IEEE P802.11
Wireless LANs

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| Specification Framework for TGbf |
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Abstract

This document provides the framework from which the draft TGbf 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.

# Revision history

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| --- | --- | --- |
| **Revision** | **Date** | **Changes** |
| 0 | March 19, 2021 | Initial draft version. Includes motions up to and including the 802.11 March 2021 plenary meeting. |
| 1 | April 28, 2021 | Includes feedback received on r0 of the document, as well as motions accepted after the March 2021 plenary meeting and before the May 2021 interim meeting. |
| 2 | July 20, 2021 | Includes motions accepted during and after the May 2021 interim up to and including the July 2021 plenary. |
| 3 | September 24, 2021 | Includes motions accepted after the July 2021 plenary up to and including the September 2021 interim. |
| 4 | November 30, 2021 | Includes motions accepted after the September 2021 interim up to and including the November 2021 plenary. |
| 5 | December 21, 2021 | Includes motions approved in the December 21, 2021 conference call.  |
| 6 | January 12, 2022 | Includes motions approved in the January 11, 2022 conference call. |

# Definitions, acronyms, and abbreviations (Clause 3, [1])

## Definitions

## Abbreviations and acronyms

|  |  |
| --- | --- |
| SENS | WLAN Sensing |
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# General description (Clause 4, [1])

[Editor’s note: 4.3 Components of the IEEE 802.11 architecture, 4.3.19 Wireless network management]

# Layer management (Clause 6, [1])

[Editor’s note: 6.3 MLME SAP interface]

The 11bf amendment shall define a new subclause under 6.3 (MLME SAP interface) that specifies request, confirm, indication, and response primitives for WLAN sensing (Motion 50, 20/1949r0).

# PHY service specification (Clause 8, [1])

# Frame formats (Clause 9, [1])

[Editor’s note: 9.3 Format of individual frame types]

[Editor’s note: 9.4 Management and extension frame body components]

[Editor’s note: 9.6 Action frame format details]

Note: Topic – Sensing NDPA frame

(Motion 25c, 21/0990r2; Motion 26c, 21/1015r2; Motion 39, 21/1433r2) A Sensing NDP Announcement (NDPA) frame is defined that allows an AP STA to indicate the transmission of an NDP frame used to obtain sensing measurements.

* Details of the format of the Sensing NDPA frame are TBD.

Note: Topic – Trigger frame

(Motion 25c, 21/0990r2; Motion 27, 21/1015r2) A Trigger frame variant is defined that allows an AP STA to solicit NDP transmission(s) from STA(s) to obtain sensing measurements.

* Details of the format of the Trigger frame variant are TBD.

Note: Topic – Sensing Measurement Report frame

(Motion 21, 21/0908r2) A Sensing Measurement Report frame, which allows a sensing receiver to report sensing measurements, is defined. This frame contains at least the following two fields:

* Measurement report control field: Contains information necessary to interpret the measurement report field.
* Measurement report field: Carries CSI measurements obtained by a sensing receiver.

Note: Topic – SBP frames

(Motion 38, 21/1692r4) A Sensing by Proxy Request frame, which allows a non-AP STA to invoke a sensing by proxy procedure, is defined.

* The format and contents of the Sensing by Proxy Request frame are TBD.

(Motion 38, 21/1692r4) A Sensing by Proxy Response frame, which allows an AP STA to accept or reject a request for a sensing by proxy procedure, is defined.

* The format and contents of the Sensing by Proxy Response frame are TBD.

Note: Topic – Sensing Measurement Setup frames

(Motion 41, 21/1735r3) Sensing Measurement Setup Request and Response frames, which allow to perform a sensing measurement setup, are defined.

* The subtype of Sensing Measurement Setup Request and Response frames are Action and those are individually addressed.
* Formats of the Sensing Measurement Setup Request and Response frames are TBD.

Note: Topic – BRP frames

EDMG/DMG sensing receiver initiator bistatic sensing is based on a BRP Request frame (Motion 46, 21/1735r3).

Feedback for DMG sensing measurement is carried in the BRP Response frame (Motion 45, 21/1735r3).

Note: Topic – DMG sensing capability

(Motion 47, 21/1865r1) EDMG/DMG bistatic and multistatic sensing capability set may include (at least):

* TRN field Golay sequence lengths supported
* Maximum number of directions in Tx and Rx (Number of Tx/RX AWV sets used for sensing)
* Beam sets in which every beam has direction, gain, and beam width.

Note: Topic – DMG Sensing Measurement Setup frames

(Motion 48, 21/1865r1) In an DMG/EDMG bistatic and multistatic measurement setup exchange (at least) the following parameters may be exchanged:

* set of beam directions in TX (sets of TX AWV settings to be used in the measurements)
* set of beam directions in RX (sets of RX AWV settings to be used in the measurements)
* beamforming TRN field information such as TRN-P, TRN-M, TRN-N
* location and orientation of each of the STAs
* coordinates can be local or earth coordinates
* relative locations orientation may be estimated using TGaz based exchanges or available from management layer
* Scheduling

Note: Topic – DMG sensing measurement information element

(Motion 42, 21/1801r2) The 11bf amendment shall define at least one measurement report type for 2D, 3D and 4D filtered maps.

* This measurement report type is an optional feature.
* Supporting 2D, 3D and 4D are each optional feature
* The details of the measurement report format is TBD
* 2D is a two-dimensional map, where the two dimensions are any from: Range, Azimuth, Elevation & Doppler.
* 3D is a three-dimensional map, where the three dimensions are any from: Range, Azimuth, Elevation & Doppler.
* 4D is a four-dimensional map, where the four dimensions are: Range, Azimuth, Elevation & Doppler.

(Motion 43, 21/1801r2) The 11bf amendment shall define at least one measurement report type for targets.

* “Target” is a detected object
* This measurement report type is an optional feature.
* The details of the measurement report format is TBD.

# MAC sublayer functional description (Clause 10, [1])

# MLME (Clause 11, [1])

[Editor’s note: 11.21 Wireless network management procedures]

## 7.1 WLAN sensing (SENS) procedure

### 7.1.1 Overview

A WLAN sensing procedure allows a STA to perform WLAN sensing and obtain measurement results (Motion 8, 20/1849r4).

A sensing initiator is a STA that initiates a WLAN sensing procedure. A sensing responder is a STA that participates in a WLAN sensing procedure initiated by a sensing initiator. A sensing transmitter is a STA that transmits PPDUs used for sensing measurements in a WLAN sensing procedure. A sensing receiver is a STA that receives PPDUs sent by a sensing transmitter and performs sensing measurements in a WLAN sensing procedure (Motion 9, 20/1849r4; Motion 29, 21/1543r1).

A STA can assume multiple roles in a WLAN sensing procedure (Motion 9, 20/1849r4; Motion 29, 21/1543r1). In a WLAN sensing procedure, a sensing initiator might be a sensing transmitter, a sensing receiver, both or neither (Motion 10c, 21/0147r3; Motion 29, 21/1543r1). In a WLAN sensing procedure, a sensing responder might be a sensing transmitter, a sensing receiver, or both (Motion 29, 21/1543r1).

A WLAN sensing procedure is composed of one or more of the following: sensing session setup, sensing measurement setup, sensing measurement instance, sensing measurement setup termination, and sensing session termination (Motion 15, 20/1851r4; Motion 29, 21/1543r1).

A WLAN sensing procedure may be comprised of multiple sensing measurement instances (Motion 14, 21/0145r4; Motion 29, 21/1543r1).

Examples of WLAN sensing procedures are shown in Figure 1 and Figure 2 (Motion 29, 21/1543r1; Motion 35, 21/1701r1).

More than one type of sensing measurement results may be defined (Motion 12, 21/0147r3).



**Figure 1: WLAN sensing procedure (example). (Motion 29, 21/1543r1)**



**Figure 2: WLAN sensing procedure (example). (21/1701r1)**

### 7.1.2 Sensing session setup

A sensing session is an agreement between a sensing initiator and a sensing responder to participate in a WLAN sensing procedure (Motion 8, 20/1849r4; Motion 29, 21/1543r1).

In the sensing session setup of a WLAN sensing procedure, a sensing session is established, and operational parameters associated with the sensing session are determined and may be exchanged between STAs (Motion 15, 20/1851r4; Motion 29, 21/1543r1).

A sensing session is pairwise and is identified by MAC addresses and/or associated AID/UID (Motion 23, 21/0644r4).

A sensing initiator may maintain multiple sensing sessions (Motion 23, 21/0644r4).

### 7.1.3 Sensing measurement setup

**7.1.3.1 General**

An optional negotiation process in the sensing measurement setup is defined that allows for a sensing initiator and a sensing responder to exchange and agree on operational attributes associated with a sensing measurement instance (Motion 17, 20/0370r1; Motion 23, 21/0644r4; Motion 29, 21/1543r1). The operational attributes may include initiator’s and responder’s roles, measurement report types, and other operational parameters (Motion 29, 21/1543r1).

The type of measurement result reported in a WLAN sensing procedure shall be decided by its initiator (Motion 13, 21/0147r3; Motion 29, 21/1543r1).

(Motion 36, 21/1736r2) During a sensing measurement setup, the role(s) of a sensing responder shall be determined as one of following:

* Sensing receiver
* Sensing transmitter
* Sensing transmitter and sensing receiver

The Measurement Setup ID may be used to identify attributes of the sensing measurement instances (Motion 24, 21/0644r4).

The sensing transmitter and sensing receiver role(s) of a STA corresponding to a Measurement Setup ID until the sensing measurement setup is terminated shall be fixed as determined during the sensing measurement setup (Motion 37, 21/1736r2).

A sensing initiator transmits a sensing measurement setup request frame to a sensing responder with which it intends to perform a sensing measurement setup. The sensing responder, which receives the sensing measurement setup request frame, shall transmit a sensing measurement setup response frame to the sensing initiator which transmitted the sensing measurement setup request frame to accept or reject the sensing measurement setup (Motion 41, 21/1735r3).

**7.1.3.2 Trigger-based (TB) sensing measurement setup**

**7.1.3.3 Non-Trigger based (non-TB) sensing measurement setup**

### 7.1.4 Sensing measurement instance

**7.1.4.1 General**

In a sensing measurement instance of a WLAN sensing procedure, sensing measurements are performed (Motion 15, 20/1851r4; Motion 29, 21/1543r1).

The Measurement Instance ID may be used to identify the sensing measurement instance that utilizes attributes of the same Measurement Setup ID (Motion 24, 21/0644r4).

The Dialog Token field may be a possibility to contain both the Measurement Setup ID and the Measurement Instance ID (Motion 24, 21/0644r4).

More than one sensing responder may participate in a sensing measurement instance (Motion 16, 20/0145r5; Motion 29, 21/1543r1).

**7.1.4.2 TB sensing measurement instance**

(Motion 25c, 21/0990r2) A TB sensing measurement instance includes a polling phase, an NDPA sounding phase, and a TF sounding phase. The order of the NDPA sounding phase and of the TF sounding phase is TBD.

* Note: This is for HE and/or EHT STAs. Methods to support other STAs are TBD.

(Motion 29, 21/1543r1) Examples of possible TB sensing measurement instances are shown in Figure 3. In this figure,

* How to define the sounding order, as in example 3 or as in example 4, is TBD.
* The reporting phase in example 5 may be separated from the sounding phases (TBD).
* The polling in the reporting phase in example 5 could be addressed to responders other than those involved in the sounding (TBD).
* LTF security update is TBD.

 

**Figure 3: TB sensing measurement instance (examples). (Motion 29, 21/1543r1)**

*7.1.4.2.1 Polling phase*

In the polling phase, an AP sends a Trigger frame to check the availability of STAs. If a STA is available, it responds with a CTS-to-self (Motion 25c, 21/0990r2).

*7.1.4.2.2 NDPA sounding phase*

The NDPA sounding phase shall be present in a TB sensing measurement instance if at least one STA that is a sensing receiver responds in the polling phase (Motion 25c, 21/0990r2).

(Motion 25c, 21/0990r2; Motion 26c, 21/1015r2) The NDPA sounding phase consists of

* The transmission of a Sensing NDP Announcement (NDPA) frame by an AP; and
* The transmission of an NDP by an AP SIFS after the transmission of the Sensing NDPA frame.
* Note: NDPA sounding may be used by pre-HE STAs (i.e., its use is not limited to HE and/or EHT STAs).

NDP can be used for the channel measurement (e.g. CSI) between sensing transmitter and sensing receiver(s) in sub-7 GHz bands. NDP format for sensing is TBD (Motion 22, 21/1015r1; Motion 29, 21/1543r1).

*7.1.4.2.3 Trigger frame (TF) sounding phase*

The TF sounding phase shall be present in a TB sensing measurement instance if at least one STA that is a sensing transmitter responds in the polling phase (Motion 25c, 21/0990r2).

(Motion 25c, 21/0990r2; Motion 27, 21/1015r2) The TF sounding phase consists of

* The transmission of a Trigger frame by an AP to solicit NDP transmission(s) from STA(s); and
* The transmission of an NDP by STA(s) SIFS after receiving the Trigger frame.
* Note: TF sounding is defined for HE and/or EHT STAs. Supporting other STAs is TBD.

NDP can be used for the channel measurement (e.g. CSI) between sensing transmitter(s) and sensing receiver in sub-7 GHz bands. NDP format for sensing is TBD (Motion 22, 21/1015r1; Motion 29, 21/1543r1).

*7.1.4.2.4 Reporting phase*

In the reporting phase of a sensing measurement instance, sensing measurement results are reported (Motion 15, 20/1851r4; Motion 29, 21/1543r1).

Results of measurements performed in a WLAN sensing procedure should be obtained by or reported to its initiator (Motion 11, 21/0147r3; Motion 29, 21/1543r1).

Transmission of the Sensing Measurement Report frame is initiated by an MLME primitive. Both immediate and delayed reporting are acceptable (Motion 21, 21/0908r2).

(Motion 34, 21/1438r1) In the reporting phase, sensing measurement results of multiple sensing measurement setups of a sensing responder may be included in a single Sensing Measurement Report frame for delayed reporting.

* Support for obtaining more than one sensing measurement result in a single Sensing Measurement Report frame sent by the sensing responder is optional for the sensing initiator.
* Support for buffering more than one sensing measurement result and sending it in a single Sensing Measurement Report frame to the sensing initiator is optional for the sensing responder.

**7.1.4.3 Non-TB sensing measurement instance**

(Motion 39, 21/1433r2) A non-TB sensing measurement instance is defined as follows:

* One non-AP STA is the sensing initiator and one AP is the sensing responder.
* Once the non-AP STA obtains a TXOP, it initiates a non-TB sensing measurement instance by transmitting an NDPA frame to the AP followed by an Initiator-to-Responder (I2R) NDP after SIFS. SIFS after the I2R NDP, the AP shall transmit a Responder-to-Initiator (R2I) NDP to the non-AP STA.
* If the non-AP STA is only the sensing transmitter, then the NDPA frame should configure the R2I NDP to be transmitted with minimum possible length with one LTF symbol.
* If the non-AP STA is only the sensing receiver, then the NDPA frame should configure the I2R NDP to be transmitted with minimum possible length with one LTF symbol.
* The details of the NDPA frame are TBD.
* I2R/R2I NDP formats are TBD.

### 7.1.5 Sensing measurement setup termination

(Motion 35, 21/1701r1) The following holds for sensing measurement setup termination:

* The device keeps active the established sensing measurement setup identified with the Measurement Setup ID until it is terminated.
* Termination of the sensing measurement setup identified with the Measurement Setup ID by one device does not impact the activity of this sensing measurement setup of another device(s)/session(s).
* Termination of the sensing measurement setup identified with one Measurement Setup ID does not impact the device/session activity of another sensing measurement setup with a different Measurement Setup ID.
* The sensing initiator and/or the sensing responder may initiate termination of the sensing measurement setup.
* A handshake between the sensing initiator and the sensing responder and/or expiration of the predefined inactivity time may terminate the sensing measurement setup. (Detailed protocol is TBD.)
* The sensing initiator and the sensing responder may release the resources they allocated to store the setup after the termination of the sensing measurement setup.
* The sensing initiator shall not indicate the Measurement setup ID of the terminated sensing measurement setup in the sensing measurement instances it initiates.
* The sensing initiator may ignore the pending report(s) indicated to belong to the terminated sensing measurement setup.
* The sensing responder should not respond to request/poll/trigger that all sensing measurement setups it indicates are terminated.
* The sensing responder should not transmit the report that indicates the terminated sensing measurement setup.

### 7.1.6 Sensing session termination

In the sensing session termination, STAs stop performing measurements and terminate the sensing session (Motion 15, 20/1851r4; Motion 29, 21/1543r1).

### 7.1.7 Threshold-based measurement and reporting

(Motion 18, 21/0351r5; Motion 33; 21/1364r3) An optional threshold-based measurement and reporting procedure is defined in which

* The difference between the current measured CSI and the previous measured CSI is quantified. The difference is referred to as CSI variation.
* A threshold value to be used by the sensing receiver in the threshold-based procedure is defined.
* The threshold value for each responder is determined by the initiator.
* By comparing the CSI variation with the threshold, the sensing receiver can send a feedback resulting from the large CSI variation to the sensing transmitter.
* Whether the threshold is predefined, or defined by the sensing receiver, transmitter, initiator or responder is TBD.
* The threshold-based procedure is not always required (Procedure A in 21/0351r5 is not always required).

## 7.2 Sensing by proxy (SBP) procedure

(Motion 38, 21/1692r4) An optional sensing by proxy (SBP) procedure is defined in which:

* An “SBP request” consists of a non-AP STA sending an SBP Request frame to an SBP-capable AP STA.
	+ A STA that sends an SBP Request frame to invoke SBP (and, as a result, WLAN sensing) is denoted by “SBP requesting STA”.
* An AP STA that receives an SBP request shall send to the SBP requesting STA an SBP Response frame to accept or reject the request.
* An AP STA that accepts an SBP request shall initiate a WLAN sensing procedure with one or more non-AP STAs using operational parameters derived from those indicated within the SBP Request frame.
	+ Whether the SBP requesting STA participates or not in the WLAN sensing procedure as a sensing responder is TBD.
* Measurement results obtained in a WLAN sensing procedure resultant from an SBP request shall be reported to the SBP requesting STA.

## 7.3 DMG sensing procedure

### 7.3.1 Overview

### 7.3.2 Monostatic sensing

DMG/EDMG-based WLAN sensing supports both monostatic sensing and monostatic sensing with coordination configurations. In the monostatic sensing with coordination configuration, the transmissions of one or more devices that perform monostatic sensing are coordinated by a PCP/AP (Motion 40, 21/1914r0).

### 7.3.3 Bistatic sensing

(Motion 45, 21/1865r1) EDMG transmitter initiator bistatic sensing is based on a BRP Request frame in a BRP-RX/TX, BRP-TX, BRP-RX PPDU (as defined in Clause 28 of 802.11) and a BRP Response frame. Feedback for DMG sensing measurement is carried in the BRP response frame:

* Feedback may be delayed
* Feedback may be aggregated (single feedback for some measurements, to facilitate Doppler measurement)

(Motion 46, 21/1865r1) EDMG/DMG sensing receiver initiator bistatic sensing is based on a BRP request frame that includes a request for the responder to transmit a BRP-RX/TX, BRP-TX, BRP-RX PPDU (as defined in Clause 28 of 802.11).

# PHY (sub-7 GHz)

CSI (that is, the channel measured during the training symbols of a received PPDU) is a type of sensing measurement result for sub-7 GHz WLAN sensing (Motion 20, 21/0908r2).

To enable sub-7 GHz WLAN sensing, an RXVECTOR parameter CSI\_ESTIMATE is defined that contains the channel measured during the training symbols of the received PPDU. The format of CSI\_ESTIMATE is the same one used in the measurement report field within the Sensing Measurement Report frame. The format of CSI\_ESTIMATE is TBD (Motion 21, 21/0908r2).

## 8.1 HT PHY specification (Clause 19, [1])

### 8.1.1 HT PHY service interface

## 8.2 VHT PHY specification (Clause 21, [1])

### 8.2.1 VHT PHY service interface

## 8.3 HE PHY specification (Clause 27, [2])

### 8.3.1 HE PHY service interface

## 8.4 EHT PHY specification (Clause 36, [3])

### 8.4.1 EHT PHY service interface

# PHY (60 GHz)

## 9.1 DMG PHY specification (Clause 20, [1])

## 9.2 EDMG PHY specification (Clause 28, [4])

# References

[1] Draft IEEE P802.11-REVme/D0.4

[2] IEEE Std 802.11ax-2021

[3] Draft IEEE P802.11be/D1.3

[4] IEEE Std 802.11ay-2021