IEEE 802.11ay: Next-Generation 60 GHz Communication for 100 Gb/s Wi-Fi - Summary

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Physical Layer

The physical layer of IEEE 802.11ay includes both SC (Single Carrier) and OFDM (Orthogonal Frequency Division Multiplexing) modulations. The defined packet supports MIMO (Multiple Input Multiple Output) transmission and channel bonding along with backward capability. This packet has 3 modes: SC, OFDM and control. All of these fields are not used at the same time, it depends on whether it is used for single channel or channel bonding, SISO (Single Input Single Output) or MIMO transmission and for beam-forming training/tracking. The packet structure has two parts which consist of Non-EDMG and EDMG portions. In order to enable backward compatibility the Non-EDMG portion is used. The fields L-STF (legacy-short training field) and L-CEF (legacy-channel estimation field) are used for packet detection, carrier frequency earning and timing. Lastly, the L-Header part has the same characteristics as in 802.11ad, but some of its bits are redefined. On the other hand, the EDMG portion has 6 fields which are only recognized by EDMG stations. The EDMG Header-A contains the information to interpret the EDMG packets in addition with bandwidth, modulation, coding scheme and spatial streaming. EDMG-STF and EDMG-CEF fields are used by the EDMG stations to perceive different signal parameters and the channel when bonding and/or MIMO are utilized. The EDMG-Header B field is utilized when MU-MIMO (Multiple User MIMO) is used. The DATA field contains the payload data which is padded with zeroes and if necessary it can be scrambled, encoded, decoded with respect to EDMG MCS. Groups consist of symbols, and groups are joined together using the modulated Golay sequence which all together form a block. The SC block size is 512xN_{CB} symbols (N is the number of utilized 2.16 GHz channels). The control mode corresponding to MCS 0 in DMG and EDMG physical layers allow low SNR operation prior to beam-forming with BPSK (Binary Phase Shift Keying) modulation and a spreading factor of 32. On the other side, other MCS modes are based on BPSK, QPSK (Quadrative Phase Shift Keying), 16 QAM (Quadrative Amplitude Modulation), 64 QAM modulations and LDPC codes with rates of 1/2, 5/8, 3/4, 13/16, 7/8. The TRN field uses the BRP (Beam Refinement Protocol) in which a station improves its antenna configuration for transmission and/or reception. The 802.11ay redefined it to increase the efficiency and made it configurable based on its characteristics of the particular beam-forming training procedure. 6 Golay complementary sequences form a TRN subfield which is also known as “basic unit”. A TRN-Unit is formed with a variable number of TRN subfields and TRN-Units are formed according to parameter EDMG TRN Length which is denoted by L. All the TRN subfields are transmitted with the same AWV (Antenna Weight Vector: A vector of weights containing amplitude and phase for each element in the array) in order to configure the receiver to switch AWVs when receiving various TRN subfields to reconfigure itself for a better antenna setting. In BRP the transmitter sends different AWVs and the receiver uses the same AWV to train the transmitter. There are 3 parameters to train beam-forming transmission: P which transmits the TRN subfields at the same AWV in which the receiver uses this info to synchronize and estimate the channel, M which enhances the robustness of the beam-forming training process (may be transmitted with the same AWV over and over again) and N is the number of sequential TRN subfields with the same AWV.

Medium Access Control Layer

This segment portrays the primary changes made to the IEEE 802.11ad MAC layer detail to help MIMO transmission and multi-channel task. IEEE 802.11ay composes access to the medium in beacon interval (BIs), like 802.11ad. a typical BI comprising of two primary access periods: beacon header interim (BHI) and data transmission interval (DTI). The BHI is additionally partitioned into three sub-intervals:

- Beacon transmission interval (BTI) used by the access point (AP) or the personal basic service set control point (PCP) for transmission of beacon frames.
- Association Beamforming training (A-BFT) used by stations to perform beam-forming training with the stations that transmitted beacon frames during the preceding BTI.
- Announcement transmission interval (ATI) used for management frame exchange between the AP/PCP and beam-trained stations.

A-BFT is slotted (up to eight slots for 802.11ad) and stations haphazardly pick one of the slots for transmitting sector sweep (SSW) or short SSW frames; subsequently, collisions may happen when more than one station pick a similar slot. To suit a bigger number of attempting access amid A-BFT, IEEE 802.11ay backings up to 40 A-BFT slots in every BI. The BHI is followed by the DTI, which facilitates different types of medium access for data transmission and beam-forming training. In the DTI, data frames can be exchanged either in contention-based access periods (CBAPs) or scheduled service periods (SPs) for contention-free communications. The BHI is trailed by the DTI, which facilitates diverse sorts of medium access for data transmission and beam-forming training. In the DTI, data frames can be traded either in contention based access periods (CBAPs) or scheduled service periods (SPs) for contention-free communications. The channel width of the primary channel is 2.16 GHz to facilitate the coexistence of EDMG STAs with DMG STAs. Network announcement and management frames need to be transmitted through primary channel to enable the coexistence of DMG and EDMG STAs. EDMG stations must be capable of performing physical and virtual carrier sensing and at least energy detection in secondary channels. To perform a MIMO transmission, transmitter must obtain TXOP. To this end, EDMG STAs that support MIMO maintain physical and virtual carrier sensing and perform the backoff procedure.

Beam-forming Control

Beamforming training is utilized to decide the proper transmit and get receiving antenna designs for a couple of stations through two sub-stages. IEEE 802.11ay incorporates a few new beam-forming preparing conventions, including SU-MIMO/MU-MIMO beam-forming trainings, BRP transmit sector sweep and beam-forming for asymmetric links. SU-MIMO gave various floods of information to be at the same time transmitted or got between two Wi-Fi gadgets utilizing numerous reception apparatuses and beam-forming innovation. MU-MIMO increment number of gadgets and throughput. The paper centers around MIMO beam-forming techniques. SU-MIMO BF decides transmit and get reception apparatus designs between two STAs. It comprise of two back to back stages: SISO and MIMO. SISO phase: Both STAs gathers vital criticisms for conceivable competitor parts (feedbacks). All transmissions are in DMG mode. MIMO phase: Enables the synchronous training of transmit and receive divisions for each DMG reception apparatus. There are four required sub-phases: setup, training, responder, feedback. MU-MIMO BF empowers an initiator and a gathering of responders to decide fitting antenna setups for concurrent transmission of various information streams with least between stream impedance.