IEEE P802.11  
Wireless LANs

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| --- | --- | --- | --- | --- |
| Proposed Specification Framework for TGah | | | | |
| Date: 2012-11-15 | | | | |
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Abstract

This document provides the framework from which the draft TGah amendment will be developed. The document provides an outline of each the functional blocks that will be a part of the final amendment. The document is intended to reflect the working consensus of the group on the broad outline for the draft specification. As such it is expected to begin with minimal detail reflecting agreement on specific techniques and highlighting areas on which agreement is still required. It may also begin with an incomplete feature list with additional features added as they are justified. The document will evolve over time until it includes sufficient detail on all the functional blocks and their inter-dependencies so that work can begin on the draft amendment itself.

# 0 Revision Notes

|  |  |
| --- | --- |
| R0 | Initial draft document with a table of content |
| R1 | Added supporting bandwidth modes [11/1294r0]  Added the number of tones for 2MHz PHY transmission and the tone spacing for all other bandwidth modes [11/1311r0] |
| R2 | Added max number of space-time streams [11/1275r1]  Added channelization [11/1329r1] |
| R3 | Modified South Korea channelization [11/1422r0]  Added support for a new frame format for a short beacon [11/1503r1] |
| R4/5 | Added the motions passed in January 2012 |
| R6 | Added the motions passed in March 2012 |
| R7/8/9 | Added the motions passed in May 2012 |
| R10 | Added the motions passed in July 2012 |
| R11 | Added the motions passed in September 2012 |
| R12 | Added the motions passed in November 2012 |

# 1 Definitions

# 2 Abbreviations and Acronyms

S1G sub 1 GHz

PLCP physical layer convergence procedure

STA station

MAC medium access control

MCS0 BPSK, ½ code rate

SUBF single user beamforming

MU-MIMO multi-user, multiple input, multiple output

Non-TIM STA a STA that does not include its paged status in TIM

TIM STA a STA that includes its paged status in TIM

# 3 S1G Physical Layer

This section describes the functional blocks of the physical layer.

R.3.A: PHY mandatory features: [Nov 2012 meeting minutes, 11-12/1333r0]

1. An 11ah non-AP STA shall support:
   1. 1MHz and 2MHz channel width
   2. 1MHz PPDU, 2MHz PPDU with short preamble
   3. Single spatial stream MCS0 to 2, and MCS10 (for 1MHz PPDU only)
   4. Binary convolutional coding
   5. Normal Guard Interval
   6. Fixed Pilots
2. An 11ah AP STA shall support:
   1. 1MHz and 2MHz channel width
   2. 1MHz PPDU, 2MHz PPDU with short preamble
   3. Single spatial stream MCS0 to 7, and MCS10 (for 1MHz PPDU only)
   4. Binary convolutional coding
   5. Normal Guard Interval
   6. Fixed Pilots

## 3.1 Channelization

R.3.1.A: The draft specification shall include support for 1 MHz, 2 MHz, 4 MHz, 8 MHz, and 16 MHz PHY transmissions. [11/1294r0]

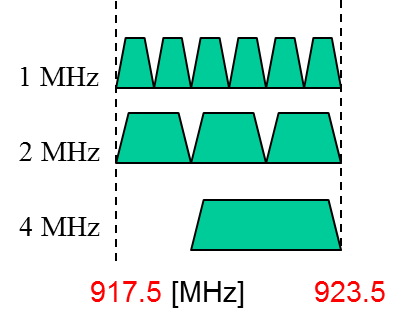
R.3.1.B: An 802.11ah STA shall support reception of 1 MHz and 2 MHz PHY transmissions. [11/1294r0]

R.3.1.C: The 2 MHz PHY transmission shall be an OFDM based waveform consisting of a total of 64 tones (including tones allocated as pilot, guard and DC). Note: This implies a tone spacing of 31.25 kHz. [11/1311r0]

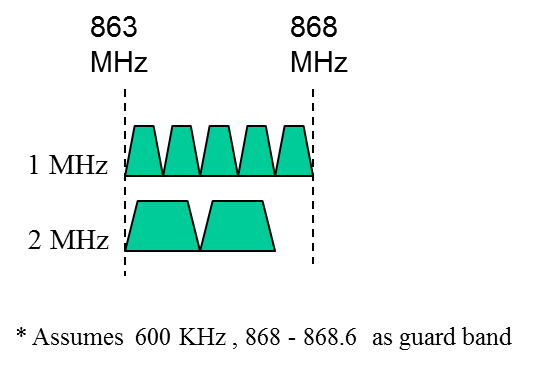
R.3.1.D: The tone spacing for all other bandwidths PHY transmissions shall be same as the tone spacing in the 2 MHz PHY transmission. [11/1311r0]

R.3.1.E: The draft specification shall include the following channelization [11/1329r1]

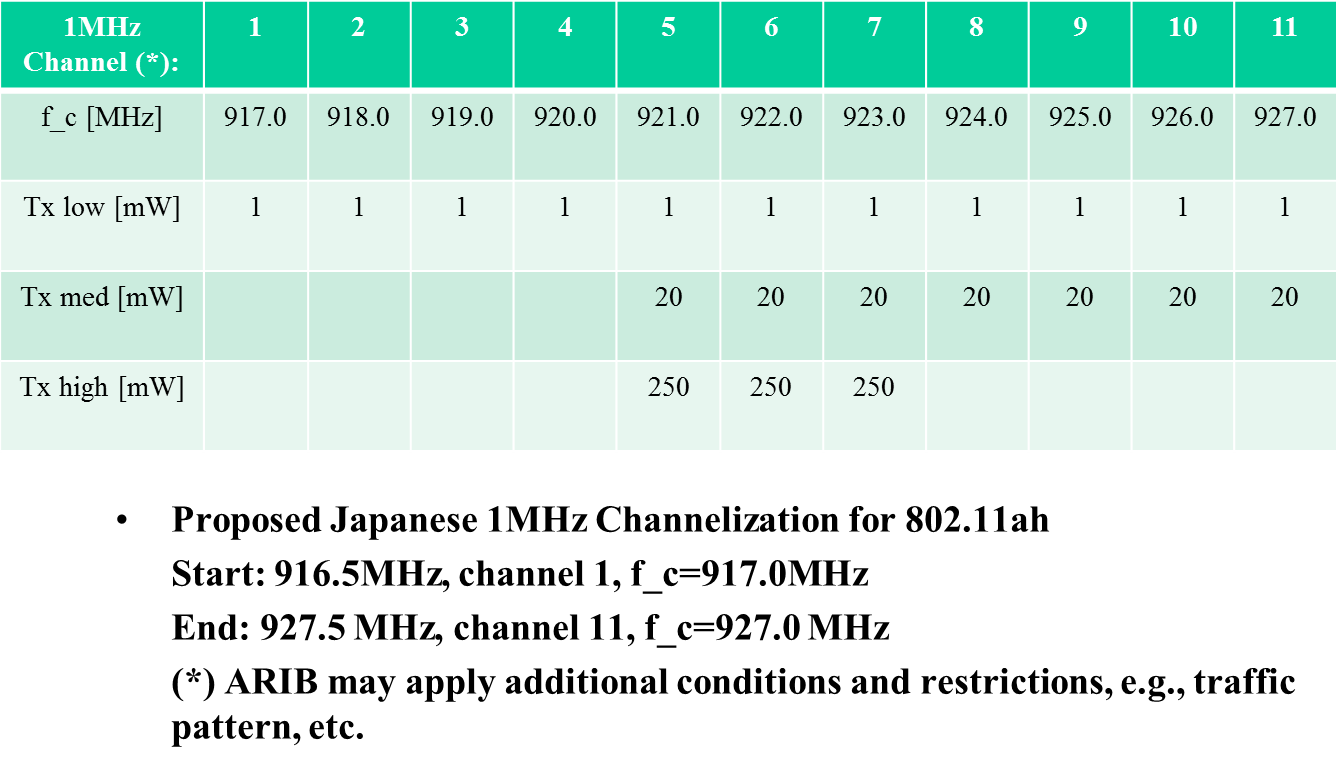
1. South Korea [11/1422r0]



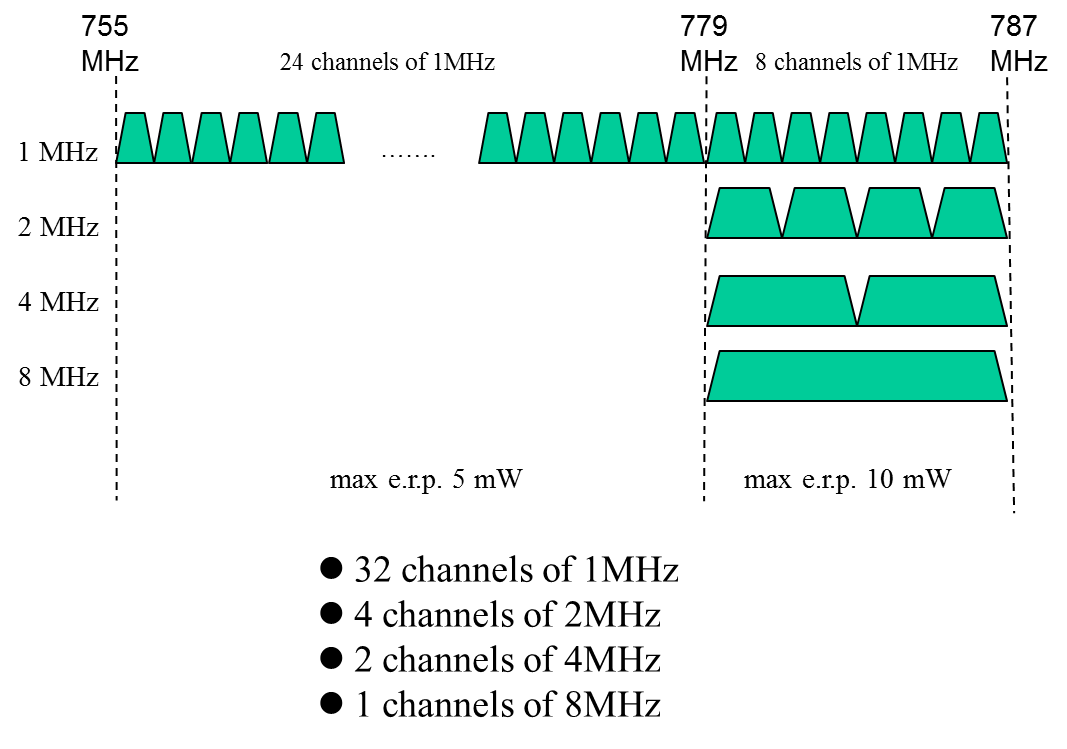
1. Europe



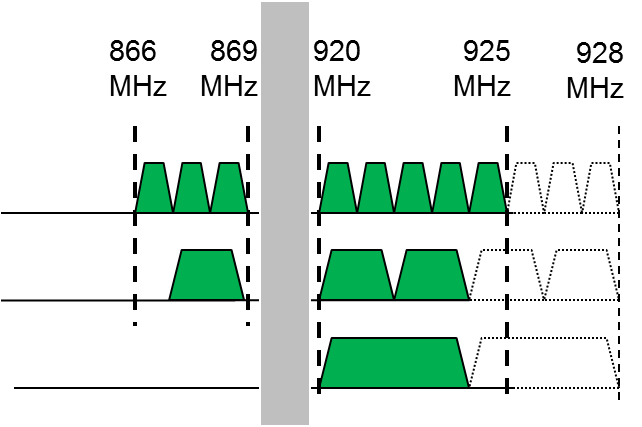
1. Japan



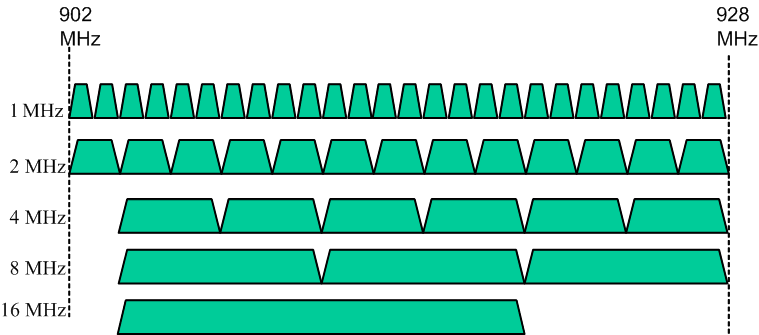
1. China



1. Singapore [12/111r1]:
2. Supporting bands: 866-869 MHz, 920-925MHz



1. United States [May 2012 meeting minutes, 12/0613r0]
2. 26 1MHz channels, 13 2MHz channels, 6 4MHz channels, 3 8MHz channels and one 16MHz channel



R.3.1.F: PHY and MAC management entity of 11ah shall provide appropriate parameters (TBD) of PLME and MLME service primitives to support Spectrum access and Tx Control functions in order to comply to each regulatory domain. [July 2012 meeting minutes, 1-12/871r1]

1. These appropriate parameters to be added are TBD so far, but are supposed to be a part of “behavior limit set” entry in the Annex Table which corresponds to new operating classes of 11ah.

### 3.1.1 Transmission rules

R.3.1.1.A: The draft specification shall support the following 1 MHz transmission rules. [12/309r1][Nov 2012 meeting minutes, 11-12/1313r0]

1. When establishing a 2/4/8/16MHz BSS, the AP determines and announces the location of 1MHz primary channel located at either upper or lower side of the 2MHz primary channel.
2. A 11ah STA that does not participate in the frequency selective transmission protocol shall neither transmit nor be transmitted to, a 1 MHz non-duplicated PPDU on 1MHz subchannels other than the primary 1Mhz channel of a 2/4/8/16 MHz BSSs.
3. A non-duplicated 1MHz transmission from a STA that participates in the frequency selective transmission protocol in a 4/8/16MHz BSS, shall use the same upper or lower 1MHz subchannel in any of the allowed 2MHz channel(s).

### 3.1.2 Channel selection rules

R.3.1.2.A: Among all available channels, the new BSS should select an idle channel which can help keep maximum number of idle (available) wider bandwidth channels after it is selected (Details TBD). [2012 July meeting minutes, 11-12/816r1]

## 3.2 S1G PLCP Sublayer

R.3.2.A: 11ah defines single stream pilots in the LTF, SIG and Data fields of short preamble packets, using the first column of P matrix for multi-stream mapping, as below:

1. For SIG field in Short Preamble Format, the transmitted pilot tone signals, in the k-th tone and n-th OFDM symbol in each 2MHz subband of the >=2MHz short preamble format SIG field is expressed as: [May 2012 meeting minutes, 12/363r2]





1. For SIGA Field in >=2MHz Long Preamble Format, the transmitted pilot tone signals, in the k-th tone and n-th OFDM symbol in each 2MHz subband of the >=2MHz long preamble format SIGA field is expressed as:





1. For **>=**2MHz LTFs in Short Preamble format, and D-LTFs in the Long preamble format, the transmitted pilot tone signals, in the k-th tone of each LTF field in the >=2MHz short preamble format, and of each D-LTF field in the >=2MHz long preamble format is expressed as:





1. For **>=**2MHz SIGB/Data, the transmitted pilot tone signals, in the k-th tone and n-th OFDM symbol in SIGB (when applicable) and Data fields in >=2MHz PPDUs is expressed as:





[July 2012 meeting minutes, 11-12/832r2]

The pilot mapping and values for 2/4/8/16 MHz transmissions, respectively, refer those for 20/40/80/160 MHz transmissions in section 22.3.10.10 (Pilot subcarriers) of IEEE P802.11ac™/D2.0. [May 2012 meeting minutes, 12/363r2-motion2]

1. For 1MHz LTFs, the transmitted pilot tone signals, in the k-th tone and in each LTFs for 1MHz PPDU is expressed as:





1. For 1MHz SIG field and Data Field, the transmitted pilot tone signals, in the k-th tone and n-th OFDM symbol of 1MHz SIG and Data fields is expressed as:





For a 1MHz transmission, two pilot tones shall be inserted in. The pilot mapping for subcarrier *k* for symbol *n* shall be as specified in the following equation. [May 2012 meeting minutes, 12/363r2-motion1]

where, is given in Table 22-20 of IEEE P802.11ac™/D2.0 and where *n* is the DATA symbol index.

### 3.2.1 Preamble

R.3.2.1.A: In any 11ah short GI packet, short GI starts from the 2nd Data symbol, and the 1st Data symbol is always long GI.

* Include Multi-stream or MU packets

R.3.2.1.B: The draft specification shall include 2-bit Ack Indication (00: Ack; 01: BA; 10: No Ack; 11: a frame that is not ACK, BA or CTS) in SIG.

* + 1. The definition of value (b11) response frame type to indicate the presence of a frame that is not ACK, CTS or BA following current transmission. [July 2012 meeting minutes, 11-12/834r0]

R.3.2.1.C: The 4-bit CRC in 11ah 2MHz and 1MHz SIG(A) fields shall be calculated using the same procedure as the 11n HTSIG field 8-bit CRC, except that the generator polynomial G(D) = D4 + D + 1. The draft specification shall use the same 11n HTSIG field 8-bit CRC in SIGB field of the >=2MHz long preamble when in MU mode [May 2012 meeting minutes, 12/596r0; July 2012 meeting minutes, 12/832r2][ 12/1092r0, September 2012 meeting minutes].

### 3.2.1.1 PHY greater than or equal to 2 MHz

R.3.2.1.1.A: The general short preamble structure for greater than or equal to 2 MHz PHY packet is defined as in the figure below: [July 2012 meeting minutes, 11-12/819r1]



Each field is defined as follows:

1. STF Field
   1. Use the same tone design as in 11n, i.e. in each 2MHz, STF occupies 12 non-zero tones in {±4 ±8 ±12 ±16 ±20 ±24}.
   2. None-zero tones are mapped to space-time streams using the first column of P matrix, the same way as in 11n GF preamble.



1. LTF Fields
   1. Define the 11ah LTF signs for >= 2MHz PPDUs the same as the VHTLTF signs in the corresponding 11ac packets with the same FFT sizes.
      1. This is also applicable to the LTF1 and D-LTFs fields in the long preamble format. [12/597r0 –motion1]
   2. In data tones of LTF, the mapping from NSTS space-time streams to NLTF LTFs is the same as in 11n green field preamble, with the P matrix.



### SIG Field

* 1. 2 symbols, each modulated using Q-BPSK, same as in 11n green field preamble.
  2. 48 data tones occupying tones {-26:26} within each 2MHz subband, and modulated using 11n/11ac MCS0. [12/308r2, Motion1]
  3. Data tones are mapped to multiple space-time streams using the first column of P matrix—the same as in 11n GF preamble.

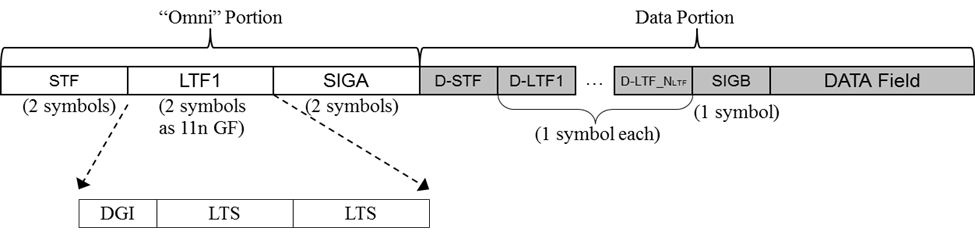


### The following CSD table (to be applied Per-Per-Space-Time-Stream) shall be used for the >=2MHz Short Frame format [2012 July meeting minutes, 11-12/833r1: motion1, 2]

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| T\_cs(n) for >=2MHz, Short Frame Format and Data portion of Long Frame Format | | | | |
| Total number of space-time streams | Cyclic shift (for Tx Stream n) (μs) | | | |
| 1 | 2 | 3 | 4 |
| 1 | 0 | - | - | - |
| 2 | 0 | -4 | - | - |
| 3 | 0 | -4 | -2 | - |
| 4 | 0 | -4 | -2 | -6 |

R.3.2.1.1.B: The long preamble structure uses a “mixed-mode” format shown below: (long preamble)

* This frame format can be used for MU and SUBF [12/373r0]



1. Omni Portion
   1. SIGA field has 48 data tones, occupying tones {-26:26} as in 11n/11ac SIG fields [12/597r0-motion1]
   2. STF/LTF1/SIG fields applies single stream in each subcarrier (without the 1st column P matrix mapping as seen in short preamble), similar to the legacy portion of 11n MM preamble and 11ac preamble.



* 1. SIG field subfield definition is different from short preamble, and the two symbols in SIG field are modulated using QBPSK and BPSK respectively
     1. Refer to R.3.2.1.1.C.
  2. The following CSD table (to be applied Per-Antenna) shall be used for the >=2MHz Omni portion of the Long Frame format [2012 July meeting minutes, 11-12/833r1:motion1,3]:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| T\_cs(n) for >=2MHz, Omni Portion of Long Frame Format | | | | |
| Total number of Tx antennas | Cyclic shift (for Tx Antenna n) (μs) | | | |
| 1 | 2 | 3 | 4 |
| 1 | 0 | - | - | - |
| 2 | 0 | -4 | - | - |
| 3 | 0 | -4 | -2 | - |
| 4 | 0 | -4 | -2 | -6 |

1. Data Portion
   1. D-STF is the same as (downclocked) 11ac VHT-STF.
   2. Modulation flows of D-STF, D-LTFs, and SIGB are the same as 11ac MU packets.
      1. i.e. all streams for all users are trained by D-LTFs.
      2. Up to 4 space-time stream across all users (refer to [11/1275r1]).
   3. The following CSD table (to be applied Per-Per-Space-Time-Stream) shall be used for the >=2MHz Data portion of the Long Frame format [2012 July meeting minutes, 11-12/833r1: motion1, 2]:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| T\_cs(n) for >=2MHz, Short Frame Format and Data portion of Long Frame Format | | | | |
| Total number of space-time streams | Cyclic shift (for Tx Stream n) (μs) | | | |
| 1 | 2 | 3 | 4 |
| 1 | 0 | - | - | - |
| 2 | 0 | -4 | - | - |
| 3 | 0 | -4 | -2 | - |
| 4 | 0 | -4 | -2 | -6 |

R.3.2.1.1.C: Auto-detection between 1MHz and 2MHz and between >=2MHz short and long preambles [July 2012 meeting minutes, 11-12/815r0]

1. Auto-detection between short and long >=2MHz preambles is facilitated by having a 90 degrees phase rotation on the 2nd SIG symbol as shown in the figure below.
2. Auto-detection between 1MHz and 2MHz preambles is facilitated using two options as shown in the figure below
   1. The first auto-detection method uses the property of orthogonal LTF sequences as described in 11/1482r4 and 12/0115 and defined by the orthogonality metric in Appendix-A of 12/0115.
   2. The second auto-detection method is facilitated by noting that for >=2MHz short preamble and long preamble the 1st SIG symbol is always QBPSK whereas the corresponding time-wise symbol of the 1MHz preamble (in the figure below) is BPSK modulated - refer to 11/1482r3.



R.3.2.1.1.D: 4/8/16 MHz frame format

1. For 4MHz, 8MHz, and 16MHz packets, the STF/LTF/SIG field designs are similar to 11ac 40/80/160MHz.
   1. STF/SIG fields are repeated and phase rotated (same as in 11ac) over each 2MHz subband.

R.3.2.1.1.E: SIG field content for >=2MHz

1. 2MHz SIGA [July 2012 meeting minutes, 11-12/825r2]

|  |  |  |  |
| --- | --- | --- | --- |
|  | Short preamble | Long preamble | |
| **SU** | **SU** | **MU** |
| SU/MU Indication | - | 1 | 1 |
| Length / Duration | 9 | 9 | 9 |
| MCS | 4 | 4 | - |
| BW | 2 | 2 | 2 |
| Aggregation | 1 | 1 | - |
| STBC | 1 | 1 | 1 |
| Coding | 2 | 2 | 5 |
| SGI | 1 | 1 | 1 |
| GID | - | - | 6 |
| Nsts | 2 | 2 | 8 |
| PAID | 9 | 9 | - |
| Ack Indication | 2 | 2 | 2 |
| Smoothing | 1 | - | - |
| Beam-change Indication | - | 1 | - |
| NDP Indication | 1 | - | - |
| Doppler | 1 | 1 | 1 |
| Reserved | 2 | 2 | 2 |
| CRC | 4 | 4 | 4 |
| Tail | 6 | 6 | 6 |
| **Total** | **48** | **48** | **48** |

* 1. LENGTH/DURATION: in number of symbols when aggregation is 1, is in number of bytes when aggregation is 0, Mandate AMPDU for packet sizes > 511 bytes and for MU.
  2. STBC: Same as in 11ac (Alamouti code on all streams or none).
  3. Nsts: for SU (2 bits), represents 1~4 STS; for MU (8 bits), represents 0~3 STS per user for the 4 users.
  4. Coding: for SU 1 bit indicates BCC/LDPC, the other bit indicates additional symbol during LDPC encoding process; for MU, 4 bits of Coding-I indicate BCC/LDPC of 4 clients, and 1 bit of Coding-II indicates whether additional symbols happens for any user when encoding LDPC (same as 11ac). [12/1102r1, September 2012 meeting minutes]
  5. MCS: for SU, 4 bit MCS index; for MU, reuse 3 bits for BCC/LDPC indicator for users 2~4—similar as in 11ac VHTSIGA.
  6. Aggregation: Mainly applicable for SU, reserved for MU.
  7. CRC: 4 bits of CRC should be enough as shown in the Appendix
  8. GID: 6-bit GID as in 11ac for MU, not needed for SU.
  9. PAID: 9 bits PAID, not needed for MU.
     1. Patial AID rules [12/1079r0, September 2012 meeting minutes]:
        1. A STA that transmits a PPDU to an AP shall set the TXVECTOR parameter PARTIAL\_AID to (dec(BSSID[39:47]) mod (29-1))+1
        2. AP should not assign an AID to a STA that results in the PARTIAL\_AID value, as computed using Equation (9-8a) (defined in IEEE 802.11ac Draft 3.0), being equal to either (dec(BSSID[39:47]) mod (29-1))+1 or (dec(Overlapping BSSID[39:47]) mod (29-1))+1
  10. Ack Indication: 2 bits [refer to R.3.2.1.B]
  11. Beam-change indication bit: a value of 1 indicates that Q matrix is changed; a value of 0 indicates that Q matrix is un-changed. [July 2012 meeting minutes, 11-12/825r2]
      1. Note: If the beam-change indication bit in long preamble is set to 0, the receiver may do channel smoothing. Otherwise, smoothing is not recommended.
  12. NDP Indication: this bit is used to indicate this frame is a MAC NDP frame. [Nov 2012 meeting minutes, 11-12/]
  13. Doppler: This bit indicates the traveling pilots usage in the packet. [Nov 2012 meeting minutes, 11-12/1322r0]
  14. Short preamble bit ordering [12/1102r1, September 2012 meeting minutes]
      1. 1st symbol of SIG



* + 1. 2nd symbol of SIG



* 1. Long preamble, SU bit ordering [12/1102r1, September 2012 meeting minutes]
     1. 1st symbol of SIG-A



* + 1. 2nd symbol of SIG-A



* 1. Long preamble, MU bit ordering [12/1102r1, September 2012 meeting minutes]
     1. 1st symbol of SIG-A



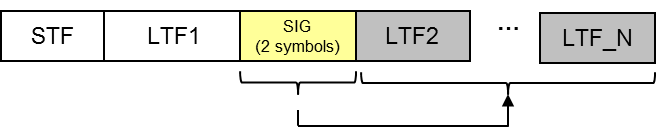
* + 1. 2nd symbol of SIG-A



1. For MU-MIMO transmission the 2MHz SIGB content is as shown in the following table. For SU-MIMO transmission the SIGB symbol is identical to D-LTF1. [July 2012 meeting minutes, 11-12/832r2]

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **BW (MHz)** | | | |
|  | **2** | **4** | **8** | **16** |
| MCS | 4 | 4 | 4 | 4 |
| Tail | 6 | 6 | 6 | 6 |
| CRC | 8 | 8 | 8 | 8 |
| Reserved | 8 | 9 | 11 | 11 |
| **Total** | 26 | 27 | 29 | 29 |

R.3.2.1.1.F: The draft specification shall include the following 11ah NDP format [May 2012 meeting minutes, 617r0-motion1]



The 11ah NDP format is same with 2MHz PHY short frame format defined in R.3.2.1.1.A.

1. The SIG field of 11ah NDP shall include following fields [May 2012 meeting minutes, 617r0-motion2]:
   1. MCS : set to 0
   2. Length/Duration: set to 0
   3. BW : set to the same value as the TXVECTOR parameter CH\_BANDWIDTH in the preceding VHT NDP Announcement frame
   4. Nsts : indicates two or more space-time streams

R.3.2.1.1.G: The draft specification shall support that all NDP frames sent in >=2MHz use the short preamble format, including Short-ACK, and all future NDP short MAC frames [May 2012 meeting minutes, 617r0-motion3].

R.3.2.1.1.H: The draft specification shall support the following rules regarding >= 2MHz preambles [July 2012 meeting minutes, 1-12/819r1][Nov 2012 meeting minutes, 11-12/1333r0].

1. For a any device,
   1. If it supports only 1MHz/2MHz, short preamble is mandatory, and long preamble is optional (exchanged by capability fields).
   2. Otherwise, both short and long preambles are mandatory.
2. Any device shall be able to detect and decode SIGA field in the long preamble for CCA.

### 3.2.1.2 1 MHz mode PHY

R.3.2.1.2.A: The 802.11ah specification shall use the following STF and LTF sequences for 32 FFT:

- STF and LTF sequences for higher FFT sizes are based on 11ac [12/186r0,26.2.9]

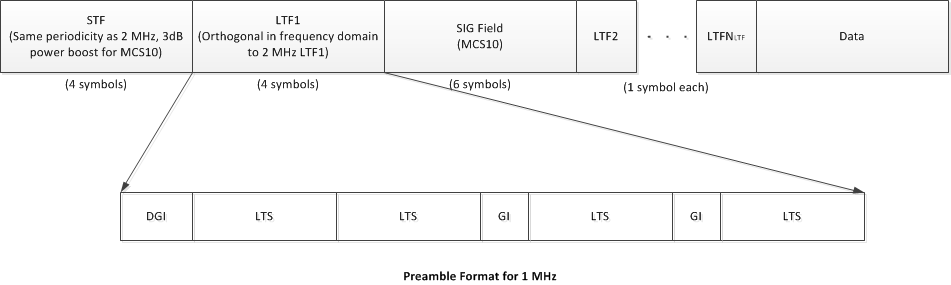
1. STF sequence [12/115r0,slide4]
   * Tone index=[-12 -8 -4 4 8 12]
   * Values: [0.5, -1, 1, -1, -1, -0.5]x(1+j)x γ   where γ is a normalization factor
   * γ = 2.4 for MCS0 rep2, 1.7 otherwise
2. LTF sequence [12/115r0, slide7]
   * Tone index is [-16 -15 -14 …. -1 0 1 ….. 14 15]   
     =[0 0 0 1 -1 1 -1 -1 1 -1 1 1 -1 1 1 1 0 -1 -1 -1 1 -1 -1 -1 1 -1 1 1 1 -1 0 0]

R.3.2.1.2.B: The 802.11ah draft specification shall have a 4 symbol packet detection section for the 1 MHz mode [11/1482r4, motion2].

1. A 3 dB power boost is only applied for 2x repetition MCS
2. Have same periodicity as 2 MHz STF with following tone allocations:
   1. For 2MHz {±4 ±8 ±12 ±16 ±20 ±24}
   2. For 1MHz {±4 ±8 ±12}.

R.3.2.1.2.C: The 802.11ah draft specification shall have the general preamble structure for 1MHz SU open loop packet as in the figure below [11/1482r4, motion3][Nov 2012 meeting minutes, 11-12/1363r1].

1. The relationship between NSTS and NLTF is the same as 11n/11ac (for 2 through 4 streams), using the same P matrix (for 1 through 4 streams)



R.3.2.1.2.D: The 802.11ah draft specification shall have 1MHz SIG field contents as follows.

|  |  |  |
| --- | --- | --- |
| **SIG Field** | **Bits** | **Comments** |
| STBC | 1 | Same as in 11ac |
| Num STS | 2 | Number of space time streams for SU [12/1085r0, September 2012 meeting minutes] |
| SGI | 1 | Short Guard Interval |
| Coding | 2 | 1st bit is coding type (LDPC/BCC), 2nd bit is for LDPC Nsym ambiguity |
| MCS | 4 | MCS |
| Aggregation bit | 1 | Signals use of AMPDU |
| Length | 9 | Length field (in symbols when aggregation is ON, is in bytes when aggregation is OFF, Mandate AMPDU for packet sizes > 511 bytes |
| Ack Indication | 2 | 00: Ack; 01: BA; 10: No Ack; 11: a frame not ACK, BA or CTS [refer to R.3.2.1.B] |
| Smoothing | 1 | [12/1085r0, September 2012 meeting minutes] |
| NDP Indication | 1 | This bit is used to indicate this frame is a MAC NDP frame. [Nov 2012 meeting g minutes, 11-12/] |
| Doppler | 1 | This bit is used to indicate the traveling pilots usage in the packet. [Nov 2012 meeting minutes, 11-12/1322r0] |
| Reserved | 1 | Some possible uses are MAC bits or any other new features etc. Details TBD |
| CRC | 4 | 4 bits of CRC should be enough |
| Tail | 6 |  |
| **Total** | **36** |  |

* **SIG goes at BPSK-rate ½ -rep 2**
* **No MU transmissions for the 1MHz mode**
* **No AID supported**

1. Bit ordering of 1 MHz SIG field [12/1102r1, September 2012 meeting minutes]



R.3.2.1.2.I: The following CSD table (to be applied Per-Space-Time-Stream) shall be used for the 1 MHz frame format [2012 July meeting minutes, 11-12/83r1:motion1, 4]:

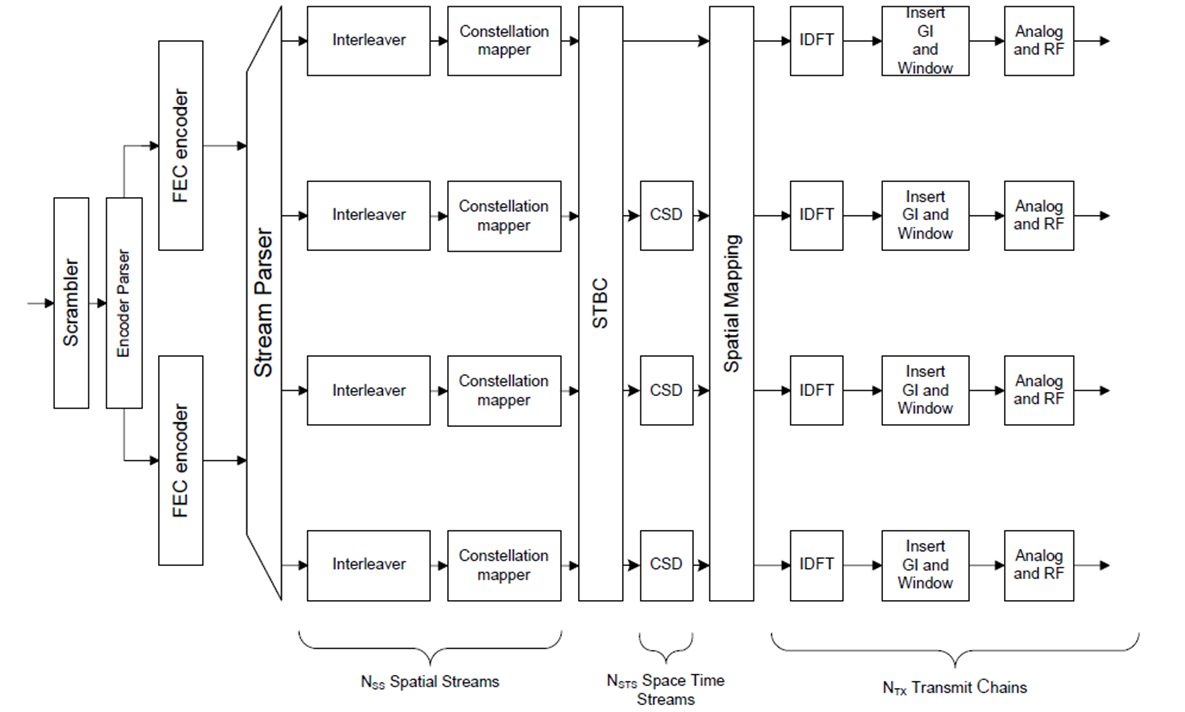
|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| T\_cs(n) for 1MHz Frame Format | | | | |
| Total number of space-time streams | Cyclic shift (for Tx Stream n) (μs) | | | |
| 1 | 2 | 3 | 4 |
| 1 | 0 | - | - | - |
| 2 | 0 | -4 | - | - |
| 3 | 0 | -4 | -1 | - |
| 4 | 0 | -4 | -1 | -5 |

### 3.2.2 Transmission flow

### 3.2.2.1 Transmission flow for 11ah regular non-repetition MCSs

R.3.2.2.1.A: The general transmission flow for 11ah regular non-repetition MCSs is shown below.

* Apply the same Tx flowin 11ac in the data tones for the data field.

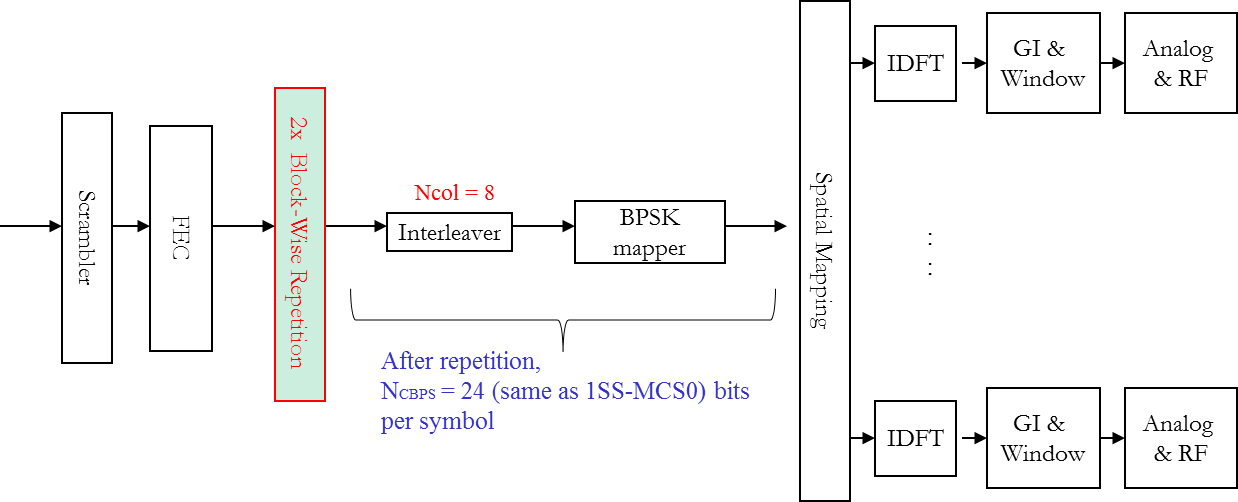


- The 11ah stream parser is the same as 11ac.

- The 11ah encoder parser and segment parser (16MHz only) are the same as 11ac; NES in the MCSs of 2/4/8/16MHz is the same as the corresponding values in 11ac; and NES = 1 in all the MCSs of 1MHz.

### 3.2.2.2 Transmission flow for MCS0-Rep2 mode

R.3.2.2.2.A: The 802.11ah specification framework shall have the following transmission flow for MCS0-Rep2 mode.[12/1484r6]



* MCS0 Rep2 is applied only for single space-time stream.
  + NSS=1, no STBC
* The “2x block-wise repetition”performed on a per-OFDM symbol basis:
  + Cout=[[C1….C2NDBPS ], [C1….C2NDBPS ] XOR s], where [C1….C2NDBPS] are the FEC output bits per symbol and s=[1  0  0  0  0  1  0  1  0  1  1  1]. [Nov 2012 meeting minutes, 11-12/1315r0]
  + Interleaver parameters are the same as regular MCS0.
* Receiver may conduct MRC combining to improve SNR.

### 3.2.2.3 Padding

R.3.2.2.3A: 11ah BCC encoded single user PPDU shall use the following padding flow [July 2012 meeting minutes, 11-12/818r0]:

Step1: Compute NSYM: 

If DURATION is indicated in SIG field: directly send NSYM in LENGTH/DURATION subfield of SIG field.

If LENGTH is indicated in SIG field: directly send PSDU\_LENGTH in number of bytes in LENGTH/DURATION subfield of SIG field.

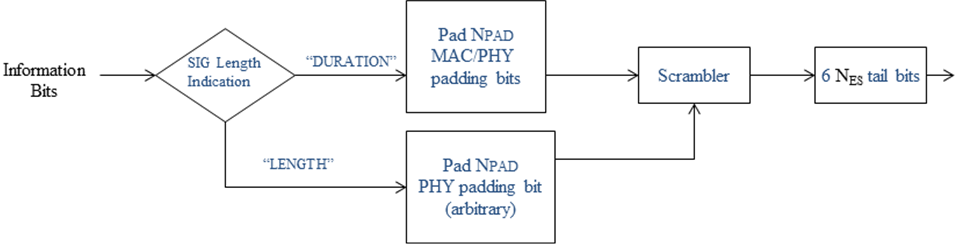
Step 2: Compute NPAD: 

Step 3: Padding:

If DURATION is indicated in SIG field: Right after the PSDU data Pad the MAC AMPDU delimiters till the last integer byte of the NPAD padding bits, then pad the remaining 0~7 PHY padding bits (arbitrary1 or 0 bits)—i.e. same as 11ac padding. Scramble the PSDU and padding bits. The 6.NES BCC tails bits are added at the end of the PPDU.

If LENGTH is indicated in SIG field: Right after the PSDU data, pad the NPAD padding bits (arbitrary 1 or 0 bits). Scramble the PSDU and padding bits. The 6.NES BCC tails bits are added at the end of the PPDU.

The above BCC padding flow is illustrated by the following figure;



R.3.2.2.3.B: 11ah LDPC encoded single user PPDU shall use the following encoding flow [July 2012 meeting minutes, 11-12/818r0]:

Step 1: Compute Npld and Navbits as in 11ac:



Step 2: Padding: compute NPAD: 

If DURATION is indicated in SIG field: Right after the PSDU data, pad the MAC AMPDU delimiters till the last integer byte of the NPAD padding bits, then pad the remaining 0~7 PHY padding bits (regardless of 1 or 0 bits)—i.e. same as 11ac padding. Scramble the PSDU and Padding bits.

If LENGTH is indicated in SIG field: Right after the PSDU data, pad the NPAD padding bits (regardless of 1 or 0 bits). Scramble the PSDU and Padding bits.

Step 3: After Scrambling, conducts the regular LDPC encoding flow as in 11n spec: shortening, puncturing, repetition, and derive updated , hence the updated NSYM, .

Step 4: Setting the SIG Field:

If DURATION is indicated in SIG field: send NSYM in LENGTH/DURATION subfield of SIG field.

If LENGTH is indicated in SIG field: send PSDU\_LENGTH in LENGTH/DURATION subfield of SIG field.

In both cases, if NSYM > NSYM, init, the “additional symbol in LDPC” bit in SIG is set to 1.

For 2/4/8/16MHz LDPC encoded PPDUs, after constellation mapping, apply the 11ac LDPC tone mapper w.r.t. the same FFT sizes. For 1MHz LDPC encoded PPDUs, no LDPC tone mapper is applied.

R.3.2.2.3.C: For 11ah Multiuser PPDUs, the BCC padding and LDPC encoding flows are the same as 11ac. [July 2012 meeting minutes, 11-12/818r0]

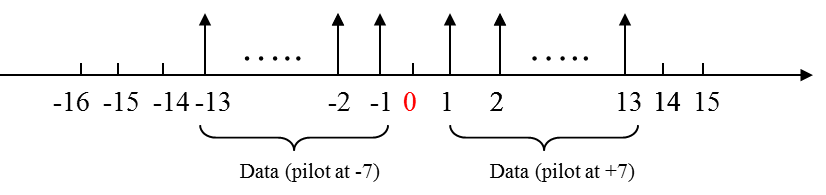
### 3.2.3 Tone plans

**3.2.3.1 >= 2MHz PHY**

R.3.2.3.1.A: >=2MHz follows the same tone plans as the corresponding FFT sizes in 11ac [11/1484r6].

**3.2.3.2 1 MHz PHY**

R.3.2.3.2.A: Define the 1MHz tone allocation as: 24 Data tones, 2 Pilot tones at tone indices +/-7, 3 Guard tones on left and 2 guard tones on right, and 1 DC tone [11/1484r6].



R.3.2.3.2.B: The 802.11ah specification shall use Ncol=8, Nrot=2 as the 32 FFT interleaver choice. [12/369r0, 12/113r0]

### 3.2.4 Duplicate mode

### 3.2.4.1 1 MHz duplicate mode in wider bandwidth

R.3.2.4.1 The draft specification shall define 1 MHz duplicate mode in wider bandwidth: [Nov 2012 meeting minutes, 11-12/1313r0]

1. Preamble and Data portions of 1MHz signal is duplicated in each 1MHz sub-channel of 2MHz/4MHz/8MHz/16MHz.
2. Either 1MHz data PPDU or 1MHz NDP may be duplicated.
3. Phase shift value in each 1MHz sub-channel for PAPR reduction is TBD.

### 3.2.5 S1G PMD receiver specification

### 3.2.5.1 Receiver minimum input sensitivity

R.3.2.5.1.A: The packet error rate (PER) shall be less than 10% for a PSDU length of 256 octets with rate-dependent input levels TBD. [Nov 2012 meeting minutes, 11-12/1326r0]

## 3.3 Modulation and Coding Scheme (MCS)

R.3.3.A: The 802.11ah specification shall allow following 11ah MCSs [11/1484r6]:

1. For 1MHz, 11ac MCS0~9, as well as an MCS0-rep2 mode and more modes TBD.
2. For >=2MHz, the MCS tables for BCC are the same as the corresponding tables in 11ac before downclocking, i.e. same MCS exclusions for BCC as in 11ac.

R.3.3.B: The 802.11ah specification shall adopt MCS0 rep 2 as the lowest rate for 1 MHz [11/1484r4, motion1].

1. MCS0~9, same constellation sizes and coding rates as defined in 802.11ac [12/1085r0, September 2012 meeting minutes]
2. MCS10, BPSK, rate ½, and 2x repetition [12/1085r0, September 2012 meeting minutes]

## 3.4 Spatial Multiplexing

R.3.4.1.A: The maximum number of space-time streams (NSTS) in a data PPDU transmission shall be less than or equal to 4. [11/1275r1]

## 3.5 Transmit Beamforming

R.3.5.A: The 802.11ah specification shall support, for all applicable BW, the SUBF and MU-MIMO feedback structure and protocol as specified in the following sections of IEEE P802.11ac™/D2.0, as an optional feature [12/371r0] [Nov 2012 meeting minutes, 11-12/1312r0]:

* 8.4.1.46 VHT MIMO Control field
* 8.4.1.47 VHT Compressed Beamforming Report field - contents of feedback frame
* 8.4.1.48 MU Exclusive Beamforming Report field - contents of MU frame
* 9.31.5 VHT sounding protocol
* 22.3.11 and its subsections: SU-MIMO and MU-MIMO Beamforming
* Tone grouping values (Ng) and the corresponding tone map for each Ng when bandwidth >=2MHz are the same as in 11ac with the same FFT sizes.
* For MU feedback, and SU feedback with Nc>1, angle alignment, angle quantization bitwidth and the definition of the codebook info subfield of VHT MIMO Control field are the same as in 11ac.
* For SU feedback with Nc=1, modify the codebook info subfield of VHT MIMO control field as below:
  + Set to 0 for 2 bits for ϕ, and ψ is not fed back.
  + Set to 1 for 2 bits for ψ, and 4 bits for ϕ.
* The angle alignment table is as below.
* Beamformer shall be capable of receiving and processing a beamforming feedback frame with any tone grouping and angle quantization bitwidth.
* When the ψ angle is not included in the feedback frame, in the case of SU feedback Nc=1, ψ angle values are assumed as given below, which correspond to the first column of the V matrix having elements with equal magnitude:



|  |  |  |  |
| --- | --- | --- | --- |
|  | Order of angles in the Compressed Beamforming Feedback Matrix subfield if the Feedback Type is SU | | |
| Size of *V* (*Nr × Nc*) | Codebook Information Field | Number of angles (*Na*) | The order of angles in the Compressed Beamforming Feedback Matrix subfield |
| 2×1 | 0 | 1 | 11 |
| 2×1 | 1 | 2 | 11, 21 |
| 2×2 | 0 or 1 | 2 | 11, 21 |
| 3×1 | 0 | 2 | 11, 21 |
| 3×1 | 1 | 4 | 11, 21, 21, 31 |
| 3×2 | 0 or 1 | 6 | 11, 21, 21, 31, 22, 32 |
| 3×3 | 0 or 1 | 6 | 11, 21, 21, 31, 22, 32 |
| 4×1 | 0 | 3 | 11, 21, 31 |
| 4×1 | 1 | 6 | 11, 21, 31, 21, 31, 41 |
| 4×2 | 0 or 1 | 10 | 11, 21, 31, 21, 31, 41, 22, 32, 32, 42 |
| 4×3 | 0 or 1 | 12 | 11, 21, 31, 21, 31, 41, 22, 32, 32, 42, 33, 43 |
| 4×4 | 0 or 1 | 12 | 11, 21, 31, 21, 31, 41, 22, 32, 32, 42, 33, 43 |

|  |  |  |  |
| --- | --- | --- | --- |
|  | Order of angles in the Compressed Beamforming Feedback Matrix subfield if the Feedback Type is MU | | |
| Size of *V* (*Nr × Nc*) | Codebook Information Field | Number of angles (*Na*) | The order of angles in the Compressed Beamforming Feedback Matrix subfield |
| 2×1 | 0 or 1 | 2 | 11, 21 |
| 2×2 | 0 or 1 | 2 | 11, 21 |
| 3×1 | 0 or 1 | 4 | 11, 21, 21, 31 |
| 3×2 | 0 or 1 | 6 | 11, 21, 21, 31, 22, 32 |
| 3×3 | 0 or 1 | 6 | 11, 21, 21, 31, 22, 32 |
| 4×1 | 0 or 1 | 6 | 11, 21, 31, 21, 31, 41 |
| 4×2 | 0 or 1 | 10 | 11, 21, 31, 21, 31, 41, 22, 32, 32, 42 |
| 4×3 | 0 or 1 | 12 | 11, 21, 31, 21, 31, 41, 22, 32, 32, 42, 33, 43 |
| 4×4 | 0 or 1 | 12 | 11, 21, 31, 21, 31, 41, 22, 32, 32, 42, 33, 43 |

## 3.6 Spatial Mapping Matrix

The auto-detection between 1MHz and 2MHz preambles as described in sub-section 2a of section R.3.2.1.1.C assumes channel smoothness. It is recommended that the spatial mapping matrix Q applied to LTF1 is chosen such that it preserves the smoothness of the physical channel. This can, for example, be achieved by minimizing the amplitude and phase variation of each element of Q in successive tones. [July 2012 meeting minutes, 11-12/815r0]

Examples:

1. The following Q may be used: Q as defined for cyclic shift diversity using the values specified in the corresponding tables.
2. The following Q should not be used – antenna hopping as described in 802.11REVmb section 20.3.11.11.2 (C)-(2) - the values of Q on successive tones flip between 1 and 0.

## 3.7 Traveling Pilots

R.3.7.A: Traveling pilots are an optional feature used to improve channel estimation under high Doppler scenarios. [Nov 2012 meeting minutes, 11-12/1322r0]

R.3.7.B: Support for traveling pilots receive capability shall be indicated by two bits – the first indicating one space time stream and the second two space time stream. [Nov 2012 meeting minutes, 11-12/1322r0]

R.3.7.C: Traveling pilots design [Nov 2012 meeting minutes, 11-12/1322r0]

1. 32FFT
   1. Nsts=1

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Pilot Index \ Pattern Index | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| 0 | -2 | -10 | -5 | -13 | -8 | -3 | -11 | -6 | -1 | -9 | -4 | -12 | -7 |
| 1 | 12 | 4 | 9 | 1 | 6 | 11 | 3 | 8 | 13 | 5 | 10 | 2 | 7 |

* 1. STBC for Nsts=2 (cover odd tones)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Pilot Index \ Pattern Index | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
| 0 | -3 | -13 | -9 | -5 | -1 | -11 | -7 |
| 1 | 11 | 1 | 5 | 9 | 13 | 3 | 7 |

1. 64FFT
   1. Nsts=1

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Pilot Index \Pattern Index | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| 0 | -28 | -24 | -20 | -16 | -26 | -22 | -18 | -27 | -23 | -19 | -15 | -25 | -21 | -17 |
| 1 | -12 | -8 | -4 | -2 | -14 | -10 | -6 | -11 | -7 | -3 | 1 | -13 | -9 | -5 |
| 2 | 4 | 8 | 12 | 16 | 2 | 6 | 10 | 5 | 9 | 13 | 17 | -1 | 3 | 7 |
| 3 | 20 | 24 | 28 | 26 | 14 | 18 | 22 | 21 | 25 | 23 | 27 | 11 | 15 | 19 |

* 1. STBC for Nsts=2 (cover odd tones)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Pilot Index \Pattern Index | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
| 0 | -28 | -24 | -20 | -16 | -26 | -22 | -18 |
| 1 | -12 | -8 | -4 | -2 | -14 | -10 | -6 |
| 2 | 4 | 8 | 12 | 16 | 2 | 6 | 10 |
| 3 | 20 | 24 | 28 | 26 | 14 | 18 | 22 |

1. 128FFT
   1. Nsts=1

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Pilot Index \Pattern Index | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
| 0 | -49 | -41 | -33 | -25 | -17 | -9 | -58 | -50 | -42 | -34 | -26 | -18 | -10 | -2 | -51 | -43 | -35 | -27 | -19 |
| 1 | -30 | -22 | -14 | -6 | -55 | -47 | -39 | -31 | -23 | -15 | -7 | -56 | -48 | -40 | -32 | -24 | -16 | -8 | -57 |
| 2 | -11 | -3 | -52 | -44 | -36 | -28 | -20 | -12 | -4 | -53 | -45 | -37 | -29 | -21 | -13 | -5 | -54 | -46 | -38 |
| 3 | 11 | 19 | 27 | 35 | 43 | 51 | 2 | 10 | 18 | 26 | 34 | 42 | 50 | 58 | 9 | 17 | 25 | 33 | 41 |
| 4 | 30 | 38 | 46 | 54 | 5 | 13 | 21 | 29 | 37 | 45 | 53 | 4 | 12 | 20 | 28 | 36 | 44 | 52 | 3 |
| 5 | 49 | 57 | 8 | 16 | 24 | 32 | 40 | 48 | 56 | 7 | 15 | 23 | 31 | 39 | 47 | 55 | 6 | 14 | 22 |

* 1. STBC for Nsts=2 (cover odd tones)

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Pilot Index \Pattern Index | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| 0 | -50 | -44 | -38 | -32 | -26 | -20 | -14 | -8 | -2 | -56 |
| 1 | -30 | -24 | -18 | -12 | -6 | -58 | -54 | -48 | -42 | -36 |
| 2 | -10 | -4 | -58 | -52 | -46 | -40 | -34 | -28 | -22 | -16 |
| 3 | 10 | 16 | 22 | 28 | 34 | 40 | 46 | 52 | 58 | 4 |
| 4 | 30 | 36 | 42 | 48 | 54 | 58 | 6 | 12 | 18 | 24 |
| 5 | 50 | 56 | 2 | 8 | 14 | 20 | 26 | 32 | 38 | 44 |

1. 256FFT
   1. Nsts=1

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Pattern Index \ Pilot Index | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
| 0 | -122 | -118 | -114 | -110 | -106 | -102 | -98 | -94 | -120 | -116 | -112 | -108 | -104 | -100 | -96 | -92 | -121 | -117 | -113 | -109 | -105 | -101 | -97 | -93 | -119 | -115 | -111 | -107 | -103 | -99 | -95 | -91 |
| 1 | -90 | -86 | -82 | -78 | -74 | -70 | -66 | -62 | -88 | -84 | -80 | -76 | -72 | -68 | -64 | -60 | -89 | -85 | -81 | -77 | -73 | -69 | -65 | -61 | -87 | -83 | -79 | -75 | -71 | -67 | -63 | -59 |
| 2 | -58 | -54 | -50 | -46 | -42 | -38 | -34 | -30 | -56 | -52 | -48 | -44 | -40 | -36 | -32 | -28 | -57 | -53 | -49 | -45 | -41 | -37 | -33 | -29 | -55 | -51 | -47 | -43 | -39 | -35 | -31 | -27 |
| 3 | -26 | -22 | -18 | -14 | -10 | -6 | -2 | 2 | -24 | -20 | -16 | -12 | -8 | -4 | 2 | 4 | -25 | -21 | -17 | -13 | -9 | -5 | -2 | 3 | -23 | -19 | -15 | -11 | -7 | -3 | 2 | 5 |
| 4 | 6 | 10 | 14 | 18 | 22 | 26 | 30 | 34 | 8 | 12 | 16 | 20 | 24 | 28 | 32 | 36 | 7 | 11 | 15 | 19 | 23 | 27 | 31 | 35 | 9 | 13 | 17 | 21 | 25 | 29 | 33 | 37 |
| 5 | 38 | 42 | 46 | 50 | 54 | 58 | 62 | 66 | 40 | 44 | 48 | 52 | 56 | 60 | 64 | 68 | 39 | 43 | 47 | 51 | 55 | 59 | 63 | 67 | 41 | 45 | 49 | 53 | 57 | 61 | 65 | 69 |
| 6 | 70 | 74 | 78 | 82 | 86 | 90 | 94 | 98 | 72 | 76 | 80 | 84 | 88 | 92 | 96 | 100 | 71 | 75 | 79 | 83 | 87 | 91 | 95 | 99 | 73 | 77 | 81 | 85 | 89 | 93 | 97 | 101 |
| 7 | 102 | 106 | 110 | 114 | 118 | 122 | 120 | -120 | 104 | 108 | 112 | 116 | 120 | 122 | -2 | -122 | 103 | 107 | 111 | 115 | 119 | 121 | 2 | -121 | 105 | 109 | 113 | 117 | 121 | 121 | -2 | -121 |

* 1. STBC for Nsts=2 (cover odd tones)

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Pilot Index \ Pattern Index | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| 0 | -122 | -118 | -114 | -110 | -106 | -102 | -98 | -94 | -120 | -116 | -112 | -108 | -104 | -100 | -96 | -92 |
| 1 | -90 | -86 | -82 | -78 | -74 | -70 | -66 | -62 | -88 | -84 | -80 | -76 | -72 | -68 | -64 | -60 |
| 2 | -58 | -54 | -50 | -46 | -42 | -38 | -34 | -30 | -56 | -52 | -48 | -44 | -40 | -36 | -32 | -28 |
| 3 | -26 | -22 | -18 | -14 | -10 | -6 | -2 | 2 | -24 | -20 | -16 | -12 | -8 | -4 | 2 | 4 |
| 4 | 6 | 10 | 14 | 18 | 22 | 26 | 30 | 34 | 8 | 12 | 16 | 20 | 24 | 28 | 32 | 36 |
| 5 | 38 | 42 | 46 | 50 | 54 | 58 | 62 | 66 | 40 | 44 | 48 | 52 | 56 | 60 | 64 | 68 |
| 6 | 70 | 74 | 78 | 82 | 86 | 90 | 94 | 98 | 72 | 76 | 80 | 84 | 88 | 92 | 96 | 100 |
| 7 | 102 | 106 | 110 | 114 | 118 | 122 | 120 | -120 | 104 | 108 | 112 | 116 | 120 | 122 | -2 | -122 |

R.3.7.D: Modulation of the traveling pilots [Nov 2012 meeting minutes, 11-12/1322r0]

1. For single space time stream, traveling pilots in data field are modulated the same way as fixed pilots in data field (with the exception of boosting by a factor of 1.5).



1. For STBC, the traveling pilots tones across two consecutive data symbols are modulated the same way as the data tones in LTF.



## 3.8 Timing-Related Constants

R.3.8.A: The draft specification shall include the following timing-related constants: [Nov 2012 meeting minutes, 11-12/1363r1]

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Parameter** | **CBW1** | **CBW2** | **CBW4** | **CBW8** | **CBW16** | **Description** |
| *NSD* | 24 | 52 | 108 | 234 | 468 | Number of data subcarriers per OFDM symbol |
| *NSP* | 2 | 4 | 6 | 8 | 16 | Number of pilot subcarrier per OFDM symbol |
| *NST* | 26 | 56 | 114 | 242 | 484 | Total number of useful subcarriers per OFDM symbol |
| *NSR* | 13 | 28 | 58 | 122 | 250 | Highest data subcarrier index per OFDM symbol |
| Δ*F* | 31.25 kHz | | | | | Subcarrier frequency spacing |
| *TDFT* | 32 μs = 1/Δ*F* | | | | | IDFT/DFT period |
| *TGI* | 8μs *= TDFT*/4 | | | | | Guard interval duration |
| *TDGI* | 16μs | | | | | Double guard interval |
| *TSGI* | 4μs *= TDFT*/8 | | | | | Short guard interval duration |
| *TSYML* | 40μs *= TDFT + TGI =* 1.25 × *TDFT* | | | | | Duration of OFDM symbol with normal guard interval |
| *TSYMS* | 36μs *= TDFT + TGIS =* 1.125 × *TDFT* | | | | | Duration of OFDM symbol with short guard interval |
| *TSYM* | *TSYML* or *TSYMS* depending on the GI used | | | | | OFDM symbol duration |
| *TSTF* | 160μs *=* 4 × *TSYML* | 80μs *=* 2 × *TSYML* | | | | STF field duration |
| *TDSTF* | n.a. | 40μs *= TSYML* | | | | ≥2 MHz long preamble D-STF field duration |
| *TLTF1* | 160μs *=* 4 × *TDFT* + 2 × *TGI* + *TGI2* | 80μs *=* 2 × *TDFT* + *TGI2* | | | | First LTF field duration |
| *TLTFs* | 40μs *= TSYML* | | | | | Second and subsequent LTF field duration |
| *TDLTF* | n.a. | 40μs *= TSYML* | | | | ≥2 MHz long preamble D-LTF field duration |
| *TSIG* | 240μs *=* 6 × *TSYML* | 80μs *=* 2 × *TSYML* | | | | SIG field duration |
| *TSIGA* | n.a. | 80μs *=* 2 × *TSYML* | | | | ≥2 MHz long preamble SIGA field duration |
| *TSIGB* | n.a. | 40μs *= TSYML* | | | | ≥2 MHz long preamble SIGB field duration |

## 3.9 S1G PLME

### 3.9.1 PHY characteristics

[12/1104r2, September 2012 meeting minutes]

|  |  |
| --- | --- |
| **Characteristics** | **Value** |
| aSlotTime | 52 us |
| aCCATime | 40 us |
| aAirPropagationTime | 6 us |
| aSIFSTime | 160 us |

# 4 MAC Layer

This section describes the functional blocks of the MAC layer.

## 4.1 Power Save

R.4.1.A: An AP may provide its TSF timer accuracy information to non-AP STAs [12/130r0]**.**

R.4.1.B: The 802.11ah draft specification shall define the following operation mode. [12/127r1]

1. STA may send a PS-Poll at any time
2. AP shall respond immediately to a PS Poll with either
   1. Data for the requesting STA, or
   2. ACK frame with 1bit-field indicating
      1. 1: traffic is buffered (as indicated in the TIM map), stay awake (i.e. a service period starts)
      2. 0: no traffic is buffered, go back to sleep
      3. The bit used in current ACK frame format is the More Data field

R.4.1.C: The draft specification shall support that BSS Max Idle Period shall be able to set to a longer value (~days) by changing the unit of Max Idle Period larger than 1000 TU (1s). [May 2012 meeting minutes].

1. An AP advertises its capability of supporting “very long Max Idle Period” in probe response frame and beacon frame as an IE [July 2012 meeting minutes, 11-12/845r0]
2. A STA includes its preferred Max Idle Period value in the (Re) Association Request frame, the AP select one of its supported Max Idle Period based on the STA’s preferred Max Idle Period value, and indicates its accepted value to the STA in the (Re)Association Response frame [July 2012 meeting minutes, 11-12/845r0]

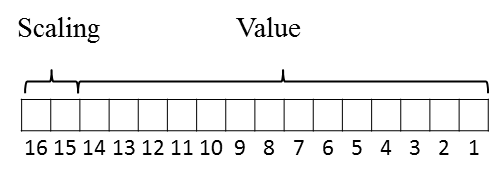
R.4.1.D: The draft specification shall support that the AP shall be able to support multiple Max Idle Periods. [May 2012 meeting minutes]

R.4.1.E: The draft specification shall support the concept that a non-TIM STA shall transmit at least one PS-Poll or trigger frame every Listen Interval and the non-TIM STA is not required to wake to receive a beacon each Listen Interval. [May 2012 meeting minutes, 12/618r0]

R.4.1.F: The draft specification shall support that an AP may reply to the PS-Poll with a timer indicating the re-scheduling of doze/awake time. [July 2012 meeting minutes, 11-12/409r6]

* Re-scheduling doze/awake time
  + PS-Poll not followed by DATA or immediate ACK, AP replies to STA with a timer indicating when it should wake up again
  + The timer is considered short enough without causing too much clock drift
  + The reply may contain traffic indication for STAs
    - If PS-Polling STA knows no buffered frame, it goes to sleep
    - If PS-Polling STA knows buffered frame for itself, it may go to sleep and wake up again after timer expires
    - Other STAs may make use of this timer
  + STA can re-sync to the beacon with the help of the timer
  + AP determines to use the protocol [11-12/127r1] or this proposed scheme

R.4.1.G: The draft specification shall define a mechanism to extend the BSS Max Idle Period, Listen Interval and WNM-Sleep Interval by introducing unified scaling factors i.e. using the first two MSBs to represent the Scaling Factor (SF) and the remaining 14 bits to indicate the actual value. [12/656r1, September 2012 meeting minutes]



1. The definition of the unified scaling factors are shown in the table below:

|  |  |
| --- | --- |
| Two MSBs | Scaling Factor (SF) |
| 00 | 1 |
| 01 | 10 |
| 10 | 1000 |
| 11 | 10000 |

R.4.1.H: The draft specification shall define a frame classification mechanism to enable classification and the subsequent processing (e.g., filtering) based on the MAC Header content. [12/1089r0, September 2012 meeting minutes]

## 4.2 Channel Access

R4.2.A: The draft specification shall support the highest channel access priority to the sensor type of STAs [May 2012 meeting minutes, 1230r1].

1. The draft specification shall support the concept of defining multiple EDCA parameters sets (signaling TBD; per STA/Type/group TBD). [July 2012 meeting minutes, 11-12/861r0]

R.4.2.B: The draft specification shall support the concept of utilizing information from an AP to spread out uplink transmissions over a period of time to mitigate the hidden node problem [May 2012 meeting minutes, 12/606r1]

R.4.2.C: Grouping of STAs shall be introduced to the draft specification for controlling the number of STAs performing channel access and to save energy. [May 2012 meeting minutes, 12/650r0]

R.4.2.D: The draft specification shall include a mechanism to set wake times and intervals for clients [July 2012 meeting minutes, 12/823r0]

R.4.2.E: The draft specification shall define synch frame procedures as follows:

1. When requested by a STA, the AP sends a synch frame at the slot boundary or the target wake time of the STA, if the channel is idle, to help the STA quickly synch to the medium. (optional to AP and STA) [July 2012 meeting minutes, 11-12/840r0]
   1. It is recommended that the AP sends a Short CTS frame defined in 4.4.2.3 as a synch frame. [12/840r1, September 2012 meeting minutes]
2. When requested by a STA, the AP schedules a DL (downlink) synch frame at the slot boundary or the target wake time of the STA as the next frame for transmission [Nov 2012 meeting minutes, 11-12/1324r0]
   1. Synch frame is an NDP frame including at least
      1. (Partial) identifier of the target STA(s)/group of STAs (# bits TBD)
      2. BU present (1 bit)
      3. Partial TSF (# bits TBD)
      4. Check beacon (# bits TBD)

R.4.2.F: The draft specification shall include the concept of speed frame exchange and use of More Data field. [July 2012 meeting minutes, 11-12/834r0]

1. For speed frame exchange, when AP receives More Data set to 0 from a non-AP STA and AP has remaining BU for this STA, the AP may indicate [Nov 2012 meeting minutes, 11-12/1329r0]
   * More Data to 1, Ack Indication to 11 in ACK, and STA shall stay awake for downlink transmissions from AP after SIFS
   * More Data to 1, Ack Indication to 10 in ACK, and STA shall stay awake until AP sends downlink transmissions
   * More Data to 0, Ack Indication to 10 in ACK, and STA may go back to sleep
2. A PS-Poll frame is allowed as the first up link frame in speed frame exchange [Nov 2012 meeting minutes, 11-12/1325r1]

R.4.2.G: AP may indicate to TIM STAs RAW information during which no TIM STA is allowed to contend. [July 2012 meeting minutes, 11-12/867r0]

1. Periodic Restricted Access Window (PRAW) [Nov 2012 meeting minutes, 11-12/1311r0]
   1. AP allocates resource for group of scheduled active polling STAs and indicates the resource allocation once in a long while.
      1. Not indicated in every short beacon frame (E.g., once in every long beacon frame)
   2. Once PRAW is setup, AP allocates the resource periodically to a group of scheduled active polling STAs.
   3. Allocated resource for PRAW will not be changed until updated PRAW information is broadcasted.
   4. Resource for scheduled active polling STAs can be allocated within the PRAW duration.
      1. Whenever scheduled active polling STA has data packet to send, it wakes up at its designated slot within the PRAW and send the packet after basic CCA.
   5. TIM STAs are not allowed to access the channel during this window.
   6. Within PRAW, each STA follows EDCA based channel access scheme.

R.4.2.H: AP may indicate a window in beacon, and during that window offloading STAs can not access medium to send uplink data. [July 2012 meeting minutes, 11-12/892r0]

R.4.2.I: The 11ah should support a mode of operation where only a selected group of stations is allowed to transmit during a specified time interval. When a STA finds that belongs to a transmission group it shall transmit only in the time interval reserved for that group and not transmit in the time interval allocated to another group. [July 2012 meeting minutes, 61]

1. The transmission group may be identified by a group ID and a group definition field that identifies a logical grouping (such as an AID range of addresses) or a physical grouping, for example using an antenna beam pattern. [July 2012 meeting minutes, 61]
2. The transmission group definition field, the time interval reserved for the group transmission and its repetition period or the time till the next transmission may be advertised via (short) beacons, probe response or another management frame TBD. [July 2012 meeting minutes, 61]
3. A STA may optionally feedback sector/group ID to AP and AP to associate the STA with a specific group based on STA’s sector. [12/1103r0, September 2012 meeting minutes]

R.4.2.J: The draft specification shall support the separation between BSS Sensor Only, Offloading Only, and BSS Mixed mode. [12/1083r0, September 2012 meeting minutes]

1. Identification of STA device types: Sensor Only, Offloading Only, and Mixed Mode STAs
2. The Sensor/Offload/Mixed BSS type is provided in beacons/Probe Response frame

R.4.2.K: A STA may transmit an immediate Block ACK with lower (or more robust) modulation and coding rate than that of the eliciting AMPDU [12/662r3, September 2012 meeting minutes]

1. The STA informs the AP the preferred MCS for downlink (indication format TBD) in the ADDBA response and the AP notes uplink MCS used by the STA and records the MCS difference for computing the duration of an immediate BA. [Nov 2012 meeting minutes, 11-12/662r4]

R.4.2.L: AP should be able to limit the number of STA to be authenticated/associated at the same time. [12/112r4, September 2012 meeting minutes]

1. AP is allowed to broadcast a value in the beacon to control the authentication/association of STA.

R.4.2.M: An active polling STA can solicit the information listed below from an AP upon waking up. AP may provide the information immediately or suggest the STA to check beacons. [12/1101r1, September 2012 meeting minutes]

1. BSS change sequence (one byte)
2. Current timestamp

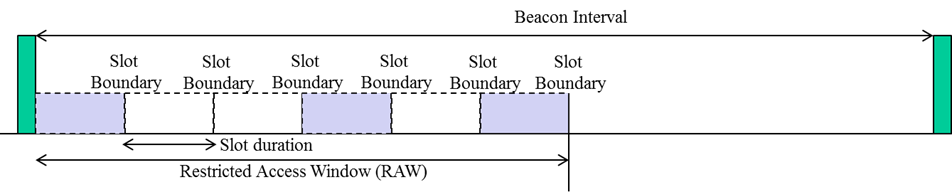
R.4.2.N: A low power mode QoS STA shall use AC\_VO to send PS-Poll frame as the default setting. [Nov 2012 meeting minutes, 11-12/1310r1]

1. The AP may inform the low-power mode QoS STA of the access category for sending PS-Poll frames at Beacon and Probe Response frames, overwriting the default value.
2. The AP and a low power mode QoS STA may negotiate the access category of sending PS-Poll frame through association request/response frame or later through a management frame exchange.
3. Upon receiving a PS-Poll, AP may use RTS/CTS protection scheme to send buffered data until no more data or TXOP limit which comes first. The RTS shall be regarded as the immediate acknowledgement to PS-Poll.

### 4.2.1 Uplink Channel Access

R. 4.2.1.A: General procedure [2012 July meeting minutes, 11-12/831r0]

1. A Restricted Access Window (RAW) is divided in time slots.
2. STA wakes up at TBTT and it listens to a Beacon frame that indicates the slot duration for each Restricted Access Window (RAW).
   1. Slot duration for each RAW may be different
3. STA determines its channel access slot assigned by AP.
4. STA may sleep before its channel access slot.
5. STA shall start to access the channel at the slot boundary of its channel access slot based on EDCA.
6. AP indicates whether the following TXOP rule is applied in each RAW:
   1. A TXOP or transmission within a TXOP shall not extend across a slot boundary
   2. If the above TXOP rule is applied, the STA does not wait for ProbeDelay when waking up at the slot boundary.



### 4.2.2 Downlink Buffered BU Delivery Procedure

R.4.2.2.A: Procedure [2012 July meeting minutes, 11-12/831r0]

1. AP may indicate to a paged STA a channel access slot after which the STA is allowed to contend
   1. Preferred an implicit indication, based on TIM, so that the Beacon is not overloaded
      1. Paged STA starts the contention at slot boundary defined as a function of STA position in the TIM IE and additional info determined by Association or Beacon frame. [July 2012 meeting minutes, 11-12/860r0]
   2. Additional information [TBD] for determining a RAW duration may be needed in (short) Beacon
2. After receiving TIM, STA transmits the PS-Poll/Trigger frames to a AP not earlier than the slot boundary of its channel access slot based on EDCA
3. AP may indicate to a paged STA, that it will be sending traffic to a STA not earlier than a given downlink BU delivery slot.
   1. Indication of the downlink BU delivery slot should not overload the beacon
      1. New management frame indicates the downlink BU delivery slot per each STA after all PS-Poll/Trigger frame transmission completed.
4. AP may protect the PS-Poll/Trigger frames by setting the NAV
   1. The paged STAs can ignore the NAV set by the AP. If NAV is set, then only paged STAs can send PS-Poll/Trigger frames during the RAW

### 4.2.3 Uplink Frame Delivery Procedure

R.4.2.3.A: Procedure [2012 July meeting minutes, 11-12/831r0]

1. AP may allow a STA/group-of-STA to transmit an uplink frame anytime.
2. AP may assign to each STA/group-of-STA a channel access slot at which the STA is allowed **to** contend through a Beacon frame
   1. STA wakes up at TBTT and it listens to a Beacon frame
   2. STA determines its channel access slot through the Beacon frame
   3. STA starts to access the channel not earlier than the slot boundary of its channel access slot; access is based on EDCA.
3. When requested by a STA, AP may assign to the STA a channel access slot at which the STA is allowed to contend, at association or later through a management frame exchange
   1. STA starts to access the channel not earlier than its slot boundary of its channel access slot; access is based on EDCA.

### 4.2.4 RAW slot assignment procedure

R.4.2.4.A: Procedure [2012 Nov meeting minutes, 11-12/1321r0]

1. Define a field in the slot definition field that indicates the slot duration (TS)
2. Derive NRAW by dividing the RAW duration (TRAW) with the slot duration (TS)
   1. i.e. NRAW = TRAW/TS
3. Define a STA-Slot mapping function :
   1. = *i* (the slot index assigned to a STA)
   2. If the RAW is for both paged and unpaged STAs
      1. *x* is the AID of a STA
   3. If the RAW is restricted to paged STAs only
      1. *x* is the position index of a paged STA among all the paged STAs when sequentially arranged based on their AIDs
         1. For example, if there are *n* paged STAs in front of the paged STA, *x*=n (assuming that the first paged STA’s bit position is defined to be *x*=0).
   4. is an offset value in the mapping function that is provided to address fairness among the STAs indicated in the TIM
      1. Use an existing field of the received Beacon frame for (e.g. Timestamp, FCS)
   5. indicates the modulo operation

### 4.2.5 TXOP truncation

R.4.2.5.A: CF-END rule [Nov 2012 meeting minutes, 11-12/1302r0]

1. Duration field value of CF-END frame is set to either zero or a truncated time.
2. *If* the Duration field value of the received CF-END frame is set to zero, *then* all STAs reset its NAV.
3. *Else if* the Duration field of the received CF-END frame is matched with the local NAV of a STA, *then* the STA resets its NAV.
   1. The matching condition allows for a tolerance of +/-TBD microsecond.
4. *Else* the received CF-END frame is discarded.

## 4.3 Large Number of STAs Support

### 4.3.1 Traffic Indication Map (TIM) operation

R.4.3.1.A: The complete traffic indication bitmap shall be divided into one or more segments and transmitting in one or more TIM elements for a large network [12/117r0].

R.4.3.1.B: When the complete traffic indication bitmap is divided into multiple segments, the range of the AIDs (bitmap) each segment is covering shall be known to the STAs [12/117r0].

R.4.3.1.C: 11ah STAs can choose not to have a TIM entry for the DL traffic signalling. For these stations, the AP will store the DL data and deliver it when the STA request it. [May 2012 meeting minutes, 12/610r0-motion 1]

R.4.3.1.D: 11ah STAs shall inform AP if they do not need a TIM entry for the DL signalling during the association process. [May 2012 meeting minutes, 12/610r0-motion2]

R.4.3.1.E: A STA can switch between TIM mode (STAs have a TIM entry) and non-TIM mode (STAs do not have a TIM entry) during operation. [July 2012 meeting minutes, 11-12/891]

1. AP may reassign a new AID to STA when it switches between TIM mode and non-TIM mode
2. TIM mode switch notify procedure [Nov 2012 meeting minutes, 11-12/1304r0 ]
   1. A STA transmits an AID Switch Request frame to an AP to inform the switch between TIM mode and non-TIM mode
   2. After receiving the AID Switch Request frame, the AP shall transmits an AID Switch Response frame to the STA

R.4.3.1.F: AP and STA inform each other their capability of supporting Non-TIM mode in association procedure with a non-TIM support field in Extended Capabilities element. [Nov 2012 meeting minutes, 11-12/1309r1]

1. STA carries a “Non-TIM” indication in Association Request frame to inform AP whether it supports Non-TIM mode.
2. Upon receiving STA's Association Request frame with Non-TIM indication, AP confirms STA whether it allows the STA entering Non-TIM mode in Association Response frame.

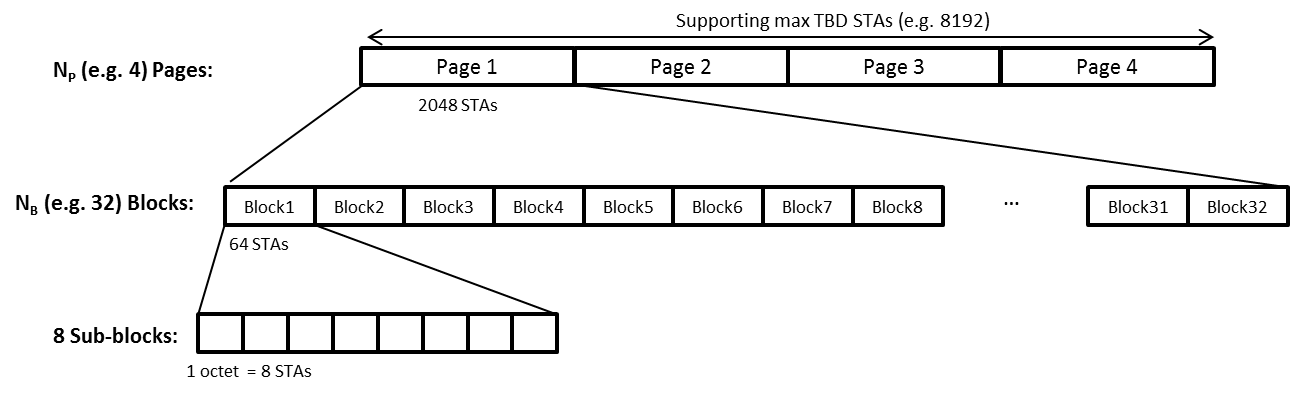
|  |  |  |
| --- | --- | --- |
| Bit | Information | Note |
|  | Non-TIM support | For non-AP STA:  0: STA does not support Non-TIM mode, it needs TIM entry as in legacy PS mode  1: STA request Non-TIM mode and it does not need TIM entry when in Non-TIM mode  For AP:  0: AP does not support STA ‘s Non-TIM mode  1: AP can support STA ‘s Non-TIM mode |

1. AP may recommend a value of listen interval different from that in Association Request frame based on its buffer management consideration in Association Response frame.
2. If a STA is NOT allowed to be in Non-TIM mode through negotiating by association procedure, the STA shall work in TIM mode.

### 4.3.2 TIM structure

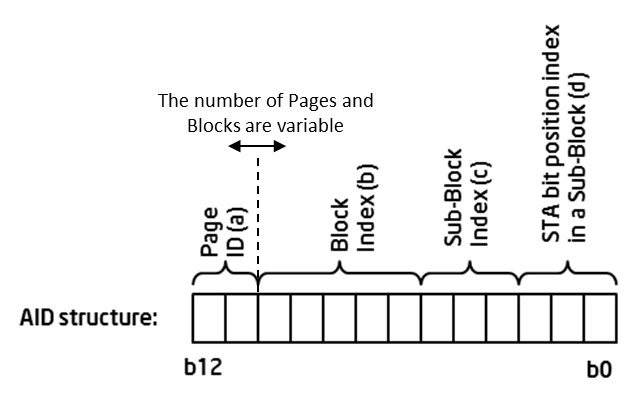
R.4.3.2.A: TIM shall have the three level hierarchical structure shown in the below figure [May 2012 meeting minutes, 12/388r2].

- Three level hierarchy: Page/Block/Sub-Block:



R.4.3.2.B: Based on the TIM structure shown in R.4.3.2.A, the association identifier (AID) structure shall be maintained as the below figure [May 2012 meeting minutes, 12/388r2].

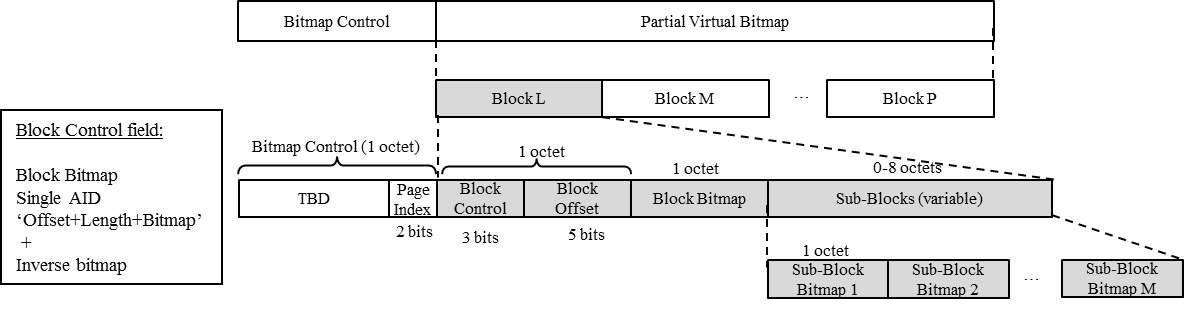
- STAs are grouped into Page, Blocks, Sub-Blocks:



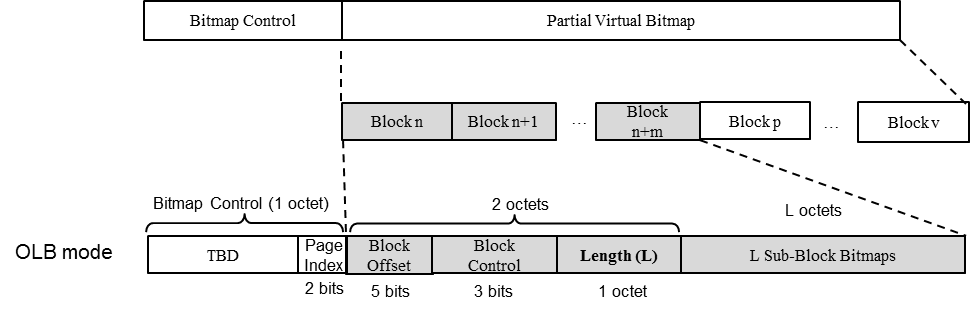
### 4.3.3 TIM encoding

R.4.3.3.A: The Partial Virtual Bitmap field shall be encoded in Block level as shown in the below figure [May 2012 meeting minutes, 12/388r2].

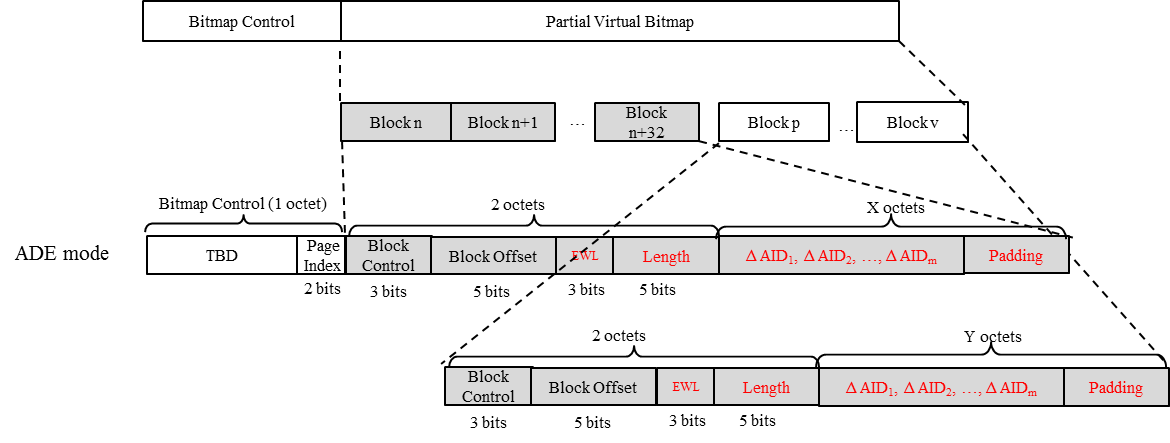
* Partial Virtual Bitmap consists of one or more encoded Blocks of a single Page.
* Basic Block encoding: Block Offset (5 bits) + Block Control(3 bits) + Block Bitmap (1 octet) + Sub-Block Bitmaps (variable)
* Block Control field: controls how the Block Bitmap and the Sub-Block Bitmap fields are used
  1. Block bitmap encoding: AID = [Page Index(2b), Block Offset(5b), n(3b), m(3b)]
     + The n-th bit position of the Block Bitmap indicates whether the n-th Sub-Block Bitmap is present in the Sub-Block field
     + The m-th bit position of the Sub-Block Bitmap indicates whether the m-th STA has data buffered at the AP
  2. Single AID: when there is a single AID in a Block, 6 bits of the Block Bitmap field is used to indicate the AID and the Sub-Block field is not present (total 2 octets): AID = [Page Index(2b), Block Offset(5b), Block Bitmap[5:0]]
  3. Inverse bitmap: if there are many 1s in the bitmap of the Block, inverse the bitmap and encode the inversed bitmap



* 1. Offset+Length+Bitmap: encodes more than 8 Sub-Block Bitmaps [20, 21]
     + The Block Bitmap field is used to indicate the *length* of Sub-Block Bitmaps following the Block Bitmap field.
     + **AID = [Page Index (2b), Block Offset(5b),zeros(6b)]+ p,** the p-th bit position of the Sub-Block Bitmap field indicates whether the p-th STA has data buffered at the AP.
     + This mode is used when more than 8 contiguous Sub-Blocks are transmitted.



* 1. AID Differential Encode (ADE) mode (optional at both transmitter and receiver side) [Nov 2012 meeting minutes, 11-12/370r3]
     + Each block encodes up to 256 consecutive AIDs.
     + Last block can be shorter.
     + The Block Bitmap field consists of following fields:
       - **Encoded Word Length (EWL) (3 bits)**: number of bits required to encode differential AID value.
       - **Length (5 bits):** the length of encoded block bitmap, in number of octets
       - Concatenated bits of differential encoded AID values of paged STAs: ∆AID1, ∆AID2, …, ∆AIDm
         * ∆AID1 = AID1 – Block Offset\*8
         * ∆AIDi = AIDi – AIDi-1, i = 2, …, m.
       - **Padding**(**1-7 bits**): padding the encoded block to the boundary of octets and indicating the termination state



### 4.3.4 TIM and Page Segmentation

### 4.3.4.1 Page Segmentation

[12/1084r4, September 2012 meeting minutes]

R.4.3.4.1.A: The draft specification shall use a fixed length page segment per TIM segment within one DTIM beacon interval as described below:

1. Length of page segment may vary over multiple DTIM beacon intervals
2. Length of page segment = (Number of blocks in one page / number of TIM segments in DTIM beacon interval)
3. Each ordered page segment is assigned sequentially to TIM segments, first page segment being assigned to DTIM segment

R.4.3.4.1.B: The draft specification shall introduce a Page Bitmap field for early indication of Block-level buffered data.

R.4.3.4.1.C: The draft specification shall define a Segment Count IE for indication of assignment of STAs in TIM segments as described below:

1. Segment count IE is only transmitted in DTIM beacon frames and not in TIM segments
2. This element indicates assignment of STAs in TIM segments
   1. Indicates wake-up interval for STAs within page segments
3. STAs within the assigned page segment wake up at corresponding TIM segment sequentially based on the page segment count field in the IE
4. Length of page segment = (Number of blocks in Page Bitmap /page segment count)
5. Page offset and Page segment count fields in the segment count IE indicate initial block offset and range of TIM element in each TIM segment
   1. Block offset / start = page offset + ((length of page segment) \* (TIM segment number -1)) + 1
   2. Block Range = page offset + length of page segment \* TIM segment number
6. STAs with their block bit set to 0 in the Page Bitmap field may not wake up at assigned TIM segment

### 4.3.5 AID assignment procedure

R.4.3.5.B: The draft specification shall define the following AID switch procedure [Nov 2012 meeting minutes, 11-12/1304r0]

1. A STA transmits an AID Switch Request frame to an AP
2. After receiving AID Switch Request frame, the AP transmits an AID Switch Response frame to the STA or the AP transmits an unsolicited AID Switch Response frame to the STA

## 4.4 Frame Formats

### 4.4.1 Management frames

### 4.4.1.1 Short Beacon frame format

R.4.4.1.1.A: The draft specification shall provide support for a new frame format for a short beacon (content is TBD). [11/1503r1]

R.4.4.1.1.B: The draft specification shall define a Short Beacon interval, in units of TUs, and to require that the Beacon Interval is an integer multiple of the Short Beacon Interval.

R.4.4.1.1.C: The Frame Control type/subtype indication for the Short Beacon.

* Frame Control
  + To indicate a Short Beacon we build on type/subtype field modifications proposed by 11ad
  + Propose: B3 B2 = 11  
     B7 B6 B5 B4 = 0 0 0 1 (currently reserved)  
    as indication of Short Beacon

R.4.4.1.1.D: The Short Beacon should include a compressed SSID field.

* 1. Compressed SSID is computed as the CRC of SSID. CRC is computed using the same function as used to compute the FCS of MPDUs [May 2012 meeting minutes, 12/129r3]

R.4.4.1.1.E: The Short Beacon shall include a 4 byte Timestamp containing the 4 LSBs of the AP Timestamp.

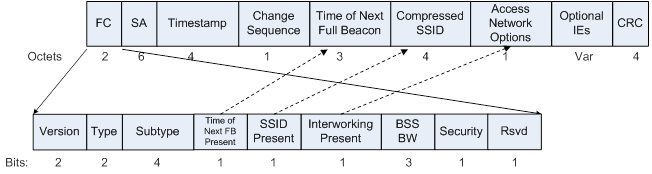
R.4.4.1.1.F: The Short Beacon shall include a 1 byte Change Sequence Field that is incremented whenever critical network information changes.

R.4.4.1.1.G: The Short Beacon should optionally include a field indicating the time of next full beacon.

1. Time of next full beacon is indicated as the higher 3 bytes of the 4 LSBs of the AP time stamp at the next full beacon [May 2012 meeting minutes, 12/129r3]
2. The Time of Next Full Beacon field shall be always present in the short Beacon frame if an AP transmits full (long) Beacon frames periodically [May 2012 meeting minutes, 12/129r3]

R.4.4.1.1.H: The draft specification may include an optional Access Network Options field in the short beacon [May 2012 meeting minutes, 12/129r3]

R.4.4.1.1.I: The 3 bit BW field shall be included in the FC field as shown in the figure below: [May 2012 meeting minutes, 12/129r3]



R.4.4.1.1.J: The following indications shall be in the short beacon: [May 2012 meeting minutes, 12/129r3]

* Presence of Time of Next Full Beaconfield
* Presence of Compressed SSIDfield
* Presence of Access Network Optionsfield

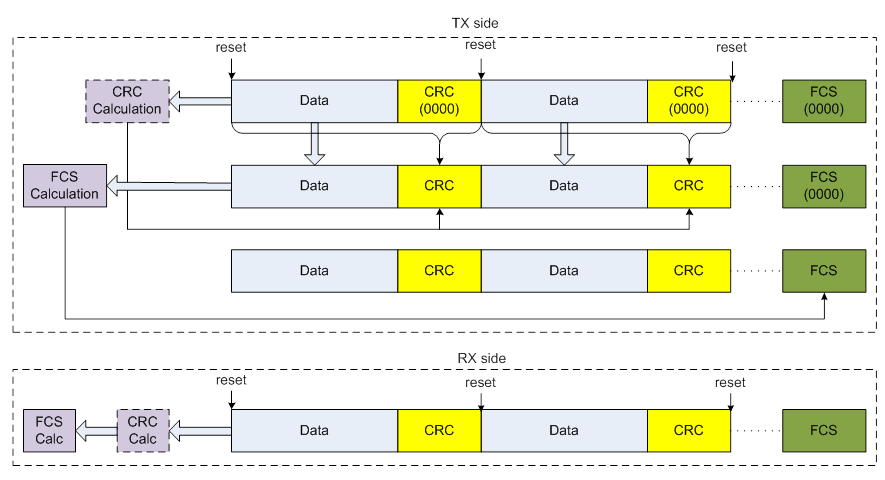
R.4.4.1.1.K: The draft specification shall support the concept of a unified beacon format for short beacon and full beacon based on the short beacon format already present in the TGah SFD. [July 2012 meeting minutes, 12/838r0]

R.4.4.1.1.L: The draft specification shall support the Mid-CRC concept [12/1100r1, September 2012 meeting minutes]:



* Beacons with some long IEs can be sent pretty frequently to attract new STAs, indicate buffered data, and control channel access, etc.
* An associated STA may not be interested in any IEs (esp. when change sequence is up-to-date), or may be interested in only a few IEs
* The Mid-CRC IE can help a STA stop processing a long beacon earlier and save power

1. Mid-CRC design



* 1. Mid-CRC calculation and End-FCS calculation are separated
     1. Note that Mid-CRC can be shorter than End-FCS
  2. Mid-CRC coverage starts from the end of the last Mid-CRC; End-FCS covers the whole frame
  3. Both Mid-CRC TX and RX are optional
     1. A STA not supporting Mid-CRC transmission need not insert any Mid-CRC IE
     2. A STA not supporting Mid-CRC receiving can decode the whole frame, ignore all Mid-CRCs, and check End-FCS only

R.4.4.1.1.M: The draft specification shall support that a STA may send the Probe Request frame including the change sequence which the STA has to AP when the STA receives the short beacon including the change sequence which is different from the sequence which the station stores. [12/1093r0]

1. AP may send the optimized probe response frame which includes only system information elements which need to be updated by STA and the change sequence when the AP receives the probe request frame including the change sequence from the STA.

### 4.4.1.2 NDP Probe Request frame format

R.4.4.1.2.A: The draft specification shall define a NDP Probe Request frame format as follows: [July 2012 meeting minutes, 11-12/830r0]



1. SIG field format for 1 MHz mode PHY [11-12/1080r0, September 2012 meeting minutes]

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| B0 B3 | B4 | B5 B12 | B13 B20 | B21 B25 | B26 B29 | B30 B35 |
| MCS | SSID/Interworking Present | Access Network Option | Reserved | Reserved | CRC | Tail |
| Compressed SSID | |

1. SIG field format for 2MHz mode PHY [11-12/1080r0, September 2012 meeting minutes]

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| B0 B3 | B4 | B5 B12 | B13 B36 | B37 | B38 B41 | B42 B47 |
| MCS | SSID/Interworking Present | Access Network Option | Reserved | Reserved | CRC | Tail |
| Compressed SSID | |

Note – The position of the MCS field is TBD.

### 4.4.1.3 Short Beamforming Report Poll frame format

R.4.4.1.3.A: The draft specification shall define a short Beamforming Report Poll frame format as follows (SIG field content TBD): [July 2012 meeting minutes1, 11-12/842r2]



### 4.4.1.4 Short Probe Response frame format

R.4.4.1.4.A: 11ah STA may use short Probe Response frame for active scanning which is a shortened version of Probe Response frame [July 2012 meeting minutes, 11-12/869r0]

R.4.4.1.4.B: Short Probe Response frame contains Timestamp, either Compressed SSID or full SSID, optional Duration to Next Full Beacon, other TBD optional fields and optional IEs

1. Frame control field of Short Probe Response frame contains Next Full Beacon present field, Full SSID Present field which indicates whether Full SSID or Compressed SSID should be included, BSS Bandwidth field and Security field, and other TBD Presence of optional fields

R.4.4.1.4.C: STA may indicate in the Probe Request which optional information to be included in the short Probe Response frame in optimized way

### 4.4.1.5 Paging frame format

R.4.4.1.5.A: The draft specification shall define a short NDP frame for paging that includes (at least) the following fields. [Nov 2012 meeting minutes, 11-12/1324r0]

1. A (Partial) identifier of the target STA(s)/group of STAs(# bits TBD)
2. BU present (1 bit)
3. Partial TSF (# bits TBD)
4. Check beacon (# bits TBD)

### 4.4.2 Control frames

### 4.4.2.1 Short ACK frame format

R.4.4.2.1.A: The draft specification shall support the following short ACK format [12/324r2, Motion1].



1. The following short ACK SIG fields are the same as those in normal SIG[12/324r2, Motion2].
   * CRC (4 bits)
   * Tail (6bits - TBD)
2. A reserved MCS value shall be used to indicate the short ACK frame [12/324r2, Motion3].
3. The short ACK SIG shall include an ACK ID field (bits TBD), and use [12/324r2, Motion4].
   * partial FCS and
   * the information from the scrambling seed in the SERVICE field of the frame being acknowledged for the computation of the ACK ID for short ACK frames.

### 4.4.2.2 Short Block Ack (BA) frame format

R.4.4.2.2.A: The draft specification shall define a short BA frame format as follows with: [July 2012 meeting minutes, 11-12/859r0]

1. Block ACK ID (length TBD)
2. Starting Sequence Control (12 bits)
3. Block Bitmap with length (TBD)
4. Other fields (TBD)



### 4.4.2.3 Short CTS frame format

R.4.4.2.3.A: The draft specification shall define a short CTS format as follows with SIG field design TBD: [May 2012 meeting minutes, 12/643r0]



### 4.4.2.4 NDP PS-Poll frame format

R.4.4.2.4.A: The draft specification shall define a NDP type PS-Poll frame format as follows: [July 2012 meeting minutes, 11-12/848r0]



1. The NDP PS-Poll frame shall include the following fields:
   1. An uplink data indication (UDI) field [Nov 2012 meeting minutes, 11-12/1308r0]

### 4.4.2.5 PS-Poll frame format

R.4.4.2.5.A: The draft specification shall allow the AID field of the PS-Poll frame to be switched to Duration. [Nov 2012 meeting minutes, 11-12/1325r1]

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 2B | 2B | 6B | 6B | 4B |
| Frame Control | Duration/ID | BSSID (RA) | TA | FCS |

### 4.4.3 Management frame body components

4.4.3.A: The specification shall support to indicate service type during association. [May 2012 meeting minutes, 12/612r0]

### 4.4.3.1 Information elements

### 4.4.3.1.1 Open-Loop Link Margin Index element

R.4.4.3.1.1.A: The draft specification shall include Open-Loop Link Margin Index element as defined below [May 2012 meeting minutes, 12/0645r1]:



where the Open-Loop Link Margin Index is computed according to the following equation.



The detailed format and description are TBD.

### 4.4.3.1.2 RAW (Restricted Access Window) Parameter Set element

R.4.4.3.1.2.A: The draft specification shall include the concept of an optionally present RAW Parameter Set element in the (short) beacon and the following sub fields in the RAW Parameter Set IE. [July 2012 meeting minutes, 11-12/843r0]

* RAW Group with TBD bit allocations
* RAW Start Time
* RAW Duration
* Options Fields
  1. Access restricted to paged STA only
  2. Group/Resource allocation frame indication
* Slot definition

|  |  |  |
| --- | --- | --- |
| **Feature** | **Value** | **Interpretation** |
| Page ID | TBD bits | Indicates the page index for hierarchical AID (based on hierarchical AID) of the allocated group |
| Block Offset | TBD bits | Assuming 32 blocks per page, these bits indicate the starting block index of the allocated group |
| Block Range | TBD bits | Indicates the number of blocks (starting from the block offset) for the allocated group |
| RAW Start Time | 8 bits | Duration in TU from end of beacon transmission to RAW Start time |
| RAW Duration | TBD  bits | Duration of RAW in TU |
| Access restricted to paged STA only | 2 bits | Bit 1: Set to 1 if only STA with their TIM bit set to 1 are allowed to perform UL transmissions  Bit 2: Set to 1 if RAW is reserved for frames with duration smaller than slot duration, such as PS-Polls / trigger frames (ignored if Bit 1 is not set) |
| Group/Resource allocation frame indication | 1 bit | Set to 1 to indicate if STAs need to wake up at the beginning of the RAW to receive group addressed frames such as resource allocation (format of the resource allocation frame TBD) |
| Slot definition | TBD bits | Include   * Slot duration signaling * Slot assignment to STA * Cross boundary transmissions allowed/not allowed   Format is TBD |

### 4.4.3.1.3 Segment Count element

[12/1084r4, September 2012 meeting minutes]

R.4.4.3.1.3.A: The segment count IE (4-8 octets) shall consist of the following fields:

1. Element ID (1 octet): Identification of the segment count IE
2. Length (1 octet): Length of this IE
3. Page Index (2 bits): Indication of page currently assigned in beacon
4. Page Segment Count (5 bits) field indicating number of TIM segments; for instance,
   1. A value of 4 indicates 4 TIM segments in DTIM beacon interval
   2. A value of 8 indicates 8 TIM segments in DTIM beacon interval
5. Page Offset (5 bits) field indicating the first block in assigned page segments
6. Reserved (4 bits): Reserved bits for future use
7. Page Bitmap (0- 4 octets) field for blocks of all page segments in DTIM element

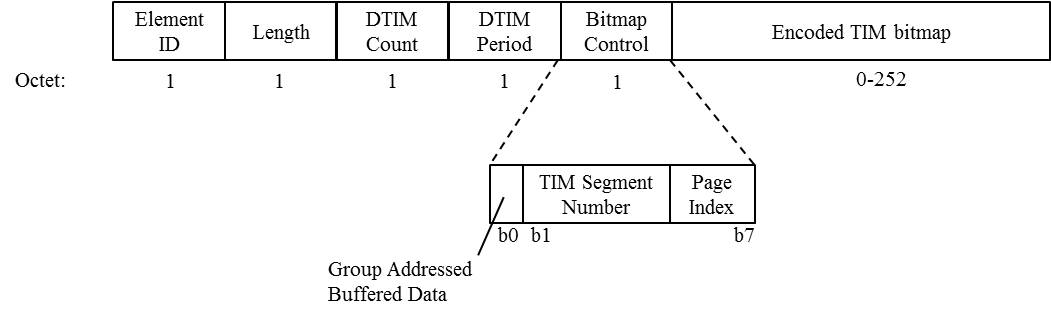


### 4.4.3.1.4 TIM element

R.4.4.3.1.4.A: The TIM element shall include the TIM Segment Number field in the Bitmap Control field as shown in in R.4.4.3.1.4.B [12/1084r4, September 2012 meeting minutes]:

1. TIM Segment Number field (5 bits): indicates the index of the TIM Segment
2. The TIM bitmap information covered in the TIM IE is calculated as follows:
   1. TIM segment start = page offset + ((length of page segment) \* (TIM segment number -1)) + 1
   2. TIM segment end = page offset + length of page segment \* TIM segment number

R.4.4.3.1.4.B: The Group Addressed Buffered Data field (Bit 0 of the Bitmap Control field) is set to 1 when one or more group addressed MSDUs/MMPDUs are buffered at the AP. [12/1086r1, September 2012 meeting minutes]



R.4.4.3.1.4.C: If there is no bit in the traffic indication bitmap set to 1 in the TIM IE, the Encoded TIM Bitmap field is not present and the Length field is set to 3. [12/1086r1, September 2012 meeting minutes]

### 4.4.3.1.5 AID Request element

R.4.4.3.1.5.A: The draft specification shall define the AID Request element as follows: [Nov 2012 meeting minutes, 11-12/1304r0]

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Element ID | Length | AID Request Mode | Wakeup Interval (optional) | Peer STA Address (optional) | Service Type (optional) |
| octet | 1 | 1 | 1 | 2 | 6 | 1 |

1. AID Request Mode: Indicate the option field of AID Request IE
   1. B0 is set to 1 when Wakeup Interval field is included
   2. B1 is set to 1 when Peer STA Address field is included
   3. B2 is set to 1 when Service Type field is included
   4. B3 is set to 1 when STA switches from TIM mode to non-TIM mode
   5. B4 is set to 1 when STA switches from non-TIM mode to TIM mode
   6. B5 – B7 are reserved.
2. Wakeup Interval: New wakeup interval (in the unit of BI) of STA
3. Peer STA Address: MAC Address of peer STA for STA-to-STA communication
4. Service Type: New Service Type of STA

### 4.4.3.1.6 AID Response element

R.4.4.3.1.6.A: The draft specification shall define the AID Response element as follows: [Nov 2012 meeting minutes, 11-12/1304r0]

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Element ID | Length | AID | AID Switch Count | Wakeup Interval |
| octet | 1 | 1 | 2 | 1 | 2 |

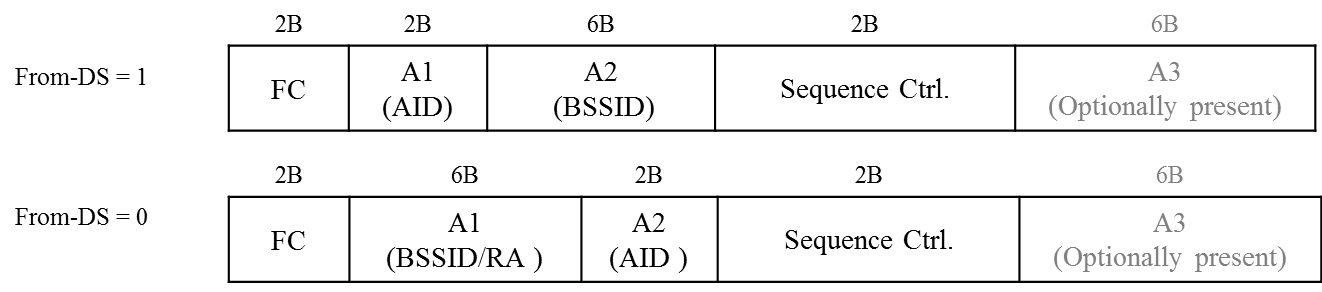
1. AID: New AID assigned from AP
   1. If AP doesn’t want to change AID of STA, AID field is set to the same AID.
2. AID Switch Count: the number of Beacon Intervals until the STA switches to the new AID
3. Wakeup Interval: the wakeup interval (in the unit of BI) for listening to Beacon frame having TIM segment of new AID

### 4.4.4 MAC header compression

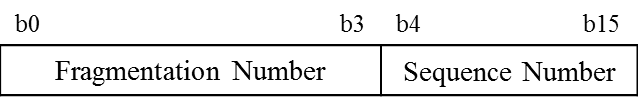
R.4.4.4.A: The draft specification shall support the concept of storing constant MAC header information (e.g. A3/A4) at the transmitter/receiver through a management exchange as an optional feature [May 2012 meeting minutes, 12/646r0]

### 4.4.4.1 Short MAC Header

R.4.4.4.1.A: The draft specification shall include the short MAC Header Format as shown below [May 2012 meeting minutes, 12/646r0]:



1. A3 is optionally present with an A3 present indication
2. Sequence Control field format [July 2012 meeting minutes, 11-12/857r0]

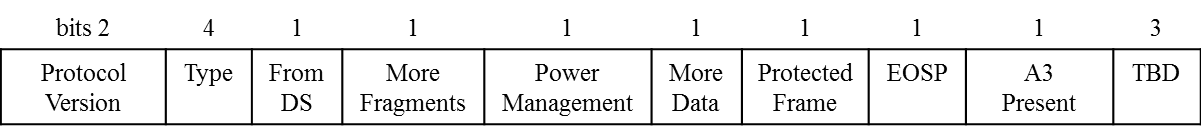


R.4.4.4.1.B: The draft specification shall support the addressing method in the following table (addressing interpretation indication for DL/UL/Direct is TBD; A3 is optionally present based on an indication TBD). [May 2012 meeting minutes, 12/646r0]

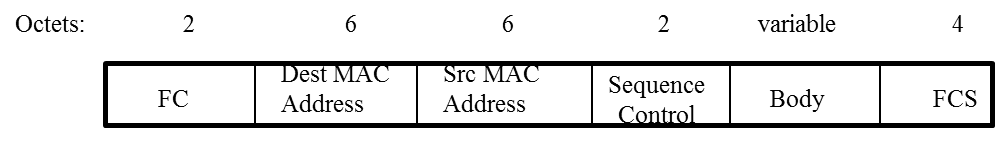
|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Data** | | | | |
| **Direction** | **Address Interpretation**  **(From-AP)** | **A1** | **A2** | **A3 (SA/DA)** |
| DL | 1 | Rx-AID | BSSID | (SA) |
| UL | 0 | BSSID | Tx-AID | (DA) |
| Direct | 0 | RA | Tx-AID |  |

R.4.4.4.1.C: The draft specification shall define the following fields in the Frame Control field of the short MAC Header for data frames: [July 2012 meeting minutes, 11-12/857r0]

* 1. Protocol version (2b), Type field (4b), From DS (1b), A3 Present (1b), More Fragments (1b), Power Management (1b), More Data(1b), Protected Frame (1b), EOSP (1b)
  2. The short MAC header is indicated by a new value of the Protocol Version field [12/1122r0, September 2012 meeting minutes]



R.4.4.4.1.D: The draft specification shall define a frame format for the Short MAC Header as shown below. The indication of the format is TBD. [12/1106r0, September 2012 meeting minutes]



### 4.4.5 Action frame format details

### 4.4.5.1 AID Switch Request frame

[Nov 2012 meeting minutes, 11-12/1304r0]

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Category | Action | Dialog Token | AID Request IE |
| octets: | 1 | 1 | 1 | variable |

### 4.4.5.2 AID Switch Response frame

[Nov 2012 meeting minutes, 11-12/1304r0]

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Category | Action | Dialog Token | AID Response IE |
| octets: | 1 | 1 | 1 | variable |

## 4.5 Relay

R.4.5.A: The draft specification shall define a simple bi-directional relay that is limited to two hops only. [Nov 2012 meeting minutes, 11-12/1330r0]

R.4.5.B: The draft specification shall support the concept of sharing one TXOP for relay (for explicit ACK exchange) to reduce the number of channel contentions. [Nov 2012 meeting minutes, 11-12/1330r0]

R.4.5.C: The draft specification shall define a flow control mechanism at the relay. [Nov 2012 meeting minutes, 11-12/1330r0]

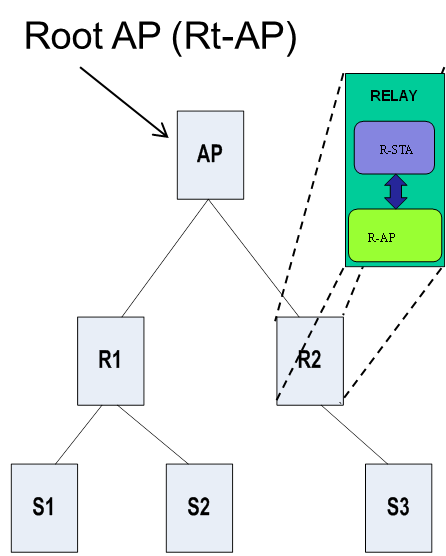
R.4.5.D: The draft specification shall support to use Probe Request for Relay discovery, and optionally, include information on AP-STA link budget. [Nov 2012 meeting minutes, 11-12/1330r0]

1. The STA initiates the discovery process.
2. The STA selects a relay based on the probe responses received.

### 4.5.1 Relay entity

R.4.5.1.A: The draft specification shall define a relay entity which constitutes of R-STA and R-AP as described below. [Nov 2012 meeting minutes, 11-12/1323r0]

1. R-STA is a non-AP STA with the following capabilities
   1. 4 address support
      1. Capable of transmitting/receiving a {ToDS=1,From DS=1} frame to /from the root AP it is associated with
   2. Supports forwarding and receiving frames from the R-AP
2. R-AP is an AP with the following additional capabilities
   1. 4 address support mandatory, i.e.
      1. R-AP is allowed to send/receive {To DS = 1, From DS = 1} frames to an associated STA based on STA capability
      2. R-AP capable receiving a 4 address frame and forwarding the frame with 3 addresses to an associated STA
   2. Supports forwarding and receiving frames to/from the R-STA
   3. Able to indicate it is a R-AP (1 bit or indicate root-AP address/SSID in beacon, TBD)



R.4.5.1.B: A relay should include the root AP’s SSID in Beacon/Probe Response frames. [Nov 2012 meeting minutes, 11-12/1323r0]

R.4.5.1.C: The draft specification shall support the frame delivery mechanism using A-MSDU format between the root AP and a relay. [Nov 2012 meeting minutes, 11-12/1323r0]

## 4.6 Sectorized beam operation

R.4.6.A: Sectorized beam operation [Nov 2012 meeting minutes, 11-12/1355r1]

1. AP can switch back and forth between sectorized beam(s) and omni beam.
2. Sectorized beam is used only when AP is aware of the STA’s sector either in scheduled transmission such as RAW or during a TXOP of a STA. AP switches back to omni otherwise.
3. The sectorized receive beam is used in conjunction with the sectorized transmit beam within a TXOP.
4. AP indicates the sectorized beam operation in Beacons, Probe Response, or Association Response.
5. This proposal requires an AP to be able to transmit/receive both omni and sectorized beam. (Only AP (not STA) uses sectorized beam).
6. The forming of the sector beam is implementation specific.

R.4.6.B: Spatial Re-use Channel Access Rules [Nov 2012 meeting minutes, 11-12/1355r1]

1. When the protection is set up by omni transmission for a duration within a TXOP and if the SO condition is confirmed by an OBSS STA/AP, the OBSS STA/AP can cancel its NAV to initiate a new SO exchange starting with a non-BF RTS/CTS.
2. Once an AP switches to the sectorized beam transmission during an exchange, it shall continue with greenfield sectorized beam transmission for the remainder of the protected duration.
3. Note: SO (Spatially Orthogonal) condition is defined as an OBSS STA/AP which receives the omni transmission but not the sectorized transmission from the AP (which is either the TXOP holder or responder) and not the transmission from the STA (which is either the TXOP responder or holder).

R.4.6.C: SO (Spatially Orthogonal) conditions [Nov 2012 meeting minutes, 11-12/1355r1]

1. SO condition 1
   1. AP can use omni-preamble to set up TXOP protection for the sectorized beam transmission.
   2. Once the proper TXOP protection is set up with a long preamble, the sectorized transmission (with greenfield BF) shall be used for the remainder of the TXOP.
   3. SO condition is confirmed by an OBSS STA/AP not receiving
      1. STA1’s transmission (OBSS STA expects a following STA1 transmission when it sees Ack Indication= 00, Ack Indication=10, Ack Indication=11/Ack Policy=00 in the AP1 Omni packet packet), and the AP1’s sectorized transmission portion within the long preamble.



1. SO condition 2
   1. AP can also use the short-preamble with omni-transmission to set up TXOP protection for the sectorized beam transmission.
   2. As shown in the examples, the TXOP protection is set up at the second transmission by AP.
   3. Once the proper TXOP protection is set up, the sectorized transmission (with greenfield BF) shall be used for the remainder of the TXOP.
   4. SO condition is confirmed by an OBSS STA/AP not receiving
      1. STA1’s transmission (OBSS STA expects a following STA1 transmission when it sees Ack Indication= 00, Ack Indication=10, or Ack Indication=11/Ack Policy=00 in the AP1 Omni packet packet)), and the AP1’s sectorized transmission (following the omni packet with ACK Policy=Block Ack\*).



1. SO condition 3: RTS/CTS



1. SO condition 4
   1. The followings illustrate an exchange initiated by STA.



## 4.7 Frequency selective transmission

R.4.7.A: General procedure [Nov 2012 meeting minutes, 11-12/1338r0]

1. A STA is allowed to choose one 2 MHz subchannel of a wideband BSS on which to transmit and receive when permitted by the AP.
2. The draft specification shall include the option for the beacon to include information about subsequently transmitted frames that allow for sounding measurements to be made at recipient STAs, e.g. number of signals, type of signals, frequency location and timing.
3. An AP may send more than one Beacon per TBTT on more than one subchannel of the BSS.
4. The draft specification shall include the concept of a subchannel permission bitmap in the Beacon to identify on which subchannels associated STA may transmit.

## 4.8 OBSS mitigation procedures

- [Nov 2012 meeting minutes, 11-12/1336r0]

# References:

11/1294r0 Spec Framework Text for 11ah Bandwidth Modes

11/1311r0 Spec Framework Text for PHY Numerology

11/1275r1 Spatial stream support in TGah specification

11/1329r0 Motions and Strawpoll on Channelization for 11ah

11/1318r0 Japanese Channelization for 802.11ah

11/1320r1 11ah Channelization of China

May 2012 meeting minutes may 2012 tgah meeting minutes.doc

July 2012 meeting minutes july 2012 tgah meeting minutes.doc

12/838r0 full beacon

12/816r1 Channel selection for 802.11ah

12/831r0 Uplink channel access general procedure

12/830r0 NDP probing

12/851r1 Tail bits in 1 MHz SIG field

12/843r0 Restricted Access Window Signaling for Uplink Channel Access

12/823r0 Target WakeTime

12/840r0 AP assisted medium synchronization

12/834r0 Speed frame exchange

12/867r0 non-TIM allocation

12/860r0 Collision reduction

12/892r0 Uplink data delivery

12/853r0 sectorization for hidden node mitigation

12/842r2 Short beamforming report poll frame

12/845r0 Max Idle Period extension

12/859r0 Short BA

12/857r0 Short MAC header design

12/848r0 NDP Type PS-Poll frame

12/832r2 SIG fields design of long preamble

12/825r2 Smoothing bit and beam\_change indication bit

12/818r0 11ah padding

12/819r1 preamble discussion

12/815r0 Q matrix requirements for 1MHz 2MHz detection

12/891r0 AID reassignment for TIM and non TIM modes switching

12/409r6 Channel access supporting low power operation

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12/1080r0 SIG Field of NDP Probe Request

12/1085r0 1MHz SIG Field Discussions

12/1102r1 SIG field ordering

12/1079r0 Partial AID

12/1093r0 System information update procedure for 11 ah

12/656r1 Extended Sleep mode for battery powered STAs

12/1106r0 A Short-Header Frame Format

12/1122r0 Short MAC Header Signaling

12/112r4 Supporting Authentication/Association for Large Number of Stations

12/662r3 Block ACK Transmission

12/1100r1 Mid-CRC in Long Beacon

12/1101r1 Active Polling

12/1083r0 Sensor Only BSS

12/1084r4 TIM and Page Segmentation

12/1086r1 TIM Compression for No Buffered Unicast Traffic

12/1104r2 11ah Interframe Spacing Values

12/1092r0 4-bit CRC Revisited

12/1089r0 Frame Classification Based on MAC Header Content

12/1103r0 Sectorized beam operation

Nov 2012 meeting minutes

12/1321r0 RAW slot assignment

12/370r3 TIM compression

12/662r4 Block Ack transmission

12/1326r0 PSDU Size for Receiver Sensitivity Power Level

12/1308r0 Uplink Data Indication in NDP PS-Poll

12/1333r0 Mandatory Optional PHY Features for 11ah

12/1302r0 TXOP truncation

12/1304r0 AID assignment protocol

12/1309r1 Non-TIM mode negotiation

12/1310r1 PS-POLL TXOP Using RTS/CTS Protection

12/1311r0 Periodic channel access

12/1315r0 PAPR reduction

12/1322r0 Traveling pilots

12/1338r0 Frequency selective transmission

12/1313r0 1 MHz dup mode

12/1330r0 Two-hop relaying

12/1329r0 PS-Poll for Downlink Bufferable Units

12/1312r0 Beamforming Feedback for Single Stream

12/1355r1 Sectorized beam operation follow up

12/1335r1 SIG field Overload indication to support NDP Frames

12/1324r0 Very Low Energy Paging

12/1323r0 Relay

12/1363r1 Clarifications on 1 MHz Preamble and Timing-Related Constants

12/1325r1 PS-Poll TXOP

12/1336r0 Overlapping OBSS of different sizes