 0 and 359°(#3380)(#1491).

The Semi-Major Axis field contains a 4-octet single precision floating point value.

The Semi-Minor Axis field contains a 4-octet single precision floating point value.

The Semi-Vertical Axis field contains a 4-octet single precision floating point value.

The format of the Arcband Location Shape Value is defined in Figure 8-237 (Arcband Location Shape Value format).

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | X-coordinate | Y-coordinate | Inner Radius | Outer Radius | Start Angle | Opening Angle |
| Octets: | 4 | 4 | 4 | 4 | 2 | 2 |
| * Arcband Location Shape Value format | | | | | | |

The X-coordinate field contains a 4-octet single precision floating point value.

The Y-coordinate field contains a 4-octet single precision floating point value.

The Inner Radius field contains a 4-octet single precision floating point value.

The Outer Radius field contains a 4-octet single precision floating point value.

The Start Angle field contains a 2-octet unsigned integer between 0 and 359.

The Opening Angle field contains a 2-octet unsigned integer between 0 and 359.

The Map Image subelement contains a map reference that is used in combination with the Location Reference and Location Shape subelements. The format of the Map Image subelement is shown in Figure 8-238 (Map Image subelement format).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Subelement ID | Length | Map Type | Map URL |
| Octets: | 1 | 1 | 1 | variable |
| * Map Image subelement format | | | | |

The Map Type field is a 1-octet unsigned integer that defines the type of map referred to by the Map URL field, as defined in Table 8-121 (Map Types).

|  |  |
| --- | --- |
| * Map Types | |
| Map Type Value | Name |
| 0 | URL Defined |
| 1 | Png |
| 2 | Gif |
| 3 | Jpeg |
| 4 | Svg |
| 5 | dxf |
| 6 | Dwg |
| 7 | Dwf |
| 8 | cad |
| 9 | Tiff |
| 10 | gml |
| 11 | Kml |
| 12 | Bmp |
| 13 | Pgm |
| 14 | ppm |
| 15 | Xbm |
| 16 | Xpm |
| 17 | ico |
| 18–255 | Reserved |

The Map Type field value “URL Defined” indicates the Map URL field value has a file extension, defined as a mime type and is self-descriptive.

The Map URL field is a variable-length field formatted in accordance with IETF RFC 3986(#6007) and provides the location of a floor map.(#2403)

The Co-Located BSSID List(Ed) subelement is used to report the list of BSSIDs of the BSSs which share the same antenna connector with the reporting STA. The Co-Located BSSID List(Ed) subelement is described in 8.4.2.21.10.

(#3269)

The Vendor Specific subelement has the same format as the Vendor Specific element (see 8.4.2.25 (Vendor Specific element))(#6593).

**8.4.2.21.18 Fine Timing Measurement Range report**

The Range Entry field indicates parameters relating to a successful(M56) range measurement with a single AP, and is formatted according to Figure 8-246 (Range Entry field format(#2403)).

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Measurement Start Time | BSSID | Range | Max Range Error Exponent | Reserved |
| Octets: | 4 | 6 | 3~~(M56)~~ | ~~3~~ 1 | 1 |
| * Range Entry field format(#2403) | | | | | |

The Measurement Start Time field contains the least significant 4 octets of the TSF (synchronized with the associated AP) at the time (± 32 µs) at which the initial(M56) Fine Timing Measurement frame was transmitted where the timestamps of both the frame and response frame were successfully measured.

The BSSID field contains the BSSID of the AP whose range is being reported.

The Range field indicates the estimated range between the requested STA and the AP using the fine timing measurement procedure, in units of 1/4096 m.(M56) A value of 224–1 indicates a range of (224–1)/4096 m or higher. See 10.11.9.11 (Fine Timing Measurement Range report(#2403)).

The Max Range Error Exponent field contains an exponent of the upper bound for the error in the value specified in the Range field~~, in units of 1/4096 m~~.(M56) A value of zero indicates an unknown error. A nonzero value indicates a maximum range error of m. The Max Range Error Exponent field has a maximum value of 25. Values in the range 26-255 are reserved. A value of ~~224–1~~ 25 indicates a maximum range error of ~~224–1/4096~~ 4096 m(M56) or higher. For instance, a value of ~~8192~~(M56) 14 in the Max Range Error Exponent field indicates that the value in the Range field has a maximum error of ± 2 m.

* Neighbor Report element

The format of the Neighbor Report element is shown in Figure 8-291 (Neighbor Report element format).

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Element ID | Length | BSSID | BSSID  Information | Operating Class | Channel Number | PHY Type | Optional -Subelements |
| Octets: | 1 | 1 | 6 | 4 | 1 | 1 | 1 | variable |
| * Neighbor Report element format | | | | | | | | |

The Element ID and Length fields are defined in 8.4.2.1 (General).(#139)

Each Report element describes an AP and consists of BSSID, BSSID Information, Channel Number, Operating Class, PHY Type, and optionally includes optional subelements. The minimum value of the Length field is 13 (i.e., with no optional subelements in the Neighbor Report element).

The BSSID is the BSSID of the BSS being reported. The subsequent fields in the Neighbor Report element pertain to this BSS.

The BSSID Information field can be used to help determine neighbor service set transition candidates. It is 4 octets in length and contains the subfields as shown in Figure 8-292 (BSSID Information field).

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | B0 B1 | B2 | B3 | B4 B9 | B10 | B11 | B12 | B13 | B14 B31 |
|  | AP Reachability | Security | Key Scope | Capabilities | Mobility  Domain | High Throughput | Very High Throughput | FTM | Reserved |
| Bits: | 2 | 1 | 1 | 6 | 1 | 1 | 1(11ac) | 1(#2403) | 18 |
| * BSSID Information field | | | | | | | | | |

The AP Reachability field indicates whether the AP identified by this BSSID is reachable by the STA that requested the neighbor report. For example, the AP identified by this BSSID is reachable for the exchange of preauthentication frames as described in 11.6.10.2 (Preauthentication and RSNA key management). The values are shown in Table 8-148 (Reachability field).

|  |  |  |
| --- | --- | --- |
| * Reachability field | | |
| Value | Reachability | Usage |
| 0 | Reserved | Not used. |
| 1 | Not Reachable | A station sending a preauthentication frame to the BSSID will not receive a response even if the AP indicated by the BSSID is capable of preauthentication. |
| 2 | Unknown | The AP is unable to determine if the value Reachable or Not Reachable is to be returned. |
| 3 | Reachable | The station sending a preauthentication frame to the BSSID can receive a response from an AP that is capable of preauthentication. |

The Security bit, if 1, indicates that the AP identified by this BSSID supports the same security provisioning as used by the STA in its current association. If the bit is 0, it indicates either that the AP does not support the same security provisioning or that the security information is not available at this time.

The Key Scope bit, when set, indicates the AP indicated by this BSSID has the same authenticator as the AP sending the report. If this bit is 0, it indicates a distinct authenticator or the information is not available.

The Capabilities subfield(#2069) contains selected capability information for the AP indicated by this BSSID. The bit fields within this subfield have the same meaning and are set to the equivalent bits within the Capability Information field (see 8.4.1.4 (Capability Information field)) being sent in the beacons by the AP being reported. The format of the Capabilities subfield is as in Figure 8-293 (Capabilities subfield).

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | B4 | B5 | B6 | B7 | B8 | B9 |
|  | Spectrum Management | QoS | APSD | Radio Measurement | Delayed Block Ack | Immediate Block Ack |
| Bits: | 1 | 1 | 1 | 1 | 1 | 1 |
| * Capabilities subfield | | | | | | |

The Mobility Domain bit is set to 1 to indicate that the AP represented by this BSSID is including an MDE in its Beacon frames and that the contents of that MDE are identical to the MDE advertised by the AP sending the report.

The High Throughput bit is set to 1 to indicate that the AP represented by this BSSID is an HT AP including the HT Capabilities element in its Beacons, and that the contents of that HT Capabilities element are identical to the HT Capabilities element advertised by the AP sending the report.

The Very High Throughput bit is set to 1 to indicate that the AP represented by this BSSID is a VHT AP and that the VHT Capabilities element, if included as a subelement in the report, is identical in content to the VHT Capabilities element included in the AP’s Beacon.(11ac)

The FTM field is set to 1 to indicate that the AP represented by this BSSID is an AP that has set the Fine Timing Measurement field of the Extended Capabilities element to 1. The FTM field is set to 0 to indicate either that the reporting AP has dot11FineTimingMsmtRespActivated(#5172) equal to false, or the reported AP has not set the Fine Timing Measurement Responder(#5172) field of the Extended Capabilities element to 1 or that the Fine Timing Measurement field of the reported AP is not available to the reporting AP at this time.(#2403)

Bits 14–31(#2403)(11ac) are reserved.

Operating Class field(11ac) indicates the channel set of the AP indicated by this BSSID. The Country, Operating Class, and Channel Number fields together specify the channel frequency and spacing for the channel on which the Beacon frames are being transmitted for the BSS being reported.(11ac) Valid operating classes(11ac) are listed in Annex E.

The Channel Number field(11ac) indicates the last known primary(11ac) channel of the AP indicated by this BSSID. Channel number is defined within an operating class(11ac) as shown in Annex E.

The PHY Type field indicates the PHY type of the AP indicated by this BSSID. It is an integer value coded according to the value of the dot11PHYType.

The Optional Subelements field contains zero or more subelements. The subelement format and ordering of subelements are defined in 8.4.3 ((#2041)Subelements).(#6707)

The Subelement ID field values for the defined (#3361)subelements are shown in Table 8-149 (Optional subelement IDs for neighbor report(#1429)).(#6707)     

|  |  |  |
| --- | --- | --- |
| * Optional subelement IDs for neighbor report(#1429) | | |
| Subelement ID | Name | Extensible |
| 0 | Reserved |  |
| 1 | TSF Information | Yes |
| 2 | Condensed Country String | Yes |
| 3 | BSS Transition Candidate Preference |  |
| 4 | BSS Termination Duration |  |
| 5 | Bearing |  |
| 6(#5184) | Wide Bandwidth Channel |  |
| 7–38 | Reserved |  |
| 39(#2403) | Measurement Report | Subelements |
| 40–44 | Reserved |  |
| 45 | HT Capabilities subelement | Yes |
| 46–60 | Reserved |  |
| 61 | HT Operation subelement | Yes |
| 62 | Secondary Channel Offset subelement |  |
| 63–65 | Reserved |  |
| 66 | Measurement Pilot Transmission | Subelements |
| 67–69 | Reserved |  |
| 70 | RM Enabled Capabilities | Yes |
| 71 | Multiple BSSID | Subelements |
| 72–190(11ac) | Reserved |  |
| 191(11ac) | VHT Capabilities | Yes |
| 192(11ac) | VHT Operation | Yes |
| 193–220 | Reserved |  |
| 221 | Vendor Specific |  |
| 222–255 | Reserved |  |

The TSF (#136)subelement contains TSF Offset and Beacon Interval subfields as shown in Figure 8-294 (TSF (#136)subelement format).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Subelement ID | Length | TSF Offset | Beacon Interval |
| Octets: | 1 | 1 | 2 | 2 |
| * TSF (#136)subelement format | | | | |

The Length field is defined in 8.4.3 ((#2041)Subelements).(#1429)

The TSF Offset subfield is 2 octets long and contains the neighbor AP’s TSF timer offset. This is the time difference, in TU units, between the serving AP and a neighbor AP. This offset is given modulo the neighbor AP’s Beacon Interval and rounded to the nearest TU boundary.

The Beacon Interval field is the beacon interval of the Neighbor AP indicated by this BSSID. This field is defined in 8.4.1.3 (Beacon Interval field) and illustrated in Figure 8-65 (Beacon Interval field).

The Condensed Country String subelement is set to the first two octets of the value contained in dot11CountryString. This subelement is present only if the country of the neighbor AP indicated by the BSSID differs from the country of the AP that sent this neighbor report.

The Measurement Pilot Transmission subelement has the same format as the Measurement Pilot Transmission element (see 8.4.2.41 (Measurement Pilot Transmission element)). The Measurement Pilot Interval subelement is not included if the reported AP is not transmitting Measurement Pilot frames or if the Measurement Pilot Interval of the reported AP is unknown.

A Measurement Report subelement with Measurement Type field(#5367) equal to LCI(M91) (see Table 8-105 (Measurement Type field definitions for measurement reports(#3265)(#5342))) is optionally present. If present, the subelement has the same format as the Measurement Report element with Measurement Type field(#5367) equal to LCI(M91).The subelement indicates the LCI of the neighbor STA and further includes the Z subelement, or the subelement indicates an unknown LCI (see 10.24.6.7 (LCI and Location Civic retrieval using fine timing measurement procedure(#2403))). The Late, Incapable and Refused bits in the Measurement Report Mode field are set to 0.(#2403) The Co-Located BSSID List(Ed) subelement is present in the Measurement Report subelement of the Neighbor Report element, when there is at least one other BSS which is co-located with the reporting BSS.(#3269)(#5184)

A Measurement Report subelement with Measurement Type field(#5367) equal to Location Civic(M91) (see Table 8-105 (Measurement Type field definitions for measurement reports(#3265)(#5342))) is optionally present. If present, the subelement has the same format as the Measurement Report element with Measurement Type field(#5367) equal to Location Civic(M91), and the subelement indicates the civic address of the transmitting STA or an unknown civic address (see 10.24.6.7 (LCI and Location Civic retrieval using fine timing measurement procedure(#2403))). The Late, Incapable and Refused bits in the Measurement Report Mode field are set to 0.(#2403)(#5184) The Co-Located BSSID List(Ed) subelement is present in the Measurement Report subelement of the Neighbor Report element, when there is at least one other BSS which is co-located with the reporting BSS. When a Measurement Report subelement with Measurement Type field equal to LCI that includes a Co-Located BSSID List(Ed) subelement is present, the Co-Located BSSID List(Ed) subelement is not present in the Measurement Report subelement with Measurement Type field(#5367) equal to Location Civic(M91).

The HT Capabilities subelement is the same as the HT Capabilities element as defined in 8.4.2.55 (HT Capabilities element).

The HT Operation subelement is the same as the HT Operation element as defined in 8.4.2.56 (HT Operation element).

The Secondary Channel Offset subelement is the same as the Secondary Channel Offset element as defined in 8.4.2.19 (Secondary Channel Offset element).

The RM Enabled Capabilities subelement has the same format as the RM Enabled Capabilities element (see 8.4.2.44 (RM Enabled Capabilities element)).

The Multiple BSSID subelement has the same format as the Multiple BSSID element (see 8.4.2.45 (Multiple BSSID element)). The reference BSSID for the Multiple BSSID subelement is the BSSID field in the Neighbor Report element. This subelement is not present if the neighbor AP is not a member of a Multiple BSSID Set with two or more members or its membership is unknown. (see 10.11.14 (Multiple BSSID Set)).

The format of the BSS Transition Candidate Preference subelement(#1432) is shown in Figure 8-295 (BSS Transition Candidate Preference subelement(#1432) format).

|  |  |  |  |
| --- | --- | --- | --- |
|  | Subelement ID | Length | Preference |
| Octets: | 1 | 1 | 1 |
| * BSS Transition Candidate Preference subelement(#1432) format | | | |

The Length field is defined in 8.4.3 ((#2041)Subelements).(#1429)

The Preference field indicates the network preference for BSS transition to the BSS listed in this BSS      Transition Candidate List Entries field in the BSS Transition Management Request frame, BSS Transition Management Query frame, and BSS Transition Management Response frame. The Preference field value is a number ranging from 0 to 255, as defined in Table 8-150 (Preference field values), indicating an ordering of preferences for the BSS transition candidates for this STA. Additional details describing use of the Preference field are provided in 10.24.7 (BSS transition management for network load balancing).

|  |  |
| --- | --- |
| * Preference field values | |
| Preference field value | Description |
| 0 | Excluded BSS; reserved when present in the BSS Transition Management Query or BSS Transition Management Response frames. |
| 1–255 | Relative values used to indicate the preferred ordering of BSSs, with 255 indicating the most preferred candidate and 1 indicating the least preferred candidate. |

The BSS Termination TSF field contained in the BSS Termination Duration subelement is the TSF time of the BSS transmitting the neighbor report that corresponds to the time when termination of the neighbor BSS occurs. How the BSS determines the neighbor BSS termination time is out of scope of the standard. The format of the BSS Termination Duration subelement(#1432) is shown in Figure 8-296 (BSS Termination Duration subelement(#1432) format).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Subelement ID | Length | BSS Termination TSF | Duration |
| Octets: | 1 | 1 | 8 | 2 |
| * BSS Termination Duration subelement(#1432) format | | | | |

The Length field is defined in 8.4.3 ((#2041)Subelements).(#1429)

The BSS Termination TSF field indicates the value of the TSF timer(#3343) when BSS termination will occur in the future. A BSS Termination TSF field value of 0 indicates that termination of the BSS will occur imminently. Prior to termination of the BSS, all associated STAs are disassociated by the AP.

The Duration field is an unsigned 2-octet integer that indicates the number of minutes for which the BSS is not present. The Duration field value of 0 is reserved. The Duration field value is 65 535 when the BSS is terminated for a period longer than or equal to 65 535 minutes.

The format of the Bearing subelement(#1432) is shown in Figure 8-297 (Bearing subelement(#1432) format).

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Subelement ID | Length | Bearing | Distance | Relative Height |
| Octets: | 1 | 1 | 2 | 4 | 2 |
| * Bearing subelement(#1432) format | | | | | |

The Length field is defined in 8.4.3 ((#2041)Subelements).(#1429)

The Bearing field specifies the direction that the neighbor, specified by the BSSID field in the Neighbor Report element, is positioned, relative to the reporting BSS and defined in relation to true north, increasing clockwise, measured in degrees from 0°(#3380)(#1491) to 359°(#3380)(#1491). If the Bearing value is unknown, the subelement is not included.

The Distance field specifies the distance that the neighbor, specified by the BSSID field in the Neighbor Report element, is positioned relative to the reporting BSS as a 4-octet single precision floating point value represented by a binary32 floating point value as defined in IEEE Std 754-2008, with the least significant bit of the fraction occurring in bit 0 of the field, in meters. If the Distance field value is unknown the field is set to 0.

The Relative Height field, defined by a 2-octet signed integer, specifies the relative height in meters that the neighbor is positioned, relative to the reporting BSS. If the Relative height is unknown or at the same height as the reporting BSS, the field is 0.

The format of the Wide Bandwidth Channel subelement is shown in Figure 8-298 (Wide Bandwidth Channel subelement format(#5184)).

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Subelement ID | Length | Channel Width | Channel Center Frequency Segment 0 | Channel Center Frequency Segment 1 |
| Octets: | 1 | 1 | 1 | 1 | 1 |
| * Wide Bandwidth Channel subelement format(#5184) | | | | | |

The Length field is defined in 8.4.3 ((#2041)Subelements).

The Channel Width, Channel Center Frequency Segment 0, and Channel Center Frequency Segment 1 subfields are defined in Table 8-151 (HT/VHT Operation Information subfields(#5184)).

|  |  |  |
| --- | --- | --- |
| * HT/VHT Operation Information subfields(#5184) | | |
| Field | Definition | Encoding |
| Channel Width | This field defines the BSS operating channel width (see 10.40.1 (Basic VHT BSS functionality(11ac))). | Set to 0 for 20 MHz operating channel width.  Set to 1 for 40 MHz operating channel width.  Set to 2 for 80 MHz operating channel width.  Set to 3 for 160 MHz operating channel width.  Set to 4 for non-contiguous 80+80 MHz operating  channel width.  Values in the range 5 to 255 are reserved. |
| Channel Center Frequency Segment 0 | Defines the channel center frequency for an HT or VHT BSS or the frequency segment 0 channel center frequency for an 80+80 MHz VHT BSS. See 22.3.14 (Channelization). | For 20, 40, 80, or 160 MHz operating channel width, indicates the channel center frequency index for the channel on which the HT or VHT BSS operates.  For 80+80 MHz operating channel width, indicates the channel center frequency index for the 80 MHz channel of frequency segment 0 on which the VHT BSS operates. |
| Channel Center Frequency Segment 1 | Defines the frequency segment 1 channel center frequency for an 80+80 MHz VHT BSS. See 22.3.14 (Channelization). | For an 80+80 MHz operating channel width, indicates the channel center frequency index of the 80 MHz channel of frequency segment 1 on which the VHT BSS operates. Reserved otherwise. |

The VHT Capabilities subelement is the same as the VHT Capabilities element as defined in 8.4.2.157 (VHT Capabilities element(11ac)).(11ac)

The VHT Operation subelement is the same as the VHT Operation element as defined in 8.4.2.158 (VHT Operation element(11ac)).(11ac)

The Vendor Specific subelement has the same format as the Vendor Specific element (see 8.4.2.25 (Vendor Specific element)). Multiple Vendor Specific subelements are optionally present in the list of optional subelements.

* Geospatial Location ANQP-element

The AP Geospatial Location ANQP-element provides the AP’s location in LCI format; see 8.4.2.21.10 (LCI report (Location configuration information report)(#1294)(#5350)).

The format of the AP Geospatial Location ANQP-element is provided in Figure 8-604 (AP Geospatial Location ANQP-element format).

|  |  |  |  |
| --- | --- | --- | --- |
|  | Info ID | Length | Location Configuration Report |
| Octets: | 2 | 2 | variable(M56)(#3269) |
| * AP Geospatial Location ANQP-element format | | | |

The Info ID and Length fields are defined in 8.4.5.1 (General).(#1430)

The Location Configuration Report field is of variable length and(#3269)(Ed) defined in (LCI report (Location configuration information report)(#1294)(#5350)).(#3269) The Z and Usage Rules/Policy subelements are optionally present in the Location Configuration Report field(Ed), when it is used in the AP Geospatial Location ANQP element. The Co-Located BSSID List(Ed) subelement ~~may also~~ ~~be~~ is present when there is at least one other BSS which is co-located with the reporting BSS.(#3269)

* AP Civic Location ANQP-element

The AP Civic Location ANQP-element provides the AP’s location in civic(#3616) format. The format of the AP Civic Location ANQP-element is provided in Figure 8-605 (AP Civic Location ANQP-element format).

|  |  |  |  |
| --- | --- | --- | --- |
|  | Info ID | Length | Location Civic Report |
| Octets: | 2 | 2 | variable |
| * AP Civic Location ANQP-element format | | | |

The Info ID and Length fields are defined in 8.4.5.1 (General).(#1430)

The Location Civic Report is a variable-length field and the format is provided in 8.4.2.21.13 (Location Civic (#1294)report). This information is taken from dot11APCivicLocationTable(#5047). The Co-Located BSSID List(Ed) subelement is present when there is at least one other BSS which is co-located with the reporting BSS and the Co-Located BSSID List(Ed) subelement is not present in the Geospatial Location ANQP-element, and is not present otherwise.(#3269)

(MDR)

* Neighbor Report ANQP-element

The Neighbor Report ANQP-element provides zero or more neighbor reports about neighboring APs. This is of benefit to a STA in a preassociated state.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Info ID | Length | Neighbor Report element (optional) |
| Octets: | 2 | 2 | variable |
| * Neighbor Report ANQP-element format | | | |

The Info ID and Length fields are defined in 8.4.5.1 (General).(#1430)

The format of the Neighbor Report element is shown in Figure 8-291 (Neighbor Report element format) defined in 8.4.2.36 (Neighbor Report element). The Element ID and the Length fields of the Neighbor Report element, as shown in Figure 8-291 (Neighbor Report element format), are not included. The Co-Located BSSID List(Ed) subelement is present when there is at least one other BSS which is co-located with the reporting BSS.

**8.6.8.33 Fine Timing Measurement frame format**

The (M56)Category field is defined in 8.4.1.11 (Action field).(#6544)

The Public Action field is defined in 8.6.8.1 (Public Action frames).(#3403)

The TOD Error field is structured as shown in Figure 8-676 (Format of the TOD Error field(#2164)).

|  |  |  |  |
| --- | --- | --- | --- |
|  | B0 B4 ~~B14~~(M56) | B5 B14(M56) | B15 |
|  | Max TOD Error Exponent | Reserved | TOD Not Continuous |
| Bits: | ~~15~~ 5 | 10 | 1 |
| * Format of the TOD Error field(#2164) | | |  |

The TOA Error field is structured as shown in 8-677 (Format of the TOA Error field(#2164)).

|  |  |  |
| --- | --- | --- |
|  | B0 B4 ~~B14~~(M56) | B5 B15(M56) |
|  | Max TOA Error  Exponent | Reserved(#5172) |
| Bits: | ~~15~~ 5 | ~~1~~11 |
| * Format of the TOA Error field(#2164) | | |

The Dialog Token field is a nonzero value chosen by the responding(#2164) STA to identify the Fine(M56) Timing Measurement frame as the first of a pair, with the second or follow-up Fine(M56) Timing Measurement frame to be sent later. The Dialog Token field is set to 0 to indicate the end of the FTM session (see 10.24.6.6 (Fine timing measurement termination(#2164)) and 10.24.6.4 (Measurement exchange(#2164))).(#5185)

The Follow Up Dialog Token field(Ed) is the nonzero value of the Dialog Token field of the last(#2164) transmitted Fine(M56) Timing Measurement frame to indicate that it is the follow up Fine(Ed) Timing Measurement frame and that the TOD, TOA, Max TOD Error and Max TOA Error fields contain the values of the timestamps captured with the first Fine Timing Measurement frame of the pair. The Follow Up Dialog Token field(Ed) is 0 to indicate that the Fine Timing Measurement frame is not a follow up to a last(#2164) transmitted Fine Timing Measurement frame. The value 0 in this field also indicates that TOD, TOA, (#3267)TOD Error, and (#3267)TOA Error fields are reserved. See 10.24.6 (Fine timing measurement procedure(#46)(#3446)).

The TOD and TOA fields are expressed in units of picoseconds.(M159)

The maximum exponent errors in the TOD and TOA values are represented using the ~~piecewise linear~~ function defined in Equation (8-4).(M159)

* (M159)

where(M159)

*~~F~~* ~~is the integer value of the Max TOD Error or Max TOA Error fields~~

*Emax* is the maximum TOD or TOA error, respectively, in units of picoseconds

The TOD field contains a timestamp that represents the time, with respect to a time base, at which the start of the preamble of the last(#2164) transmitted Fine(M56) Timing Measurement frame appeared at the transmit antenna connector(#1410).

The TOA field contains a timestamp that represents the time, with respect to a time base,(#3267) at which the start of the preamble of the (#190)(#1198)Ack frame to the last(#2164) transmitted Fine(M56) Timing Measurement frame arrived at the receive antenna connector(#1410).

NOTE—The values specified in the TOD and TOA fields are described in 6.3.70 (Fine timing measurement request(#46)).

The Max TOD Error Exponent field contains an upper bound for the error exponent in the value specified in the TOD field.

(#2164)NOTE—For instance, a value of 2 in the Max TOD Error Exponent field indicates that the value in the TOD field has a maximum error of ± 2 ps.(M159)

The TOD Not Continuous field indicates that the TOD value is with respect to a different underlying time base than the last transmitted TOA(#5172) value. It is set to 1 when a discontinuity is present. (#3267)Otherwise, it is set to 0.(#2164)(Ed)

The Max TOA Error Exponent field contains an upper bound for the error exponent in the value specified in the TOA field. (#2164)(#5172)(Ed)

A value of 0 for the Max TOD Error Exponent or the Max TOA Error Exponent field indicates that the upper bound on the error in the corresponding TOD or TOA value is unknown. A value of ~~32 767(M56)~~ 31 indicates that the upper bound on the error is greater than or equal to ~~1.064896~~ 1.073741824 ~~µs~~ ms.(M159)(M56)

The FTM Synchronization Information field is present in the initial Fine Timing Measurement frame and its retransmissions if any, and in the first Fine Timing Measurement frame within each burst and its retransmissions if any; otherwise it is not present. If present, it contains an(Ed) FTM Synchronization Information element with a TSF Sync Info field containing the 4 least significant bytes of the TSF at the responding STA corresponding to the time(Ed) the responding STA received the last Fine Timing Measurement Request frame with the Trigger field equal(Ed) to 1. (#6419)

The LCI Report field is optionally present. If present, it contains a Measurement Report element with Measurement Type field(#5404) equal to LCI(M91) (see Table 8-105 (Measurement Type field definitions for measurement reports(#3265)(#5342))), which either indicates the LCI of the transmitting STA and includes the Z and Usage Rules/Policy(#5172) subelement or (Ed)indicates an unknown LCI (see 10.24.6.7 (LCI and Location Civic retrieval using fine timing measurement procedure(#2403))). The Late, Incapable and Refused bits in the Measurement Report Mode field are set to 0.(#2403) The Co-Located BSSID List(Ed) subelement is present in the Measurement Report element with Measurement Type field(#5404) equal to LCI(M91), when there is at least one other BSS which is co-located withe the reporting BSS.(#3269)

The Location Civic Report field is optionally present. If present, it contains a Measurement Report element with Measurement Type field(#5404) equal to Location Civic(M91) (see Table 8-105 (Measurement Type field definitions for measurement reports(#3265)(#5342))), which either indicates the Civic address of the transmitting STA or an unknown Civic address (see 10.24.6.7 (LCI and Location Civic retrieval using fine timing measurement procedure(#2403))). The Late, Incapable and Refused bits in the Measurement Report Mode field are set to 0. The Co-Located BSSID List(Ed) subelement is present in the Measurement Report element with Measurement Type field(#5404) equal to LCI(M91), when there is at least one other BSS which is co-located withe the reporting BSS. When the LCI Report field contains a Co-Located BSSID List(Ed) subelement, the Co-Located BSSID List(Ed) subelement is not present in the Location Civic Report field.(#3269)

(MDR) (#3269) (#2403)The Fine Timing Measurement Parameters(#3465) field is present in the initial Fine Timing Measurement Frame, and is not present in subsequent Fine Timing Measurement frames(#3267). If present, it(M56) contains a Fine Timing Measurement Parameters(#3465) element as defined in 8.4.2.166 (Fine Timing Measurement Parameters(#3465) element(#2164)).(#2164)