IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent of:	Geonjung Ko, et al.	Attorney Docket No. 39843-0196IP1
U.S. Patent No.:	11,129,163	
Issue Date:	September 21, 2021	
Appl. Serial No.:	16/121,546	
Filing Date:	September 4, 2018	
Title:	WIRELESS COMMUNICATION METHOD AND WIRELESS COMMUNICATION TERMINAL IN BASIC SERVICE SET OVERLAPPING WITH ANOTHER BASIC SERVICE SET	

DECLARATION OF CHRISTOPHER HANSEN, PH.D.

I declare that all statements made herein on my own knowledge are true and that all statements made on information and belief are believed to be true, and further, that these statements were made with the knowledge that willful false statements and the like so made are punishable under Section 1001 of Title 18 of the United States Code.

Date: 4/28/25

By: _____
Christopher Hansen

SAMSUNG 1021

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I, Christopher Hansen, do hereby declare the following:

1. I submit this Declaration at the request of Samsung Electronics Co., Ltd. and Samsung Electronics America, Inc. (collectively, "Samsung") for consideration by the Patent Trial and Appeal Board in *inter partes* review proceedings.

2. I reside in Los Altos, California.

3. I am over eighteen years of age, and I am otherwise competent to testify as to the matters set forth herein if I am called upon to do so.

4. I am being compensated for my time at my standard consulting rate. I am also being reimbursed for expenses that I incur during the course of this work. My compensation is not contingent upon the results of my study and analysis, the substance of my testimony, or the outcome of any proceeding involving the challenged patent or patents. I have no financial interest in the outcome of this matter or in any litigation involving the challenged patent or patents.

I. PROFESSIONAL BACKGROUND

5. I have attached a copy of my C.V. as Appendix A.

6. I received a Bachelor of Science (B.S.) degree in Electrical Engineering from Rensselaer Polytechnic Institute in 1987. I received a Ph.D. in Electrical Engineering from the University of California, Los Angeles ("UCLA") in 1997.

7. I was employed by Broadcom Corporation ("Broadcom") in Sunnyvale, California from January 2000 to May 2012. From January 2000 to February 2011, I held several titles, including Sr. Staff Scientist, Engineering Manager, and Sr. Principal Scientist. My duties in these roles included, among other things, Institute of Electrical and Electronics Engineers ("IEEE") 802.11 (*i.e.*, Wi-Fi) physical layer ("PHY") application-specific integrated circuit ("ASIC") development. I also participated in Bluetooth standard development during this timeframe. From March 2011 to May 2012, I was employed as an Associate Technical Director and my duties included, among other things, performing wireless communications technology research and development ("R&D") as well as standards and intellectual property development. Throughout my time at Broadcom, I regularly attended meetings for the IEEE 802.11 Working Group. I submitted technical contributions to Task Group E ("TGe"), Task Group H ("TGh"), and Task Group N ("TGn"). I also regularly accessed and reviewed documents submitted by members of the IEEE 802.11 Working Group, including through the IEEE's 802wirelessworld server and, later, the IEEE Mentor website.

8. I served on the Board of Directors of the Wireless Gigabit Alliance ("WiGig Alliance") from March 2010 to March 2012. Specifically, I served as the Board's Secretary. The WiGig Alliance was a trade association focused on the development and promotion of high-speed wireless communications technology.

The WiGig Alliance collaborated for multiple years with the Wi-Fi Alliance (an industry organization that owns the "Wi-Fi" brand and certifies devices for interoperability and security), and the two organizations eventually merged in 2013.

9. I served as the Vice Chair of the IEEE 802.11ad Task Group ("TGad") from May 2011 to March 2012. TGad developed an amendment to the IEEE 802.11 wireless networking standard focused on directional multi-gigabit (*i.e.*, DMG) technology. In this role, I assisted the task group Chair, Eldad Perahia, and Technical Editor, Carlos Cordeiro, with the operation of the task group meetings and developing the 802.11ad draft standards amendment documents.

10. I was employed as a Senior Wireless System Architect by Apple Inc. ("Apple") in Cupertino, California from June 2012 to July 2013. During my tenure at Apple, I was responsible for, among other things, performing systems engineering for iPhone Operating System ("iOS") Wi-Fi functionality. During this time, I participated in multiple IEEE 802.11 groups, including Task Group AF ("TGaf") and the HEW Study Group, on behalf of Apple. I also regularly accessed and reviewed documents submitted by members of the IEEE 802.11 Working Group, including through the IEEE Mentor server.

11. Since August 2013, I have been employed as President of Covariant Corporation in Los Altos, California. As part of this role, I provide technical

consulting services related to wireless communications, IEEE 802.11/Wi-Fi, signal processing technology, integrated circuits technology, and intellectual property. During the time I have been employed by Covariant, I have continued to regularly attend meetings for multiple IEEE 802.11 task groups. I submitted several technical contributions to Task Group AY ("TGay") (responsible for 802.11ay) which led to new mmWave features, Task Group M ("TGm") (responsible for the 802.11-2020 standard), and the Integrated mmWave Study Group ("IMW SG") (the precursor for TGbq). I received awards from the IEEE for my contributions to TGay and TGm. Appendix B. I have also continued to regularly access and review documents submitted by members of the IEEE 802.11 Working Group, including through the IEEE Mentor server.

12. I served as a member of the Board of Directors for the Professional and Technical Consultants Association ("PATCA") in Silicon Valley, California from March 2017 to March 2024. I was President of the Board of Directors from June 2019 to March 2024. PATCA is a non-profit corporation that supports technical consultants in Silicon Valley and elsewhere.

13. Since June 2020, I have been employed as a Guest Instructor for the UCLA Department of Electrical and Computer Engineering. I teach classes on wireless communications for upper-level undergraduate students and graduate

students in electrical engineering. In these classes, I use examples from the IEEE 802.11 standards.

14. I am a named inventor on over 100 issued United States patents related to wireless communications, signal processing, and integrated circuits.

15. I have been a member of the Institute of Electrical and Electronics Engineers ("IEEE") since 1981 (41 years) and am currently a Senior member. I have participated in the activities of the IEEE Standards Association ("IEEE-SA") continuously since 2000. I have participated in the IEEE 802.11 Wireless Local Area Networks ("WLAN") Working Group as a voting member since 2000.

16. Through my membership at the IEEE and participation in IEEE standards development, I have personal knowledge of the IEEE's policies and procedures, including with respect to documents management practices, the standard development process, as well as organization and operation of IEEE's working groups and task groups.

II. THE IEEE 802.11 WORKING GROUP AND TASK GROUP AX

17. IEEE-SA is an operating unit within the IEEE that develops global standards across a wide range of industries and technologies. The IEEE 802.11 Working Group is part of the IEEE-SA and includes several task groups.

18. A task group is created to develop a draft amendment to the baseline IEEE 802.11 standard. The standard amendment development and approval

process is as follows. First, a study group is created by the working group to investigate a new feature or technology. Study group members make contributions and discuss and refine the features that will be a part of the new task group. Then, the study group produces a Project Authorization Request ("PAR"). The PAR must be approved by the study group, the 802.11 Working Group, and IEEE-SA for a task group to be created. Once these steps have been completed, the new task group can begin meeting and taking contributions.

19. The new task group receives technical contributions and votes on technical details as it develops a new draft standard amendment. Next, the task group forwards the draft standard amendment to the 802.11 Working Group for approval. If the draft standard amendment is approved by the 802.11 Working Group, it is presented to the IEEE 802 Sponsor Executive Committee ("SEC") for approval. Finally, assuming the draft standard amendment is approved by the 802 SEC, it is presented to the IEEE-SA for approval. Upon the IEEE-SA's approval, the draft standard amendment transitions into the final form, and becomes an official standard amendment.

20. Task Group AX ("TGax") was formed in May 2014 to develop the IEEE 802.11ax standard amendment. Appendix C. The task group continued to meet until November of 2020. Appendix C. During this time, I followed the

activities of TGax, including reviewing and voting on the 802.11ax standard amendment drafts.

21. During the May 2014 to November 2020 timeframe, the time when TGax was active, the 802.11 Working Group held meetings every two months. Specifically, the 802.11 Working Group held meetings in January, March, May, July, September, and November of each year. Three of the six meetings in any given year were "plenary" meetings, *i.e.*, larger meetings across all IEEE 802 Working Groups. The remaining three 802.11 Working Group meetings in a given year were "interim" meetings, *i.e.*, the members of the 802.11 Working Group and other wireless Working Groups (such as 802.15) met separately from other IEEE 802 Working Groups. In July 2014, around the time when TGax was started, there were 533 members of the 802.11 Working Group, with 321 being voting members. Appendix D at 13. Roughly 300 people would attend each 802.11 Working Group meeting.

22. TGax meetings took place as part of these broader 802.11 Working Group meetings—in other words, TGax met six times per year from May 2014 to November 2020. Appendix C. TGax meeting attendees were generally engineers and researchers interested in wireless local area network ("WLAN") technology. The 802.11ax standard amendment was a major 802.11 Working Group project

and, as a result, a majority of the roughly 300 802.11 Working Group meeting attendees would attend each TGax meeting.

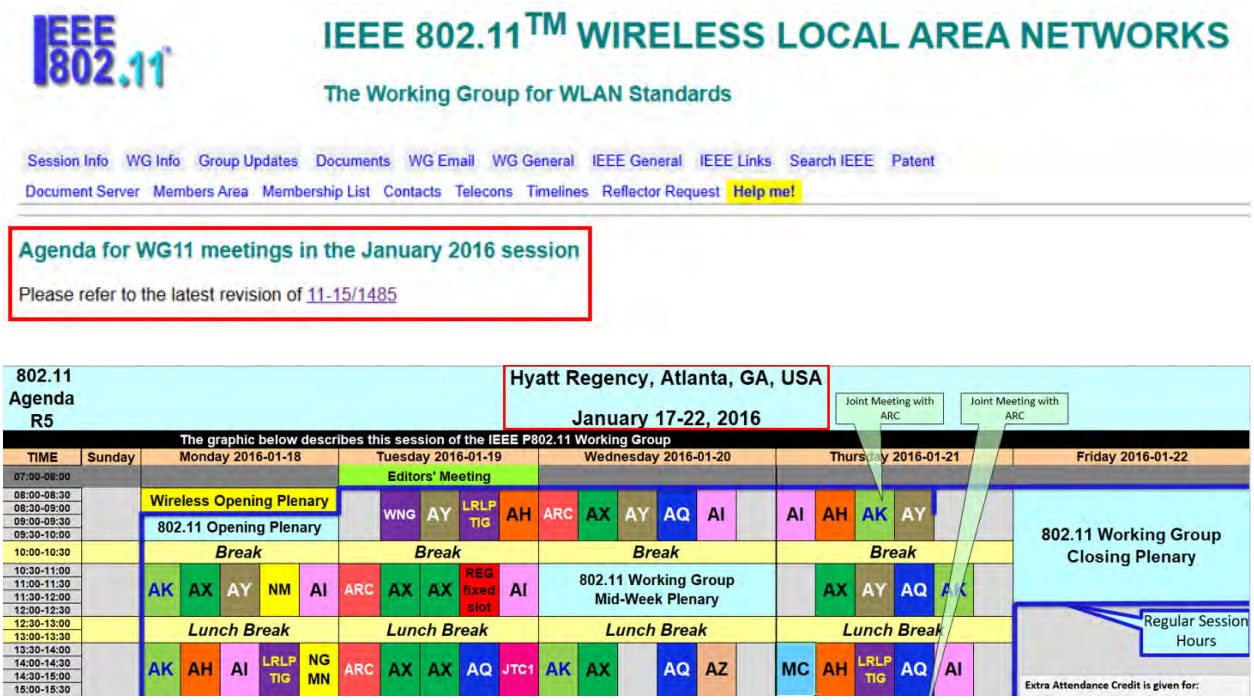
23. During the May 2014 to November 2020 timeframe, TGax participants could submit and present technical submissions at TGax meetings. These submissions generally included technical proposals for the standard amendment draft. These submissions were made available to the public through the IEEE Mentor website. Appendix E. After the submission was presented, TGax members would generally vote on whether to incorporate the submission into the current standard amendment draft. Appendix F at 7.

24. TGax meetings were open to the public.[1] Appendix G. However, only "voting members" could vote on technical submissions and letter ballots.

25. During the relevant time period, the IEEE 802.11 Working Group published information about upcoming meetings on its website. As an example, a January 1, 2016 archive of the 802.11 Working Group website includes a link to an "[a]genda for WG11 meetings in the January 2016 session. Appendix H. Clicking on the link downloads a spreadsheet with information about the dates, location, and

[1] Meeting attendees were required to pay a registration fee, but the fee could be waived for certain visitors, such as academics, professors, and students from educational institutes in the surrounding area.

agenda for the January 2016 802.11 Working Group meeting, including the times for TGax working sessions, which are designated by a green "AX." Appendix I.



III. PUBLIC ACCESSIBILITY ANALYSIS

26. The public accessibility information below relates to Robert Stacey et al., *Proposed TGax Draft Specification*, Document Control Number ("DCN") IEEE 802.11-16/0024r1 ("Stacey"). Appendix J.

27. In my opinion, the interested public for purposes of this analysis are those interested in wireless standards development, including the area of Wireless Local Area Networks ("WLANs"), and in particular the development of the 802.11 standard, which is the leading WLAN standard. This includes persons interested in the improvement of reliability and speed for Wi-Fi communications in dense networking environments. This group generally includes engineers and

researchers working in the wireless communications industry as well as academics, professors, and students in disciplines related to wireless communications.

28. The interested public would certainly have been aware of the IEEE and the 802.11 standard. At the time of the '163 patent—and still today—the 802.11 standard was the most widely used WLAN standard and one of the most widely used wireless communication standards.

29. Many members of the interested public would have already been members of IEEE. Other members of the interested public would have subscribed to IEEE publications and/or other publications related to the wireless communications industry including, for example, IEEE Spectrum magazine.

30. The IEEE 802.11ax project was discussed in various publicly disseminated articles such that a member of the interested public would have been aware of the project no later than early 2016.

31. For example, in January 2015, The Beacon—the Wi-Fi Alliance's official blog—published an article by Craig Mathias entitled *Wi-Fi 2015: The Top-10 List*. Appendix K. Mr. Mathias noted "continued work on 802.11ax, which could reach . . . the magical 10 Gbps level of throughput . . . ." Appendix K at 3.

32. In September 2015, IEEE Spectrum magazine published an interview with 802.11 Working Group Vice Chair Dorothy Stanley. Appendix L. When asked "What can we expect next-generation Wi-Fi standards to deliver?", Ms.

Stanley noted "the 802.11ax amendment for high- efficiency wireless local area networks. That looks for efficiency in dense deployments such as stadiums, shopping malls, and subways where you have a lot of people accessing the Wi-Fi system." Appendix L at 4-5.

33. The 802.11ax project was discussed extensively in a February 2016 article in the IEEE Wireless Communications magazine entitled *IEEE 802.11ax: High-efficiency WLANs* (Appendix M). From these articles, a member of the interested public would have understood the general scope of TGax's work—namely, improving Wi-Fi "efficiency in dense deployments." (Appendix L at 4-5).

34. Moreover, the IEEE maintains a public webpage entitled "Official IEEE 802.11 Working Group Project Timelines" where it publishes status information about past and present 802.11 task groups and projects. Appendix N. Information about the 802.11ax project, including a predicted timeline, is listed on archived versions of the webpage dating back to July 2, 2014 (Appendix O).

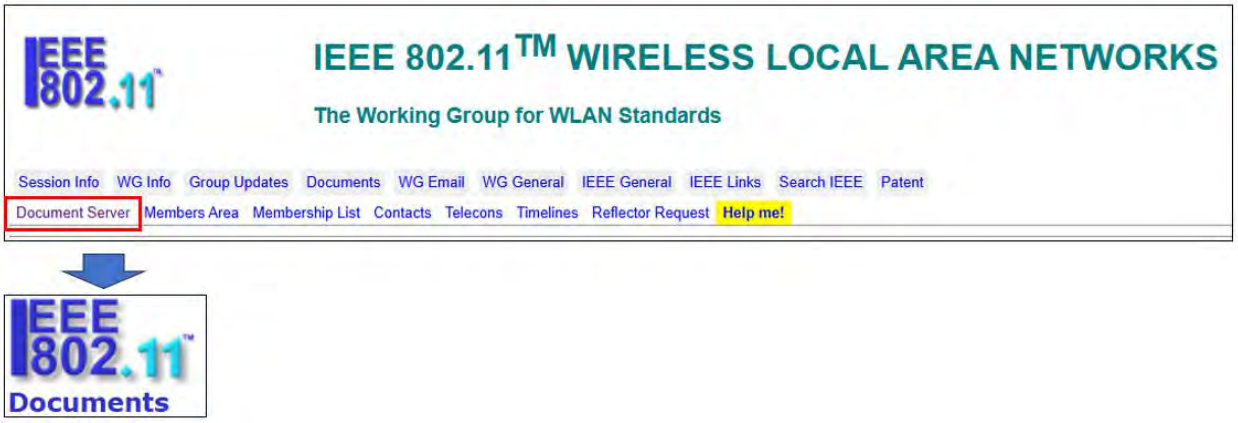
IEEE Project and Final Document	Final Doc Type	Project Authorization Request (PAR)	Task Group and Activity	Documentation: Session End Snapshot: Format & Version	Documentation: Session End Snapshot: Incorporated Baselines	Current Status	PAR Approved, Modified, or Extended [Expires]	WG Letter Ballots: Draft: Date: Predicted Initial	WG Letter Ballots: Draft: Result: Predicted Recirc
IEEE Std P802.11ax	A	High Efficiency WLAN	TGax	None	802.11REVmc 802.11ai 802.11ah 802.11ak 802.11aq 802.11aj	Actual	2014-03-25		
						Predicted	C	Jul 2016	

35. The IEEE maintains a public website called IEEE Mentor that houses working documents related to its various working groups and task groups. Appendix P. As discussed above, the IEEE Mentor website hosted TGax working

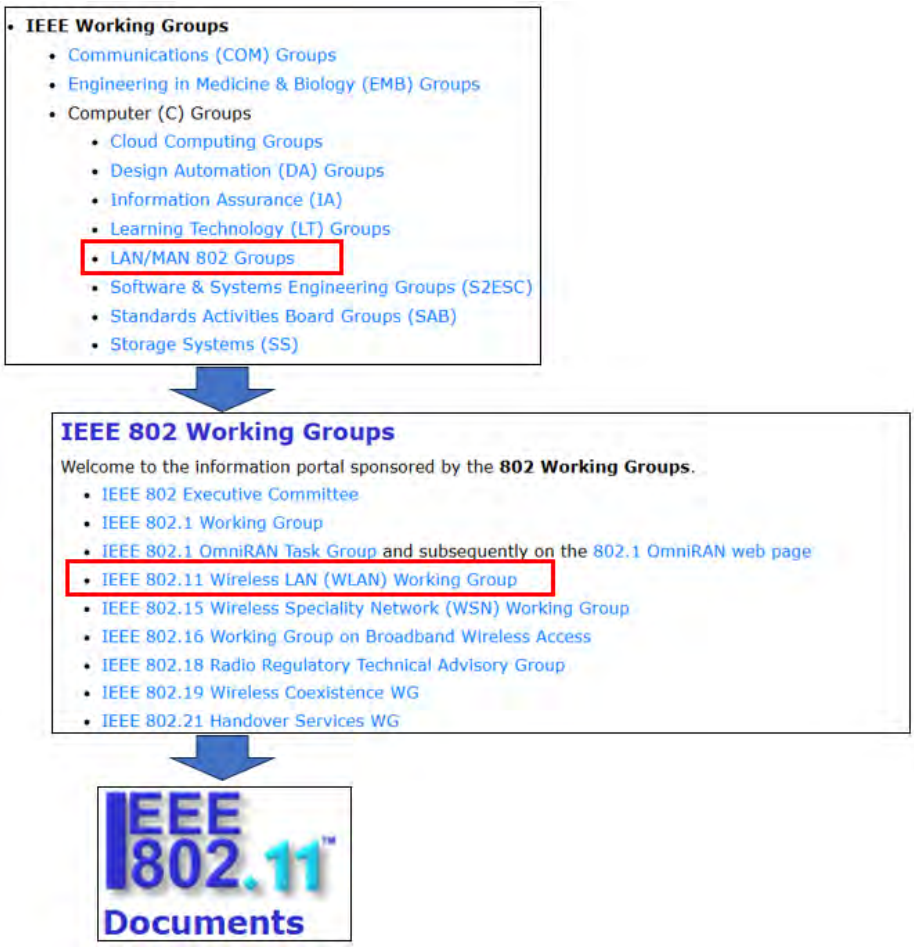
documents and technical submissions while the task group was active. These TGax documents remain on the Mentor website today.

36. A member of the interested public would have either already been aware of the IEEE Mentor webpage or could have discovered its existence through a number of public sources. For example, the IEEE Mentor webpage was directly linked to the 802.11 Working Group website through the "Document Server" link, as corroborated by an archived version of the webpage from January 1, 2016. Appendix H. A member of the interested public seeking to stay up-to-date on TGax's development of the 802.11ax standard amendment would have been motivated to review the task group's working documents on the Mentor website.

37. The 802.11 Working Group documents on the IEEE Mentor website—including documents related to TGax—were easily accessible. As described above, clicking on the "Document Server" link on the 802.11 Working Group website would take a user to the "IEEE 802.11 Documents" page on the IEEE Mentor website. This is corroborated by a January 1, 2016 archived version of the 802.11 Working Group website. Appendix H.



38. Alternatively, assuming one accessed the IEEE Mentor website directly (without first going to the 802.11 Working Group website), the 802.11 Working Group documents could have been accessed by (1) opening the Mentor home page (Appendix P), (2) selecting "LAN/MAN 802 Groups," which directs the user to the "IEEE 802 Working Groups" page (Appendix Q), and (3) selecting "IEEE 802.11 Wirelesss LAN (WLAN) Working Group," which directs the user to the "IEEE 802.11 Documents" page (Appendix R). The Mentor website operated in the same manner during the time period that TGax was actively developing the 802.11ax standard amendment. This is confirmed by archived copies of the Mentor home page (Appendix S), the "IEEE 802 Working Groups" page (Appendix T), and the "IEEE 802.11 Documents" page (Appendix U).



39. The "IEEE 802.11 Documents" page provides a list of documents that have been uploaded related to 802.11 standard projects. Appendix R. The webpage also includes identifying information for each document, including the created date, year, document control number (DCN), revision number, group (*e.g.*, TGax), document title, author and author affiliation (*e.g.*, employer), and the date and time the document was uploaded. Appendix R. The web page also includes a "Download" link for each document. Appendix R. The "IEEE 802.11 Documents" page operated in the same manner during the time when TGax was active. Appendix U.

40. Documents uploaded to the IEEE Mentor website are publicly accessible immediately after they are uploaded. For instance, the screen capture below of the "IEEE 802.11 Documents" page was taken on April 28, 2025, and several documents that were uploaded to the website the same day are available for download. Appendix R. The webpage operated in the same manner during the time TGax was active. Appendix U.

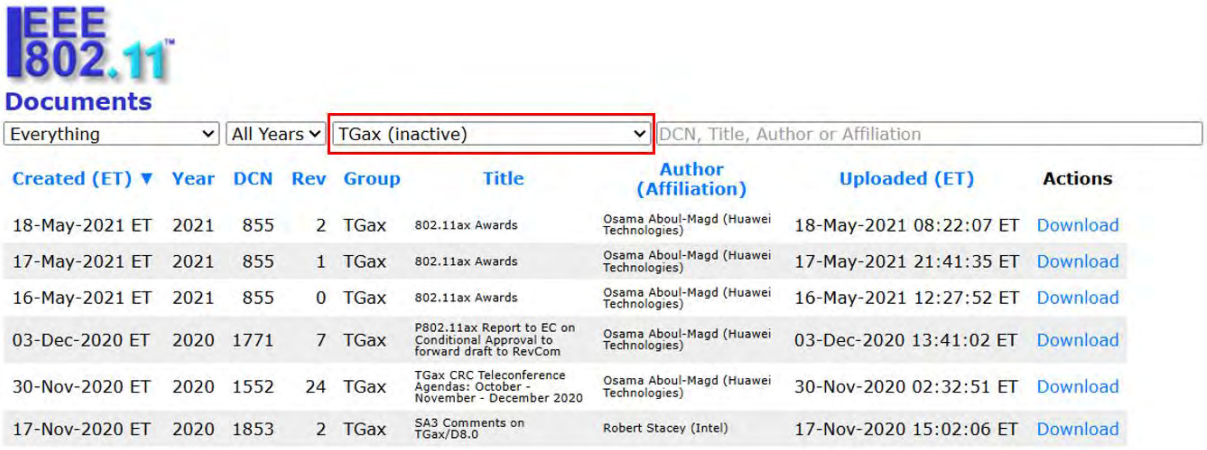
IEEE 802.11™

Documents

Everything | All Years | All Groups | DCN, Title, Author or Affiliation

Created (ET) ▼	Year	DCN	Rev	Group	Title	Author (Affiliation)	Uploaded (ET)	Actions
28-Apr-2025 ET	2025	255	3	TGm	P2P TWT Harmonization	Brian Hart (Cisco Systems)	28-Apr-2025 13:34:11 ET	Download
28-Apr-2025 ET	2024	1925	6	TGm	REVmf Motions	Michael Montemurro (Huawei)	28-Apr-2025 12:17:19 ET	Download
28-Apr-2025 ET	2025	662	3	TGm	April 28 Teleconference Agenda	Michael Montemurro (Huawei)	28-Apr-2025 12:14:48 ET	Download
28-Apr-2025 ET	2025	371	1	TGm	NR-IE_6GHz_Bits	Abhishek Patil (Qualcomm)	28-Apr-2025 11:33:33 ET	Download
28-Apr-2025 ET	2025	345	5	TGm	PASN ID for MLO	Yan Li(ZTE)	28-Apr-2025 09:42:37 ET	Download
28-Apr-2025 ET	2025	676	1	TGbn	CC50 CR for CID3866	Bo Cao (ZTE)	28-Apr-2025 09:37:41 ET	Download
28-Apr-2025 ET	2025	638	2	TGbn	CRs for CID related to definitions in MAPC scheme	Chun Huang (ZTE)	28-Apr-2025 08:18:13 ET	Download
28-Apr-2025 ET	2024	2080	1	TGbn	High-Capability Protection in DPS Follow Up	Maolin Zhang (Huawei)	28-Apr-2025 06:32:10 ET	Download
28-Apr-2025 ET	2025	3	2	TGbn	NPCA follow up	Yan Li(ZTE)	28-Apr-2025 04:45:27 ET	Download
28-Apr-2025 ET	2025	5	3	TGbn	MAP discovery follow up	Jay Yang(ZTE)	28-Apr-2025 03:46:33 ET	Download

41. The "Group" filter on the "IEEE 802.11 Documents" page can be used to filter the document list to only those documents related to TGax, as shown in the screenshot below. The webpage operated in the same manner during the time TGax was active, as confirmed by an archived version of the "IEEE 802.11 Documents" page from June 13, 2015. Appendix U.



IEEE 802.11

Documents

Everything | All Years | TGax (inactive) | DCN, Title, Author or Affiliation

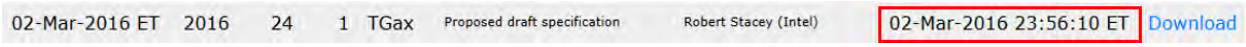
Created (ET) ▼	Year	DCN	Rev	Group	Title	Author (Affiliation)	Uploaded (ET)	Actions
18-May-2021 ET	2021	855	2	TGax	802.11ax Awards	Osama Aboul-Magd (Huawei Technologies)	18-May-2021 08:22:07 ET	Download
17-May-2021 ET	2021	855	1	TGax	802.11ax Awards	Osama Aboul-Magd (Huawei Technologies)	17-May-2021 21:41:35 ET	Download
16-May-2021 ET	2021	855	0	TGax	802.11ax Awards	Osama Aboul-Magd (Huawei Technologies)	16-May-2021 12:27:52 ET	Download
03-Dec-2020 ET	2020	1771	7	TGax	P802.11ax Report to EC on Conditional Approval to forward draft to RevCom	Osama Aboul-Magd (Huawei Technologies)	03-Dec-2020 13:41:02 ET	Download
30-Nov-2020 ET	2020	1552	24	TGax	TGax CRC Teleconference Agendas: October - November - December 2020	Osama Aboul-Magd (Huawei Technologies)	30-Nov-2020 02:32:51 ET	Download
17-Nov-2020 ET	2020	1853	2	TGax	SA3 Comments on TGax/D8.0	Robert Stacey (Intel)	17-Nov-2020 15:02:06 ET	Download

42. Upon accessing the IEEE Mentor website, a member of the interested public could have downloaded and reviewed any potentially relevant documents. The individual could have identified relevant documents by using the search bar to search by document control number (DCN), title, author, or affiliation (*i.e.*, company or organization the author(s) are affiliated with). In my experience, sometimes persons interested in the development of particular standards would download all of the files on the IEEE Mentor site and perform offline searches based on document content. For instance, I personally used a tool called "wget" to scrape the documents on the IEEE Mentor website so that I could search their contents. Appendix V.

43. The Stacey reference can be located by going to the IEEE 802.11 Documents page on the Mentor website, selecting "TGax" in the "Group" filter, and searching "draft"—the Stacey reference is the second-to-last search result. Appendix W.



44. The IEEE Mentor website shows that the Stacey reference was uploaded to the Mentor website on March 2, 2016. Appendix W. Thus, based on the foregoing, it is my opinion that the Stacey reference was publicly accessible to members of the interested public as of March 2, 2016.



IV. CONCLUSION

45. I currently hold the opinions expressed in this declaration. But my analysis may continue, and I may acquire additional information and/or attain supplemental insights that may result in added observations.

APPENDIX A

CHRISTOPHER J. HANSEN

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I. SUMMARY

- Senior electrical engineer - more than 25 years in industry plus Ph.D. (UCLA 1997).
- Named inventor on more than 125 issued patents, including many related to IEE802.11/Wi-Fi and Bluetooth wireless standards.
- Technical skills encompass wireless network physical layer (PHY) design, systems engineering, communication theory, integrated circuit (IC) design, signal processing, RF/microwave systems, intellectual property, and standardization.
- Experience with multiple successful product developments (802.11 WLAN chipsets and cellular base-station systems), research in new technologies (802.11n MIMO and 60 GHz), and leading standards bodies (IEEE 802.11, Bluetooth SIG, Wireless Gigabit Alliance).

II. EXPERIENCE

Covariant Corporation, Los Altos, California
President — August 2013 – present

- Consulting in wireless communication systems, signal processing, standards, and intellectual property.
- Recent clients include Octoscope, Google, and Peraso Technologies.
- Example projects:
  - Developed and executed IEEE 802.11 standards strategy for a technology startup company. Led standards participation in industry special interest group and IEEE 802.11ay and 802.11md task groups. Developed simulations in Matlab to support standards contributions.

- Developed Matlab tools to predict mmwave system performance including impact of cascade non-linearities and temperature variations.
- Analyzed patent portfolio for potential standards related patents related to IEEE 802.11 standards and Wi-Fi Alliance specifications. Developed claim charts for appropriate patents.
- Developed Matlab simulation tools as part of technical support for patent litigation. Analyzed performance benefits of physical layer features in IEEE 802.11 standards.
- Reviewed C, assembler, Verilog, and VHDL code for technical support in patent litigation.
- Developed and prototyped novel radar detection algorithms in Matlab and C for specialized radio receiver,

Apple, Cupertino, California
Senior Wireless System Architect — June 2012 – July 2013

- Analysis of 802.11 wireless networks for iOS products.

Broadcom Corporation, Sunnyvale, California

Associate Technical Director, Office of the CTO	March 2011 – May 2012
Senior Principal Scientist, Office of the CTO	March 2007 - March 2011
Principal Scientist, Office of the CTO	March 2006 - March 2007
Engineering Manager, Wireless LAN Business Unit	June 2004 - March 2006
Senior Staff Scientist, Wireless LAN Business Unit	January 2000 - June 2004

- Analysis and development of new wireless networking technologies for application to WiGig (60 GHz wireless), WirelessHD, Bluetooth, Wimedia Ultrawideband, IEEE 802.11, and 802.15 systems. Investigation of inter-networking, antenna systems, beamforming techniques, signal processing and advanced devices employing multiple wireless technologies.
- Secretary, board member, and vice chair of the Technical Working Group of the Wireless Gigabit Alliance.
- Vice chair of the IEEE 802.11ad (60 GHz MAC/PHY) task group.
- Developed BT/802.11 technology and co-chaired the Bluetooth SIG 802.11 AMP (Alternate MAC/PHY) Study Group. The resulting specification was the hallmark feature of the Bluetooth 3.0 release.
- Developed significant intellectual property related to wireless networks and contributed to the management of company patent portfolio through patent review committee.

- Project manager and lead physical layer (PHY) systems engineer for 802.11n proposal to the IEEE. Key elements of this proposal and further contributions became the basis of the IEEE 802.11n standard including MIMO-OFDM physical layer and enhanced MAC layer for higher throughput wireless networks. Made contributions in the areas of preamble design, advanced channel coding, MIMO-OFDM, channel estimation, and multiple antenna beamforming. (See: https://en.wikipedia.org/wiki/IEEE_802.11n-2009)
- Led Broadcom effort to standardize power control and dynamic frequency selection for wireless networks in IEEE 802.11 Task Group H. Proposal is now part of 802.11h standard. (See: https://en.wikipedia.org/wiki/IEEE_802.11h-2003)
- System engineering for 802.11a/b/g wireless local area network chipsets, including analysis of radio and base-band dsp architectures for the physical layer design. Developed signal processing algorithms, channel models, radio system models, and laboratory radios.
- Designed and developed MATLAB and bit accurate C models for the physical layers of 802.11 WLAN chipsets. These included models for equalizers, convolutional coders/decoders, beamforming, nonlinear distortion in radio transceivers, and radio channels.
- Analyzed and debugged first silicon versions of commercially successful 802.11a/b/g integrated circuit products.
- Developed radar detection and dynamic frequency selection hardware and software for 802.11a chipsets to meet ETSI (European) and FCC (U.S.) regulations.

Excess Bandwidth Corporation (now **Conexant**), Santa Clara, California
Principal Systems Engineer 1998–1999

- System engineering and architecture for HDSL2/G.shdsl digital subscriber line modems, including MATLAB and C code to simulate equalizers, error correcting codes, timing recovery, digital phase locked loops, waiting time jitter, and performance in crosstalk.
- Developed DSP software in C and assembler (TI C6x) for prototype HDSL2/G.shdsl modem. Implemented modules for adaptive equalization, timing recovery, and activation frame handshake.

Amati Communications Corporation (now **Texas Instruments**)
San Jose, California
Senior Research Engineer 1997-1998

- Developed, analyzed, and implemented advanced equalizer training algorithms for discrete multi-tone (DMT) based asymmetric digital subscriber line (ADSL) models.

AT&T Bell Laboratories, Whippany, New Jersey
Member of Technical Staff 1990-1992

- Developed RF and analog circuit designs for AT&T Autoplex 1000 fiber optic micro-cell radio transceiver.
- Managed testing group and developed test program for high power 900 MHz feed-forward linear amplifier used in cellular telephone base stations.

MIT Lincoln Laboratory, Lexington, Massachusetts
Member of Technical Staff 1989-1990

- Developed signal processing software and RF hardware for experimental X-band and Ka-band radar.
- Conducted radar measurements at Lincoln Laboratory sites in Lexington, MA and Kwajalein Atoll, U.S. Marshall Islands.

III. LITIGATION EXPERIENCE

- NXP B.V. v. Broadcom Corp., No. 5:14-cv-826 (N.D. Cal.). Retained on behalf of Broadcom.
- Linex Techs., Inc. v. Hewlett-Packard Co. et al., No. 4:13-cv-00159 (N.D. Cal.). Retained on behalf of Broadcom.
- TomTom Int'l, B.V. v. Broadcom Corp., No. 8:14-cv-475 (C.D. Cal.). Retained on behalf of Broadcom.
- Certain Electronics Products, Including Products with Near-Field Communication ("NFC") System-Level Functionality and/or Battery Power-Up Functionality, Components Thereof, and Products Containing Same, No. 337-TA-950 (ITC). Retained on behalf of Dell.
- NXP B.V. et al. v. Dell Inc., No. 1:14-cv-00146 (D. Del.). Retained on behalf of Dell.
- California Institute of Tech. v. Broadcom Ltd. et al., No. 2:16-cv-3714 (C.D. Cal.). Retained on behalf of Broadcom. Deposed.
- Nokia Techs. Oy et al. v. Apple Inc., Nos. 2:16-cv-1440, 2:16-cv-1441 (E.D. Tex.). Retained on behalf of Apple Inc.

- Certain Electronic Devices, Including Mobile Phones, Tablet Computers, and Components Thereof, Nos. 337-TA-1038, 337-TA-1039 (ITC). Retained on behalf of Apple Inc.

- Ruckus Wireless, Inc., Belkin International, Inc., Amazon.com, Inc., Netgear, Inc., and Roku, Inc. v. Hera Wireless S.A., U.S. Patent and Trademark Office *Inter Partes Review*. Retained on behalf of Ruckus Wireless (Arris, Inc.).

- Certain Mobile Electronic Devices and Radio Frequency and Processing Components Thereof, Inv. No. 3337-TA-1065; Qualcomm Inc. v. Apple Inc, Civ. Action No. 3:17-cv-01375-JAH-MDD. Retained on behalf of Apple.

- VLSI Technology LLC v. Intel Corporation, No. 1:18-cv-00966 (Delaware). Retained on behalf of Intel Corporation.

- Nokia Techs. Oy v. Lenovo (Shanghai) Elects. Tech. Co. Ltd, et al., No. 5:19-cv-427 (E.D.N.C.) and In re Certain Electronic Devices, Including Computers, Tablet Computers, and Components and Modules Thereof, Inv. No. 337-TA-1208 (U.S.I.T.C). Retained on behalf of Lenovo.

- Koss Corporation v. Apple, Inc, No. 6:20-cv-00665 (W.D. Texas). Retained on behalf of Apple, Inc. Deposed.

- Aegis 11 S.A. v. Hisense Company, Ltd. and Hisense USA Corporation, No. 1:20-cv-03891 (N.D. Georgia). Retained on behalf of Hisense.

- Mediatek, Inc. v. NXP Semiconductors, No. 2:21-cv-04970 (C.D. California), In the Matter of Certain Integrated Circuits And Products Containing Same, Inv. No. 337-TA-1272. Retained on behalf of NXP. Deposed. Testified at evidentiary hearing.

- One-E-Way, Inc. v. Apple Inc., No. 2:20-cv-06339-JAK-PD (C.D. Cal.)

- NXP Semiconductors v. Mediatek, Inc. In the Matter of Certain Integrated Circuits And Products Containing Same, Inv. No. 337-TA-1287. Retained on behalf of NXP. Deposed.

- Intellectual Ventures v. General Motors, No. 6:21-cv-1088 (W.D. Texas). Retained on behalf of General Motors.

- XR Communications, LLC v. Hewlett Packard, 6:21-cv-00694 (W.D. Texas). Retained on behalf of Hewlett Packard.

- American Patents, LLC v. Marvell Semiconductors, 6:22-cv-771 (W.D. Texas). Retained on behalf of Marvell Semiconductors.

- TexasLDPC, Inc. v. Broadcom, C.A. No. 18-1966-SB (Delaware). Retained on behalf of Broadcom.

- Atlas Global Technologies v. OnePlus, 6:21-cv-01217-ADA. Retained on behalf of OnePlus.

- LG Electronics Inc. v. TCL Electronics Holding Ltd., 2:22-cv-122-JRG. Retained on behalf of LG Electronics Inc.

- Atlas Global Technologies v. TP-Link, 2:21-cv-430-JRG. Retained on behalf of TP-Link. Deposed. Testified at Trial.

- Panasonic Automotive Systems Co., Ltd. v. UNM Rainforest Innovations, U.S. Patent and Trademark Office *Inter Partes Review*. Retained on behalf of Panasonic.

- Intellectual Ventures I, LLC v. Ubiquiti, Inc., C.A. No. 23-cv-00865-GBW. Retained on behalf of Ubiquiti.

- Motorola Mobility LLC v. Ericsson AB, Certain Cellular Base Station Communications Equipment Components Thereof, And Products Containing Same. ITC 337-TA- . Retained on behalf of Ericsson.

- ASUS Technology. Licensing Inc., et al v. AT&T Corp., et al, Case No. 2:23-cv-00486 (EDTX); ASUS Technology. Licensing Inc., et al v. T-Mobile USA, Inc., Case No. 2:23-cv-00487 (EDTX); ASUS Technology. Licensing Inc., et al v. Cellco Partnership d/b/a Verizon Wireless, et al, Case No. 2:23-cv-00488 (EDTX); Innovative Sonic Ltd., et al v. AT&T Corp., et al Case No. 2:23-cv-00489 (EDTX); Innovative Sonic Ltd., et al v. T-Mobile USA, Inc. Case No. 2:23-cv-00490 (EDTX); Innovative Sonic Ltd., et al v. Cellco Partnership d/b/a Verizon Wireless, et al Case No. 2:23-cv-00491 (EDTX). Retained on behalf of Ericsson for defendants. Deposed.

- Secure Communications Technologies, LLC v. Samsung Electronics Co., Ltd. Case No. 2:24-cv-484 (E.D. Texas). Retained on behalf of Samsung.

IV. EDUCATION

Ph.D., Electrical Engineering 1997
University of California, Los Angeles
Dissertation: *Probing Techniques for Multiuser Channels with Power Control*
Research Area: Wireless and Digital Communications
Advisor: Gregory J. Pottie

M.S., Electrical Engineering 1989
University of Massachusetts, Amherst
Concentration: Signal Processing and Microwave Systems

B.S., Electrical Engineering 1987
Rensselaer Polytechnic Institute

V. HONORS AND AFFILIATIONS

- Institute of Electrical and Electronics Engineers (IEEE) Senior Member.
- Member, Society for Industrial and Applied Mathematics.
- Reviewer, IEEE Communications Magazine, 2014 - present.
- Board of Directors, PATCA - Professional and Technical Consultants Association, Silicon Valley, 2007 - present.
- Vice Chair, IEEE 802.11ad Task Group, 2011-2012.
- Secretary, Wireless Gigabit Alliance, 2010-2012.
- Rockwell graduate fellowship recipient, UCLA, 1992-1996.
- Eta Kappa Nu, Electrical Engineering Honor Society, Rensselaer Polytechnic Institute, 1987.

VI. SKILLS

- Architecture and analysis of wireless digital communication systems, including 802.11a/b/g/n/ac/ad/ax/ay, Bluetooth, Wimedia UWB, WirelessHD, and WiGig.

- DSP Programming (TI TMS320C62x and 320C5x) in C and assembler and general programming in C++, C, Matlab, and Python.
- RF/microwave/mmwave laboratory and over-the-air channel measurements.
- Extra class Amateur Radio license (W6COV) and Commercial General Radiotelephone license.

VII. PUBLICATIONS

C. J. Hansen, "Semi-blind Channel Estimation on 802.11 OFDM Data Symbols", International Conference on Computing, Networking and Communications (ICNC 2024), February 2024.

A. Tompkins, et al, "A 16-Element Phased-Array Transceiver in 130-nm SiGe BiCMOS for Fixed Wireless Access Covering the Full 57-71 GHz Band", IEEE Radio and Wireless Symposium (RWS), January 2020.

C. J. Hansen, "Internetworking with Bluetooth Low Energy", ACM GetMobile, Vol 19, Issue #2, April 2015.

C. J. Hansen, "WiGig – Multigigabit Wireless Communication in the 60 GHz Band", IEEE Communications Magazine, December 2011.

C. J. Hansen and G. J. Pottie, "A Distributed Access Algorithm for Cellular Personal Communication Systems with Channel Partitioning", IEEE Transactions on Vehicular Technology, January 1999.

C. J. Hansen and G. J. Pottie, "Distributed Access Control in Wireless and Wireline Systems," International Symposium on Information Theory, Whistler, B.C., 1995.

C. J. Hansen, C. C. Wang, and G. J. Pottie, "Distributed Dynamic Channel Resource Allocation in Wireless Communication Systems", Asilomar Conference on Signals, Systems, and Computers, 1994.

VIII. PATENTS

Named inventor on the following United States patents:

US Patent Number	***Patent Title***
11,297,625	Method, system and apparatus for signaling station capabilities to establish wireless connections
11,121,818	Method and apparatus for unsolicited block acknowledgements
10,886,975	Single-carrier wideband beamforming method and system
10,820,328	Method and apparatus for de-centralized spatial reuse in wireless communications systems
10,784,990	Method and apparatus for encoding and modulating data for wireless transmission
10,735,133	Method and apparatus for configurable MIMO processing in wireless communications
10,716,117	Method, system and apparatus for signaling station capabilities to establish wireless connections
10,681,632	System and method for low power signaling in a wireless local area network
10,630,359	Method and apparatus for beamforming training using frames
10,498,419	Method and apparatus for determining direction for transmission to establish wireless connections
10,243,635	Method and apparatus for beamforming training using frames
10,236,964	Method and apparatus for beamforming training in basic service set discovery
10,110,273	Interference mitigation in wireless communication systems
10,015,741	System and method for low power signaling in a wireless local area network
9,960,865	Filtering of Wi-Fi physical layer measurements
9,949,227	Location determination
9,680,563	System and method for partial bandwidth communication
9,596,637	Dynamically adapting wireless communication
9,826,373	WLAN transmitter having high data throughput
9,622,216	Method and system for low rate MAC/PHY for 60 GHz transmission
9,516,483	Wireless communication between stations of differing protocols
9,356,673	Communication device incorporating beamforming handshaking
9,344,535	Multiple protocol wireless communications in a WLAN
9,307,350	Protocol adaptation layer for wireless communications
9,300,368	Method and system for 60 GHz antenna adaptation and user coordination based on base station beacons
9,247,439	High data throughput wireless local area network receiver

9,241,331	Method and system for optimal beamforming in wireless networks
9,198,035	Simple pairing to generate private keys for different protocol communications
9,130,705	Transmitting high rate data within a MIMO WLAN
9,104,569	Method and apparatus for signal detection and decoding
9,037,092	Method, apparatus and computer program for determining whether a received signal comprises a first signal component
9,025,491	High speed data transmission utilizing a high frequency physical layer for a wireless personal area network device
8,996,949	Encoding system and method for a transmitter in wireless communications
8,965,431	Multimode control device for allocating resources to communication devices that use differing protocols and methods for use therewith
8,964,895	WLAN transmitter having high data throughput
8,964,521	Method and system for compromise greenfield preambles for 802.11N
8,929,317	Transmission of wide bandwidth signals in a network having legacy devices
8,917,676	Device and method for transmitting long training sequence for wireless communications
8,909,272	Control device for allocating resources to communication devices that use differing protocols and methods for use therewith
8,897,320	High data throughput WLAN frame format
8,892,056	Protocol adaptation layer for wireless communications
8,891,642	Mixed mode preamble for MIMO wireless communications
8,805,277	Method and system for Bluetooth 802.11 alternate MAC/PHY (AMP) transmit power control (TPC)
8,804,685	Dual mode operation in a wireless network
8,774,327	Adjustable RF receiver
8,750,252	Long training sequence method and device for wireless communications
8,743,994	Feedback of channel information in a closed loop beamforming wireless communication system
8,737,189	Method and system for compromise greenfield preambles for 802.11n
8,725,101	Wireless device and method of operation
8,644,770	Protocol adaptation layer for wireless communications
8,644,284	Dual mode operation in a wireless network
8,638,263	Platform enhancements for planar array antennas
8,634,777	Pairing with directional code sequence
8,630,367	Signaling format for wireless communications

8,620,368	Method and system for 60 GHz antenna adaptation and user coordination based on base station beacons
8,611,821	Communication device that detects and adapts to the presence of other devices and methods for use therewith
8,588,283	Method and system for frame formats for MIMO channel measurement exchange
8,577,416	Transceiver with plural space hopping array antennas and methods for use therewith
8,576,695	Preamble formats for MIMO wireless communications
8,553,659	Method and system for optimal beamforming in wireless networks
8,548,087	Long training sequence for MIMO WLAN systems
8,520,669	High data throughput wireless local area network receiver
8,437,419	Method and system for frame formats for MIMO channel measurement exchange
8,437,362	Asymmetrical MIMO wireless communications
8,407,556	LDPC (low density parity check) coding and interleaving implemented in MIMO communication systems
8,406,204	Transmission of wide bandwidth signals in a network having legacy devices
8,385,844	Transceiver with plural space hopping phased array antennas and methods for use therewith
8,369,784	High speed data transmission utilizing a high frequency physical layer for a wireless personal area network device
8,363,642	High data throughput wireless local area network receiver
8,351,399	MIMO wireless communication greenfield preamble formats
8,345,732	Feedback of channel information in a closed loop beamforming wireless communication system
8,320,877	Method and system for 60 GHz location determination and coordination of WLAN/WPAN/GPS multimode devices
8,284,867	Mixed mode preamble for MIMO wireless communications
8,284,651	Preamble formats for MIMO wireless communications
8,265,185	Method and system for encoding a signal for wireless communications
8,254,407	Asymmetrical MIMO wireless communications
8,233,565	Method and system for high speed wireless data transmission between communication devices
8,213,395	Method and system for dual mode operation in wireless networks
8,195,092	Method and system for utilizing a high frequency PHY layer for high speed data transmission between wireless devices
8,190,162	Radar detection circuit for a WLAN transceiver
8,184,679	RF transceiver having adaptive modulation

8,176,380	Algebraic construction of LDPC (low density parity check) codes with corresponding parity check matrix having CSI (cyclic shifted identity) sub-matrices
8,175,542	Transceiver with plural space hopping phased array antennas and methods for use therewith
8,170,504	Modified preamble for programmable transmitter
8,170,496	Transceiver with space hopping phased array antenna and methods for use therewith
8,170,495	Collaborative pairing transceiver with space hopping phased array antenna and methods for use therewith
8,169,998	Method and system for an AD HOC wireless network with master control of network parameters
8,144,798	Long training sequence for MIMO WLAN systems
8,126,425	Method and system for 60 GHZ location determination based on varying antenna direction and coordination of WLAN/WPAN/GPS multimode devices
8,095,162	Control device for allocating resources to communication devices that use differing protocols and methods for use therewith
8,094,749	Signaling format for wireless communications
8,089,890	Transmitting high rate data within a MIMO WLAN
8,085,871	Adaptive modulation in a multiple input multiple output wireless communication system with optional beamforming
8,081,926	Method and system for multisession communication using multiple physical (PHY) layers
8,081,104	Radar detection circuit for a WLAN transceiver
8,077,810	Apparatus for high data throughput reception in a WLAN
8,059,740	WLAN transmitter having high data throughput
8,041,333	Method and system for 60 GHz antenna adaptation and user coordination based on base station beacons
8,032,167	Multimode control device for allocating resources to communication devices that use differing protocols and methods for use therewith
8,031,806	Mixed mode preamble for MIMO wireless communications
7,995,667	Reduced latency concatenated reed solomon-convolutional coding for MIMO wireless LAN
7,991,056	Method and system for encoding a signal for wireless communications
7,991,009	Preamble formats for MIMO wireless communications
7,978,729	High data throughput WLAN frame format
7,974,591	Modified preamble for programmable transmitter
7,957,450	Method and system for frame formats for MIMO channel measurement exchange
7,940,751	Personal area network data encapsulation in WLAN communications

7,924,943	Method and system for optional closed loop mechanism with adaptive modulations for multiple input multiple output (MIMO) wireless local area network (WLAN) system
7,920,526	Long training sequence method and device for wireless communications
7,912,449	Method and system for 60 GHz location determination and coordination of WLAN/WPAN/GPS multimode devices
7,894,852	Channel reciprocity matrix determination in a wireless MIMO communication system
7,873,022	Multiple input multiple output wireless local area network communications
7,865,142	Method and system for multisession bluetooth communication using multiple physical (PHY) layers
7,840,184	Method and system for utilizing a 60 GHZ PHY layer for high speed data transmission between bluetooth devices
7,826,547	Mixed mode preamble for MIMO wireless communications
7,801,098	Parallel MAC/PHY for enhanced transmission rate in a wireless network
7,796,696	Asymmetrical multiple stream wireless communication using STBC
7,773,565	MIMO wireless communication greenfield preamble formats
7,746,886	Asymmetrical MIMO wireless communications
7,702,291	Radar detection from pulse record with interference
7,701,382	Radar detection circuit for a WLAN transceiver
7,680,059	Multiple protocol wireless communications in a WLAN
7,617,439	Algebraic construction of LDPC (Low Density Parity Check) codes with corresponding parity check matrix having CSI (Cyclic Shifted Identity) sub-matrices
7,593,692	Radar detection circuit for a WLAN transceiver
7,590,429	RF transceiver configuring for a MIMO communication
7,590,189	Signaling format for wireless communications
7,586,881	MIMO wireless communication greenfield preamble formats
7,583,933	Dynamic frequency selection in a wireless communication network
7,570,619	Long training sequence method and device for wireless communications
7,564,914	Method and system for frame formats for MIMO channel measurement exchange
7,558,537	Modified preamble for programmable transmitter
7,555,053	Long training sequence for MIMO WLAN systems
7,539,501	High data throughput wireless local area network receiver
7,516,390	LDPC (Low Density Parity Check) coding and interleaving implemented in MIMO communication systems
7,502,408	RF transceiver having adaptive modulation

7,466,773	WLAN receiver having an iterative decoder
7,444,134	Device and method for transmitting long training sequence for wireless communications
7,423,989	Preamble formats for MIMO wireless communications
7,417,974	Transmitting high rate data within a MIMO WLAN
7,400,643	Transmission of wide bandwidth signals in a network having legacy devices
7,330,501	Orthogonal normalization for a radio frequency integrated circuit
7,324,785	Transmit power control of wireless communication devices
7,269,430	Frame format for high data throughput wireless local area network transmissions
7,242,961	Channel reciprocity matrix determination in a wireless MIMO communication system
7,233,773	Configuring a MIMO communication
7,162,204	Configurable spectral mask for use in a high data throughput wireless communication
7,158,759	Dynamic frequency selection in a wireless communication network
7,020,220	Digital estimation and correction of I/Q mismatch in direct conversion receivers

APPENDIX B

2023-01-18 TGay Awards Photographs

The TGay awards ceremony was held during the electronic July 2021 session and the accompanying presentation is here. The awards themselves were kept in storage and presented at the January 2023 session at the Hilton Balitmore Inner Harbor, Baltimore, MD, USA, the photos for which are below. Not all recipients were able to attend.



WG and TGay Officer Awards



Dorothy Stanley

WG Chair



Jon Rosdahl

WG Vice Chair



Robert Stacey

WG Vice Chair



Stephen McCann

WG Secretary



Edward Au

TGay Chair



Sang Kim

TGay Vice Chair



Jeorge Hurtarte

TGay Secretary



Robert Stacey accepting on behalf of Carlos Coredeiro

TGay Editor



SangHyun Chang

Former TGay Vice Chair



Yan Xin

Former TGay Vice Chair, major contributor to EDMG PHY and comment resolution

TGay Significant Contributor Awards



Claudio da Silva

For significant contribution to EDMG PHY, coexistance assurance document, and comment resolution



Alecsander Eitan

For signficant contribution to EDMG PHY and comment resolution



Lei Huang

For signficant contribution to EDMG PHY and comment resolution



Assaf Kasher

For signficant contribution to EDMG MAC and comment resolution



Artyom Lomayev

For significant contribution to the EDMG channel modelling, EDMG PHY, and comment resolution



Alexander Maltsev

For significant contribution to the EDMG channel modelling and EDMG PHY



Payam Torab

For significant contribution to TDD millimeter wave distribution networks



Solomon Trainin

For significant contribution to the EDMG MAC and comment resolution



Hiroyuki Motozuka

For major contribution to EDMG PHY comment resolution



Kome Oteri

For major contribution to EDMG PHY and comment resolution



Ilya Bolotin

For major contribution to EDMG MAC and comment resolution



Cheng Chen

For major contribution to EDMG MAC, TDD millimeter wave distribution networks, and comment resolution



James Wang

For major contribution to EDMG MAC and comment resolution



Al Petrick

For major contribution to comment resolution. Award given at March 2023 session.



Rui Yang

For major contribution to comment resolution



Rob Sun

For major contribution to comment resolution

TGay PHY Contributor Awards



Nelson Costa

For contribution to comment resolution



Thomas Handte

For contribution to EDMG PHY and comment resoliution



Takenori Sakamoto

For contribution to EDMG PHY and comment resoliution



Sunwoong Yun

For contribution to EDMG PHY

TGay MAC Contributor Awards



Djordje Tujkovic

For contribution to TDD millimeter wave distribution networks



Mohamed AbouelSeoud

For contribution to EDMG MAC comment resoliution

Sauhee Bang

For contribution to EDMG MAC and comment resoliution



George Calcev

For contribution to EDMG MAC comment resoliution



Tony Xiao Han

For contribution to EDMG MAC



Chris Hansen

For contribution to EDMG MAC comment resoliution. Award given at March 2023 session.

Kyungtae Jo

For contribution to EDMG MAC

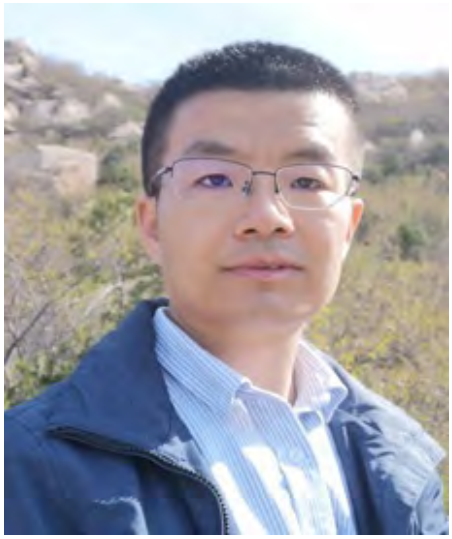


Oren Kedem

For contribution to EDMG MAC and comment resoliution

Jinmin Kim

For contribution to EDMG MAC and comment resoliution



Dejian Li

For contribution to EDMG MAC comment resoliution

Sungjin Park

For contribution to EDMG MAC and comment resoliution



Kazuyuki Sakoda

For contribution to EDMG MAC comment resoliution



Li-Hsiang Sun

contribution to EDMG MAC comment resoliution

Acknowledgment

Working Group IEEE 802.11 gratefully acknowledges Matthew Fischer and Mark Hamilton for taking these photographs.

This page is maintained by Robert Stacey. Comments are welcome.

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APPENDIX C

Status of Project IEEE 802.11ax

High Efficiency (HE) Wireless LAN Task Group

Task Group Leadership

Chair	**Osama Aboul-Magd (Huawei Technologies)**
1st Vice Chair	**Ron Porat (Broadcom Ltd.)**
2nd Vice Chair	**Alfred Asterjadhi (Qualcomm)**
Secretary	**Yasuhiko Inoue (NTT)**
Technical Editor	**Robert Stacey (Intel)**

Background

In May 2013, the High Efficiency WLAN Study Group (HEW SG), a study group within IEEE 802.11 working group had started its activity to consider the improvement of spectrum efficiency to enhance the system throughput/area in high density scenarios of APs and/or STAs.

The study group was created based on the following straw poll and motion:

< Straw Poll >
Do you support starting a new study group called "high efficiency WLAN" to enhance 802.11 PHY and MAC in 2.4 and 5GHz with a focus on:

- Improving spectrum efficiency and area throughput
- Improving real world performance in indoor and outdoor deployments
  - in the presence of interfering sources, dense heterogeneous networks
  - in moderate to heavy user loaded APs

< Motion >
Request an approval by IEEE 802 LMSC to form an 802.11 Study Group to consider High-efficiency WLAN [as described in doc 11-13-0339r2] with the intent of creating a PAR and five criteria.

The HEW SG has successfully developed PAR and CSD documents and the project 802.11ax has started in May 2014.

Task Group Documents

The lastest version of the task group offical documents can be found here.

- 11-14-0165 Project Authorization Request (PAR)
- 11-14-0169 Criteria for Standard Developement (CSD)
- 11-14-0938 TGax Selection Procedure
- 11-14-0980 TGax Simulation Scenarios
- 11-14-0571 TGax Evaluation Methodology
- 11-14-0882 TGax Channel Models

- 11-14-1009 TGax Functional Requirements
- 11-15-0132 TGax Specification Framework

Previous Meetings

Links to the reports of previous meetings.

TGax	2020	November 2020	September 2020	July 2020
		May 2020	March 2020	January 2020
	2019	November 2019	September 2019	July 2019
		May 2019	March 2019	January 2019
	2018	November 2018	September 2018	July 2018
		May 2018	March 2018	January 2018
	2017	November 2017	September 2017	July 2017
		May 2017	March 2017	January 2017
	2016	November 2016	September 2016	July 2016
		May 2016	March 2016	January 2016
	2015	November 2015	September 2015	July 2015
		May 2015	March 2015	January 2015
	2014	November 2014	September 2014	July 2014
		May 2014	---	---
HEW SG	2014	---	March 2014	January 2014
	2013	November 2013	September 2013	July 2013
		May 2013	---	---

November 2020 — Online Meeting

The IEEE 802 Plenary Session November 2020 was held online.
The P802.11ax D8.0 was in the process of the second IEEE-SA recirculation ballot from November 3rd to 12th, 2020.
TGax had two online meetings during the November 2020 plenary.

Main documents

The TGax meeting agenda, draft meeting minutes and closing report can be found here.

- 11-20-1552-21, TGax CRC Teleconference Agendas: October - November - December 2020
- 11-20-1785-01, (draft) TGax November 2020 Meeting Minutes
- 11-20-1822-00, TGax November 2020 Closing Report

Accomplishments

- The TG was scheduled for two time slots - Tuesday @ 16:00 ET and Thursday @ 19:00 ET
- The TG reviewed and approved the report to the EC requesting conditional approval to forward to RevCom.
  The TG approved r3 of the report. R4 is on the server updating the number of unsatisfied comments.
  The report is available at:
  - https://mentor.ieee.org/802.11/dcn/20/11-20-1771-04-00ax-p802-11ax-report-to-ec-on-conditional-approval-to-forward-draft-to-revcom.pptx

- The TG reaffirmed the TG CSD.
  - https://mentor.ieee.org/802.11/dcn/14/11-14-0169-03-0hew-ieee-802-11-hew-sg-proposed-csd.docx
- **The TG is on time to submit the draft (8.0) for the January 2021 RevCom meeting.**

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October 2020 — Status Update

- The first IEEE-SA recirculation ballot on the P802.11ax D7.0 completed successfully with 88% approval ratio. 132 comments were received.
- TGax continued two or three teleconferences to resolve the comments for D7.0.
- During TGax CRC teleconference on October 30th, TGax completed comment resolution for D7.0 and passed the motion
  - to instruct the TGax technical editor to create the IEEE 802.11ax draft 8.0 incorporating the resolutions, and
  - to approve a 10-day IEEE-SA Recirculation Ballot asking the question " Should P802.11ax Draft 8.0 be forwarded to RevCom?"

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September 2020 — Online Meeting

The IEEE 802 Wireless Interim Session September 2020 was held online.
The P802.11ax D7.0 was in the process of the first IEEE-SA recirculation ballot
and the TGax had one online meeting during the week.

Main documents

The TGax meeting agenda and meeting minutes can be found here.

- 11-20-1169-18, TGax CRC Teleconference Agendas: August - September 2020
- 11-20-1522-00, TGax September 2020 Meeting Minutes

Accomplishments

- Approved TGax CRC teleconference minutes from July to August, 2020
- Reaffirmed Ron Porat (Broadcom) and Alfred Asterjadhi (Qualcomm) as the fist and the second vice-chairs, respectively.
- Reaffirmed Yasuhiko Inoue (NTT) as the TGax secretary.
- Reviewed the IEEE-SA Comment Resolution Guideline.

Timeline

- RevCom meeting scheduled at January 26, 2021.
  - Deadline for submission is December 11, 2020.
- 802 WG virtual meeting is scheduled during the period October 30 to November 13, 2020.
  - The CRC needs the 802.11 WG and 802 WG approvals to proceed to RevCom in January.
- The CRC seems to have about 40 days to complete resolutions of all comments received on draft 7.0.

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- TGax had one session continued two teleconferences to resolve the comments for D6.0.
- During TGax CRC teleconference on August 27th, TGax completed comment resolution for D6.0 and passed the motion
  - to instruct the TGax technical editor to create the IEEE 802.11ax draft 7.0 incorporating the resolutions, and

    - to approve a 15-day IEEE-SA Recirculation Ballot asking the question " Should P802.11ax Draft 7.0 be forwarded to RevCom?"
- The 15-day IEEE-SA Recirculation Ballot on the IEEE 802.11ax D7.0 has opened on **September 3rd** and will close on **September 17th, 2020, 23:59 (ET)**.

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August 2020 — Status Update

- TGax continued two teleconferences to resolve the comments for D6.0.
- During TGax CRC teleconference on August 27th, TGax completed comment resolution for D6.0 and passed the motion
    - to instruct the TGax technical editor to create the IEEE 802.11ax draft 7.0 incorporating the resolutions, and
    - to approve a 15-day IEEE-SA Recirculation Ballot asking the question " Should P802.11ax Draft 7.0 be forwarded to RevCom?"
- The 15-day IEEE-SA Recirculation Ballot on the IEEE 802.11ax D7.0 has opened on **September 3rd** and will close on **September 17th, 2020, 23:59 (ET)**.

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July 2020 — Online Meeting

The IEEE 802 Plenary July 2020 Session was held online.
TGax had one meeting during the plenary session and another one after closing plenary.

Main documents

The meeting agenda and minutes of the TGax and its subgroups, and the TGax closing report can be found here.

- TGax
    - 11-20-0538-45, TGax CRC Teleconference march-July 2020 Teleconference Agendas
    - 11-20-1103-00, (Draft) TGax July 2020 Meeting Minutes

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May 2020

The IEEE 802 Wireless Interim Session May 2020 was also cancelled due to COVID-19.
In the meantime, TGax continued to accelerate comment resolution process by two teleconferences every week.

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March 2020

The IEEE 802 Plenary Session March 2020 was cancelled due to COVID-19.
In the meantime, TGax accelerated comment resolution process by having two teleconferences per week.

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January 2020 — Irvine, CA

The TGax had only one meeting during the week since the initial IEEE-SA ballot on the IEEE 802.11ax D6.0 is going on.

	Monday	Tuesday	Wednesday	Thursday
AM1				
AM2	**TGax** (full session)			
PM1				
PM2				
PM3				

Main documents

The meeting agenda and minutes of the TGax and its subgroups, and the TGax closing report can be found here.

- TGax
  - 11-19-2118-02, TGax January 2020 Meeting Agenda
  - 11-20-0190-00, TGax January 2020 Closing Report
  - 11-20-0148-00, (Draft) TGax January 2020 Irvine Meeting Minutes

Achievements

1. **Work Completed**
   - The TG was scheduled for one time slot on Monday AM-2
     - Approved November F2F meeting minute and December 13 teleconference minutes.
     - Decided on a TG teleconference schedule.
     - Decided no to have an ad hoc (CRC) meeting in March.
     - Reviewed the rules to be followed during the CRC operation.
   - Draft 6.0 is in SA ballot. The ballot closes on January 24th.
     - Please vote and submit your comments by the deadline.
2. Submissions
   - TGax received no submission to discuss during January 2020 session.
3. Timeline
   - No changes to current timeline.

Goals for the March 2020 session

- comments received on draft D6.0.

Teleconferences

Following TGax teleconferences were authorized during the January 2020 session.

Thursday	January 30th, 2020	10:00 - 12:00 (ET)
Thursday	February 13th & 27th , 2020	10:00 - 12:00 (ET)
Thursday	February 6th, 20th & March 5th, 2020	20:00 - 22:00 (ET)

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November 2019 — Waikoloa, HI

TGax had eight meeting slots during the week.
All sessions are full TG session.

	Monday	Tuesday	Wednesday	Thursday
AM1		**TGax** (full session)	**TGax** (full session)	
AM2		**TGax** (full session)		**TGax** (full session)
PM1			**TGax** (full session)	
PM2	**TGax** (full session)	**TGax** (full session)		**TGax** (full session)
PM3				

Main documents

The meeting agenda and minutes of the TGax and its subgroups, and the TGax closing report can be found here.

- TGax
  - 11-19-1732-09, TGax November 2019 Meeting Agenda
  - 11-19-2096-00, TGax November 2019 Closing Report
  - 11-19-2012-00, (Draft) TGax November 2019 Waikoloa Meeting Minutes

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Achievements

1. **Work Completed**
   - The group completed the resolution of all comments received on draft 5.0.
   - Motion passed in the TG to instruct the Editor to prepare draft 6.0 and start a 15-day recirculation ballot.
   - A new revision of the TG Coexistence Assurance document is available.
     - TGax Coexistence Assurance Document
   - The EC Report on conditional approval to go to SA ballot is available at 11-19/2063.

2. **Technical Submissions**
   TGax received following submissions.
   - 11-19-1684, "CR on dot11HECCAIndicatinMode," Robert Stacey (Intel)
   - 11-19-1796, "Comments on TGax CA doc r6," Eldad Perahia (HPE-Aruba)
   - 11-19-1810, "11ax D5.0 Comment Resolution for NAV related comments," Po-Kai Huang (Intel)
   - 11-19-1814, "11ax D5.0 MAC Comment Resolution for SM Power Save," Po-Kai Huang (Intel)
   - 11-19-1816, "11ax D5.0 MAC Comment Resolution for Duration-based RTS/CTS," Po-Kai Huang (Intel)
   - 11-19-1819, "Resolution to comment to subclause 9.3.1.7.1" Tomoko Adachi (Toshiba)
   - 11-19-1831, "Comment resolutions for miscellaneous comments," Alfred Asterjadhi (Qualcomm)
   - 11-19-1832, "Comment resolutions for subclause 26.8," Alfred Asterjadhi (Qualcomm)/Robert Stacey (Intel)
   - 11-19-1833, "Comment resolution for subclause 26.15," Alfred Asterjadhi (Qualcomm)
   - 11-19-1834, "Comment resolution for subclause 26.17," Alfred Asterjadhi (Qualcomm)
   - 11-19-1835, "Comment resolutions for TWT IE," Alfred Asterjadhi (Qualcomm)
   - 11-19-1871, "Resolution to HESIGB and Related Comments," Brian Hart (Cisco Systems)
   - 11-19-1896, "Comment Resolutions for 11ax D5.0 HE PHY Service Interface Section," Bo Sun (ZTE)
   - 11-19-1905, "Resolution for CIDs related to Multiple BSSID," Abhishek Patil (Qualcomm)
   - 11-19-1906, "Resolution for CIDs related to BSS Color," Abhishek Patil (Qualcomm)
   - 11-19-1922, "Some 802.11ax comment resolutions," Jarkko Kneckt (Apple)
   - 11-19-1936, "Ack related comments," George Cherian (Qualcomm)
   - 11-19-1941, "CIDs on Clause 27.3.10.7 for D5.1," Jianhan Liu (MediaTek)
   - 11-19-1947, "MAC CR on Fragmentation," Ming Gan (Huawei Technologies)

- 11-19-1948, "MAC CR on CID 22386 and 22387," Ming Gan (Huawei Technologies)
- 11-19-1949, "CR for CID 22030, 22031, 22032, 22447," Xiaogang Chen (Intel)
- 11-19-1956, "CR for BSS Color Related CIDs," Xiaofei Wang (InterDigital Communications)
- 11-19-1957, "LB244 CR MAC Miscellaneous," Yongho Seok (MediaTek)
- 11-19-1977, "CR for BSS Color Related CIDs Part 2," Xiaofei Wang (InterDigital Commincations)
- 11-19-1983, "Remaining PHY Math comment resolutions," Yang Zhang (Marvell Semiconductor)
- 11-19-1986, "Sounding CRs 11ax D5.0," Menzo Wentink (Qualcomm)
- 11-19-1995, "CR for MU EDCA parameters," Laurent Carioou (Intel)
- 11-19-1996, "CR for OPS," Laurent Carioou (Intel)
- 11-19-1997, "CR for Out of band discovery," Laurent Cariou (Intel)
- 11-19-1998, "CR for misc CIDs," Laurent Cariou (Intel)
- 11-19-2004, "D5.0 PHY C," Youhan Kim (Qualcomm)
- 11-19-2016, "CR BQR," Zhou Lan (Broadcom)
- 11-19-2020, "11ax D5.0 comment resolution of various cubclauses," Liwen Chu (Marvell)
- 11-19-2021, "Security parameter constraints," Jouni Malinen (Qualcomm)
- 11-19-2023, "CRs on MCS Tables," Bin Tian (Qualcomm)
- 11-19-2025, "11ax D5.0 comment resolution 26.6.3.1," Liwen Chu (Marvell)
- 11-19-2030, "CR on CID 22392," Ross Jian Yu (Huawei Technologies)
- 11-19-2035, "Transmit Spectral Mask for Preamble Punctured Channels," Dorin Viorel (Quantenna Communications)
- 11-19-2041, "Updated Channelizatin for 6 GHz," Imran Latif (Quantenna Communications)
- 11-19-2047, "LB244 CR for FTM CIDs," Jonathan Segev (Intel)
- 11-19-2048, "Proposed resolution for CIDs Related to Quiet Time Period," Kaiying Lu (MediaTek)
- 11-19-2053, "Proposed resolution for CIDs Related to Quiet Time Period," Kaiying Lu (MediaTek)
- 11-19-2057, "CID 22413, 22414," Youhan Kim (Qualcomm)
- 11-19-2068, "11ax D5.0 comment resolution of various subclauses," Liwen Chu (Marvell)
- 11-19-2075, "Proposed resolution for CID 22058," Kaiying Lu (MediaTek)
- 11-19-2077, "CID 22417," Youhan Kim (Qualcomm)
- 11-19-2083, "CR for RNR," Laurent Cariou (Intel)

3. **Timeline**
   No discussion on the timeline during the week.
   However, TGax timeline was updated as shown here.

Goals for the January 2020 session

- Start working on comments received on draft D6.0.

Teleconferences

No TGax teleconferences were authorized during the November 2019 session. A teleconference may be scheduled with a 10-day notice.

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September 2019 — Hanoi, Vietnam

TGax had nine meeting slots during the week.

	Monday	Tuesday	Wednesday	Thursday
AM1			**TGax** (full session)	**TGax** (full session)
AM2	**TGax** (full session)	**TGax** (MAC ad hoc) **TGax** (MU ad hoc)		
PM1			**TGax** (full session)	**TGax** (full session)

	Monday	Tuesday	Wednesday	Thursday
PM2	**TGax** (MAC ad hoc) **TGax** (PHY ad hoc)	**TGax** (MAC ad hoc) **TGax** (PHY ad hoc)		
PM3	**TGax** (full session)			

Main documents

The meeting agenda and minutes of the TGax and its subgroups, and the TGax closing report can be found here.

- TGax
  - 11-19-1409-06, TGax September 2019 Meeting Agenda
  - 11-19-1708-00, TGax September 2019 Closing Report
  - 11-19-1630-00, TGax September 2019 Hanoi Meeting Minutes
- TGax PHY ad hoc
  - 11-19-1634-01, TGax September 2019 Meeting - PHY Ad hoc Agenda
- TGax MAC ad hoc
  - 11-19-1409-06, TGax September 2019 Meeting Agenda (Agenda for the MAC ad hoc is contained in the TGax agenda)
- TGax MU ad hoc
  - 11-19-1649-02, September 2019 TGax MU Ad hoc Meeting Agenda

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Achievements

1. **Work Completed**
   - The group completed the resolution of all comments received on draft 4.0.
   - Motion passed in the TG to instruct the Editor to prepare draft 5.0 and start a 15-day recirculation ballot.
   - Motion passed to approve the new revision of the TG Coexistence Assurance document.
     - TGax Coexistence Assurance Document
   - Motion passed to approve the TG MDR

2. **Technical Submissions**
   TGax received following submissions.
   - PHY submissions
     - 11-19-0422, "CR for CID 21501, 21502, 21436," Xiaogang Chen (Intel)
     - 11-19-1377, "11ax D4.2 Comment Resolution for PHY Introduction," Sameer Vermani (Qualcomm)
     - 11-19-1386, "Resolution to PHY-related CID 21366," Brian Harts (Cisco Systems)
     - 11-19-1515, "Remaining PHY Math comment resolutions," Yan Zhang (Marvell)
     - 11-19-1530, "LB238 CID 20742, 20751," Youhan Kim (Qualcomm)
     - 11-19-1531, "LB238 CID 20785, 20934," Youhan Kim (Qualcomm)
     - 11-19-1560, "D4.0 CR PHY Misc," Tianyu Wu (Samsung)
     - 11-19-1581, "HE-SIG-A fields proposed text changes," Yan Zhang (Marvell)
   - MAC submissions
     - 11-19-0463, "Comment resolutions for Miscellaneous 11ax CID," David Kloper (Cisco Systems)
     - 11-19-0552, "CID 20073," Abhishek Patil (Qualcomm)
     - 11-19-0594, "Comment resolutions for transmit power control - part 2," Alfred Asterjadhi (Qualcomm)
     - 11-19-0619, "Proposed Resolutions to selected comments on D4.0," Mark Rison (Samsung)
     - 11-19-0770, "LB238 CR PPDU format, BW, MCS, NSS and DCM slection," Yongho Seok (MediaTek)
     - 11-19-0966, "Comment resolutions for miscellaneous TWT - part 2," Alfred Asterjadhi (Qualcomm)
     - 11-19-0968, "Proposed changes for some bug fixes and clarifications," Alfred Asterjadhi (Qualcomm)
     - 11-19-1064, "CR Disallowed Subchannels," Matthew Fischer (Broadcom)
     - 11-19-1137, "11ax sounding comments D4.0," Menzo Wentink (Qualcomm)
     - 11-19-1150, "Resolution for CIDs related to Co-located BSSID," Abhishek Patil (Qualcomm)
     - 11-19-1155, "LB-238 Miscellaneous Comment Resolution," Osama Aboul-Magd (Huawei Technologies)
     - 11-19-1167, "11ax D4.2 MAC Comment Resolution for SM Power Save Part II," Po-Kai Huang (Intel)

        - 11-19-1209, "11ax D4.0 CR for TXOP Duration-based RTS Threshold," Huizhao Wang (Quantenna Communications)
        - 11-19-1219, "Comment resolution for one CID," Alfred Asterjadhi (Qualcomm)
        - 11-19-1275, "Proposed Resolution to TGax D4.0 CR 20268," Srinivas Kandala (Samsung)
        - 11-19-1388, "Comment resolutions for non-AP STA scanning - part 2," Alfred Asterjadhi (Qualcomm)
        - 11-19-1390, "Comment resolutions for additional rules for preassociation," Alfred Asterjadhi (Qualcomm)
        - 11-19-1496, "Comment resolutions for 2 CIDs," Alfred Asterjadhi (Qualcomm)
        - 11-19-1520, "Resolution for CIDs related to Multiple BSSID - Part 3," Abhishek Patil (Qualcomm)
        - 11-19-1590, "CBF contents padding to 8bits," Huizhao Wang (Quantenna Communications)
        - 11-19-1610, "Comment resolutions for Reason Code CIDs," Pooya Monajemi (Cisco Systems)
        - 11-19-1618, "CR for CIDs 20475, 20788 and 21618," Jarkko Kneckt (Apple)
        - 11-19-1629, "11ax D4.0 MAC miscellaneous CIDs," Liwen Chu (Marvell)
        - 11-19-1631, "Proposed resolution for CIDs Related to Quiet Time Period," Kaiying Lu (MediaTek)
        - 11-19-1635, "Comment resolution on CID 20566," Edward Au (Huawei Technologies)
        - 11-19-1655, "11ax Comment Resolution Misc.," Zhou Lan (Broadcom)
        - 11-19-1658, "LB238 CR MAC Miscellaneous Part 2," Yongho Seok (MediaTek)
        - 11-19-1661, "Comment resolution on CIDs 20644 and 20645," Edward Au (Huawei Technologies)
        - 11-19-1662, "Resolutions to comments 20111 and 21011 of LB 238," Srinivas Kandala (Samsung)
        - 11-19-1667, "Resolutions for some comments on 11ax/D4.0 (LB238)," Mark Rison (Samsung)
        - 11-19-1668, "EOF handling in ack-enabled A-MPDU," Jarkko Kneckt (Apple)
        - 11-19-1673, "Proposed Resolution to TGax D4.0 CR20268," Srinivas Kandala (Samsung)
        - 11-19-1676, "MAC CR Fragment Flush," Ming Gan (Huawei Technologies)
        - 11-19-1682, "Comment resolutions for UORA," Chittabrata Ghosh (Intel)
        - 11-19-1684, "CR on dot11HECCAIndicationMode," Robert Stacey (Intel)
        - 11-19-1690, "Comment Resolution on MU Operation Part 2," Lochan Verma (Qualcomm)
    - MU submissions
        - 11-19-0765, "CR MU EDCA Timer," Zhou Lan (Broadcom)
        - 11-19-0908, "MU EDCA parameter update frame," Matthew Fischer (Broadcom)
        - 11-19-0917, "UORA Misc," Matthew Fischer (Broadcom)
        - 11-19-1186, "Comment Resolution on MU Operation," Lochan Veram (Qualcomm)
        - 11-19-1609, "MAC CR MU cascading," Ming Gan (Huawei Technologies)
        - 11-19-1627, "Last CIDs and fixes," Laurent Cariou (Intel)
    - SR submissions
        - 11-19-0613, "SRP Comments," Matthew Fischer (Broadcom)
    - Other submissions
        - 11-16-1348, "TGax Coexistence Assurance Document," Eldad Perahia (HPE/Aruba)
        - 11-19-0292, "Comments on TGax D4.0," Robert Stacey (Intel)
        - 11-19-1236, "Comment resolution on MIBs for LB238," Edward Au (Huawei Technologies)
        - 11-19-1243, "Comment Resolution on PICS for LB238," Edward Au (Huawei Technologies)

3. **Timeline**
   No discussion on the timeline during the week.
   However, TGax timeline was updated as shown here.

Goals for the November 2019 session

- Start working on comments received on draft D5.0.

Teleconferences

No TGax teleconferences were authorized during the September 2019 session. However, one teleconference was announced by a 10-day notice.

Tuesday	October 29th, 2019	13:00 - 15:00 (ET)

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July 2019 — Vienna, Austria

TGax had ten meeting slots during the week.

	Monday	Tuesday	Wednesday	Thursday
AM1	**TGax ad hoc** (full session)			
AM2		**TGax** (PHY ad hoc) **TGax** (MAC ad hoc)		**TGax** (full session)
PM1	**TGax** (full session)	**TGax** (PHY ad hoc) **TGax** (MAC ad hoc)	**TGax full** (PHY topic)	
PM2		**TGax ad hoc** (full session)	**TGax full** (MAC topic)	**TGax** (full session)
PM3	**TGax** (MAC ad hoc) **TGax** (MU ad hoc)			

Main documents

The meeting agenda and minutes of the TGax and its subgroups, and the TGax closing report can be found here.

- TGax
  - 11-19-0983-06, TGax July 2019 Meeting Agenda
  - 11-19-1347-00, TGax July 2019 Closing Report
  - 11-19-1264-00, TGax July 2019 Vienna Meeting Minutes
- TGax PHY ad hoc
  - 11-19-1274-03, TGax July 2019 Meeting Agenda - PHY Adhoc
  - 11-19-xxxx-yy, (Draft) TGax PHY Ad Hoc July 2019 Meeting Minutes (not available)
- TGax MAC ad hoc
  - 11-19-1279-02, TGax MAC Adhoc July 2019 Meeting Agenda
  - 11-19-1294-00, (Draft) July 15 PM3 TGax MAC Ad hoc meeting minutes
  - 11-19-1312-00, (Draft) July 16 TGax MAC Ad hoc meeting minutes
- TGax MU ad hoc
  - 11-19-1292-01, July 2019 TGax MU Ad hoc Meeting Agenda
  - 11-19-xxxx-yy, (Draft) TGax MU ad hoc July 2019 meeting minutes (not available)

Achievements

1. **Work Completed**
   - More time is needed to complete the resolution of all comments submitted during LB 238 on draft D4.0.
     - Almost 260 technical comments are remaining.

2. **Technical Submissions**
   TGax received following submissions.
   - PHY submissions
     - 11-19-0422, "CR for CID 21497, 21501, 21502," Xiaogang Chen (Intel)
     - 11-19-0793, "Remaining PHY Math comment resolutions," Yan Zhang (Marvell)
     - 11-19-0826, "CR on DCM and STBC Combinations," Youhan Kim (Qualcomm)
     - 11-19-0827, "CR on Punctured Non-HT Duplicate PPDU," Youhan Kim (Qualcomm)
     - 11-19-0830, "CR on Clause 17," Youhan Kim (Qualcomm)

- 11-19-0831, "D4.0 Comment Resolution - Part 2," Youhan Kim (Qualcomm)
- 11-19-0836, "D4.0 Comment Resolution - Part 3," Youhan Kim (Qualcomm)
- 11-19-0837, "CR on HE Capabilities," Youhan Kim (Qualcomm)
- 11-19-0858, "PHY CR in Clause 10," Youhan Kim (Qualcomm)
- 11-19-0866, "CR for Misc.," Xiangang Chen (Intel)
- 11-19-0971, "CR on CID 20760 and 20793," Ross Jian Yu (Huawei Technologies)
- 11-19-0972, "Remaining CR on SIG-B Part I," Ross Jian Yu (Huawei Technologies)
- 11-19-0973, "Resolution to CID20718," Yujin Noh (Newracom)
- 11-19-1013, "Spec Text Changes on MCS Table," Ross Jian Yu (Huawei Technologies)
- 11-19-1125, "Remaining CR on SIG-B Part II," Dandan Liang (Huawei Technologies)
- 11-19-1127, "Comment Resolution on CIDs on Clause 27.3.10.7," Jianhan Liu (MediaTek)
- 11-19-1150, "Proposed resolutions to comments on clause 26.3.10.15 (Packet Extension)," Ross Jian Yu (Huawei Technologies)
- 11-19-1185, "CR on PHY SIGB," Ming Gan (Huawei Technologies)
- 11-19-1225, "D4.0 Comment Resolution - Part 3," Youhan Kim (Qualcomm)
- 11-19-1226, "D4.0 Comment Resolution - Part 4," Youhan Kim (Qualcomm)
- 11-19-1271, "PHY Miscellaneous Comment Resolution," Sameer Vermani (Qualcomm)

- MAC submissions
  - 11-19-0339, "11ax D4.0 MAC Comment Resolution for Co-hosted BSSID," Po-Kai Huang (Intel)
  - 11-19-0414, "CR for NFRP," Laurent Cariou (Intel)
  - 11-19-0417, "CR for 6 GHz out of band," Laurent Cariou (Intel)
  - 11-19-0488, "CR for Reduced Neighbor Report," Jarkko Kneckt (Apple)
  - 11-19-0494, "Resolution for CID 20346 related to BSS Color," Kaiying Lu (ZTE)
  - 11-19-0594, "Comment resolutions for transmit power control - part 2," Alfred Asterjadhi (Qualcomm)
  - 11-19-0604, "11ax D4.1 MAC Comment Resolution for NAV part I," Po-Kai Huang (Intel)
  - 11-19-0696, "OMI Comment Resolutions," Jarkko Kineckt (Apple)
  - 11-19-0734, "11ax D4.0 Comment Resolution 9.7.3," Liwen Chu (Marvell)
  - 11-19-0735, "11ax D4.0 Comment Resolution 10.24," Liwen Chu (Marvell)
  - 11-19-0736, "11ax D4.0 Comment Resolution 10.32.2," Liwen Chu (Marvell)
  - 11-19-0737, "11ax D4.0 comment-resolution 9.2.4.6, 9.4.2.242.2," Liwen Chu (Marvell)
  - 11-19-0745, "MAC CR for subclause 9.4.2," Ming Gan (Huawei)
  - 11-19-0748, "11ax D4.0 Comment Resolution 26.2.8," Liwen Chu (Marvell)
  - 11-19-0750, "11ax D4.0 comment-resolution 26.5.3.4," Liwen Chu (Marvell)
  - 11-19-0769, "CR for NFRP," Laurent Cariou (Intel)
  - 11-19-0771, "LB238 CR HE Subchannnel Selective Transmission," Yongho Seok (MediaTek)
  - 11-19-0835, "Comment resolution for subclause 26.2.2," Kaiying Lu (MediaTek)
  - 11-19-0910, "Comment resolutions for fast passive scanning," Alfred Asterjadhi (Qualcomm)
  - 11-19-0915, "Fragment Flushing," Matthew Fischer (Broadcom)
  - 11-19-0961, "Comment resolutions for group addressed MPDUs delivery," Alfred Asterjadhi (Qualcomm)
  - 11-19-0962, "Comment resolutions for non-AP STA scanning (26.17.2.3.3)," Alfred Asterjadhi (Qualcomm)
  - 11-19-0963, "Comment resolutions for HE BSS operation - part 2," Alfred Asterjadhi (Qualcomm)
  - 11-19-0964, "Comment resolutions for additional rules for preassociation," Alfred Asterjadhi (Qualcomm)
  - 11-19-0965, "Comment resolutions for HE BSS operation in 6 GHz - part 2," Alfred Asterjadhi (Qualcomm)
  - 11-19-0967, "Comment resolutions for fast passive scanning - part 2," Alfred Asterjadhi (Qualcomm)
  - 11-19-1023, "11ax D4.0 Comment Resolution 21.6.4.1," Liwen Chu (Marvell)
  - 11-19-1035, "11ax D4.0 Comment Resolution 26.6.4.2 26.6.4.4," Liwen Chu (Marvell)
  - 11-19-1061, "Comment resolutions for HE FTM in 6 Ghz," Alfred Asterjadhi (Qualcomm)
  - 11-19-1064, "CR Disallowed Subchannels," Matthrew Fischer (Broadcom)
  - 11-19-1138, "LB238 CR HLA," Yongho Seok (MediaTek)
  - 11-19-1139, "LB238 CR AID assignment," Yongho Seok (MediaTek)
  - 11-19-1141, "LB238 CR MAC Miscellaneous," Yongho Seok (MediaTek)
  - 11-19-1147, "CID 20000," Abhishek Patil (Qualcomm)
  - 11-19-1148, "Resolution for CIDs related to Multiple BSSID - Part 2," Abhishek Patil (Qualcomm)
  - 11-19-1149, "Resolution for CIDs 21172 and 20013," Abhishek Patil (Qualcomm)

- 11-19-1155, "LB-238 Miscellaneous Comment Resolution," Osama Aboul-Magd (Huawei Technologies)
- 11-19-1161, "CR for Misc CIDs," Laurent Cariou (Intel)
- 11-19-1163, "Proposed resolution for CIDs Related to Quiet Time Period," Kaiying Lu (MediaTek)
- 11-19-1167, "11ax D4.2 MAC Comment Resolution for SM Power Save Part II," Po-Kai Huang (Intel)
- 11-19-1183, "Comment Resolution on Trigger Frame Format," Lochan Verma (Qualcomm)
- 11-19-1184, "CR for MAC Misc," Ming Gan (Huawei Technologies)
- 11-19-1200, "Resolutions to comments 20104, 20648, 21124, and 21469," Tomoko Adachi (Toshiba)
- 11-19-1209, "11ax D4.0 sounding comments," Huizhao Wang (Quantenna Communications)
- 11-19-1211, "Ack related CRs," George Cherian (Qualcomm)
- 11-19-1219, "Comment resolutions for one CID," Alfred Asterjadhi (Qualcomm)
- 11-19-1222, "CR for 20253, 20255, 20264 and 20265," Jarkko Kneckt (Apple)
- 11-19-1236, "Comment resolution on MIBs for LB238," Edward Au (Huawei Technologies)
- 11-19-1237, "Proposed resolution for some CIDs in section 3.2 and 4.3.15a," Guoqing Li (Apple)
- 11-19-1243, "Comment resolution on PICs for LB238," Edward Au (Huawei Technologies)
- 11-19-1259, "LB 238 Annex G Comment Resolution," Osama Aboul-Magd (Huawei Technologies)
- 11-19-1275, "Proposed Resolution to Tgax D4.0 CR20268," Srinivas Kandala (Samsung)

◦ MU submissions
- 11-19-0765, "CR MU EDCA Timer," Zhou Lan (Broadcom)
- 11-19-0908, "MU EDCA parameters update frame," Matthew Fischer (Broadcom)
- 11-19-0917, "UORA Misc," Matthew Fischer (Broadcom)
- 11-19-1130, "11ax D4.0 Comment Resolution for RDG MU," Yunbo Li (Huawei Technologies)
- 11-19-1140, "LB238 CR UL MU Power Capabilities," Yongho Seok (MediaTek)
- 11-19-1186, "Comment Resolution on MU Operation," Lochan Verma (Qualcomm)
- 11-19-1204, "CR for CID20624," Laurent Cariou (Intel)
- 11-19-1217, "Resolution for CID 21110," Abhishek Patil (Qualcomm)
- 11-19-1218, "Resolution for CIDs related to UORA - Part 2," Abhishek Patil (Qualcomm)
- 11-19-1263, "11ax D4.2 RA Setting for Response to Trigger frame," Po-Kai Huang (Intel)

◦ SR submissions
- 11-19-0416, "CR for Spatial reuse," Laurent Cariou (Intel)
- 11-19-0613, "SRP Comments," Matthew Fischer (Broadcom)

◦ Other submissions (presented in TG full session)
- 11-19-0099, "11ax D4.0 sounding comments," Huizhao Wang (Quantenna Communications)
- 11-19-0619, "Proposed Resolutions to select comments on D4.0," Mark Rison (Samsung)
- 11-19-0863, "11ax D4.0 sounding comments," Menzo Wentink (Qualcomm)
- 11-19-0876, "Updated Channelization for 6 GHz," Imran Latif (Quantenna Communications)
- 11-19-0909, "Comment resolutions for 6 ghz scanning," Alfred Asterjadhi (Qualcomm)
- 11-19-0912, "Editorial changes to approved resolutions," Robert Stacey (Intel)
- 11-19-1017, "D4.0 CR for 6GHz channelization," Ruchen Duan (Samsung)
- 11-19-1122, "11ax D4.2 Padding for Random Access," Po-Kai Huang (Intel)
- 11-19-1123, "Editorial Comments on TGax/D4.0," Po-Kai Huang/Robert Stacey (Intel)
- 11-19-1183, "Comment Resolution on Trigger Frame Format," Lochan Verma (Qualcomm)
- 11-19-1199, "Updated Channelization for 6 GHz," Imran Latif (Quantenna Communications)

3. **Timeline**

No discussion on the timeline during the week.

Here is the current timeline.

Current Timeline	
May 2014	**Start of TG**
November 2014	**First draft of the TG SFD approved**
January 2016	**Proposed TG draft**
March 2016	**Draft 0.1 was approved and Comment Collection started**
November 2016	**Issue Draft 1.0 and start WG Letter Ballot — Failed (57.77%)** **LB 225: opened Dec. 1st, 2016 and closed Jan. 8th, 2017**

September 2017	**Draft 2.0 and WG Letter Ballot — Failed (62.84%)** **LB 230: opened Oct. 5th, 2017 and closed Nov. 4th, 2017**
May 2018	**Draft 3.0 and WG Letter Ballot — Passes (86.5%)**
Janury 2019	**Draft 4.0 and Recirculation Ballot — Passes (92.2%)**
May 2019	**Mandatory Draft Review**
June 2019	**Formation of Sponsor Ballot pool**
August 2019	**Initial Sponsor Ballot**
January 2020	**Final 802.11 Approval**
March 2020	**Conditional EC Approval**
June 2020	**RevCom submittal and publication**

Goals for the September 2019 session

- Complete the comment resolution on draft D4.0.
- Instruct the TG Editor to prepare draft D5.0 and start a new WG Recirculation ballot.
- Approve the new revision of the TG Coexistence Assurance document.

Teleconferences

Following TGax teleconferences were authorized during the July 2019 session.

Thursday	August 1st, 2019	10:30 - 13:30 (ET)
Thursday	August 8th, 2019	19:00 - 22:30 (ET)
Thursday	August 15th, 2019	10:30 - 13:30 (ET)
Thursday	August 22nd, 2019	19:00 - 22:30 (ET)
Thursday	August 29th, 2019	10:30 - 13:30 (ET)
Thursday	September 5th, 2019	19:00 - 22:30 (ET)

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May 2019 — Atlanta, GA

TGax had eight meeting slots during the week.

	Monday	Tuesday	Wednesday	Thursday
AM1				**TGax** **(full session)**
AM2	**TGax** **(full session)**	**TGax** **(PHY ad hoc)** **TGax** **(MAC ad hoc)**		
PM1	**TGax** **(PHY ad hoc)** **TGax** **(MAC ad hoc)**	**TGax** **(PHY ad hoc)** **TGax** **(MAC ad hoc)**	**TGax** **(full session)**	**TGax** **(full session)**
PM2			**TGax** **(PHY ad hoc)** **TGax** **(MAC ad hoc)**	
PM3				

Main documents

The meeting agenda and minutes of the TGax and its subgroups, and the TGax closing report can be found here.

- TGax
  - 11-19-0615-06, TGax May 2019 Meeting Agenda
  - 11-19-0925-00, TGax May 2019 Closing Report
  - 11-19-0872-00, TGax May 2019 Atlanta Meeting Minutes
- TGax PHY ad hoc
  - 11-19-0880-01, TGax Mar 2019 Meeting Agenda - PHY Adhoc
  - 11-19-0xxx-00, Draft TGax PHY Ad Hoc May 2019 Meeting Minutes (not available)
- TGax MAC ad hoc
  - 11-19-0881-03, TGax MAC Adhoc May 2019 Meeting Agenda
  - 11-19-0918-00, TGax MAC Ad-hoc meeting minutes May 2019

Achievements

1. **Work Completed**
   - The TG completed the resolution of about 430 comments.
   - The TG passed a motion to have an ad-hoc meeting in Rennes, France hosted by Cannon during the period July 10-12.
   - Discussed the TG timeline and made few adjustments.

2. **Technical Submissions**
   TGax received following submissions.
   - PHY submissions
     - 11-18-1774, "Resolution to CID 16624 (HESIGB)," Brian Hart (Cisco Systems)
     - 11-19-0378, "D4.0 CID20395 Unused Tone EVM," Youhan Kim (Qualcomm)
     - 11-19-0379, "D4.0 Comment Resolution - Part 1," Youhan Kim (Qualcomm)
     - 11-19-0385, "Resolution for CIDs in 27.1.1," Sameer Vermani (Qualcomm)
     - 11-19-0386, "CR Disallowed Subchannels," Ron Porat (Broadcom)
     - 11-19-0407, "Comment Resolutions PHY xVECTORs," Bo Sun (ZTE)
     - 11-19-0422, "CR for CID 21497, 21501, 21502," Xiaogang Chen (Intel)
     - 11-19-0553, "Comment Resolutions on Clause 27.3.15.2 (Beamforming feedback matrix V)," Kome Oteri (InterDigital)
     - 11-19-0793, "Remaining PHY Math comment resolutions," Yan Zhang (Marvell)
     - 11-19-0826, "CR on DCM and STBC Combinations," Youhan Kim (Qualcomm)
     - 11-19-0827, "CR on Punctured Non-HT Duplicate PPDU," Youhan Kim (Qualcomm)
     - 11-19-0830, "CR on Clause 17," Youhan Kim (Qualcomm)
     - 11-19-0831, "D4.0 Comment Resolution - Part 2," Youhan Kim (Qualcomm)
     - 11-19-0836, "D4.0 Comment Resolution - Part 3," Youhan Kim (Qualcomm)
     - 11-19-0837, "CR on HE Capabilities," Youhan Kim (Qualcomm)
     - 11-19-0858, "PHY CR in Clause 10," Youhan Kim (Qualcomm)
     - 11-19-0866, "CR for Misc.," Xiangang Chaen (Intel)
   - MAC submissions
     - 11-18-0218, "Fragment Flush BlockAckReq," Matthew Fischer (Broadcom)
     - 11-18-1822, "Temporarily Limited Connection," Matthew Fischer (Broadcom)
     - 11-19-0288, "CR for HE Beacon," Po-Kai Huang (Intel)
     - 11-19-0292, "Comments on TGax D4.0," Po-Kai Huang (Intel)
     - 11-19-0301, "Comment resolutions for HE beacon in 6 Ghz band," Alfred Asterjadhi (Qualcomm)
     - 11-19-0302, "Comment resolutions for HE BSS operation," Alfred Asterjadhi (Qualcomm)
     - 11-19-0303, "Comment Resolution for QoS Control," Alfred Asterjadhi (Qualcomm)
     - 11-19-0304, "Comment resolutions for HE BSS operation in 6 GHz," Alfred Asterjadhi (Qualcomm)
     - 11-19-0305, "Comment resolutions for transmit power control," Alfred Asterjadhi (Qualcomm)
     - 11-19-0309, "Comment resolutions for Frame Control," Alfred Asterjadhi (Qualcomm)
     - 11-19-0315, "Comment resolutions for TWT power save," Alfred Asterjadhi (Qualcomm)

- 11-19-0316, "Comment resolutions for BSR operation," Alfred Asterjadhi (Qualcomm)
- 11-19-0325, "11ax D4.0 MAC Comment Resolution for SM Power Save," Po-Kai Huang (Intel)
- 11-19-0339, "11ax D4.0 MAC Comment Resolution for Co-hosted BSSID," Po-Kai Huang (Intel)
- 11-19-0394, "Resolution for CIDs in 9.3.1.22," Abhishek Patil (Qualcomm)
- 11-19-0395, "Resolution for CIDs related to BSS Color - Part 1," Abhishek Patil (Qualcomm)
- 11-19-0413, "CR for MU EDCA," Laurent Cariou (Intel)
- 11-19-0414, "CR for NFRP," Laurent Cariou (Intel)
- 11-19-0415, "CR for OPS," Laurent Cariou (Intel)
- 11-19-0417, "CR for 6 GHz out of band," Laurent Cariou (Intel)
- 11-19-0427, "Comment resolution on CID 20175," Zhou Lan (Broadcom)
- 11-19-0436, "Resolution for CIDs in clause 11.1.4," Abhishek Patil (Qualcomm)
- 11-19-0447, "Resolutions to CID 20256, 20257," Jarkko Kneckt (Apple)
- 11-19-0479, "Resolution for CID 20012," Abhishek Patil (Qualcomm)
- 11-19-0488, "CR for Reduced Neighbor Report," Jarkko Kneckt (Apple)
- 11-19-0492, "11ax D4.0 MAC Comment Resolution for MU-RTS/CTS," Po-Kai Huang (Intel)
- 11-19-0494, "Resolution for CID 20346 related to BSS Color," Kaiying Lu (ZTE)
- 11-19-0505, "Resolution for CIDs related to BSS Color - Part 2," Abhishek Patil (Qualcomm)
- 11-19-0506, "Resolution for CIDs related to Multiple BSSID," Abhishek Patil (Qualcomm)
- 11-19-0508, "Resolution for CIDs related to UORA," Abhishek Patil (Qualcomm)
- 11-19-0510, "Resolution for CIDs related to MU Operation," Abhishek Patil (Qualcomm)
- 11-19-0548, "Resolution for CIDs related to TF format (9.3.1.22) - Part 2," Abhishek Patil (Qualcomm)
- 11-19-0561, "Comment resolutions for miscellaneous TWT," Alfred Asterjadhi (Qualcomm)
- 11-19-0593, "Comment resolutions for Frame Control," Alfred Asterjadhi (Qualcomm)
- 11-19-0594, "Comment resolutions for transmit power control - part 2," Alfred Asterjadhi (Qualcomm)
- 11-19-0604, "11ax D4.1 MAC Comment Resolution for NAV part I," Po-Kai Huang (Intel)
- 11-19-0605, "11ax D4.0 MAC Comment Resolution for MU-RTS part II," Po-Kai Huang (Intel)
- 11-19-0652, "Comment resolutions for TWT Information frames," Alfred Asterjadhi (Qualcomm)
- 11-19-0696, "OMI Comment Resolutions," Jarkko Kineckt (Apple)
- 11-19-0703, "11ax D4.0 comment and resolution for Trigger frame MAC padding," Tianyu Wu (Apple)
- 11-19-0724, "Comment resolutions for broadcast TWT," Alfred Asterjadhi (Qualcomm)
- 11-19-0725, "Comment resolutions for Individual TWT," Alfred Asterjadhi (Qualcomm)
- 11-19-0734, "11ax D4.0 Comment Resolution 9.7.3," Liwen Chu (Marvell)
- 11-19-0735, "11ax D4.0 Comment Resolution 10.24," Liwen Chu (Marvell)
- 11-19-0737, "11ax D4.0 comment-resolution 9.2.4.6, 9.4.2.242.2," Liwen Chu (Marvell)
- 11-19-0745, "MAC CR for subclause 9.4.2," Ming Gan (Huawei)
- 11-19-0748, "11ax D4.0 Comment Resolution 26.2.8," Liwen Chu (Marvell)
- 11-19-0750, "11ax D4.0 comment-resolution 26.5.3.4," Liwen Chu (Marvell)
- 11-19-0751, "Figure 26-3a," Abhishek Patil (Qualcomm)
- 11-19-0753, "11ax D4.1 MAC Multiple BSSID Minor Bug Fix," Po-Kai Huang (Intel)
- 11-19-0756, "Ack related CRs on Section 26.4," George Cherian (Qualcomm)
- 11-19-0765, "CR MU EDCA Timer," Zhou Lan (Broadcom)
- 11-19-0769, "CR for NFRP," Laurent Cariou (Intel)
- 11-19-0770, "LB238 CR PPDU format, BW, MCS, NSS, and DCM selection," Yongho Seok (MediaTek)
- 11-19-0785, "MAC CR Comment Resolution," Ming Gan (Huawei)
- 11-19-0795, "Visio file for (updated) Figure 26-5," Abhishek Patil (Qualcomm)
- 11-19-0816, "Resolutions to comments to subclause 9.3.1.8," Tomoko Adachi (Toshiba)
- 11-19-0835, "Comment resolution for subclause 26.2.2," Kaiying Lu (ZTE)

◦ SR submissions

- 11-19-0416, "CR for Spatial reuse," Laurent Cariou (Intel)
- 11-19-0613, "SRP Comments," Matthew Fischer (Broadcom)

3. **Timeline**

A little adjustments to the current timeline are made.

Current Timeline

May 2014	**Start of TG**
November 2014	**First draft of the TG SFD approved**
January 2016	**Proposed TG draft**
March 2016	**Draft 0.1 was approved and Comment Collection started**
November 2016	**Issue Draft 1.0 and start WG Letter Ballot — Failed (57.77%)** **LB 225: opened Dec. 1st, 2016 and closed Jan. 8th, 2017**
September 2017	**Draft 2.0 and WG Letter Ballot — Failed (62.84%)** **LB 230: opened Oct. 5th, 2017 and closed Nov. 4th, 2017**
May 2018	**Draft 3.0 and WG Letter Ballot — Passes (86.5%)**
Janury 2019	**Draft 4.0 and Recirculation Ballot — Passes (92.2%)**
May 2019	**Mandatory Draft Review**
June 2019	**Formation of Sponsor Ballot pool**
August 2019	**Initial Sponsor Ballot**
January 2020	**Final 802.11 Approval**
March 2020	**Conditional EC Approval**
June 2020	**RevCom submittal and publication**

Goals for the July 2019 session

- Complete the comment resolution on draft D4.0.
- Instruct the TG Editor to prepare draft D5.0 and start a new WG Recirculation ballot.

Teleconferences

Following TGax teleconferences were authorized during the March 2019 session.

Thursday	May 23rd, 2019 (approved during the March 2019 meeting)	10:00 - 12:00 (ET)
Thursday	May 30th, 2019	20:00 - 22:00 (ET)
Thursday	June 13th, 2019	10:00 - 12:00 (ET)
Thursday	June 20st, 2019	20:00 - 22:00 (ET)
Thursday	June 27th, 2019	10:00 - 12:00 (ET)

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March 2019 — Vancouver, BC, Canada

TGax had seven meeting slots during the week.

	Monday	Tuesday		Wednesday	Thursday
AM1					**TGax** **(full session)**
AM2		**TGax** **(PHY ad hoc)**	**TGax** **(MAC ad hoc)**		
PM1	**TGax** **(full session)**			**TGax** **(full session)**	**TGax** **(full session)**

	Monday	Tuesday		Wednesday		Thursday
PM2		**TGax** (PHY ad hoc)	**TGax** (MAC ad hoc)	**TGax** (PHY ad hoc)	**TGax** (MAC ad hoc)	
PM3						

Main documents

The meeting agenda and minutes of the TGax and its subgroups, and the TGax closing report can be found here.

- TGax
  - 11-19-0238-05, TGax March 2019 Meeting Agenda
  - 11-19-0521-00, TGax March 2019 Closing Report
  - 11-19-0428-00, TGax March 2019 Vancouver Meeting Minutes
- TGax PHY ad hoc
  - 11-19-0457-02, TGax Mar 2019 Meeting Agenda - PHY Adhoc
  - 11-19-0462-00, TGax March 2019 Vancouver PHY Ad Hoc Meeting Minutes
- TGax MAC ad hoc
  - 11-19-0453-02, TGax MAC Adhoc March 2019 Meeting Agenda
  - 11-19-0501-00, TGax MAC Ad-hoc meeting minutes March 2019

Achievements

1. **Work Completed**
   - The TG completed the resolution of about 200 comments.
   - Completed the assignment of almost all the CIDs.
   - The TG passed a motion to have an adhoc meeting in San Diego during the period May 8-10.

2. **Technical Submissions**
   TGax received following submissions.
   - PHY submissions
     - 11-18-1774, "Resolution to HESIGB-related CIDs," Brian Hart (Cisco Systems)
     - 11-19-0378, "D4.0 CID20395 - Unused Tone EVM," Youhan Kim (Qualcomm)
     - 11-19-0379, "D4.0 PHY Comment Resolution - Part 1," Youhan Kim (Qualcomm)
     - 11-19-0385, "Resolution for CIDs in 27.1.1," Sameer Vermani (Qualcomm)
     - 11-19-0386, "Disallowed Subchannels Comment Resolution," Ron Porat (Broadcom)
     - 11-19-0407, "Comment Resolutions for xVECTORs," Bo Sun (ZTE)
     - 11-19-0422, "CR for CID 21497, 21501, 21502," Xiaogang Chen (Intel)
   - MAC submissions
     - 11-18-0218, "Fragment Flushing BlockAckReq," Matthew Fischer (Broadcom Ltd.)
     - 11-18-1822, "Temporary Limited Connection," Matthew Fischer (Broadcom Ltd.)
     - 11-19-0301, "Comment resolutions for HE beacon in 6 Ghz band," Alfred Asterjadhi (Qualcomm)
     - 11-19-0302, "Comment resolutions for HE BSS operation," Alfred Asterjadhi (Qualcomm)
     - 11-19-0303, "Comment resolutions for QoS Control," Alfred Asterjadhi (Qualcomm)
     - 11-19-0305, "Comment resolutions for transmit power control," Alfred Asterjadhi (Qualcomm)
     - 11-19-0309, "Comment resolutions for Frame Control," Alfred Asterjadhi (Qualcomm)
     - 11-19-0315, "Comment resolutions for TWT power save," Alfred Asterjadhi (Qualcomm)
     - 11-19-0316, "Comment resolutions for BSR operation," Alfred Asterjadhi (Qualcomm)
     - 11-19-0325, "11ax D4.0 MAC Comment Resolution for SM Power Save," Po-Kai Huang (Intel)
     - 11-19-0339, "11ax D4.0 MAC Comment Resolution for Co-hosted BSSID," Po-Kai Huang (Intel)
     - 11-19-0394, "Resolution for CIDs in 9.3.1.22," Abhishek Patil (Qualcomm)
     - 11-19-0395, "Resolution for CIDs related to BSS Color - Part 1," Abhishek Patil (Qualcomm)
     - 11-19-0413, "CR for MU EDCA parameters," Laurent Cariou (Intel)
     - 11-19-0414, "CR for NFRP," Laurent Cariou (Intel)
     - 11-19-0416, "CR for Spatial reuse," Laurent Cariou (Intel)

- 11-19-0427, "Comment resolution on CID 20175," Zhou Lan (Broadcom Ltd.)
- 11-19-0436, "Resolution for CIDs in clause 11.1.4," Abhishek Patil (Qualcomm)

3. **Timeline**
   No change to current timeline.

Current Timeline	
May 2014	**Start of TG**
November 2014	**First draft of the TG SFD approved**
January 2016	**Proposed TG draft**
March 2016	**Draft 0.1 was approved and Comment Collection started**
November 2016	**Issue Draft 1.0 and start WG Letter Ballot — Failed (57.77%)** LB 225: opened Dec. 1st, 2016 and closed Jan. 8th, 2017
September 2017	**Draft 2.0 and WG Letter Ballot — Failed (62.84%)** LB 230: opened Oct. 5th, 2017 and closed Nov. 4th, 2017
May 2018	**Draft 3.0 and WG Letter Ballot — Passes (86.5%)**
Janury 2019	**Draft 4.0 and Recirculation Ballot — Passes (92.2%)**
February 2019	**Formation of Sponsor Ballot pool**
March 2019	**Mandatory Draft Review**
July 2019	**Initial Sponsor Ballot**
January 2020	**Final 802.11 Approval**
March 2020	**Conditional EC Approval**
June 2020	**RevCom submittal and publication**

Goals for the May 2019 session

- Continue the comment resolution on draft D4.0.

Teleconferences

Following TGax teleconferences were authorized during the March 2019 session.

Thursday	March 29th, 2019	10:00 - 12:00 (ET)
Thursday	April 11th, 2019	10:00 - 12:00 (ET)
Thursday	April 25th, 2019	10:00 - 12:00 (ET)
Thursday	May 21st, 2019	10:00 - 12:00 (ET)

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January 2019 — St. Louis, MO

TGax planed ten sessions during the week.
During WG mid-week plenary session, one more session was added on Thursday PM2.

	Monday	Tuesday	Wednesday	Thursday
AM1		**TGax** **(full session)**	**TGax** **(full session)**	**TGax** **(full session)**

	Monday	Tuesday	Wednesday	Thursday
AM2	**TGax** (full session)	**TGax** (full session)		
PM1	**TGax** (full session)		**TGax** (full session)	**TGax** (full session)
PM2		**TGax** (full session)		**TGax** (full session)
PM3	**TGax** (full session)	**TGax** (full session)		

Main documents

The meeting agenda and minutes of the TGax and its subgroups, and the TGax closing report can be found here.

- TGax
  - 11-18-2114-10, TGax January 2019 Meeting Agenda
  - 11-19-0208-00, TGax January 2019 Closing Report
  - 11-19-0126-00, Draft TGax January 2019 St. Louis Meeting Minutes

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Achievements

1. **Work Completed**
   - The TG completed the resolution of all comments submitted on draft D3.0.
   - The TG passed a motion to allow the Editor to prepare draft D4.0 and start a 15 day WG Ballot.
   - The TG approved a new revision of the Coexistence Assurance document.
   - TGax Timeline was adjusted.

2. **Technical Submissions**
   TGax received following submissions during the TGax sessions.
   - 11-18-0218, "Fragment Flushing BlockAckReq," Matthrew Fischer (Broadcom Ltd.)
   - 11-18-1211, "Comment resolutions for 27.16.1 related to 6 Ghz band," Alfred Asterjadhi (Qualcomm)
   - 11-18-1227, "CR for 6GHz - Discovery," Laurent Cariou (Intel)
   - 11-18-1471, "Comment resolutions for 27.16.1 related to 6 GHz band," Alfred Asterjadhi (Qualcomm)
   - 11-18-1472, "Comment resolutions for 27.7.4," Alfred Asrterjadhi (Qualcomm)
   - 11-18-1489, "Operation at 6GHz Band," Liwen Chu (Marvell Semiconductor)
   - 11-18-1506, "LB233 CR ER Beacon," Yongho Seok (MediaTek)
   - 11-18-1697, "MAC CR 27.7.3," Alfred Asterjadhi (Qualcomm)
   - 11-18-1779, "LB233 CR Transmit Power Control," Yongho Seok (MediaTek)
   - 11-18-1807, "Resolutions for Miscellaneous CIDs," Yasuhiko Inoue (NTT)
   - 11-18-1821, "Maximum RX PPDU Duration Signaling," Matthew Fischer (Broadcom Ltd.)
   - 11-18-1822, "TLC Signaling," Matthew Fischer (Broadcom Ltd.)
   - 11-18-1827, "6 GHz operation for 11ax follow up," Wookbong Lee (Samsung)
   - 11-18-1831, "Comment resolution to CIDs 15990, 17031 and 17033," Jarkko Kneckt (Apple)
   - 11-18-1853, "Resolutions to comments to subclauses 10.3.7, 3.1, 3.2, and 27.5.1.1," Tomoko Adachi (Toshiba)
   - 11-18-1855, "Comment Resolution for 27.16.4," Chao-Chun Wang (MediaTek)
   - 11-18-1859, "11ax D3.0 Comment Resolution 27.10.4," Liwen Chu (Marvell Semiconductor)
   - 11-18-1866, "CR for OBSS_PD," Laurent Cariou (Intel)
   - 11-18-1887, "11ax D3.2 MAC Comment Resolution for Section 27.5," Zhou Lan (Broadcom Ltd.)
   - 11-18-1932, "Proposed Resolutions to Miscs PHY and MAC CIDs," Peter Loc (Huawei Technologies)
   - 11-18-1987, "D3.0 Comment Resolution on MAC Miscellaneous," Jae Seung Lee (ETRI)
   - 11-18-1995, "Resolution for CIDs: 15302, 15906, 16750," Huizhao Wang (Quantenna Communications)
   - 11-18-1999, "RTS CTS protection coverage," Jarkko Kneckt (Apple)
   - 11-18-2033, "Changes to D3.3," Xiaogang Chen (Intel)
   - 11-18-2040, "11ax D3.0 Comment Resolution miscellaneous," Liwen Chu (Marvell Semiconductor)
   - 11-18-2085, "11ax D3.0 MAC Comment Resolution for Capability of MU Transmission and Reception," Po-Kai Huang (Intel)
   - 11-19-0002, "HE beamforming feedback subcarriers," Mark Rison (Samsung)

- 11-19-0006, "CR Default UORA Parameters," Matthew Fischer (Broadcom Ltd.)
- 11-19-0028, "Multiple BSSID Clarification - Part 3," Abhishek Patil (Qualcomm)
- 11-19-0041, "TWT Capability Support Signaling," Matthew Fischer (Broadcom Ltd.)
- 11-19-0061, "CR for 6GHz - Active Scanning Part I," Jarkko Kneckt (Apple)
- 11-19-0076, "LB233 CR on CID 16486 17140 and 16449," Ming Gan (Huawei Technologies)
- 11-19-0085, "LB233 CR MAC Miscellaneous Part 2," Yongho Seok (MediaTek)
- 11-19-0095, "CR for 6GHz - Active Scanning Part II," Jarkko Kneckt (Apple)
- 11-19-0096, "Comment resolutions for TWT fixes," Alfred Asterjadhi (Qualcomm)
- 11-19-0097, "Comment resolutions for HE SU beacon and miscellaneous rules for 6 GHz," Alfred Asterjadhi (Qualcomm)
- 11-19-0098, "11ax D3.0 Comment Resolution miscellaneous," Liwen Chu (Marvell Semiconductor)
- 11-19-0099, "11ax D3.0 sounding comments," Huizhao Wang (Quantenna Communications)
- 11-19-0117, "Changes to D3.3 (Power Deboosting Pre HE)," Xiaogang Chen (Intel)
- 11-19-0120, "CR for CID 15153," Guoqing Li (Apple)
- 11-19-0121, "Proposed Spec Text change on Trigger Frame MAC padding," Tianyu Wu (Samsung)
- 11-19-0140, "CR misc MAC," Matthew Fischer (Broadcom Ltd.)
- 11-19-0148, "CR for CID 17129," Yunbo Li (Huawei Technologies)
- 11-19-0160, "11ax D3.0 MAC Comment Resolution for Co-hosted BSS," Po-Kai Huang (Intel)
- 11-19-0161, "CR misc MAC - CID 16535," Sean Coffey (RealTek)
- 11-19-0162, "11ax D3.0 MAC MU-CTS Clarification," Po-Kai Huang (Intel)
- 11-19-0166, "11ax D3.0 MAC Comment Resolution for Bandwidth Queue Report," Zhou Lan (Broadcom Ltd.)
- 11-19-0170, "Remaining Ack related CRs," George Cherian (Qualcomm)
- 11-19-0177, "CR for OPS," Laurent Cariou (Intel)
- 11-19-0180, "FTM in 6 GHz," Alfred Asterjadhi (Qualcomm)
- 11-19-0184, "CID 16444 and 15178 discussion -- Why 11ax should maintain current data channel access rules on 6GHz," Guoqing Li (Apple)
- 11-19-0192, "Comment resolutions for last CIDs," Alfred Asterjadhi (Qualcomm)
- 11-19-0194, "Clarification of HE TB PPDU timing requirements," Mark Rison (Samsung)

3. **Timeline update**
   Current timeline has been updated as follow.

Current Timeline (Updated)	
May 2014	**Start of TG**
November 2014	**First draft of the TG SFD approved**
January 2016	**Proposed TG draft**
March 2016	**Draft 0.1 was approved and Comment Collection started**
November 2016	**Issue Draft 1.0 and start WG Letter Ballot — Failed (57.77%)** **LB 225: opened Dec. 1st, 2016 and closed Jan. 8th, 2017**
September 2017	**Draft 2.0 and WG Letter Ballot — Failed (62.84%)** **LB 230: opened Oct. 5th, 2017 and closed Nov. 4th, 2017**
May 2018	**Draft 3.0 and WG Letter Ballot — Passes (86.5%)**
Janury 2019	**Draft 4.0 and Recirculation Ballot**
February 2019	**Formation of Sponsor Ballot pool**
March 2019	**Mandatory Draft Review**
July 2019	**Initial Sponsor Ballot**
January 2020	**Final 802.11 Approval**
March 2020	**Conditional EC Approval**
June 2020	**RevCom submittal and publication**

Goals for the March 2019 session

- Start comment resolution on draft D4.0.

Teleconferences

TGax teleconferences will be scheduled with a 10-day notice.

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November 2018 — Bangkok, Thailand

TGax planed ten sessions during the week.
During WG mid-week plenary session, one more session was added in Thursday PM2.

	Monday	Tuesday	Wednesday	Thursday
AM1	**TGax** (full ad hoc session)	**TGax** (MAC ad hoc)	**TGax** (full session)	**TGax** (full session)
AM2		**TGax** (PHY ad hoc) **TGax** (MAC ad hoc)		**TGax** (full session)
PM1			**TGax** (PHY ad hoc) **TGax** (MAC ad hoc)	
PM2	**TGax** (full)	**TGax** (PHY ad hoc) **TGax** (MAC ad hoc)		**TGax** (full session)
PM3		**TGax** (MAC ad hoc)		

Submissions for MU and SR ad hoc groups were considered in the MAC ad hoc group.

Main documents

The meeting agenda and minutes of the TGax and its subgroups, and the TGax closing report can be found here.

- TGax
  - 11-18-1517-08, TGax November 2018 Meeting Agenda
  - 11-18-2061-00, TGax November 2018 Closing Report
  - 11-18-1933-00, TGax November 2018 Bangkok Meeting Minutes

  - PHY ad hoc
    - 11-18-1997-02, TGax Nov 2018 Meeting Agenda - PHY Adhoc
    - 11-18-2024-00, IEEE 802.11 TGax November 2018 Bangkok PHY Ad Hoc Meeting Minutes
  - MAC ad hoc
    - 11-18-2006-02, TGax November 2018 MAC ad hoc Meeting Agenda
    - 11-18-2008-00, Minutes of TGax MAC ad hoc meeting November 2018 in Bangkok

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Achievements

1. **Work Completed**
   - The TG approved resolutions to 500+ technical comments
   - The TG needs more time to complete resolutions of the rest of the comments ~ 250 to 300 CIDs are left
   - The TG plans to complete the comment resolution in January 2019

2. **Technical Submissions**
   TGax received following submissions during the TGax sessions.
   - PHY Submissions
     - 11-18-1492, "Remaining PHY Math comment resolutions," Yan Zhang (Marvell Semiconductor)
     - 11-18-1534, "CR for PPDU formats," Tianyu Wu (Samsung)
     - 11-18-1734, "PHY subcarriers and RU part 2," Yujin Noh (Newracom)

- 11-18-1735, "CR on PHY Intro," Yujin Noh (Newracom)
- 11-18-1759, "Comment Resolutions for xVECTORs," Bo Sun (ZTE)
- 11-18-1764, "CR on HE-SIG-A and HE-SIG-B - Part 6," Ross Jian Yu (Huawei Technologies)
- 11-18-1774, "Resolution to CID 16624 (HE-SIG-B)," Brian Hart (Cisco Systems)
- 11-18-1790, "CR on PHY Miscellaneous," Yujin Noh (Newracom)
- 11-18-1832, "D3.0 Comment Resolution on CID for 28.4.3," Jianhan Liu (MediaTek)
- 11-18-1841, "Comment Resolution on PHY Introduction," Bin Tian (Qualcomm)
- 11-18-1842, "Comment Resolution on PHY Miscellaneous," Bin Tian (Qualcomm)
- 11-18-1848, "CID 17100," Youhan Kim (Qualcomm)
- 11-18-1849, "D3.0 Comment Resolution Part 3," Youhan Kim (Qualcomm)
- 11-18-1850, "D3.0 Comment Resolution Part 4," Youhan Kim (Qualcomm)
- 11-18-1891, "Discussions on Trigger Frame MAC Padding," Hongyuan Zhang (Marvell Semiconductor)
- 11-18-1906, "Comment Resolution on Trigger Frame MAC Padding," Hongyuan Zhang (Marvell Semiconductor)
- 11-18-1907, "Comment Resolution of MU-CTS Scrambling," Hongyuan Zhang (Marvell Semiconductor)
- 11-18-1980, "D3.0 CR for PHY Misc," Tianyu Wu (Samsung)
- 11-18-2007, "Changes to D3.0," Xiaogang Chen (Intel)
- 11-18-2017, "PHY Remaining CSD," Bin Tian (Qualcomm)
- 11-18-2019, "Resolution for SIG_B_Compression_Mode definition in TxVector," Jerome Vanthournout (CEVA-DSP)
- 11-18-2023, "Comment Resolution on CID 16768," Jianhan Liu (MediaTek)

- MAC Submissions
  - 11-18-0218, "Fragment Flushing BlockAckReq," Matthew Fischer (Broadcom Ltd.)
  - 11-18-1432, "Doze Transition Signaling," Matthew Fischer (Broadcom Ltd.)
  - 11-18-1454, "Figure 27-12," Abhishek Patil (Qualcomm)
  - 11-18-1471, "Comment resolutions for 27.16.1 related to 6 Ghz band," Alfred Asterjadhi (Qualcomm)
  - 11-18-1472, "Comment resolutions for 27.7.4," Alfred Asterjadhi (Qualcomm)
  - 11-18-1473, "Comment resolutions for miscellaneous CIDs - Part 1," Alfred Asterjadhi (Qualcomm)
  - 11-18-1474, "Comment resolutions for 27.7.2," Alfred Asterjadhi (Qualcomm)
  - 11-18-1487, "11ax D3.0 Comment Resolution 27.5.3.2.3," Liwen Chu (Marvell Semiconductor)
  - 11-18-1498, "CR for 27.5.6," Laurent Cariou (Intel)
  - 11-18-1505, "LB233 CR MAC TXVECTOR," Yongho Seok (MediaTek)
  - 11-18-1506, "LB233 CR ER Beacon," Yongho Seok (MediaTek)
  - 11-18-1507, "11ax D3.0 MAC Comment Resolution for Co-located BSS," Po-Kai Huang (Intel)
  - 11-18-1508, "11ax D3.0 MAC Comment Resolution for Multiple BSSID," Po-Kai Huang (Intel)
  - 11-18-1519, "11ax D3.0 MAC Comment Resolution for Control response," Robert Stacey (Intel)
  - 11-18-1696, "Comment resolutions for 9.6.25," Alfred Asterjadhi (Qualcomm)
  - 11-18-1697, "Comment resolutions for 27.7.3," Alfred Asterjadhi (Qualcomm)
  - 11-18-1698, "Comment resolutions for miscellaneous CIDs part 2," Alfred Asterjadhi (Qualcomm)
  - 11-18-1699, "Comment resolutions for subclause 9.2.4," Alfred Asterjadhi (Qualcomm)
  - 11-18-1703, "Resolution to CID 17150," Tomoko Adachi (Toshiba)
  - 11-18-1733, "CID 16364 on Packet Extension," Yujin Noh (Newracom)
  - 11-18-1775, "Comment resolutions for miscellaneous - Part 3," Alfred Asterjadhi (Qualcomm)
  - 11-18-1777, "Ack-related CIDs remaining," George Cherian (Qualcomm)
  - 11-18-1778, "LB233 CR subclause 27.15.2 and 27.15.3," Yongho Seok (MediaTek)
  - 11-18-1779, "LB233 CR Transmit Power Control," Yongho Seok (MediaTek)
  - 11-18-1780, "LB233 CR MAC Miscellaneous," Yongho Seok (MediaTek)
  - 11-18-1799, "CR for 16668," Po-Kai Huang (Intel)
  - 11-18-1800, "CR for Miscelaneous CIDs," Po-Kai Huang (Intel)
  - 11-18-1807, "Proposed Resolutions for Miscellaneous CIDs," Yasuhiko Inoue (NTT)
  - 11-18-1808, "Proposed Resolutions for CIDs related to HE MAC Capabilities," Yasuhiko Inoue (NTT)
  - 11-18-1812, "Resolution for CIDs related to Random Access," Abhishek Patil (Qualcomm)
  - 11-18-1814, "Resolution for CIDs related to Multiple BSSID - Part 2," Abhishek Patil (Qualcomm)
  - 11-18-1815, "Resolution for miscellaneous CIDs," Abhishek Patil (Qualcomm)
  - 11-18-1817, "Figure 9-63j1," Abhishek Patil (Qualcomm)
  - 11-18-1820, "Doze Transition Signaling MoreData," Matthew Fischer (Broadcom Ltd.)

- 11-18-1821, "Maximum RX PPDU Duration Signaling," Matthew Fischer (Broadcom Ltd.)
- 11-18-1822, "Temporarily Limited Connection," Matthew Fischer (Broadcom Ltd.)
- 11-18-1830, "CR for TSPEC," Jarkko Kneckt (Apple)
- 11-18-1831, "OMI comment resolution," Jarkko Kneckt (Apple)
- 11-18-1844, "LB233 CR on Fragmentation," Ming Gan (Huawei Technologies)
- 11-18-1851, "Resolutions to comments to subclause 9.3.1.9," Tomoko Adachi (Toshiba)
- 11-18-1852, "General and Annex G Comment Resolution," Osama Aboul-Magd (Huawei Technologies)
- 11-18-1853, "Resolutions to comments to subclauses 10.3.7, 3.1, 3.2, and 27.5.1.1," Tomoko Adachi (Toshiba)
- 11-18-1855, "Comments Resolution - 27.16.4," Chao-Chun Wang (MediaTek)
- 11-18-1856, "11ax D3.0 Comment Resolution 9.7.1," Liwen Chu (Marvell)
- 11-18-1857, "11ax D3.0 Comment Resolution 27.10.1 27.10.3" Liwen Chu (Marvell)
- 11-18-1858, "11ax D3.0 Comment Resolution 9.7.3," Liwen Chu (Marvell)
- 11-18-1859, "11ax D3.0 Comment Resolution 27.10.4," Liwen Chu (Marvell)
- 11-18-1867, "CR for OPS 2," Laurent Cariou (Intel)
- 11-18-1868, "CR for Clause 4," Guoqing Li (Apple)
- 11-18-1876, "Resolutions to Miscellaneous MAC Comments," Osama Aboul-Magd (HuaweiTechnoloies)
- 11-18-1887, "11ax D3.2 MAC Comment Resolution for Section 27.5," Zhou Lan (Broadcom Ltd.)
- 11-18-1900, "11ax D3.2 MAC Comment Resolution for Section 27.7.7," Zhou Lan (Broadcom Ltd.)
- 11-18-1901, "D3.0 Comment Resolution - Part 5," Youhan Kim (Qualcomm)
- 11-18-1921, "11ax D3.0 sounding comments," Menzo Wentink (Qualcomm)
- 11-18-1932, "Proposed Resolutions to Miscs PHY and MAC CIDs," Peter Loc (Huawei Technologies)
- 11-18-1935, "Resolutions to CIDs 15935 and 16150," Osama Aboul-Magd (Huawei Technologies)
- 11-18-1939, "Comment resolution on MIBs - part 1," Edward Au (Huawei Technologies)
- 11-18-1942, "Comment resolution on PICs," Edward Au (Huawei Technologies)
- 11-18-1944, "Comment resolution on MIBs - part 2," Edward Au (Huawei Technologies)
- 11-18-1958, "CR for CID 16643," Yunbo Li (Huawei Technologies)
- 11-18-1969, "Proposed resolution for CIDs for 27-2-2-Part 2," Kaiying Lv (ZTE)
- 11-18-1975, "11ax D3.0 Comment Resolution 27.5.3.4," Liwen Chu (Marvell Semiconductor)
- 11-18-1987, "D3.0 Comment Resolution on MAC Miscellaneous," Jae Seung Li (ETRI)
- 11-18-1995, "Resolution for CIDs: 15302, 15906, 16750," Huizhao Wang (Quantenna)
- 11-18-1999, "RTS CTS protection coverage," Jarkko Kneckt (Apple)

◦ MU Submissions
- 11-18-1803, "CR on MU-RTS/CTS part II," Po-Kai Huang (Intel)
- 11-18-1812, "Resolution for CIDs related to Random Access - Part 2," Abhishek Patil (Qualcomm)

◦ SR Submission
- 11-18-1531, "Spatial Reuse DSC and TPC," Graham Smith (SR Technologies)
- 11-18-1866, "CR for OBSS_PD 2," Laurent Cariou (Intel)

◦ TG submissions
- 11-18-0496, "Disallowed Sub-Channels," Matthew Fischer (Broadcom Ltd.)
- 11-18-1489, "Operation at 6GHz Band," Liwen Chu (Marvell Semiconductor)
- 11-18-1500, "CR for 6 GHz - 6 GHz Map," Laurent Cariou (Intel)
- 11-18-1532, "TGax Coexistence Assurance Document Comments," Eldad Perahia (HP Enterprize)
- 11-18-1827, "6 GHz operation for 11ax follow up," Wook Bong Lee (Samsing)
- 11-18-1828, "D3.0 CR for 6GHz Post Association," Wook Bong Lee (Samsing)
- 11-18-1922, "Considerations on 6 GHz Discovery," Thomas Derham (Broadcom Ltd.)
- 11-18-1959, "CR for 6GHz - Out-of-band association," Lauernt Cariou (Intel)
- 11-18-1960, "6 GHz - Out-of-band discovery discussion," Laurent Cariou (Intel)
- 11-18-1961, "6 GHz association discussion," Laurent Cariou (Intel)

3. **Timeline update**

Current timeline needs to be updated. Details will be discussed in the January 2019 session.

Current Timeline (to be updated)	
May 2014	**Start of TG**
November 2014	**First draft of the TG SFD approved**

January 2016	**Proposed TG draft**
March 2016	**Draft 0.1 was approved and Comment Collection started**
November 2016	**Issue Draft 1.0 and start WG Letter Ballot — Failed (57.77%)** **LB 225: opened Dec. 1st, 2016 and closed Jan. 8th, 2017**
September 2017	**Draft 2.0 and WG Letter Ballot — Failed (62.84%)** **LB 230: opened Oct. 5th, 2017 and closed Nov. 4th, 2017**
May 2018	**Draft 3.0 and WG Letter Ballot — Passes (86.5%)**
November 2018	**Mandatory Draft Review**
November 2018	**Draft 4.0 and Recirculation Ballot**
February 2019	**Formation of Sponsor Ballot pool**
March 2019	**Draft 5.0 and Recirculation (unchanged)**
July 2019	**Initial Sponsor Ballot**
January 2020	**RevCom submittal and publication**

Goals for the January 2019 session

- Complete the resolution of comments received on draft D3.0, generate draft D4.0, and go to recirculation ballot.

Teleconferences

Following TGax teleconferences were authorized during the September 2018 session.

Thursday	November 29th, 2018	18:00 - 20:00 (ET)
Thursday	December 06th, 2018	10:00 - 12:00 (ET)
Thursday	December 13th, 2018	18:00 - 20:00 (ET)
Thursday	December 20th, 2018	10:00 - 12:00 (ET)
Thursday	January 03rd, 2019	10:00 - 12:00 (ET)

Additional TGax teleconference may be scheduled with 10-day notice if needed.

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September 2018 — Waikoloa, HI

TGax had ten sessions during the week.

	Monday	Tuesday	Wednesday	Thursday
AM1		**TGax (full)** **6 GHz discussion**	**TGax (full)** **6 GHz discussion**	**TGax** **(full)**
AM2		**TGax** **(PHY ad hoc)** **TGax** **(MAC ad hoc)**		
PM1	**TGax** **(full)**	**TGax** **(PHY ad hoc)** **TGax** **(MAC ad hoc)**	**TGax** **(PHY ad hoc)** **TGax** **(MAC ad hoc)**	**TGax (full)** **COEX discussion with 802.19**
PM2		**TGax** **(PHY ad hoc)** **TGax** **(MAC ad hoc)**	**TGax** **(full)**	
PM3	**TGax** **(SR ad hoc)** **TGax** **(MAC ad hoc)**	**TGax (full)** **(6 GHz discussions)**		

Submissions for MU ad hoc were considered in the MAC ad hoc.

Main documents

The meeting agenda and minutes of the TGax and its subgroups, and the TGax closing report can be found here.

- TGax
  - 11-18-1373-05, TGax September 2018 Meeting Agenda
  - 11-18-1672-00, TGax September 2018 Closing Report
  - 11-18-1617-00, TGax September 2018 Waikoloa Meeting Minutes

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Achievements

1. **Work Completed**
   - The TG approved resolutions to 500+ technical comments
   - The plan is to have draft D4.0 ready for recirculation after November meeting.
   - The TG reviewed a number of submissions on 6 GHz discovery and management. More discussion is needed to reach consensus.
   - The TG revisited the coexistence issues with members from 802.15 and 802.18.
   - The TG is planning a 3-day ad hoc meeting in Shenzhen, China the week before the November F2F meeting on November 7-9. The PHY ad hoc has a 2-day meeting on November 8-9.

2. **Technical Submissions**

   TGax received following submissions during the TGax sessions.
   - PHY Submissions
     - 11-18-1258, "Punctured NDP Comment Resolution," Ron Porat (Broadcom Ltd.)
     - 11-18-1434, "CR on HE-SIG-A and HE-SIG-B - Part 1," Ross Jian Yu (Huawei Technologies)
     - 11-18-1435, "CR on HE-SIG-A and HE-SIG-B - Part 2," Ross Jian Yu (Huawei Technologies)
     - 11-18-1436, "CR on HE-SIG-A and HE-SIG-B - Part 3," Ross Jian Yu (Huawei Technologies)
     - 11-18-1441, "CR on HE-SIG-A and HE-SIG-B - Part 4," Xin Zuo (Huawei Technologies)
     - 11-18-1442, "Spec Text Changes Regarding Single Stream Pilot," Ross Jian Yu (Huawei Technologies)
     - 11-18-1452, "CR on Packet Extension," Yujin Noh (Newracom)
     - 11-18-1453, "CR on PHY subcarriers and RU part 1," Yujin Noh (Newracom)
     - 11-18-1459, "Comment Resolution on PHY Introduction Part - 1," Lochan Verma (Qualcomm)
     - 11-18-1460, "Comment Resolution on PHY Introduction Part - 2," Lochan Verma (Qualcomm)
     - 11-18-1492, "Remaining PHY Math comment resolutions," Yan Zhang (Marvell)
     - 11-18-1493, "Changes to D3.0," Xiaogang Chen (Intel)
     - 11-18-1514, "Preamble Comment Resolution," Ron Porat (Broadcom Ltd.)
     - 11-18-1522, "Comment Resolution of Nominal Packet Padding Definition," Hongyuan Zhang (Marvell)
     - 11-18-1534, "D3.0 CR for PHY 28.3.4/28.3.16/28.3.17," Tianyu Wu (Samsung)
     - 11-18-1590, "D3.0 Comment Resolution - Part 1," Youhan Kim (Qualcomm)
     - 11-18-1591, "D3.0 Comment Resolution - Part 2," Youhan Kim (Qualcomm)
     - 11-18-1601, "CR on HE-SIG-A and HE-SIG-B - Part 5," Ross Jian Yu (Huawei Technologies)
   - MAC & MU Submissions
     - 11-18-0496, "Disallowed Sub channels," Matthew Fischer (Broadcom Ltd.)
     - 11-18-0946, "No Action frame in multi-TID A-MPDU," Robert Stacey (Intel)
     - 11-18-1181, "11ax D3.0 MAC Comment Resolution for FTM," Jonathan Segev (Intel)
     - 11-18-1189, "11ax D3.0 MAC Comment Resolution for NAV - Part I," Po-Kai Huang (Intel)
     - 11-18-1246, "OM Control Comment Resolutions," Jarkko Kneckt (Apple)
     - 11-18-1266, "Resolution for CIDs related to Random Access," Abhishek Patil (Qualcomm)
     - 11-18-1320, "Resolution for CIDs related to Multiple BSSID," Abhishek Patil (Qualcomm)
     - 11-18-1415, "11ax D3.0 MAC Comment Resolution for SM Power Save," Po-Kai Huang (Intel)
     - 11-18-1418, "11ax D3.0 MAC Comment Resolution for MU-RTS/CTS - Part I," Po-Kai Huang (Intel)
     - 11-18-1432, "Doze Transition Signaling," Matthew Fischer (Broadcom Ltd.)
     - 11-18-1454, "Figure 27-12," Abhishek Patil (Qualcomm)

- 11-18-1455, "Resolution for CIDs in 27.5.3.3," Abhishek Patil (Qualcomm)
- 11-18-1458, "11ax D3.0 MAC Comment Resolution for Random Access with multiple BSS," Pascal Vigar (Canon Research)
- 11-18-1465, "Comment resolutions for 9.4.2.200," Alfred Asterjadhi (Qualcomm)
- 11-18-1466, "Comment resolutions for 10.43.1," Alfred Asterjadhi (Qualcomm)
- 11-18-1467, "Comment resolutions for 27.16.1 not related to 6 GHz band," Alfred Asterjadhi (Qualcomm)
- 11-18-1468, "Comment resolutions for 27.7.7," Alfred Asterjadhi (Qualcomm)
- 11-18-1469, "Comment resolutions for 27.7.6," Alfred Asterjadhi (Qualcomm)
- 11-18-1470, "Comment resolutions for 27.7.5," Alfred Asterjadhi (Qualcomm)
- 11-18-1471, "Comment resolutions for 27.16.1 related to 6 Ghz band," Alfred Asterjadhi (Qualcomm)
- 11-18-1484, "11ax D3.0 Comment Resolution 27.15.2," Liwen Chu (Marvell Semiconductors)
- 11-18-1485, "11ax D3.0 Comment Resolution 27.5.3.2.1," Liwen Chu (Marvell Semiconductors)
- 11-18-1486, "11ax D3.0 Comment Resolution 27.5.3.5," Liwen Chu (Marvell Semiconductors)
- 11-18-1496, "CR for MU EDCA parameters," Laurent Cariou (Intel)
- 11-18-1497, "CR for OPS," Laurent Cariou (Intel)
- 11-18-1498, "CR for 27.5.6," Laurent Cariou (Intel)
- 11-18-1501, "Remaining Ack related CRs on misc sections," George Cheria (Qualcomm)
- 11-18-1502, "CR on differentiating non-TB and TB sounding," Robert Stacey (Intel)
- 11-18-1504, "LB233 CR A-Control Subfield," Yongho Seok (MediaTek)
- 11-18-1507, "11ax D3.0 MAC Comment Resolution for Co-located BSS," Po-Kai Huang (Intel)
- 11-18-1511, "LB233 CR on CID 17024," Ming Han (Huawei Technologies)
- 11-18-1512, "LB233 CR on MU Cascadingu," Ming Han (Huawei Technologies)
- 11-18-1515, "11ax D3.0 MAC Comment Resolution for Bandwidth Queue Report," Zhou Lan (Broadcom Ltd.)
- 11-18-1516, "11ax D3.0 MAC Comment Resolution for Bandwidth Queue Report," Zhou Lan (Broadcom Ltd.)
- 11-18-1519, "11ax D3.0 MAC Comment Resolution for Control response," Robert Stacey (Intel)
- 11-18-1548, "CR for CID 15105," Kiseon Ryu (LG Electronics)

◦ SR Submission
- 11-18-1410, "LB233 CR Spatial Reuse," Matthew Fischer (Broadcom Ltd.)
- 11-18-1495, "CR for OBSS_PD," Laurent Cariou (Intel)
- 11-18-1531, "TGax Spatial Reuse DSC and TPC," Graham Smith (SR Technologies)

◦ TG submissions
- 11-18-1211, "Comment resolutions for 27.16.1 related to 6 Ghz band," Alfred Asterjadhi (Qualcomm)
- 11-18-1227, "CR for 6GHz - Discovery," Laurent Cariou (Intel)
- 11-18-1229, "CR for 6GHz - Policy," Laurent Cariou (Intel)
- 11-18-1256, "802.11ax operation in 6GHz band," George Cherian (Qualcomm)>
- 11-18-1489, "Operation at 6GHz Band," Liwen Chu (Marvell)
- 11-18-1500, "CR for 6GHz - 6GHz Map," Laurent Cariou (Intel)
- 11-18-1508, "11ax D3.0 MAC Comment Resolution for Multiple BSS," Po-Kai Huang (Intel)
- 11-18-1532, "TGax Coexistence Assurance Document Comments," Eldad Perahia (HP Enterprize)
- 11-18-1607, "6 GHz operation for 11ax," Ravi Gidvani (Samsung)
- 11-18-1624, "Discovery Channels For 6 GHz Band," Alfred Asterjadhi (Qualcomm)

3. **Timeline update**

There are small adjustments to the TGax Timeline.

Current Timeline	
May 2014	**Start of TG**
November 2014	**First draft of the TG SFD approved**
January 2016	**Proposed TG draft**
March 2016	**Draft 0.1 was approved and Comment Collection started**
November 2016	**Issue Draft 1.0 and start WG Letter Ballot — Failed (57.77%)** **LB 225: opened Dec. 1st, 2016 and closed Jan. 8th, 2017**
September 2017	**Draft 2.0 and WG Letter Ballot — Failed (62.84%)** **LB 230: opened Oct. 5th, 2017 and closed Nov. 4th, 2017**
May 2018	**Draft 3.0 and WG Letter Ballot — Passes (86.5%)**

November 2018	**Mandatory Draft Review**
November 2018	**Draft 4.0 and Recirculation Ballot**
February 2019	**Formation of Sponsor Ballot pool**
March 2019	**Draft 5.0 and Recirculation (unchanged)**
July 2019	**Initial Sponsor Ballot**
January 2020	**RevCom submittal and publication**

Goals for the November 2018 session

- Complete the resolution of comments received on draft D3.0.
- Generate draft D4.0.
- Go to the WG recirculation ballot.

Teleconferences

Following TGax teleconferences were authorized during the September 2018 session.

Thursday	September 20th, 2018	10:00 - 12:00 (ET)
Thursday	September 27th, 2018	20:00 - 22:00 (ET)
Thursday	October 04th, 2018	10:00 - 12:00 (ET)
Thursday	October 11th, 2018	20:00 - 22:00 (ET)
Thursday	October 18th, 2018	10:00 - 12:00 (ET)
Thursday	November 01st, 2018	10:00 - 12:00 (ET)

Additional TGax teleconference may be scheduled with 10-day notice if needed.

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July 2018 — San Diego, CA

TGax had eight sessions during the week.

	Monday	Tuesday	Wednesday	Thursday
AM1	**TGax** (ad hoc)		**TGax** (with 802.19)	**TGax** (full)
AM2		**TGax** (full)		
PM1	**TGax** (full)			**TGax** (full)
PM2		**TGax** (full)	**TGax** (full)	
PM3				

Main documents

The meeting agenda and minutes of the TGax and its subgroups, and the TGax closing report can be found here.

- TGax
  - 11-18-1036-05, TGax July 2018 Meeting Agenda
  - 11-18-1330-00, TGax July 2018 Closing Report
  - 11-18-1093-00, Draft TGax July 2018 San Diego Meeting Minutes

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802.11 WG Letter Ballot #233

- The IEEE 802.11ax draft 3.0 passed the WG Letter Ballot #233 with 86.5 % approval ratio.
  - Visit http://www.ieee802.org/11/LetterBallots.shtml for more information.
- About 2250 comments are received.

Achievements

1. **Work Completed**
   - The TG started the resolution of comments received on draft D3.0
   - Members of 802.19 WG were invited to make a presentation on their concerns related to the TG Coexistence Assurance document.
     - 19-18-0040, ``802.11ax and 802.15.4 HRP_LRP Coexistence," Tim Harrington (Pro-ID)
   - The TG approved the proposed the PAR extension request and the revised CSD accommodating comments received from 802.3 WG.
   - The TG prepared and approved a liaison response to WBA.
     - https://mentor.ieee.org/802.11/dcn/18/11-18-1291-02-00ax-proposed-response-to-liaison-from-wba-on-11ax.docx

2. **Technical Submissions**
   TGax received following submissions during the TGax sessions.
   - PHY Submissions
     - 11-18-0477, "Punctured NDP," Ron Porat (Broadcom Ltd.)
     - 11-18-1183, "Spec text change for error correction on STBC," Jianhan Liu (MediaTek)
   - MAC Submissions
     - 11-18-0496, "Disallow Sub-Channels," Matthew Fischer (Broadcom Ltd.)
     - 11-18-1181, "CR in FTM," Jonathan Segev (Intel)
     - 11-18-1189, "CR for NAV Part 1," Po-kai Huang (Intel)
     - 11-18-1211, "MAC CR subclause 27.16.1," Alfred Asterjadhi (Qualcomm)
     - 11-18-1219, "CR for ER SU Disable," Po-Kau Huang (Intel)
     - 11-18-1220, "CR for Random Access," Po-Kai Huang (Intel)
     - 11-18-1244, "Resolutions for CIDs related to BSS Color," Abhishek Patil (Qualcomm)
     - 11-18-1252, "D3.0 Comment Resolution for CIDs on Clause 6," Jae Seung Lee (ETRI)
     - 11-18-1246, "CR for OMI," Jarkko Kneckt (Apple)
   - MU Submission
     - 11-18-1266, "Resolution for CIDs related to random access - Part 1," Abhishek Patil (Qualcomm)
   - TG submissions
     - 11-18-1227, "CR for 6GHz - Discovery," Laurent Cariou (Intel)
     - 11-18-1229, "CR for 6GHz - Policy," Laurent Cariou (Intel)
     - 11-18-1256, "11ax 6GHz Operation," George Cherian (Qualcomm)
     - 11-18-1258, "CR for Punctured NDP," Ron Porat (Broadcom Ltd.)
3. **Timeline update**
   TG reviewed the timeline - No change.

Current Timeline	
May 2014	**Start of TG**
November 2014	**First draft of the TG SFD approved**
January 2016	**Proposed TG draft**
March 2016	**Draft 0.1 was approved and Comment Collection started**

November 2016	**Issue Draft 1.0 and start WG Letter Ballot — Failed (57.77%)** LB 225: opened Dec. 1st, 2016 and closed Jan. 8th, 2017
September 2017	**Draft 2.0 and WG Letter Ballot — Failed (62.84%)** LB 230: opened Oct. 5th, 2017 and closed Nov. 4th, 2017
May 2018	**Draft 3.0 and WG Letter Ballot — Passes (86.5%)**
July 2018	**Mandatory Draft Review**
November 2018	**Draft 4.0 and Recirculation Ballot**
February 2019	**Formation of Sponsor Ballot pool**
September 2019	**Initial Sponsor Ballot**
December 2019	**RevCom submittal**

Goals for the September 2018 session

- Continue the resolution of comments on draft D3.0.

Teleconferences

Following TGax teleconferences were authorized during the July 2018 plenary.

Thursday	July 26th, 2018	10:00 - 12:00 (ET)
Thursday	August 02nd, 2018	20:00 - 22:00 (ET)
Thursday	August 09th, 2018	10:00 - 12:00 (ET)
Thursday	August 16th, 2018	20:00 - 22:00 (ET)
Thursday	August 23rd, 2018	10:00 - 12:00 (ET)
Thursday	August 30th, 2018	20:00 - 22:00 (ET)
Thursday	September 20rd, 2018	10:00 - 12:00 (ET)

Additional TGax teleconference may be scheduled with 10-day notice if needed.

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May 2018 — Warsaw, Poland

TGax had nine sessions during the week.

	Monday	Tuesday	Wednesday	Thursday
AM1			**TGax (full)**	**TGax (full)**
AM2		**TGax** (PHY ad hoc) **TGax** (MAC ad hoc)		
PM1	**TGax (full)**			**TGax (full)**
PM2		**TGax** (PHY ad hoc) **TGax** (MAC ad hoc)	**TGax** (SR ad hoc) **TGax** (MAC ad hoc)	
PM3	**TGax** (SR ad hoc) **TGax** (MAC ad hoc)	**TGax** (PHY ad hoc) **TGax** (MAC adx hoc)		

Main documents

The meeting agenda and minutes of the TGax and its subgroups, and the TGax closing report can be found here.

- TGax
  - 11-18-0635-10, TGax May 2018 Meeting Agenda
  - 11-18-0976-00, TGax May 2018 Closing Report
  - 11-18-0888-00, TGax May 2018 Warsaw Meeting Minutes

  - TGax PHY ad hoc group
    - 11-18-0800-01, TGax May 2018 Meeting Agenda - PHY Ad Hoc
  - TGax MAC ad hoc group
    - 11-18-0914-03, TGax May 2018 MAC Ad Hoc Meeting Agenda
    - 11-18-0920-00, TGax MAC Ad hoc May 2018 Meeting Minutes
  - TGax SR ad hoc group
    - 11-18-0912-01, Agenda of the IEEE 802.11ax Spatial Reuse ad hoc group
    - 11-18-0922-00, IEEE 802.11ax Spatial Reuse ad hoc minutes

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Achievements

1. **Work Completed**
   - The TG completed resolution of comments submitted on draft D2.0.
   - The TG passed a motion to instruct the TGax Editor to prepare draft D3.0 and start a 30-day WG letter Ballot.
   - The TG approved the PAR extension.
   - The TG approved the updated Coexistence Assurance document 11-16/1348r3 that has already been discussed during the TGax teleconference.
   - No changes to the TG timeline.
2. **Technical Submissions**
   TGax received following submissions during the TGax ad hoc meeting and in the TGax sessions.
   - PHY Submissions
     - 11-18-0469, "CR Packet Extension," Ron Porat (Broadcom Ltd.)
     - 11-18-0477, "Punctured NDP," Ron Porat (Broadcom Ltd.)
     - 11-18-0725, "Comment Resolutions on PHY Sounding Part 1," Lochan Verma (Qualcomm)
     - 11-18-0753, "PHY CR on midamble TxEVM," Hongyuan Zhang (Marvell Semiconductors)
     - 11-18-0754, "CID14038 scrambler," Hongyuan Zhang (Marvell Semiconductors)
     - 11-18-0755, "HE Capabilities on HE MU single user full BW," Hongyuan Zhang (Marvell Semiconductors)
     - 11-18-0756, "Capabilities on midamble Tx," Hongyuan Zhang (Marvell Semiconductors)
     - 11-18-0765, "CR on HE PHY MIB attributes," Edward Au (Huawei Technologies)
     - 11-18-0779, "D2.0 PHY Comment Resolution - Part 3," Youhan Kim (Qualcomm)
     - 11-18-0799, "Comment resolution on CIDs 11727 and12102," Jianhan Liu (MediaTek)
     - 11-18-0803, "Spec text change on PHY padding," Tianyu Wu (Samsung)
     - 11-18-0806, "PHY Miscellaneous CIDs," Bin Tian (Qualcomm)
     - 11-18-0807, "D2.0 DFS Comment Resolution," Youhan Kim (Qualcomm)
     - 11-18-0815, "D2.0 DFS Comment Resolution," Sigurd Schelstraete (Quantenna Communications)
     - 11-18-0819, "comment-resolution-on-cids-for-28-3-part-3," Jianhan Liu (MediaTek)
     - 11-18-0823, "D2.0 CR for SAP and TRIGVECTOR," Tianyu Wu (Samsug)
     - 11-18-0868, "Spec. change on Receiver minimum input sensitivity on 1024-QAM for 20MHz bandwidth, Jianhan Liu (MediaTek)
   - MAC Submissions
     - 11-17-1860, "Resolution for CID 11002," Abhishek Patil (Qualcomm)
     - 11-18-0044, "LB230 MAC CR 27.7 and 27.7.1," Alfred Asterjadhi (Qualcomm)
     - 11-18-0077, "D2.0 comment resolution 27.4.2," Liwen Chu (Marvell)
     - 11-18-0083, "LB230 CR for BSS Load Text," Frank Hsu (MediaTek)

- 11-18-0155, "Resolutions for CIDs related to GCR," Yusuke Tanaka (SONY)
- 11-18-0161, "CR CID 13754," Zhou Lan (Broadcom Ltd)
- 11-18-0181, "LB230 CR on BSS Load Information in subclause 9.4.2," Ming Gan (Huawei)
- 11-18-0200, "Decouple Channel Width Capabilities Between VHT and HE Modes," Huizhao Wang
- 11-18-0218, "Fragment Flushing BlockAckReq," Matthew Fischer (Broadcom Ltd.)
- 11-18-0368, "Muliple BSSID," Abhishek Patil (Qualcomm)
- 11-18-0378, "Comment resolutions for 9.3.1.20 Ppart 2," Alfred Asterjadhi (Qualcomm)
- 11-18-0380, "Comment resolution for some CIDs in 9.4.2.237," Alfred Asterjadhi (Qualcomm)
- 11-18-0424, "D2.0 comment resolution-CID 11327," Liwen Chu (Marvell)
- 11-18-0425, "D2.0 comment resolution 9.7.1," Liwen Chu (Marvell)
- 11-18-0426, "D2.0 comment resolution 9.7.3," Liwen Chu (Marvell)
- 11-18-0427, "D2.0 comment resolution 27.10.2," Liwen Chu (Marvell)
- 11-18-0428, "D2.0 comment resolution 27.10.3," Liwen Chu (Marvell)
- 11-18-0431, "comment-resolution-on-cid-13082-13083-and-14141," Jason Yuchen Guo (Huawei)
- 11-18-0454, "CR for CID 11499 and 14324," Kiseon Ryu (LG Electronics)
- 11-18-0496, "Disallowed Sub-Channels," Matthew Fischer (Broadcom Ltd.)
- 11-18-0548, "CR for CID 13415," Yunbo Li (Huawei)
- 11-18-0558, "Comment resolution for 27.2.2 part 1," Kaiying Lv (ZTE)
- 11-18-0602, "LB230 CR CID 13870," Yongho Seok (MediaTek)
- 11-18-0603, "LB230 CR CID 13530 and 14183," Yongho Seok (MediaTek)
- 11-18-0604, "LB230 CR Preamble Puncturing," Yongho Seok (MediaTek)
- 11-18-0627, "LB230 CR HT Control," Yongho Seok (MediaTek)
- 11-18-0628, "LB230 CR STA_ID_LIST," Yongho Seok (MediaTek)
- 11-18-0629, "LB230 CR UPLINK_FLAG," Yongho Seok (MediaTek)
- 11-18-0630, "LB230 CR HE Sounding NDP," Yongho Seok (MediaTek)
- 11-18-0660, "Comment resolution for several miscellaneous comments part 2," Alfred Asterjadhi (Qualcomm)
- 11-18-0661, "Comment resolution for 27.7.2," Alfred Asterjadhi (Qualcomm)
- 11-18-0662, "LB230-MAC-CR-27.7.3.1," Alfred Asterjadhi (Qualcomm)
- 11-18-0663, "LB230-MAC-CR-27.7.3.2," Alfred Asterjadhi (Qualcomm)
- 11-18-0664, "LB230-MAC-CR-27.7.3.3," Alfred Asterjadhi (Qualcomm)
- 11-18-0665, "LB230-MAC-CR-10.22.2.9-revisit," Alfred Asterjadhi (Qualcomm)
- 11-18-0684, "LB230-MAC-CR-Misc Part 3," Alfred Asterjadhi (Qualcomm)
- 11-18-0685, "LB230-MAC-CR-Misc Part 4," Alfred Asterjadhi (Qualcomm)
- 11-18-0688, "CR for NAV Part IV," Po-Kai Huang (Intel)
- 11-18-0693, "Multiple BSSID Group Addressed Transmission," Po-Kai Huang (Intel)
- 11-18-0705, "CR-section 4 and 5," Guoqing Li (Apple)
- 11-18-0717, "Remaining Ack related CRs," George Cherian (Qualcomm)
- 11-18-0720, "Comment Resolution for 27.15.2," Guoqing Li (Apple)
- 11-18-0724, "Remaining Ack related CRs on misc sections," George Cherian (Qualcomm)
- 11-18-0726, "LB230 CR MAC Miscellaneous," Yongho Seok (Mediatek)
- 11-18-0733, "Resolutions to LB230 comments submitted to subclauses 9.3.1.8 and 10.24.6," Tomoko Adachi (Toshiba)
- 11-18-0734, "Resolutions to LB230 comments submitted to subclause 9.3.1.9.1," Tomoko Adachi (Toshiba)
- 11-18-0737, "Single-STA trigger-based sounding," Mark Rison (Samsung)
- 11-18-0739, "CIDs in 27.7.3.1 (TWT)," Abhishek Patil (Qualcomm)
- 11-18-0740, "Various CIDs in Clause 9," Abhishek Patil (Qualcomm)
- 11-18-0741, "Various CIDs in 27.5," Abhishek Patil (Qualcomm)
- 11-18-0744, "CID 13078," Abhishek Patil (Qualcomm)
- 11-18-0745, "CR BQR part2," Zhou Lan (Broadcom Ltd.)
- 11-18-0763, "CR for PICS comments on D2.0 - Part 2," Edward Au (Huawei)
- 11-18-0764, "LB230 CR on Fragmentation - Part 3," Ming Gan (Huawei)
- 11-18-0767, "CR related to 27.5.6 - Misc," Laurent Cariou (Intel)
- 11-18-0792, "11ax D2.0 Comment Resolution 10.13.1 10.13.3," Liwen Chu (Marvell)
- 11-18-0793, "11ax D2.0 Comment Resolution 9.4.2.237.2," Liwen Chu (Marvell)
- 11-18-0794, "11ax D2.0 Comment Resolution CID 11314, 12883," Liwen Chu (Marvell)

- 11-18-0795, "11ax D2.0 BSS Operation BW," Liwen Chu (Marvell)
- 11-18-0796, "11ax D2.0 Comment Resolution 27.10.4.2, 27.10.4.3," Liwen Chu (Marvell)
- 11-18-0797, "11ax D2.0 Comment Resolution 27.10.4.1," Liwen Chu (Marvell)
- 11-18-0798, "11ax D2.0 Comment Resolution 9.4.1.62," Liwen Chu (Marvell)
- 11-18-0811, "11ax D2.0 MAC Comment Resolution for Dynamic Fragmentation Coexistence," Frank Hsu (MediaTek)
- 11-18-0813, "CR for CID 12295," Jeongki Kim (LG Electronics)
- 11-18-0869, "CR on remaining CIDs for BSR," Kiseon Ryu (LG Electronics)
- 11-18-0890, "Resolutions to LB230 comments submitted to subclauses 9.3.1.9.3 and 9.3.1.9.7," Tomoko Adachi (Toshiba)

◦ MU Submissions
- 11-18-0388, "Comment resolution for CID 13084," Stephane Baron (Canon Research)
- 11-18-0390, "CIDs related to Random Access for unassociated STAs," Stephane Baron (Canon Research)
- 11-18-0445, "ACK non QoS data frame in TB PPDU," Zhou Lan (Broadcom Ltd.)
- 11-18-0692, "Comment Resolution for Random Access," Po-Kai Huang (Intel)
- 11-18-0694, "CIDs resolution for UORA procedure - part 2," Stephane Baron (Canon Research)
- 11-18-0695, "CIDs resolution for UORA procedure - part 1," Stephane Baron (Canon Research)
- 11-18-0707, "CIDs related to MU Cascading," David Xun Yang (Huawei Technologies)
- 11-18-0724, "CIDs related to random access," Abhishek Patil (Qualcomm)
- 11-18-0906, "DL MU MIMO signaling," Guoqing Li (Apple)

◦ SR Submissions
- 11-18-0026, "CR-SRG-and-SRP," Matthew Fischer (Broadcom Ltd.)
- 11-18-0225, "CR-SRG-Management-CID-12044-12304," Matthew Fischer (Broadcom Ltd.)
- 11-18-0456, "lb230-cr-txvector-parameter-bss-color," Yongho Seok (MediaTek)
- 11-18-0579, "11ax D2.0 CR on SR and CCA," Yuichi Morioka (Sony)
- 11-18-0617, "Dynamic OBSS_PD level," Graham Smith (SR Technologies)
- 11-18-0743, "CIDs related to BSS Color," Abhishek Patil (Qualcomm)

◦ TG Submission
- 11-18-0902, "CID 12102: Remove DCM," Sean Coffey (RealTek)

3. **Timeline update**
   TG reviewed the timeline - No change.

Current Timeline	
May 2014	**Start of TG**
November 2014	**First draft of the TG SFD approved**
January 2016	**Proposed TG draft**
March 2016	**Draft 0.1 was approved and Comment Collection started**
November 2016	**Issue Draft 1.0 and start WG Letter Ballot — Failed (57.77%)** **LB 225: opened Dec. 1st, 2016 and closed Jan. 8th, 2017**
September 2017	**Draft 2.0 and WG Letter Ballot — Failed (62.84%)** **LB 230: opened Oct. 5th, 2017 and closed Nov. 4th, 2017**
May 2018	**Draft 3.0 and WG Letter Ballot**
July 2018	**Mandatory Draft Review**
February 2019	**Formation of Sponsor Ballot pool**
May 2019	**Initial Sponsor Ballot**
December 2019	**RevCom submittal**

Goals for the July 2018 session

- Start resolving comments received on draft D3.0.

Teleconferences

Following TGax teleconferences has already approved during the March 2018 plenary.

Thursday	May 17th, 2018	10:00 - 12:00 (ET)

Additional TGax teleconference may be scheduled with 10-day notice if needed.

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March 2018 — Rosemont, IL

TGax had ten sessions during the week.

	Monday	Tuesday	Wednesday	Thursday
AM1	**TGax (full, ad hoc)**	**TGax (MAC & MU ad hoc)**	**TGax (full)**	
AM2		**TGax (PHY ad hoc)** **TGax (MAC & MU ad hoc)**		**TGax (full)**
PM1	**TGax (full)**			
PM2		**TGax (PHY ad hoc)** **TGax (MAC & MU ad hoc)**	**TGax (PHY ad hoc)** **TGax (MAC & MU ad hoc)**	**TGax (full)**
PM3		**TGax (SR ad hoc)** **TGax (MAC & MU ad hoc)**		

Main documents

The meeting agenda and minutes of the TGax and its subgroups, and the TGax closing report can be found here.

- TGax
  - 11-18-0286-06, TGax March 2018 Meeting Agenda
  - 11-18-0582-00, TGax March 2018 Closing Report
  - 11-18-0518-00, TGax March 2018 Rosemont Meeting Minutes

  - TGax PHY ad hoc group
    - 11-18-0535-02, TGax March 2018 Meeting Agenda - PHY Ad Hoc
    - 11-18-0594-00, IEEE 802.11 TGax March 2018 Rosemont Plenary Ad Hoc Meeting Minutes
  - TGax MAC/MU ad hoc group
    - 11-18-0545-04, TGax MU/MAC Ad-hoc March 2018 Meeting Agenda
    - 11-18-0566-00, March 2018 TGax MAC/MU Ad hoc Meeting Minutes
  - TGax SR ad hoc group
    - 11-18-0526-02, 802.11ax Spatial Reuse Ad Hoc Group Agenda

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Achievements

1. **Work Completed**
   - Approved resolutions to over 800 technical CIDs.
   - The TG Editor is planning to produce a new revision based on approved resolutions.
   - A TG motion passed to hold an ad hoc meeting in Rennes during the period from February 28th to March 2nd, 2018.
   - No changes to the TG timeline.

2. **Technical Submissions**

TGax received following submissions during the TGax ad hoc meeting and in the TGax sessions.

- MAC/MU Submissions
  - 11-17-1860, "Resolution for CID 11002," Abhishek Patil (Qualcomm)
  - 11-18-0012, "Comment resolutions for 27.15.2, Alfred Asterjadhi (Qualcomm)
  - 11-18-0029, "Default UORA Parameters," Matthew Fischer (Broadcom)
  - 11-18-0044, "Comment resolutions for 27.7 and 27.7.1," Alfred Asterjadhi (Qualcomm)
  - 11-18-0055, "CR for CID 14324," Zhou Lan (Broadcom)
  - 11-18-0056, "CR for CID 14328," Zhou Lan (Broadcom)
  - 11-18-0075, "11ax D2.0 Comment Resolution 27.5.3.2.2," Liwen Chu (Marvell)
  - 11-18-0078, "11ax D2.0 Comment Resolution 27.6.4," Liwen Chu (Marvell)
  - 11-18-0149, "CR for NDP feedback report - part 1," Laurent Cariou (Intel)
  - 11-18-0161, "CR of CID 13754," Zhou Lan (Broadcom)
  - 11-18-0185, "CR of CID 11001," Zhou Lan (Broadcom)
  - 11-18-0200, "Decouple Channel Width Capabilities between VHT and HE PHY Mode," Huizhao Wang (Quantenna)
  - 11-18-0218, "Fragment Flushing BlockAckReq," Matthew Fischer (Broadcom)
  - 11-18-0241, "Comment resolutions for Misc CIDs," Alfred Asterjadhi (Qualcomm)
  - 11-18-0312, "Comment resolutions for 27.6.3," Alfred Asterjadhi (Qualcomm)
  - 11-18-0337, "Comment resolutions for 10.43" Alfred Asterjadhi (Qualcomm)
  - 11-18-0338, "Comment resolutions for 27.16.1," Alfred Asterjadhi (Qualcomm)
  - 11-18-0343, "Comment resolutions for CID 13744," Alfred Asterjadhi (Qualcomm)
  - 11-18-0360, "CIDs related to Random Accessb - Part 2," Abhishek Patil (Qualcomm)
  - 11-18-0361, "visio file for fig 10-1," Abhishek Patil (Qualcomm)
  - 11-18-0362, "CIDs in 10.2.6," Abhishek Patil (Qualcomm)
  - 11-18-0363, "Resolution for CID 13136," Abhishek Patil (Qualcomm)
  - 11-18-0364, "CID 11001," Abhishek Patil (Qualcomm)
  - 11-18-0365, "CIDs related to BSS Color - Part 1," Abhishek Patil (Qualcomm)
  - 11-18-0366, "Resolutions to various CIDs in Trigger Frame format," Abhishek Patil (Qualcomm)
  - 11-18-0367, "Resolutions to CIDs in 27.5.3.3," Abhishek Patil (Qualcomm)
  - 11-18-0368, "Address inconsistencies & ambiguities in 11.1.3.8 (Multiple BSSID topic)," Abhishek Patil (Qualcomm)
  - 11-18-0369, "Resolutions to various CIDs in clause 9," Abhishek Patil (Qualcomm)
  - 11-18-0370, "Comment resolutions for 27.7.5," Alfred Asterjadhi (Qualcomm)
  - 11-18-0371, "Comment resolutions for 27.7.4," Alfred Asterjadhi (Qualcomm)
  - 11-18-0372, "Comment resolutions for 9.4.2.200 part 2," Alfred Asterjadhi (Qualcomm)
  - 11-18-0373, "Comment resolutions for 27.7.3.4," Alfred Asterjadhi (Qualcomm)
  - 11-18-0379, "Comment resolutions for 9.3.3.X," Alfred Asterjadhi (Qualcomm)
  - 11-18-0380, "Comment resolutions for some CIDs in 9.4.2.237," Alfred Asterjadhi (Qualcomm)
  - 11-18-0390, "CIDs related to 27.5.1," Pascal Viger (Canon Research)
  - 11-18-0423, "11ax D2.0 Comment Resolution CID14318," Liwen Chu (Marvell)
  - 11-18-0425, "11ax D2.0 Comment Resolution 9.7.1," Liwen Chu (Marvell)
  - 11-18-0426, "11ax D2.0 Comment Resolution 9.7.3," Liwen Chu (Marvell)
  - 11-18-0427, "11ax D2.0 Comment Resolution 27.10.2," Liwen Chu (Marvell)
  - 11-18-0428, "11ax D2.0 Comment Resolution 27.10.2," Liwen Chu (Marvell)
  - 11-18-0429, "11ax D2.0 Comment Resolution 27.5.3.2.4 remaining CIDs," Liwen Chu (Marvell)
  - 11-18-0432, "LB230 CR on Fragmentation - Part 4," Ming Gan (Huawei)
  - 11-18-0433, "LB230 CR on Fragmentation - Part 2," Ming Gan (Huawei)
  - 11-18-0443, "11ax D1.0 MAC Comment Resolution for 9.4.2.24," Chao-Chun Wang (MediaTek)
  - 11-18-0444, "11ax D2.0 MAC Comment Resolution for 27.16.4," Chao-Chun Wang (MediaTek)
  - 11-18-0455, "LB230 CR TXOP duration-based RTS/CTS," Yongho Seok (MediaTek)
  - 11-18-0512, "11ax D2.0 Comment Resolution for CID 14207," Yunbo Li (Huawei)
- SR Submissions
  - 11-18-0026, "CR SRG and SRP," Matthew Fischer (Broadcom)
  - 11-18-0106, "LB230 CR Spatial Reuse Operation on Secondary Channel," Yongho Seok (MediaTek)
  - 11-18-0225, "CR Spatial Reuse Group Management CID 12044 12304," Matthew Fischer (Broadcom)

        - 11-18-0391, "CID 11775 Should be re-considered," Graham Smith (SR Technologies)
    - PHY Submissions
        - 11-18-0059, "PPE Threshold Field," Hongyuan Zhang (Marvell)
        - 11-18-0110, "11ax Comment Resolutions for PHY Preamble," Yan Zhang (Marvell)
        - 11-18-0111, "11ax Comment Resolutions for PHY Data field," Yan Zhang (Marvell)
        - 11-18-0136, "Comment Resolutions for Clause 28.2.2 (TXVECTOR and RXVECTOR parameters) Part 1," Bo Sun (ZTE)
        - 11-18-0150, "CR for CIDs related to HE ER SU PPDU," Tianyu Wu (MediaTek)
        - 11-18-0151, "CR for PHY PPDU formats," Tianyu Wu (MediaTek)
        - 11-18-0162, "LB230 CR on CID 12060 and 13047," Ming Gan (Huawei)
        - 11-18-0324, "CR on HE-SIG-B part 3," Yujin Noh (Newracom)
        - 11-18-0349, "Comment Resolutions on Clause 28.3.3 (OFDMA and SU Tone Allocation)," Jung Hoon Suh (Huawei)
        - 11-18-0352, "CR for HE-SIG-B," Tianyu Wu (MediaTek)
        - 11-18-0359, "PHY Comment Resolution on 1024 QAM," Ron Porat (Broadcom)
        - 11-18-0404, "Comment Resolutions on PHY INTRODUCTION Part 4," Lochan Verma (Qualcomm)
        - 11-18-0409, "Comment Resolutions on PHY INTRODUCTION Part 5," Lochan Verma (Qualcomm)
        - 11-18-0463, "Proposed Changes to D2.2 Clause 28.3.20, 28.3.21," Xiaogang Chen (Intel)
        - 11-18-0469, "PHY Comment Resolution on Packet Extension," Ron Porat (Broadcom)
        - 11-18-0475, "Comment resolution on CIDs on Clause 28.3 Part 2," Jianhan Liu (MediaTek)
        - 11-18-0476, "Comment resolution on CIDs on Clause 28.3.18.1 for signal leakage to preamble punctured channels," Jianhan Liu (MediaTek)
        - 11-18-0478, "Comment resolution on CID 11896," Jianhan Liu (MediaTek)
        - 11-18-0483, "Corrections to "Number Of HE-LTF Symbols And Midamble Periodicity" subfield," Sigurd Schelstraete (Quantenna)
        - 11-18-0508, "D2.0 PHY Comment Resolution - Part 2," Youhan Kim (Qualcomm)
3. **Timeline update**
   TG reviewed the timeline - No change.

Current Timeline	
May 2014	**Start of TG**
November 2014	**First draft of the TG SFD approved**
January 2016	**Proposed TG draft**
March 2016	**Draft 0.1 was approved and Comment Collection started**
November 2016	**Issue Draft 1.0 and start WG Letter Ballot — Failed (57.77%)** **LB 225: opened Dec. 1st, 2016 and closed Jan. 8th, 2017**
September 2017	**Draft 2.0 and WG Letter Ballot — Failed (62.84%)** **LB 230: opened Oct. 5th, 2017 and closed Nov. 4th, 2017**
May 2018	**Draft 3.0 and WG Letter Ballot**
July 2018	**Mandatory Draft Review**
February 2019	**Formation of Sponsor Ballot pool**
May 2019	**Initial Sponsor Ballot**
December 2019	**RevCom submittal**

Goals for the May 2018 session

- Complete comment resolution and initiate a 30-day WG letter ballot.
- Approve a new revision of the Coexistence. Assurance document taking into account the new added band.
- Prepare and approve PAR extension.

Teleconferences

TGax teleconferences are scheduled after the March 2018 session as follows:

Thursday	March 22nd, April 5th, April 19th, 2018	10:00 - 12:00 (ET)
Thursday	March 29th, April 12th, April 26th, 2018	20:00 - 22:00 (ET)
Thursday	May 17th, 2018	10:00 - 12:00 (ET)

TGax PHY calls are scheduled instead of face-to-face ad hoc meeting:

Wednesday	May 2nd, 2018	20:00 - 22:00 (ET)
Thursday	May 3rd, 2018	20:00 - 22:00 (ET)
Friday	May 4th, 2018	10:00 - 12:00 (ET)

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January 2018 — Orlando, FL

TGax had nine sessions during the week.

	Monday	Tuesday	Wednesday	Thursday
AM1			**TGax (full)**	
AM2		**TGax** (PHY ad hoc) **TGax** (MAC & MU ad hoc)		**TGax (full)**
PM1	**TGax (full)**			
PM2		**TGax** (PHY ad hoc) **TGax** (MAC & MU ad hoc)	**TGax** (PHY ad hoc) **TGax** (MAC & MU ad hoc)	**TGax (full)**
PM3	**TGax** (PHY ad hoc) **TGax** (MAC & MU ad hoc)	**TGax** (SR ad hoc) **TGax** (MAC & MU ad hoc)		

Main documents

The meeting agenda and minutes of the TGax and its subgroups, and the TGax closing report can be found here.

- TGax
  - 11-17-1851-06, TGax January 2018 Meeting Agenda
  - 11-18-0213-00, TGax January 2018 Irvine Meeting Minutes
  - 11-18-0261-00, TGax January 2018 Closing Report
  - TGax PHY ad hoc group
    - 11-18-0201-03, TGax January 2018 Meeting Agenda - PHY Ad Hoc
    - 11-18-0255-00, IEEE 802.11 TGax Jan 2018 Irvine Interim PHY Ad Hoc Meeting Minutes
  - TGax MAC MU ad hoc group
    - 11-18-0204-02, TGax MAC-MU Ad-hoc January 2018 Meeting Agenda
    - 11-18-0245-00, IEEE 802.11 TGax Jan 2018 TGax MAC/MU Ad hoc Meeting Minutes
  - TGax SR ad hoc group
    - 11-18-0217-01, Agenda of the IEEE 802.11ax Spatial Reuse ad hoc group
    - 11-18-0239-00, Minutes of the January 2018 meeting of the IEEE 802.11ax Spatial Reuse ad hoc group

Achievements

1. **Work Completed**
   - Approved resolutions for about 750 technical CIDs.
   - Approved resolutions of Editorial CIDs implemented in draft D 2.1.
   - The TG Editor is planning to produce a new revision based on approved resolutions.
   - A TG motion passed to hold an ad hoc meeting in the Bay Area during the period from February 28th to March 2nd, 2018.
   - No changes to the TG timeline.
2. **Technical Submissions**

   TGax received following submissions during the TGax ad hoc meeting and in the TGax sessions.
   - PHY - 25 submissions
     - 11-18-0006, "Misc CR," Ross Jian Yu (Huawei Technologies)
     - 11-18-0023, "Changes to D2.0 Clause 28.2.5, 28.2.6," Xiaogang Chen (Intel)
     - 11-18-0024, "Changes to D2.0 Clause 28.3.5," Xiaogang Chen (Intel)
     - 11-18-0025, "Proposed Changes to D2.0 Clause 28.3.6," Xiaogang Chen (Intel)
     - 11-18-0028, "Proposed Changes to D2.0 on the HE TB NDP feedback," Xiaogang Chen (Intel)
     - 11-18-0036, "Comment Resolutions on PHY INTRODUCTION Part 1," Lochan Verma (Qualcomm)
     - 11-18-0037, "Comment Resolutions on PHY INTRODUCTION Part 2," Lochan Verma (Qualcomm)
     - 11-18-0038, "Comment Resolutions on HE-SIG-A Part 1," Lochan Verma (Qualcomm)
     - 11-18-0046, "Comment Resolutions on PHY INTRODUCTION Part 3," Lochan Verma (Qualcomm)
     - 11-18-0050, "CR on HE-SIG-B part 1," Yujin Noh (Newracom)
     - 11-18-0051, "CR on HE-SIG-B part 2," Yujin Noh (Newracom)
     - 11-18-0057, "D2.0 PHY Comment Resolution," Youhan Kim (Qualcomm)
     - 11-18-0058, "Comment Resolutions on Midamble," Hongyuan Zhang (Marvell Semiconductors)
     - 11-18-0059, "PPE Threshold Field," Hongyuan Zhang (Marvell Semiconductors)
     - 11-18-0079, "Comment Resolutions on Clause 28.3.15 (SU-MIMO and DL MU-MIMO beamforming)," Kome Oteri (InterDigital)
     - 11-18-0080, "Comment Resolutions on Clause 9.4.1.63 D2.0 (HE Compressed Beamforming Report field)," Kome Oteri (InterDigital)
     - 11-18-0109, "11ax Comment Resolutions for PHY mathematical descriptions," Yan Zhang (Marvell Semiconductors)
     - 11-18-0110, "11ax Comment Resolutions for PHY Preamble," Yan Zhang (Marvell Semiconductors)
     - 11-18-0111, "11ax Comment Resolutions for PHY Data field," Yan Zhang (Marvell Semiconductors)
     - 11-18-0118, "PHY Comment Resolution," Ron Porat (Broadcom Ltd.)
     - 11-18-0136, "Comment Resolutions for Clause 28.2.2 (TXVECTOR and RXVECTOR parameters) Part 1," Bo Sun (ZTE)
     - 11-18-0150, "CR for CIDs related to HE ER SU PPDU," Tianyu Wu (Samsung)
     - 11-18-0151, "CR for PHY PPDU formats," Tianyu Wu (Samsung) - not on the server
     - 11-18-0159, "Comment resolution on CIDs on Clause 28.3 Part 1," Jianhan Liu (MediaTek)
     - 11-18-0162, "LB230 CR on CID 12060 and 13047," Ming Gan (Huawei Technologies)
     - 11-18-0187, "Tx EVM for Beamformed Transmission," Bin Tian (Qualcomm) - not on the server
     - 11-18-0230, "Misc CR Follow up," Ross Jian Yu (Huawei Technologies)
   - MAC 37 submissions
     - 11-17-1837, "11ax D2.0 Comment Resolution 27.5.3.5," Liwen Chu (Marvell Semiconductors)
     - 11-17-1847, "CIDs related to Multiple BSSID topic - Part 1," Abhishek Patil (Qualcomm)
     - 11-17-1850, "Resolution for CIDs in 9.4.2.37," Abhishek Patil (Qualcomm)
     - 11-17-1857, "CIDs related to Multiple BSSID topic - Part 2," Abhishek Patil (Qualcomm)
     - 11-17-1858, "Resolution for CID 13142," Abhishek Patil (Qualcomm)
     - 11-17-1859, "Resolution for CID 11742," Abhishek Patil (Qualcomm)
     - 11-17-1861, "CIDs related to Multiple BSSID topic - Part 3," Abhishek Patil (Qualcomm)
     - 11-17-1874, "11ax D2.0 MAC Comment Resolution for NAV Part I," Po-Kai Huang (Intel)
     - 11-17-1893, "CR TWT IE," Matthew Fischer (Broadcom Ltd.)
     - 11-18-0009, "LB230 MAC CR 10.22.2.4," Alfred Asterjadhi (Qualcomm)
     - 11-18-0010, "LB230 MAC CR 26.8.36," Alfred Asterjadhi (Qualcomm)
     - 11-18-0012, "LB230 MAC CR 27.15.2," Alfred Asterjadhi (Qualcomm)

- 11-18-0013, "LB230 MAC CR 27.15.3," Alfred Asterjadhi (Qualcomm)
- 11-18-0014, "LB230 MAC CR 27.15.4," Alfred Asterjadhi (Qualcomm)
- 11-18-0015, "LB230 MAC CR 27.17," Alfred Asterjadhi (Qualcomm)
- 11-18-0027, "Ack related CIDs Section 27.4," George Cherian (Qualcomm)
- 11-18-0035, "OMI Comment Resolutions," Jarkko Kneckt (Apple)
- 11-18-0039, "LB230 MAC CR 10.22.2.5," Alfred Asterjadhi (Qualcomm)
- 11-18-0040, "LB230 MAC CR 10.22.2.6-9," Alfred Asterjadhi (Qualcomm)
- 11-18-0041, "LB230 MAC CR 11.24," Alfred Asterjadhi (Qualcomm)
- 11-18-0044, "LB230 MAC CR 27.7 and 27.7.1," Alfred Asterjadhi (Qualcomm) - not on the server
- 11-18-0055, "CR CID 14324," Zhou Lan (Broadcom Ltd.)
- 11-18-0066, "Resolution for CIDs in 9.4.2.245," Abhishek Patil (Qualcomm)
- 11-18-0068, "Resolution for CID 11374," Abhishek Patil (Qualcomm)
- 11-18-0074, "11ax D2.0 Comment Resolution 27.5.3.2.4 10.22.2.7, " Liwen Chu (Marvell)
- 11-18-0075, "11ax D2.0 comment resolution 27.5.3.2.2," Liwen Chu (Marvell)
- 11-18-0076, "11ax D2.0 comment resolution 27.5.3.2.3," Liwen Chu (Marvell)
- 11-18-0077, "11ax D2.0 comment resolution 27.4.2," Liwen Chu (Marvell) - not on the server
- 11-18-0078, "11ax D2.0 comment resolution 27.6.4," Liwen Chu (Marvell)
- 11-18-0081, "11ax D2.0 MAC Comment Resolution for HE link adaptation," Frank Hsu (MediaTek)
- 11-18-0082, "LB230 CR for BSS Load Slides," Frank Hsu (MediaTek) - not on the server
- 11-18-0083, "LB230 CR for BSS Load Text," Frank Hsu (MediaTek) - not on the server
- 11-18-0088, "CR CID 14349," Zhou Lan (Broadcom Ltd.) - not on the server
- 11-18-0090, "CR for Opportunistic power save," Laurent Carious (Intel)
- 11-18-0098, "LB230 CR on CIDs 12757, 11149 and 13675," Ming Gan (Huawei Technologies)
- 11-18-0099, "LB230 CR on Fragmentation - Part 1," Ming Gan (Huawei Technologies)
- 11-18-0105, "LB230 CR Multi-TID Capability Indication," Yongho Seok (MediaTek)
- 11-18-0107, "LB230 CR 20MHz only STA on Secondary Channel," Yongho Seok (MediaTek) - not on the server
- 11-18-0149, "CR for 27.5.6," Laurent Cariou (Intel) - not on the server
- 11-18-0153, "Resolution for CID 11742," Po-Kai Huang (Intel)
- 11-18-0155, "Resolutions for CIDs related to GCR," Yusuke Tanaka (Sony)
- 11-18-0161, "CR of CID 13754," Zhou Lan (Broadcom Ltd.)
- 11-18-0182, "11ax D2.0 MAC Comment Resolution for CID 18555," Guoqing Li (Apple)
- 11-18-0200, "Decouple Channel Width Capabilities between VHT and HE PHY Mode," Huizhao Wang (Quantenna Communications)

◦ Multi-User (MU) - 19 submissions

- 11-17-1828, "CR for MU EDCA parameters," Laurent Cariou (Intel)
- 11-17-1849, "CIDs related to Random Access - Part 1," Abhishek Patil (Qualcomm)
- 11-17-1860, "Resolution for CID 11002," Abhishek Patil (Qualcomm)
- 11-17-1878, "11ax D2.0 MAC Comment Resolution for NAV Part II," Po-Kai Huang (Intel)
- 11-18-0008, "LB230-MAC-CR-9.3.1.20," Alfred Asterjadhi (Qualcomm)
- 11-18-0011, "Comment resolutions for 27.5.3.4," Alfred Asterjadhi (Qualcomm)
- 11-18-0029, "Default UORA Parameters," Matthew Fischer (Broadcom Ltd.)
- 11-18-0030, "ER DL Protection Sequence," Matthew Fischer (Broadcom Ltd.) - not on the server
- 11-18-0031, "BQRP BQR LCTS DL MU," Matthew Fischer (Broadcom Ltd.)
- 11-18-0042, "Comment resolutions for 27.6.2," Alfred Asterjadhi (Qualcomm)
- 11-18-0043, "Comment resolutions for 27.6 and 27.6.1," Alfred Asterjadhi (Qualcomm)
- 11-18-0053, "CR of BQR (on D2.0)," Zhou Lan (Broadcom Ltd.)
- 11-18-0054, "CR of DL MU procedure (D2.0)," Zhou Lan (Broadcom Ltd.)
- 11-18-0056, "CR of CID 14328," Zhou Lan (Broadcom Ltd.)
- 11-18-0063, "CR on UORA Power Saving," Jeongki Kim (LG Electronics)
- 11-18-0065, "Resolution for CIDs in 9.3.1.23," Abhishek Patil (Qualcomm)
- 11-18-0079, "Comment Resolutions on Clause 28.3.15 (SU-MIMO and DL MU-MIMO beamforming)," Kome Oteri (InterDigital)
- 11-18-0080, "Comment Resolutions on Clause 9.4.1.63 D2.0 (HE Compressed Beamforming Report field)," Kome Oteri (InterDigital)

- 11-18-0108, "CIDs for: Section 27.5.3.6 HE buffer status feedback operation for UL MU," Kiseon Ryu (LG Electronics)
- 11-18-0185, "CR of CID 11001," Zhou Lan (Broadcom)

◦ Spatial Reuse (SR) - 3 submissions

- 11-17-1852, "CR for 27.9," Laurent Cariou (Intel)
- 11-18-0026, "CR SRG and SRP," Matthew Fischer (Broadcon Ltd.)
- 11-18-0105, "LB230 CR Spatial Reuse," Yongho Seok (MediaTek)

3. **Timeline update**
   TG reviewed the timeline - No change.

Current Timeline	
May 2014	**Start of TG**
November 2014	**First draft of the TG SFD approved**
January 2016	**Proposed TG draft**
March 2016	**Draft 0.1 was approved and Comment Collection started**
November 2016	**Issue Draft 1.0 and start WG Letter Ballot — Failed (57.77%)** LB 225: opened Dec. 1st, 2016 and closed Jan. 8th, 2017
September 2017	**Draft 2.0 and WG Letter Ballot — Failed (62.84%)** LB 230: opened Oct. 5th, 2017 and closed Nov. 4th, 2017
May 2018	**Draft 3.0 and WG Letter Ballot**
July 2018	**Mandatory Draft Review**
February 2019	**Formation of Sponsor Ballot pool**
May 2019	**Initial Sponsor Ballot**
December 2019	**RevCom submittal**

Goals for the March 2018 session

- Continue with comment resolution on draft D2.0.

Teleconferences

TGax teleconferences are scheduled after the January 2018 session as follows:

Thursday	January 25th, 2018	20:00 - 22:00 (ET)
Thursday	February 1st, 2018	10:00 - 12:00 (ET)
Thursday	February 8th, 2018	20:00 - 22:00 (ET)
Thursday	February 22nd, 2018	20:00 - 22:00 (ET)

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November 2017 — Orlando, FL

TGax had four sessions during the week.

	Monday	Tuesday	Wednesday	Thursday
AM1			**TGax (full)**	
AM2		**TGax (full)**		**TGax (full)**
PM1	**TGax (full)**			
PM2		**TGax (cancelled)**	**TGax (cancelled)**	**TGax (cancelled)**
PM3				

Main documents

The meeting agenda and minutes of the TGax and its subgroups, and the TGax closing report can be found here.

- TGax
  - 11-17-1546-04, TGax November 2017 Meeting Agenda
  - 11-17-1727-00, TGax November 2017 Orlando Meeting Minutes
  - 11-17-1789-00, TGax November 2017 Closing Report

WG Letter Ballot #230 on IEEE 802.11ax draft 2.0

- Ballot opened on Oct. 5th, 2017 and closed on Nov. 4th, 2017 (30 days).
- Failed with 62.84% approval.
- 3374 comments are collected.

Achievements

1. **Work Completed**
   - The TG almost completed the assignment of comments received on draft D2.0.
     - A lead is identified for various clauses of the draft. The lead is responsible for coordinating resolutions of relevant CIDs.
   - The TG approved resolutions to 36 CIDs.
   - The TG updated its timeline to reflect the outcome of WG LB #230
   - The TG passed a motion to hold an ad hoc meeting in San Diego during the period of January 10 - 12, 2018.
2. **Technical Presentations**
   TGax received 12 submissions. All of the submissions are presented during the week.
   - 11-17-1682, "Comments on TGax D2.0," Robert Stacy (Intel)
   - 11-17-1687, "TGax Editor[illegible]fs Report," Robert Stacy (Intel)
   - 11-17-1717, "Associated Congestion Avoidance Method Based on Dynamic Adjustment of Beacon Interval," Hongyan Li (Xidian Univ.)
   - 11-17-1719, "Contention Based UL-OFDMA Random Access without back-off," Hongyan Li (Xidian Univ.)
   - 11-17-1723, "TPC combined with channel allocation method for OBSS environment," Hongyan Li (Xidian Univ.)
   - 11-17-1730, "PHY CID 17890 Resolution," Hongyuan Zhang (Marvell)
   - 11-17-1731, "PHY CID 17895 Resolution," Hongyuan Zhang (Marvell)
   - 11-17-1763, "CRs for 20 MHz-only STA - RU Restriction," Sungeun Lee (Cypress)
   - 11-17-1764, "CRs for 28.4.2 and 28.4.4," Sungeun Lee (Cypress)
   - 11-17-1766, "D2.0 Comment Resolution for CIDs on MLME SAP (Clause 6)," Jae Seung Lee (ETRI)
   - 11-17-1769, "Discussion on Dynamic Fragmentation Level 3," Huizhao Wang (Quantenna Communications)
   - 11-17-1774, "Resolution for the TBD in Annex C.3," Edward Au (Huawei Technologies)
   - 11-17-1775, "CR for PICS comments on D2.0 - Part 1," Edward Au (Huawei Technologies)
3. **Timeline update**
   TG reviewed the timeline. No change was made.

Previous Timeline	Modified (new) Timeline

May 2014	Start of TG	May 2014	Start of TG
November 2014	First draft of the TG SFD approved	November 2014	First draft of the TG SFD approved
January 2016	Proposed TG draft	January 2016	Proposed TG draft
March 2016	Draft 0.1 was approved and Comment Collection started	March 2016	Draft 0.1 was approved and Comment Collection started
November 2016	Issue Draft 1.0 and start WG Letter Ballot LB 225: opened Dec. 1st, 2016 and closed Jan. 8th, 2017	November 2016	Issue Draft 1.0 and start WG Letter Ballot — Failed (57.77%) LB 225: opened Dec. 1st, 2016 and closed Jan. 8th, 2017
September 2017	Draft 2.0 and WG Letter Ballot LB 230: opened Oct. 5th, 2017 and closed Nov. 4th, 2017	September 2017	Draft 2.0 and WG Letter Ballot — Failed (62.84%) LB 230: opened Oct. 5th, 2017 and closed Nov. 4th, 2017
May 2018	Mandatory Draft Review	May 2018	Draft 3.0 and WG Letter Ballot
May 2018	Formation of Sponsor Ballot pool	July 2018	Mandatory Draft Review
November 2018	Initial Sponsor Ballot	February 2019	Formation of Sponsor Ballot pool
July 2019	RevCom submittal	May 2019	Initial Sponsor Ballot
		December 2019	RevCom submittal

Goals for the January 2018 session

- Continue with comment resolution on draft D2.0.

Teleconferences

TGax teleconferences are scheduled after the November 2017 session as follows:

Thursday	November 30th, 2017	10:00 - 12:00 (ET)
Thursday	December 7th, 2017	20:00 - 22:00 (ET)
Thursday	December 14th, 2017	10:00 - 12:00 (ET)
Thursday	December 21st, 2017	20:00 - 22:00 (ET)
Thursday	January 4th, 2018	10:00 - 12:00 (ET)
Thursday	January 25th, 2018	20:00 - 22:00 (ET)

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September 2017 — Waikoloa, Big Island, HI

TGax had 11 sessions during the week.
Seven out of eleven sessions were assigned to the ad hoc groups.

	Monday	Tuesday	Wednesday	Thursday
AM1			**TGax (full)**	
AM2	**TGax (full)**	**TGax** (PHY ad hoc) **TGax** (MAC ad hoc)		
PM1			**TGax** (PHY ad hoc) **TGax** (MAC ad hoc)	**TGax (full)**

	Monday		Tuesday		Wednesday		Thursday
PM2	**TGax** (PHY ad hoc)	**TGax** (MAC ad hoc)	**TGax** (PHY ad hoc)	**TGax** (MAC ad hoc)	**TGax** (PHY ad hocs)	**TGax** (MAC ad hoc)	**TGax (full)**
PM3	**TGax** (PHY ad hocs)	**TGax** (MAC ad hoc)	**TGax** (MU ad hocs)	**TGax** (MAC ad hoc)			

Main documents

The meeting agenda and minutes of the TGax and its subgroups, and the TGax closing report can be found here.

- TGax
  - 11-17-1219-06, TGax September 2017 Meeting Agenda
  - 11-17-1465-00, TGax September 2017 Waikoloa Meeting Minutes
  - 11-17-1515-00, TGax September 2017 Closing Report

  - TGax PHY ad hoc group
    - 11-17-1434-03, TGax Sep 2017 Meeting PHY Ad Hoc Agenda
    - 11-17-1531-00, IEEE 802.11 TGax September 2017 Hawaii PHY Ad Hoc Meeting Minutes
  - TGax MAC ad hoc group
    - 11-17-1453-04, TGax MAC Ad-hoc September 2017 Meeting Agenda
    - 11-17-1543-00, IEEE 802.11 TGax, MAC Ad hoc, September 2017 TGax Meeting Minutes
  - TGax MU ad hoc group
    - 11-17-1487-01, TGax September 2017 Meeting MU ad-hoc Agenda
    - 11-17-1491-02, IEEE 802.11 TGax, MU ad hoc, September 2017 TGax Meeting Minutes

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Achievements

1. **Work Completed**
   - The TG completed the comment resolution on comments received during WG LB225 on draft D1.0.
   - The TG approved a motion to prepare draft D2.0 and start a WG LB.
   - Motion passed to affirm the applicability of the IEEE P802.11ax CSD to the modified PAR.
2. **Technical Presentations**

   Following documents are discussed during the TGax teleconferences and the ad hoc meeting after July 2017 session.
   - 11-17-0389, "CIDs-for-27-2-1-part1," Kaiying Lv (ZTE)
   - 11-17-0553, "LB225 11ax D1.0 Comment Resolution 27.10.4 Part 1," Liwen Chu (Marvell)
   - 11-17-0777, "CR TWT IE," Matthew Fischer (Broadcom)
   - 11-17-0811, "Comment Resolution on TIM Broadcast," Jarkko Kneckt (Apple)
   - 11-17-0925, "CR on HE Duration-based RTS," Huizhao Wang (Quantenna)
   - 11-17-1009, "Quiet time period - part 3 (27.26.3.x)," Chao-Chun Wang (MediaTek)
   - 11-17-1010, "Quiet time period - part 4 (9.4.2.223-225)," Chao-Chun Wang (MediaTek)
   - 11-17-1011, "Quiet time period - part 5 (9.6.29.x)," Chao-Chun Wang (MediaTek)
   - 11-17-1034, "Quiet time period - part 6," Chao-Chun Wang (MediaTek)
   - 11-17-1067, "LB225 11ax D1.0 Comment Resolution OMI and Operation Mode," Liwen Chu (Marvell)
   - 11-17-1068, "LB225 11ax D1.0 Comment Resolution 10.7," Liwen Chu (Marvell)
   - 11-17-1072, "Remaining OMI comment resolutions," Jarkko Kneckt (Apple)
   - 11-17-1082, "Comment resolutions for BRP and BSRP trigger frames," Menzo Wentink (Qualcomm)
   - 11-17-1135, "CR QOS SF," Matthew Fischer (Broadcom)
   - 11-17-1173, "Proposed Resolutions to CID 5011, 6900, 6998, and 9056," Osama Aboul-Magd (Huawei Technologies)
   - 11-17-1174, "Clauses 3.2, 3.3, and 3.4 Comment Resolutions," Osama Aboul-Magd (Huawei Technologies)
   - 11-17-1183, "CR for CID 5772, 9476, 9480," Po-Kai Huang (Intel)
   - 11-17-1220, "Clause 10.2 Comment Resolution," Osama Aboul-Magd (Huawei Technologies)
   - 11-17-1248, "Clause 27.1 Comment Resolution," Osama Aboul-Magd (Huawei Technologies)
   - 11-17-1263, "Misc for HE Ops IE," Alfred Asterjadhi (Qualcomm)
   - 11-17-1267, "LB225 11ax D1.0 Comment Resolution 27.10.2, 27.10.3," Liwen Chu (Marvell)

- 11-17-1268, "Clause 4.3.14a Comment Resolution," Osama Aboul-Magd (Huawei Technologies)
- 11-17-1270, "LB225 CR 10.22.2.11 CID 5374," Yongho Seok (MediaTek) Need more discussion
- 11-17-1271, "LB225 CR 9.7.3 CID 9389," Yongho Seok (MediaTek)
- 11-17-1272, "LB225 CR 10.3.2.10.3 CID 9429," Yongho Seok (MediaTek)
- 11-17-1275, "CIDs related to TF," Abhishek Patil (Qualcomm)
- 11-17-1276, "CIDs related to Random Access," Abhishek Patil (Qualcomm)
- 11-17-1277, "Pending CIDs in 27.16," Abhishek Patil (Qualcomm)
- 11-17-1278, "Proposed Resolution for CID 9846," Abhishek Patil (Qualcomm)
- 11-17-1279, "Various CIDs in Clause 9," Abhishek Patil (Qualcomm)
- 11-17-1283, "CR for 10.5 MPDU Fragmentation," Woojin Ahn (WILUS)
- 11-17-1313, "LB225 CR CID 8538 9377," Yongho Seok (MediaTek)
- 11-17-1317, "CR for 10.3.2.10," Kiseon Ryu (LG Electronics)
- 11-17-1335, "CR for 27.3.1," Laurent Cariou (Intel)
- 11-17-1336, "CR for 9.4.2.240," Laurent Cariou (Intel)
- 11-17-1342, "PHY CR 8348 6433," Alfred Asterjadhi (Qualcomm)
- 11-17-1351, "CR on 27.14.2," Jeongki Kim (LG Electronics)
- 11-17-1362, "CIDs on Subclause 27.3.3 Part 2," Ming Gan (Huawei Technologies)
- 11-17-1363, "CIDs on Subclause 27.3.3 Part 3," Ming Gan (Huawei Technologies)

TGax received 62 submissions. All of the submissions are presented during the week.

- **PHY** — 21 submissions
  - 11-17-0995, "Doppler Comment Resolution," Hongyuan Zhang (Marvell)
  - 11-17-1001, "Comment Resolutions on Clause 28.2.2 (TXVECTOR and RXVECTOR parameters) Part 1," Bo Sun (ZTE)
  - 11-17-1296, "Comment Resolutions on Miscellaneous Comments," Lochan Verma (Qualcomm)
  - 11-17-1306, "CRs on Clause 28.3.3.2," Xiaogang Chen (Intel)
  - 11-17-1307, "Changes for the Tx/Rx Vectors related to HE TB NDP feedback," Xiaogang Chen (Intel)
  - 11-17-1315, "Comment Resolution to CID8576," Yujin Noh (Newracom)
  - 11-17-1320, "N_{SYM} and T_{PE} at RX side for Midamble design - Follow up," Yujin Noh (Newracom)
  - 11-17-1324, "Usage of Doppler bit in A-Control subfield," Yujin Noh (Newracom)
  - 11-17-1325, "Text Proposal on Usage of Doppler bit in A-Control subfield," Yujin Noh (Newracom)
  - 11-17-1327, "Interleaver for HE-SIGA and HE-SIGB," Dongguk Lim (LG Electronics)
  - 11-17-1332, "Comment Resolutions on Clause 28.3.3.4 (Pilot subcarriers)," Junghoon Suh (Huawei Technologies)
  - 11-17-1350, "On TX EVM," Ron Porat (Broadcom)
  - 11-17-1357, "Capability on Doppler Mode," Ross jian Yu (Huawei Technologies)
  - 11-17-1361, "CRs for 20 MHz-only STA - Part 4," Sungeun Lee (Cypress)
  - 11-17-1366, "Midamble Design Continued," Yang Zhang (Marvell)
  - 11-17-1374, "On Amplitude Drift Compensation," Jianhan Liu (MediaTek)
  - 11-17-1375, "Text Changes on Transmitter modulation accuracy (EVM) test," Jianhan Liu (MediaTek)
  - 11-17-1376, "Usage of Doppler Bit in 11ax," Jianhan Liu (MediaTek)
  - 11-17-1380, "HE SIG-B Spatial Configuration Field Fixing," Hongyuan Zhang (Marvell)
  - 11-17-1381, "DCM in HE TB PPDU," Yan Zhang (Marvell)
  - 11-17-1383, "Proposed Change to the Resolution to CID 9551," Yasuhiko Inoue (NTT)
- **MAC** — 37 submissions
  - 11-17-0307, "HE BSS Load Information Element," Frank Hsu (MediaTek)
  - 11-17-0308, "HE BSS Load Information Element for 11ax," Frank Hsu (MediaTek)
  - 11-17-0619, "Proposed Text Changes for Client Management," Eldad Perahia (HPE-Aruba)
  - 11-17-0719, "Unifying QoS Control and BSR A-Control for Buffer Status Report," Zhou Lan (Broadcom)
  - 11-17-0765, "Follow UP of Unifying Queue Size Report," Zhou Lan (Broadcom)
  - 11-17-1054, "LB225 CR 27.13 (Link Adaptation," Frank Hsu (MediaTek)
  - 11-17-1069, "LB225 11ax D1.0 Comment Resolution 9.7.3," Liwen Chu (Marvell)
  - 11-17-1081, "Comment Resolutions for HE NDP Announcement frame," Menzo Wentink (Qualcomm)
  - 11-17-1087, "MAC CR CIDs 4813-4814," Alfred Asterjadhi (Qualcomm)
  - 11-17-1138, "CR TWT Operation," Matthew Fischer (Broadcom)
  - 11-17-1244, "BSS Basic HE-MCS per Bandwidth," Matthew Fischer (Broadcom)
  - 11-17-1258, "Resolution to CID9863," Yujin Noh (Newracom)

- 11-17-1262, "Miscellaneous for HE sounding," Alfred Asterjadhi (Qualcomm)
- 11-17-1264, "Misc for Trigger frame format," Alfred Asterjadhi (Qualcomm)
- 11-17-1280, "visio file for figure 27.12," Abhishek Patil (Qualcomm)
- 11-17-1282, "LB225 11ax D1.0 Comment Resolution 27.11.1, 27.11.2," Liwen Chu (Marvell)
- 11-17-1285, "LB225 11ax D1.0 Comment Resolution HE MAC Capabilities," Liwen Chu (Marvell)
- 11-17-1290, "LB225 11ax D1.0 Comment Resolution HE PHY Capabilities, PPE," Liwen Chu (Marvell)
- 11-17-1294, "LB225 11ax D1.0 Comment Resolution 10.7 Remaining CIDs," Liwen Chu (Marvell)
- 11-17-1295, "Proposed Resolution for CID 9501," Guoqing Li (Apple)
- 11-17-1299, "CID 10276 related to 27.5.5," Laurent Cariou (Intel)
- 11-17-1301, "11ax D1.4 MAC Comment Resolution for CID 9636, 9699," Po-Kai Huang (Intel)
- 11-17-1304, "LB225 11ax D1.0 Comment Resolution on Clause 10.9 HT Control Field," James Yee (MesiaTek)
- 11-17-1330, "CIDs: Acknowledgment related comments," George Cherian (Qualcomm)
- 11-17-1337, "CR for CID5859 and CID 5971," Jarkko Kneckt (Apple)
- 11-17-1338, "TWT SP initiation and termination and legacy PS," Jarkko Kneckt (Apple)
- 11-17-1339, "Improvement to TWT Parameter set," Jarkko Kneckt (Apple)
- 11-17-1341, "PHY CR 8348 6433," Alfred Asterjadhi (Qualcomm) -- not available
- 11-17-1346, "Individual constrained TWT agreements," jarkkoKneckt (Apple)
- 11-17-1364, "CIDs on Subclause 27.3.3 Part 3," Ming Gan (Huawei Technologies) -- not available
- 11-17-1365, "CIDs on Subclause 27.3.3 Part 3," Ming Gan (Huawei Technologies) -- not available
- 11-17-1377, "11ax D1.0 MAC Comment Resolution for 27.13 and 9.4.2.218.2," Frank Hsu (MediaTek)
- 11-17-1399, "Resolution for CID 3099," Edward Au (Huawei Technologies)
- 11-17-1401, "Resolution for CIDs 5285, 6198, 7603," Edward Au (Huawei Technologies)
- 11-17-1402, "Resolution for PICS," Edward Au (Huawei Technologies)
- 11-17-1429, "Annex G Comment Resolution," Osama Aboul-Magd (Huawei Technologies)
- 11-17-1456, "Resolution for CID 8555," Abhishek Patil (Qualcomm)

- **MU** — 4 submissions
  - 11-17-1060, "CR on CID 6053," Jeongki Kim (LG Electronics)
  - 11-17-1091, "Proposed resolution for comments related to CIDs in 27.5.2," Jing Ma
  - 11-17-1139, "Comment Resolution on retransmission of OFDMA random access," Jing Ma (NICT)
  - 11-17-1286, "CR DL MU procedure," Zhou Lan (Broadcom)

3. **Timeline discussion**
   TG reviewed the timeline. No change was made.

Current Timeline	
May 2014	**Start of TG**
November 2014	**First draft of the TG SFD approved**
January 2016	**Proposed TG draft**
March 2016	**Draft 0.1 was approved and Comment Collection started**
November 2016	**Issue Draft 1.0 and start WG Letter Ballot**
September 2017	**Draft 2.0 and WG Letter Ballot**
May 2018	**Mandatory Draft Review**
May 2018	**Formation of Sponsor Ballot pool**
November 2018	**Initial Sponsor Ballot**
July 2019	**RevCom submittal**

Goals for the November 2017 session

- Start and complete comment assignment.
- Start comment resolution on draft D2.0.

Teleconferences

TGax teleconferences are scheduled after the September 2017 session as follows:

Approved in July	Thursday	September 28th, 2017	10:00 - 12:00 (ET)
	Thursday	September 21st, 2017	20:00 - 22:00 (ET)
New!	Thursday	November 2nd, 2017	10:00 - 12:00 (ET)

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July 2017 — Berlin, Germany

TGax originally planned 10 sessions during the week.
One ad hoc session was added during the WG mid-week plenary.
Seven out of eleven sessions were assigned to the ad hoc groups.

	Monday	Tuesday	Wednesday	Thursday
AM1			**TGax (full)**	**TGax** (MAC ad hoc)
AM2		**TGax** (PHY ad hoc) **TGax** (MAC ad hoc)		
PM1	**TGax (full)**		**TGax** (PHY ad hoc) **TGax** (MAC ad hoc)	**TGax (full)**
PM2	**TGax** (PHY ad hoc) **TGax** (MAC ad hoc)	**TGax** (MU/SR ad hoc) **TGax** (MAC ad hoc)	**TGax** (PHY ad hocs) **TGax** (MAC ad hoc)	**TGax (full)**
PM3		**TGax** (PHY ad hocs) **TGax** (MAC ad hoc)		

Main documents

The meeting agenda and minutes of the TGax and its subgroups, and the TGax closing report can be found here.

- TGax
  - 11-17-0887-06, TGax July 2017 Meeting Agenda
  - 11-17-1105-00, TGax July 2017 Berlin Meeting Minutes
  - 11-17-1158-00, TGax July 2017 Closing Report
  - TGax PHY ad hoc group
    - 11-17-1099-04, TGax Jul 2017 Meeting PHY Ad Hoc Agenda
    - 11-17-1094-00, TGax July 2017 Berlin PHY Ad Hoc Meeting Minutes
  - TGax MAC ad hoc group
    - 11-17-1098-03, TGax MAC Ad-hoc July 2017 Meeting Agenda
    - 11-17-1154-00, July 2017 TGax MAC Ad hoc Meeting Minutes
  - TGax MU & SR ad hoc group
    - 11-17-1116-01, TGax July 2017 Meeting MU & SR ad-hoc Agenda
    - 11-17-1148-00, TGax MU and SR ad hoc group meeting minutes — Berlin, July 2017

Achievements

1. **Work Completed**
   - Continued with the comment resolution on draft D1.0.

        - Resolutions of about 480 comments were approved.
        - The TG Editor is planning to produce draft D1.4 based on the resolved comments.
    - Discussed options and need for volunmrees for the .
    - Motin passswd to extend 802.11ax scope to include frequency bands up to 7.125 GHz
    - Ad hoc meeting is planned for September in the Bay area.

2. **Technical Presentations**

    TGax received 48 submissions. All of the submissions are presented during the week.

    - **PHY** — 21 submissions
        - 11-17-0650, "LB 225 — Clause 18.2 Comment Resolution," Osama Aboul-Magd (Huawei Technologies)
        - 11-17-0902, "Comment Resolutions on Clause 28 (HE PHY) Part 1," Lochan Verma (Qualcomm)
        - 11-17-0945, "CRs on 28.3.3.8," Yujin Noh (Newracom)
        - 11-17-0946, "Text modification on HE-SIG-B," Yujin Noh (Newracom)
        - 11-17-0960, "Follow-up on Doppler Design in 802.11ax," Lochan Verma (Qualcomm)
        - 11-17-0961, "Miscellaneous clarifications On HE PHY Part 1," Lochan Verma (Qualcomm)
        - 11-17-0973, "TGax D1.0 Comment Resolutions on 28.3.3.10 and 28.3.3.2," Jinsoo Choi (LG Electronics)
        - 11-17-0985, "CRs for the HE TB NDP feedback," Xiaogang Chen (Intel)
        - 11-17-0986, "CRs for the HE Trigger-based NDP feedback," Xiaogang Chen (Intel)
        - 11-17-0993, "11ax Comment Resolutions on Data Field," Yang Zhang (Marvell)
        - 11-17-0994, "Midamble Design," Hongyuan Zhang (Marvell)
        - 11-17-0995, "Doppler Comment Resolution," Hongyuan Zhang (Marvell)
        - 11-17-0996, "Update on Timing Related Constants and Some Equations," Bin Tian (Qualcomm)
        - 11-17-0998, "N_{SYM} and T_{PE} at RX side for Midamble design," Yujin Noh (Newracom)
        - 11-17-1001, "Comment Resolutions on Clause 28.2.2 (TXVECTOR and RXVECTOR parameters) Part 1," Bo Sun (ZTE)
        - 11-17-1006, "Miscellaneous HE-SIG-B related CIDs," Sigurd Schelstraete (Quantenna)
        - 11-17-1007, "Proposed resolution for CID 9021," Sigurd Schelstraete (Quantenna)
        - 11-17-1016, "Improvement Comment on Clause 28.3.3.4 (Pilot subcarriers)," Jung Hoon Suh (Huawei Technologies)
        - 11-17-1021, "Usage of Doppler Bit in 11ax," Jianhan Liu (MediaTek)
        - 11-17-1050, "Additional Editorial Update Related to CID 9769," Youhan Kim (Qualcomm)
        - 11-17-1063, "DCM Text Correction," Tianyu Wu (MediaTek)
    - **MAC** — 28 submissions
        - 11-17-0389, "Proposed resolution for CIDs for 27-2-1," Kaiying Lv (ZTE)
        - 11-17-0533, "LB225 CR Sub-clause 27.16.1," Yongho Seok (Newracom)
        - 11-17-0553, "LB225 11ax D1.0 Comment Resolution 27.10.4 Part 1," Liwen Chu (Marvell)
        - 11-17-0693, "11ax D1.0 MAC Comment Resolution for Quiet Time Period Part 1," Chao-Chun Wang (MediaTek)
        - 11-17-0759, "Comment Resolution on trigger frame for random access," Jason Yuchen Guo (Huawei Technologies)
        - 11-17-0812, "Trigger Frame for Random Access," Jason Yuchen Guo (Huawei Technologies)
        - 11-17-0925, "LB225 11ax D1.0 Comment Resolution 10.3.x," Huizhao Wang (Quantenna)
        - 11-17-0926, "CR HE MCS NSS Not Supported," Matthew Fischer (Broadcom Limited)
        - 11-17-0957, "Comment resolution for Fragmentation," Suhwook Kim (LG Electronics)
        - 11-17-1002, "Comment resolution for HCF," Suhwook Kim (LG Electronics)
        - 11-17-1009, "11ax D1.0 MAC Comment Resolution for Quiet Time Period Part 3," Chao-Chun Wang (MediaTek)
        - 11-17-1010, "11ax D1.0 MAC Comment Resolution for Quiet Time Period Part 4," Chao-Chun Wang (MediaTek)
        - 11-17-1011, "11ax D1.0 MAC Comment Resolution for Quiet Time Period Part 5," Chao-Chun Wang (MediaTek)
        - 11-17-1014, "Resolution for CIDs on Association Exchange with DL MU," Stephane Baron (Canon Research)
        - 11-17-1023, "LB225 CR Sub-clause 27.11.3," Yongho Seok (Newracom)
        - 11-17-1031, "CR for remaining CIDs related to 27.5.5," Laurent Cariou (Intel)
        - 11-17-1032, "Proposed resolution for comments in 27.5.2," Abhishek Patil (Qualcomm)
        - 11-17-1034, "11ax D1.0 MAC Comment Resolution for Quiet Time Period Part 6," Chao-Chun Wang (MediaTek)
        - 11-17-1044, "CIDs: Acknowledgment related comments," George Cherian (Qualcomm)
        - 11-17-1046, "Proposed Resolution to CID 7043," Kaiying Lv (ZTE)
        - 11-17-1049, "Target RSSI field," Laurent Cariou (Intel) — *Not on the server*
        - 11-17-1052, "HE MCS and NSS Comment resolutions," Alfred Asterjadhi (Qualcomm)
        - 11-17-1053, "Comment resolutions for remaining CIDs in OM Control," Alfred Asterjadhi (Qualcomm)
        - 11-17-1054, "LB225 CR 27.13 (Link Adaptation)," Frank Hsu (MediaTek)

- 11-17-1055, "LB225 CR CID 7407,"Yongho Seok (Newracom) — *Not on the server*
- 11-17-1060, "CR on CID 6053," Jeongki Kim (LG Electronics)
- 11-17-1062, "Proposed resolution for CID 9958," Abhishek Patil (Qualcomm)
- 11-17-1067, "LB225 11ax D1.0 Comment Resolution OMI and Operation Mode," Liwen Chu (Marvell)
- 11-17-1068, "LB225 11ax D1.0 Comment Resolution 10.7," Liwen Chu (Marvell)
- 11-17-1069, "LB225 11ax D1.0 Comment Resolution 9.7.3," Liwen Chu (Mervall) —*Not on the server*
- 11-17-1070, "Resolution for CID 5863," Kiseon Ryu (LG Electronics)
- 11-17-1072, "OMI comment resolutions," Jarkko Kneckt (Apple)
- 11-17-1077, "11ax D1.3 MAC Comment Resolution for 10.3.2.4 and 27.2.2 Part III," Po-Kai Huang (Intel)
- 11-17-1081, "11ax D1.0 MAC Comment Resolution for 9.3.1.20," Menzo Wentink (Qualcomm)
- 11-17-1082, "11ax D1.0 MAC Comment Resolution for 9.3.1.23.2/5," Menzo Wentink (Qualcomm)
- 11-17-1087, "MAC-CR-CIDs 4813-4814," Alfred Asterjadhi (Qualcomm)
- 11-17-1088, "Editorial fixes," Alfred Asterjadhi (Qualcomm)
- 11-17-1091, "Proposed resolution for comments related to CIDs in 27.5.2," Jing Ma (NICT) — *Not on the server*

◦ **SR** — 3 submissions
- 11-17-0669, "Proposed resolution for CID 4928," Kaiying Lv (ZTE)
- 11-17-0941, "CR for 27.9 spatial reuse," Laurent Cariou (Intel)
- 11-17-1003, "Text DSC, CCAT and OBSS_PD to Resolve SR Comments," Graham Smith (SRT Wireless)

◦ **MU** — 3 submissions
- 11-17-0935, "Comment resolution for UL OFDMA-based random access (UORA)," Patrice Nezou (Canon Research)
- 11-17-1059, "CR on 27.5.2.6.2 Part 3," Jeongki Kim (LG Electronics)
- 11-17-1071, "Resolution for CID 6106, 9571, 10173," Kiseon Ryu (LG Electronics)

◦ **Others (covered in the TGax full sessions)** — 7 submissions
- 11-17-0308, "BSS Load Information Element for 11ax," Frank Hsu (MediaTek)
- 11-17-0711, "Comment Resolution on PHY-CCA.indication," Rojan Chitrakar (Panasonic)
- 11-17-0913, "P802.11ax PAR Modification to support 6 GHz band," Richard Kennedy (HPE)
- 11-17-0933, "P802.11ax PAR Modification," Richard Kennedy (HPE)
- 11-17-1058, "Proposed resolution for comments related to Section 4.3.14a," Guoqing Li (Apple)
- 11-17-1066, "CR on UL OFDMA in DFS Channels," Youhan Kim (Qualcomm)
- 11-17-1080, "Providing Reference Waveform Generator For 11ax PHY Specification," Fei Tong (Samsung)

3. **Timeline discussion**
   TG discussed the timeline. No change was made.

Current Timeline	
May 2014	**Start of TG**
November 2014	**First draft of the TG SFD approved**
January 2016	**Proposed TG draft**
March 2016	**Draft 0.1 was approved and Comment Collection started**
November 2016	**Issue Draft 1.0 and start WG Letter Ballot**
September 2017	**Draft 2.0 and WG Letter Ballot**
May 2018	**Mandatory Draft Review**
May 2018	**Formation of Sponsor Ballot pool**
November 2018	**Initial Sponsor Ballot**
July 2019	**RevCom submittal**

Goals for the September 2017 session

- Continue with the resolution of comments on draft D1.0.
- Prepare draft D2.0 and plan for WG letter ballot.

Teleconferences

TGax teleconferences are scheduled after the July 2017 session as follows:

Thursday	July 20th, 2017	10:00 - 12:00 (ET)
Thursday	July 27th, 2017	20:00 - 22:00 (ET)
Thursday	August 3rd, 2017 August 17th, 2017 August 31st, 2017	10:00 - 12:00 (ET)
Thursday	August 10th, 2017 August 24th, 2017	10:00 - 12:00 (ET)
Thursday	September 21st, 2017	20:00 - 22:00 (ET)
Thursday	September 28th, 2017	10:00 - 12:00 (ET)

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May 2017 — Daejeon, South Korea

TGax had 11 sessions during the week.
Six out of eleven sessions were assigned to the ad hoc groups.

	Monday	Tuesday	Wednesday	Thursday
AM1			**TGax (full)**	
AM2	**TGax (full)**	**TGax (full)**		
PM1			**TGax** (PHY ad hoc) **TGax** (MAC ad hoc)	**TGax (full)**
PM2	**TGax** (PHY ad hoc) **TGax** (MAC ad hoc)	**TGax** (SR ad hoc) **TGax** (MAC ad hoc)	**TGax** (PHY ad hocs) **TGax** (MAC ad hoc)	**TGax (full)**
PM3	**TGax** (PHY ad hocs) **TGax** (MAC ad hoc)	**TGax** (SR ad hocs) **TGax** (MAC ad hoc)		

Main documents

The meeting agenda and minutes of the TGax and its subgroups, and the TGax closing report can be found here.

- TGax
  - 11-17-0555-05, TGax May 2017 Meeting Agenda
  - 11-17-0749-00, IEEE 802.11 TGax May 2017 Deajeon Meeting Minutes
  - 11-17-0832-00, TGax May 2017 Closing Report
  - TGax PHY ad hoc group
    - 11-17-0783-02, TGax May 2017 Meeting PHY Ad Hoc Agenda
    - 11-17-0850-00, IEEE 802.11 TGax May 2017 PHY Ad Hoc Meeting Minutes
  - TGax MAC ad hoc group
    - 11-17-0786-02, TGax MAC Ad-hoc May 2017 Meeting Agenda
    - 11-17-0829-00, May 2017 TGax MAC Ad hoc Meeting Minutes
  - TGax MU ad hoc group

- Submissions for the MU ad hoc was presented in the MAC ad hoc session.
- TGax SR ad hoc group
  - 11-17-0797-02, TGax Spatial Reuse Ad Hoc Group May 2017 Meeting Agenda
  - 11-17-0817-00, Minutes of the May 2017 meetings of the Spatial Reuse ad hoc group of IEEE Task Group AX (TGax)

Achievements

1. **Work Completed**
   - Continued with the comment resolution on draft D1.0.
     - Good progress during the ad hoc meeting and this meeting.
     - Resolutions of over 900 comments were approved.
     - The TG Editor is planning to produce draft D1.3 based on the resolved comments.
   - Discussed the need to produce a reference waveform generator similar to that for HT and VHT $#151 looking for volunteers.
   - No ad hoc meeting is planned for June/July.
     - Increase the frequency of the teleconferences during the week of June 26.
2. **Technical Presentations**

   TGax received 48 submissions. All of the submissions are presented during the week.
   - **PHY** — 19 submissions
     - 11-17-0044, "NDP Feedback Report Design," Ron Porat (Broadcom Limited)
     - 11-17-0232, "CR_clause 28.3.6," Xiaogang Chen (Intel)
     - 11-17-0233, "CR_4905," Xiaogang Chen (Intel)
     - 11-17-0288, "CRs on HE-SIG-B 28.3.10.8.4-5 part 1," Yujin Noh (Newracom)
     - 11-17-0289, "CRs on HE-SIG-B terminologies on 28.3.10.8.1-3," Yujin Noh (Newracom)
     - 11-17-0290, "CRs on TX specification," Yujin Noh (Newracom)
     - 11-17-0465, "CR on TXTIME and PSDU_LENGTH," Youhan Kim (Qualcomm)
     - 11-17-0648, "CR on HE-SIG-A," Ron Porat (Broadcom Limited)
     - 11-17-0650, "LB 225 - Cluase 18.2 Comment Resolution," Osama Aboul-Magd (Huawei Technologies)
     - 11-17-0678, "Discussion of CID 9021," Sigurd Schelstraete (Quantenna Communications)
     - 11-17-0690, "CRs on 28.3.10.7.3," Yujin Noh (Newracom)
     - 11-17-0694, "CRs for packet extension in 28.3.12," Sungeun Lee (Cypress)
     - 11-17-0698, "CRS on Miscellaneous PHY CIDs," Bin Tian (Qualcomm)
     - 11-17-0714, "CSD update for 28.3.6," Dongguk Lim (LG Electronics)
     - 11-17-0734, "Doppler Discussions," Hongyuan Zhang (Marvell)
     - 11-17-0736, "HE Link Adaptation," Xiaogang Chen (Intel)
     - 11-17-0769, "CRs for 20MHz-only STA - Part 3," Sungeun Lee (Cypress)
     - 11-17-0773, "Thoughts on Doppler Design in 802.11ax," Lochan Verma (Qualcomm)
     - 11-17-0774, "CID 8975 resolution," Hongyuan Zhang (Marvell)
   - **MAC** — 28 submissions
     - 11-17-0073, "CR for 27.5.2.7 NDP feedback report," Laurent Cariou (Intel)
     - 11-17-0088, "Discussion for CR on 10.22.2.8 TXOP limits," Woojin Ahn (Wilus)
     - 11-17-0340, "CR for 11-1-3-10," Yonggang Fang (ZTE)
     - 11-17-0360, "LB225 CR for Subclause 27.3.3-Part 1," Ming Gan (Huawei Technologies)
     - 11-17-0389, "CIDs-for-27-2-1-part1," Kaiying Lv (ZTE)
     - 11-17-0553, "LB225 11ax D1.0 Comment Resolution 27.10.4 Part 1," Liwen Chu (Marvell)
     - 11-17-0576, "Resolutions for Comments related to Extended Range Beacon," Tomoko Adachi (Toshiba)
     - 11-17-0581, "LB225-MAC-CR-Miscellaneous," Alfred Asterjadhi (Qualcomm)
     - 11-17-0586, "lb225-cr-mac_miscellaneous_part2," Yongho Seok (Newracom)
     - 11-17-0602, "Misc 27_12," Alfred Asterjadhi (Qualcomm)
     - 11-17-0603, "Misc 27_15," Alfres Asterjadhi (Qualcomm)
     - 11-17-0604, "Misc RDP Control," Alfred Asterjadhi (Qualcomm)
     - 11-17-0607, "LB225-MAC-CR-Misc BSR Control," Alfred Asterjadhi (Qualcomm)
     - 11-17-0621, "CRs for Section 27.4 - part 2," George Cherian (Qualcomm)
     - 11-17-0677, "CRs for Section 9.3.1.9 block ack - part 2," George Cherian (Qualcomm)
     - 11-17-0688, "LB225 11ax D1.0 Comment Resolution 27.10.4 - Part II," Chittabrata Ghosh (Intel)

        - 11-17-0702, "CR for CID 9574," Kaiying Lv (ZTE)
        - 11-17-0727, "LB225 MAC CR for Clause 10-9," James Yee (MediaTek)
        - 11-17-0729, "CR for CID 7250, 7251 and 7252," Kiseon Ryu (LG Electronics)
        - 11-17-0730, "CR for CID 7255," Kiseon Ryu (LG Electronics)
        - 11-17-0733, "Comment Resolution on TIM broadcast," Jason Yuchen Guo (Huawei Technologies)
        - 11-17-0735, "CR to CID4850 and CID8153 on TWT," Jarkko Kneckt (Apple)
        - 11-17-0744, "CR for 10.3.2.4 and 27.2.2 Part II," Po-Kai Huang (Intel)
        - 11-17-0759, "Comment Resolution on CID 9333 and 9969," Jason Yuchen Guo (Huawei Technologies)
        - 11-17-0765, "Follow up unify queue size report," Zhou Lan (Broadcom Limited)
        - 11-17-0766, "Spec text unify queue size report," Zhou Lan (Broadcom Limited)
        - 11-17-0775, "Non-HT definition," Matthew Fischer (Broadcom Limited)
        - 11-17-0777, "CR TWT IE," Matthew Fischer (Broadcom Limited)
    - **MU** — 1 submissions
        - 11-17-0751, "Comment Resolution on retransmission of OFDMA random access," Yunbo Li (Huawei Technologies)
    - **SR** — 5 submissions
        - 11-17-0633, "CR 27.9 spatial reuse updates," Matthew Fischer (Broadcom Limited)
        - 11-17-0640, "CR 27.2 SRG updates," Matthew Fischer (Broadcom Limited)
        - 11-17-0669, "CR for CID 4928," Kaiying Lv (ZTE)
        - 11-17-0724, "LBS2 various," Matthew Fischer (Broadcom Limited)
        - 11-17-0748, "Supplementary instructions related to OBSS_PD spatial reuse Disallow / Prohibit," Sean Coffey (RealTek)
    - **Others (covered in the TGax full sessions)** — 10 submissions
        - 11-17-0112, "Link Transmit Power," Matthew Fischer (Broadcom Limited)
        - 11-17-0123, "Link Transmit Power text," Matthew Fischer (Broadcom Limited)
        - 11-17-0308, "BSS Load Information Element for 11ax," Frank Hsu (MediaTek)
        - 11-17-0336, "CR for CID 8555 - Virtual CS during UL MU CS," Rojan Chitrakar (Panasonic)
        - 11-17-0337, "Explanation of CR for CID 8555," Rojan Chitrakar (Panasonic)
        - 11-17-0361, "BSS Load Information in 802.11ax," Ming Gan (Huawei Technologies)
        - 11-17-0582, "OBSS_PD/TPC Examined," Graham Smith (SR Technologies)
        - 11-17-0665, "Proposed Resolutions to CID 6901 and 7690," Osama Aboul-Magd (Huawei Technologies)
        - 11-17-0707, "CR for CID 8555," Po-Kai Huang (Intel)
        - 11-17-0711, "CR for PHY-CCA.indication," Rojan Chitrakar (Panasonic)
3. **Timeline discussion**
   TG discussed and updated the timeline.

Current Timeline		Modified Timeline	
May 2014	**Start of TG**	**May 2014**	**Start of TG**
November 2014	**First draft of the TG SFD approved**	**November 2014**	**First draft of the TG SFD approved**
January 2016	**Proposed TG draft**	**January 2016**	**Proposed TG draft**
March 2016	**Draft 0.1 was approved and Comment Collection started**	**March 2016**	**Draft 0.1 was approved and Comment Collection started**
November 2016	**Issue Draft 1.0 and start WG Letter Ballot**	**November 2016**	**Issue Draft 1.0 and start WG Letter Ballot**
September 2017	**Draft 2.0 and WG ~~Recirculation~~ Ballot**	**September 2017**	**Draft 2.0 and WG Letter Ballot**
May 2018	**Mandatory Draft Review**	**May 2018**	**Mandatory Draft Review**
May 2018	**Formation of Sponsor Ballot pool**	**May 2018**	**Formation of Sponsor Ballot pool**
November 2018	**Initial Sponsor Ballot**	**November 2018**	**Initial Sponsor Ballot**
July 2019	**RevCom submittal**	**July 2019**	**RevCom submittal**

Goals for the July 2017 session

- Continue with the resolution of comments on draft D1.0.

Teleconferences

TGax teleconferences are scheduled after the May 2017 session as follows:

Thursday	May 18th, 2017	20:00 - 22:00 (ET)
Thursday	May 25th, 2017	10:00 - 12:00 (ET)
Thursday	June 1st, 2017 June 15th, 2017	20:00 - 22:00 (ET)
Thursday	June 8th, 2017 June 22nd, 2017	10:00 - 12:00 (ET)
Monday Tuesday Wednesday Thursday	June 26th, 2017 June 27th, 2017 June 28th, 2017 June 29th, 2017	20:00 - 22:00 (ET) 10:00 - 12:00 (ET) 20:00 - 22:00 (ET) 10:00 - 12:00 (ET)
Thursday	July 20th, 2017	10:00 - 12:00 (ET)

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March 2017 — Vancouver, BC, Canada

TGax had 10 sessions during the week.
Six out of ten sessions were assigned to the ad hoc groups.

	Monday	Tuesday	Wednesday	Thursday
AM1			**TGax (full)**	
AM2		**TGax** (PHY ad hoc) **TGax** (MAC ad hoc)		
PM1	**TGax (full)**		**TGax** (MAC ad hoc) **TGax** (PHY ad hoc)	**TGax (full)**
PM2	**TGax** (MAC ad hoc) **TGax** (PHY ad hoc)	**TGax** (MAC ad hoc) **TGax** (PHY ad hoc)	**TGax** (MU/PHY ad hocs) **TGax** (MAC ad hoc)	**TGax (full)**
PM3		**TGax** (MAC ad hoc)		

Main documents

The meeting agenda and minutes of the TGax and its subgroups, and the TGax closing report can be found here.

- TGax
  - 11-17-0199-06, TGax March 2017 Meeting Agenda
  - 11-17-0454-00, IEEE 802.11 TGax March 2017 Vancouver Meeting Minutes
  - 11-17-0512-00, TGax March 2017 Closing Report
  - TGax PHY ad hoc group
    - 11-17-0464-02, TGax Ad Hoc PHY Session Mar 2017 Pre-Meeting Agenda
    - 11-17-0494-00, IEEE 802.11 TGax January 2017 Atlanta PHY Ad Hoc Meeting Minutes
  - TGax MAC ad hoc group

- 11-17-0453-05, TGax MAC Ad-hoc March 2017 Meeting Agenda
- 11-17-0155-01, March 2017 TGax MAC Ad hoc Meeting Minutes

- TGax MU ad hoc group
  - 11-17-0485-01, TGax MU Ad Hoc Agenda - March 2017
  - 11-17-0495-00, March 2017 TGax MU Ad hoc Meeting Minutes
- TGax SR ad hoc group
  - 11-17-0482-01, TGax SR Ad-hoc March 2017 Meeting Agenda
  - 11-17-0504-00, Spatial Reuse ad hoc group March 2017 minutes

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Achievements

1. **Work Completed**
   - Continued with the comment resolution on draft D1.0.
     - Very good progress during the ad hoc meeting and this meeting.
     - The TG Editor is planning to generate a new revision of the TG draft (D1.2) and a new revision of the status of the comment resolution.
   - Spatial Reuse issues were discussed at length.
     - Some progress on spatial reuse.
   - Agreed to hold an ad hoc meeting in Seoul, Korea, May 3-5.
     - PHY ad hoc meeting will be only for one day, Friday May 5.
2. **Technical Presentations**

   TGax received 48 submissions. All of the submissions are presented during the week.
   - **PHY** — 11 submissions
     - 11-17-0044, "NDP Feedback Report Design," Ron Porat (Broadcom)
     - 11-17-0078, "RBW of 11ax," Xiaogang Chen (Intel)
     - 11-17-0231, "CR_clause 28.3.5," Xiaogang Chen (Intel)
     - 11-17-0234, "CR_clause 28.3.19_28.3.20," Xiaogang Chen (Intel)
     - 11-17-0247, "CR HE PHY Introduction Part 4," Lochan Verma (Qualcomm)
     - 11-17-0261, "CR HE PHY Transmit Requirements HE_TRIG_PPDU Part 1," Lochan Verma (Qualcomm)
     - 11-17-0290, "CRs on TX specification," Yujin Noh (Newracom)
     - 11-17-0345, "LB225 CR on TXOP_DURATION (28.2.2)," Jeongki Kim (LG Electronics)
     - 11-17-0398, "11ax Comment Resolutions for HE Preamble," Yan Zhang (Marvell)
     - 11-17-0400, "CRs for 20MHz-only STA - Part 1," Sungeun Lee (Cypress)
     - 11-17-0404, "CR on Pre-HE preamble transmission for trigger based PPDU," Ross Jian Yu (Huawei)
     - 11-17-0414, "CR on clause 28-3-11 HE PHY data field," Tianyu Wu (MediaTek)
     - 11-17-0436, "LB225 Comment Resolution of CID 7517," Jianhan Liu (MediaTek)
   - **MAC** — 25 submissions
     - 11-17-0074, "Explanations for CR on 27.5.2.7," Laurent Cariou (Intel)
     - 11-17-0088, "Discussion for CR on 10.22.2.8 TXOP limits," Woojin Ahn (Wilus)
     - 11-17-0239, "LB225-MAC-CR-HT Control subclause 9.2.4.6.X and 10.1 - Block 2," Alfred Asterjadhi (Qualcomm)
     - 11-17-0240, "LB225-MAC-CR-HT Control subclause 9.2.4.6.X and 10.1 - Block 3," Alfred Asterjadhi (Qualcomm)
     - 11-17-0283, "lb225-mac-cr-9-3-1-23," Raja Banerjea (Qualcomm)
     - 11-17-0285 (not available), "LB225-MAC-CR-HE MCS_NSS resolutions," Alfred Asterjadhi (Qualcomm)
     - 11-17-0308, "CR for section 9.4.2 BSS load PPT," Frank Hsu (MediaTek)
     - 11-17-0319, "CR for Section 27.4," George Cherian (Qualcomm)
     - 11-17-0341, "LB225 11ax D1.0 Comment Resolution 10.13," Liwen Chu (Marvell)
     - 11-17-0344, "LB225 CR on EIFS and TXOP_DURATION (10.3.2.3.7 and 27.11.5)," Jeongki Kim (LG Electronics)
     - 11-17-0346, "LB225 CR on TXOP Truncation (10.22.2.9)," Jeongki Kim (LG Electronics)
     - 11-17-0347, "LB225 CR on Intra-PPDU PS (27.14.1)," Jeongki Kim (LG Electronics)
     - 11-17-0353, "LB225-CRs-on-OFDMA-based-random-access-Response," Suhwook Kim (LG Electronics)
     - 11-17-0359, "Comment resolution for CS Required subfield," Raja Banerjea (Qualcomm)
     - 11-17-0360, "LB225 CR for CID5917 and CID8165," Ming Gan (Huawei)
     - 11-17-0361, "BSS Load Information in 802.11ax," Ming Gan (Huawei)
     - 11-17-0362, "LB225 CR for Subclause 9.4.2.218.2," Ming Gan (Huawei)

- 11-17-0384, "LB225, Comment resolution for 10.24.10," Reza Hedayat (Newracom)
- 11-17-0389, "CIDs-for-27-2-1-part1," Kaiying Lv (ZTE)
- 11-17-0395, "LB225-CR-on-Pre-association," Ming Gan (Huawei)
- 11-17-0396, "Association Exchange using Contention based UL OFDMA," Ming Gan (Huawei)
- 11-17-0421, "cr-for-11.49-HE BSS operation," Chao-Chun Wang (MediaTek)
- 11-17-0443, "LB225-CRs-on-OFDMA-based-random-access-Figure," Suhwook Kim (LG Electronics)
- 11-17-0445, "CR on Per-TID All Ack in Multi-STA BlockAck Frame," Geonjung Ko (Wilus)
- 11-17-0448, "Proposed resolution for comments related to CIDs in 27.5.2," Jing Ma (NICT)

- **MU** — 9 submissions
  - 11-17-0271, "CR for 17.2.2.1 and 17.3.9.10," Po-kai Huang (Intel)
  - 11-17-0282, "11-17-xxxx-0x-00ax-lb225-mac-cr-number-of-ss-9-3-1-23," Raja Banerjea (Qualcomm)
  - 11-17-0302, "D1.0 MAC Resolution CR for 27.5.2.4," Po-Kai Huang (Intel)
  - 11-17-0325, "CR for 27.14.3 OPS," Laurent Cariou (Intel)
  - 11-17-0335, "CR for CID 8142 - Random Access acronym," Rojan Chitrakar (Panasonic)
  - 11-17-0338, "CR for 27.5.2.4 - Physical CS CIDs," Rojan Chitrakar (Panasonic)
  - 11-17-0349, "LB225 CR for 25.5.2.4 Setting of CS Required Bit," Kiseon Ryu (LG Electronics)
  - 11-17-0403, "CR-Subclause-27-5-3-MU-Cascading," David Xun Yang (Huawei)
  - 11-17-0442, "LB225, CR CIDs 3215, 3216," Reza Hedayat (Newracom)
- **SR** — 10 submissions
  - 11-16-1063, "Unified SR text DSC, ATPC, inter-BSS," Graham Smith (SR Technologies)
  - 11-16-1476, "CR-for section-25-9-spatial-reuse-operation-for-HE-PPDU," Matthew Fischer (Broadcom)
  - 11-17-0075, "SRP-based SR Summary and Update," Matthew Fischer (Broadcom)
  - 11-17-0163, "DSC as OBSS_PD," Graham Smith (SR Technologies)
  - 11-17-0267, "CR for 25.9.2.2 OBSS_PD Spatial reuse," Laurent Cariou (Intel)
  - 11-17-0383, "Spatial Reuse Group Challenges," Reza Hedayat (Newracom)
  - 11-17-0452, "LB225, CR for CID3222," Reza Hedayat (Newracom)
  - 11-17-0455, "Some clarifications on current SR spec text," Laurent Cariou (Intel)
  - 11-17-0458, "OBSS_PD: Threshold problems," Sean Coffey (RealTek)
  - 11-17-0459 (not available), Kaiying Lv (ZTE)
- **Others (covered in the TGax full sessions)** — 5 submissions
  - 11-17-0112, "Link Transmit Power," Matthew Fischer (Broadcom)
  - 11-17-0328, "Link Adaptation Feedback for Combating Interference," Feng Jiang (InterDigital)
  - 11-17-0334, "Proposed Text for Simulation Scenarios," Frank Hsu (MediaTek)
  - 11-17-0369, "Some CIDs related to 20MHz operation," Guoqing Li (Apple)
  - 11-17-0370, "Some CIDs related to 20MHz operation -- text," Guoqing Li (Apple)

3. **Timeline discussion**

TG discussed and updated the timeline.

Current Timeline		Modified Timeline	
May 2014	**Start of TG**	**May 2014**	**Start of TG**
November 2014	**First draft of the TG SFD approved**	**November 2014**	**First draft of the TG SFD approved**
January 2016	**Proposed TG draft**	**January 2016**	**Proposed TG draft**
March 2016	**Draft 0.1 was approved and Comment Collection started**	**March 2016**	**Draft 0.1 was approved and Comment Collection started**
November 2016	**Issue Draft 1.0 and start WG Letter Ballot**	**November 2016**	**Issue Draft 1.0 and start WG Letter Ballot**
May 2017	**Draft 2.0 and WG recirculation ballot**	**September 2017**	**Draft 2.0 and WG recirculation ballot**
November 2017	**Mandatory Draft Review**	**May 2018**	**Mandatory Draft Review**
January 2018	**Formstion of Sponsor Ballot pool**	**May 2018**	**Formation of Sponsor Ballot pool**
March 2018	**Initial Sponsor Ballot**	**November 2018**	**Initial Sponsor Ballot**
December 2018	**RevCom submittal**	**July 2019**	**RevCom submittal**

Goals for the May 2017 session

- Continue with the resolution of comments on draft D1.0.

Teleconferences

TGax teleconferences are scheduled after the March 2017 session as follows:

Thursday	March 23rd, 2017	20:00 - 22:00 (ET)
Thursday	March 30th, 2017	10:00 - 12:00 (ET)
Thursday	April 6th, 2017	20:00 - 22:00 (ET)
Thursday	April 13th, 2017	10:00 - 12:00 (ET)
Thursday	April 20th, 2017	20:00 - 22:00 (ET)
Thursday	April 27th, 2017	10:00 - 12:00 (ET)
Thursday	May 18th, 2017	20:00 - 22:00 (ET)
Thursday	May 25th, 2017	10:00 - 12:00 (ET)

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January 2017 — Atlanta, GA

TGax had 9 sessions during the week.
Three out of nine sessions were the ad hoc sessions of PHY and MAC ad hocs.

	Monday	Tuesday	Wednesday	Thursday
AM1			**TGax (full)**	
AM2	**TGax (full)**	**TGax (PHY ad hoc)** **TGax (MAC ad hoc)**		
PM1			**TGax (full)**	**TGax (full)**
PM2	**TGax (PHY ad hoc)** **TGax (MAC ad hoc)**	**TGax (PHY ad hoc)** **TGax (MAC ad hoc)**	**TGax (full)**	**TGax (full)**
PM3				

Main documents

The meeting agenda and minutes of the TGax and its subgroups, and the TGax closing report can be found here.

- TGax
  - 11-16-1587-05, TGax January 2017 Meeting Agenda
  - 11-17-0126-00, IEEE 802.11 TGax January 2017 Atlanta Meeting Minutes
  - 11-17-0179-00, TGax January 2017 Closing Report

  - TGax PHY ad hoc group
    - 11-17-0127-03, TGax PHY Ad Hoc Jan 2017 Meeting Agenda
    - IEEE 802.11 TGax January 2017 Atlanta PHY Ad Hoc Meeting Minutes

- TGax MAC ad hoc group
  - 11-17-0128-02, TGax MAC Ad Hoc January 2017 Meeting Agenda
  - 11-17-0155-00, IEEE 802.11 TGax, MAC Ad hoc January 2017 TGax MAC Ad hoc Meeting Minutes

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Achievements

1. **Work Completed**
   - The working group letter ballot #225 on the IEEE 802.11ax draft 1.0 was conducted from December 1st, 2016 to January 8th, 2017.
   - The 802.11ax draft 1.0 did *NOT* meet the requirement of >= 75% approval ratio.
   - Over 7300 comments received.
     - About 4700 out of 7300 comments are technical and general comments.
     - Assignment of comments is completed during the first session of the week.
   - The TG started discussing resolutions of comments submitted on draft D1.0.
     - Approximately 200 comments are resolved.
   - Spatial Reuse issues were discussed at length.
     - Slow progress on SRP-based SR.
   - Proposal to include simplified simulation models in the TG simulation scenarios document was discussed and passed straw poll.
   - Agreed to hold an ad hoc meeting in San Diego, from March 8th to 10th, 2017.
   - Vacant positions of ad hoc co-chairs are filled.

MAC	PHY	Multi-User (MU)	Spatial Reuse (SR)
Eric Wong (Apple)	Bo Sun (ZTE)	Sigurd Schelstraete (Quantenna)	Laurent Cariou (Orange)
Reza Hedayat (Newracom)	Jianhan Liu (MediaTek)	Kiseon Ryu (LG Electronics)	Guido R. Hiertz (Ericsson)
" open " → Chao-Chun Wang (MadiaTek)	Hongyuan Zhang (Marvell)	" open " → David Xun Yang (Huawei)	Jae Seung Lee (ETRI)

2. **Technical Presentations**

   TGax received 48 submissions. All of the submissions are presented during the week.
   - **PHY** — 11 submissions
     - 11-17-0044, "NDP Feedback Report Design," Ron Porat (Broadcom)
     - 11-17-0047, "lb225-cr-28_4_3," Yongho Seok (Newracom)
     - 11-17-0056, "CR HE PHY Capabilities_Part_1," Lochan Verma (Qualcomm)
     - 11-17-0060, "comment resolution for the CCA of preamble puncturing," Yunbo Li (Huawei)
     - 11-17-0072, "CID 6124 Resolution: Remove 2x LTF+08.us GI for UL Transmission," Jianhan Liu (MediaTek)
     - 11-17-0077, "Proposed changes to Draft 1.0," Xiaogang Chen (Intel)
     - 11-17-0078, "RBW of 11ax," Xiaogang Chen (Intel)
     - 11-17-0110, "Discussions on Signaling for UL HE MU PPDU," John Son (Wilus)
     - 11-17-0112, "Link Transmit Power," Mattew Fischer (Broadcom)
     - 11-17-0113, "Steering Vector Sanctity," Matthew Fischer (Broadcom)
     - 11-17-0114, "CID-Trigger frame_Part-1," Lochan Verma (Qualcomm)
   - **MAC** — 14 submissions
     - 11-17-0037, "Comment resolution for clause 10.28," Jarkko Kneckt (Apple)
     - 11-17-0045, "lb225-cr-27_11_4," Yongho Seok (Newracom)
     - 11-17-0046, "lb225-cr-27_6_4," Yongho Seok (Newracom)
     - 11-17-0073, "CR for 27.5.2.7 NDP feedback report," Laurent Cariou (Intel)
     - 11-17-0074, "Explanations for CR on 27.5.2.7," Laurent Cariou (Intel)
     - 11-17-0082, "comment resolution for subclause 11.2.2.8," Kaiying Lv (ZTE)
     - 11-17-0085, "CR for 9.2.5.2 and 9.2.5.7," Po-Kai Huang (Intel)
     - 11-17-0088, "CR on 10.22.2.8 TXOP limits," Woojin Ahn (Wilus)
     - 11-17-0089, "Discussion for CR on 10.22.2.8 TXOP limits," Woojin Ahn (Wilus)
     - 11-17-0104, "Discussion on CR for CID 5066," Dengyu Qiao (Huawei)

- 11-17-0115, "Comment resolution to clause 27.8," Jarkko Kneckt (Apple)
- 11-17-0116, "TWT Schedule Bitmap," Mattew Fischer (Broadcom)
- 11-17-0117, "Broadcast TWT TIM," Mattew Fischer (Broadcom)
- 11-17-0118, "Mandated Response MCS," Mattew Fischer (Broadcom)

◦ **Others (covered in the TGax full sessions)** — 13 submissions
- 11-16-0947, "Proposed text changes for OBSS_PD-based SR parameters," Matthew Fischer (Broadcom)
- 11-16-1063, "Unified SR text DSC, ATPC, inter-BSS," Graham Smith (SR Technologies)
- 11-16-1363, "PAR Verification Through OFDMA," Suhwook Kim (LG Electronics)
- 11-16-1476, "CR-for section-25-9-spatial-reuse-operation-for-HE-PPDU," Matthew Fischer (Broadcom)
- 11-16-1567, "Proposal for DSC, ATPC, Inter-BSS with Responses to Comments," Graham Smith (SR Technologies)
- 11-17-0032, "Proposal on Simulation Scenario Document for 11ax PAR verification," Suhwook Kim (LG Electronics)
- 11-17-0075, "SRP-based SR Summary and Update," James Wang (MediaTek)
- 11-17-0076, "Multiple BSS Simulations for PAR Verification," Frank Hsu (MediaTek)
- 11-17-0081, "consideration of spatial reuse," Kaiying Lv (ZTE)
- 11-17-0090, "11ax PAR Verification using UL MU-MIMO," Narendar Madhavan (Toshiba)
- 11-17-0095, "Proposal on Simulation Scenario Document for 11ax PAR verification(doc)," Suhwook Kim (LG Electronics)
- 11-17-0099, "Additional background for CID 8908," Sigurd Schelstraete (Quantenna)
- 11-17-0102, "LB225 comments on Spatial Reuse," Sean Coffey (RealTek)

Goals for the March 2017 session

- Continue with the resolution of comments on draft D1.0.

Teleconferences

TGax teleconferences are scheduled after the January 2017 session as follows:

Thursday	February 2nd, 2017	10:00 - 12:00 (ET)
Thursday	February 16th, 2017	20:00 - 22:00 (ET)
Thursday	February 23rd, 2017	10:00 - 12:00 (ET)
Thursday	March 2nd, 2017	20:00 - 22:00 (ET)
Thursday	March 23rd, 2017	20:00 - 22:00 (ET)
Thursday	March 30th, 2017	10:00 - 12:00 (ET)
Thursday	April 6th, 2017	20:00 - 22:00 (ET)

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November 2016 — San Antonio, TX

TGax had 12 sessions during the week.
Six out of twelve sessions were the ad hoc sessions.

	Monday	Tuesday	Wednesday	Thursday
AM1	**TGax** (full, ad hoc)		**TGax (full)**	**TGax (full)**

	Monday	Tuesday	Wednesday	Thursday
AM2		**TGax** (PHY ad hoc) **TGax** (MAC ad hoc)		
PM1	**TGax** (full)		**TGax** (PHY ad hoc) **TGax** (MAC ad hoc)	**TGax** (full)
PM2	**TGax** (PHY ad hoc) **TGax** (MAC ad hoc)	**TGax** (MU ad hoc) **TGax** (SR ad hoc)	**TGax** (MU ad hoc) **TGax** (MAC ad hoc)	**TGax** (full)
PM3	**TGax** (MU ad hoc) **TGax** (SR ad hoc)			

Main documents

The meeting agenda and minutes of the TGax and its subgroups, and the TGax closing report can be found here.

- TGax
  - 11-16-1310-05, TGax November 2016 Meeting Agenda
  - 11-16-1466-01, IEEE 802.11 TGax November 2016 San Antonio Meeting Minutes
  - 11-16-1546-00, TGax November 2016 Closing Report

  - TGax PHY ad hoc group
    - 11-16-1475-03, TGax PHY Ad Hoc Nov 2016 Meeting Agenda
    - 11-16-1530-00, November 2016 San Antonio PHY Ad Hoc Meeting Minutes
  - TGax MAC ad hoc group
    - 11-16-1478-02, TGax MAC Ad Hoc November 2016 Meeting Agenda
    - 11-16-1480-01, November 2016 TGax MAC Ad hoc Meeting Minutes
  - TGax Multi-User (MU) ad hoc group
    - 11-16-1487-01, TGax MU Ad-hoc Agenda November 2016
    - 11-16-1520-00, IEEE 802.11 TGax, MU Ad hoc September 2016 TGax Meeting Minutes
  - TGax Spatial Reuse (SR) ad hoc group
    - 11-16-1481-02, 802.11ax Spatial Reuse Ad Hoc Group Agenda
    - 11-16-1569-00, TGax Spatial Reuse ad hoc group meeting minutes - San Antonio, November 2016

Achievements

1. **Work Completed**
   - The TG completed the discussion of all the submissions received.
   - Completed resolution of most of the comments received on draft D0.1.
   - Passed a motion to prepare draft D1.0 and start 30-day WG LB.
2. **Technical Presentations**
   TG received 90 submissions which are classified into PHY, MAC, MU, SR and TG submimssions.
   - **PHY** — 29 submissions
     - 11-16-1295, "CC23 PHY CR Miscellaneous Part-1," Yongho Seok (Newracom)
     - 11-16-1340, "CR HE-PHY Miscellaneous Part-3," Lochan Verma (Qualcomm)
     - 11-16-1341, "CR HE-PHY-Introduction-Part-2," Lochan Verma (Qualcomm)
     - 11-16-1356, "Spec text for HE NDP," Yongho Seok (Newracom)
     - 11-16-1370, "Proposed Spec Text for CCA Section," Laurent Cariou (Intel)
     - 11-16-1371, "CR HE-SIG-B part III," Ross Jian Yu (Huawei)
     - 11-16-1372, "Some proposed changes to D0.5," Ross Jian Yu (Huawei)
     - 11-16-1374, "Resolution on CID495 and Removal of Unnecessary PHY TBDs," Yujin Noh (Newracom)
     - 11-16-1375, "Comment Resolution for CID2867 and Text Change Proposal of 26.3.10.8 HE-SIG-B," Yujin Noh (Newracom)
     - 11-16-1377, "Comment resolution on Clauses 26.3.9 and 26.3.10," Yusuke Asai (NTT)
     - 11-16-1387, "Comment resolution on CID2506 and proposed changes," Jinsoo Chio (LG Electronics)
     - 11-16-1393, "EVM Definition for UL OFDMA," Ron Porat (Broadcom)
     - 11-16-1398, "CR for CID 2077," Sriram Venkateswaran (Broadcom)

- 11-16-1399, "Changes to D0.5," Sriram Venkateswaran (Broadcom)
- 11-16-1402, "11ax Receiver Specification," Bin Tian (Qualcomm)
- 11-16-1406, "Spec Text for 11ax Receiver Requirements," Bin Tian (Qualcomm)
- 11-16-1407, "Changes to D0.5," Xiaogang Chen (Intel)
- 11-16-1408, "PHY CRs 26.3.3,26.3.18,26.3.19," Xiaogang Chen (Intel)
- 11-16-1410, "Clause 26 Fixes," Hongyuan Zhang (Marvell)
- 11-16-1411, "TXTIME and RXTIME Fixes," Hongyuan Zhang (Marvell)
- 11-16-1421, "Smoothness Recommendation for 4x HE-LTF," Feng Jiang (Intel)
- 11-16-1427, "Remove TBDs in PHY Transmit Spec.," Yujin Noh (Newracom)
- 11-16-1434, "Miscellaneous HE PHY corrections," Lochan Verma (Qualcomm)
- 11-16-1437, "Updated Text for DCM," Jianhan Liu (MediaTek)
- 11-16-1438, "0.8us GI with 4x HE LTF," Jianhan Liu (MediaTek)
- 11-16-1439, "Error correction to D0.5_on Beam-change text," Jianhan Liu (MediaTek)
- 11-16-1443, "Spec text: Smoothness Recommendation for HE-LTF," Feng Jiang (Intel)
- 11-16-1448, "Remaining CR on secition-26-2-2 TXRXVECTOR Parameters," Ke Yao (ZTE)
- 11-16-1449, "Proposed Text Changes to TXRXVECTOR in Clause 26.2.2," Ke Yao (ZTE)

◦ **MAC** — 36 submissions
- 11-16-1238, "Setting Quiet time period - text," Chao-Chun Wang (MediaTek)
- 11-16-1352, "CC23 MAC CR Miscellaneous Part-1," Yongho Seok (Newracom)
- 11-16-1354, "CC23 CR Annex C," Yongho Seok (Newracom)
- 11-16-1355, "Spec text for 10.22.2.5 and 3.2," Yongho Seok (Newracom)
- 11-16-1358, "CC0-Remaining CIDs on BA," Alfred Asterjadhi (Qualcomm)
- 11-16-1359, "CC0-Some remaining CIDs related to TWT," Alfred Asterjadhi (Qualcomm)
- 11-16-1360, "CC0-HE variant HT control - Some Remaining CIDs," Alfred Asterjadhi (Qualcomm)
- 11-16-1362, "CC0-Complete RTS Enablement," Alfred Asterjadhi (Qualcomm)
- 11-16-1367, "NDP feedback report," Laurent Cariou (Intel)
- 11-16-1368, "Follow-up on MU EDCA parameters," Laurent Cariou (Intel)
- 11-16-1380, "Proposed text changes for TWT in congested environment," Laurent Cariou (Intel)
- 11-16-1381, "Proposed text changes for fragmentation operation," Laurent Cariou (Intel)
- 11-16-1404, "Early TWT SP Termination in TWT Operation," Jayh hyunhee Park (LG Electronics)
- 11-16-1409, "A-MSDU Fragmentation," Matthew Fischer (Broadcom)
- 11-16-1413, "CID 193 BSS Color Disabled Indication," Abhishek Patil (Qualcomm)
- 11-16-1415, "CID 72 BSS Color change mechanism," Abhishek Patil (Qualcomm)
- 11-16-1416, "CC0-HE BSS operation11-16-xxxx-00-00ax-CC0-HE BSS operation," Alfred Asterjadhi (Qualcomm)
- 11-16-1417, "CC0-HE BSS operation," Alfred Asterjadhi (Qualcomm)
- 11-16-1418, "CC0-HE Multirate Support and 2G4 40MHz HE STA," Alfred Asterjadhi (Qualcomm)
- 11-16-1419, "MCS_NSS_BW_PPDU_Selection_for_11ax," Alfred Asterjadhi (Qualcomm)
- 11-16-1420, "TWT Information frames in 11ax," Alfred Asterjadhi (Qualcomm)
- 11-16-1423, "NAV Update Rule Considering UL MU Operation," Geonjung Ko (WILUS)
- 11-16-1424, "Issue on the CWmax value in MU EDCA," Woojin Ahn (WILUS)
- 11-16-1425, "Clarification on applying MU EDCA parameter set," Woojin Ahn (WILUS)
- 11-16-1431, "IEEE 802.11ax Annex G," Osama Aboul-Magd (Huawei Technologies)
- 11-16-1442, "Spec texts for section 25.4 BA," Jeongki Kim (LG Electronics)
- 11-16-1452, "Multiple BSSID and MU," Liwen Chu (Marvell)
- 11-16-1453, "A-MPDU content," Liwen Chu (Marvell)
- 11-16-1454, "Multiple BSSID and MU Discussion," Liwen Chu (Marvell)
- 11-16-1456, "A-MPDU content discussion," Liwen Chu (Marvell)
- 11-16-1458, "Comment Resolution for Sub-clause 25.13.2," Chittabrata Ghosh (Intel)
- 11-16-1459, "Considerations on Quiet Time Period," Jinsoo Ahn (Yonsei Univ.)
- 11-16-1461, "MU BAR comment resolutions," Reza Hedayat (Newracom)
- 11-16-1464, "RD Protocol," Jarkko Kneckt (Apple)
- 11-16-1468, "A-MPDU Content Capabilities," Raja Banerjea (Qualcomm)
- 11-16-1477, "CC23 Proposed Resolution (Update for) TWT Element," Matthew Fischer (Broadcom)

◦ **Multi-User (MU)** — 12 submissions

        - 11-16-1353, "CC23 MAC CR Miscellaneous Part-2," Yongho Seok (Newracom)
        - 11-16-1357, "CC0 Remaining CIDs on sounding," Alfred Asterjadhi (Qualcomm)
        - 11-16-1361, "CC0- Remaining CIDs on MU Operation," Alfred Asterjadhi (Qualcomm)
        - 11-16-1382, "MAC support of preamble puncture," Zhou Lan (Broadcom)
        - 11-16-1383, "Spec Text: MAC support of preamble puncture," Zhou Lan (Broadcom)
        - 11-16-1389, "Comment Resolution for CID 807," Po-Kai Huang (Intel)
        - 11-16-1390, "Spec Text: Revision for NAV Setting Rule under Immediate Response," Po-Kai Huang (Intel)
        - 11-16-1391, "Comment Resolution Random Access miscellaneous," Young Hoon Kwon (Newracom)
        - 11-16-1392, "Comment Resolution CID 2624 and 2738," Young Hoon Kwon (Newracom)
        - 11-16-1426, "DL/UL indication in MU-RTS," Woojin Ahn (WILUS)
        - 11-16-1441, "Consideration on Internal Contention Between Data and Trigger Frame," Jing Ma (NICT)
        - 11-16-1457, "11ax D0.1 Comment Resolution for Clause 25.5.3," David Xun Yang (Huawei)
    - **Spatial Reuse (SR)** — 9 submissions
        - 11-16-0947, "Proposed text changes for OBSS_PD-based SR parameters," Matthew Fischer (Broadcom)
        - 11-16-1063, "Unified SR text DSC, ATPC, inter-BSS," Graham Smith (SR Technologies)
        - 11-16-1064, "Unified SR approach DSC, ATPC and Inter-BSS," Graham Smith (SR Technologies)
        - 11-16-1121, "Spec Texts: Spatial Reuse Indication for Trigger," Po-Kai Huang (Intel)
        - 11-16-1337, "CR on SR CCA rules clause 25.9," Bo Sum (ZTE)
        - 11-16-1403, "SR Backoff Procedure," Jayh Hyunhee Park (LG Electronics)
        - 11-16-1430, "Comment Resolution for SR on BSS Color," Junichi Iwatani (NTT)
        - 11-16-1440, "Proposed Resolutions to CID 2719," Jing Ma (NICT)
        - 11-16-1450, "CR for CID 2492 section 25.9 spatial reuse operation," Kaiying Lv (ZTE)
    - **Others (covered in the TGax full sessions)** — 4 submissions
        - 11-16-0995, "Editor's report," Robert Stacy (Intel)
        - 11-16-1363, "11ax PAR Verification through OFDMA," Suhwook Kim (LG Electronics)
        - 11-16-1414, "Verifying 11ax&#xF7fs PAR by UL MU-MIMO," Jason Yuchen Guo (Huawei)
        - 11-16-1435, "PAR Verification Simulation Followup," James Yee (MediaTek)

Timeline

TG discussed the timeline. No changes since last update.

Current Timeline	
May 2014	**Start of TG**
November 2014	**First draft of the TG, SFD approved**
January 2016	**Proposed TG draft**
March 2016	**Draft 0.1 was approved and CC started**
November 2016	**Issue Draft 1.0 and start WG Letter Ballot**
May 2017	**Draft 2.0 and WG recirculation ballot**
November 2017	**Mandatory Draft Review**
January 2018	**Formation of Sponsor Ballot pool**
March 2018	**Initial Sponsor Ballot**
December 2018	**RevCom submittal**

Goals for the January 2017 session

- Start Comment Resolutions on the IEEE 802.11ax draft D1.0.

Teleconferences

Weekly teleconferences are scheduled after the November 2016 session.

Thursday	December 1st, 2016	21:00 - 23:00 (ET)
Thursday	December 8th, 2016	21:00 - 23:00 (ET)
Thursday	December 15th, 2016	21:00 - 23:00 (ET)
Tuesday	January 5th, 2017	11:00 - 13:00 (ET)
Thursday	January 12th, 2017	20:00 - 22:00 (ET)

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September 2016 — Warsaw, Poland

The TGax had 11 sessions during the week.
Six out of eleven sessions were assigned to the ad hoc group sessions.

	Monday	Tuesday	Wednesday	Thursday
AM1			**TGax (full)**	
AM2	**TGax (full)**	**TGax** (MU ad hoc) **TGax** (MAC ad hoc)		**TGax (full)**
PM1			**TGax** (PHY ad hoc) **TGax** (MAC ad hoc)	**TGax (full)**
PM2	**TGax** (PHY ad hoc) **TGax** (MAC ad hoc)	**TGax** (PHY ad hoc) **TGax** (MAC ad hoc)	**TGax** (MU ad hoc) **TGax** (MAC ad hoc)	**TGax (full)**
PM3	**TGax** (PHY ad hoc) **TGax** (SR ad hoc)			

Main documents

The meeting agenda and minutes of the TGax and its subgroups, and TGax closing report can be found here.

- TGax
  - 11-16-1077-06, TGax September 2016 Meeting Agenda
  - 11-16-1231-00, IEEE 802.11 TGax September 2016 Warsaw Meeting Minutes
  - 11-16-1284-00, TGax September 2016 Closing Report
  - TGax PHY ad hoc group
    - 11-16-1246-06, TGax PHY Ad Hoc Sep 2016 Meeting Agenda
    - 11-16-1276-00, IEEE 802.11 TGax September 2016 Warsaw PHY Ad Hoc Meeting Minutes
  - TGax MAC ad hoc group
    - 11-16-1247-02, TGax MAC Ad Hoc September 2016 Meeting Agenda
    - 11-16-1252-01, IEEE 802.11 TGax, MAC Ad hoc September 2016 Warsaw TGax MAC Ad hoc Meeting Minutes
  - TGax Multi-User (MU) ad hoc group
    - 11-16-1244-01, TGax MU Ad-hoc Agenda September 2016
    - 11-16-1275-00, IEEE 802.11 TGax, MU Ad hoc September 2016 TGax Meeting Minutes
  - TGax Spatial Reuse (SR) ad hoc group
    - 11-16-1245-02, TGax Spatial Reuse Ad-hoc Agenda September 2016 Meeting
    - 11-16-1300-00, TGax Spatial Reuse ad hoc group meeting minutes — Warsaw, September 2016

Achievements

1. **Work Completed**
   - TG received 90 submissions.
     - Number of submissions: PHY/MAC/MU/SR/TG = 28/43/12/9/6.
       The TG completed the discussion of all the submissions.
       Exact count of resolved CIDs will be published by the Editor.
   - The TG editor is planning to have draft revision D0.5 ready based on resolved comments.
2. **Technical Presentations**
   TG received 90 submissions which are categorized into PHY, MAC, MU, SR and TG.
   - **PHY** — 28 submissions
     - 11-16-1133, "11ax sounding modes reduction," Yan Zhang (Marvell)
     - 11-16-1134, "11ax spec text on sounding modes reduction," Yan Zhang (Marvell)
     - 11-16-1135, "11ax comment resolutions for clause 26.3.5," Yan Zhang (Marvell)
     - 11-16-1136, "11ax comment resolutions for clause 26.3.8," Yan Zhang (Marvell)
     - 11-16-1137, "11ax comment resolutions for clause 26.3.9," Yan Zhang (Marvell)
     - 11-16-1138, "11ax comment resolutions for clause 26.3.10," Yan Zhang (Marvell)
     - 11-16-1148, "CR HE-SIG-A part III," Ross Jian Yu (Huawei)
     - 11-16-1149, "CR HE-SIG-A part II," Ross Jian Yu (Huawei)
     - 11-16-1150, "CR Packet Extension part I," Ross Jian Yu (Huawei)
     - 11-16-1160, "Comment Resolution for CID 355," Eunsung Park (LG Electronics)
     - 11-16-1167, "UL MU Clarifications," Ron Porat (Broadcom)
     - 11-16-1168, "DCM TBDs," Sriram Venkateswaran (Broadcom)
     - 11-16-1169, "CR Duplicate MU MIMO," Sriram Venkateswaran (Broadcom)
     - 11-16-1170, "HE PHY Capabilities," Lochan Verma (Qualcomm)
     - 11-16-1171, "PHY Miscellaneous Part-1," Lochan Verma (Qualcomm)
     - 11-16-1176, "PHY CR Miscellaneous Part-2," Lochan Verma (Qualcomm)
     - 11-16-1179, "PHY section editorial comments on D0.4," Sungeun Lee (Cypress)
     - 11-16-1190, "Tx Quality Requirements," Daewon Lee (Newracom)
     - 11-16-1191, "Comment Resolution for CIDs on PHY Transmit Spec," Daewon Lee (Newracom)
     - 11-16-1192, "Comment Resolution for CID 1450," Daewon Lee (Newracom)
     - 11-16-1193, "HE variant HT Control - HE Link Adaptation," Daewon Lee (Newracom)
     - 11-16-1194, "Removal of Unnecessary PHY TBDs," Daewon Lee (Newracom)
     - 11-16-1202, "CR HE-LTF," Ming Gan (Huawei)
     - 11-16-1227, "cr-on-26-3-7," Shahrnaz Azizi (Intel)
     - 11-16-1232, "Text change proposal of TXTIME in 26.3.19 and 26.4.3," Daewon Lee (Newracom)
     - 11-16-1233, "CR for DCM related CID 503, 504 and 2750," Daewon Lee (Newracom)
     - 11-16-1240, "Packet Extension Factor calculation fix," Yan Zhang (Marvell)
     - 11-16-1242, "spec text for packet extension factor calculation fix," Yan Zhang (Marvell)
   - **MAC** — 43 submissions
     - 11-16-0864, "Comment Resolutions on Clause 6 & 8 comments," Yasuhiko Inoue (NTT)
     - 11-16-0869, "Misc. TWT comment resolution," Zhou Lan (Broadcom)
     - 11-16-0881, "Comment resolution on ROMI," Jayh Park (LG Electronics)
     - 11-16-0882, "Comment resolution on TOMI," Alfred Asterjadhi (Qualcomm)
     - 11-16-0883, "Comment resolution for CID152," JayhPark (LG Electronics)
     - 11-16-0884, "Spec. Text for HE Operation element and AID Assign Rule," Jianhan Liu (MediaTek)
     - 11-16-0913, "SU Multi-TID Rules," Jarkko Kneckt (Apple)
     - 11-16-0917, "Text for TID value of ALL ACK signaling," Woojin Ahn (WILUS)
     - 11-16-0918, "Discussions on Partial BSS Color," Geonjung Ko (WILUS)
     - 11-16-0924, "NAV resetting with RTS/MU-RTS," Weiming Xing (ZTE)
     - 11-16-0925, "Spec text on NAV resetting with RTS/MU-RTS," Weiming Xing (ZTE)
     - 11-16-0941, "CR HE Fragmentation - part 2," Ming Gan (Huawei)
     - 11-16-0942, "CR Service Field," Ming Gan (Huawei)
     - 11-16-0960, "AP access procedure for UL MU operation," Jinsoo Ahn (Yonsei Univ.)

- 11-16-0961, "Consideration on Multi-STA BlockAck Optimization," Hanseul Hong (Yonsei Univ.)
- 11-16-0962, "EDCA rules-follow up 1," Jing Ma (NICT)
- 11-16-0963, "EDCA rules-follow up 2," Jing Ma (NICT)
- 11-16-0998, "Rules for 2 EDCA parameters," Laurent Cariou (Intel)
- 11-16-1110, "Comment Resolution on subclause 10.22.2 and 10.22.4," Yongho Seok (Newracom)
- 11-16-1131, "Comment Resolution on MU Ack Policy," Yongho Seok (Newracom)
- 11-16-1154, "MAC CR for CID 966," Weiming Xing (ZTE)
- 11-16-1157, "Comment resolution on SU_MU ACK procedures," Jeongki Kim (LG Electronics)
- 11-16-1173, "Comment Resolution on Two NAVs - Part II," Po-Kai Huang (Intel)
- 11-16-1180, "Proposed text changes for MU EDCA parameters," Laurent Cariou (Intel)
- 11-16-1181, "CW value after UL MU procedure," Woojin Ahn (WILUS)
- 11-16-1182, "HE Sounding Feedback Segmentation," Liwen Chu (Marvell)
- 11-16-1183, "MU RTS CTS data rate comment," Liwen Chu (Marvell)
- 11-16-1184, "A-MPDU 25.10 25.10.2 comment resolution," Liwen Chu (Marvell)
- 11-16-1185, "A-MPDU 25.10.3 comment resolution," Liwen Chu (Marvell)
- 11-16-1186, "A-MPDU Content Comment Resolution," Liwen Chu (Marvell)
- 11-16-1188, "MAC Capabilities in HE Capabilities IE," Alfred Asterjadhi (Qualcomm)
- 11-16-1189, "CC0-TWT operation," Alfred Asterjadhi (Qualcomm)
- 11-16-1195, "MAC Clarifications," Alfred Asterjadhi (Qualcomm)
- 11-16-1204, "Intra-PPDU Power Save for a Multiple BSSID Set Case," Geonjung Ko (Wilus)
- 11-16-1205, "Text for Intra-PPDU Power Save for a Multiple BSSID Set Case," Geonjung Ko (Wilus)
- 11-16-1210, "Comment Resolution on MU acknowledgement procedure," Junichi Iwatani (NTT)
- 11-16-1211, "CR_CID_122_576_972_2598," Huizao Wang (Quantenna)
- 11-16-1213, "CR TWT and HE element related," Matthew Fischer (Broadcom)
- 11-16-1220, "MU mode EDCA control," Jinsoo Ahn (Yonsei Univ.)
- 11-16-1234, "Spec Text for TWT Protection field," Hanseul Hong (Yonsei Univ.)
- 11-16-1236, "Text for Partial BSS Color and AID Assignment Rule," Geonjung Ko (Wilus)
- 11-16-1237, "Setting Quiet Time Period," Chao-Chun Wang (MediaTek)
- 11-16-1238, "Setting Quiet Time Period - text," Chao-Chun Wang (MediaTek)

◦ **Multi-User (MU)** — 12 submissions
- 11-16-0773, "Comment Resolution Section 25.6 HE Sounding," Raja Banerjea (Qualcomm)
- 11-16-0929, "CR - UL MU Operation," Simone Merlin (Qualcomm)
- 11-16-1152, "DL OFDMA Ack rule for uplink trigger based PPDU," Ming Gan (Huawei)
- 11-16-1158, "Comment resolution on OFDMA random access procedure," Jeongki Kim (LG Electronics)
- 11-16-1162, "Comment Resolution on Retransmission of OFDMA Random Access," Yunbo Li (Huawei)
- 11-16-1163, "Concluding OFDMA M-BA transmission," Zhou Lan (Broadcom)
- 11-16-1177, "comment-resolution-TXOP-truncation," Young Hoon Kwon (Newracom)
- 11-16-1199, "Proposed text changes for DL OFDMA Acknowledge rule for trigger based PPDU," Ming Gan (Huawei)
- 11-16-1222, "Comment Resolution on UL OFDMA Random Access," Chittabrata Ghosh (Intel)
- 11-16-1224, "Random Access Parameter Set (RAPS) element," Chittabrata Ghosh (Intel)
- 11-16-1239, "Trigger Frame MU BAR part 1," Raja Banerjea (Qualcomm)
- 11-16-1241, "Trigger Frame MU BAR part 2," Raja Banerjea (Qualcomm)

◦ **Spatial Reuse (SR)** — 9 submissions
- 11-16-0945, "Clarification for OBSS_PD-based SR parameters," Matthew Fischer (Broadcom)
- 11-16-0947, "Proposed text changes for OBSS_PD-based SR parameters," Laurent Cariou (Intel)
- 11-16-1064, "Unified SR approach DSC, ATPC and Inter-BSS," Graham Smith (SR Technologies)
- 11-16-1155, "SR Comment Resolution for CID994," Kaiying Lv (ZTE) - not available
- 11-16-1161, "Simulation-based evaluation of OBSS_PD-based SR default parameters," Tanguy Ropitault (NIST)
- 11-16-1178, "comment-resolution-SR-RSSI," Young Hoon Kwon (Newracom)
- 11-16-1216, "SR Field SRP Table for HE-Trigger-Based PPDU," James Wang (MediaTek)
- 11-16-1223, "CR for Section 25.9.2 OBSS_PD Spatial reuse," Laurent Cariou (Intel)
- 11-16-1225, "Heads We Win, Tails We Don't Lose: Proposals for Dynamic CCA," Sean Coffey (RealTek)

◦ **Others (covered in the TGax full session)** — 6 submissions
- 11-15-1095, "OFDMA performance in 11ax," Suhwook Kim (LG Electronics)

- 11-16-1143, "11ax PAR Verification," Paul Cheng (MediaTek)
- 11-16-1159, "Summary of Mandatory or Optional Features of 802.11ax," Joonsuk Kim (Apple)
- 11-16-1166, "Meeting PAR requirements with UL OFDMA," Sriram Venkateswaran (Broadcom)
- 11-16-1198, "Preliminary 11ax PAR Verification," Jiyong Pang (Huawei)
- 11-16-1219, "Considerations on CR for 2665 and 2715," Jing Ma (NICT)

3. **Timeline discussion**
   TG discussed and updated the timeline.

Current Timeline		Modified Timeline	
May 2014	**Start of TG**	**May 2014**	**Start of TG**
November 2014	**First draft of the TG SFD approved**	**November 2014**	**First draft of the TG SFD approved**
January 2016	**Proposed TG draft**	**January 2016**	**Proposed TG draft**
March 2016	**Draft 0.1 was approved and CC started**	**March 2016**	**Draft 0.1 was approved and CC started**
September 2016	**Issue Draft 1.0 and start WG Letter Ballot**	**November 2016**	**Issue Draft 1.0 and start WG Letter Ballot**
March 2017	**Draft 2.0 and WG recirculation ballot**	**May 2017**	**Draft 2.0 and WG recirculation ballot**
November 2017	**Mandatory Draft Review and formstion of Sponsor Ballot pool**	**January 2018**	**Mandatory Draft Review and formation of Sponsor Ballot pool**
March 2018	**Initial Sponsor Ballot**	**March 2018**	**Initial Sponsor Ballot**
December 2018	**RevCom submittal**	**December 2018**	**RevCom submittal**

Goals for the November 2016 session

- Continue with comment resolutions.
- Prepare draft 1.0 and start WG letter ballot.

Teleconferences

TGax teleconferences are scheduled after the September 2016 session as follows.

Thursday	September 29th, 2016	10:00 - 12:00 (ET)
Thursday	October 20th and 27th, 2016	10:00 - 12:00 (ET)
Thursday	October 30th, 2016	20:00 - 22:00 (ET)
Thursday	November 17th, 2016	10:00 - 12:00 (ET)

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July 2016 — San Diego, CA

The TGax had 11 sessions during the week.
Six out of eleven sessions were assigned to the ad hoc group sessions.

	Monday	Tuesday	Wednesday	Thursday
AM1	**TGax** (full, ad hoc)		**TGax** (full)	
AM2		**TGax** (PHY ad hoc) **TGax** (MAC ad hoc)		**TGax** (full)

	Monday	Tuesday		Wednesday		Thursday
PM1				**TGax** (PHY ad hoc)	**TGax** (MAC ad hoc)	**TGax** (full)
PM2	**TGax** (full)	**TGax** (MU ad hoc)	**TGax** (SR ad hoc)	**TGax** (full)		
PM3		**TGax** (PHY ad hoc)	**TGax** (MAC ad hoc)			

Main documents

The meeting agenda and minutes of the TGax and its subgroups, and TGax closing report can be found here.

- TGax
  - 11-16-0779-06, TGax July 2016 Meeting Agenda
  - 11-16-0967-00, IEEE 802.11 TGax July 2016 San Diego Meeting Minutes
  - 11-16-1051-00, TGax July 2016 Closing Report

  - TGax PHY ad hoc group
    - 11-16-1007-03, TGax PHY Ad Hoc July 2016 Meeting Agenda
    - 11-16-1040-00, IEEE 802.11 TGax July 2016 San Diego PHY Ad Hoc Meeting Minutes
  - TGax MAC ad hoc group
    - 11-16-0997-01, TGax MAC Ad Hoc July 2016 Meeting Agenda
    - 11-16-1000-02, July 2016 San Diego TGax MAC Ad hoc Meeting Minutes
  - TGax Multi-User (MU) ad hoc group
    - 11-16-1012-00, TGax MU Ad-hoc Agenda July 2016
    - 11-16-1027-00, IEEE 802.11 TGax, MU Ad hoc July 2016 Meeting Minutes
  - TGax Spatial Reuse (SR) ad hoc group
    - 11-16-1016-01, 802.11ax Spatial Reuse Ad Hoc Group Agenda
    - 11-16-1022-00, TGax Spatial Reuse ad hoc group meeting minutes

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Achievements

1. **Work Completed**
   - TGax received about 90 submissions.
     - Number of submissions: PHY/MAC/MU/SR/TG = 26/34/12/10/8.

     Most of the submissions are proposed resolutions for the comments on the draft 0.1.

     A number of submissions were proposing new text to be added to the draft.
     - A long list of submissions are yet to be considered.
   - Approved the resolutions of about 230 comments discussed during telecons.
     - Exact count of resolved CIDs will be published by the Editor.
     - The TG editor is planning to have draft revision D0.3 ready based on resolved comments.
2. **Technical Presentations**

   Here is the list of 90 submissions.
   - **PHY** — 26 submissions
     - 11-16-0816, "Comment Resolution for CID 2183," Daewon Lee (Newracom)
     - 11-16-0872, "CR HE-SIG-A Part II," Ross Jian Yu (Huawei Technologies)
     - 11-16-0873, "CR HE-SIG-A Part I," Ross Jian Yu (Huawei Technologies)
     - 11-16-0891, "LDPC for 1024QAM," Hongyuan Zhang (Marvell)
     - 11-16-0892, "Spec Text on LDPC for 1024QAM," Hongyuan Zhang (Marvell)
     - 11-16-0893, "11ax Extended Range PPDU," Bin Tian (Qualcomm)
     - 11-16-0894, "HE-LTF Capabilities," Hongyuan Zhang (Marvell)
     - 11-16-0895, "Spec Text for HE-LTF Capabilities," Hongyuan Zhang (Marvell)
     - 11-16-0896, "11ax Beamformee Capabilities," Hongyuan Zhang (Marvell)
     - 11-16-0897, "Spec Text for Beamformee Capabilities," Hongyuan Zhang (Marvell)

- 11-16-0898, "BW Field in HE-MU Format," Hongyuan Zhang (Marvell)
- 11-16-0899, "Spec Text for BW Field in HE-MU Format," Hongyuan Zhang (Marvell)
- 11-16-0900, "PHY Comment Resolution for CID 1052 and 2519," Bin Tian (Qualcomm)
- 11-16-0903, "Gamma phase rotation for HE PPDU," Yujin Noh (Newracom)
- 11-16-0904, "Proposed text for gamma phase rotation for HE PPDU," Yujin Noh (Newracom)
- 11-16-0906, "RU restriction on 20MHz operating STAs," Joonsuk Kim (Apple)
- 11-16-0908, "CR - proposed text on RU restriction of 20MHz STAs," Joonsuk Kim (Apple)
- 11-16-0910, "Minimum Occupied Bandwidth," Ron Porat (Broadcom)
- 11-16-0914, "Bit field finalization of HE-SIG-A," Lochan Verma (Qualcomm)
- 11-16-0915, "Text for bit field finalization of HE-SIG-A," Lochan Verma (Qualcomm)
- 11-16-0920, "PHY comment resolution for CID 1659,493,494," Xiaogang Chen (Intel)
- 11-16-0922, "PHY CR 1024 QAM," Sriram Venkateswaran (Broadcom)
- 11-16-0923, "PHY CR DCM Constellation Mapping," Sriram Venkateswaran (Broadcom)
- 11-16-0928, "CR on Section 26.3.9.8 - HE-SIG-B," Kaushik Josiam
- 11-16-0937, "11ax Comment Resolutions for Clauses 26.3.2-26.3.9.3-26.3.9.4-26.3.9.5-26.3.10.2- 26.3.10.13," Rui Cao (Marvell)
- 11-16-0964, "Considerations on MAC-PHY interactions during SR operations," Jing Ma (NICT)

- **MAC** — 34 submissions
  - 11-16-0828, "HE Fragmentation - part 1," Alfred Asterjadhi (Qualcomm)
  - 11-16-0829, "Comment Resolution for Section 10.24.10 Block Ack/GCR block ack," Reza Hedayat (Newracom)
  - 11-16-0844, "CC0-Intra_PPDU_PS," Alfred Asterjadhi (Qualcomm)
  - 11-16-0856, "Issue of Buffer Status reporting," Stephane Baron (Canon)
  - 11-16-0860, "comment resolution on A-MPDU format," Yongho Seok (Newracom)
  - 11-16-0861, "comment resolution on mu acknowledgment procedure," Yongho Seok (Newracom)
  - 11-16-0862, "comment resolution on subclause 25.11," Yongho Seok (Newracom)
  - 11-16-0864, "d0.1 comment resolution on clause 6," Yasuhiko Inoue (NTT)
  - 11-16-0867, "CIDs for CIDs: Section 9.3.1.9.3 Compressed BA format," George Cherian (Qualcomm)
  - 11-16-0868, "CIDs for Section 9.3.1.9.7 Multi STA BAs," George Cherian (Qualcomm)
  - 11-16-0869, "Comment resolution section 9.3 TWT," Zhou Lan (Broadcom)
  - 11-16-0871, "Trigger Frame Per User Info Order," Zhou Lan (Broadcom)
  - 11-16-0877, "Comment resolution on CID 783 (TXOP Duration field format)," Jeongki Kim (LG Electronics)
  - 11-16-0878, "Comment resolution on CID 782 (Intra-PPDU PS)," Jeongki Kim (LG Electronics)
  - 11-16-0881, "Comment resolution on ROMI," Jayh Park (LG Electronics)
  - 11-16-0882, "Comment resolution on TOMI," Jayh Park (LG Electronics)
  - 11-16-0883, "Comment resolution for CID 152," Jayh Park (LG Electronics)
  - 11-16-0884, "Spec. Text for HE Operation element and AID Assign Rule," Jianhan Liu (MediaTek)
  - 11-16-0890, "Comment Resolution on NAV Setting of Single and Multiple Protection and Control Response," Po-Kai Huang (Intel)
  - 11-16-0913, "SU Multi-TID Rules," Jarkko Kneckt (Apple)
  - 11-16-0916, "TID value of ALL ACK signaling," Woojin Ahn (Wilus Institute)
  - 11-16-0917, "Text for TID value of ALL ACK signaling," Woojin Ahn (Wilus Institute)
  - 11-16-0918, "Discussions on Partial BSS Color," Geonjung Ko (Wilus Institute)
  - 11-16-0924, "NAV resetting with RTS/MU-RTS," Weimin Xing (ZTE)
  - 11-16-0925, "Spex text on NAV resetting with RTS/MU-RTS," Weimin Xing (ZTE)
  - 11-16-0941, "CR HE Fragmentation - part 2," Ming Gan (Huawei technologies)
  - 11-16-0942, "CR Service Field," Ming Gan (Huawei Technologies)
  - 11-16-0951, "Setting for TXOP Duration Field," Po-Kai Huang (Intel)
  - 11-16-0952, "Spec text trigger frame per user info order," Zhou Lan (Broadcom)
  - 11-16-0953, "Comment Resolution and Spec Text for Setting for TXOP Duration field," Po-Kai Huang (Intel)
  - 11-16-0960, "AP access procedure for UL MU operation," Jinsoo Ahn (Yonsei Univ.)
  - 11-16-0961, "Consideration on Multi-STA BlockAck Optimization," Hanseul Hong (Yonsei Univ.)
  - 11-16-0962, "EDCA rules follow up 1," Jing Ma (NICT)
  - 11-16-0963, "EDCA rules follow up 2," Jing Ma (NICT)
  - 11-16-0966, "CID 71 and CID 190 Resolutions," Jarkko Kneckt (Apple)

        - 11-16-0998, "2 sets of EDCA parameters," Laurent Cariou (Intel)
    - **Multi-User (MU)** — 12 submissions
        - 11-16-0866, "Comment Resolution of Section 26.3.13 MU-MIMO," Kome Oteri (InterDigital)
        - 11-16-0875, "CR for the section 10.3.2.8a CS Condition to Respond CTS," Kiseon Ryu (LG Electronics)
        - 11-16-0876, "CR for the section 25.5.2.4 UL MU CS CCA and CS Required Bit," Kiseon Ryu (LG Electronics)
        - 11-16-0880, "UL MU Transmission Rules - EDCA backoff," Jayh Park (LG Electronics)
        - 11-16-0885, "Comment Resolution on UL MU CS NAV Consideration," Po-Kai Huang (Intel)
        - 11-16-0886, "Comment Resolution for some UL MU CS TBD," Po-Kai Huang (Intel)
        - 11-16-0887, "Spec Text for MU-RTS restriction on HE MU PPDU," Po-Kai Huang (Intel)
        - 11-16-0926, "Soliciting UL_MU_ACK," Raja Banerjea (Qualcomm)
        - 11-16-0929, "CR - UL MU Operation," Simone Merlin (Qualcomm)
        - 11-16-0930, "CR - DL MU Operation," Simone Merlin (Qualcomm)
        - 11-16-0938, "Comment Resolution for Sub-clause 25.10.4," Chittabrata Ghosh (Intel)
        - 11-16-0958, "UL OFDMA for Unassociated STAs," Leonardo Lanante (Kyushu Institute of Tech.)
    - **Spatial Reuse (SR)** — 10 submissions
        - 11-16-0879, "Comment resolution on SR for VHT PPDUs," Jeongki Kim (LG Electronics)
        - 11-16-0889, "Comment Resolution for Spatial Reuse (Intra BSS detection)," Young Hoon Kwon (Newracom)
        - 11-16-0901, "Clarification of SR Fields in HE Trigger Based PPDU," Daewon Lee (Newracom)
        - 11-16-0902, "Proposed Text Changes for SR Fields in HE Trigger-Based PPDU," Daewon Lee (Newracom)
        - 11-16-0905, "SR Fields Clarification," Ron Porat (Broadcom)
        - 11-16-0919, "Discussions on SR Fields in HE Trigger-based PPDU," Geonjung Ko (Wilus Institute)
        - 11-16-0310, "DSC Proposal Text," Graham Smith (SR Technologies)
        - 11-16-0945, "Clarifications for OBSS_PD-based SR parameters," Laurent Cariou (Intel)
        - 11-16-0947, "Proposed text changes for OBSS_PD-based SR parameters," Laurent Cariou (Intel)
        - 11-16-0957, "Comment Resolutions on OBSS_PD Conditions in 25.9.3," James Wang (MediaTek)
    - **Others (covered in the TGax full sessions)** — 8 submissions
        - 11-15-1095, "OFDMA Performance in 11ax," Suhwook Kim (LG Electronics)
        - 11-16-0835, "EIFS," Alfred Asterjadhi (Qualcomm)
        - 11-16-0870, "Conclusing MAC Trigger Padding," Zhou Lan (Broadcom)
        - 11-16-0907, "20MHz HE devices," Joonsuk Kim (Apple)
        - 11-16-0909, "CR - proposed text on 20 MHz devices," Joonsuk Kim (Apple)
        - 11-16-0949, "MAC trigger frame padding follow up," Zhou Lan (Broadcom)
        - 11-16-0965, "On High Efficiency WLAN (HEW) TG PAR Scope," Osama Aboul-Magd (Huawei Technologies)
3. **Timeline**
   TG discussed the timeline. No changes since last update.

Current Timeline	
May 2014	**Start of TG**
November 2014	**First draft of the TG SFD approved**
January 2016	**Proposed TG draft**
March 2016	**Draft 0.1 was approved and CC started**
September 2016	**Issue Draft 1.0 and start WG Letter Ballot**
March 2017	**Draft 2.0 and WG recirculation ballot**
July 2017	**MDR (Mandatory Draft Review)**
November 2017	**Formstion of Sponsor Ballot pool**
March 2018	**Initial Sponsor Ballot**
December 2018	**RevCom submittal**

Goals for the September 2016 session

- Continue with Comment Resolutions.

Teleconferences

TGax teleconferences are scheduled after the July 2016 session.

Thursday	August 4th, 2016	20:00 - 22:00 (ET) (approved during the May 2016 session)
Thursday	August 11th and 25th, 2016, September 1st, 2016	10:00 - 12:00 (ET)
Thursday	August 18th, 2016, September 1st and 22nd, 2016	20:00 - 22:00 (ET)

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May 2016 — Waikoloa, HI

The TGax had 10 sessions during the week.
Six out of ten sessions were assigned to the ad hoc groups.

	Monday	Tuesday	Wednesday	Thursday
AM1				
AM2	**TGax** (full)	**TGax** (MU ad hoc) **TGax** (MAC+SR ad hoc)		**TGax** (full)
PM1			**TGax** (PHY ad hoc) **TGax** (MAC+SR ad hoc)	
PM2	**TGax** (PHY ad hoc) **TGax** (MAC+SR ad hoc)	**TGax** (PHY ad hoc) **TGax** (MU ad hoc)	**TGax** (PHY ad hoc) **TGax** (MAC+SR ad hoc)	**TGax** (full)
PM3	**TGax** (PHY ad hoc) **TGax** (MU ad hoc)			

Main documents

The meeting agenda and minutes of the TGax and its subgroups, and the TGax closing report can be found here.

- TGax
  - 11-16-0512-04, TGax May 2016 Meeting Agenda
  - 11-16-0686-00, IEEE 802.11 TGax May 2016 Waikoloa Meeting Minutes
  - 11-16-0739-00, TGax May 2016 Closing Report

  - TGax PHY ad hoc group
    - 11-16-0693-03, TGax PHY Ad Hoc May 2016 Meeting Agenda
    - 11-16-0755-00, May 2016 Waikoloa PHY Ad Hoc Meeting Minutes
  - TGax MAC and Spatial Reuse (SR) ad hoc group
    - 11-16-0698-04, TGax MAC and Spatial Reuse Ad Hoc Agenda May 2016 Meeting
    - 11-16-0701-00, Combined Spatial Reuse and MAC ad hoc group meeting minutes
  - TGax Multi-User (MU) ad hoc group
    - 11-16-0697-02, TGax MU Ad-hoc Agenda May 2016
    - 11-16-0716-00, May 2016 Waikoloa TGax MU Ad Hoc Meeting minutes

Achievements

1. **Work Completed**
   - TGax received about 70 submissions.
     - Numbers of submissions: PHY/MAC/MUSR/TG = 33/18/9/3/6.

     Majority of the submission were requesting changes to the TG Specification Framework.
     Few submissions were addressing comment resolution mainly of the PHY clause.
   - Agreed to terminate the Specification Framework process. The frame of reference is Draft D0.1.
     - Future submissions shall bring text to continue developing the TG draft.
     - The TG Technical Editor is planning to generate draft D0.2 based on outcome of this meeting.
   - Approved the resolutions of about 200 comments, most of them addressing the PHY clause.
   - Revisited and accepted a new modified timeline.
2. **Technical Presentations**

   70 technical submissions have been received and have been covered during the week.
   A list of the submissions is also available in the agenda document.
   - **PHY** — 33 submissions
     - 11-16-0608, "Beamforming Feedback Report Structure," Sameer Vermani (Qualcomm)
     - 11-16-0610, "CR HE-SIG-A Part I," Ross Jian Yu (Huawei Technologies)
     - 11-16-0611, "Remaining Issues in Trigger Frame Design," Sameer Vermani (Qualcomm)
     - 11-16-0613, "SIG-B Related Issues," Lochan Verma (Qualcomm)
     - 11-16-0614, "Comment Resolution on Clause 26.1.1 Part 1," Lochan Verma (Qualcomm)
     - 11-16-0615, "Comment Resolution on Clause 26.3.12 Part 1," Lochan Verma (Qualcomm)
     - 11-16-0617, "Remaining Topics in Power Control," Bin Tian (Qualcomm)
     - 11-16-0618, "11ax CSD Design," Bin Tian (Qualcomm)
     - 11-16-0619, "PAPR Reduction of HE-SIGB," Bin Tian (Qualcomm)
     - 11-16-0620, "DCM PHY Parameters," Hongyuan Zhang (Marvell)
     - 11-16-0621, "DCM Interleaver," Tianyu Wu (MediaTek)
     - 11-16-0622, "16 QAM Napping for DCM," Sudhir Srinivasa (Marvell)
     - 11-16-0623, "CR on Section 26.3.10.12," Bin Tian (Qualcomm)
     - 11-16-0625, "CR on Section 26.3.6," Bin Tian (Qualcomm)
     - 11-16-0626, "Feedback Element Compression for 802.11ax," Kome Oteri (InterDigital Communications)
     - 11-16-0633, "Left over Issues in RU Signaling for HE-SIGB," Yan Zhang (Marvell)
     - 11-16-0634, "11ax Comment Resolutions for Clauses 26.3.2," Yan Zhang (Marvell)
     - 11-16-0635, "BW indication for Non-contiguous Channel Bonding," Yunbo Li (Huawei Technologies)
     - 11-16-0636, "TXOP Duration field in HE-SIG-A," Jeongki Kim (LG Electronics)
     - 11-16-0637, "Load balancing indication for MU-MIMO over 484-tone and larger RU in OFDMA," Ming Gan (Huawei Technologies)
     - 11-16-0638, "Discussions for Non-contiguous Channel Bonding," John Son (Wilus)
     - 11-16-0639, "Follow-up on HE-SIG-B user-specific field," Jinsoo Choi (LG Electronics)
     - 11-16-0649, "Feedback Tone Map and Quantization," Sriram Venkateswaran (Broadcom)
     - 11-16-0652, "Power scaling of 4 extra tones," Xiaogang Chen (Intel)
     - 11-16-0653, "CR on section 26.3.3," Xiaogang Chen (Intel)
     - 11-16-0654, "CP and LTF Options and Signaling," Ron Porat (Broadcom)
     - 11-16-0655, "On MCS0 DCM Modulation and DCM Capability," Jianhan Liu (MediaTek)
     - 11-16-0656, "1024QAM Modulation," Jianhan Liu (MediaTek)
     - 11-16-0658, "CR on 26.3.7.1," Jinsoo Choi (LG Electronics)
     - 11-16-0659, "CR on 26.3.9.9 and 26.3.5," Eunsung Park (LG Electronics)
     - 11-16-0663, "CR on Secition 26.2.2," Ke Yao (ZTE)
     - 11-16-0681, "Comment Resolution CID 215 2486," Daewon Lee (Newracom)
     - 11-16-0682, "CR CID on PHY data field other," Daewon Lee (Newracom)
   - **MAC** — 18 submissions
     - 11-16-0583, "Backoff Procedure Handling Upon TF Reception," Yu Wang (Ericsson)
     - 11-16-0584, "Need of SDU Fragmentation to Reduce Padding Ratio in UL-OFDMA Transmission," Yu Wang (Ericsson)
     - 11-16-0588, "Channel State Estimation based Bidirectional Initialized Random Access," Bo Li (Northwestern Polytechnical Univ.)

- 11-16-0590, "Multi-BSS Association for Edge Users'f Throughput Improvements," Mao Yang (Northwestern Polytechnical Univ.)
- 11-16-0616, "BlockAck generation and selection rules," Alfred Asterjadhi (Qualcomm)
- 11-16-0627, "ROM Recovery Rules," Jayh Hyunhee Park (LG Electronics)
- 11-16-0628, "Buffer Status Report in HE Control field," Jayh Hyunhee Park (LG Electronics)
- 11-16-0640, "BSS Color Collision," Geonjung Ko (Wilus Institute)
- 11-16-0641, "Regarding HE fragmentation," Woojin Ahn (Yonsei Univ.)
- 11-16-0643, "HE Control Scheduling," Liwen Chu (Marvell)
- 11-16-0644, "SS Allocation in Trigger," Liwen Chu (Marvell)
- 11-16-0645, "MU Minimum MPDU Start Spacing," Liwen Chu (Marvell)
- 11-16-0646, "HE Beamforming Feedback," Liwen Chu (Marvell)
- 11-16-0657, "In-device Multi-radio Coexistence and UL MU operation," Robert Stacy (Intel)
- 11-16-0673, "Multi-User EDCA," Jinsoo Ahn (Yonsei Univ.)
- 11-16-0674, "EIFS excess problem of Acknowledgement for UL MU procedure," Hanseul Hon (Yonsei Univ.)
- 11-16-0675, "comment resolution for CID2383," Yonggang Fang (ZTE)
- 11-16-0684, "Channel Access Efficiency," Evgeny Khorov (IITP)

- **Multi-User (MU)** — 9 submissions
  - 11-16-0582, "Random Access RU Allocation in the Trigger Frame," Evgeny Khorov (IITP)
  - 11-16-0591, "Issues related to OCW management," Patrice Nezou (Canon)
  - 11-16-0592, "Follow up on Issue related to unused UL OFDMA RUs," Stephane Baron (Canon)
  - 11-16-0648, "MU-RTS/CTS PHY Format," Po-Kai Huang (Intel)
  - 11-16-0661, "Adaptive Random Access UL OFDMA," Leonardo Lanante (Kyushu Institute of Technology)
  - 11-16-0662, "Further consideration on channel access rule to facilitate MU transmission opportunity," Jing Ma (NICT)
  - 11-16-0664, "Consideration on backoff procedure for UL MU transmission," Jing Ma (NICT)
  - 11-16-0665, "Some Notes on Interference Alignment for Downlink Multi-User MIMO," Dzevdan Kapetanovic (Ericsson)
  - 11-16-0667, "Signaling of Multi-TID Aggregation Limit," Chittabrata Ghosh (Intel)
- **Spatial Reuse (SR)** — 3 submissions
  - 11-16-0581, "Proposed changes to SR clause," Soma Tayamon (Ericsson)
  - 11-16-0589, "Fractional-Backoff Procedure and Dynamic CCA," Bo Li (Northwestern Polytechnical University)
  - 11-16-0647, "Consideration of Spatial Reuse for Trigger Frame," Po-Kai Huang (Intel)
- **Others (covered in TGax full sessions)** — 6 submissions
  - 11-16-0571, "QoS Handling of Trigger Frame," Yu Wang (Ericsson)
  - 11-16-0597, "TG ax Indoor Enterprise Scenarios, Color, DSC and TPC," Graham Smith (SR Technologies)
  - 11-16-0604, "Simulation-based evaluation of DSC in enterprise scenario," Tanguy Ropitault (NIST)
  - 11-16-0609, "HE NDPA frame format," Ross Jian Yu (Huawei)
  - 11-16-0612, "Mandatory/Optional Issues for 802.11ax," Sameer Vermani (Qualcomm)
  - 11-16/0629, "Box 5 Calibration Results," Marik Hsiao (MediaTek)

3. **Timeline**

TG discussed and revised the timeline as follows.

Current Timeline		Modified Timeline	
May 2014	**Start of TG**	**May 2014**	**Start of TG**
November 2014	**First draft of the TG SFD approved**	**November 2014**	**First draft of the TG SFD approved**
January 2016	**Proposed TG draft**	**January 2016**	**Proposed TG draft**
March 2016	**Draft 0.1 was approved and CC started**	**March 2016**	**Draft 0.1 was approved and CC started**
July 2016	**Issue Draft 1.0 and start WG Letter Ballot**	**September 2016**	**Issue Draft 1.0 and start WG Letter Ballot**
March 2017	**Draft 2.0 and WG recirculation ballot**	**March 2017**	**Draft 2.0 and WG recirculation ballot**
		July 2017	**MDR (Mandatory Draft Review)**
		November 2017	**Formation of Sponsor Ballot pool**
January 2018	**Initial Sponsor Ballot**	**March 2018**	**Initial Sponsor Ballot**
		December 2018	**RevCom submittal**

Goals for the July 2016 session

- Continue with comment resolutions.

Teleconferences

Weekly teleconferences are planned after the May 2016 session.

Thursday	June 2nd, 2016	10:00 - 12:00 (ET)
Thursday	June 16th, 2016	10:00 - 12:00 (ET)
Thursday	June 23rd, 2016	20:00 - 22:00 (ET)
Thursday	June 30th, 2016	10:00 - 12:00 (ET)
Thursday	July 7th, 2016,	20:00 - 22:00 (ET)
Thursday	July 14th, 2016	10:00 - 12:00 (ET)
Thursday	August 4th, 2016	20:00 - 22:00 (ET)

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March 2016 — Macau

The TGax had 9 sessions during the week.
Five out of nine sessions were assigned to the ad hoc groups.

	Monday	Tuesday	Wednesday	Thursday
AM1				
AM2		**TGax** (PHY ad hoc) **TGax** (MAC ad hoc)		**TGax** (full)
PM1	**TGax** (full)		**TGax** (PHY ad hoc) **TGax** (MAC ad hoc)	
PM2		**TGax** (MAC ad hoc) **TGax** (SR ad hoc)	**TGax** (MAC ad hoc) **TGax** (MU ad hoc)	**TGax** (full)
PM3	**TGax** (SR ad hoc) **TGax** (MU ad hoc)	**TGax** (full)		

Main documents

The meeting agenda and minutes of the TGax and its subgroups, and the TGax closing report can be found here.

- TGax
  - 11-16-0235-07, TGax March 2016 Meeting Agenda
  - 11-16-0415-00, IEEE 802.11 TGax March 2016 Macau Meeting Minutes
  - 11-16-0475-00, TGax March 2016 Closing Report

  - TGax PHY ad hoc group
    - 11-16-0421-03, TGax PHY Ad Hoc March 2016 Meeting Agenda
    - 11-16-0509-00, TGax March 2016 Macau PHY Ad Hoc Meeting Minutes
  - TGax MAC ad hoc group

- 11-16-0427-04, TGax MAC Ad Hoc March 2016 Meeting Agenda
- 11-16-0439-01, March 2016 Macau TGax MAC ad hoc meeting minutes

- TGax Multi-User (MU) ad hoc group
  - 11-16-0419-02, TGax MU Ad-hoc Agenda March 2016
  - 11-16-0466-00, TGax MU Ad Hoc Meeting minutes March 2016
- TGax Spatial Reuse (SR) ad hoc group
  - 11-16-0422-02, TGax SR Ad Hoc March 2016 Agenda
  - 11-16-0537-00, TGax SR Ad Hoc group March 2016 minutes

Achievements

1. **Passed a number of motions affecting all aspects of the TG Specification Framework**
   - PHY — 22 motions passed.
   - MAC — 17 motions passed.
   - MU — 9 motions passed.
   - SR — 2 motions passes.
2. **TG Documents**
   - Latest revision of the Specification Framework is available at; https://mentor.ieee.org/802.11/dcn/15/11-15-0132-16-00ax-spec-framework.docx
   - Other TG documents
     - Simulation Scenarios: https://mentor.ieee.org/802.11/dcn/14/11-14-0980-16-00ax-simulation-scenarios.docx
     - Evaluation Methodology: https://mentor.ieee.org/802.11/dcn/14/11-14-0571-12-00ax-evaluation-methodology.docx
     - Channel Models: https://mentor.ieee.org/802.11/dcn/14/11-14-0882-04-00ax-tgax-channel-model-document.docx
     - Functional Requirements: https://mentor.ieee.org/802.11/dcn/14/11-14-1009-02-00ax-proposed-802-11ax-functional-requirements.doc
3. **Technical Presentations**

   48 technical submissions have been covered during the week.

   Here is the list of submissions which is also available in the agenda document.
   - **PHY** — 12 submissions
     - 11-15-1354, "SIGA fields and Bitwidths," Ron Porat (Broadcom)
     - 11-16-0203, "Signalling Support for Full Bandwidth MU-MIMO Compressed SIG-B Mode," Lei Huang (Panasonic)
     - 11-16-0319, "I-Q Decoupled OFDM: A Solution To I/Q Imbalance," Shouxing Simon Qu (Blackberry)
     - 11-16-0335, "HE-STF sequences for 160/80+80MHz," Eunsung Park (LG Electronics)
     - 11-16-0343, "Spectral Mask Discussion," Hongyuan Zhang (Marvell)
     - 11-16-0344, "PHY Padding Related Issues," Hongyuan Zhang (Marvell)
     - 11-16-0346, "11ax Pilot Sequence," Bin Tian (Qualcomm)
     - 11-16-0349, "HE-SIG-B Compression Mode," Kaushik Josiam (Samsung)
     - 11-16-0367, "Power Scaling of L-LTF and L-STF," Yakun Sun (Marvell)
     - 11-16-0389, "Sounding Design," Sriram Venkateswaran (Broadcom)
     - 11-16-0395, "Preamble transmission for Uplink OFDMA," Ming Gan (Huawei)
     - 11-16/0397, "HE-SIG-B Signaling Discussions," John Son (WILUS Institute)
   - **MAC** — 18 submissions
     - 11-16-0297, "Results for beacon collisions," Evgeny Khorov (IITP RAS)
     - 11-16-0345, "Simultaneous NAK for MU GCR-BA," Jinsoo Ahn (Yonsei Univ.)
     - 11-16-0347, "Fragmentation for MU frames-Follow up on parameters," Alfred Asterjadhi (Qualcomm)
     - 11-16-0352, "Considerations on MU initial link setup," Woojin Ahn (Yonsei Univ.)
     - 11-16-0353, "MU-RTS/CTS for TWT Protection," Hanseul Hong (Yonsei Univ.)
     - 11-16-0358, "Maximal A-MPDU Size," Liwen Chu (Marvell)
     - 11-16-0359, "Management ACK," Liwen Chu (Marvell)
     - 11-16-0361, "Ack Policy of UL MU frame," Jeongki Kim (LG Electronics)
     - 11-16-0362, "Multi-TID Aggregation Limit," Chittabrata Ghosh (Intel)
     - 11-16-0365, "Multi-STA BA Design," Xiaofei Wang (InterDigital)
     - 11-16-0368, "MAC padding options for legacy trigger frame," Zhou Lan (Broadcom)
     - 11-16-0369, "M-BA aggregated trigger frame," Zhou Lan (Broadcom)

        - 11-16-0377, "Sounding Sequences Clarifications," Simone Merlin (Qualcomm)
        - 11-16-0378, "Extended BA Bitmap," Simone Merlin (Qualcomm)
        - 11-16-0383, "RU Signaling in Trigger Frame," Yunbo Li (Huawei)
        - 11-16-0396, "Issues on BSS Color Bits Collision," Geonjung Ko (WILUS Institute)
        - 11-16-0399, "Considerations on Trigger Frame for Random Access Procedure," Evgeny Khorov (IITP RAS)
        - 11-16-0404, "BlockAck Bitmap," Dengyu Qiao (Huawei)
    - **Multi-User (MU)** — 6 submissions
        - 11-16-0331, "Power Control for Multi-User Transmission in 802.11ax," Kome Oteri (InterDigital)
        - 11-16-0333, "Issue related to unused UL OFDMA RUs," Stephane Baron (Canon)
        - 11-16-0340, "Random Access UL MU Resource Allocation and Indication," Leonardo Lanante (Kyushu Institute of Technology)
        - 11-16-0371, "Further consideration for MU-RTS/CTS," Jing Ma (NICT)
        - 11-16-0379, "Trigger Frame Format," Simone Merlin (Qualcomm)
        - 11-16-0413, "Power Control for UL MU," Arjun Bharadwaj (Qualcomm)
    - **Spatial Reuse (SR)** — 7 submissions
        - 11-16-0212, "Enterprise Scenario DSC and Color," Graham Smith (SR Technplogies)
        - 11-16-0310, "DSC Proposed Text," Graham Smith (SR Technplogies)
        - 11-16-0350, "Enterprise Scenario TPC and DSC," Graham Smith (SR Technplogies)
        - 11-16-0360, "Simulation results of spatial reuse with various MCSs," Junichi Iwatani (NTT)
        - 11-16-0382, "Discussion on Spatial Reuse Operations in 11ax," Yunbo Li (Huawei)
        - 11-16-0403, "Spatial Re-Use with Adaptive CCA and TPC Simulation," Frank Hsu (MediaTek)
        - 11-16-0414, "Adjustment Rules for Adaptive CCA and TPC," James Wang (MediaTek)
    - **Others (covered in the TGax full session)** — 5 submissions
        - 11-15-1095, "OFDMA Performance in 11ax," Suhwook Kim (LG Electronics)
        - 11-16-0066, "Views on UL MU Features," Joonsuk Kim (Apple)
        - 11-16-0355, "Snapshot of Residential Use 2016," Carol Ansley (ARRIS Group)
        - 11-16-0364, "AID Assign Rules Based on BSS Color and HE Operation Element," Jianhan Liu (MediaTek)
        - 11-16-0394, "Achieving High Efficiency in Medium Access via Roster Mode," Sean Coffey (RealTek)
4. **Draft Specification**
   The TGax approved version 0.1 of the draft specification.

> **< TG Motion >**
> Move to accept document 11-16/0024r1 as the TG draft specification D0.1, and start a 21 day comment collection period.
> - The submission is available at: https://mentor.ieee.org/802.11/dcn/16/11-16-0024-01-00ax-proposed-draft-specification.docx
>
> Moved by Robert Stacey, Second by Simone Merlin.
> Result: Y/N/A = 75/0/5, motion passes.

Goals for the May 2016 session

- Comment Resolution.
- Technical presentations.
- Revisit the timeline based on the number of comments received.

Teleconferences

TGax teleconferences are planned before the May 2016 session.

Thursday	April 14th, 2016,	10:00 - 12:00 (ET)

Thursday	April 21st, 2016	20:00 - 22:00 (ET)
Thursday	April 28th, 2016,	10:00 - 12:00 (ET)
Thursday	May 5th, 2016	20:00 - 22:00 (ET)

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January 2016 — Atlanta, GA

The TGax had 10 sessions during the week.
Four out of ten sessions were assigned to the ad hoc groups.

	Monday	Tuesday	Wednesday	Thursday
AM1			**TGax** (full)	
AM2	**TGax** (full)	**TGax** (PHY ad hoc) **TGax** (MAC ad hoc)		**TGax** (full)
PM1		**TGax** (PHY ad hoc) **TGax** (MAC ad hoc)	**TGax** (full)	
PM2	**TGax** (MAC ad hoc) **TGax** (SR ad hoc)		**TGax** (full)	**TGax** (full)
PM3		**TGax** (MU ad hoc)		

Main documents

The meeting agenda and minutes of the TGax and its subgroups, and the TGax closing report can be found here.

- TGax
  - 11-15-1516-03, TGax January 2016 Meeting Agenda
  - 11-16-0096-00, IEEE 802.11 TGax January 2016 Atlanta Meeting Minutes
  - 11-16-0187-00, TGax January 2016 Closing Report

  - TGax PHY ad hoc group
    - 11-16-0108-02, TGax PHY Ad Hoc January 2016 Meeting Agenda
    - 11-16-0119-00, TGax January 2016 Atlanta PHY Ad Hoc Meeting Minutes
  - TGax MAC ad hoc group
    - 11-16-0109-02, TGax MAC Ad Hoc January 2016 Meeting Agenda
    - 11-16-0110-00, Jan 2016 Atlanta TGax MAC ad hoc meeting minutes
  - TGax Multi-User (MU) ad hoc group
    - 11-16-0147-01, TGax MU Ad-hoc Agenda January 2016
    - 11-16-0150-00, January 2016 Atlanta TGax MU Ad Hoc Meeting minutes

Achievements

1. **Passed a number of motions affecting all aspects of the TG Specification Framework**
   - PHY — 30 motions passed.
   - MAC — 9 motions passed.
   - MU — 7 motions passed.
2. **TG Documents**
   - Latest revision (rev. 15) of the Specification Framework is available at; https://mentor.ieee.org/802.11/dcn/15/11-15-0132-15-00ax-spec-framework.docx

- Other TG documents
  - Simulation Scenarios: https://mentor.ieee.org/802.11/dcn/14/11-14-0980-16-00ax-simulation-scenarios.docx
  - Evaluation Methodology: https://mentor.ieee.org/802.11/dcn/14/11-14-0571-12-00ax-evaluation-methodology.docx
  - Channel Models: https://mentor.ieee.org/802.11/dcn/14/11-14-0882-04-00ax-tgax-channel-model-document.docx
  - Functional Requirements: https://mentor.ieee.org/802.11/dcn/14/11-14-1009-02-00ax-proposed-802-11ax-functional-requirements.doc

3. **Technical Presentations**

   48 technical submissions have been covered during the week.

   A list of the submissions is available in the agenda document.

   - **PHY** — 22 submissions
     - 11-16-0030, "Maximum Tone Grouping Size for 802.11ax Feedback with MU-MIMO," Kome Oteri (InterDigital)
     - 11-16-0033, "1x HE-LTF for ULMUMIMO," Hongyuan Zhang (Marvell)
     - 11-16-0034, "Beamforming with HE-LTF Compression," Hongyuan Zhang (Marvell)
     - 11-16-0036, "CRC Generation for HE-SIG," Yakun Sun (Marvell)
     - 11-16-0037, "Continuous Puncturing for HE-SIGB Encoding," Yakun Sun (Marvell)
     - 11-16-0038, "Sequence for 1x LTF," Daewon Lee (Newracom)
     - 11-16-0039, "RU Allocation in SIG-B," Daewon Lee (Newracom)
     - 11-16-0040, "Issues with Compressed SIG-B Mode," Yujin Noh (Newracom)
     - 11-16-0041, "Link Adaptation for HE WLAN," Yujin Noh (Newracom)
     - 11-16-0044, "MCS Levels and TX EVM Requirement for 1024 QAM," Eunsung Park (LG Electronics)
     - 11-16-0045, "Flexible Wider Bandwidth Transmission," John Son (WILUS)
     - 11-16-0046, "Content for the extra tones in LSIG and RLSIG," Jiayin Zhang (Huawei)
     - 11-16-0047, "Discussion on the HE Extended Range SU PPDU," Jiayin Zhang (Huawei)
     - 11-16-0052, "Remaining HE-LTF Sequence Design," Le Liu (Huawei)
     - 11-16-0053, "Requirements for UL MU Transmissions," Arjun Bharadwaj (Qualcomm)
     - 11-16-0056, "On QPSK DCM Modulation and LDPC Tone Mapper for DCM," Jianhan Liu (MediaTek)
     - 11-16-0071, "Packet Extension Follow Up," Ron Porat (Broadcom)
     - 11-16-0079, "Allocation sizes for BCC in OFDMA," Ken Taniguchi (Toshiba)
     - 11-16-0080, "1x/2x/4x OFDM Symbol in HE SU PPDU with BCC," Heejung Yu (Yeungnam Univ./NEWRACOM)
     - 11-16-0088, "Ng for Compressed Beamforming feedback," Sriram Venkateswaran (Broadcom)
     - 11-16-0089, "Single Stream Pilots in UL MU MIMO," Sriram Venkateswaran (Broadcom)
     - 11-16-0104, "Rate Matching for HE-SIG-B," Daewon Lee (Newracom)
   - **MAC** — 12 submissions
     - 11-16-0015, "Explicit Block Ack Request in DL MU PPDU," Yongho Seok (Newracom)
     - 11-16-0017, "Beacon Collision Avoidance," Evgeny Khorov (IITP)
     - 11-16-0018, "TDMA for Eliminating Hidden Station Effect in Dense Networks," Evgeny Khorov (IITP)
     - 11-16-0028, "Follow Up for Multi-STA BA for SU Transmissions," Xiaofei Wang (InterDigital)
     - 11-16-0029, "TXOP Truncation Enhancement," Xiaofei Wang (InterDigital)
     - 11-16-0042, "BSS Color Settings for a Multiple BSSID Set," Geonjung Ko (WILUS)
     - 11-16-0050, "Fragmentation for MU frames-Follow up on acks," Alfred Asterjadhi (Qualcomm)
     - 11-16-0051, "Response Give Trigger Type," David Xun Yang (Huawei)
     - 11-16-0068, "BSS Color and Multiple BSSID," Liwen Chu (Marvell)
     - 11-16-0069, "Multi-TID A-MPDU in MU Transmission," Liwen Chu (Marvell)
     - 11-16-0087, "NAV cancellation issues on MU protection," Jinsoo Ahn (Yonsei Univ.)
     - 11-16-0102, "High Efficiency Medium Access via Rosters," Sean Coffey (RealTek)
   - **Multi-User (MU)** — 9 submissions
     - 11-16-0031, "Proposed UL MU CS Rules," Lei Wang (Marvell)
     - 11-16-0048, "Protection using MU RTS/CTS," Young Hoon Kwon (Newracom)
     - 11-16-0054, "UL MU CCA Response," Kaiying Lv (ZTE)
     - 11-16-0057, "Indication for UL MU Carrier Sensing," Kiseon Ryu (LG Electronics)
     - 11-16-0065, "Duration/ID field in UL-MU," Tomo Adachi (Toshiba)
     - 11-16-0066, "Views on UL-MU Features," Joonsuk Kim (Apple)
     - 11-16-0067, "MAC Padding in Trigger Frame," Liwen Chu (Marvell)
     - 11-16-0085, "Congestion control for UL MU random access," Woojin Ahn (Yonsei Univ.)

        - 11-16-0091, "Regarding HE NDPA frame for DL Sounding Sequence," Narendar Madhavan (Toshiba)
    - **Spatial Reuse (SR)** — 1 submission
        - 11-16-0060, "Recipient-aware Spatial Reuse," Reza Hedayat (Newracom)
    - **Others (presented in the TGax full session)** — 4 submissions
        - 11-15-1095, "OFDMA Performance in 11ax," Suhwook Kim (LG Electronics)
        - 11-16-0024, "Proposed draft specification," Robert Stacy (Intel)
        - 11-16-0043, "Clarification of SFD Texts," John Son (WILUS)
        - 11-16-0059, "Non-contiguous Channel Bonding in 11ax," Yunbo Li (Huawei)
4. **Draft Specification**
    - Document 11-16-0024-00 was submitted by the TG Editor and it includes a "draft" draft specification.
    - The submission was reviewed by the TG Editor and is available on mentor to be reviewed by TG members.
5. **Plan for Progressing TG Draft**
    - Approve the TG draft specification during the March 2016 meeting.
        - Draft 0.1
    - Start a comment collection (CC) for 30 days on draft 0.1 - Ends some time in April.
    - Comment resolution (May and July)
    - Draft 1.0 in July 2016 and start WG LB.

Goals for the March 2016 session

- Discuss Proposals affecting the TG Specification Framework document
- Approve D0.1 of the TG Draft
- Approve a 30-day Comment Collection Process.

Teleconferences

Three teleconferences are planned before the March 2016 session.

Thursday	February 4th, 2016,	10:00 - 12:00 (ET)
Thursday	February 18th, 2016	20:00 - 22:00 (ET)
Thursday	March 3rd, 2016,	10:00 - 12:00 (ET)

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November 2015 — Dallas, TX

The TGax originally planned 10 sessions during the week.
One session was added during the WG mid-week plenary session.
Five out of eleven sessions were assigned to the ad hoc groups.

	Monday	Tuesday		Wednesday		Thursday
AM1	**TGax** (full, ad hoc)			**TGax** (full)		**TGax** (full)
AM2		**TGax** (PHY ad hoc)	**TGax** (MAC ad hoc)			**TGax** (full)
PM1	**TGax** (full)	**TGax** (MU ad hoc)	**TGax** (SR ad hoc)	**TGax** (PHY ad hoc)	**TGax** (SR ad hoc)	**TGax** (full)
PM2				**TGax** (PHY ad hoc)	**TGax** (MU ad hoc)	
PM3		**TGax** (PHY ad hoc)	**TGax** (MAC ad hoc)			

Main documents

The meeting agenda and minutes of the TGax and its subgroups, and the TGax closing report can be found here.

- TGax
  - 11-15-1232-04, TGax November 2015 Meeting Agenda
  - 11-15-1368-01, IEEE 802.11 TGax November 2015 Dallas Meeting Minutes
  - 11-15-1457-00, TGax November 2015 Closing Report

  - TGax PHY ad hoc group
    - 11-15-1385-03, TGax PHY Ad Hoc November 2015 Meeting Agenda
    - 11-15-1442-00, November 2015 Dallas TGax PHY Ad Hoc Meeting Minutes
  - TGax MAC ad hoc group
    - 11-15-1382-03, TGax MAC Ad Hoc November 2015 Meeting Agenda
    - 11-15-1414-00, Nov 2015 Dallas TGax MAC ad hoc meeting minutes
  - TGax Multi-User (MU) ad hoc group
    - 11-15-1418-02, TGax MU Ad-hoc Agenda November 2015
    - 11-15-1423-01, November 2015 Dallas TGax MU Ad Hoc Meeting minutes
  - TGax Spatial Reuse (SR) ad hoc group
    - 11-15-1403-06, TGax SR Ad Hoc November 2015 Agenda
    - 11-15-1421-01, Minutes of the IEEE 802.11ax Spatial Reuse ad hoc group meeting - Dallas, November 2015

Achievements

1. **Passed a number of motions affecting all aspects of the TG Specification Framework**
   - PHY — 33 motions.
   - MAC — 16 motions.
   - Multi-User (MU) — 12 motions.
   - Spatial Reuse (SR) — 1 motion.
2. **TG Documents**
   - Latest revision of the Specification Framework is available
     - https://mentor.ieee.org/802.11/dcn/15/11-15-0132-10-00ax-spec-framework.docx
   - Approved new revisions of the TGax Simulation Scenario and Evaluation Methodology documents.
     - Simulation Scenarios
     - Evaluation Methodology
   - Other documents
     - TGax Channel Models
     - 802.11ax Functional Requirements
3. **Technical Presentations**
   70 technical submissions have been covered during the week.
   A list of the submissions is here which is also contained in the agenda document.
   - **PHY** — 27 submissions
     - 11-15-1059, "SIG-B Encoding Structure Part II," Ron Porat (Broadcom)
     - 11-15-1289, "Non-Uniform Constellations for 1024-QAM," Thomas Handte (Sony)
     - 11-15-1303, "LTF Sequence Designs," Sungho Moon (Newracom)
     - 11-15-1304, "Supported Resource Allocations in SIG-B," Sungho Moon (Newracom)
     - 11-15-1305, "STBC and Padding Discussions" Hongyuan Zhang (Marvell)
     - 11-15-1309, "Extended Range Support for 11ax," Sameer Vermani (Qualcomm)
     - 11-15-1310, "11ax LDPC Tone Mapper for 160MHz," Bin Tian (Qualcomm)
     - 11-15-1311, "11ax Spectral Mask," Bin Tian (Qualcomm)
     - 11-15-1315, "HE-SIG-B Mapping and Compression," Kaushik Josiam (Samsung)
     - 11-15-1320, "Maximum Tone Grouping Size for 802.11ax Feedback," Kome Oteri (InterDigital)

- 11-15-1321, "Reducing Explicit MIMO Compressed Beamforming Feedback Overhead for 802.11a," Kome Oteri (InterDigital)
- 11-15-1322, "Channel Estimation Enhancement and Transmission Efficiency Improvement Using Beam-Change Indication and 1x HE-LTF," Jianhan Liu (MediaTek)
- 11-15-1323, "HE-STF Sequence," Ensung Park (LG Electronics)
- 11-15-1324, "MCS for HE-SIG-B," Dongguk Lim (LG Electronics)
- 11-15-1327, "Diversity Mode in OFDMA," Yujin Noh (Newracom)
- 11-15-1329, "Link Adaptation for HE WLAN," Yujin Noh (Newracom)
- 11-15-1331, "PHY Padding Capability Signaling," Daewon Lee (Newracom)
- 11-15-1332, "Implicit Sounding for HE WLAN," Daewon Lee (Newracom)
- 11-15-1334, "HE-LTF Sequence Design," Le Liu (Huawei)
- 11-15-1335, "HE-SIG-B Contents," Le Liu (Huawei)
- 11-15-1347, "Strategies to reduce MIMO feedback overhead," Filippo Tosato (Toshiba)
- 11-15-1349, "Sounding for Uplink Transmission," Sungho Moon (Newracom)
- 11-15-1350, "Spatial Configuration And Signaling for MU-MIMO," Yakun Sun (Marvell)
- 11-15-1353, "Preamble Formats," Ron Porat (Broadcom)
- 11-15-1354, "SIGA fields and Bitwidths," Ron Porat (Broadcom)
- 11-15-1357, "Extra tones in the preamble," Xiaogang Chen (Intel)
- 11-15-1372, "L-LENGTH Equation Updates," Hongyuan Zhang (Marvell)

- **MAC** — 14 submissions
  - 11-15-1265, "RTS/CTS for UL DL OFDMA Control," Cheeha Kim (POSTECH)
  - 11-15-1278, "HE MU Acknowledgment Procedure," Yongho Seok (Newracom)
  - 11-15-1300, "DL MU transmission sequence," Yong Hoon Kwon (Newracom)
  - 11-15-1318, "Fragmentation for MU frames-Follow up," Alfred Asterjadhi (Qualcomm)
  - 11-15-1319, "Scheduled Trigger frames-Follow up," Alfred Asterjadhi (Qualcomm)
  - 11-15-1330, "A method of transmitting Multi-STA Block frame," Jeongki Kim (LG Electronics)
  - 11-15-1341, "Reception Status of Frames Transmitted in Random Access RUs," Tomoko Adachi (Toshiba)
  - 11-15-1344, "Trigger Frame Format," Simone Merlin (Qualcomm)
  - 11-15-1345, "Trigger type specific information," Kiseon Ryu (LG Electronics)
  - 11-15-1346, "Ack Policy for UL MU Ack transmission," Kiseon Ryu (LG Electronics)
  - 11-15-1351, "Rate MCS Selection Rules for M-BA and DL OFDMA BA," Liwen Chu (Marvell)
  - 11-15-1352, "broadcast STAID in HE SIG B," Liwen Chu (Marvell)
  - 11-15-1355, "Considerations for TDLS transmission in 11ax," Yingpei Lin (Huawei)
  - 11-15-1359, "System Performance Evaluation of 802.11ae," Yu Wang (Ericsson)
- **Multi-User (MU)** — 12 submissions
  - 11-15-1280, "Traffic priority for random Multi User Uplink OFDMA," Stephane Baron (Canon)
  - 11-15-1301, "NAV Rule for UL MU Response," Yingpei Lin (Huawei)
  - 11-15-1312, "MU BAR Frame Format," Reza Hedayat (Newracom)
  - 11-15-1314, "I/Q Imbalance Impact to TGax OFDMA Uplink Reception," Rui Yang (InterDigital)
  - 11-15-1325, "MU-RTS/CTS Follow Up," Po-Kai Huang (Intel)
  - 11-15-1326, "NAV Consideration for UL MU Response Follow Up," Po-Kai Huang (Intel)
  - 11-15-1328, "Scheduling information for UL OFDMA Acknowledgement,"Yujin Noh (Newracom)
  - 11-15-1340, "NDP Announcement for HE Sequence," Narendar Madhavan (Toshiba)
  - 11-15-1364, "Signaling Trigger Information for STAs in 11ax," Chittabrata Ghosh (Intel)
  - 11-15-1369, "Random access based buffer status report," Woojin Ahn (Yunsei Univ.)
  - 11-15-1370, "UL OFDMA Random Access Control," Jinsoo Ahn (Yonsei Univ.)
  - 11-15-1374, "Consideration for protecting cascading MU DL/UL transmission with MU RTS/CTS," Jing Ma (NICT)
- **Spatial Reuse (SR)** — 9 submissions
  - 11-15-1259, "Use of TG ax Scenarios for Spatial Reuse," Graham Smith (SR Tecnologies)
  - 11-15-1284, "Simulation results for spatial reuse in 11ax," Jinmin Kim (LG Electronics)
  - 11-15-1313, "Considerations for Spatial Reuse," Reza Hedayat (Newracom)
  - 11-15-1316, "DSC calibration results with NS-3," M. Shahwaiz Afaqui (T.U. Catalonia)
  - 11-15-1336, "BSS Color Field Size Measurements," Chuck Lukaszewski (Aruba-HP)
  - 11-15-1337, "Secondary Channel CCA of HE STA," John Son (Willus Institute)

- 11-15-1338, "Improving Spatial Reuse During OBSS UL MU Procedure," Geonjung Ko (Willus Institute)
- 11-15-1348, "Multiple NAVs for Spatial Reuse," Sigurd Schelstraete (Quantenna)
- 11-15-1427, "Drivers of the dynamic CCA adaptation," Eduard Garcia-Villegas (Technical Univ. of Catalonia)

- **Others (presented in the TGax full session)** — 8 submissions
  - 11-15-1288, "An issue of wider bandwidth operation at real denser environment," Katsuo Yunoki (KDDI R&D Labs)
  - 11-15-1302, "System Level Simulator Evaluation with/without Capture Effect," Vida Ferdowsi (Newracom)
  - 11-15-1360, "Implications of wrap-around for TGax Scenario 3 and Scenario 4 - follow-up," Marcin Filo (Univ. of Surrey)
  - 11-15-1361, "Energy consumption with Scheduled PSP," Dmitry Akhmetov (Intel)
  - 11-15-1362, "On TGax Scenario 4 channel model - follow-up," Marcin Filo (Univ. of Surrey)
  - 11-15-1363, "Regulatory Landscape for Narrowband Transmissions in 11ax," Ilan Sutskover (Intel)
  - 11-15-1373, "Updated Box5 Calibration Results," Narendar Madhavan (Toshiba)
  - 11-15-1375, "11ax Support for IoT - Requirements and Technological Implications," Shimo Shilo (Huawei)

Goals for the January 2016 session

- Continue to advance TG documents based on submissions.
  - Priority to the TG Specification Framework document.
- TG timeline indicates draft D0.1 will be available in January 2016.
- Technical Presentations.

Teleconferences

One teleconference is planned before the January 2016 session.

Thursday	December 10th, 2015	10:00 - 12:00 (ET)

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September 2015 — Bangkok, Thailand

The TGax originally planned to have 10 sessions during the week.
However, two more sessions are added due to a large number of contributions.
Six out of twelve sessions were assigned to the ad hoc groups.

	Monday	Tuesday	Wednesday	Thursday
AM1			**TGax** (full)	**TGax** (full)
AM2	**TGax** (full)	**TGax** (PHY ad hoc) **TGax** (MAC ad hoc)		
PM1	**TGax** (PHY ad hoc) **TGax** (MAC ad hoc)	**TGax** (MU ad hoc) **TGax** (SR ad hoc)	**TGax** (PHY ad hoc) **TGax** (SR ad hoc)	**TGax** (full)
PM2		**TGax** (full)	**TGax** (full)	
PM3	**TGax** (PHY ad hoc) **TGax** (MAC ad hoc)	**TGax** (MU ad hoc) **TGax** (SR ad hoc)		

Main documents

The meeting agenda and minutes of the TGax and its subgroups, and the TGax closing report can be found here.

- TGax
  - 11-15-0987-06, TGax September 2015 Meeting Agenda

- 11-15-1093-00, IEEE 802.11 TGax September 2015 Bangkok Meeting Minutes
- 11-15-1190-00, TGax September 2015 Closing Report

- TGax PHY ad hoc group
  - 11-15-1125-04, TGax PHY Ad Hoc September 2015 Meeting Agenda
  - 11-15-1205-00, September 2015 Bangkok TGax PHY Ad hoc Meeting Minutes
- TGax MAC ad hoc group
  - 11-15-1126-03, TGax MAC Ad Hoc September 2015 Meeting Agenda
  - 11-15-1130-02, Sep 2015 Bangkok TGax MAC Ad hoc Meeting Minutes
- TGax Multi-User (MU) ad hoc group
  - 11-15-1141-02, TGax MU Ad-hoc Agenda September 2015
  - 11-15-1160-00, September 2015 Bangkok TGax MU Ad Hoc Meeting Minutes
- TGax Spatial Reuse (SR) ad hoc group
  - 11-15-1143-03, TGax Spatial Reuse Ad Hoc September 2015 Agenda
  - 11-15-1206-00, Minutes of the IEEE 802.11ax Spatial Reuse ad hoc group meeting - Bangkok, September 2015

Achievements

1. **Passed a number of motions affecting all aspects of the TG Specification Framework**
   - PHY — 29 motions.
   - MAC — 12 motions.
   - Multi-User (MU) — 15 motions.
   - Spatial Reuse (SR) — 4 motion.
2. **TG Documents**
   - Latest revision of the Specification Framework is available
     - https://mentor.ieee.org/802.11/dcn/15/11-15-0132-09-00ax-spec-framework.docx
   - Approved new revisions of the TGax Simulation Scenarios and Evaluation Methodology documents.
     - Simulation Scenarios (rev. 14)
     - Evaluation Methodology (rev. 10)
   - Other documents
     - TGax Channel Models
     - 802.11ax Functional Requirements
3. **Technical Presentations**

   70 technical submissions have been covered during the week.

   A list of the submissions is here which is also contained in the agenda document.
   - **PHY** — 24 submissions
     - 11-15-0579, "Preamble Design and Auto-detection," Hongyuan Zhang (Marvell)
     - 11-15-0580, "11ax Coding Discussion," Hongyuan Zhang (Marvell)
     - 11-15-0602, "HE-LTF squence for UL MU-MIMO," Xiaogang Chen (Intel)
     - 11-15-0810, "HE PHY Padding and Packet Extension," Hongyuan Zhang (Marvell)
     - 11-15-0823, "Preamble Design and Auto-Detection for 11ax," Sungho Moon (Newracom)
     - 11-15-0826, "HE-SIG-A Transmission for Range Extension," Jiayin Zhang (Huawei)
     - 11-15-0853, "Extensible Preamble Format Design," Leonardo Lanante (Kyutech)
     - 11-15-1031, "DL MU Signaling," Katsuo Yunoki (KDDI)
     - 11-15-1051, "HE NDP frame for sounding," Young Hoon Kwon (Newracom)
     - 11-15-1059, "SIG-B Encoding Structure Part II," Ron Porat (Broadcom)
     - 11-15-1066, "HE-SIG-B Contents," Kaushik Josiam (Samsung)
     - 11-15-1068, "Reliable Transmission Scheme for HE-SIG-B and Data," Jianhan Liu (MediaTek)
     - 11-15-1070, "1024 QAM Proposal," Eunsung Park (LG Electronics)
     - 11-15-1071, "Tone Grouping Factors and NDP format for 11ax," Sameer Vermani (Qualcomm)
     - 11-15-1075, "Number of BSS Color bits," Junichi Iwatani (NTT)
     - 11-15-1077, "HE-SIG-A Content," Jiayin Zhang (Huawei)
     - 11-15-1088, "LTF Design for Uplink MU-MIMO," Daewon Lee (Newracom)
     - 11-15-1089, "Considerations on PHY Padding and Packet Extension in 11ax," Yujin Noh (Newracom)

- 11-15-1091, "Considerations on Range Extension with SIG-A Repetition," Yujin Noh (Newracom)
- 11-15-1092, "Support of 1x/2x/4x OFDM Symbol in HE SU PPDU," Heejung Yu (Yeungnam Univ.)
- 11-15-1106, "SIG-B Structure," Reza Hedayat (Newracom)
- 11-15-1111, "SIG-B Resource Unit Allocation Coding," Amin Jafarian (Newracom)
- 11-15-1119, "Discussions on HE SIG-A Structure," John Son (Wilus Institute)
- 11-15-1122, "Identifiers in HE PPDUs for power saving," Alfed Asterjadhi (Qualcomm)

◦ **MAC** — 18 submissions
- 11-15-1013, "802.11ae & 802.11ax," Guido R. Hiertz (Ericsson)
- 11-15-1014, "Multiple BSSID Element," Guido R. Hiertz (Ericsson)
- 11-15-1015, "Proxy ARB in 802.11ax," Guido R. Hiertz (Ericsson)
- 11-15-1033, "Data field in HE PPDU," Yongho Seok (Newracom)
- 11-15-1034, "Notification of Operating Mode Changes," Yongho Seok (Newracom)
- 11-15-1044, "Further Study of 11ax Multicast," Kazuyuki Sakoda (Sony)
- 11-15-1052, "Bandwidth for UL MU transmission," Young Hoon Kwon (Newracom)
- 11-15-1060, "Receive Operating Mode Indication for Power Save," Eric Wong (Apple)
- 11-15-1063, "11ax Channel access procedure," Chao-Chun Wang (MediaTek)
- 11-15-1067, "MU TXOP truncation," Jeongki Kim (LG Electronics)
- 11-15-1096, "Recovery Procedures in Cascading Sequences," John Son (Wilus Institute)
- 11-15-1098, "ACK/BA frame for UL MU under cascading structure," Narendar Madhavan (Toshiba)
- 11-15-1114, "Airtime Analysis of EDCA," Sean Coffey (RealTek)
- 11-15-1115, "High Efficiency in Accessing the Medium," Sean Coffey (RealTek)
- 11-15-1116, "Trigger Frame Channel Access," Jinsoo Ahn (Yonsei Univ.)
- 11-15-1120, "Buffer Status Report," Alfred Asterjadhi (Qualcomm)
- 11-15-1121, "HE A-Control field," Alfred Asterjadhi (Qualcomm)
- 11-15-1137, "Triggered OFDMA Random Access Observations," Russell Huang (MediaTek)

◦ **Multi-User (MU)** — 15 submissions
- 11-15-1043, "Overall Protocol of UL MU BA for Multicast Transmission," Kazuyuki Sakoda (Sony)
- 11-15-1047, "RU selection process upon TF-R reception," Stephane Baron (Canon)
- 11-15-1053, "Multiuser Block ACK Request (MU-BAR)," Guoqing Li (Apple)
- 11-15-1057, "Multiple Resource Unit Allocation for TGax OFDMA," Kome Oteri (InterDigital)
- 11-15-1062, "NAV Consideration for UL MU Response to Trigger frame," Po-Kai Huang (Intel)
- 11-15-1065, "11ax uplink Multi-TID aggregation," Chao-Chun Wang (MediaTek)
- 11-15-1086, "Consideration on multi-STA BA frame indication," Jing Ma (NICT)
- 11-15-1097, "Reducing Channel Sounding Protocol Overhead for 11ax," Narendar Madhavan (Toshiba)
- 11-15-1102, "Fragmentation with MU Operation," Chittabrata Ghosh (Intel)
- 11-15-1103, "DL Sounding Sequence with UL MU Feedback," Chittabrata Ghosh (Intel)
- 11-15-1105, "UL OFDMA-based Random Access Procedure," Chittabrata Ghosh (Intel)
- 11-15-1107, "Power Save with Random Access," Chittarata Ghosh (Intel)
- 11-15-1117, "Regarding UL MU protection," Woojin Ahn (Yonei Univ.)
- 11-15-1123, "Acknowledgement to DL MU," Liwen Chu (Marvell)
- 11-15-1129, "Feedback overhead in DL-MU-MIMO," Filippo Tosato (Toshiba)

◦ **Spatial Reuse (SR)** — 12 submissions
- 11-15-1045, "Dynamic CCA control and TPC Simulation Results with SS1-SS3," Takeshi Itagaki (Sony)
- 11-15-1058, "CCA consideration for UL MU transmission," Kiseon Ryu (LG Electronics)
- 11-15-1069, "Adaptive CCA and TPC," James Wang (MediaTek)
- 11-15-1081, "Further consideration on receive behaviour based on the cascading structure and the BSS color scheme," Jing Ma (NICT)
- 11-15-1082, "Analysis of BSS and ESS Structure During Concurrent SR Transmissions," Chuck Lukaszewski (Aruba/HP)
- 11-15-1083, "Cost/Benefit Analysis of SR Techniques," Chuck Lukaszewski (Aruba/HP)
- 11-15-1101, "DSC/DCCA Calibration with TGax Agreed Scenarios," Masahito Mori (Sony)
- 11-15-1104, "TXOP Considerations for Spatial Reuse," Reza Hedayat (Newracom)
- 11-15-1109, "OBSS NAV and PD Threshold Rule for Spatial Reuse," Rossi Jun Luo (Huawei)
- 11-15-1110, "BSS TXOP," Amin Jafarian (Newracom)
- 11-15-1118, "Discussions on Spatial Reuse Enhancement," Geonjung Ko (WILUS)

    - 11-15-1138, "To DSC or not to DSC," Filip Mestanov (Ericsson)
  - **Simulation, calibration, and other submissions** — 12 submissions
    - 11-15-1039, "Spatial Reuse Measurements," Chuck Lukaszewski (Aruba Networks, a HP company)
    - 11-15-1046, "MAC calibration results," Stephane Baron (Canon)
    - 11-15-1048, "On TGax Scenario 4 channel model," Marcin Filo (Univ. of Surrey)
    - 11-15-1049, "Implications of wrap-around for TGax Scenario 3 and Scenario 4," Marcin Filo (Univ. of Surrey)
    - 11-15-1056, "Clarifying Link Level Simulator Assumptions," Kome Oteri (InterDigital)
    - 11-15-1087, "MU BFee Interference channel feedback," Sigurd Schelstraete (Quantenna)
    - 11-15-1095, "OFDMA performance in 11ax," Suhwook Kim (LG Electronics)
    - 11-15-1099, "Power Save Simulation Results," Hyeyoung Choi (LG Electronics)
    - 11-15-1100, "Discussion on Deep and Shallow Sleep States," Chittabrata Ghosh (Intel)
    - 11-15-1113, "Box5 Calibration results," Vida Ferdowsi (Newracom)
    - 11-15-1134, "11ax Support for IoT," Shimi Shilo (Huawei)
    - 11-15-1135, "Results for SS6 calibration case for single BSS and OBSS," Esa Tuomaala (Nokia)

Goals for the November 2015 session

- Continue to advance TG documents based on submissions.
  - Priority to the TG Specification Framework document.
- Technical Presentations.

Teleconferences

Three teleconferences are scheduled after the November 2015 session.

Thursday	October 15th, 2015	10:00 - 12:00 (ET)

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July 2015 — Waikoloa, HI

TGax originally planned to have nine sessions during the week.
Two more sessions were added during the mid-week plenary session (marked red).
Four out of eleven sessions were ad hoc sessions.

	Monday	Tuesday	Wednesday	Thursday
AM1	**TGax** (full, ad hoc)			**TGax** (full)
AM2		**TGax** (PHY ad hoc) **TGax** (MAC ad hoc)		**TGax** (full)
PM1	**TGax** (full)	**TGax** (MU ad hoc) **TGax** (SR ad hoc)	**TGax** (PHY ad hoc) **TGax** (MAC ad hoc)	**TGax** (full)
PM2			**TGax** (PHY ad hoc) **TGax** (MU ad hoc)	**TGax** (full)
PM3		**TGax** (full)		

Main documents

The meeting agenda and minutes of the TGax and its subgroups, and the TGax closing report can be found here.

- TGax

- 11-15-0735-05, TGax July 2015 Meeting Agenda
- 11-15-0884-00, IEEE 802.11 TGax July 2015 Waikoloa Meeting Minutes
- 11-15-0963-00, TGax July 2015 Closing Report

- TGax PHY ad hoc group
  - 11-15-0898-03, TGax PHY Ad Hoc July 2015 Meeting Agenda
  - 11-15-0913-00, July 2015 Hawaii TGax PHY Ad hoc Meeting Minutes
- TGax MAC ad hoc group
  - 11-15-0888-02, TGax MAC Ad Hoc July 2015 Meeting Agenda
  - 11-15-922-01, July 2015 Hawaii TGax MAC Ad hoc Meeting Minutes
- TGax Multi-User (MU) ad hoc group
  - 11-15-0899-02, TGax MU Ad-hoc Agenda July 2015
  - 11-15-0949-01, July 2015 Hawaii TGax MU Ad Hoc Meeting Minutes
- TGax Spatial Reuse (SR) ad hoc group
  - 11-15-0911-01, TGax Spatial Reuse Ad Hoc July 2015 Agenda
  - 11-15-0971-01, Minutes of the IEEE 802.11ax Spatial Reuse ad hoc group meeting - Hawaii, July 2015

Achievements

1. **Passed a number of PHY, MAC and MU motions affecting the TGax Specification Framework**
   - PHY — SIG-A, SIG-B, Pilots, etc.
   - MAC — Trigger frame, etc.
   - Multi-User (MU) — Trigger frame for random access, MU CTS, etc.
2. **TG Documents**
   - Latest revision of the Specification Framework (rev. 7) is available.
     - https://mentor.ieee.org/802.11/dcn/15/11-15-0132-07-00ax-spec-framework.docx
   - Approved new revisions of the TGax Simulation Scenarios and Evaluation Methodology documents.
     - Simulation Scenarios (rev. 14)
     - Evaluation Methodology (rev. 10)
   - Other documents
     - TGax Channel Models
     - 802.11ax Functional Requirements
3. **Technical Presentations**

   More than 70 technical submissions have been covered during the week.

   A list of the submissions is here which is also contained in the agenda document.
   - **PHY** — 23 submissions
     - 11-15-0579, "preamble design and autodetection," Hongyuan Zhang (Marvell)
     - 11-15-0580, "11ax coding discussion," Hongyuan Zhang (Marvell)
     - 11-15-0602, "HE-LTF sequence for UL MU-MIMO," Qinghua Li (Intel)
     - 11-15-0805, "SIG-B field for HEW PPDU," Young Hoon Kwon (Newracom)
     - 11-15-0810, "HE PHY Padding and Packet Extension," Hongyuan Zhang (Marvell)
     - 11-15-0812, "Pilot Design for Data Section," Sameer Vermani (Qualcomm)
     - 11-15-0813, "CP Indication for UL MU Transmission," Zhigang Rong (Huawei)
     - 11-15-0816, "Interleaver and Tone Mapper for OFDMA," Yakun Sun (Marvell)
     - 11-15-0817, "P Matrix for HE-LTF," Yakun Sun (Marvell)
     - 11-15-0819, "11ax OFDMA Tone Plan Leftover Tones and Pilot Structure," Bin Tian (Qualcomm)
     - 11-15-0821, "HE SIG-B Structure," Joonsuk Kim (Apple)
     - 11-15-0822, "SIG-A Structure in 11ax Preamble," Jianhan Liu (MediaTek)
     - 11-15-0823, "Preamble Design and Auto-Detection for 11ax," Sungho Moon (Newracom)
     - 11-15-0824, "Pilot Design for 11ax Downlink Transmissions," Yujin Noh (Newracom)
     - 11-15-0826, "HE-SIG-A transmission for range extension," Jiayin Zhang (Huawei)
     - 11-15-0827, "Considerations on HE-SIG-A and B," Katsuo Yunoki (KDDI Labs)
     - 11-15-0832, "Performance evaluation of SU/MU MIMO in OFDMA," Jiayin Zhang (Huawei)
     - 11-15-0845, "LTF Design for Uplink MU-MIMO," Daewon Lee (Newracom)

- 11-15-0853, "Extensible Preamble Format Design," Leonardo Lanante (Kyushu Institute of Technology)
- 11-15-0865, "Discussion of ACI performance and ACI requirements for IEEE 802.11ax," Leif Wilhelmsson (Ericsson AB)
- 11-15-0868, "Impact of Frequency Selective Scheduling Feedback for OFDMA," Hakan Persson (Ericsson)
- 11-15-0873, "SIG-B Encoding Structure," Ron Porat (Broadcom)
- 11-15-0887, "Efficient padding for last OFDM symbol," Heejung Yu (Newracom)

- **MAC** — 14 submissions
  - 11-15-0615, "DL OFDMA Bandwidth," Liwen Chu (Marvell)
  - 11-15-0803, "Frame Collision Information Management," Peng Shao (NEC Communication Systems)
  - 11-15-0831, "Broadcast and Unicast (Trigger) in DL MU," Liwen Chu (Marvell)
  - 11-15-0841, "Cascading Structure," David Xun Yang (Huawei Technologies)
  - 11-15-0851, "HE Trigger Frame Format," John Son (WILUS Institute)
  - 11-15-0856, "Compressed Uplink Trigger Frame," Vida Ferdowsi (Newracom)
  - 11-15-0871, "Efficiency enhancement for 802.11ax," Guido R. Hiertz (Ericsson)
  - 11-15-0872, "802.11ai and 802.11ax," Guido R. Hiertz (Ericsson)
  - 11-15-0874, "Minimal data rates management frame transmissions in 2.4 GHz," Guido R. Hiertz (Ericsson)
  - 11-15-0876, "Duration and MAC Padding for MU PPDU," Simone Merlin (Qualcomm)
  - 11-15-0877, "Trigger Frame Format," Simone Merlin (Qualcomm)
  - 11-15-0878, "Issues on Trigger Frame Retransmission," Jinsoo Ahn (Yonsei Univ.)
  - 11-15-0880, "Scheduled Trigger frames," Alfred Asterjadhi (Qualcomm)
  - 11-15-0914, "Enlarged minimal contention window size," Guido R. Hiertz (Ericsson)
- **Multi-User (MU)** — 13 submissions
  - 11-15-0800, "Multiplexing of Acknowledgements for Multicast Transmission," Yusuke Tanaka (Sony)
  - 11-15-0806, "Protection for MU transmission," Young Hoon Kwon (Newracom)
  - 11-15-0818, "Further Analysis of Feedback and Frequency Selective Scheduling (FSS) for TGax OFDMA," Kome Oteri (InterDigital Communication)
  - 11-15-0829, "Uplink ACK and BA Multiplexing," Reza Hedayat (Newracom)
  - 11-15-0843, "UL MU OFDMA analysis," Yonggang Fang (ZTE)
  - 11-15-0852, "Transmission Interval of Trigger Frames," Leonardo Lanante (Kyushu Institute of Technology)
  - 11-15-0854, "DL OFDMA Signalling," Tomoko Adachi (Toshiba)
  - 11-15-0855, "How to collect STAs[illegible]f Tx demands for UL MU," Tomoko Adachi (Toshiba)
  - 11-15-0858, "MU BFee Interference channel feedback," Sigurd Schelstraete (Quantenna)
  - 11-15-0859, "A mechanism for incremental updates to MU precoding," Sigurd Schelstraete (Quantenna)
  - 11-15-0867, "MU-RTS/CTS for DL MU," Po-kai Huang (Intel)
  - 11-15-0875, "Random Access with Trigger Frames using OFDMA," Chittabrata Ghosh (Intel)
  - 11-15-0881, "Regarding buffer status of UL-STAs in UL-OFDMA," Woojin Ahn (Yonsei Univ.)
- **Spatial Reuse (SR)** — 8 submissions
  - 11-15-0797, "NAV Operation for Spatial Reuse," Yongho Seok (Newracom)
  - 11-15-0801, "DCCA/DSC Reference Simulation Results," Masahito Mori (Sony)
  - 11-15-0804, "Outdoor Enterprise Scenario and DSC," Graham Smith (SR Technologies)
  - 11-15-0807, "DSC Summary," Graham Smith (SR Technologies)
  - 11-15-0811, "Topics for Consideration for Spatial Reuse," Xiaofei Wang (InterDigital)
  - 11-15-0882, "DSC leveraging uplink RTS/CTS control," M. Shahwaiz Afaqui (Technical University of Catalonia)
  - 11-15-0883, "Follow Up Discussion on The Receiver Behavior," Yasuhiko Inoue (NTT)
  - 11-15-0886, "DSC Calibration Results," Chinghwa Yu (MediaTek)
- **Simulation, calibration, and others** — 13 submissions
  - 11-15-0754, "WLAN Packet traffic and efficiency analysis," Jim Lansford (CSR)
  - 11-15-0781, "Summary of Power Save Calibration Results," Eric Wong (Apple)
  - 11-15-0787, "Power Save Calibration Results," Eric Wong (Apple)
  - 11-15-0788, "Box 1 and Box 2 calibration results," Takeshi Itagaki (Sony)
  - 11-15-0789, "Proposed Changes to Evaluation Methodologies," Allan Jones (Activision)
  - 11-15-0802, "Box5 Calibration Results of SS6," Jiyong Pang (Huawei)
  - 11-15-0814, "Simulation Results for Box5 Calibration," Ke Yao (ZTE)
  - 11-15-0833, "Calibration results for PSP and UAPSD for 20, 40 and 80MHz bands," Dmitry Akhmetov (Intel)
  - 11-15-0680, "Reference Box5 Calibration Assumptions and Parameters," Jiyong Pang (Huawei)

- 11-15-0849, "Simulation Results for Box5 Calibration," Rongzhen Yang (Intel)
- 11-15-0869, "OFDMA and VoIP Capacity," Hakan Persson (Ericsson)
- 11-15-0870, "802.11ax in 2.4 GHz," Guido R. Hiertz (Ericsson)
- 11-15-0885, "Box 5 Calibration Results," ChingHwa Yu (MediaTek)

Goals for the September 2015 session

- Continue to advance TG documents based on submissions.
  - Priority to the TG Specification Framework document.
- Technical Presentations.

Teleconferences

Three teleconferences are planned before the September 2015 meeting.

Thursday	August 20th, 2015	10:00 - 12:00 (ET)

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May 2015 — Vancouver, BC, Canada

The TGax had 10 sessions during the week.
Six out of ten sessions were assigned to the ad hoc groups.

	Monday	Tuesday	Wednesday	Thursday
AM1				**TGax** (full)
AM2	**TGax** (full)	**TGax** (MU ad hoc) **TGax** (SR ad hoc)		
PM1	**TGax** (PHY ad hoc) **TGax** (MAC ad hoc)	**TGax** (PHY ad hoc) **TGax** (SR ad hoc)	**TGax** (PHY ad hoc) **TGax** (MU ad hoc)	**TGax** (full)
PM2			**TGax** (full)	
PM3	**TGax** (full)			

Main documents

The meeting agenda and minutes of the TGax and its subgroups, and the TGax closing report can be found here.

- TGax
  - 11-15-0500-08, TGax May 2015 Meeting Agenda
  - 11-15-0622-00, TGax May 2015 Vancouver Meeting Minutes
  - 11-15-0692-01, TGax May 2015 Closing Report

  - TGax PHY ad hoc group
    - 11-15-0640-04, TGax PHY Ad Hoc May 2015 Meeting Agenda
    - 11-15-0651-02, May 2015 Vancouver TGax PHY Ad hoc Meeting Minutes
  - TGax MAC ad hoc group
    - 11-15-0599-02, TGax MAC Ad Hoc May 2015 Meeting Agenda
    - 11-15-0637-00, May 2015 Vancouver TGax MAC Ad hoc Meeting Minutes
  - TGax Multi-User (MU) ad hoc group
    - 11-15-0645-01, TGax MU Ad-hoc Agenda May 2015

- 11-15-0679-00, May 2015 Vancouver TGax MU Ad Hoc Meeting Minutes
- TGax Spatial Reuse (SR) ad hoc group
  - 11-15-0650-02, TGax Spatial Reuse Ad Hoc May 2015 Agenda
  - 11-15-0662-01, Minutes of the IEEE 802.11ax Spatial Reuse ad hoc group meeting - Vancouver, May 2015

Achievements

1. **Passed a number of PHY, MAC and MU motions affecting the TGax Specification Framework**
   - PHY — SIG-A, SIG-B, Pilots, etc.
   - MAC — Trigger frame, etc.
   - Multi-User (MU) — Trigger frame for random access, MU CTS, etc.
2. **TG Documents**
   - Latest revision of the Specification Framework (rev. 7) is available.
     - https://mentor.ieee.org/802.11/dcn/15/11-15-0132-07-00ax-spec-framework.docx
   - Approved new revisions of the TGax Simulation Scenarios and Evaluation Methodology documents.
     - Simulation Scenarios (rev. 14)
     - Evaluation Methodology (rev. 10)
   - Other documents
     - TGax Channel Models
     - 802.11ax Functional Requirements
3. **Technical Presentations**

   More than 50 technical submissions have been covered during the week.

   A list of the submissions is here which is also contained in the agenda document.
   - **PHY** — 14 submissions
     - 11-15-0550, "L-preamble issues for UL-OFDMA," Katsuo Yunoki (KDDI Labs)
     - 11-15-0553, "Enhancing Performance of Hybrid-ARQ with Linear Constellation Precoding," Muhammad Mehboob Fareed (King Abdullah Univ. of Science and Technology)
     - 11-15-0569, "Performance of 1x, 2x, and 4x HE-LTF," Kome Oteri (InterDigital)
     - 11-15-0572, "Inefficiency of 256-FFT per 20MHz," Heejung Yu (Yeungnam Univ./Newracom)
     - 11-15-0574, "SIG structure for UL PPDU," Young Hoon Kwon (Newracom)
     - 11-15-0575, "Preamble Structure in 802.11ax," Yujin Noh (Newracom)
     - 11-15-0577, "Pilot Design for 11ax," Daewon Lee (Newracom)
     - 11-15-0579, "Preamble design and auto-detection," Hongyuan Zhang (Marvell)
     - 11-15-0580, "11ax coding discussion," Hongyuan Zhang (Marvell)
     - 11-15-0584, "Considerations on LTF Sequence Design," Sungho Moon (Newracom)
     - 11-15-0600, "Non Uniform Constellations for 1024QAM," Daniel Schneider (Sony)
     - 11-15-0602, "HE-LTF sequence for UL MU-MIMO," Qinghua Li (Intel)
     - 11-15-0621, "Design Principles for HE Preamble," John Son (WILUS)
     - 11-15-0381, "HE-STF Proposal," Yakun Sun (Marvell)
   - **MAC** — 6 submissions
     - 11-15-0567, "Multi-STA BA for SU Transmissions," Xiaofei Wang (InterDigital)
     - 11-15-0604, "Random Access with Trigger Frames using OFDMA," Chittabrata Ghosh (Intel)
     - 11-15-0611, "Multi-STA Block ACK Protection," Jinsoo Ahn (Yonsei Univ.)
     - 11-15-0615, "UL OFDMA Bandwidth," Liwen Chu (Marvell)
     - 11-15-0617, "Duration and MAC Padding for UL MU PPDUs," Gang Ding (Qualcomm)
     - 11-15-0626, "Further consideration for Multi-STA Block ACK frame," Jeongki Kim (LG)
     -
   - **Multi-User (MU)** — 7 submissions
     - 11-15-0378, "Channel Sensing in UL OFDMA," Reza Hedayat (Newracom)
     - 11-15-0568, "Frequency Selective Scheduling (FSS) for TGax OFDMA," Kome Oteri (InterDigital)
     - 11-15-0586, "Frequency Diversity Options in OFDMA," Reza Hedayat (Newracom)
     - 11-15-0587, "Uplink ACK and BA Multiplexing," Reza Hedayat (Newracom)
     - 11-15-0597, "Beamformed HE PPDU," Yongho Seok (Newracom)
     - 11-15-0608, "Regarding trigger frame in UL MU," Tomo Adachi (Toshiba)

- 11-15-0612, "Multi Channel availability for UL-OFDMA," Woojin Ahn (Yonsei Univ.)

- **Spatial Reuse (SR)** — 5 submissions
  - 11-15-0543, "Simulation Scenario changes for Frequency Re-use," Graham Smith (SR Technologies)
  - 11-15-0544, "Proposed text additions to 14/980 for frequency re-use," Graham Smith (SR Technologies)
  - 11-15-0548, "Enterprise Scenario and DSC," Graham Smith (SR Technologies)
  - 11-15-0588, "CCA revisited II," Amin Jafarian (Newracom)
  - 11-15-0595, "Discussion on The Receiver Behavior for CCAC/DSC with BSS Color," Yasuhiko Inoue (NTT)
- **Simulation, calibration, and others** — 18 submissions
  - 11-15-0551, "OBSS Preamble Detection," Suhwook Kim (LG Electronics)
  - 11-15-0552, "IEEE 802.11 performance in dense, cellular-like, outdoor deployments," Richard Edgar (Imagination Technologies)
  - 11-15-0330, "OFDMA Numerology and Structure," Sharnaz Azizi (Intel)
  - 11-15-0583, "OBSS Preamble Error Probability," Jiyong Pan (Huawei)
  - 11-15-0590, "Traffic Model Updates to Evaluation Methodology," Phil Barber (Huawei)
  - 11-15-0674, "Joint submission for Box 5 Calibration," Suhwook Kin (LG Electronics)
  - 11-15-0581, "LSP Correlation Clarification for Scenario 4," Daewon Lee (Newracom)
  - 11-15-0582, "Clarifications to Box 2 MIMO simulation calibrations," Daewon Lee (Newracom)
  - 11-15-0373, "Mixed traffic configurations on simulation scenarios," Yingpei Lin (Huawei)
    - Not presented since the contents of this submission was merged into 11-15-0590.
  - 11-15-0610, "Simulation Results for Box 5 Calibration," Vida Ferdowsi (Newracom)
  - 11-15-0613, "Box 5 Calibration Result," Chinghwa Yu (MediaTek)
  - 11-15-0623, "TGax simulation scenario "Box 5" - calibration results," Guido Hiertz (Ericsson)
  - 11-15-0316, "Power Save Calibrations," Hyeyoung Choi (LG Electronic)
  - 11-15-0564, "802.11ax Calibration and Modeling Adjacent Channel Interference," Naveen Kakani (CSR)
  - 11-15-0576, "Latency and Power Consumption in State Transitions," Chittabrata Ghosh (Intel)
  - 11-15-0592, "More Power Save Calibration Results," Eric Wong (Apple)
  - 11-15-0598, "U-APSD Enhancement for HE," Jarkko Kneckt (Nokia)
  - 11-15-0603, "Calibration Results for PSP and U-APSD," Chittabrata Ghosh (Intel)

Goals for the July 2015 session

- Continue to advance TG documents based on submissions.
  - Expectation is more submissions affecting the TG specification framework document will be considered.
- Technical Presentations.

Teleconferences

Three teleconferences are planned before the July 2015 session.

Thursday	June 18th, 2015	10:00 - 12:00 (ET)

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March 2015 — Berlin, Germany

TGax originally planned nine sessions during the week.
However, one more session was added (Wednesday PM2).

	Monday	Tuesday	Wednesday		Thursday
AM1	**TGax** (full, ad hoc)		**TGax** (MU ad hoc)	**TGax** (SR ad hoc)	**TGax** (full)

	Monday	Tuesday	Wednesday	Thursday
AM2		**TGax** (PHY ad hoc) **TGax** (MAC ad hoc)		
PM1	**TGax** (full)	**TGax** (full)	**TGax** (full)	**TGax** (full)
PM2			**TGax** (full)	
PM3		**TGax** (full)		

Main documents

The meeting agenda, minutes, and closing report of the TGax can be found here.

- 11-15-0235-08, TGax March 2015 Meeting Agenda
- 11-15-0309-01, TGax March 2015 Berlin Meeting Minutes
- 11-15-0465-00, TGax March 2015 Closing Report

Achievements

1. **Passed a number of PHY, MAC and MU motions affecting the TGax Specification Framework**
   - PHY — LTF and SIG-B design.
   - MAC — Multi-User Block Ack and Multi-User procedures.
   - Multi-User (MU) — Ack multiplexing.
   - etc.
2. **TG Documents**
   - Approved new revisions of the TGax Simulation Scenarios and Evaluation Methodology documents.
     - Simulation Scenarios (rev. 9)
     - Evaluation Methodology (rev. 8)
   - Other documents
     - TGax Channel Models
     - 802.11ax Functional Requirements
3. **Technical Presentations**

   Following technical submissions have been covered during the week.
   - **PHY** — 12 submissions
     - 11-15-0305, "Effective Subcarrier Assignment for DL-OFDMA," Katsuo Yunoki (KDDI R&D Laboratories)
     - 11-15-0330, "OFDMA Numerology and Structure," Shahrnaz Azizi (Intel Corporation)
     - 11-15-0344, "SIG field design principle for 11ax," Young Hoon Kwon (Newracom)
     - 11-15-0349, "HE-LTF Proposal," Hongyuan Zhang (Marvell)
     - 11-15-0358, "Numerology for 11ax," Daewon Lee (Newracom)
     - 11-15-0360, "Preamble Auto-Detection for 802.11ax," Sungho Moon (NEWRACOM)
     - 11-15-0364, "11ax Preamble design: training sequence," Sigurd Schelstraete (Quantenna)
     - 11-15-0375, "Minimum Resource Granularity in OFDMA," John Son (WILUS Institute)
     - 11-15-0378, "Channel Sensing in UL OFDMA," Reza Hedayat (Newracom)
     - 11-15-0380, "Discussion on OFDMA scheduling for 802.11ax," Le Liu (Huawei Technologies)
     - 11-15-0381, "HE-STF Proposal," Yakun Sun (Marvell)
     - 11-15-0383, "Impact of number of sub-channels in OFDMA," Leif Wilhelmsson (Ericsson)
   - **MAC** — 6 submissions
     - 11-15-0320, "GCR-BA with Measurement Report Performance in OBSS," Yuichi Morioka (SONY)
     - 11-15-0336, "MAC Overhead Analysis of MU Transmissions," Xiaofei WANG (InterDigital)
     - 11-15-0362, "Beacon Transmission Issues," Yonggang Fang (ZTE)
     - 11-15-0365, "UL MU Procedure," Kiseon Ryu (LG Electronics)
     - 11-15-0366, "Multi-STA BA," Simone Merlin (Qualcomm)
     - 11-15-0376, "UL-MU MAC Throughput Under Non-Full Buffer Traffic," Tatsumi Uwai (Radrix Co. Ltd)
   - **Multi-User (MU)** — 9 submissions

- 11-15-0331, "Uplink Multi-User MIMO Protocol Design," Yongho Seok (NEWRACOM)
- 11-15-0333, "Throughput Comparison of Some Multi-user Schemes in 802.11ax," Kome Oteri (InterDigital)
- 11-15-0336, "MAC Overhead Analysis of MU Transmissions," Xiaofei WANG (InterDigital)
- 11-15-0353, "OFDMA Non-contiguous Channel Utilization," Jinsoo Ahn (Yonsei univ.)
- 11-15-0354, "Bandwidth granularity on UL-OFDMA data allocation," Woojin Ahn (Yonsei Univ.)
- 11-15-0363, "UL MU Synchronization Requirements," Yonggang Fang (ZTE)
- 11-15-0377, "Considerations on UL MU Resource Scheduling," Leonardo Lanante (Kyutech)
- 11-15-0379, "DL OFDMA Performance and ACK Aggregation," Reza Hedayat (Newracom)
- 11-15-0384, "Discussion on DL-OFDMA Sub-channel Indication Method," Yu Cai (Lenovo)

- **Spatial Reuse (SR)** — 7 submissions
  - 11-15-0300, "Potential of Modified Signal Detection Thresholds," Gustav Wikstrom (Ericsson AB)
  - 11-15-0318, "CCA Regime Evaluation Revisited," Amin Jafarian (Newracom Inc.)
  - 11-15-0319, "Impact of TPC coupled to DSC for legacy unfairness issue," Masahito Mori (Sony)
  - 11-15-0338, "Discussions on the Definition of CCA Threshold," Akira Kishida (NTT)
  - 11-15-0367, "OBSS preamble detection," Gwen Barriac (Qualcomm)
  - 11-15-0371, "Proposal and simulatin based evaluation of DSC-AP Algorithm," Eduard Garcia-Villegas (UPC)
  - 11-15-0374, "Further Considerations on Legacy Fairness with Enhanced CCA," John Son (WILUS Institute)
- **Simulation, calibration, and others** — 24 submissions
  - 11-14-1392, "Simulation results for Box-5 calibration," Suhwook Kim (LG Electronics)
  - 11-14-1434, "SLS Box4 Calibration Results," Russell Huang (MediaTek Inc.)
  - 11-15-0053, "Box5 Results of 11ac SS6," Jiyong Pang (eHuawei)
  - 11-15-0072, "U-APSD power saving calibration results," Yanchun Li (Huawei)
  - 11-15-0125, "Box 1 and Box 2 Calibration Results," Ron Porat (Broadcom)
  - 11-15-0304, "Evaluating Power Save Performance," Joonsuk Kim (Apple)
  - 11-15-0306, "Power Save Mode Calibration Results," Eric Wong (Apple)
  - 11-15-0307, "MAC calibration results for Test 4," Ke Yao (ZTE Corp.)
  - 11-15-0308, "Simulation results for box 5," Ke Yao (ZTE Corp.)
  - 11-15-0314, "Sleep States in IEEE 802.11ax Simulation Scenarios," Chittabrata Ghosh (Intel)
  - 11-15-0316, "Power Save Calibration," Hyeyoung Choi (LG)
  - 11-15-0326, "U-APSD Enhancements for HE," Jarkko Kneckt (Nokia)
  - 11-15-0327, "Microsleep for HE STA," Jarkko Kneckt (Nokia)
  - 11-15-0343, "In Situ Frame Size Measurements," Chuck Lukaszewski (Aruba Networks)
  - 11-15-0351, "Empirical Measurements of Channel Degradation Under Load," Chuck Lukaszewski (Aruba Networks)
  - 11-15-0357, "Scenario 1 CCA Simulation," Knut Odman (Broadcom Corporation)
  - 11-15-0359, "Clarification of MIMO Box2 calibration," Jaehyun Ahn (Newracom)
  - 11-15-0368, "Box 5 results for Single BSS Calibration Case," Esa Tuomaala (Nokia)
  - 11-15-0369, "MAC calibration test 4 simulation results," Enrico-Henrik Rantala (Nokia)
  - 11-15-0370, "MAC Calibration Results," Guoqing Li (Apple)
  - 11-15-0372, "Corrections on Reference Traffic Profile for Scenario 2 in Simulation Scenarios Document," Yingpei Lin (Huawei)
  - 11-15-0373, "Mixed traffic configurations on simulation scenarios," Yingpei Lin (Huawei)
  - 11-15-0382, "MAC calibration test 4 simulation results," Yanchun Li (Huawei)
  - 11-15-0441, "Proposed text to TGax Simulation Scenarios MAC test 4," Enrico-Henrik Rantala (Nokia)

Goals for the May 2015 session

- Continue to advance TG documents based on submissions.
  - Expectation is more submissions affecting the TG specification framework document will be considered.
- Technical Presentations.

Teleconferences

Three teleconferences are planned before the May 2015 session.

Thursday	April 9th, 2015	10:00 - 12:00 (ET)
Thursday	April 30th, 2015	20:00 - 22:00 (ET)

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January 2015 — Atlanta, GA

The TGax planned to have 9 sessions during the week.
One session (Thursday PM2) was cancelled upon completion of the business.

	Monday	Tuesday	Wednesday	Thursday
AM1			**TGax** (full)	**TGax** (full)
AM2	**TGax** (full)	**TGax** (full)		
PM1	**TGax** (full)	**TGax** (full)	**TGax** (full)	**TGax** (Cancelled)
PM2				
PM3	**TGax** (full)			

Main documents

The meeting agenda, minutes, and closing report of the TGax can be found here.

- 11-14-1578-06, TGax January 2015 Meeting Agenda
- 11-15-0090-00, TGax January 2015 Atlanta Meeting Minutes
- 11-15-0186-00, TGax January 2015 Closing Report

Achievements

1. **TG Structure**
   Co-chairs for the ad hoc groups are elected.

MAC	PHY	Multi-User (MU)	Spatial Reuse (SR)
Eric Wong (Apple)	Bo Sun (ZTE)	Sigurd Schelstraete (Quantenna)	Laurent Cariou (Orange)
Reza Hedayat (Newracom)	Jianhan Liu (MediaTek)	Kiseon Ryu (LG Electronics)	Guido R. Hiertz (Ericsson)
Brian Hart (Cisco)	Yakun Sun (Marvell)	Kaushik Josiam (Samsung)	Jae Seung Lee (ETRI)

2. **TG Documents**
   - Passed a number of motions affecting the TG specification Framework.
   - Approved new revisions of Simulation Scenarios and Evaluation Methodology TG documents.
     - TGax Simularion Scenarios (11-14-0980-06)
     - TGax Evaluation Methodology (11-14-0571-07)
3. **Technical Presentations**
   Here is the list of the submissions that the TGax received during the week.
   - **DSC and CCA**
     - 11-15-0025, "DSC and Roaming," Graham Smith (SR Technologies)
     - 11-15-0027, "Simulation Based Evaluation DSC in residential scenario," M. Shahwaiz Afaqui (UPC)
     - 11-15-0045, "Performance Analysis of BSS Color and DSC," Masahito Mori (Sony)

- 11-15-0050, "Modeling components impacting throughput gain from CCAT adjustment," Yu Wang (Ericsson AB)
- 11-15-0085, "Legacy Fairness Issues of Enhanced CCA," John Son (WILUS Institute)
- 11-15-0105, "Dynamic CCA Management," Sean Coffey (RealTek)

◦ **OFDMA**
- 11-15-0034, "DL-OFDMA Map Frame," Katsuo Yunoki (KDDI Labs)
- 11-15-0066, "Downlink OFDMA Protocol Design," Yongho Seok (Newracom)
- 11-15-0079, "OFDM Numerology for 11ax," Daewon Lee (Newracom)
- 11-15-0091, "UL-OFDMA Procedure in IEEE 802.11ax," Woojin Ahn (Yonsei Univ.)
- 11-15-0092, "DL-OFDMA Procedure in IEEE 802.11ax," Jinsoo Ahn (Yonsei Univ.)

◦ **Multi-User (MU)**
- 11-15-0010, "draft for integrated UL DL MU MIMO Frame Format," Tae-Yoon Kim (Korea Univ.) - Not presented
- 11-15-0029, "Discussion on integrated UL/DL MU-MIMO," Tae-Yoon Kim (Korea Univ.) - Not presented
- 11-15-0040, "Discussion on integrated UL-DL MU-MIMO-MAC," TaeYoon Kim (Korea Univ.)
- 11-15-0064, "Consideration on UL-MU overheads," Tomoko Adachi (Toshiba)
- 11-15-0086, "Uplink MU Transmission and Legacy Coexistence," Reza Hedayat (NEWRACOM)
- 11-15-0089, "MAC Efficiency Gain of Uplink Multi-user Transmission," Leonardo Lanante Jr (Kyushu Inst. of Tech.)

◦ **MAC**
- 11-15-0035, "Scalable Channel Utilization," Katsuo Yunoki (KDDI R&D Laboratories)
- 11-15-0037, "Structural Format Change," Kyonggi University
- 11-15-0046, "11aa GCR-BA Performance in OBSS," Yuichi Morioka (Sony)
- 11-15-0059, "Uplink RTS/CTS Control," Sigurd Schelstraete (Quantenna)

◦ **PHY**
- 11-15-0048, "Non-Uniform Constellations for Higher Order QAMs," Daniel Schneider (Sony)
- 11-15-0068, "Support of outdoor environments," Young Hoon Kwon (NEWRACOM)
- 11-15-0079, "OFDM Numerology for 11ax," Daewon Lee (NEWRACOM)
- 11-15-0081, "Considerations on 11ax Auto-detection Methods," Jaeyoung Song (KAIST)
- 11-15-0082, "Considerations on 11ax OFDMA Frequency Granularity," Young-bin Kim (KAIST)
- 11-15-0097, "Performance Analysis of Frequency Selective Scheduling," Ningbo Zhang (BUPT)
- 11-15-0099, "Payload Symbol Size for 11ax," Sriram Venkateswaran (Broadcom)
- 11-15-0101, "Preamble structure for 11ax system," Jiayin Zhang (Huawei)

◦ **Simulation Scenarios and Evaluation Methodology**
- 11-14-1342, "MAC Calibration Results," Igor Kim (ETRI)
- 11-14-1343, "Multicast Scenarios for MAC Calibration," Igor Kim (ETRI)
- 11-14-1392, "Simulation Results for Box-5 Calibration," Suhwook Kim (LGE)
- 11-14-1523, "Offline Discussion Minutes of SLS Calibration," Jiyong Pang (Huawei)
- 11-14-1590, "Multi-wall penetration loss model for HEW system level simulation," Kejun Zhao et al. (National Engineering Research Center for Broadband Networks & Applications)
- 11-14-1597, "PHY abstraction and performance for outdoor channel models," Kejun Zhao et al. (National Engineering Research Center for Broadband Networks & Applications)
- 11-15-0022, "MAC Calibration Results," Xiaofei Wang (InterDigital)
- 11-15-0044, "Proposed Changes to Simulation Scenarios," Masahito Mori (Sony)
- 11-15-0051, "Box5 Calibration Results," Jiyong Pang (Huawei)
- 11-15-0052, "Box5 Results of One BSS Case," Jiyong Pang (Huawei)
- 11-15-0053, "Box5 Results of 11ac SS6," Jiyong Pang (Huawei)
- 11-15-0061, "FPS Network Traffic Model," Allan Jones (Activision)
- 11-15-0065, "11ax EMD Revision Straw Poll," Jiyong Pang (Huawei)
- 11-15-0071, "MAC calibration test 4 results," Yanchun Li (Huawei)
- 11-15-0072, "U-APSD power saving calibration results," Yanchun Li (Huawei)
- 11-15-0073, "Simulation Results of Box5," Ke Yao (ZTE)
- 11-15-0078, "Clarification on calibration test cases," Guoqing Li (Apple)
- 11-15-0080, "MAC Calibration Results," Geonjung Ko (WILUS Institute)
- 11-15-0093, "Text Update on PHY Abstraction and SP," Yakun Sun (Marvell)
- 11-15-0103, "Power Save Calibration," Yarkko Kneckt (Nokia)
- 11-15-0104, "SLS MAC Test 4 Results," Chinghwa Yu (MediaTek)

- **Others**
  - 11-15-0043, "In-band Full Duplex Radios and System Performance," Kapseok Chang (ETRI)
  - 11-15-0075, "Operating Rules for TGax Ad Hoc groups," Osama Aboul-Magd (TGax chair)
  - 11-15-0076, "Field Sample OBSS and Client Data," Carol Ansley (ARRIS Group)

Goals for the March 2015 session

- Continue to advance TG documents based on submissions.
  - Expectation is more submissions affecting the TG specification framework document will be considered.
- Technical Presentations.

Teleconferences

Three teleconferences are planned before the March 2015 session.

Thursday	February 26th, 2015	10:00 - 12:00 (ET)

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November 2014 — San Antonio, TX

The TGax originally planned to have 9 sessions during the week.
FourHowever, one session (Tuesday PM3) was cancelled.

	Monday	Tuesday	Wednesday	Thursday
AM1	**TGax** (ad hoc)			**TGax**
AM2		**TGax**		
PM1		**TGax**	**TGax**	**TGax**
PM2	**TGax**	**TGax**		
PM3		**TGax** (Cancelled)		

Main documents

The meeting agenda, minutes, and the closing report of TGax can be found here.

- 11-14-1319-07, TGax November 2014 Meeting Agenda
- 11-14-1460-00, TGax November 2014 San Antonio Meeting Minutes
- 11-14-1536-00, TGax November 2014 Closing Report

Achievements

1. **Discussions on the TG Structure**
   - The TG approved a motion to create four ad hoc groups.
     - PHY, MAC, Multi-User (MU) and Spatial Reuse (SR)
   - The TG approved a motion to have 3 co-chairs for each of the ad hocs.
   - Ad hoc chairs election is scheduled for January 2015 meeting on Tuesday.
   - Ad hoc meetings will start on March 2015
   - Robert Stacy (Intel) was appointed as the technical editor of the TGax.
2. **TG Documents — The group approved updated documents.**

- The group approved the first version of TGax Specification Framework document (11-14-1453-02).
- The group approved new revisions of the following documents.
  - TGax Simulation Scenarios (11-14-0980-05)
  - TGax Evaluation Methodology (11-14-0571-06).

3. **Technical Presentations**

Here is the list of the 44 submissions that the TGax received.

- **Evaluation Methodology**
  - 11-14-1388, "Consideration on PER Prediction for PHY Abstraction," Bo Sun (ZTE Corp)
  - 11-14-1418, "Further Study of Time Varying Interference and PHY Abstraction," Yakun Sun (Marvell)
  - 11-14-1420, "The Impact of Preamble Error on MAC System Performance," Po-Kai Huang (Intel)
  - 11-14-1424, "Proposed Changes to Evaluation Methodology and Simulation Scenario," Yuichi Morioka (Sony)
  - 11-14-1440, "A Few Corrections to Video Traffic Model," Guoqing Li (Apple)
- **Simulation Scenarios and Calibration**
  - 11-14-1177, "Discussion about Box5 Calibration," Jiyong Pang (Huawei)
  - 11-14-1342, "MAC Calibration Results," Igor Kim (ETRI)
  - 11-14-1343, "Multicast Scenarios for MAC Calibration," Igor Kim (ETRI)
  - 11-14-1392, "Simulation results for Box 5 calibration," Suhwook Kim (LG Electronics)
  - 11-14-1402, "Box1 and Box3 calibration results," Masahito Mori (Sony)
  - 11-14-1419, "SLS Box5 Calibration Results and Discussions," Yakun Sun (Marvell)
  - 11-14-1434, "TGax SLS Box4 Calibration Results," Russell Huang (MediaTek Inc.)
  - 11-14-1441, "Simulation Setting of Box5 Calibration," Jiyong Pang (Huawei)
  - 11-14-1444, "Energy Efficiency Evaluation and Simulation Model," Chinghwa Yu (MediaTek)
  - 11-14-1449, "MAC Calibration Results," Newracom
  - 11-14-1450, "Box 0 calibration results," Hongsup Lee (Newracom)
  - 11-14-1451, "Box 1 and Box 2 Calibration Results," Jaehyun Ahn (Newracom)
- **Technology/Other**
  - 11-14-1228, "Issues on 256-FFT per 20MHz," Heejung Yu (NEWRACOM/YU)
  - 11-14-1380, "Efficiency Measurement for RTS/CTS," Katsuo Yunoki (KDDI R&D Laboratories)
  - 11-14-1381, "Novel RTS/CTS Procedure," Katsuo Yunoki (KDDI R&D Laboratories)
  - 11-14-1382, "Responses to the comments on doc.1169," Katsuo Yunoki (KDDI R&D Laboratories)
  - 11-14-1397, "Discussion on Frame Structure for Future WLAN Systems with OFDMA," Myeong-Jin Kim (Korea University)
  - 11-14-1403, "Performance Analysis of BSS Color and DSC," Masahito Mori (Sony)
  - 11-14-1404, "11aa GCR-BA Performance in OBSS," Yuichi Morioka (Sony)
  - 11-14-1416, "Observed protocol violations caused by DSC with roaming STAs," Chuck Lukaszewski (Aruba Networks)
  - 11-14-1417, "HEW PPDU Transmission Discussion," Yongho Seok (NEWRACOM)
  - 11-14-1426, "DSC and legacy coexistence," Gustav Wikstrom et al. (Ericsson)
  - 11-14-1427, "DSC Performance," Gustav Wikstrom et al. (Ericsson)
  - 11-14-1428, "Clear Channel Assessment for OFDMA PHY," K. C. Chen (NTU) and D. J. Deng (NCUE)
  - 11-14-1431, "Issues on UL-OFDMA Transmission," Young Hoon Kwon (Newracom)
  - 11-14-1433, "Protocol and signaling framework for OFDMA," Sigurd Schelstraete (Quantenna)
  - 11-14-1435, "Considerations on OBSS Spatial Re-Use," Jianhan Liu (Mediatek Inc.)
  - 11-14-1436, "Overhead Analysis for Simultaneous Downlink Transmissions," Pengfei Xia (interdigita)
  - 11-14-1437, "Efficient Wider Bandwidth Operation in IEEE 802.11ax," Jinsoo Ahn (Yonsei Univ)
  - 11-14-1439, "Preamble Considerations in Large Channel Delay Spread Scenarios," Daewon Lee (Newracom)
  - 11-14-1442, "Considerations on DL OFDMA control mechanism," Woojin Ahn (Yonsei Univ.)
  - 11-14-1443, "Adapting CCA and Receiver Sensitivity," Esa Tuomaala (Nokia)
  - 11-14-1446, "Analysis of frequency and power requirements for UL-OFDM," Leif Wilhelmsson (Ericsson)
  - 11-14-1448, "Considerations for Adaptive CCA," Reza Hedayat (Newracom)
  - 11-14-1452, "Frequency selective scheduling in OFDMA," Leif Wilhelmsson (Ericsson)
- **Specification Framework**
  - 11-14-1429, "Proposed 802.11ax specification framework document," Minho Cheong (Newracom)
  - 11-14-1432, "Proposed 802.11ax specification framework - background," Minho Cheong (Newracom)

- 11-14-1447, "Proposed Spec Framework Document for 11ax considering potential tech features," John Son (WILUS Institute), Young Doo Kim (SK Telecom)
- 11-14-1453, "Spec Framework Proposal," Robert Stacey (Intel)

Goals for the January 2015 session

- Elect ad hoc chairs - 3 co-chairs/ad hoc group as agreed.
- Continue to advance TG documents.
- Technical Presentations.

Teleconferences

One teleconference is planned before the January 2015 session.

Thursday	December 4th, 2014,	10:00 - 12:00 (ET)

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September 2014 — Athens, Greece

The TGax had nine sessions during the week.

	Monday	Tuesday	Wednesday	Thursday
AM1				**TGax**
AM2	**TGax**	**TGax**		
PM1		**TGax**	**TGax**	**TGax**
PM2	**TGax**	**TGax**		
PM3	**TGax**			

Main documents

The meeting agenda, minutes, and the closing report of TGax can be found here.

- 11-14-1033-05, TGax September 2014 Meeting Agenda
- 11-14-1460-00, TGax November 2014 Athens Meeting Minutes
- 11-14-1304-00, TGax November 2014 Closing Report

Achievements

1. **The group elected two vice chairs and discussed about the TG structure.**
   Election of Vice Chairs took place during this meeting and two TG Vice Chairs are elected:
   - Simone Merlin (Qualcomm)
   - Ron Porat

   The group started discussion on the Ad Hoc groups. Discussion will be continued in future meetings.
2. **The group approved minutes from the July 2014 San Diego meeting.**
   - 11-14-0864-00, TGax July 2014 San Diego Meeting Minutes
3. **TG Documents**
   The group approved updated documents.
   - 11-14-0980-04, TGax Simulation Scenarios
   - 11-14-0571-05, TGax Evaluation Methodology

- 11-14-0882-04, TGax Channel Models
- 11-14-1009-02, TGax Functional Requirements

4. **Technical Presentations**

54 submissions were submitted to the group and 52 of them were covered during the week.

- **Functional Requirements**
  - 11-14-0636, "Discussion on Functional Requirements," David Xun Yang (Huawei Technologies)
  - 11-14-0920, "Considerations of Functional Requirements Documents," David Xun Yang (Huawei Technologies)
  - 11-14-1009, "Proposed 802.11ax Functional Requirements," Lei Wang (Marvell)
  - 11-14-1164, "Meaningful 11ax Functional Requirements," Joe Kwak (InterDigital)
  - 11-14-1167, "TGax Functional Requirement Discussion," Yonggang Fang (ZTE)
  - 11-14-1170, "Functional Requirements Discussions on Coex with Legacy STAs," Masahito Mori (Sony)
  - 11-14-1234, "Requirements Discussion," Joseph Levy (InterDigital)
- **Simulation Scenarios and Calibration**
  - 11-14-0800, "Box 1 and Box 2 Calibration Results," Nihae Jindal (Broadcom)
  - 11-14-1147, "MAC Simulator Calibration Results," Shoko Shinohara, Akira Kishida (NTT)
  - 11-14-1175, "MAC Calibration results," Suhwook Kim (LG Electronics)
  - 11-14-1177, "Discussion about Box5 Calibration," Jiyong Pang (Huawei Technologies)
  - 11-14-1187, "The Effect of Preamble Error Model on MAC Simulator," Po-Kai Huang (Intel)
  - 11-14-1191, "MAC calibration results," Zhou Lan (Huawei Technologies)
  - 11-14-1192, "MAC calibration results comparison," Zhou Lan (Huawei Technologies)
  - 11-14-1198, "Additional Test Cases for MAC calibration," Gwen Barriac (Qualcomm)
  - 11-14-1217, "MAC Calibration Results for Test 1 and 2," Esa Tuomaala (Nokia)
  - 11-14-1223, "Stadium Measurements," Brian Hart (Cisco Systems)
  - 11-14-1226, "SLS Box 1&2 Calibration Results," Russell Huang (MediaTek)
  - 11-14-1230, "MAC Calibration Result," Chinghwa Yu (MediaTek)
- **Evaluation Methodology**
  - 11-14-1161, "Parameters for Power Save Mechanisms," Eric Wong (Apple)
  - 11-14-1162, "Energy Efficiency Evaluation Methodology Follow Up," Eric Wong (Apple)
  - 11-14-1174, "PHY Abstraction with Time Varying Interference," Yakun Sun (Marvell)
  - 11-14-1176, "PHY abstraction tables for 11ax system level simulation," Jiayin Zhang (Huawei Technologies)
  - 11-14-1221, "Traffic Generator for OBSS Calibration Case," Chao-Chun Wang (MediaTek)
- **Channel Model**
  - 11-14-1214, "Impact of correlated shadowing in 802.11ax system evaluations," Leif Wilhelmsson (Ericsson AB)
  - 11-14-1222, "Doppler Effect Evaluation for 11ax," Jianhan Liu (MediaTek)
- **Technologies/Others**
  - 11-14-1106, "WLAN Frame Collision Information," Peng Shao (NEC Communication Systems)
  - 11-14-1148, "Consideration of asynchronous interference in OBSS environment," Koichi Ishihara (NTT)
  - 11-14-1168, "802.11 TGax PHY Frame Structure Discussion for Enabling New Contention Mechanism," Yonggang Fang (ZTE)
  - 11-14-1169, "DL-FDMA considerations," Katsuo Yunoki (KDDI R&D Labs.)
  - 11-14-1171, "DSC Simulation Results for Scenario 3," Masahiro Mori (Sony)
  - 11-14-1172, "Multicast Performance in OBSS," Yuichi Morioka (Sony)
  - 11-14-1178, "Inter-BSS interference in WLANs," Hyunduk Kang (ETRI)
  - 11-14-1179, "Considerations for Partial Band Interference between WLAN Systems," Gwangzeen Ko (ETRI)
  - 11-14-1180, "Discussions on Interference between TD-LTE & WLAN around 2.4GHz Band," Meng Yang (CATR)
  - 11-14-1181, "Measurements on A-MPDU performances under various channel conditions," John Sun (WILUS Institute)
  - 11-14-1186, "Comparisons of Simultaneous Downlink Transmissions," Pengfei Xia (InterDigital)
  - 11-14-1190, "Frame Exchange Control for Uplink Multi-user transmission," Kaying Lv (ZTE)
  - 11-14-1199, "Effect of CCA in residential scenario part 2," Gwen Barriac (Qualcomm)
  - 11-14-1207, "OBSS reuse mechanism which preserves fairness," Laurent Cariou (Orange)
  - 11-14-1208, "MAC considerations on 802.11ax OFDMA," Jinsoo Ahn (Yonsei Univ.)
  - 11-14-1209, "Multiple RF operation for 802.11ax OFDMA," Woojin Ahn (Yonsei Univ.)
  - 11-14-1210, "HEW PPDU Format for Supporting MIMO-OFDMA," Yongho Seok (NEWRACOM)
  - 11-14-1211, "ACK Procedure for OFDMA," Yongho Seok (NEWRACOM)

- 11-14-1216, "Consideration on Coexistence between LTE-U and 802.11 WLAN," Jae Seung Lee (ETRI)
- 11-14-1224, "Link-Aware CCA," Brian Hart (Cisco Systems)
- 11-14-1225, "Considerations on CCA for OBSS Opearation in 802.11ax," Luo Jun (Huawei Technologies)
- 11-14-1227, "OFDMA Performance Analysis," Tianyu Wu (MediaTek)
- 11-14-1228, "Issues on 256-FFT per 20MHz," Heejung Yu (NEWRACOM)
- 11-14-1229, "Dynamic OFDM Symbol Duration," Alan Jauh (MediaTek)
- 11-14-1232, "On MU Aggregation Mechanisms for 11ax," Reza Hedyat (NEWRACOM)
- 11-14-1233, "Adaptive CCA for 11ax," Reza Hedyat (NEWRACOM)

Goals for the November 2014 session

- Continue to advance TG documents.
- Technical Presentations.

Teleconferences

Three teleconferences are planned before the November 2014 session.

Thursday	October 9th, 2014	10:00 - 12:00 (ET)

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July 2014 — San Diego, CA

The TGax had 10 sessions during the week.

	Monday	Tuesday	Wednesday	Thursday
AM1	**TGax**		**TGax**	**TGax**
AM2		**TGax**		
PM1			**TGax**	**TGax**
PM2	**TGax**	**TGax**	**TGax**	
PM3		**TGax**		

Main documents

The meeting agenda, minutes, and the closing report of TGax can be found here.

- 11-14-0748-06, TGax July 2014 Meeting Agenda
- 11-14-0864-00, TGax July 2014 San Diego Meeting Minutes
- 11-14-0984-01, TGax July 2014 Closing Report

Achievements

1. **The group discussed on the TG structure.**
   - The group will have two vice chairs to be election during the initial meeting slot of TGax in September 2014.
     - Chair has sent out the call for nominations to the reflector.
   - The group will have some ad hoc groups in the future, however, the discussion on the ad hoc structure was deferred.
2. **The group approved minutes from the May 2014 Waikoloa meeting and Teleconference on July 2nd, 2014.**
   - 11-14-0655-03, May 2014 Waikoloa Meeting Minutes
   - 11-14-0788-02, Minutes from the teleconference on July 2nd, 2014

3. **TG Documents**

The group discussed and approved following documents as current TG documents.

- The group approved new version of the Simulation Scenarios Document (11-14-0980-01).
- The group approved new version of the Evaluation Methodology Document (11-14-0571-03).
- The group approved the initial version of the TGax Channel Model document (11-14-0882r3).
- The group adopted the initial version of the TGax Selection Procedure (11-14-0938r4).
- The group had discussion on the Functional Requirements document.

4. **Technical Presentations**

More than 40 submissions were covered during the week.

- **Simulation Scenarios and Calibration**
  - 11-14-0799, "Modifications to Simulation Scenarios and Calibration Process," Nihar Jindal (Broadcom)
  - 11-14-0800, "Box 1 and Box 2 Calibration Results," Nihar Jindal (Broadcom)
  - 11-14-0803, "Packet Length for Box 0 Calibration," Wookbong Lee (LG Electronics)
  - 11-14-0850, "Clarification for MAC Calibration," Gwen Barriac (Qualcomm)
  - 11-14-0851, "Proposed Rate Control for MAC Simulator," Gwen Barriac (Qualcomm)
  - 11-14-0859, "Proposing a Stadium Scenario," Hakan Persson (Ericsson)
  - 11-14-0860, "Text proposal of a Stadium scenario to ax," Hakan Persson (Ericsson)
  - 11-14-0869, "MAC calibration results," Zhou Lan (Huawei)
  - 11-14-0871, "Further Calibration Results towards Integrated System Level Simulation," Jiyong Pang (Huawei)
  - 11-14-0892, "MAC Calibration Text to Simulation Scenarios," Jarkko Kneckt (Nokia)
  - 11-14-0894, "Calibration of System Level Simulators," Sayantan Choudhury (Nokia)
  - 11-14-0895, "Calibration of MAC simulator with OBSS Network Scenario," Chao-CHun Wang (MediaTek)
- **Evaluation Methodology**
  - 11-14-0571, "Evaluation Methodologies," Ron Porat (Broadcom)
  - 11-14-0810, "RBIR-based PHY Abstraction with Channel Estimation Error," Yukun Sun (Marvell)
  - 11-14-0811, "Overview on RBIR-based PHY Abstraction," Yukun Sun (Marvell)
  - 11-14-0827, "Energy Efficiency Evaluation Methodology," Eric Wong (Apple)
  - 11-14-0865, "ACI and AACI for 802.11ax System Simulations," Yu Cai (Huawei)
  - 11-14-0866, "Traffic modeling and system capacity performance measure," Johan Soder (Ericsson)
  - 11-14-0873, "PHY Abstraction Table for 11ax System Level Simulations," Jiayin Zhang (Huawei)
  - 11-14-0874, "Unified Traffic Model on Enterprise Scenario," Phillip Barber (Huawei)
  - 11-14-0875, "VoIP Traffic Model Content for 11ax TG Simulation Scenarios & Evaluation Methodology," Phillip Barber (Huawei)
- **Channel Models**
  - 11-14-0882, "IEEE 802.11ax Channel Model Document," Jianhan Liu (Mediatek)
  - 11-14-0904, "In-Cabin WiFi Channel Channel: Preliminary Ray Tracing Simulations," Fan Bai (General Motors)
- **Functional requirements**
  - 11-14-0567, "Proposed 802.11ax Functional Requirements," Lei Wang (Marvell)
  - 11-14-0818, "Synchronization Requirements," Yonggang Fang (ZTE)
  - 11-14-0821, "Coexistence Requirements of 802.11 WLAN and LTE in Unlicensed Spectrum," Alireza Babaei (CableLabs)
  - 11-14-0835, "Functional Requirements Discussion," Joe Kwak (InterDigital)
- **Technologies/Others**
  - 11-14-0779, "Dynamic Sensitivity Control Practical Usage," Graham Smith (DSP Group)
  - 11-14-0801, "Envisioning 11ax PHY Structure - Part II," Dongguk Lim(LG Electronics)
  - 11-14-0802, "Consideration on UL MU transmission," Jinyoung Chun (LG Electronics)
  - 11-14-0804, "Envisioning 11ax PHY Structure - Part I," Jinsoo Choi (LG Electronics)
  - 11-14-0832, "Performance Evaluation of OBSS Densification," Po-Kai Huang (Intel)
  - 11-14-0833, "Residential Scenario Sensitivity and Transmit Power Control Simulation Results," Ron Murias (InterDigital)
  - 11-14-0838, "Discussion on dual-link STR in IEEE 802.11ax," Jinsoo Ahn (Yonsei Univ)
  - 11-14-0839, "Discussion on OFDMA in IEEE 802.11ax," Jinsoo Ahn (Yonsei Univ)
  - 11-14-0846, "Changing CCA in the Residential Environment," Gwen Barriac (Qualcomm)
  - 11-14-0847, "Further Considerations on Enhanced CCA for 11ax," John Son (WILUS Institute)
  - 11-14-0854, "DSC and Legacy Coexistence," Yuichi Morioka (SONY)
  - 11-15-0855, "Techniques for Short Downlink Frames," Brian Hart (Cisco Systems)

- 11-15-0856, "Evaluating Dynamic CCA/Receiver Sensitivity Algorithms," Brian Hart (Cisco Systems)
- 11-14-0858, "Analysis on Multiplexing Schemes exploiting frequency selectivity," Kaushik Josiam (Samsung)
- 11-14-0861, "Impact of CCA adaptation on spatial reuse in dense residential scenario," Sayantan Choudhury (Nokia)
- 11-14-0868, "UL & DL DSC and TPC MAC simulations," Johan Soder (Ericsson)
- 11-14-0872, "A Protocol Framework for Dynamic CCA," Sean Coffey (Realtek)
- 11-14-0880, "Increased Network Throughput with Channel Width Related CCA and Rules," James Wang (Mediatek)
- 11-14-0889, "Performance Gains from CCA Optimization," Nihar Jindal (Broadcom)

5. **Timeline**
   No change was made to the tGax initial timeline that was approved during the May 2014 Waikoloa session.

Current Timeline	
May 2014	**Start of TG**
November 2014	**Start to work on the specification framework**
July 2016	**Draft 1.0 to be ready**
March 2017	**Draft 2.0 to be ready**
1H 2019	**Publication of IEEE 802.11ax amendment**

Goals for the September 2014 session

- TG vice-chairs election.
- Continue to advance TG documents.
- Technical Presentations.

Teleconferences

Three teleconferences are planned before the September 2014 session.

Thursday	August 14th, 2014	10:00 - 12:00 (ET)

Chair had sent out call for submissions on the TGax reflector.

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May 2014 — Waikoloa, HI

The TGax had 10 sessions during the week.
Four out of ten sessions were assigned to the ad hoc groups.

	Monday	Tuesday	Wednesday	Thursday
AM1			**TGax**	**TGax**
AM2	**TGax**	**TGax**		
PM1				**Tgax**
PM2	**TGax**	**TGax**		
PM3	**TGax**	**TGax**		

Main documents

The meeting agenda, minutes, and the closing report of TGax can be found here.

- 11-14-0478-05, TGax May 2014 Meeting Agenda
- 11-14-0655-01, TGax May 2014 Waikoloa Meeting Minutes

- 11-14-0702-00, TGax May 2014 Closing Report

Achievements

1. **The group elected the chairperson and the secretary.**
   - **Chairperson: Osama Aboul-Magd (Huawei Technologies)**
   - **Secretary: Yasuhiko Inoue (NTT)**

   Other officer psitions and TG structure will be discussed in the July 2014 session.
2. **The group approved minutes from the March 2014 Beijing meeting and Teleconference on April 17th, 2014.**
   - 11-14-0380-01, HEW SG March 2014 Beijing Meeting Minutes
   - 11-14-0530-00, TGax teleconference minutes - 2014.04.17
3. **TG Documents**
   - The group approved initial version of the Simulation Scenarios (11-14-0621-04) and Evaluation Methodology (11-14-0571-02) documents.
   - The group started the discussion related to Functional Requirements document. Expectation is to approve the initial revision of the document in July.
   - Discussion related to Channel Model document is expected to start in July.
4. **Technical Presentations**

   40 submissions were covered during the week.
   - 11-14-0527, "PHY Abstraction for TGax System Level Simulations", Pengfei Xia (InterDigital)
   - 11-14-0546, "IEEE 802.11ax High Efficiency WLAN Packet measurements around Boulder Colorado", Jim Lansford (CSR)
   - 11-14-0567, "Proposed 802.11ax Functional Requirements", Lei Wang (Marvell)
   - 11-14-0571, "11ax Evaluation Methodologies", Ron Porat (Broadcom)
   - 11-14-0577, "Path Loss Model for Scenario 1," Nihar Jindal (Broadcom)
   - 11-14-0578, "Residential Scenario CCA/TPC Simulation Discussion," Frank La Sita (InterDigital)
   - 11-14-0581, "Further Discussions on PHY Abstraction," Yakun Sun (Marvell)
   - 11-14-0582, "Calibrating MAC Simulator Through Function Test," Jinjing Jiang (Marvell)
   - 11-14-0583, "Further Discussions on Instantaneous SINR Calibration for System Simulation," Yakun Sun (Marvell)
   - 11-14-0584, "System Level Simulations on Beamforming and Link Adaptation," Yan Zhang (Marvell)
   - 11-14-0585, "PHY Abstractions for and IEEE 11ax PHY System Simulation and Integrated System Level Simulation," Jianhan Liu (MediaTek)
   - 11-14-0586, "Automotive Considerations for the Simulation Scenarios," Igal Kotzer (General Motors)
   - 11-14-0594, "Insert Virtual Desktop Infrastructure (VDI) Traffic Model Content for HEW Simulation Scenarios," Yingpei Lin (Huawei)
   - 11-14-0595, "Edits on Some Traffic Content for HEW SG Simulation Scenarios," Yingpei Lin (Huawei)
   - 11-14-0598, "Uplink multi-user MAC protocol for 11ax," Tran Thi Thao Nguyen (Kyushu Inst. of Tech.)
   - 11-14-0600, "Proposed Calibration For MAC simulator," Gwen Barriac (Qualcomm)
   - 11-14-0604, "Modeling and Evaluating Variable Bit rate Video Streaming for 802.11ax," Chao-Chun Wang (MediaTek)
   - 11-14-0612, "Calibration Procedures towards Integrated System Level Simulation," Jiayin Zhang (Huawei)
   - 11-14-0613, "Discussions on adaptive frame length in MAC based on block ACK," Ningbo Zhang (BUPT)
   - 11-14-0614, "Joint Coding and Modulation Diversity with LRA MMSE VP by QR precoding MIMO," Ningbo Zhang (BUPT)
   - 11-14-0616, "CSMA/CA Enhancement Suggestion," Yonggang Fang (ZTE)
   - 11-14-0617, "Discussion on timeline for 802.11ax," Laurent Cariou (Orange)
   - 11-14-0620, "Link Adaptation for PHY SLS calibration," Jinyoung Chun (LG Electronics)
   - 11-14-0621, "TGax Simulation Scenarios," Simone Merlin (Qualcomm)
   - 11-14-0624, "Investigation on 1024 QAM feasibility in 11ax," Eunsung Park (LG Electronics)
   - 11-14-0625, "Multi-channel operation in Simulation scenarios," Suhwook Kim (LG Electronics)
   - 11-14-0626, "IEEE 802.11ax Functional Requirements," SangHyun Chang (Samsung)
   - 11-14-0627, "Outdoor Channel Models for System Level Simulations," Kaushik Josiam (Samsung)
   - 11-14-0628, "Measurements on CCA Thresholds in OBSS Environment," John Son (WILUS Institute), Young Doo Kim (SK Telecom)
   - 11-14-0634, "Consideration on MAC system calibration," Zhou Lan (Huawei)
   - 11-14-0635, "Dynamic Sensitivity Control Implementation," Graham Smith (DSP Group)
   - 11-14-0636, "Consideration on functional requirements," Zhou Lan (Huawei)

- 11-14-0637, "Spatial Reuse and Coexistence with Legacy Devices," James Wang (MediaTek)
- 11-14-0647, "PHY abstraction method comparison," Tianyu Wu (MediaTek)
- 11-14-0648, "Performance Observation of a Dense Campus Network," Chinghwa Yu (MediaTek)
- 11-14-0649, "802.11ax Timeline Scenarios," Rolf de Vegt (Qualcomm)
- 11-14-0656, "How to Describe 802.11ax Functional Requirements," Minho Cheong
- 11-14-0660, "802.11ax Timeline," Minho Cheong (NEWRACOM)
- 11-14-0677, "Comparison of Calibration Methodology for MAC Simulation," Chinghwa Yu (MediaTek)
- 11-14-0682, "In Situ Spectrum Reuse Measurements in Indoor 20,000 Seat Arena," Chuck Lukaszewski (Aruba Networks)

5. **Timeline**
   The group approved initial timeline.

Current Timeline	
May 2014	**Start of TG**
November 2014	**Start to work on the specification framework**
July 2016	**Draft 1.0 to be ready**
March 2017	**Draft 2.0 to be ready**
1H 2019	**Publication of IEEE 802.11ax amendment**

Goals for the July 2014 session

- Continue to advance simulation scenarios (11-14/0621) and Evaluation Methodologies (11-14/0571) documents.
- Approve an initial Functional Requirements document.
- Approve an initial Channel Model document.
- Discuss and approve TG structure and process.
- Technical Presentations.

Teleconferences

Three teleconferences are planned before the July 2014 meeting.

Wednesday	June 4th, 2014	10:00 - 12:00 (ET)
Wednesday	June 18th, 2014	20:00 - 22:00 (ET)
Wednesday	July 2nd, 2014	10:00 - 12:00 (ET)

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High Efficiency WLAN (HEW) Study Group

March 2014 — Beijing, China

The HEW SG had 7 sessions during the week.

	Monday	Tuesday	Wednesday	Thursday
AM1			**HEW**	**HEW**
AM2		**HEW**		
PM1				**HEW**

	Monday	Tuesday	Wednesday	Thursday
PM2	**HEW**	**HEW**		
PM3		**HEW**		

Main documents

The meeting agenda, minutes, and the closing report of HEW SG can be found here.

- 11-14-0219-04, HEW SG Maarch 2014 Meeting Agenda
- 11-14-0380-00, HEW SG March 2014 Beijing Meeting Minutes
- 11-14-0457-00, HEW SG March 2014 Closing Report

Achievements

1. **The group approved minutes from the January 2014 Los Angeles meeting and teleconferences on February 6th, 2014 and February 13th, 2014.**
   - 11-14-0199-00, January 2014 Los Angeles Meeting Minutes
   - 11-14-0229-02, Minutes from the teleconference on February 6th, 2014
   - 11-14-0242-00, Minutes from the teleconference on February 13th, 2014
2. **Addressed comments related to the PAR and CSD received from individuals and other IEEE 802 WGs. Resolutions of comments are contained in the following document:**
   - https://mentor.ieee.org/802.11/dcn/14/11-14-0424-00-0hew-hew-sg-par-and-csd-comments-and-resolutions.pptx
3. **Updated the PAR and the CSD documents based on received comments:**
   - https://mentor.ieee.org/802.11/dcn/14/11-14-0165-01-0hew-802-11-hew-sg-proposed-par.docx
   - https://mentor.ieee.org/802.11/dcn/14/11-14-0169-01-0hew-ieee-802-11-hew-sg-proposed-csd.docx
4. **The group passed motions to approve revised PAR and CSD documents, and SG extension.**

   Revised PAR (11-14/0165r1): Y/N/A = 94/0/1, Motion passes.
   Revised CSD (11-14/0169r1): Y/N/A = 97/0/1, Motion passes.
   SG extension: Y/N/A = 105/0/0, Motion passes.

   HEW SG has completed its work and the IEEE standard board approved 802.11ax project.

5. **The group received more than 30 submissions in the categories of simulation scenarios, evaluation methodologies, channel models, functional requirements, technologies and selection procedure.**
   Following submissions have been presented and discussed during the week.
   - 11-13-1359, "HEW-Evaluation-Methodology" Ron Porat (Broadcom)
   - 11-14-0112, "Wi-Fi interference measurements in Korea - part II", Minho Cheong (NEWRACOM)
   - 11-14-0113, "Modeling of additional channel loss in dense WLAN environments", Minho Cheong (NEWRACOM)
   - 11-14-0294, "DSC Channel Selection and Legacy Sharing" Graham Smith (DSP Group)
   - 11-14-0301, "Multicast Considerations for HEW", Eisuke Sakai (Sony Corporation)
   - 11-14-0306, "Discussions on HEW Functional Requirements", Lei Wang (Marvell)
   - 11-14-0307, "PHY Calibration Results", Nihar Jindal (Broadcom)
   - 11-14-0328, "Dense Apartment Complex Throughput Calculations", Graham Smith (DSP Group)
   - 11-14-0329, "Channel Models for different links in Simulations", Kaushik Josiam (Samsung)
   - 11-14-0330, "HEW PHY Abstraction", Sameer Vermani (Qualcomm)
   - 11-14-0335, "Instantaneous SINR Calibration for System Simulation", Yakun Sun (Marvell)
   - 11-14-0336, "Calibration of Long-Term SINR for System Simulator" Yakun Sun (Marvell)
   - 11-14-0339, "A simplified STR Mechanism", Raja Banerjea (CSR)
   - 11-14-0340, "A simplified STR Mechanism - MAC", Raja Banerjea (CSR)
   - 11-14-0342, "Short Packet Optimizations", Naveen Kakani (CSR, Inc)
   - 11-14-0345, "Joint Coding and Modulation Diversity with RBD pre-coding for next generation WLAN", Zhanji Wu (BUPT)
   - 11-14-0350, "Suggestion on Evaluation Methodology", Jinyoung Chun (LG Electronics)

- 11-14-0352, "Discussion on power save mode for real time traffic", Giwon Park (LG Electronics)
- 11-14-0353, "Suggestion on PHY Abstraction for Evaluation Methodology", Dongguk Lim (LG Electronics)
- 11-14-0355, "Simulation Scenario 1 Revised", Simone Merlin (Qualcomm)
- 11-14-0356, "Calibration of System Level Simulators", Jarkko Kneckt (Nokia)
- 11-14-0357, "Utilizing Unused Resources for Simultaneous Transmissions", Jarkko Kneckt (Nokia)
- 11-14-0365, "Extended Intra-Vehicle Channel Model", Igal Kotzer (General Motors)
- 11-14-0372, "System level simulations on increased spatial reuse", Liwen Chu (Marvell)
- 11-14-0373, "Energy Efficiency in HEW", Pingping Xu, Wei Wang (Southeast University)
- 11-14-0381, "Stadium scenario for HEW", Johan Soder, Filip Mestanov (Ericsson AB)
- 11-14-0383, "Considerations on evaluation methodology for candidate HEW PHY&MAC techniques", Le Liu (Huawei)
- 11-14-0385, "Simulation Methodology and Calibration", Gwen Barriac (Qualcomm)
- 11-14-0386, "Discussions on MCS selection" , Tianyu Wu (MediaTek)
- 11-14-0392, "Traffic Separation Scheme for Optimizing WLANs using PHY and MAC options", Takayuki Nishio (Kyoto University)
- 11-14-0393, "Possible Indoor Channel Models for HEW System Simulations", Leif Wilhelmsson (Ericsson AB)
- 11-14-0419, "802.11ax Spec Development Process Proposal", Rolf de Vegt (Qualcomm)

Goals for the May 2014 session

- Meet as a new TG and will have officer elections.
- Continue the work on simulation scenarios, evaluation methodologies, channel models, and function requirements.

Teleconferences

Three teleconferences are planned before the May 2014 meeting.

Thursday	April 174th, 2014	10:00 - 12:00 (ET)

Details to be announced.

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January 2014 — Los Angeles, CA

The HEW SG had 9 sessions during the week.

	Monday	Tuesday	Wednesday	Thursday
AM1				**HEW**
AM2	**HEW**	**HEW**		
PM1				**HEW**
PM2	**HEW**	**HEW**	**HEW**	
PM3	**HEW**	**HEW**		

Main documents

- 11-13-1506-05, HEW SG January 2014 Meeting Agenda
- 11-14-0199-00, HEW SG January 2014 Los Angeles Meeting Minutes
- 11-14-0187-00, HEW SG January 2014 Closing Report

Achievements

1. **The group approved minutes from the November 2013 Dallas meeting and teleconferences on December 4th, 2013, December 18th, 2013 and January 8th, 2014.**
   - 11-13-1465-01, November 2013 Dallas Meeting Minutes
   - 11-13-1495-00, Minutes from the teleconference on December 4th, 2013
   - 11-13-1532-01, Minutes from the teleconference on December 18th, 2013
   - 11-14-0024-01, Minutes from the teleconference on January 8th, 2014
2. **The group resolved open issues related to the PAR and CSD.**
3. **The group received 28 submissions that were categorized into (1) PAR and 5 Criteria related submissions, and (2) Best Effort submissions. Best Effort submissions basically related to simulation scenario and evaluation methodology.**
4. **The group passed motions to approve PAR and CSD.**
   - **PAR and 5 Criteria related submissions (high priority)**
     - 11-13-1410, "802.11 HEW Draft PAR and 5C", Osama Aboul-Magd and All
     - 11-13-1489, "Airport Capacity Analysis", Graham Smith (DSP Group)
     - 11-14-0026, "thoughts on hew par", Yong Liu (Apple)
     - 11-14-0045, "E-Education Analysis", Graham Smith (DSP Group)
     - 11-14-0058, "Pico Cell Use Case Analysis ", Graham Smith (DSP Group)
     - 11-14-0061, "Some findings from real world measurement", Katsuo Yunoki (KDDI Labs)
     - 11-14-0065, "Comments on Draft HEW PAR", Bill Carney (SONY)
     - 11-14-0101, "Comments on 802.11 HEW Draft PAR & 5C", Rakesh Taori (Samsung Electronics)
     - 11-14-0106, "Discussion on HEW PAR", Kiseon Ryu (LG Electronics)
     - 11-14-0119, "Suggested PAR Changes", James Yee (MediaTek)
     - 11-14-0163, "Raising the PAR", Mat Fischer (Broadcom)
   - **Best Effort submissions**
     - 11-14-0043, "PHY abstraction in system level simulation for HEW study", Fei Tong (Samsung)
     - 11-14-0051, "Wireless Office with Interference", David Xun Yang (Huawei)
     - 11-14-0053, "Further Considerations on Calibration of System Level Simulation", Jiayin Zhang (Huawei)
     - 11-14-0056, "Traffic Model on Virtual Desktop Infrastructure", Yingpei Lin (Huawei)
     - 11-14-0059, "Integrated System Level Simulation", Jun Luo (Huawei)
     - 11-14-0063, "Design Challenges for 802.11 HEW Radios", Yu Cai (Huawei)
     - 11-14-0070, "Joint MAC/PHY Evaluation Methodology", Kaushik Josiam (Samsung)
     - 11-14-0082, "Improved Spatial Reuse Feasibility - Part I", Ron Porat (Broadcom)
     - 11-14-0083, "Improved Spatial Reuse Feasibility - Part II", Ron Porat (Broadcom)
     - 11-14-0086, "Outdoor AP Measurement in Tokyo", Tsugu Aoki (Toshiba)
     - 11-14-0088, "Intra-Vehicular Channel Model", Igal Kotzer (General Motors)
     - 11-14-0095, "OFDM-IDMA Uplink Communication", Leonardo Lanante (Kyushu Inst. Of Tech)
     - 11-14-0107, "HEW Evaluation Metrics", Yonggang Fang (ZTETX)
     - 11-14-0116, "Long-Term SINR Calibration for System Level Simulation", Yakun Sun (Marvell)
     - 11-14-0117, "PHY Abstraction for HEW System Level Simulation", Yakun Sun (Marvell)
     - 11-14-0118, "Consideration on System Level Simulation", Jinsoo Chio (LG Electronics)
5. **The group passed motions to approve PAR and CSD**
   - 11-14-165-00, IEEE 802.11 HEW SG Proposed PAR
   - 11-14-169-00, IEEE 802.11 HEW SG Proposed CSD

Goals for the March 2014 session

- Resolve comments expected from EC members and other IEEE 802 WGs
- Continue with presentations relevant to the SG topics.
  - Simulation scenarios
  - Evaluation Methodologies
  - Channel Models
  - Technology
  - etc.

Teleconferences

The group agreed to have four teleconferences before the March 2014 session.

Thursday	February 6th, 2014	20:00 - 22:00 (ET)
Thursday	February 13th, 2014	10:00 - 12:00 (ET)
Thursday	February 20th, 2014	10:00 - 12:00 (ET)
Thursday	February 27th, 2014	20:00 - 22:00 (ET)

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November 2013 — Dallas, TX

The HEW SG had 10 sessions during the week.

	Monday	Tuesday	Wednesday	Thursday
AM1			**HEW**	**HEW**
AM2		**HEW**		
PM1		**HEW**	**HEW**	**HEW**
PM2	**HEW**	**HEW**	**HEW**	**HEW**
PM3				

Main documents

- 11-13-1263-05, HEW SG November 2013 Meeting Agenda
- 11-13-1465-01, HEW SG November 2013 Dallas Meeting Minutes
- 11-13-1476-01, HEW SG November 2013 Closing Report

Achievements

1. **The group approved minutes from the September 2013 Nanjing meeting and teleconferences on October 3rd and October 30th, 2013.**
   - 11-13-1117-01, September 2013 Nanjing Meeting Minutes
   - 11-13-1275-01, Minutes from the teleconference on October 3rd, 2013
   - 11-13-1303-00, Minutes from the teleconference on October 30th, 2013
2. **The group received more than 40 submissions that were categorized into three categories, i.e., (1) Channel Mode/Simulation Scenarios and Evaluation Methodologies, (2) MAC/PHY technologies and (3) PAR proposals.**
   Following submissions were presented during the week.
   - **Channel Models, Simulation Scenarios and Evaluation Methodologies**
     - 11-13-1001, "HEW SG Simulation Scenarios", Simone Merlin (Qualcomm)
     - 11-13-1305, "Simplification on HEW traffic models", Bill Carney (Sony)
     - 11-13-1334, 11-13-1335, "Video Traffic Modeling", Guiqing Li (Intel)
     - 11-13-1359, "HEW Evaluation Methodology", Ron Porat (Broadcom)
     - 11-13-1370, "LTE OOB Interference to 2.4 GHz Band", Yonggang Fang (ZTE TX)
     - 11-13-1376, "Discussions on Penetration Loss", Jianhan Liu (MediaTek)
     - 11-13-1380, "Outdoor Channel Model Simulation Follow-up", Hongyuan Zhang (Marvell)
     - 11-13-1383, "System Level Simulation Parameters", Wookbong Lee (LG Electronics)
     - 11-13-1387, "HEW channel modeling for system level simulation", Yan Zhang (Marvell)

        - 11-13-1390, "PHY Abstraction for HEW System Level Simulations", Yakun Sun (Marvell)
        - 11-13-1391, "About SINR conversion for PHY Abstraction", Yakun Sun (Marvell)
        - 11-13-1392, "Methodology of Calibrating System Level Simulation Results", Yakun Sun (Marvell)
        - 11-13-1401, "System Level Assessments for Outdoor HEW Deployments", Kaushik Josiam (Samsung)
        - 11-13-1406, "Traffic Modeling for HEW Simulations", Huai-Rong Shao (Samsung)
        - 11-13-1407, "Simulation based study of QoE", Chao-Chun Wang (MediaTek)
        - 11-13-1412, "How to use simulation scenarios in HEW", Minho Cheong (ETIR)
        - 11-13-1419, "Modifications to ITU Channel Model to Support 160MHz bandwidth of operation", Shahrnaz Azizi (Intel)
        - 11-13-1420, "HEW Considerations for the Vehicular Environment", Igal Kotzer (General Motors)
        - 11-13-1438, "Traffic Observation and Study on Virtual Desktop Infrastructure", Phillip Barber (Huawei Technologies)
        - 11-13-1456, "Considerations on WFA feedback", Simone Merlin (Qualcomm)
    - **MAC/PHY Technologies**
        - 11-13-1325, "IEEE 802.11ai overview", Hiroshi Mano (ATRD), chair of TGai
        - 11-13-1349, "Access Control Enhancement", Katsuo Yunoki (KDDI)
        - 11-13-1375, "Summary and Discussions of Proposals on Potential PHY Technologies in HEW", Jianhan Liu (MediaTek)
        - 11-13-1377, "DL efficiency enhancement in high density network", Kiseon Ryu (LG Electronics)
        - 11-13-1382, "Discussion on OFDMA in HEW", Jinsoo Choi (LG Electronics)
        - 11-13-1386, "Improving WLAN Efficiency and QoE - A Top Down Approach", Veli-Pekka Kentonen (7 Signals)
        - 11-13-1388, "UL MU-MIMO transmission", Jinyoung Chun (LG)
        - 11-13-1395, "Simultaneous Transmission Technologies for HEW", Koichi Ishihara (NTT)
        - 11-13-1409, "Dual Wi-Fi: Dual Channel Wi-Fi for Congested WLANs with Asymmetric Traffic Loads", Adriana Flores (Rice University)
        - 11-13-1421, "STR Radios and STR Media Access", Phillip Levis (Stanford University)
        - 11-13-1440, "Argos | Practical Masive-MIMO", Clayton Shepard (Rice University)
    - **PAR proposals**
        - 11-13-1331, "Proposed direction and priorities for HEW", Guido R. Hiertz (Ericsson)
        - 11-13-1333, "Power Efficiency PAR Requirements", Chris Hansen (Covariant)
        - 11-13-1361, "Discussion to derive HEW Functional Requirements", Yasunao Misawa (KDDI)
        - 11-13-1366, "Some propositions to progress towards the PAR definition", Laurent Cariou (Orange)
        - 11-13-1389, "Discussion on HEW PAR", HanGyu Cho (LG Electronics)
        - 11-13-1397, "Renewing 2.4 GHz", Brian Hart (Cisco Systems)
        - 11-13-1398, "Requirements for HEW", Akira Yamada (NTT DOCOMO)
        - 11-13-1404, "Some Thoughts on PAR", and
          11-13-1405, "HEW PAR", Eldad Perahia (Intel)
        - 11-13-1450, "Summary of PAR Discussions", Osama Aboul-Magd (HEW SG chair)
        - 11-13-1470 and 11-13-1471, "802.11 HEW proposed basis for PAR discussion", Laurent Cariou (Orange)
3. **Discussed the WFA feedback on prioritization of the usage cases and approved a liaison letter back to WFA.**
    - Feedback from the Wi-Fi Alliance:
        - 11-13-1443-00, Liaison from Wi-Fi Alliance - HEW Use Cases
    - Approved a liaison document to the Wi-Fi Alliance:
        - 11-13-1446-00, IEEE 802.11 Liaison to WFA on Prioritization of High Efficiency WLAN (HEW) Usage Scenarios
4. **Started the discussion on the PAR.**
5. **The group passed a motion to extend the study group by 136/0/2.**

Goals for the January 2014 session

- Progress the work on the PAR and 5C.

Teleconferences

Three teleconferences are planned before the March 2016 meeting.

Wednesday	December 4th, 2013	10:00 - 12:00 (ET)
Wednesday	December 18th, 2013	20:00 - 22:00 (ET)
Wednesday	January 8th, 2014	10:00 - 12:00 (ET)

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September 2013 — Nanjing, China

The HEW SG had 9 sessions during the week.

	Monday	Tuesday	Wednesday	Thursday
AM1				**HEW**
AM2		**HEW**		
PM1			**HEW**	**HEW**
PM2	**HEW**	**HEW**	**HEW**	
PM3	**HEW**	**HEW**		

Main documents

- 11-13-0951-07, HEW SG September 2013 Meeting Agenda
- 11-13-1117-01, HEW SG September 2013 Nanjing Meeting Minutes
- 11-13-1231-01, HEW SG September 2013 Closing Report

Achievements

1. **The group approved minutes from the Geneva meeting and teleconference on August 28th, 2013.**
   - 11-13-0861-01, Minutes from face-to-face meeting in Geneva, July 2013
   - 11-13-1003-00, Minutes from the teleconference on August 28th, 2013
2. **50 submissions in the following categories were received and presented during the week.**
   - **Channel Models**
     - 11-13-0996, "Outdoor Channel Model Candidates for HEW", Kaushik Josiam (Samsung)
     - 11-13-1113, "Channel Modeling for Dense Wi-Fi Environments", Minho Cheong (ETRI)
     - 11-13-1125, "HEW Outdoor Channel Model Discussions", Hongyuan Zhang (Marvell)
     - 11-13-1135, "Summary of HEW Channel Models", Jianhan Liu (MediaTek)
     - 11-13-1146, "Update on HEW Channel Model", Shahrnaz Azizi (Intel Corp)
   - **Simulation Scenarios/Simulation Methodologies**
     - 11-13-1000, "Simulation Scenarios", Simone Merlin (Qualcomm)
     - 11-13-1001, "Simulation Scenarios Document Template", Simone Merlin (Qualcomm)
     - 11-13-1079, "Outdoor Stadium Simulation Details Discussion", Joseph Levy (InterDigital)
     - 11-13-1080, "Markov Modeling of the Channel for HEW System Level Simulations", Joseph Levy (InterDigital)
     - 11-13-1081, "HEW Simulation Methodology", Sayantan Choudhury (Nokia)
     - 11-13-1083, "HEW SG Unified Simulation Scenarios", David Xun Yang (Huawei)
     - 11-13-1114, "Simulation Scenario for unplanned Wi-Fi Network", Jae Seung Lee (ETRI)
     - 11-13-1123, "Capacity Simulation of High Density Indoor WLAN Systems", Filip Mestanov (Ericsson AB)
     - 11-13-1133, "Virtual Desktop Infrastructure (VDI)", Yingpei Lin (Huawei Technologies)
     - 11-13-1153, "Simulation Scenario Proposal", Laurent Cariou (Orange)
     - 11-13-1159, "Video Performance Requirements and Simulation Parameters", Guoqing Li (Intel)
     - 11-13-1162, "Video Application Categories and Characteristics", Guoqing Li (Intel)
     - 11-13-1176, "Some Simulation Scenarios for HEW", Reza Hedayat (Cisco)

- **Evaluation Methodology**
  - 11-13-1051, "Evaluation Methodology", Ron Porat (Broadcom)
  - 11-13-1054, "HEW Evaluation Metrics Suggestions", Yonggang Fang (ZTETX)
  - 11-13-1059, "PHY Abstraction for HEW Evaluation Methodology", Dongguk Lim (LG Electronics)
  - 11-13-1131, "PHY Abstraction for HEW System Level Simulation", Jiayin Zhang (Huawei Technologies)
  - 11-13-1137, "The Definition of Performance Metrics for HEW", Haui-Rong Shao (Samsung)
  - 11-13-1144, "Simplified Traffic Model Based on Aggregated Network Statistics", William Carney (Sony)
  - 11-13-1158, "Video Traffic and Applications for HEW", William Carney (Sony)
- **Functional Requirements**
  - 11-13-1097, "Functional Requirements for HEW PAR", Minho Cheong (ETRI)
  - 11-13-1116, "Discussion on HEW Functional Requirements", Jinsoo Choi (LG Electronics)
- **MAC/PHY Technologies**
  - 11-13-1046, "Discussion for Massive MIMO for HEW", Zhigang Wen (BUPT)
  - 11-13-1056, "Enhancement on resource utilization in OBSS environment", Giwon Park (LG Electronics)
  - 11-13-1058, "Efficient wider bandwidth operation", Kiseon Ryu (LG Electronics)
  - 11-13-1061, "Multicast Transmission for HEW", Jeongki Kim (LG electronics)
  - 11-13-1073, "Access Control Enhancement", Katsuo Yunoki (KDDI Labs)
  - 11-13-1074, "Occupied air time calculation for doc.1073r0", Katsuo Yunoki (KDDI R&D Laboratories)
  - 11-13-1077, "EDCA Enhancements for HEW", Hui Zhao (BUPT)
  - 11-13-1089, "D2D Technology for HEW", Xiang Gao (BUPT)
  - 11-13-1090, "Non-linear pre-coding MIMO Scheme for next generation WLAN", Xiang Gao (BUPT)
  - 11-13-1105, "Discussion on Access Mechanism for HEW", Meng Yang (CATR)
  - 11-13-1122, "Considerations for In-Band Simultaneous Transmit and Receive (STR) feature in HEW", Rakesh Taori (Samsung Electronics)
  - 11-13-1126, "Beamforming under OBSS Interference", Hongyuan Zhang (Marvell)
  - 11-13-1154, "DL-MU-MIMO Transmission with Unequal Bandwidth", Yongming Huang (Southeast University)
  - 11-13-1155, "Space Division Multiplex for OBSS Interference Suppression", Yongming Huang (Southeast University)
  - 11-13-1156, "TXOP Redundancy NAV Clear", Yongming Huang (Southeast University)
  - 11-13-1157, "Feasibility of Coordination Transmission for HEW", Yunzhou Li (Tsunghua University)
  - 11-13-1168, "Requirements on WLAN Ad Push", Hui Tian (BUPT)
  - 11-13-1169, "WLAN Cellular Offload in High Speed Moving Environment", Hui Tian (BUPT)
- **General**
  - 11-13-1057, "Legacy support on HEW frame structure", Wookbong Lee (LG electronics)
  - 11-13-1100, "HEW SG Progress Review", Osama Aboul-Magd (HEW SG)
  - 11-13-1115, "Possible vision of the HEW-driven Wi-Fi 2020", Minho Cheong (ETRI)
  - 11-13-1163, "PAR and 5C: Comments based on 11n", Sean Coffey (RealTek)
  - 11-13-1164, "Some PAR and 5C Requirements", Paul Lambert (Marvell)

3. **Straw Polls**
   Several straw polls were conducted to sense the group consensus on topics related to simulation scenarios, evaluation methodologies and channel models.
4. **Timeline**
   The group reviewed the timeline. No changes.

Goals for the November 2013 session

- Hear presentations addressing SS/SM/EM/FR/CM/TECH
  - Attempt to consolidate documents related to the above areas of discussion.
  - Priority will be given to presentations with consolidated views
- Start discussion on PAR related issues
- Motion for SG extension
- WFA feedback on the usage cases

Teleconferences

Three teleconferences are planned before the November 2013 meeting.

Wednesday	October 9th, 2013	10:00 - 12:00 (ET)
Wednesday	October 17th, 2013	00:00 - 02:00 (ET)
Wednesday	October 30th, 2013	10:00 - 12:00 (ET)

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July 2013 — Geneva, Switzerland

The HEW SG had nine sessions during the week.

	Monday	Tuesday	Wednesday	Thursday
AM1			**HEW**	**HEW**
AM2		**HEW**		**HEW**
PM1			**HEW**	
PM2	**HEW**	**HEW**	**HEW**	**HEW**
PM3				

Main Documents

- 11-13-0664-05, HEW SG July 2013 Agenda
- 11-13-0861-00, HEW SG July 2013 Geneva Meeting Minutes
- 11-13-0922-00, HEW SG July 2013 Closing Report

Acheivements

1. **The group approved minutes from the face-to-face meeting in Waikoloa, HI and teleconferences held on June 5th and June 19th.**
   - 11-13-0560-02, HEW SG May 2013 Waikoloa meeting minutes
   - 11-13-0663-01, HEW SG Teleconference minutes 20130605
   - 11-13-0704-00, HEW SG Teleconference minutes 20130619
2. Technical Presentations
   The group received over 35 submissions in areas of (1) Usage Models/Use Cases, (2) Functional Requirements, (3) Simulation Scenarios and Evaluation Methodology, (4) MAC/PHY techniques as listed below.
   - Usage Models/Use Cases
     - 11-13-0657, "HEW SG usage models and requirements - Liaison with WFA" Laurent Cariou (Orange)
     - 11-13-0761, "Interference Control Use Case for HEW", Fang Xie (CMCC)
     - 11-13-0795, "HEW Usage Scenarios Categorization", Eldad Perahia (Intel)
     - 11-13-0802, "Proposed re-categorization of the HEW usage models", Yasuhiko Inoue (NTT)
     - 11-13-0836, "HEW Usage Models for Backhauls and Floor Automation", Minho Cheong (ETRI)
   - Functional Requirements
     - 11-13-0787, "Follow up requirements", Wu Tianyu (Huawei)
     - 11-13-0798, "Functional Requirements in HEW", Jinsoo Choi (LG Electronics)
     - 11-13-0840, "HEW Functional Requirements Follow-up (Preliminary Version for Study Group discussions)", Minho Cheong (ETRI)
     - 11-13-0850, "Quantitative QoE Requirements for HEW", Huai-Rong Shao (Samsung)
   - Simulation Scenarios and Evaluation Methodology
     - 11-13-0723, "HEW SG Evaluation Methodology Overview", Minyoung Park (Intel)
     - 11-13-0728, "Network Optimization for Expected HEW Traffic Patterns", Bill Carney (Sony)

        - 11-13-0756, "HEW Channel Model", Vinko Erceg (Broadcom)
        - 11-13-0757, "Evaluation Methodology and Simulation Scenarios" Nihar Jindal (Broadcom)
        - 11-13-0786, "Discussion on System Level Simulation Methodology" Wu Tianyu (Huawei)
        - 11-13-0800, "HEW Study Group Documentation", Hemanth Sampath (Qualcomm)
        - 11-13-0805, "On Definition of Dense Networks and Performance Metric", Jianhan Liu (MediaTek)
        - 11-13-0837, "Consideration for HEW Evaluation Methodology", Minho Cheong (ETRI)
        - 11-13-0847, "Evaluation Criteria and Simulation Scenarios" Klaus Doppler (Nokia)
        - 11-13-0858, "Enhanced Channel Model for HEW", Shahrnaz Azizi (Intel)
        - 11-13-0869, "Simulation scenarios and metrics for HEW", Thomas Derham (Orange)
        - 11-13-0872, "Clarifications on outdoor deployments", Laurent Cariou (Orange)
    - MAC/PHY Techniques
        - 11-13-0712, "A Brief Time of History", Larry Taylor (DTC)
        - 11-13-0758, "Possible Approaches for HEW", Katsuo Yunoki (KDDI Labs)
        - 11-13-0764, "Full-duplex Technology for HEW", Andre Bourdoux (IMEC)
        - 11-13-0765, "Full-duplex is an emerging radio paradigm that has the potential to improve the efficiency of future WLANs", Hongliang Bian (China Telecom)
        - 11-13-0768, "TD-uCSMA", Riccard Scopigno (ISMB)
        - 11-13-0801, "Issues of Low Rate Transmissions", Akira Kishida (NTT)
        - 11-13-0843, "Further Evaluation on outdoor Wi-Fi", Wookbong Lee (LG Electronics)
        - 11-13-0849, "New Techniques: Enabling Real World Improvement By Exposing Internal MAC state", Brian Hart (Cisco)
        - 11-13-0852, "Potential approach to improve WLAN BSS edge performance", Juho Pirskanen (Renesas Mobile)
        - 11-13-0854, "Consideration on Efficiency Enhancement", SangHyun Chang (Samsung)
        - 11-13-0865, "Video Data Rate for HEW", Huai-Rong Shao (Samsung)
        - 11-13-0871, "Discussion on Potential Techniques for HEW", Timo Koskela (Renesas Mobile)
        - 11-13-0877, "HEW Beamforming Enhancements", James Wang (MediaTek)
        - 11-13-0878, "Efficiency enhancement for dense WLAN environment", Jeongki Kim (LG Electronics)
3. HWE SG Initial Usage Models
   The group approved document 11-13-0657-06 as HEW SG initial draft of Usage Models and to send it to Wi-Fi Alliance asking for prioritization of the use cases and additional feedbacks.
4. Liaison to the Wi-Fi Alliance
   The group also approved a liaison letter to the Wi-Fi Alliance contained in the document 11-13-0902-01.
5. The group passed motion to extend the SG.
6. Timeline
   The group discusses the timeline.

TGax Initial Timeline	
May 2013	**Start of the HEW SG**
July 2013	**Presentations, SG extension**
September 2013	**Presentations**
November 2013	**Presentations, initial PAR and 5C, and SG extension**
January 2014	**Presentations, final PAR and 5C, WG approval**
March 2014	**Presentations, EC approval of PAR and 5C**
May - June, 2014	**NesCom approval of PAR and 5C**
July 2014	**Start of a new TG**

Goals for September 2013 session

During the September 2013 meeting, the HEW SG continues discussions on issues related to:

- Usage Models/Use Cases
- Functional Requirements
- Feasibility

- Scope and Process

Teleconferences

Two teleconferences are planned before the September 2013 session.

Wednesday	August 7th, 2013	10:00 - 12:00 (ET)
Wednesday	August 27th, 2013	20:00 - 22:00 (ET)

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May 2013 — Waikoloa, HI

HEW SG had six sessions during the week. The TGax had 10 sessions during the week.
Four out of ten sessions were assigned to the ad hoc groups.

	Monday	Tuesday	Wednesday	Thursday
AM1				**HEW**
AM2		**HEW**		**HEW**
PM1				
PM2	**HEW**		**HEW**	**HEW**
PM3				

Main Documents

- 11-13-0400-04, HEW SG May 2013 Agenda
- 11-13-0560-02, HEW SG May 2013 Waikoloa Meeting Minutes
- 11-13-0624-00, HEW SG May 2013 Closing Report

Acheivements

1. **The group decided leadership structure to have one chairperson and one secretary.**
   - Chair: Osama Aboul-Magd (Huawei Technologies)
   - Secretary: Yasuhiko Inoue (NTT)
2. **The group received 22 submissions as listed below.**
   - **Usage Models/Use Cases**
     - 11-13-0514, "HEW Usage Scenarios and Applications", Eldad Perahia (Intel)
     - 11-13-0538, "Dense apartment building use case for HEW", Klaus Doppler (Nokia)
     - 11-13-0554, "Use Cases", Minho Cheong (ETRI)
     - 11-13-0567, "Proposed HEW Usage Models", Yasuhiko Inoue (NTT)
     - 11-13-0527, "Usage Models for Next Generation", David Xun Yang (Huawei) and James Wang (MediaTek)
     - 11-13-0534, "Direction and Use Cases for HEW", HanGyu Cho (LG Electronics)
     - 11-13-0563-00, "D2D Technology for HEW", Zhanji Wu (BUPT) - not presented
   - **Problem Statements**
     - 11-13-0505, "MAC Efficiency Analysis for HEW SG", Minyoung Park (Intel)
     - 11-13-0545, "WLAN QoE, End User Perspective Opportunities to Improve", Veli-Pekka Ketonen (7 signals)
     - 11-13-0523, "Understanding Current Situation of Public Wi-Fi Usage - Possible Requirements for HEW -", Katsuo Yunoki (KDDI Labs)
     - 11-13-0539, "Efficient Frequency Spectrum Utilization", Yongho Seok (LG Electronics)
     - 11-13-0544, "Discussions on 11ac PHY efficiency", Jianhan Liu (MediaTek)

        - 11-13-0536-00, "HEW SG PHY Considerations For Outdoor Environment", Wookbong Lee (LG Electronics)
        - 11-13-0576, "Performance Evaluation for 11ac", Wu Tianyu (Huawei Technologies)
        - 11-13-0556, "Wi-Fi interference measurements in Korea - Part 1", Minho Cheong (ETRI)
        - 11-13-0549, "A perspective on what any High Efficiency Wireless TG should and should not do", Brian Hart (Cisco Systems)
    - **Requirements**
        - 11-13-0524, "HEW Finctional Requirements", Wu Tianyu (Huawei Technologies)
        - 11-13-0555, "Considerations on Functional Requirements for HEW", Minho Cheoung (ETRI)
    - **Scenarios and Metrics**
        - 11-13-0503, "Discussion on Basic Technical Aspects for HEW", Juho Pirskanen (Renesas Mobile)
        - 11-13-0542, "HEW Scenarios and Goals", Simone Merlin (Qualcomm)
        - 11-13-0486, "HEW - Metrics, Targets and Simulation Scenarios", Ron Porat (Broadcom)
        - 11-13-0520, "HEW scenarios and evaluation metrics", Thomas Derham (Orange)
    - **Technical Feasibility**
        - 11-13-0558, "Coexistence and Optimization of Wireless LAN: Time, Frequency, Space, Power, and Load", Jim Lansford (CSR)
3. **Liaison to the Wi-Fi Alliance**
    - The group agreed to ask the Wi-Fi Alliance for input about priority of the use cases.
    - Laurent Cariou (Orange) volunteers to develop the use case document.
4. **Project planning**
    - The group discussed about the project plan based on the submission 11-13-0616-02 by Phil Barber (Huawei)
    - Discussion to be continued in the July meeting.

Goals for July 2013 session

During July 2013 session, the HEW SG will continue discussions on:

- Use Cases,
- Functional Requirements,
- Feasibility,
- Scope and Process.

Teleconferences

Two teleconferences are planned before the July 2013 session.

Wednesday	June 5th, 2013	10:00 - 12:00 (ET)
Wednesday	June 19th, 2013	20:00 - 22:00 (ET)

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Related documents

Documents referenced in the motion that led to the creation of the study group

- https://mentor.ieee.org/802.11/dcn/13/11-13-0339-10-0wng-high-efficiency-wlan-straw-poll.ppt

Press release document

- https://mentor.ieee.org/802.11/dcn/13/11-13-0418-02-0000-proposed-edits-to-hew-press-release.doc

Useful links to other web sites

IEEE P802.11 WLANs RELATED

- Home
- IEEE 802.11 Wiki
- E-mail Reflectors Archives (Members Only)

OTHER SITES

- IEEE P802 LAN/MAN Standards Committee (LMSC)

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APPENDIX D

802.11 Working Group Opening Report July 2014

Date: 2014-07-14

Authors:

Name	Company	Address	Phone	email
Adrian Stephens	Intel Corporation			adrian.p.stephens@intel.com

Introduction

- This presentation, together with the topic reports cited on the next slide, forms the opening report of the IEEE 802.11 Working Group for May 2014.
- Subgroup status is reported in the "Snapshots" submission (see next slide for link). This is incorporated by reference into this opening report.
- "*Mx.y.z*" terminology indicates that the item was on the tentative agenda for the *M*onday 802.11 plenary, and was agenda item *x.y.z*.

M3.1 802.11 Working Group Session Documents

WG Session Reports	
WG Agenda	https://mentor.ieee.org/802.11/dcn/11-14-0736
Opening report	https://mentor.ieee.org/802.11/dcn/11-14-0737
Snapshots	https://mentor.ieee.org/802.11/dcn/11-14-0743
Supplementary Material	https://mentor.ieee.org/802.11/dcn/11-14-0738
Motions	https://mentor.ieee.org/802.11/dcn/11-14-0744
Closing report	https://mentor.ieee.org/802.11/dcn/11-14-0745
1st vice chair	https://mentor.ieee.org/802.11/dcn/11-14-0843
Treasurer	https://mentor.ieee.org/802.11/dcn/11-14-0844
2nd vice chair	https://mentor.ieee.org/802.11/dcn/11-14-0746

M4.1.1 Type of Groups

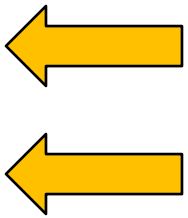
Type of Group	Description
WG	Working Group
SC	Standing Committee
TG	Task Group
SG	Study Group

M4.1.1 Groups

Type	Group	Description
WG	WG11	The IEEE 802.11 Working Group
SC	ARC	Architecture
SC	REG	Regulatory
SC	PUB	Publicity
SC	WNG	Wireless Next Generation
802 SC	JTC1	ISO/IEC JTC1/SC6
TG	MC	Revision mc (REVmc)
TG	AH	Operation in 900 MHz bands (S1G)
TG	AI	Fast Initial Link Setup (FILS)
TG	AJ	China 60 GHz (CMMW)
TG	AQ	Pre-association Discovery (PAD)
TG	AK	General Link (GLK)
TG	AX	High Efficiency Wireless LAN (HEW)

M4.1.2 PAR Expiration/Renewal Schedule

Project	PAR Expiration Date
AH	31-DEC-2014
AI	31-DEC-2014
MC	31-DEC-2016
AJ	31-DEC-2016
AK	31-DEC-2016
AQ	31-DEC-2016
AX	31-DEC-2018



July 2014 extension requests to 802 EC

http://www.ieee802.org/11/PARs/index.html

M4.1.3 802.11 Appointed positions

- **WG Secretary – Stephen McCann**
- **Treasurer – Jon Rosdahl**
- **Publicity – Stephen McCann**
- **ANA Authority – Adrian Stephens**
- **WG Technical Editors – Adrian Stephens, Peter Ecclesine**

M4.1.3 Officers

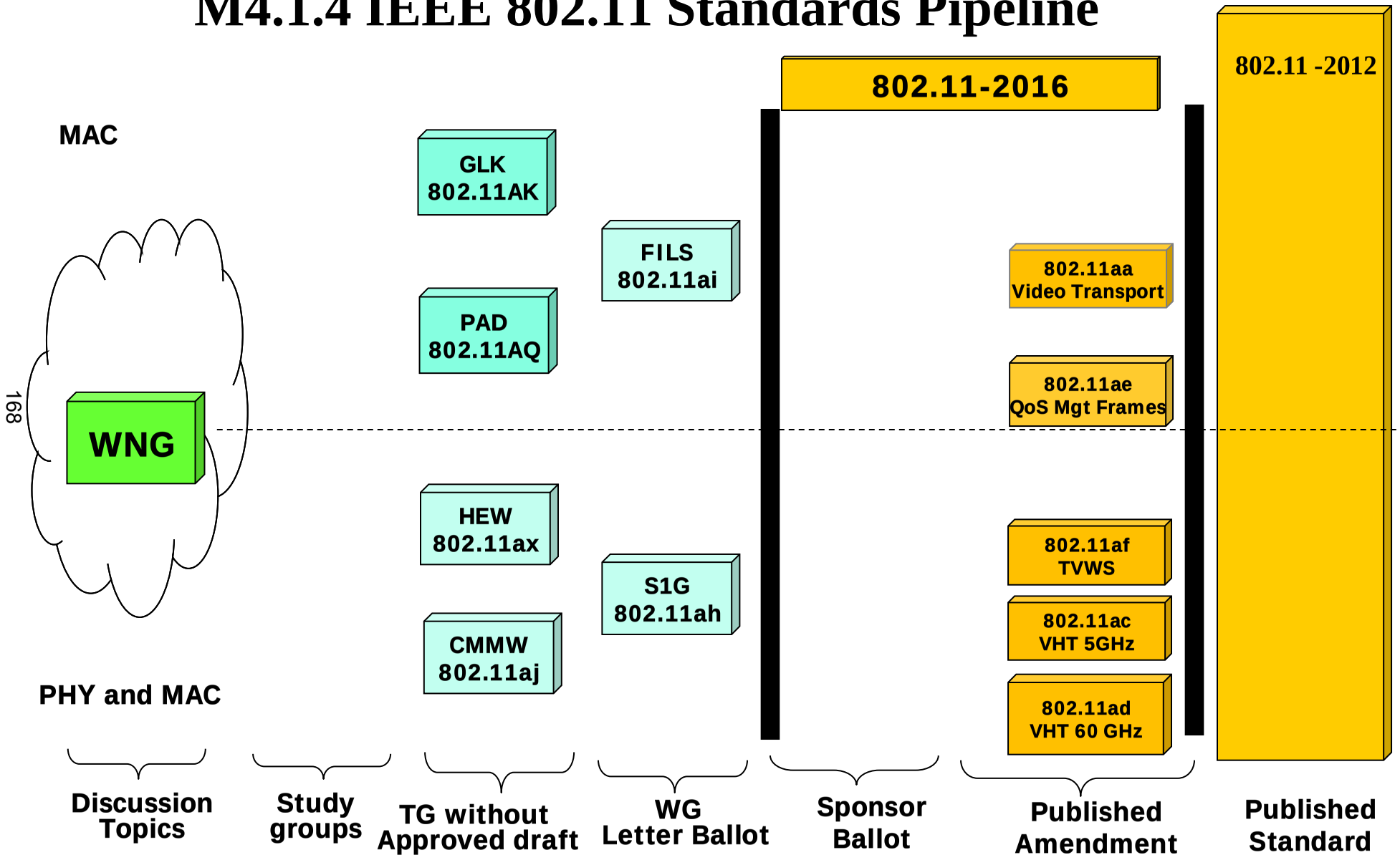
Cat	Group	Chair	Vice Chair	Technical Editor	Secretary
WG		Adrian STEPHENS	Jon ROSDAHL Dorothy STANLEY	Adrian STEPHENS Peter ECCLESINE	Stephen MCCANN
SC	ARC	Mark HAMILTON	Joseph LEVY		
SC	REG	Richard KENNEDY			
SC	PUB	Stephen MCCANN			
SC	WNG	Clint CHAPLIN	Jim LANSFORD		
TG	MC	Dorothy STANLEY	Mark HAMILTON Jon ROSDAHL	Adrian Stephens, Sub-editors Emily Qi and Edward Au	Jon ROSDAHL
TG	AH	Yongho SEOK	Alfred ASTERJADHI Zander LEI	Yongho SEOK Alfred ASTERJADHI	Zander LEI
TG	AI	Hiroshi MANO	Marc EMMELMANN	Lee ARMSTRONG Ping FANG	Hitoshi MORIOKA
TG	AJ	Xiaoming PENG	Eldad PERAHIA Haiming WANG	Jiamin CHEN	HAO Peng
TG	AK	Donald EASTLAKE	Mark HAMILTON	Donald EASTLAKE Norm FINN	Filip MESTANOV
TG	AQ	Stephen McCann	Yunsong YANG	Dan GAL	Dapeng LIU
TG	AX	Osama Aboul-Magd			Yasuhiko Inoue

OPEN = Candidate Nominations are open

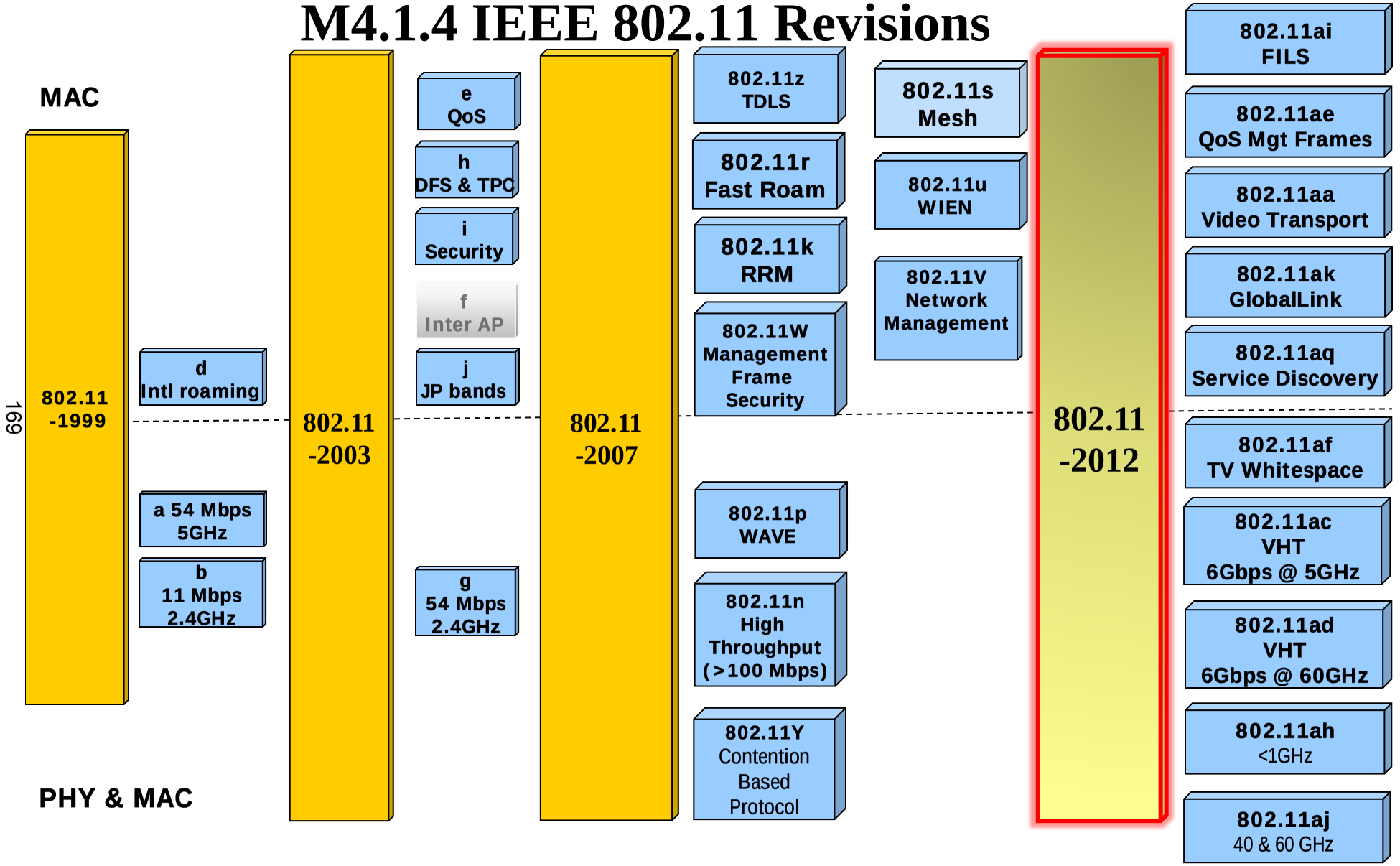
M4.1.3 Officers (this session)

Cat	Group	Chair	Vice Chair	Technical Editor	Secretary
WG		Adrian STEPHENS	Jon ROSDAHL Dorothy STANLEY	Adrian STEPHENS Peter ECCLESINE	Stephen MCCANN
SC	ARC	Mark HAMILTON	Joseph LEVY		
SC	REG	Richard KENNEDY			
SC	PUB	Stephen MCCANN			
SC	WNG	Jim LANSFORD			
TG	MC	Dorothy STANLEY	Mark HAMILTON Jon ROSDAHL	Adrian Stephens, Sub-editors Emily Qi and Edward Au	Jon ROSDAHL
TG	AH	Yongho SEOK	Alfred ASTERJADHI Zander LEI	Yongho SEOK Alfred ASTERJADHI	Zander LEI
TG	AI	Hiroshi MANO	Marc EMMELMANN	Lee ARMSTRONG Ping FANG	Hitoshi MORIOKA
TG	AJ	Xiaoming PENG	Eldad PERAHIA Haiming WANG	Jiamin CHEN	HAO Peng
TG	AK	Donald EASTLAKE	Mark HAMILTON	Donald EASTLAKE Norm FINN	Filip MESTANOV
TG	AQ	Stephen McCann	Yunsong YANG	Dan GAL	Dapeng LIU
TG	AX	Osama Aboul-Magd			Yasuhiko Inoue

M4.1.4 IEEE 802.11 Standards Pipeline



M4.1.4 IEEE 802.11 Revisions



M4.1.5 Summary of ballots and comment collections

Type	Label	Group	Opened	Dur (d)	# Comments	Pool	Approve	Disapprove	Abstain	Return %	Approve %	Result
LB	202	TGmc	Jun 3	20	775	325	219	24	19	81	90	P
LB	203	TGah	Jun 5	30	1214	330	204	43 +3	24	83	83	P
CC	19	TGaj	Jun 6	20	12							

M4.1.6 Current Membership Status

Status	Number
Aspirant	134
Potential Voter	69
Voter	321
Ex Officio Voter	9

Definitions:

Aspirant: a member who has attended 1 qualifying meeting

Potential Voter: a member who has attended 2 qualifying meetings and will become a voter at the start of the next plenary they attend

Ex Officio Voter: a voter who has voting rights by virtue of their membership of the 802 EC and has requested to be recorded as an ex officio voter in 802.11

- **Note – does not include effect of LB203ah**

Data as of 2014-05-16

M4.1.6 “Ex Officio” voting members

- **According to the 802 P&P, 802 voting EC members have the right to vote in 802.11.**
- **The EC members have been asked to indicate if they are interested in exercising this right. Those interested are recorded as “Ex Officio” voters in 802.11.**
- **Ex Officio voters will appear in WG ballot pools.**

M4.1.6 Recent voting member history

Date	Event	Gained	Lost	# Voters
2012-07-20	After July plenary	35	29	300
2012-08-20	LB189		5	295
2012-09-26	Inaugral China Interim	29		324
2012-10	Death of member		1	323
2012-11-16	After Nov plenary	24	23	324
2013-01-19	New Liaison added	1		325
2014-03-04	LB193		4	321
2014-03-22	After Mar plenary	18	16	323
2013-07-19	After July plenary	28	18	333
2013-09	Voting rights re-instated on appeal	1		334
2013-09-16	LB198		11	323
2013-11-10	LB200		16	307
2013-11-15	After Nov plenary	37	14	330
2013-03-18	7 Voters to Ex Officio		7	323
2013-03-21	After Mar plenary	35	30	328
2013-05-09	LB201		7	321

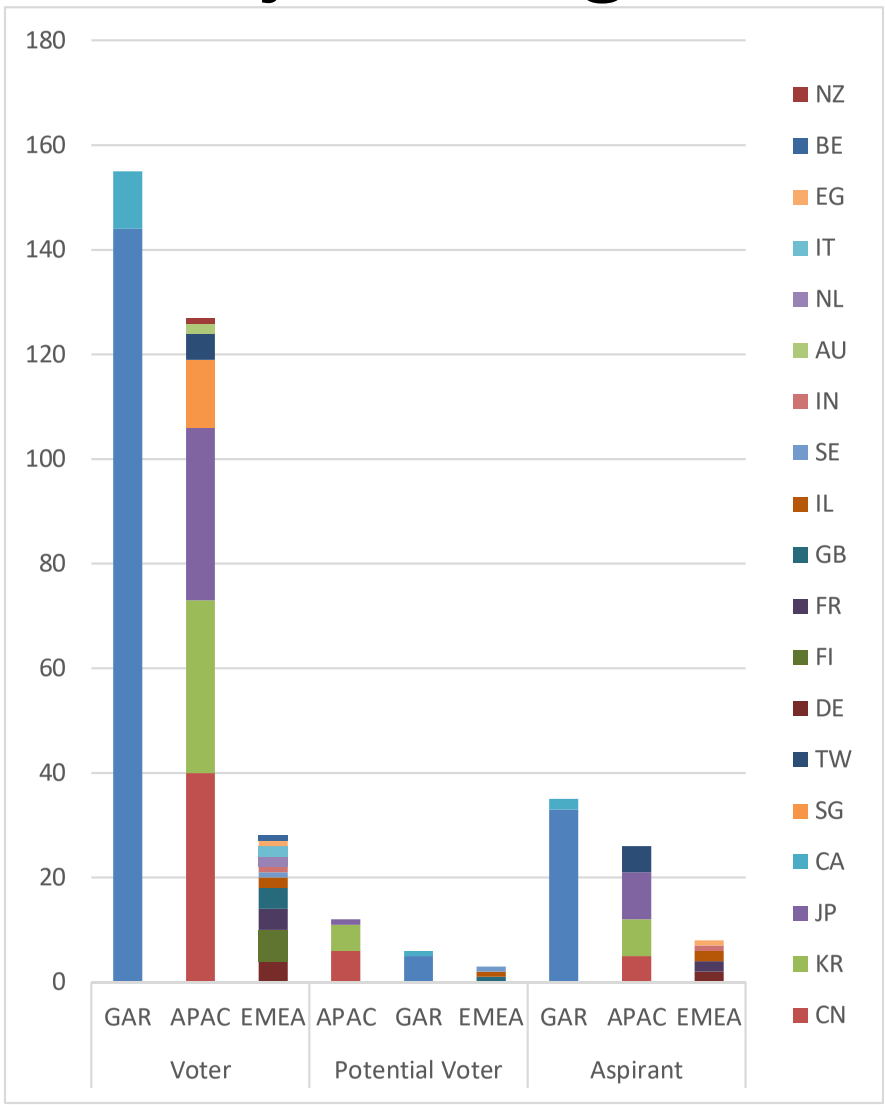
M4.1.7 ANA Status

- **The latest database is 11-11/0270r22 (July 2014)**
- **Changes since last meeting:**
  - General Link subfield added to capabilities field

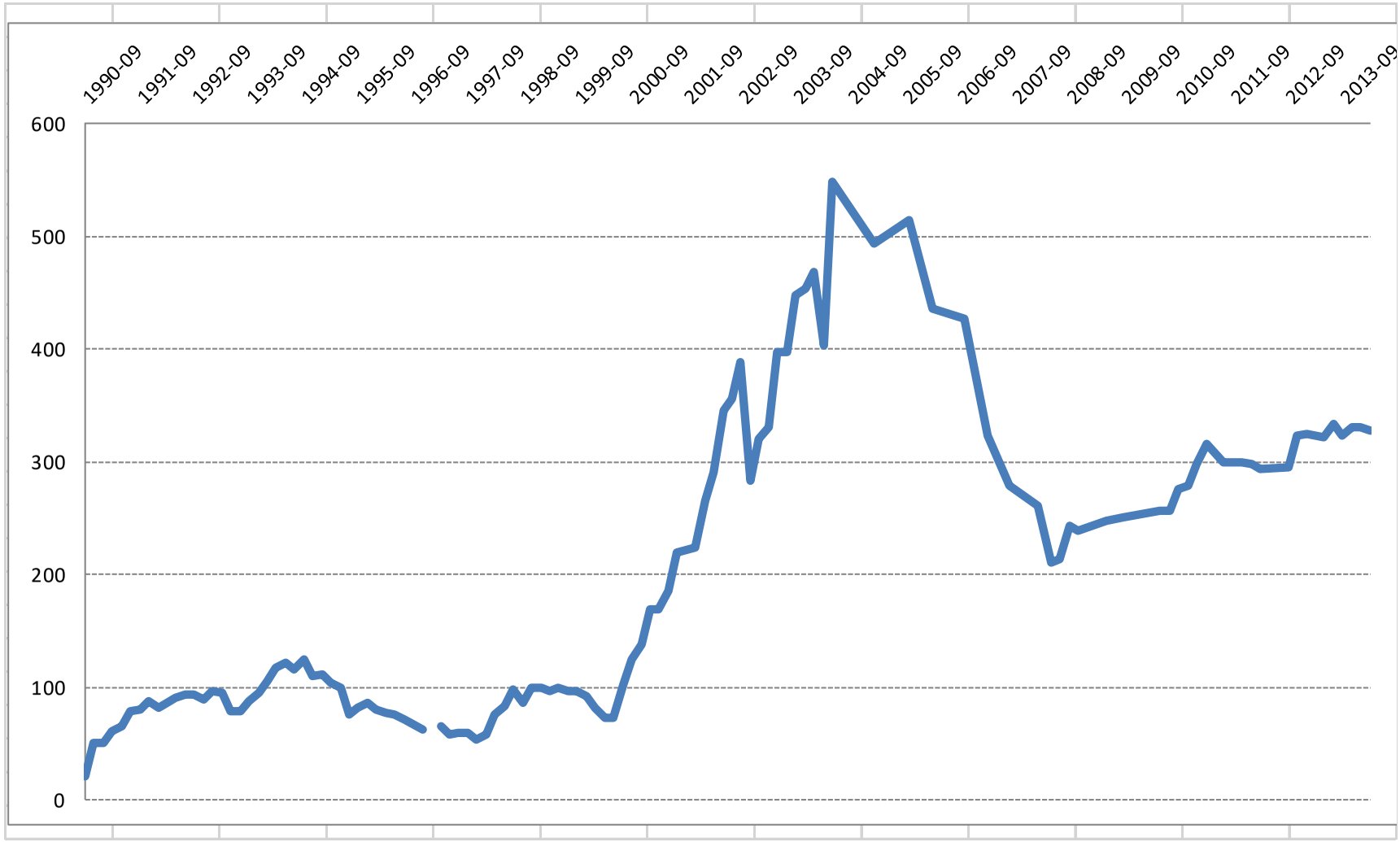
BACKGROUND DATA

Membership by Country and Region

	Voter	Potential Voter	Aspirant	Grand Total
GAR	**155**	**6**	**35**	**196**
US	144	5	33	182
CA	11	1	2	14
APAC	**127**	**12**	**26**	**165**
CN	40	6	5	51
KR	33	5	7	45
JP	33	1	9	43
SG	13			13
TW	5		5	10
AU	2			2
NZ	1			1
EMEA	**28**	**3**	**8**	**39**
FI	6			6
FR	4		2	6
DE	4		2	6
IL	2	1	2	5
GB	4	1		5
NL	2			2
IT	2			2
SE	1	1		2
EG	1		1	2
IN	1		1	2
BE	1			1
Grand Total	**310**	**21**	**69**	**400**



Membership – Historic Data



APPENDIX E

The Wayback Machine - https://web.archive.org/web/20160120211329/https://mentor.ieee.org/802.11/docu...

Documents

Everything | All Years | All Groups

DCN, Title, Author or Affiliation

Created (ET) ▼	Year	DCN	Rev	Group	Title	Author (Affiliation)	Uploaded (ET)	Actions
20-Jan-2016 ET	2016	77	1	TGah	SB0-comment-resolutions-to-CIDs-8091, 8102, 8126, 8322, 8446, 8182	Kaiying Lv (ZTE Corp.)	20-Jan-2016 16:09:31 ET	Download
20-Jan-2016 ET	2015	1511	6	TGah	January 2016 Agenda	Yongho Seok (NEWRACOM)	20-Jan-2016 15:52:05 ET	Download
20-Jan-2016 ET	2016	168	0	TGah	11ah SB0 resolution to comments on frame control field	Zander Lei (I2R), Yongho Seok (NEWRACOM)	20-Jan-2016 15:41:14 ET	Download
20-Jan-2016 ET	2016	138	2	TGak	GLK-GCR Comments Resolutions (part-3)	Ganesh Venkatesan (Intel Corporation)	20-Jan-2016 15:34:23 ET	Download
20-Jan-2016 ET	2016	166	1	TGak	Revised 11ak Figures	Donald Eastlake (Huawei Technologies)	20-Jan-2016 15:31:34 ET	Download
20-Jan-2016 ET	2016	117	2	TGm	EIFS comment	Menzo Wentink (Qualcomm)	20-Jan-2016 15:28:23 ET	Download
20-Jan-2016 ET	2016	60	3	TGax	Recipient-aware Spatial Reuse	Reza Hedayat (Newracom)	20-Jan-2016 15:18:24 ET	Download
20-Jan-2016 ET	2016	136	2	TGaq	TGaq ANQP-SD to ANQP	Jouni Malinen (Qualcomm)	20-Jan-2016 15:12:02 ET	Download
20-Jan-2016 ET	2016	92	1	TGay	Multi-Beamforming in Polarized Channels for 11ay	Kyungtae Jo (LG Electronics)	20-Jan-2016 14:09:23 ET	Download
20-Jan-2016 ET	2016	134	3	TGaz	Accuracy and Coverage functional requirements	Ganesh Venkatesan (Intel Corporation)	20-Jan-2016 13:59:42 ET	Download
20-Jan-2016 ET	2016	167	0	TGah	SB Comment Resolutions Misc 8 CIDs	Qualcomm	20-Jan-2016 13:55:53 ET	Download
20-Jan-2016 ET	2016	60	2	TGax	Recipient-aware Spatial Reuse	Reza Hedayat (Newracom)	20-Jan-2016 13:44:51 ET	Download
20-Jan-2016 ET	2015	1466	2	TGaz	TGaz Jan 2016 Meeting Agenda	Jonathan Segev (Intel corporation)	20-Jan-2016 13:30:25 ET	Download
20-Jan-2016 ET	2016	166	0	TGak	Revised 11ak Figures	Donald Eastlake (Huawei Technologies)	20-Jan-2016 13:37:40 ET	Download
20-Jan-2016 ET	2015	1530	4	TGm	VHT160 operation signaling through non-zero CCFS1	Menzo Wentink (Qualcomm)	20-Jan-2016 13:24:58 ET	Download
20-Jan-2016 ET	2016	66	2	TGax	Views on UL-MU Features	Joonsuk Kim (Apple)	20-Jan-2016 13:23:51 ET	Download
20-Jan-2016 ET	2015	556	17	TGak	LB212 Working Group Ballot Comments	Donald Eastlake (Huawei Technologies)	20-Jan-2016 13:22:17 ET	Download
20-Jan-2016 ET	2016	117	1	TGm	EIFS comment	Menzo Wentink (Qualcomm)	20-Jan-2016 13:09:54 ET	Download
20-Jan-2016 ET	2016	138	1	TGak	GLK-GCR Comments Resolutions (part-3)	Ganesh Venkatesan (Intel Corporation)	20-Jan-2016 12:17:26 ET	Download

20-Jan-2016 ET	2015	828	5	TGm	SB0 Ecclesine Resolutions	Peter Ecclesine (Cisco Systems)	20-Jan-2016 11:53:04 ET	Download
20-Jan-2016 ET	2016	120	2	TGai	TGai comments assigned to me	Jouni Malinen (Qualcomm)	20-Jan-2016 11:52:49 ET	Download
20-Jan-2016 ET	2015	1485	3	802.11 WG	Jan 2016 WG Agenda	Adrian Stephens (Intel Corporation)	20-Jan-2016 11:40:36 ET	Download
20-Jan-2016 ET	2015	1473	7	TGak	January 2016 802.11ak Agenda	Donald Eastlake (Huawei Technologies)	20-Jan-2016 11:25:42 ET	Download
20-Jan-2016 ET	2015	1196	29	TGai	TGai Comments from 1st SB	Marc Emmelmann (self)	20-Jan-2016 11:03:23 ET	Download
20-Jan-2016 ET	2016	136	1	TGaq	TGaq ANQP-SD to ANQP	Jouni Malinen (Qualcomm)	20-Jan-2016 10:54:52 ET	Download
20-Jan-2016 ET	2015	1472	5	TGay	TG AY January 2016 Meeting Agenda	Edward Au (Huawei Technologies)	20-Jan-2016 10:47:25 ET	Download
20-Jan-2016 ET	2016	134	2	TGaz	Accuracy and Coverage functional requirements	Ganesh Venkatesan (Intel Corporation)	20-Jan-2016 10:39:27 ET	Download
20-Jan-2016 ET	2015	1537	1	802.11 WG	Current State of Affairs of IEEE 802.11 Regulatory	Rich Kennedy (Mediatek)	20-Jan-2016 10:38:04 ET	Download
20-Jan-2016 ET	2015	1468	2	802.11 WG	WG Motions regarding attendance and voting rights	Knut Odman (Broadcom)	20-Jan-2016 10:24:10 ET	Download
20-Jan-2016 ET	2016	8	2	TGaq	proposals for LB216 WG Comments for 11aq Draft 3.0	Stephen McCann (BlackBerry)	20-Jan-2016 10:21:47 ET	Download
20-Jan-2016 ET	2016	164	0	TGai	Clause 11 with CID 10049 changes.docx	Lee Armstrong (US DOT)	20-Jan-2016 10:19:09 ET	Download
20-Jan-2016 ET	2016	25	1	802.11 WG	WG attendance investigation re: 2015-11-motion	Dorothy Stanley (HPE)	20-Jan-2016 10:05:41 ET	Download
20-Jan-2016 ET	2016	71	1	TGax	Packet Extension Follow Up	Andrew Blanksby	20-Jan-2016 09:53:25 ET	Download
20-Jan-2016 ET	2016	59	1	TGax	Non-contiguous Channel Bonding in 11ax	Yunbo Li (Huawei)	20-Jan-2016 09:50:47 ET	Download
20-Jan-2016 ET	2016	89	1	TGax	Single Stream Pilots in UL MU MIMO	Sriram Venkateswaran (Broadcom)	20-Jan-2016 09:46:23 ET	Download
20-Jan-2016 ET	2016	163	0	802.11 WG	What is the status of the ETSI BRAN work on a revised version of EN 301 893?	Andrew Myles (Cisco)	20-Jan-2016 09:42:37 ET	Download
20-Jan-2016 ET	2016	80	2	TGax	1x/2x/4x OFDM Symbol in HE SU PPDU with BCC	Heejung Yu (YU/Newracom)	20-Jan-2016 09:32:23 ET	Download
20-Jan-2016 ET	2016	160	1	TGai	Mandatory Probe Request Max Channel Time	Peter Khoury (Ruckus Wireless)	20-Jan-2016 09:32:07 ET	Download
20-Jan-2016 ET	2016	154	1	TGaq	LB216 Clause 6 Comment Resolutions	Emily Qi (intel)	20-Jan-2016 09:28:43 ET	Download
20-Jan-2016 ET	2016	155	1	TGaq	LB216 AnnexCClause6 Comment Resolutions	Emily Qi (Intel)	20-Jan-2016 09:28:16 ET	Download
20-Jan-2016 ET	2016	161	0	REG SC	Closing Report on NGMN Ad-Hoc Meeting	Jeorge Hurtarte (Teradyne)	20-Jan-2016 09:34:44 ET	Download
20-Jan-2016 ET	2016	160	0	TGai	Mandatory Probe Request Max Channel Time	Peter Khoury (Ruckus Wireless)	20-Jan-2016 09:24:19 ET	Download

20-Jan-2016 ET	2015	1275	2	TGak	Address 1 filtering and GLK-GCR Scoreboarding	Ganesh Venkatesan (Intel Corporation)	20-Jan-2016 08:59:43 ET	Download
20-Jan-2016 ET	2016	109	2	TGax	MAC Ad-hoc January 2016 Meeting Agenda	Reza Hedayat (Newracom)	20-Jan-2016 08:41:39 ET	Download
20-Jan-2016 ET	2016	133	1	TGaq	architecture-figures	Stephen McCann (BlackBerry)	20-Jan-2016 08:36:43 ET	Download
20-Jan-2016 ET	2016	147	1	TGax	TGax MU Ad-hoc January 2016 Agenda	Sigurd Schelstraete (Quantenna)	20-Jan-2016 08:24:06 ET	Download
20-Jan-2016 ET	2016	159	0	TGah	TGah SB0 Relay Comments	Menzo Wentink (Qualcomm)	20-Jan-2016 08:08:23 ET	Download
20-Jan-2016 ET	2013	1186	37	TGai	TGai-Motion-deck	Hiroshi Mano (KDTI)	20-Jan-2016 07:58:22 ET	Download
20-Jan-2016 ET	2015	1489	2	802.11 WG	Register of LoA requests	Adrian Stephens (Intel Corporation)	20-Jan-2016 07:16:18 ET	Download
20-Jan-2016 ET	2015	1485	2	802.11 WG	Jan 2016 WG Agenda	Adrian Stephens (Intel Corporation)	20-Jan-2016 07:15:02 ET	Download
20-Jan-2016 ET	2016	156	0	802.11 WG	IMT-2020 Discussion Review and Straw Polls	Joseph LEVY (InterDigital)	20-Jan-2016 10:33:46 ET	Download
20-Jan-2016 ET	2016	155	0	TGaq	LB216 AnnexCClause6 Comment Resolutions	Emily Qi (Intel)	20-Jan-2016 01:04:00 ET	Download
20-Jan-2016 ET	2016	154	0	TGaq	LB216 Clause 6 Comment Resolutions	Emily Qi (intel)	20-Jan-2016 00:57:54 ET	Download
20-Jan-2016 ET	2016	128	1	WNG SC	IMT-2020 Way Forward and Straw Polls	Joseph LEVY (InterDigital)	20-Jan-2016 00:30:54 ET	Download
19-Jan-2016 ET	2015	1377	6	TGaq	LB216 WG Comments for 11aq Draft 3.0	Yunsong Yang (Huawei Technologies)	19-Jan-2016 23:50:50 ET	Download
19-Jan-2016 ET	2015	1472	4	TGay	TG AY January 2016 Meeting Agenda	Edward Au (Huawei Technologies)	19-Jan-2016 23:39:03 ET	Download
19-Jan-2016 ET	2016	67	1	TGax	MAC Padding in Trigger Frame	Liwen Chu (Marvell)	19-Jan-2016 22:36:45 ET	Download
19-Jan-2016 ET	2016	153	0	TGah	ah sb0 comment resolution 8.2.4	Liwen Chu (Marvell)	20-Jan-2016 15:50:15 ET	Download
19-Jan-2016 ET	2015	1196	28	TGai	TGai Comments from 1st SB	Marc Emmelmann (self)	19-Jan-2016 21:46:07 ET	Download
19-Jan-2016 ET	2016	12	7	TGai	Resolutions for assigned CIDs	Hitoshi Morioka (SRC Software)	19-Jan-2016 21:39:03 ET	Download
19-Jan-2016 ET	2016	21	6	TGai	Proposed Resolution for Authentication frame format	Hitoshi Morioka (SRC Software)	19-Jan-2016 21:38:37 ET	Download
19-Jan-2016 ET	2016	152	0	TGai	Resolutions-Kneckt	Jarkko Kneckt (Apple)	19-Jan-2016 21:00:34 ET	Download
19-Jan-2016 ET	2016	12	6	TGai	Resolutions for assigned CIDs	Hitoshi Morioka (SRC Software)	19-Jan-2016 20:35:12 ET	Download
19-Jan-2016 ET	2016	21	5	TGai	Proposed Resolution for Authentication frame format	Hitoshi Morioka (SRC Software)	19-Jan-2016 20:34:43 ET	Download
19-Jan-2016 ET	2016	151	0	ARC SC	Proposed Updates for REVmc to 5.1.5	Joseph LEVY (InterDigital)	20-Jan-2016 00:19:47 ET	Download
19-Jan-2016 ET	2016	85	1	TGax	Congestion control □for UL MU random access	Woojin Ahn (Yonsei Univ.)	19-Jan-2016 20:03:26 ET	Download
19-Jan-2016 ET	2016	54	1	TGax	UL MU CCA Response	Kaiying Lv (ZTE Corp.)	19-Jan-2016 20:00:05 ET	Download
19-Jan-2016 ET	2016	91	2	TGax	Regarding HE NDPA frame	Narendar Madhavan	19-Jan-2016 19:46:38 ET	Download

					for DL Sounding Sequence	(Toshiba)		
19-Jan-2016 ET	2015	1275	1	TGak	Address 1 filtering and GLK-GCR Scoreboarding	Ganesh Venkatesan (Intel Corporation)	19-Jan-2016 19:45:54 ET	Download
19-Jan-2016 ET	2015	540	8	ARC SC	Updates to REVmc 5.1.5	Joseph Levy (InterDigital)	19-Jan-2016 19:44:07 ET	Download
19-Jan-2016 ET	2015	1519	3	ARC SC	ARC SC Agenda Jan 2016	Joseph Levy (InterDigital)	19-Jan-2016 19:42:45 ET	Download
19-Jan-2016 ET	2016	108	3	TGax	tgax-phy-ad-hoc-jan-2016-meeting-agenda	Bo Sun (ZTE Corporation)	19-Jan-2016 19:35:47 ET	Download
19-Jan-2016 ET	2016	150	0	TGax	TGax MU Ad hoc Meeting Minutes January 2016	Kaushik Josiam (Samsung)	20-Jan-2016 08:40:51 ET	Download
19-Jan-2016 ET	2016	12	5	TGai	Resolutions for assigned CIDs	Hitoshi Morioka (SRC Software)	19-Jan-2016 18:53:23 ET	Download
19-Jan-2016 ET	2016	21	4	TGai	Proposed Resolution for Authentication frame format	Hitoshi Morioka (SRC Software)	19-Jan-2016 18:52:45 ET	Download
19-Jan-2016 ET	2015	1196	27	TGai	TGai Comments from 1st SB	Marc Emmelmann (self)	19-Jan-2016 18:37:11 ET	Download
19-Jan-2016 ET	2016	63	1	TGah	LB215-TWT-CIDs-proposed-resolutions	Matthew Fischer (Broadcom)	19-Jan-2016 18:11:55 ET	Download
19-Jan-2016 ET	2015	1511	5	TGah	January 2016 Agenda	Yongho Seok (NEWRACOM)	19-Jan-2016 18:06:35 ET	Download
19-Jan-2016 ET	2015	1473	6	TGak	January 2016 802.11ak Agenda	Donald Eastlake (Huawei Technologies)	19-Jan-2016 17:47:52 ET	Download
19-Jan-2016 ET	2015	795	10	TGak	Addressing Comment Resolutions	David Kloper (Cisco)	19-Jan-2016 17:43:12 ET	Download
19-Jan-2016 ET	2016	7	2	TGaq	updated-text-for-annex-b-pics	Stephen McCann (BlackBerry)	19-Jan-2016 17:34:42 ET	Download
19-Jan-2016 ET	2016	148	1	TGaz	60 GHz Focus Area	Alecsander Eitan (Qualcomm)	19-Jan-2016 17:32:33 ET	Download
19-Jan-2016 ET	2016	8	1	TGaq	proposals for LB216 WG Comments for 11aq Draft 3.0	Stephen McCann (BlackBerry)	19-Jan-2016 17:27:02 ET	Download
19-Jan-2016 ET	2016	146	5	TGai	Resolutions for pending QC comments	Abhishek Patil (Qualcomm)	19-Jan-2016 17:21:47 ET	Download
19-Jan-2016 ET	2016	146	4	TGai	Resolutions for pending QC comments	Abhishek Patil (Qualcomm)	19-Jan-2016 17:10:20 ET	Download
19-Jan-2016 ET	2016	145	1	TGai	Resolution for CID-10747	Abhishek Patil (Qualcomm)	19-Jan-2016 17:09:49 ET	Download
19-Jan-2016 ET	2016	141	1	TGm	160 and 80+80 MHz channel width signaling	Menzo Wentink (Qualcomm)	19-Jan-2016 16:59:57 ET	Download
19-Jan-2016 ET	2015	1522	3	TGm	TGmc Agenda January 2016	Dorothy Stanley (HPE)	19-Jan-2016 17:00:16 ET	Download
19-Jan-2016 ET	2016	134	1	TGaz	Accuracy and Coverage functional requirements	Ganesh Venkatesan (Intel Corporation)	19-Jan-2016 16:52:27 ET	Download
19-Jan-2016 ET	2016	126	1	TGah	Misc. Clause 24 CIDs previously unassigned	Eugene Baik (Qualcomm)	19-Jan-2016 16:30:53 ET	Download
19-Jan-2016 ET	2016	146	3	TGai	Resolutions for pending QC comments	Abhishek Patil (Qualcomm)	19-Jan-2016 16:25:26 ET	Download
19-Jan-2016 ET	2016	148	0	TGaz	60 GHz Focus Area	Alecsander Eitan (Qualcomm)	19-Jan-2016 16:25:12 ET	Download
19-Jan-2016 ET	2016	147	0	TGax	TGax MU Ad-hoc January 2016 Agenda	Sigurd Schelstraete (Quantenna)	19-Jan-2016 16:17:13 ET	Download

19-Jan-2016 ET	2015	1502	1	TGm	REVmc - BRC Minutes for F2F Dec - IEEE-SA hosted - Piscataway	Jon Rosdahl (Qualcomm)	19-Jan-2016 16:38:10 ET	Download
19-Jan-2016 ET	2016	146	2	TGai	Resolutions for pending QC comments	Abhishek Patil (Qualcomm)	19-Jan-2016 16:05:10 ET	Download
19-Jan-2016 ET	2016	21	3	TGai	Proposed Resolution for Authentication frame format	Hitoshi Morioka (SRC Software)	19-Jan-2016 16:00:37 ET	Download
19-Jan-2016 ET	2016	12	4	TGai	Resolutions for assigned CIDs	Hitoshi Morioka (SRC Software)	19-Jan-2016 15:59:40 ET	Download
19-Jan-2016 ET	2015	1511	4	TGah	January 2016 Agenda	Yongho Seok (NEWRACOM)	19-Jan-2016 15:47:09 ET	Download
19-Jan-2016 ET	2016	109	1	TGax	MAC Ad-hoc January 2016 Meeting Agenda	Reza Hedayat (Newracom)	19-Jan-2016 15:39:21 ET	Download
19-Jan-2016 ET	2015	1530	3	TGm	VHT160 operation signaling through non-zero CCFS1	Menzo Wentink (Qualcomm)	19-Jan-2016 15:30:44 ET	Download

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APPENDIX F

IEEE P802.11
Wireless LANs

IEEE 802.11 TGax, MAC Ad hoc **Mar 2016 Macau TGax MAC Ad hoc Meeting Minutes**				
Date: 2016-03-14				
Author(s):				
Name	**Affiliation**	**Address**	**Phone**	**Email**
Brian Hart	Cisco Systems			brianh@cisco.com

Abstract

TGax, MAC Ad Hoc meeting minutes from the IEEE 802.11 Macau session, Mar 15th – 17th, 2016.

Tuesday, Mar 15th, 2016, AM2 TGax MAC Ad hoc Session (10:30am-12:30pm)

1. **The meeting called to order at 10:36pm by Eric Wong (Apple), the co-chair of the TGax MAC Ad hoc**
   1.1. About 55 people are in the room at this time.

2. **Announcement**
   2.1. Agenda doc is 11-16/0427r0 is on the server.
   2.2. Meeting Protocol: The Chair asked to state name and affiliation when speaking for the first time.
   2.3. Attendance reminder.
      2.3.1. The attendance server: https://imat.ieee.org/

3. **The chair reviewed the mandatory 5 slides of P&P.**
   3.1. Instructions from the WG Chair. [reviewed~~, did not review~~]
   3.2. Participants, Patents, and Duty to Inform [reviewed~~, did not review~~]
   3.3. Patent Related Links. [reviewed~~, did not review~~]
   3.4. Call for potentially essential patents.
      3.4.1. Chair asked if anyone is aware of potentially essential patents
         [Asked~~. Did not ask~~]
      3.4.2. Potentially essential patents
         [None reported.~~ Reported as follows~~]
   3.5. Other Guidelines for IEEE WG Meetings. [reviewed~~, did not review~~]

4. The Chair called for presentations

4.1. No requests for additional presentations or reordering of were made.

5. The Chair asked for approval of the agenda

5.1. No objection raised

6. Presentation of contributions

Liwen Chu (Marvell) presented 11-16/0358r0, "Maximal A-MPDU size"

11-16/0358-SP1: Do you support adding the following text to 11ax SFD:
A HE STA can announce its maximum A-MPDU length limits to 2^{21}, 2^{22}?

Y29 N0 A13 – strawpoll [pre-motion] passes

Chitta Ghosh (Intel) presented 11-16/0362r0, "Multi-TID Aggregation Limit"

11-16/0362-SP1: Do you support to add to the 11ax SFD that the recipient indicates the maximum number of TIDs of the MPDUs that the originator can aggregate in a multi-TID A-MPDU in MU PPDU?

Y38 N0 A11 – strawpoll [pre-motion] passes

11-16/0362-SP2: Do you support to add to the 11ax SFD that within a single A-MPDU containing MPDUs with different value of TIDs, the MPDUs with the same TID value are not required to be in contiguous A-MPDU subframes?

Y33 N0 A10 – strawpoll [pre-motion] passes

Xiaofei Wang presented 11-16/0365r0, "Multi-STA BA Design"

11-16/0356-SP1: Do you agree to insert into the 802.11ax SFD
"4.2 The RA field of the Multi-STA BA with BA information for multiple AIDs may be set to a group address."

Y8 N9 A32 – strawpoll [pre-motion] fails

SP2 postponed for further discussion

Simone Merlin presented 11-16/0378r1, "Extended BA Bitmap"

11-16/078-SP1: Do you support to add to the SFD the definition of a variant of the Compressed BA frame format with a 256-bits BA Bitmap field?

Y42 N0 A7 – strawpoll [pre-motion] passes

11-16/078-SP2: Do you support to add to the SFD:
Reserved bit(s) in Fragment Number field are used to indicate the length of the BA Bitmap within the same BA Information field?

Y37 N1 A7 – strawpoll [pre-motion] passes

Mid session attendee count: **about 76 people in the room.**

Dengyu Qiao (Huawei) presented 11-16/404r0 "BlockAck-Bitmap"

11-16/404-SP1 Do you agree to add the following text into the SFD?
The spec shall define a length indication of Block Ack Bitmap subfield included in Fragment Number subfield of the Block Ack Starting Sequence Control field for a multi-STA BA frame, if the Block Ack Bitmap and the Block Ack Starting Sequence Control subfields are present.

Y36 N0 A5 – strawpoll [pre-motion] passes

Delayed strawpoll from Xiaofei Wang presented 11-16/0365r0

11-16/0356-SP2: Do you agree to insert into the 802.11ax SFD
"The RA field of a Multi-STA BA for a single STA should be set to the MAC address of that STA."

Y7 N0 A28 – strawpoll [pre-motion] passes

7. The Chair [recessed~~, did not recess~~] the MAC ad hoc session at 12:25 pm.
// recess = short break, adjournment = long break

Tuesday, Mar 15th, 2016, PM2 TGax MAC Ad hoc Session (4pm-6pm)

1. **The meeting called to order at 4:05pm by Eric Wong (Apple), the co-chair of the TGax MAC Ad hoc**
   1.1. About 55 people are in the room at this time.

2. Announcement

2.1. Agenda doc is 11-16/0427r1 is on the server.

2.2. Meeting Protocol: The Chair asked to state name and affiliation when speaking for the first time.

2.3. Attendance reminder.

2.3.1. The attendance server: https://imat.ieee.org/

3. The chair reviewed the mandatory 5 slides of P&P.

3.1. Instructions from the WG Chair. [reviewed~~, did not review~~]

3.2. Participants, Patents, and Duty to Inform [reviewed~~, did not review~~]

3.3. Patent Related Links. [reviewed~~, did not review~~]

3.4. Call for potentially essential patents.

3.4.1. Chair asked if anyone is aware of potentially essential patents
[Asked.~~ Did not ask~~]

3.4.2. Potentially essential patents
[None reported. ~~Reported as follows~~]

3.5. Other Guidelines for IEEE WG Meetings. [reviewed~~, did not review~~]

4. The Chair asked for approval of the agenda

4.1. No objection raised

5. Presentation of contributions

Evgeny Khorov (IITP RAS) presented 11-16/0399r1, "Considerations on Trigger Frame for Random Access Procedure"

11-16/0399-SP1: Do you agree to add the following text in SFD:
x.y.z. In case of unsuccessful transmission attempt triggered by a Trigger frame for random access, OFDMA Contention Window (OCW) is doubled (similar to CW in DCF) until it reaches OCWmax.

Y6 N9 A22– strawpoll [pre-motion] fails

Youbo Li (Huawei) presented 116-11/0383r0 "RU Signaling in Trigger Frame"

Do you support to add to SFD
9.3.1.23 Trigger frame
Use 8 bits to signal the RU allocation for each STA in per user info field of Trigger frame.
The first bit indicates the allocated RU is located in the primary or non-primary 80MHz.
The mapping of the subsequent 7 bits indices to the RU allocation is defined in the table below.

7 bits indices	Message	Number of entries

0000000 ~ 0100100	Possible 26 RU cases in 80MHz	37
0100101 ~ 0110100	Possible 52 RU cases in 80MHz	16
0110101 ~ 0111100	Possible 106 RU cases in 80MHz	8
0111101 ~ 1000000	Possible 242 RU cases in 80MHz	4
1000001 ~ 1000010	Possible 484 RU cases in 80MHz	2
1000011	996 RU cases in 80MHz	1
1000100	160MHz/80+80MHz case	1
Total		69

Y28 N0 A6– strawpoll [pre-motion] passes

Mid session attendee count: **about 64 people in the room.**

Matt Fischer (Broadcom) presented 11-16/0368r0, "MAC padding options for legacy trigger frame"

11-16/0368-SP1 Do you support to add to the SFD that the draft specification shall specify that when a Trigger needs to be padded to allow sufficient UL PPDU transmission preparation time, the padding shall be at the MAC layer and the padding shall not include an FCS?

Y44 N0 A10– strawpoll [pre-motion] passes

Matt Fischer (Broadcom) presented 11-16/0369r0, "M-BA aggregated trigger frame"

11-16/0369-SP1: Do you support to add to the SFD, that the draft specification shall specify that M-BA/BA/ACK may be aggregated with a trigger frame in an A-MPDU without accompanying Data?

Y48 N0 A2– strawpoll [pre-motion] passes

Jeongki Kim (LGE) presented 11-16/0361r0, "Ack Policy of UL MU frame"

11-16/0361-SP1: Do you agree to add to SFD?
The ACK Policy of the QoS data frame(s) sent in an HE trigger-based PPDU shall be set to 00 (Normal Ack or Implicit BAR) when the QoS data frame requires to be acknowledged (i.e., the Ack Policy cannot be set to 11 (Block Ack)).
Y37 N0 A7– strawpoll [pre-motion] passes

Jinsoo Ahm (Yonsei University) presented 11-16/0345r1, "Simultaneous NAK for MU GCR-BA"

11-16/0345-SP1: Do you agree to add to the TG Specification Frame work document?
4.7.X The spec shall define a mechanism to utilize a simultaneous NAK (TBD) for multicast operation
When AP allocates common RU for a simultaneous NAK, multicast destination STAs, which cannot successfully decode its multicast PPDU, transmit a simultaneous NAK frame (TBD) via the allocated common RU

Y9 N10 A40 – strawpoll [pre-motion] fails

6. The Chair [recessed~~, did not recess~~] the MAC ad hoc session at 5:57 pm.
// recess = short break, adjournment = long break

Wednesday, Mar 16th, 2016, PM1 TGax MAC Ad hoc Session (1:30pm-3:30pm)

1. **The meeting called to order at 1:35pm by Eric Wong (Apple), the co-chair of the TGax MAC Ad hoc**
   1.1. About 42 people are in the room at this time.

2. **Announcement**
   2.1. Agenda doc is 11-16/0427r2 is on the server.

3. **The chair reviewed the mandatory 5 slides of P&P.**
   3.1. Instructions from the WG Chair. [reviewed~~, did not review~~]
   3.2. Participants, Patents, and Duty to Inform [reviewed~~, did not review~~]
   3.3. Patent Related Links. [reviewed~~, did not review~~]
   3.4. Call for potentially essential patents.
      3.4.1. Chair asked if anyone is aware of potentially essential patents
         [Asked~~. Did not ask~~]
      3.4.2. Potentially essential patents
         [None reported.~~ Reported as follows~~]
   3.5. Other Guidelines for IEEE WG Meetings. [reviewed~~, did not review~~]

4. **The Chair asked for approval of the agenda**
   4.1. No objection raised

5. **Presentation of contributions**

Alfred Asterjadhi (Qualcomm) presented 11-16/347r0, "Fragmentation for MU frames-Follow up on parameters"

11-16/347-SP1: Do you support to add to the SFD:
An HE STA specifies the following parameters related to fragmentation:
- Minimum Fragment Size: The minimum payload size for the first fragment of an MSDU supported by the STA

    - Possible values: 128, 256, 512, Unspecified/No Limit
- Maximum Number of F-MSDUs: The maximum number of fragmented MSDUs/MMPDUs that can be concurrently received by the STA
    - Possible values: 1, 2, 8, 16, 32, Unspecified/No Limit
    - Note: Whether the counter is per <RA, TA> or per <RA, TA, TID> is currently TBD.

Y25 N0 A8– strawpoll [pre-motion] passes

Woojin Ahn (Yonsei University) presented 11-16/352r1, "Considerations on MU initial link setup"

11-16/352-SP1: Do you agree to add to the TG Specification Frame work document?
x.y.z the spec shall define a procedure for multiuser initial link setup (MU authentication, MU association)

Y13 N10 A26 – strawpoll [pre-motion] fails

Hanseul Hong (Yonsei Unicersity) presented 11-16/353r1, "MU-RTS/CTS for TWT Protection"

Mid session attendee count: **about 89 people in the room.**

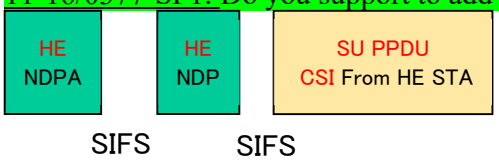
Liwen Chu (Marvell) presented 11-16/359r0, "Management Ack"

11-16/359-SP1: Do you support adding the following test to 11ax SFD:
A value of 15 in the TID subfield in the Per STA Info field of the M-BA frame indicate the successful acknowledgement of a MGMT frame that requires an immediate response and is carried in the soliciting A-MPDU?

Y40 N0 A9 – strawpoll [pre-motion] passes

Simone Merlin (Qualcomm) presented 11-16/0377r0 "Sounding Sequences Clarifications"

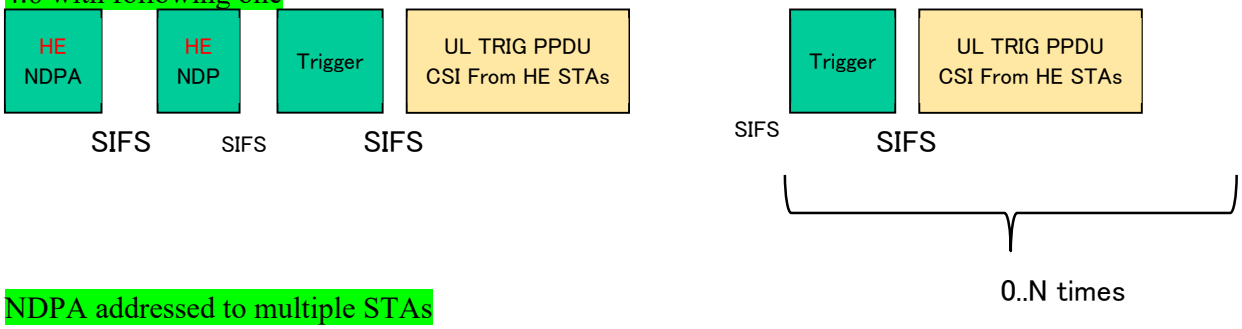
11-16/0377-SP1: Do you support to add to the SFD the following sounding sequence?



HE NDPA is addressed to 1 STA

Y46 N0 A4 – strawpoll [pre-motion] passes

11-16/0377-SP2: Do you support to replace the sounding sequence figure in SFD section 4.6 with following one



NDPA addressed to multiple STAs

Y42 N0 A3 – strawpoll [pre-motion] passes

Evgeny Khorov (IITP RAS) presented 11-16/0297r2 "Results for beacon collisions"

11-16/0297-SP1: Do you agree that TGax should address beacon collision problem?

Y9 N0 A33

The Chair [recessed~~, did not recess~~] the MAC ad hoc session at 3:30 pm.
// recess = short break, adjournment = long break

Wednesday, Mar 16th, 2016, PM2 TGax MAC Ad hoc Session (4pm-6pm)

1. **The meeting called to order at 4:05pm by Eric Wong (Apple), the co-chair of the TGax MAC Ad hoc**
   1.1. About 60 people are in the room at this time.

2. **Announcement**
   2.1. Agenda doc is 11-16/0427r3 is on the server.

3. **The chair reviewed the mandatory 5 slides of P&P.**
   3.1. Instructions from the WG Chair. [reviewed~~, did not review~~]
   3.2. Participants, Patents, and Duty to Inform [reviewed~~, did not review~~]
   3.3. Patent Related Links. [reviewed~~, did not review~~]
   3.4. Call for potentially essential patents.
      3.4.1. Chair asked if anyone is aware of potentially essential patents
         [Asked~~. Did not ask~~]
      3.4.2. Potentially essential patents
         [None reported.~~ Reported as follows~~]
   3.5. Other Guidelines for IEEE WG Meetings. [reviewed~~, did not review~~]

4. The Chair asked for approval of the agenda
4.1. No objection raised

5. Presentation of contributions

Geonjung Ko (WILUS) presented 11-16/0396r0, "Issues on BSS Color Bits Collision"

Hanseul Hong (Yonsei University) polled:

11-16/353-SP1: Do you agree to add to the TG Specification Framework document? Spec shall define a mechanism to protect TWT SP.

- A TWT requesting STA sets the TWT Protection subfield to 1 in TWT Request frame to request the AP to provide protection of the set of TWT SPs using a NAV protection mechanism defined in 802.11ax (e.g. (MU)RTS/CTS or CTS-to-self, etc)

Y8 N2 A37 – strawpoll [pre-motion] passes

The Chair [adjourned] the MAC ad hoc session at 5:07 pm.
// recess = short break, adjournment = long break

APPENDIX G

The Wayback Machine - https://web.archive.org/web/20161121130718/http://www.ieee802.org/11/abt80211.h…

ABOUT IEEE P802.11 AND HOW TO PARTICIPATE

The following are general statements of how to participate in the IEEE802.11 Working Group. For the official rules, please see the Policies and Procedures of the IEEE Project 802, LAN MAN Standards Committee (LMSC) and the IEEE 802.11 Working Group Operations Manual.

Introduction

IEEE P802.11 is a standards working group on wireless local area networks. The working group is a part of IEEE LMSC (LAN MAN Standards Committee) formerly called IEEE Project 802. IEEE LMSC reports to the Standards Activity Board (SAB) of the IEEE Computer Society.

Open Forum

All meetings of the standards activities of IEEE are open meetings. Everybody is allowed to attend as long as he/she pays their dues to the organization to offset the costs of the meeting. It is not required to be a member of IEEE to participate in, or to become a voting member of the working group. We recommend, however, that you become a member of either the IEEE or of the Computer Society.

Voting

At all meetings of the working group and its sub and ad-hoc groups, participation in the discussions and voting is limited to the voting members (see section Membership for the rules to become a member), although the chair has the discretion to allow non-members to participate in the discussions. At study-group meetings, however, all attendees can participate in discussions and in voting. The voting rules are defined in LMSC WG P&P, and described in the 802.11 Operations Manual.

Organizational matters

A handy guide for how to develop standards is provided in the IEEE Standards Association Develop Standards site. More formal rules regarding the organization of our work are provided in the IEEE Standards Board Bylaws and the IEEE Standards Operations Manual. A short summary made specifically for 802.11 follows below.

Before a standard can be developed, a Project Authorization Request (PAR) has to be approved by the IEEE Standards Board. The PARs approved for the work of 802.11 are available here.

Once the working group has agreed on a draft standard (i.e., the draft was approved by a working group letter ballot), the draft is balloted in a sponsor balloting group. Membership of sponsor balloting groups is limited to members of the IEEE or the Computer Society. After approval by the balloting group, the result is reviewed by the Standards Board before publication. The IEEE Standards Board Review Committee (RevCom) are responsible for deciding whether the procedure for the development of the standard was followed correctly.

Meeting schedule

Currently the 802.11 standards working group meets 3 times a year during the plenary sessions of IEEE LMSC. LMSC meets in plenary sessions in March, July and November. And 802.11 holds interim meetings an additional 3 times a year in January, May and September. Refer to the meeting plan.

Additional 802.11 interim meetings are held to host TGaj (China Milli-Metre Wave) meetings in China.

Membership of standards development working group

The membership rules are defined in LMSC WG P&P, and described in the 802.11 Operations Manual.

In summary, membership belongs to an individual, not to an organization, and may not be transferred. You have to gain voting membership rights by participating in at least 2 plenary meetings out of 4 consecutive plenary meetings and then recording attendance at a subsequent plenary (at which you may vote). Participation means that you attend at least 75% of the time of the whole session of meetings. You may substitute one interim meeting for a plenary meeting.

Member categories and gaining voting rights

IEEE 802.11 recognises the following categories of membership:

1. Aspirant members. Those members have participated in one plenary or interim session of meetings within the last 4 plenary sessions.
2. Potential voter members. Those have participated in two sessions of meetings, at least one of which being a plenary session within the last 4 plenary sessions.
3. Voter members. Those members qualify for voting membership status.

Potential voter members become voter members in the beginning of the first session they attend and and at which they record attendance.

"Participation" means recording electronic attendance for 75% of the "in hours" 802.11 meeting slots during a meeting and paying the meeting fee.

Note that recording attendance in some other (i.e., non-802.11) working-group's meeting during an 802.11 session does not count towards this 75% target.

Sponsor Ballot Group

Before LMSC sends a proposed standard to the IEEE Standards Board for approval, they must have a positive response from a letter ballot among the members of the related sponsor ballot group (the "pool") within its organization. The sponsor ballot pool for an 802.11 standard is established by invitation to interested members of IEEE-SA before the first sponsor ballot of that standard. The pool is not changed once it has been established - i.e., the voters on the first sponsor ballot are also the voters for all subsequent recirculation ballots of the same standard.

The rules and procedures for sponsor ballot groups are provided in section 5.4 of the IEEE Standards Operations Manual. In summary they are as follows. For each main PAR, LMSC establishes a ballot pool. If you want to be invited to participate in sponsor ballots of IEEE P802.11 and you are a member of the IEEE Standards

Association (IEEE-SA), you can register interest in a standards project. A short time before a sponsor ballot for the project is issued, the IEEE sends the people in the pool an invitation to ballot. If you agree to commit to review and vote on the acceptability, you can apply for membership of that ballot pool. LMSC is responsible for balancing the membership of the ballot pool among various classifications, typically: producer, user and general-interest.

Document distribution

All documents submitted to and produced by the P802.11 working Group (excluding draft standards), such as liaison statements, minutes of meetings, meeting announcements, etc., are provided to the members of the working group by way of the IEEE802.11 document server (see https://mentor.ieee.org/802.11/documents).

Draft standards are available to active participants of 802.11 in its members area. (Access is available by username/password supplied to active participants by 802.11 officers).

During 802.11 plenary and interim sessions, documents and drafts are available to all attendees using a local fileserver.

Procedures

The Policies and Procedures of IEEE Project 802, LAN MAN Standards Committee require that Robert's Rules of Order are used in combination with the LMSC Policies and Procedures and the Working Group Policies and Procedures with the LMSC Policies and Procedure taking precedence.

Submissions to the working group

The 802.11 Working Group Policies and Procedures requires that every document must be formatted to a common standard before being submitted to the document server. Special tools and instructions are available to make the task for submitters easy.

All submissions made to 802.11 WG and its sub-groups must be submitted to the document server before any presentation is made. The ensures that all members have equal access to the material at the time is is being presented.

This page is maintained by Adrian Stephens. Comments are welcome.

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APPENDIX H

The Wayback Machine - https://web.archive.org/web/20160205145836/http://www.ieee802.org/11/

IEEE 802.11™ WIRELESS LOCAL AREA NETWORKS

The Working Group for WLAN Standards

Agenda for WG11 meetings in the January 2016 session

Please refer to the latest revision of 11-15/1485

IEEE 802.11 Presentation

The publicity standing committee (PUB SC) have produced a presentation called "What 802.11 is doing" intended to be used to explain 802.11's current activities to those outside 802.11. This is now available on this website.

IEEE 802 STANDARDS AVAILABLE FOR FREE DOWNLOAD !

The IEEE has made available IEEE 802 standards for free download. Under this program, a standard may be downloaded for free six months after the initial publication of the standard.

All relevant IEEE 802.11 Standard, Amendments, and Recommended Practices are listed here.

ACCESS TO 802 DRAFT STANDARDS

Draft standards are available from a number of sources:

- If you are a voting 802.11 member, go to the members' area and log in using the 802.11 members ID and password supplied to you by the 802.11 officers. Contact Adrian Stephens if you have lost this. During an 802.11 session, attendees may access 802.11 draft standards from a local fileserver, regardless of their membership status.
- If you are an active member of one of the other 802 groups, you may be able to access the 802.11 members' area using the same credentials used to access your own group. If this doesn't work, ask your group's Chair to request access from the 802.11 Chair (Adrian Stephens).
- Draft IEEE standards are, from time to time, made available for purchase using the IEEE store or Techstreet.

IEEE STANDARDS DEVELOPMENT GUIDE

The IEEE-SA has created an easy to use Online Standards Development web site that has a wealth of information that details the whole standards process flow, from creation of the initial PAR, to balloting to final draft, and beyond. It even includes, tutorials, and online forms of the various processes evolved. This site is recommended for all Members and Chairs involved.

Many of the IEEE 802.11 teleconferences use "Join Me". We share a single IEEE-SA supplied account amongst these meetings. The meeting credentials and local dial-in numbers are shown here.

802 11
Today
Thursday, January 21
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APPENDIX I

155th IEEE 802.11 WIRELESS LOCAL AREA NETWORKS SESSION
Hyatt Regency, Atlanta, GA, USA
January 17-22, 2016

WG Chair - Adrian Stephens (Intel Corporation)
WG Vice Chair - Jon Rosdahl (CSR - Qualcomm)
WG Vice Chair - Dorothy Stanley (HPE - Aruba)
WG Secretary - Stephen McCann (Blackberry)

Agenda R5

WG11 Agenda - Mon 2016-01-18 - 09:00 to 10:00

Item	Type	Description	Document	Presenter	Start Time	Duration	End Time	Changes
1		**Opening formalities**						
1.1	II	Meeting called to order & assertion of quorum		Stephens	9:00	1	9:01	
1.2	II	Front table introductions. Introduce IEEE-SA staff representative, if present.		All	9:01	1	9:02	
1.3	II	Meeting Decorum (i.e., how to behave in meetings)	Opening Report	Stephens	9:02	1	9:03	
1.4	MI	Review and approve 802.11 session agenda	WG Agenda	Stephens	9:03	2	9:05	
1.5	MI	Review and approve WG minutes	WG minutes	McCann	9:05	1	9:06	
1.6	II	Straw poll of new attendees		Stephens	9:06	0	9:06	
2		**Announcements**						
2.1	**II**	**Policies and procedures (P&Ps)**						
2.1.1	II	Review Patent Policy slides (including call for essential patents)	PatCom materials	Stanley	9:06	6	9:12	
2.1.2	**II**	**Inform participants of the following P&Ps**						

2.1.2.1	II	IEEE Code of Ethics	Code of ethics	Stanley	9:12	1	9:13
2.1.2.2	II	IEEE Standards Association (IEEE-SA) Affiliation FAQ	Affiliation FAQ	Stanley	9:13	0	9:13
2.1.2.3	II	IEEE-SA Antitrust and Competition Policy		Stanley	9:13	0	9:13
2.1.2.4	II	IEEE-SA Letter of Assurance (LoA) form	LoA form	Stanley	9:13	0	9:13
2.1.2.5	II	IEEE-SA Patent Committee (PatCom) information	PatCom website	Stanley	9:13	0	9:13
2.1.2.6	II	IEEE 802 LAN/MAN Standards Committee (LMSC) P&Ps, Chairs Guidelines, Operations Manual	LMSC P&P	Stanley	9:13	0	9:13
2.1.2.7	II	IEEE 802 LMSC WG P&P	LMSC WG P&P	Stanley	9:13	0	9:13
2.1.2.8	II	IEEE 802 LMSC rules changes		Stanley	9:13	1	9:14
2.1.2.9	II	IEEE 802.11 Operations Manual changes		Stanley	9:14	1	9:15
2.2	II	Reflectors		Stanley	9:15	1	9:16
2.3	II	Attendance action from November 2015		Stanley	9:16	1	9:17
2.4		**Incoming Liaisons**					
2.4.1	II	Summary of new and pending liaisons and processing this week	Opening Report	Stephens	9:17	2	9:19
2.5	II	Other Anouncements		All	9:19	0	9:19
2.6					9:19	0	9:19
3		**Logistics and Key events/activities**					
3.1	II	Working group session documents	Opening Report	Stephens	9:19	1	9:20
3.2	II	Joint meetings & Reciprocal Credit	Opening Report	Stephens	9:20	1	9:21
3.3	II	Other WG meeting plans	1st VC Report	Rosdahl	9:21	1	9:22
3.4	II	Meeting room locations	1st VC Report	Rosdahl	9:22	1	9:23
3.5	II	Next meeting reminder	1st VC Report	Rosdahl	9:23	1	9:24
3.6	II	Meeting registration	1st VC Report	Rosdahl	9:24	1	9:25
3.7	II	Recording attendance	1st VC Report	Rosdahl	9:25	1	9:26
3.8	II	File server	1st VC Report	Rosdahl	9:26	1	9:27
3.9	II	Breakfast, breaks, Social logistics	1st VC Report	Rosdahl	9:27	1	9:28
3.10	II	Wednesday Topics	Opening Report	Stephens	9:28	1	9:29
3.11	II	Report on 802 EC or IEEE-SA Standards Board decisions	Opening Report	Stephens	9:29	3	9:32
3.12					9:32	0	9:32
4		**Opening reports, objectives & plans**					

4.1		**WG reports**					
4.1.1	II	802.11 groups	Opening Report	Stephens	9:32	1	9:33
4.1.2	II	802.11 PARS	Opening Report	Stephens	9:33	1	9:34
4.1.3	II	Officers	Opening Report	Stephens	9:34	1	9:35
4.1.4	II	Standards pipeline and 802.11 revisions	Opening Report	Stephens	9:35	1	9:36
4.1.5	II	Summary of Ballots / Comment collections	Opening Report	Stephens	9:36	2	9:38
4.1.6	II	WG membership summary	Opening Report	Stephens	9:38	1	9:39
4.1.7	II	WG ANA report	Opening Report	Stephens	9:39	1	9:40
4.1.8	II	WG timeline report / planning		McCann	9:40	1	9:41
4.1.9	II	WG technical editor	Snapshots Report	Ecclesine	9:41	1	9:42
4.1.10					9:42	0	9:42
4.2		**Standing committee reports**					
4.2.1	II	Architecture (ARC) (including 802 Architecture status)	Snapshots Report	Levy	9:42	2	9:44
4.2.2	II	PAR Review (PAR)	Snapshots Report	Rosdahl	9:44	1	9:45
4.2.3	II	Regulatory (REG)	Snapshots Report	Kennedy	9:45	1	9:46
4.2.4	II	Wireless Next Generation (WNG)	Snapshots Report	Lansford	9:46	1	9:47
4.2.5	II	JTC1 802 SC	Snapshots Report	Myles	9:47	1	9:48
4.3		**Task Group reports**					
4.3.1	II	TGmc - Revision mc (REVmc)	Snapshots Report	Stanley	9:48	1	9:49
4.3.2	II	TGah - Sub 1 GHz (S1G)	Snapshots Report	Seok	9:49	1	9:50
4.3.3	II	TGai - Fast Initial Link Setup (FILS)	Snapshots Report	Mano	9:50	1	9:51
4.3.4	II	TGaj - China Millimeter-Wave (CMMW)	Snapshots Report	Stanley	9:51	1	9:52
4.3.5	II	TGak - General Link (GLK)	Snapshots Report	Eastlake	9:52	1	9:53
4.3.6	II	TGaq - Pre-Association Discovery (PAD)	Snapshots Report	McCann	9:53	1	9:54
4.3.7	II	TGax - High Efficiency Wireless LAN (HEW)	Snapshots Report	Aboul-Magd	9:54	1	9:55
4.3.8	II	TGay - Next generation 60 GHz	Snapshots Report	Au	9:55	1	9:56
4.3.9	II	TGaz - Next generation positioning (NGP)	Snapshots Report	Segev	9:56	1	9:57
4.4		**Study Group / TIG reports**					
4.4.1	II	LRLP - Long Range Low Power TIG	Snapshots Report	Godfrey	9:57	1	9:58

5		**New Business**					
5.1					9:58	0	9:58
5.2					9:58	0	9:58

6		**Recess**		**Stephens**	**9:58**	**0**	**9:58**
		Slack Time				**2**	**10:00**

WG11 Agenda - Wed 2016-01-20 - 10:30 to 12:30								
Item	**Type**	**Description**	**Document**	**Presenter**	**Start Time**	**Duration**	**End Time**	**Changes**
1		**Opening formalities**						
1.1	II	Meeting called to order		Stephens	10:30	1	10:31	
1.2	II	Front Table introductions		All	10:31	1	10:32	
1.3	MI	Modify and approve modifications to agenda	WG Agenda	Stephens	10:32	1	10:33	
2		**Announcements**						
2.1	II	Policies and Procedures (P&P) reminder	Supplementary	Stephens	10:33	1	10:34	
2.2	II	Call for essential patents	Supplementary	Stephens	10:34	1	10:35	
2.3	II	Reminder of Thursday night CAC meeting	Supplementary	Stephens	10:35	1	10:36	
2.4	II	Any other announcements		All	10:36	0	10:36	
2.5					10:36	0	10:36	
3		**Old business**						
3.1	II	Treasurer's Report	11-15/1525	Rosdahl	10:36	0	10:36	
3.2	II	Any WG reports carried forward			10:36	5	10:41	
3.3					10:41	0	10:41	
4		**Liaisons**						
4.1		**External (non-802) liaisons**						
4.1.1	II	Wi Fi Alliance		Sherlock	10:41	5	10:46	
4.1.2	II	Internet Engineering Task Force (IETF)		Stanley	10:46	10	10:56	
4.2		**Internal (802) liaisons**						
4.2.1					10:56	0	10:56	
4.2.2					10:56	0	10:56	
5		**New business**						

5.1	MI	Room change requests & Graphic update	WG Agenda	Stephens	10:56	6	11:02	
5.2	II	Status & Future of Regulatory		Stephens	11:02	2	11:04	
5.3	DT	State of Regulatory in 802 / 802.11	11-15/1537	Kennedy	11:04	15	11:19	
5.4	II	Reminder about process		Stephens	11:19	5	11:24	
5.5	II	EC workshop description		Stephens	11:24	5	11:29	
5.6	II	Report on leadership summit with WFA		Stephens	11:29	10	11:39	
5.7	II	Report on Attendance Rules	11-16/0025	Stanley	11:39	15	11:54	
5.8	DT	Making progress on IMT-2020		Levy	11:54	30	12:24	
5.9	II	Macau Logistics		Slykhouse	12:24	10	12:34	
6		**Recess**		**Stephens**	**12:34**	**0**	**12:34**	
		Slack Time				**-4**	**12:30**	

WG11 Agenda - Fri 2016-01-22 - 08:00 to 12:00

Item	Type	Description	Document	Presenter	Start Time	Duration	End Time	Changes
1		**Opening formalities**						
1.1	II	Meeting called to order		Stephens	8:00	1	8:01	
1.2	II	Front Table introductions		All	8:01	1	8:02	
1.3	MI	Modify and approve modifications to agenda	WG Agenda	Stephens	8:02	1	8:03	
2		**Announcements**						
2.1	II	Policies and Procedures (P&P) reminder	Supplementary	Stephens	8:03	1	8:04	
2.2	II	Call for essential patents	Supplementary	Stephens	8:04	1	8:05	
2.3	II	Reminder to get minutes to WG secretary		McCann	8:05	1	8:06	
2.4	II	Reminder to get objectives & agendas for next session to WG Chair by 1st CAC telecon	Supplementary	Stephens	8:06	1	8:07	
2.5	II	Letters of Assurance (LoAs) received	Supplementary	Stephens	8:07	1	8:08	
2.6	II	Drafts for Sale in IEEE Shop	Supplementary	Stephens	8:08	1	8:09	
2.7	II	Drafts to liaise with ISO/JTC1/SC6	Supplementary	Stephens	8:09	1	8:10	
2.8	II	Status of ballots	Supplementary	Stephens	8:10	1	8:11	
2.9	II	3GPP presentation on LWA (LTE WiFi Access)		Stephens	8:11	1	8:12	

3		**Closing reports**					
3.1		**Working Group**					
3.1.1	II	Straw Poll of membership regarding this meeting location		Rosdahl	8:12	2	8:14
3.1.2	DT	Future venues insight	1st VC Report	Rosdahl	8:14	10	8:24
3.1.3	II	Treasurer's report		Rosdahl	8:24	10	8:34
3.1.4	II	Timeline		McCann	8:34	5	8:39
3.1.5	II	Attendance report	Closing Report	Stephens	8:39	2	8:41
3.1.6	II	WG Editor	Closing Report	Ecclesine	8:41	3	8:44
3.1.7					8:44	0	8:44
3.2		**Standing committee reports**					
3.2.1	II	Architecture (ARC)	Closing Report	Levy	8:44	3	8:47
3.2.2	II	PAR Review (PAR)	Closing Report	Rosdahl	8:47	0	8:47
3.2.3	II	Regulatory (REG)	Closing Report	Kennedy	8:47	3	8:50
3.2.4	II	Wireless Next Generation (WNG)	Closing Report	Lansford	8:50	3	8:53
3.2.5	II	JTC1 802 SC	Closing Report	Myles	8:53	3	8:56
3.3		**Task Group reports**					
3.3.1	II	TGmc - Revision mc (REVmc)	Closing Report	Stanley	8:56	3	8:59
3.3.2	II	TGah - Sub 1 GHz (S1G)	Closing Report	Seok	8:59	3	9:02
3.3.3	II	TGai - Fast Initial Link Setup (FILS)	Closing Report	Mano	9:02	3	9:05
3.3.4	II	TGaj - China Millimeter-Wave (CMMW)	Closing Report	Peng	9:05	0	9:05
3.3.5	II	TGak - General Link (GLK)	Closing Report	Eastlake	9:05	3	9:08
3.3.6	II	TGaq - Pre-Association Discovery (PAD)	Closing Report	McCann	9:08	3	9:11
3.3.7	II	TGax - High Efficiency Wireless LAN (HEW)	Closing Report	Aboul-Magd	9:11	3	9:14
3.3.8	II	TGay - Next Generation 60 GHz	Closing Report	Au	9:14	3	9:17
3.3.9	II	TGaz - Next Generation Positioning (NGP)	Closing Report	Segev	9:17	3	9:20
3.4		**Study Group / Topic Interest Group**					
3.4.1	II	LRLP - Long Range Low Power TIG	Closing Report	Godfrey	9:20	3	9:23
3.5		**Ad-hoc reports**					
3.5.1		NGMN ad-hoc	Closing Report	Stanley	9:23	3	9:26
3.6		**Liaison**					
3.6.1	II	802.15 liaison report	Closing Report	Chaplin	9:26	5	9:31
3.6.2	II	802.18 RR TAG liaison report	Closing Report	Kennedy	9:31	3	9:34
3.6.3	II	802.24 liaison report	Closing Report	Godfrey	9:34	5	9:39

3.6.4	II	802.1CF (OmniRAN) Status Update	Closing Report	Riegel	9:39	5	9:44
4		**Discussion topics**					
4.1					9:44	0	9:44
5		**Motions (old business)**					
5.1		**Working Group motions**					
5.1.1	MI	Telecon schedule	Motions	Stanley	9:44	3	9:47
5.1.2	MI	OM Updates		Stanley	9:47	0	9:47
5.1.3					9:47	0	9:47
5.2		**Standing committee motions**					
5.2.1	ME	Architecture (ARC)		Hamilton	9:47	0	9:47
5.2.2	ME	PAR Review (PAR)		Rosdahl	9:47	0	9:47
5.2.3	ME	Publicity (PUB)		McCann	9:47	0	9:47
5.2.4	ME	Regulatory (REG)		Kennedy	9:47	0	9:47
5.2.5	MI	Wireless Next Generation (WNG)		Lansford	9:47	0	9:47
5.2.6	ME	JTC1 802 SC		Myles	9:47	0	9:47
5.3		**Task Group motions**					
5.3.1	ME	TGmc - Revision mc (REVmc)		Stanley	9:47	0	9:47
5.3.2	MI	TGah - Sub 1 GHz (S1G		Seok	9:47	0	9:47
5.3.4	MI	TGai - Fast Initial Link Setup (FILS)		Mano	9:47	0	9:47
5.3.5	MI	TGaj - China Millimeter-Wave (CMMW)		Peng	9:47	0	9:47
5.3.6	MI	TGak - General Link (GLK)	Motions	Eastlake	9:47	5	9:52
5.3.7	MI	TGaq - Pre-Association Discovery (PAD)		McCann	9:52	0	9:52
5.3.8	MI	TGax - High Efficiency Wireless LAN (HEW)		Aboul-Magd	9:52	0	9:52
5.3.9	MI	TGay - Next Generation 60 GHz (NG60)		Au	9:52	0	9:52
5.3.10	MI	TGaz - Next Generation Positioning (NGP)		Segev	9:52	0	9:52
5.4		**Study Group / Topic Interest Group motions**					
5.4.1	ME	LRLP - Long Range Low Power TIG		Godfrey	9:52	0	9:52
6		**New Business**					
6.1	ME	802 liaison to ITU-R WP5D	Motions	Myles	9:52	10	10:02
6.2	DT	Making progress with IMT-2020 - Straw polls	Motions	Levy	10:02	30	10:32

6.3	DT	Leadership summit - does the WG need to approve?		Stephens	10:32	15	10:47
6.4	DT	Future of 802.18	11-16/196r0	Kennedy	10:47	15	11:02
6.5					11:02	0	11:02
7		**Closing formalities**					
7.1	II	Reminder about wireless chairs meeting	Supplementary	Stephens	11:02	1	11:03
7.2	II	Next meeting reminder	Supplementary	Stephens	11:03	1	11:04
7.3	MI	Adjourn		Stephens	11:04	0	11:04
		Slack Time				**56**	**12:00**

APPENDIX J

IEEE P802.11
Wireless LANs

Proposed TGax draft specification

Date: 2016-03-02

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1

Abstract

This document contains a proposal for the TGax draft amendment. It captures the feature requirements outlined in the TGax specification framework document (11-15/0132) in detailed draft text.

1 Preface

1.1 Revision history

Revision	Date	Changes
0	January 15, 2016	Initial draft
1	March 2, 2016	Created a new MAC clause and moved most of the MAC stuff there. Added text contributions for recent SFD additions. Additional authors.

1.2 Notation

Editing instructions are shown in ***bold italic***.

Editor's notes in ***red bold italics*** are provided to aid in drafting the document. For example, missing text or indicating the placement of future text.

1.3 Baseline document

This document is written as an amendment to the Draft P802.11-REVmc/D5.00 revision of the 802.11 specification as amended by Draft P802.11ai/D6.3 and Draft P802.11ah/D6.0.

2 Normative references

3 Definitions, acronyms, and abbreviations

3.1 Definitions

3.2 Definitions specific to IEEE Std 802.11

3.3 Definitions specific to IEEE 802.11 operation in some regulatory domains

3.4 Abbreviations and acronyms

Insert the following acronym definitions:

DL	Dowlink
DL MU	Downlink multi-user
HE	High Efficiency
OFDMA	Orthogonal Frequency-Division Multiple Access
MU-RTS	Multi-user request to send
UL	Uplink

3.5 Abbreviations and acronyms in some regulatory domains

4 General description

4.3 Components of the IEEE Std 802.11 architecture

4.3.12a High efficiency (HE) STA

The IEEE Std 802.11 HE STA operates in frequency bands between 1 GHz and 6 GHz.

An HE STA is VHT STA that, in addition to the features supported as a VHT STA, supports the MAC features defined in Clause 25 and the PHY features defined in Clause 26.

5 MAC service definition

6 Layer management

6.3 MLME SAP interface

6.3.7 Associate

6.3.7.2 MLME-ASSOCIATE.request

6.3.7.2.2 Semantics of the service primitive

Insert the following new parameter into the primitive:

HE Capabilities

Insert the following new entiry to the unnumbered table in this subclause:

HE Capabilities	As defined in frame format HE Capabilities element.	As defined in 9.4.2.213 (HE Capabilities element)	Specifies the parameters within the HE Capabilities element that are supported by the MAC entity. The parameter is optionally present if dot11HighEfficiencyOptionImplemented is true; otherwise, this parameter is not present.

6.3.7.3 MLME-ASSOCIATE.confirm

6.3.7.3.2 Semantics of the service primitive

Insert the following new parameter into the primitive:

HE Capabilities

Insert the following new entiry to the unnumbered table in this subclause:

HE Capabilities	As defined in frame format HE Capabilities element.	As defined in 9.4.2.213 (HE Capabilities element)	Specifies the parameters within the HE Capabilities element that are supported by the MAC entity. The parameter is optionally present if dot11HighEfficiencyOptionImplemented is true; otherwise, this parameter is not present.

6.3.8 Reassociate

6.3.8.2 MLME-REASSOCIATE.request

6.3.8.2.2 Semantics of the service primitive

Insert the following new parameter into the primitive:

HE Capabilities

Insert the following new entiry to the unnumbered table in this subclause:

HE Capabilities	As defined in frame format HE Capabilities element.	As defined in 9.4.2.213 (HE Capabilities element)	Specifies the parameters within the HE Capabilities element that are supported by the MAC entity. The parameter is optionally present if dot11HighEfficiencyOptionImplemented is true; otherwise, this parameter is not present.

6.3.8.3 MLME-REASSOCIATE.confirm

6.3.8.3.1 Semantics of the service primitive

Insert the following new parameter into the MLME-START.request primitive:

HE Capabilities

Insert the following new entiry to the unnumbered table in this subclause:

HE Capabilities	As defined in frame format HE Capabilities element.	As defined in 9.4.2.213 (HE Capabilities element)	Specifies the parameters within the HE Capabilities element that are supported by the MAC entity. The parameter is optionally present if dot11HighEfficiencyOptionImplemented is true; otherwise, this parameter is not present.

6.3.11 Start

6.3.11.2 MLME-START.request

6.3.11.2.2 Semantics of the service primitive

Insert the following new parameters into the MLME-START.request primitive:

HE Capbilities

HE Operation

Insert the following new entires to the unnumbered table in this subclause:

Name	Type	Valid Range	Description
HE Capabilities	As defined in frame format HE Capabilities element.	As defined in 9.4.2.213 (HE Capabilities element)	The HE capabilities to be advertised for the BSS. The parameter is present if dot11HighEfficiencyOptionImplemented is true; otherwise, this parameter is not present.
HE Operation	As defined in frame format HE Operation element.	As defined in 9.4.2.214 (HE Operation element)	The additional HE capabilities to be advertised for the BSS. The parameter is present if BSSType = INFRASTRUCTURE and dot11HighEfficiencyOptionImplemented is true; otherwise, this parameter is not present.

7 DS SAP specification

8 PHY service specification

9 Frame formats

9.1 General requirements

9.2 MAC frame formats

9.2.4 Frame fields

9.2.4.1 Frame Control field

9.2.4.1.3 Type and Subtype fields

Change the row below and insert a new row immediately after it in Table 8-1 as follows:

Table 9-1 - Valid type and subtype combinations

Type value B3 B2	Type	Subtype value B7 B6 B5 B4	Subtype description
01	Control	0000-~~0011~~<ANA>	Reserved
01	Control	<ANA>	Trigger

9.2.4.1.10 Order field

Change as follows:

The Order field is 1 bit in length. It is used for two purposes:

— It is set to 1 in a non-QoS Data frame transmitted by a non-QoS STA to indicate that the frame contains an MSDU, or fragment thereof, that is being transferred using the StrictlyOrdered service class.

— It is set to 1 in a QoS Data or Management frame transmitted with a value of HT_GF, HT_MF, ~~or~~ VHT, or HE for the FORMAT parameter of the TXVECTOR to indicate that the frame contains an HT Control field.

Otherwise, the Order field is set to 0.

NOTE—The Order field is always set to 0 for frames transmitted by a DMG STA.

9.2.4.6 HT Control field

9.2.4.6.1 General

Remove Figure 9-7 (HT Control field).

Insert Table 9-9a (HT Control field) as follows:

Table 9-9a – HT Control field

Variant	Bit 0 (value)	Bit 1 (value)	Bit 2-29	Bit 30	Bit 31
HT variant	VHT (0)	HT Control Middle		AC Constraint	RDG/More PPDU
VHT variant	VHT (1)	HE (0)	VHT Control Middle	AC Constraint	RDG/More PPDU
HE variant	VHT(1)	HE (1)	Aggregated Control		

Change the paragraphs below of 9.2.4.6.1 as follows:

The HT Control field has ~~two~~ different forms, the HT variant, ~~and~~ the VHT variant, and the HE variant. These forms differ in the values of the VHT and/or HE subfields and in their formats, which are shown in Table 8-9a (HT Control field).

The VHT subfield is set to 0 to indicate a HT variant HT Control field. The VHT subfield is set to 1 and the HE subfield is set to 0 to indicate a VHT variant HT Control field. The VHT subfield is set to 1 and the HE subfield is set to 1 to indicate a HE variant HE Control field.

The two forms differ in the format of tThe HT Control Middle subfield, described is defined in 8.2.4.6.2 (HT variant) for the HT variant and

The VHT Control Middle subfield is defined in 8.2.4.6.3 (VHT variant) ~~for the VHT variant and in the value of the VHT subfield~~.

The Aggregated Control subfield is defined in 8.2.4.6.4 (HE variant).

~~The VHT subfield of the HT Control field indicates whether the HT Control Middle subfield is the VHT Variant or the HT Variant. The VHT subfield is set to 1 to indicate that the HT Control Middle subfield is the VHT Variant and is set to 0 to indicate that the HT Control Middle subfield is the HT Variant.~~

9.2.4.6.3 VHT variant

Change the paragraph below as follows:

The format of the VHT Control Middle subfield of the VHT variant HT Control field is shown in Figure 9-12 (VHT Control Middle subfield of the VHT variant HT Control field).

Change Figure 9-12 as follows:

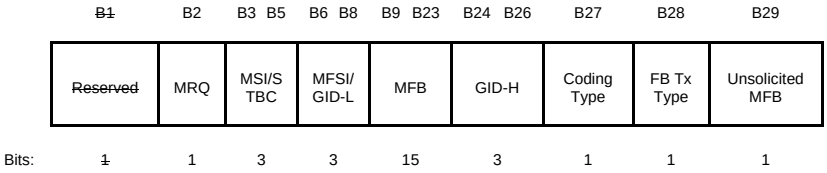


Figure 9-12 — VHT Control Middle subfield of the VHT variant HT Control field

Insert a new subclause 9.2.4.6.4 following 9.2.4.6.3:

9.2.4.6.4 HE variant

9.2.4.6.4.1 General

The format of the Aggregated Control (A-Control) subfield of the HE variant HT Control is shown in Figure 9.14a (HE variant HT Control field format).

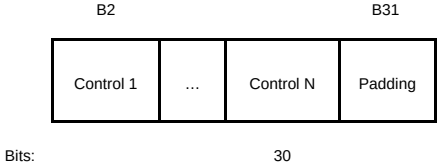


Figure 9-14a - A-Control subfield of the HE variant HT Control field

The A-Control subfield contains a sequence of one or more Control subfields. The format of each Control subfield is defined in Figure 9.14b (Control subfield format). The Control subfield with Control ID subfield equal to 0, if present, is the first subfield of the sequence.

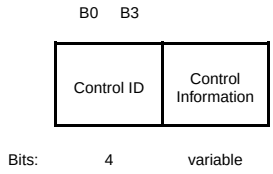


Figure 9-14b - Control subfield format

The Control ID subfield indicates the type of information carried in the Control Information subfield, and the length of the Control Information subfield, which is fixed and that corresponds to each value of the Control ID subfield. The values of the Control ID subfield and the associated length of the Control Information subfield are defined in Table 9-18a (Control ID subfield values).

Table 9-18a - Control ID subfield values

Control ID value	Meaning	Length, in bits, of the Control Information subfield	Contents of the Control Information subfield
0	UL MU response scheduling	*TBD*	See 8.2.4.6.4.2 (UL MU response scheduling)
1	Receive operation mode indication	*TBD*	See 8.2.4.6.4.3 (Receive operation mode indication)
2	HE link adaptation	*TBD*	See 8.2.4.6.4.4 (HE link adaptation)
TBD	…		
8-15	Reserved		

The Control Information subfield carries control information that depends on the Control ID value, as defined in Table 9-18a (Control ID subfield values).

The Padding subfield follows the last Control subfield and is set to a sequence of zeros so that the length of the A-Control subfield is 30 bits.

9.2.4.6.4.2 UL MU response scheduling

The Control Information subfield, when the Control ID subfield is 0, contains scheduling information for an HE trigger-based PPDU that carries an immediate acknowledgement, which is sent as a response to the soliciting A-MPDU (see 9.42.2 (UL MU operation)).

The format of the Control Information subfield is defined in Figure 9-14c (Control Information subfield format when Control ID subfield is 0).

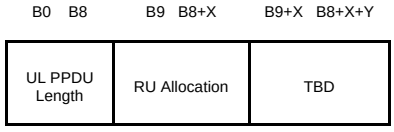


Figure 9-14c - Control Information subfield format when Control ID subfield is 0

The UL PPDU Length subfield indicates the length of the HE trigger-based PPDU response and is set to a nonzero value that is TBD.

The RU Allocation subfield indicates the resource unit (RU) assigned for transmitting the HE trigger-based PPDU response and is set to TBD.

9.2.4.6.4.3 Receive operation mode indication

The Control Information subfield, when the Control ID subfield is 1, contains information related to the receive operation mode of the STA transmitting the frame containing this information (see 25.8 (Receive operating mode indication)).

The format of the Control Information subfield is defined in Figure 9-14d (Control Information subfield format when Control ID subfield is 1).

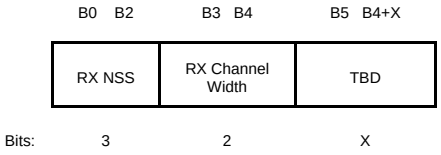


Figure 9-14d - Control Information subfield format when Control ID subfield is 1

The RX NSS subfield indicates the maximum number of spatial streams, N_{SS}, supported by the STA in reception, and is set to $N_{SS} - 1$.

The RX Channel Width subfield indicates the operating channel width supported by the STA in reception, and is set to 0 for 20 MHz, 1 for 40 MHz, 2 for 80 MHz, and 3 for 160 MHz.

9.2.4.6.4.4 HE link adaptation

The Control Information subfield, when the Control ID subfield is 2, contains information related to the HE link adaptation procedure (see 9.31.4 (Link adaptation using the HE variant HT Control field)).

The format of the Control Information subfield is defined in Figure 9-14e (Control Information subfield format when Control ID subfield is 2).

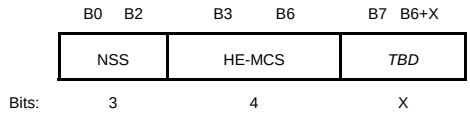


Figure 9-14e - Control Information subfield format when Control ID subfield is 2

The NSS subfield indicates the recommended number of spatial streams, N_{SS}, and is set to $N_{SS} - 1$.

The HE-MCS subfield indicates the recommended HE-MCS, and is set to the HE-MCS Index value (defined in 26.5 (Parameters for HE-MCSs)).

9.2.5 Duration/ID field (QoS STA)

9.2.5.2 Setting for single and multiple protection under enhanced distributed channel access (EDCA)

Change item a) of the 2nd paragraph of this subclause as follows:

The Duration/ID field is determined as follows:

a) Single protection settings.
   1) In an RTS frame that is not part of a dual clear-to-send (CTS) exchange, the Duration/ID field is set to the estimated time, in microseconds, required to transmit the pending frame, plus one CTS frame, plus one Ack or BlockAck frame if required, plus any NDPs required, plus explicit feedback if required, plus applicable IFSs.

   1a) In an MU-RTS frame, the Duration/ID field is set to the estimated time, in microseconds, required for the pending transmission.

Change item b) of the 2nd paragraph of this subclause as follows:

b) Multiple protection settings. The Duration/ID field is set to a value D as follows:
   1) If $T_{TXOP} = 0$ and $T_{END\_NAV} = 0$, then $D = T_{SINGLE\text{-}MSDU} - T_{PPDU}$
   2) Else if $T_{TXOP} = 0$ and $T_{END\_NAV} > 0$, then $D = \max(0, T_{END\text{-}NAV} - T_{PPDU})$
   3) Else if $T_{END\text{-}NAV} = 0$, then $\min(T_{PENDING}, T_{TXOP} - T_{PPDU}) \le D \le T_{TXOP} - T_{PPDU}$
   4) Else $T_{END\text{-}NAV} - T_{PPDU} \le D \le T_{TXOP\text{-}REMAINING} - T_{PPDU}$
      where
      $T_{SINGLE\text{-}MSDU}$ is the estimated time required for the transmission of the allowed frame exchange sequence defined in 9.22.2.8 (TXOP limits) (for a TXOP limit of 0), including applicable IFSs
      $T_{PENDING}$ is the estimated time required for the transmission of
      — Pending MPDUs of the same AC
      — Any associated immediate response frames
      — Any HT NDP, VHT NDP, or Beamforming Report Poll frame transmissions and explicit feedback response frames
      — Applicable IFSs
      — Any RDG
      — Any DL MU PPDUs
      — Any HE trigger-based PPDUs
      — Any Trigger frames to solicit HE trigger-based PPDUs
      T_{TXOP} is the duration given by dot11EDCATable-TXOPLimit (dot11QAP-EDCATableTXOPLimit for the AP) for that AC
      $T_{TXOP\text{-}REMAINING}$ is T_{TXOP} less the time already used time within the TXOP
      $T_{END\text{-}NAV}$ is the remaining duration of any NAV set by the TXOP holder, or 0 if no NAV has been established
      T_{PPDU} is the time required for transmission of the current PPDU

9.2.5.7 Setting for control response frames

Insert a new paragraph after the 2nd paragraph of this subclause:

In a CTS frame that is transmitted in response to an MU-RTS frame, the Duration/ID field is set to the value obtained from the Duration/ID field of the MU-RTS frame that elicited the CTS frame minus the time, in microseconds, between the end of the PPDU carrying the MU-RTS frame and the end of the PPDU carrying the CTS frame.

9.3 Format of individual frame types

9.3.1 Control frames

9.3.1.3 CTS frame format

Change the 2nd paragraph of this subclause as follows:

When the CTS frame is a response to an RTS frame, the value of the RA field of the CTS frame is set to the address from the TA field of the RTS frame with the Individual/Group bit forced to the value 0. When the CTS frame is a response to an MU-RTS frame, the value of the RA field of the CTS frame is set to the address from the TA field of the MU-RTS frame with the Individual/Group bit forced to the value 0.

9.3.1.9 BlockAck frame format

Change Figure 9-32 as follows:

	B0	B1	B2	B3	B4	~~B4~~B5 B11	B12 B15
	BA Ack Policy	Multi-TID	Compressed Bitmap	GCR	Multi-STA	Reserved	TID_INFO
Bits	1	1	1	1	1	~~8~~7	4

Figure 9-32 - BA Control field

Change the 6th paragraph of this subclause as follows:

For BlockAck frames sent under Delayed and HT-delayed agreements, the BA Ack Policy subfield of the BA Control field has the meaning shown in Table 9-23 (BA Ack Policy subfield). For BlockAck frames sent under other types of agreement, the BA Ack Policy subfield is reserved. A BlockAck frame with the Multi-STA subfield equal to 1 is not sent under Delayed and HT-delayed agreements.

Change Table 9-24 as follows:

Table 9-24 - Block Ack frame variant encoding

Multi-TID subfield value	Compressed Bitmap subfield value	GCR subfield value	Multi-STA Subfield value	BlockAck frame variant
0	0	0	0	Basic BlockAck
0	1	0	0	Compressed BlockAck
1	0	0	0	Extended Compressed BlockAck
1	1	0	0	Multi-TID BlockAck
0	0	1	0	Reserved
0	1	1	0	GCR Block Ack
1	0	1	0	Reserved
1	1	1	0	Reserved
0	0	0	1	Reserved
0	1	0	1	Reserved
1	0	0	1	Reserved
1	1	0	1	Multi-STA BlockAck
0	0	1	1	Reserved
0	1	1	1	Reserved
1	0	1	1	Reserved
1	1	1	1	Reserved

Change the 7th paragraph of this subclause as follows:

The values of the Multi-TID, Compressed Bitmap, ~~and~~ GCR and Multi-STA subfields of the BA Control field determine which of the BlockAck frame variants is represented, as indicated in the Table 9-24.

9.3.1.9.3 Compressed BlockAck variant

Change subclause 9.3.1.9.3 as follows:

The TID_INFO subfield of the BA Control field of the Compressed BlockAck frame contains the TID for which this BlockAck frame is sent.

The BA Information field of the Compressed BlockAck frame comprises the Block Ack Starting Sequence Control subfield and the Block Ack Bitmap subfield, as shown in Figure 9-34 (BA Information field (Compressed BlockAck)). The Starting Sequence Number subfield of the Block Ack Starting Sequence Control subfield contains the sequence number of the first MSDU or A-MSDU for which this BlockAck frame is sent. The value of this subfield is defined in 10.24.7.5 (Generation and transmission of BlockAck frames by an HT STA or DMG STA). ~~The Fragment Number subfield of the Block Ack Starting Sequence Control subfield is set to 0.~~

When the Fragment Number subfield is 0, ~~T~~the Block Ack Bitmap subfield of the BA Information field of the Compressed BlockAck frame is 8 octets in length and is used to indicate the received status of up to 64 MSDUs and A-MSDUs. Each bit that is equal to 1 in the compressed Block Ack Bitmap field acknowledges the successful reception of a single MSDU or A-MSDU in the order of sequence number, with the first bit of the Block Ack Bitmap field corresponding to the MSDU or A-MSDU with the sequence number that matches the value of the Starting Sequence Number subfield of the Block Ack Starting Sequence Control subfield.

When the Fragment Number subfield is 1, the Block Ack Bitmap subfield of the BA Information field of the Compressed BlockAck frame is used to indicate the receive status of up to 16 MSDUs and A-MSDUs. Bit position *n* of the Block Ack Bitmap field, if equal to 1, acknowledges receipt of an MPDU with sequence number value, *SN* and fragment number value, *FN* with *n* equal to $4 \times (SN - SSN) + FN$, where *SSN* is the value of the Starting Sequence Number subfield of the Block Ack Starting Sequence Control subfield and the operations on the sequence numbers are performed modulo 4096. When bit position *n* of the Block Ack Bitmap field is equal to 0 it indicates that the MPDU has not been received.

NOTE—When the Fragment Number subfield is equal to 1 then the BlockAck Bitmap field is split into 16 subbitmaps, each of which indicates receive status for 4 fragments of each of the 16 MSDUs.

Insert a new subclause after 9.3.1.9.6:

9.3.1.9.7 Multi-STA BlockAck variant

The TID_INFO subfield of the BA Control field of the Multi-STA BlockAck frame is reserved.

The BA Information field of the Multi-STA BlockAck frame comprises one or more instances of the Per STA Info subfields. The Per STA Info subfield is shown in Figure 9-37a.

	Per-AID TID Info	Block Ack Starting Sequence Control	Block Ack Bitmap
Octets	2	0 or 2	0 or 8

Figure 9-37a - Per STA Info subfield format

The Per AID TID Info subfield is shown in Figure 9-37b.

	B0 B10	B11	B12-B15
	AID	ACK Type	TID
Bits	11	1	4

Figure 9-37b - Per AID TID Info subfield format

The AID field carries the AID of the STA for which the Per STA Info field is intended.

The TID field contains the TID for which the acknowledgement or block acknowledgement applies.

If the ACK Type field is 0, then the Block Ack Starting Sequence Control and Block Ack Bitmap are not present and the Per STA Info field indicates the acknowledgement of successful reception of either a single MPDU or of all the MPDUs carried in the eliciting (A-) MPDU. If the ACK Type subfield is 1, then the Block Ack Starting Sequence Control and Block Ack Bitmap fields are present.

When the Fragment Number subfield is 1, the Block Ack Starting Sequence Control subfield is as shown in Figure 9-27. The Block Ack Bitmap subfield of the BA Information field of the Multi-STA BlockAck frame contains an 8-octet block ack bitmap. Each bit that is equal to 1 in the Block Ack Bitmap subfield acknowledges the successful reception of a single MSDU or A-MSDU in the order of sequence number with the first bit of the Block Ack Bitmap subfield corresponding to the MSDU or A-MSDU with the sequence number that matches the value of the Starting Sequence Number subfield of the Block Ack Starting Sequence Control subfield.

When the Fragment Number subfield is 1, the Block Ack Bitmap subfield of the BA Information field of the Multi-STA Block Ack frame is used to indicate the receive status of up to 16 MSDUs and A-MSDUs. Bit position *n* of the Block Ack Bitmap field, if equal to 1, acknowledges receipt of an MPDU with sequence number value, *SN* and fragment number value, *FN* with n equal to $4 \times (SN - SSN) + FN$, where *SSN* is the value of the Starting Sequence Number subfield of the Block Ack Starting Sequence Control subfield and the operations on the sequence numbers are performed modulo 4096. When bit position *n* of the Block Ack Bitmap field is equal to 0 it indicates that the MPDU has not been received.

NOTE—When the Fragment Number subfield is equal to 1 then the BlockAck Bitmap field is split into 16 subbitmaps, each of which indicates receive status for 4 fragments of each of the 16 MSDUs.

Insert a new subclause after 9.3.1.22:

9.3.1.23 Trigger frame

The Trigger frame is used to allocate resource for UL MU transmission and to solicit an UL MU transmission at [TBD IFS] after the PPDU that carries the Trigger frame. The Trigger frame also carries other information required by the responding STA to send UL MU.

The frame format for the Trigger frame is as defined in Figure 9-51a (Trigger frame).

	Frame Control	Duration	(RA)	TA	Common Info	Per User Info	…	Per User Info	Padding	FCS
Octets:	2	2	6	6	TBD	TBD		TBD		4

Figure 9-51a - Trigger frame

The Duration/ID field is set as defined in 9.2.5 (Duration/ID field (QoS STA)).

The RA field of the Trigger frame is the address of the recipient STA. Whether RA is not part of Trigger frame is TBD.

The TA field value is the address of the STA transmitting the Trigger frame.

The Common Info field is defined in Figure 9-51b.

	Length	Cascade Indication	CS Required	HE-SIG-A Info	CP and LTF Type	Trigger Type	Trigger-dependent Common Info
Bits:	12	1	1	TBD	TBD	TBD	variable

Figure 9-51b - Common Info field

The Length subfield of the Common Info field indicates the value of the L-SIG Length field of the HE trigger-based PPDU that is the response to the Trigger frame.

If the Cascade Indication subfield is 1, then a subsequent Trigger frame follows the current Trigger frame. Otherwise the Cascade Indication subfield is 0.

The CS Required subfield is set to 1 to indicate that the STAs identified in the Per User Info fields are required to use ED to sense the medium and to consider the medium state and the NAV in determining

whether or not to repond. The CS Requred subfield is set to 0 to indicate that the STAs identified in the Per User Info fields are not required consider the medium state or the NAV in determining whether or not to respond.

The HE-SIG-A Info subfield of the Common Info field indicates the content of the HE-SIG-A field of the HE trigger-based PPDU response. The TBD bits in HE-SIG-A of the HE trigger-based PPDU that may be implicitly known by all responding STAs can be excluded.

The CP and LTF Type subfield of the Common Info field indicates the CP and HE-LTF type of the HE trigger-based PPDU response. The CP and LTF field encoding is defined in Table 9-2.

Table 9-2 - CP and LTF field encoding

CP and LTF field value	Description
0	2x LTF + 0.8 μs CP
1	2x LTF + 1.6 μs CP
2	4x LTF + 3.2 μs CP
3-TBD	Reserved

The Trigger Type subfield indicates the type of the Trigger frame. The Trigger frame can include an optional type-specific Common Info and optional type-specific Per User Info. Table 9-3 defines the valid Trigger Type.

Table 9-3 - Trigger Type field encoding

Trigger Type value	Trigger Type description
0	Basic Trigger
1	Beamforming Report Poll Trigger
2	MU-BAR
3	MU-RTS
4-TBD	Reserved

The Per User Info field is defined in Figure 9-1.

	User Indentifier	RU Allocation	Coding Type	MCS	DCM	SS Allocation	Trigger dependent Per User Info
Bits:	12	TBD	TBD	TBD	TBD	TBD	variable

Figure 9-1 - Per User Info field

The User Identifier subfield of the Per User Info field indicates the AID of the STA allocated the RU to transmit the MPDU(s) in the HE trigger-based PPDU.

The RU Allocation subfield of the Per User Info field indicates the RU used by the HE trigger-based PPDU of the STA identified by User Identifier subfield. The length and coding of RU Allocation subfield are TBD.

The Coding Type subfield of the Per User Info field indicates the code type of the HE trigger-based PPDU response of the STA identified by User Identifier subfield. Set to 0 for BCC and set to 1 for LDPC.

The MCS subfield of the Per User Info field indicates the MCS of the HE trigger-based PPDU response of the STA identified by User Identifier field. The encoding of the MCS field is as defined in Section XXX.

The DCM subfield of the Per User Info field indicates dual carrier modulation of the HE trigger-based PPDU response of the STA identified by User Identifier subfield. A value of 1 indicates that the HE trigger-based PPDU response shall use DCM as defined in section XXX. Set to 0 to indicate that DCM shall not be used.

The SS Allocation subfield of the Per User Info field indicates the spatial streams of the HE trigger-based PPDU response of the STA identified by User Identifier field.

The Padding field extends the frame length to give the recipient STAs more time to prepare a response. The length and the content of Padding field are TBD.

9.3.1.23.1 MU-BAR variant

If the Trigger frame is an MU-BAR vaiant, then the Trigger-dependent Common Info field is define in Figure 9-2.

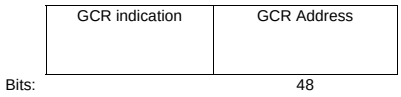


Figure 9-2 – Trigger-dependent Common Info field for MU-BAR variant

If the Trigger frame is an MU-BAR vaiant, then the Trigger-dependent Per User Info field is define in Figure 9-3.

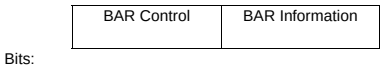


Figure 9-3 - Trigger-dependent Per User Info field for MU-BAR variant

The BAR Control subfield is defined in 9.3.1.8 (BlockAckReq frame format).

The BAR Information subfield is defined in 9.3.1.8 (BlockAckReq frame format).

9.3.1.23.2 MU-RTS variant

The MU-RTS frame format is a variant of Trigger frame format as shown in Figure 9-51a.

If an MU-RTS frame requests a STA to respond with a CTS frame carried in a non-HT or non-HT duplicate PPDU, the RU Allocation subfield in the Per-User Info field addressed to the STA indicates whether the CTS frame is transmitted on the primary 20 MHz channel, primary 40 MHz channel, primary 80 MHz channel, 160 MHz channel, or 80+80 MHz channel.

The Duration/ID field is defined in 9.2.5.2 Duration/ID field (QoS STA).

9.3.2 Data frames

9.3.3 Management frames

9.3.3.2 Beacon frame format

Insert the following new rows (header row shown for convenience) into Table 9-27 (Beacon frame body):

Order	Information	Notes
TBD	HE Capabilities	The HE Capabilities element is present when the dot11HEOptionImplemented is true; otherwise it is not present.
TBD	HE Operation	The HE Operation element is present when the dot11HEOptionImplemented is true; otherwise it is not present.
TBD	TWT	The TWT element is optionally present when the dot11TWTOptionActivated is true; otherwise it is not present.

9.3.3.5 Association Request frame format

Insert the following new rows (header row shown for convenience) into Table 9-29 (Association frame body):

Order	Information	Notes
TBD	HE Capabilities	The HE Capabilities element is present when the dot11HEOptionImplemented is true; otherwise it is not present.

TBD	HE Operation	The HE Operation element is present when the dot11HEOptionImplemented is true; otherwise it is not present.

9.3.3.6 Association Response frame format

Insert the following new rows (header row shown for convenience) into Table 9-30 (Beacon frame body):

Order	Information	Notes
TBD	HE Capabilities	The HE Capabilities element is present when the dot11HEOptionImplemented is true; otherwise it is not present.
TBD	HE Operation	The HE Operation element is present when the dot11HEOptionImplemented is true; otherwise it is not present.

9.3.3.7 Reassociation Request frame format

Order	Information	Notes
TBD	HE Capabilities	The HE Capabilities element is present when the dot11HEOptionImplemented is true; otherwise it is not present.
TBD	HE Operation	The HE Operation element is present when the dot11HEOptionImplemented is true; otherwise it is not present.

9.3.3.8 Reassociation Response frame format

Insert the following new rows (header row shown for convenience) into Table 9-32 (Reassociation Response frame body):

Order	Information	Notes
TBD	HE Capabilities	The HE Capabilities element is present when the dot11HEOptionImplemented is true; otherwise it is not present.
TBD	HE Operation	The HE Operation element is present when the dot11HEOptionImplemented is true; otherwise it is not present.

9.3.3.9 Probe Request frame format

Insert the following new rows (header row shown for convenience) into Table 9-33 (Probe Request frame body):

Order	Information	Notes
TBD	HE Capabilities	The HE Capabilities element is present when the dot11HEOptionImplemented is true; otherwise it is not present.
TBD	HE Operation	The HE Operation element is present when the dot11HEOptionImplemented is true; otherwise it is not present.

9.3.3.10 Probe Response frame format

Insert the following new rows (header row shown for convenience) into Table 9-34 (Probe Response frame body):

Order	Information	Notes
TBD	HE Capabilities	The HE Capabilities element is present when the dot11HEOptionImplemented is true; otherwise it is not present.
TBD	HE Operation	The HE Operation element is present when the dot11HEOptionImplemented is true; otherwise it is not present.

9.4 Management and Extension frame body components

9.4.1 Fields that are not elements

Insert the following two sublauses:

9.4.1.62 HE Compressed Beamforming Report field

The format of the HE Compressed Beamforming Report field is based on the VHT Compressed Beamforming Report field in 9.4.1.48 (VHT Compressed Beamforming Report field) except for the following modifications.

The supported values for the tone grouping factor Ng shall be *Ng* = 4 and *Ng* = 16 for SU-MIMO, MU-MIMO and OFDMA. Here, the tone grouping factor Ng is defined with respect to data tones of the HE PPDU.

Other modification are TBD.

9.4.1.63 HE MU Exclusive Beamforming Report field

The HE MU Exclusive Beamforming Report Field is based on the VHT Exclusive Beamforming Report Field in 9.4.1.50, except for the following modifications.

The MU Exclusive Beamforming Report information consists of Delta SNR subfields for each space-time stream (1 to *Nc*) of a subset of the subcarriers spaced *Ng* apart (where *Ng* is the tone grouping factor). Specifically, the locations of the feedback tones for delta SNR subfields shall be identical to the tone locations of the compressed V matrices fed back.

Other modification are TBD.

9.4.2 Elements

9.4.2.1 General

Insert the following new rows into Table 9-75 Element IDs (header row shown for convenience):

Element	Element ID	Element ID Extension	Extensible
HE Capabilities (see 9.4.2.213 (HE Capabilities element))	<ANA>	N/A	Yes
HE Operation (see 9.4.2.214 (HE Operation element))	<ANA>	N/A	Yes

9.4.2.196 TWT element

Change bit B3 from "Reserved" to "Broadcast" in Figure 8-577ax (Control field format).

Insert the following paragraph after Table 9-248l (TWT Setup Command field values):

The Broadcast field indicates if the TWT SP indicated by the TWT element is a broadcast TWT as defined in 9.44.3 (Broadcast TWT Operation). The Broadcast field is set to 1 to indicate that the TWT(s) defined by the TWT element are broadcast TWT(s); otherwise, it is set to 0.

Change bit B4 from "Reserved" to "Trigger" in Figure 9-577ay (Request Type field format).

Insert the following paragraph after Table 9-248l (TWT Setup Command field values):

The Trigger field indicates if the TWT SP indicated by the TWT element includes Trigger frames as defined in 10.44 (Target wake time (TWT)). The Trigger field is set to 1 to indicate that at least one Trigger frame is transmitted during the TWT SP. The Trigger field is set to 0 otherwise.

Change the text as shown in subclause 9.4.2.196 TWT element:

For a TWT SP that is not a broadcast TWT SP, Tthe TWT Flow Identifier subfield contains a 3-bit value which identifies the specific information for this TWT request uniquely from other requests made between the same TWT requesting STA and TWT responding STA pair. For a TWT SP that is a broadcast TWT SP, the TWT Flow Identifier subfield contains a value that indicates recommendations on the types of frames that are transmitted during the broadcast TWT SP, encoded according to Table 9-248l1 (TWT Flow Identifier field for a broadcast TWT element).

Table 9-248l1 - TWT Flow Identifier field for a broadcast TWT element

TWT Flow Identifier field value	Description when transmitted in a broadcast TWT element
0	No constraints on the frames transmitted during a broadcast TWT SP.

1	Frames transmitted during a broadcast TWT SP are recommended to be limited to: PS-Poll, CQI, QoS Null with buffer status, Sounding Feedback, Management Action Trigger frames transmitted by the AP during the broadcast TWT SP do not contain RUs for random access.
2	Frames transmitted during a broadcast TWT SP are recommended to be limited to: PS-Poll, CQI, QoS Null with buffer status, Sounding Feedback, Management Action, (Re)Association Request Trigger frames transmitted by the AP during the broadcast TWT SP contain at least one RU for random access.
3-7	Reserved

Change the paragraph below as follows:

In a TWT element transmitted by a TWT requesting STA, the TWT wake interval is equal to the average time that the TWT requesting STA expects to elapse between successive TWT SPs. In a TWT element transmitted by a TWT responding STA, the TWT wake interval is equal to the average time that the TWT-responding STA expects to elapse between successive TWT SPs. In a TWT element contained in a TWT request/response that is sent to negotiate the wake intervals for beacon frames containing broadcast TWT, the TWT wake interval indicates the value of the listen interval (see 10.44.3.4 (Negotiation of TBTT and listen interval).

The TWT Wake Interval Exponent subfield is set to the value of the exponent of the TWT wake interval value in microseconds, base 2. The TWT wake interval of the requesting STA is equal to (TWT Wake Interval Mantissa) × 2^(TWT Wake Interval Exponent).

Change the paragraph below as follows:

When transmitted by a TWT requesting STA or a TWT scheduled STA, the Target Wake Time field contains a positive integer which corresponds to a TSF time at which the STA requests to wake, or a value of zero when the TWT Setup Command subfield contains the value corresponding to the command "Request TWT". When a TWT responding STA or a TWT scheduling STA with dot11TWTGroupingSupport equal to 0 transmits a TWT element to the TWT requesting STA, the TWT element contains a value in the Target Wake Time field which corresponds to a TSF time at which the TWT responding STA requests the TWT requesting STA or TWT scheduled STA to wake and it does not contain the TWT Group Assignment field.

Change Table 9-248l – TWT Setup Command field values by adding two new columns as shown:

Table 9-248l – TWT Setup Command field values

TWT Setup Command field value	**Command name**	**Description when transmitted by a TWT requesting STA**	**Description when transmitted by a TWT responding STA**	**Description when transmitted by a TWT scheduled STA**	**Description when transmitted by a TWT scheduling STA**
0	Request TWT	The Target Wake Time field of the TWT element contains 0s as the TWT responding STA specifies the target wake time value for this case, other TWT parameters* are suggested by the TWT requesting	N/A	The Target Wake Time field of the TWT element contains 0s as the TWT scheduling STA specifies the target wake time value for this case, other TWT parameters* are suggested by the TWT scheduled STA in the TWT request.	N/A

		STA in the TWT request.			
1	Suggest TWT	TWT requesting STA includes a set of TWT parameters such that if the requested target wake time value and/or other TWT parameters cannot be accommodate, then the TWT setup might still be accepted.	N/A		N/A
2	Demand TWT	TWT requesting STA includes a set of TWT parameters such that if the requested target wake time value and/or other TWT parameters cannot be accommodate, then the TWT setup will be rejected.	N/A		N/A
3	TWT Grouping		N/A	N/A	N/A
4	Accept TWT	N/A	TWT responding STA accepts the TWT request with the TWT parameters* indicated in the TWT element transmitted by the responding STA.	N/A	TWT scheduling STA accepts the TWT request with the TWT parameters* indicated in the TWT element transmtted by the TWT scheduled STA.
5	Alternate TWT	N/A	TWT responding STA suggests TWT parameters that are different from TWT requesting STA suggested or demanded TWT parameters	N/A	N/A
6	Dictate TWT	N/A	TWT responding STA demands TWT parameters that are different from TWT requesting STA TWT suggested or demanded parameters	N/A	
7	Reject TWT	N/A	TWT responding STA rejects TWT setup	N/A	TWT scheduling STA rejects TWT setup
*TWT Parameters are: TWT, Nominal Minimum Wake Duration, TWT Wake Interval and TWT Channel subfield values indicated in the element.					

Insert the following new subclauses after the last subclause in 9.4.2:

9.4.2.213 HE Capabilities element

An HE STA declares that it is an HE STA by transmitting the HE Capabilities element.

The HE Capabilities element contains a number of fields that are used to advertise the HE capabilities of an HE STA. The HE Capabilities element is defined in Figure 9-554aa (HE Capabilities element format).

	Element ID	Length	HE Capabilities Information	PPE Thresholds (optional)
Octets:	1	1	2	variable

Figure 9-554aa - HE Capabilities element format

The Element ID and Length fields are defined in 9.4.2.1 (General).

The format of the HE Capabilities Information field is defined in Figure 9-554ab (HE Capabilities field format).

	B0	B1	B2	B3 B4	B5 B15
	PPE Thresholds Present	TWT Requester Support	TWT Responder Support	Fragmentation Support	Reserved
Bits:	1	1	1	2	12

Figure 9-554b - HE Capabilities field format

The PPE Thresholds Present field indicates if the HE PPE Thresholds field is present or not. A value of 1 in this field means that the PPE Thresholds field is present. A value of 0 in this field means that the HE PPE Thresholds field is not present because no packet extension is ever required for the STA transmitting this field.

The TWT Requester Support field indicates support by an HE STA for the role of TWT requesting STA as described in 10.44 (Target wake time (TWT)). The field is set to 1 if dot11TWTOptionActivated is true, the STA is an HE STA and the STA supports TWT requester STA functionality (see 10.44 (Target wake time (TWT))). Set to 0 otherwise.

The TWT Responder Support field indicates support by an HE STA for the role of TWT responder STA as described in 10.44 (Target wake time (TWT)). The field is set to 1 if dot11TWTOptionActivated is true, the STA is an HE STA and the STA supports TWT responder STA functionality (see 10.44 (Target wake time (TWT))). Set to 0 otherwise.

The Fragmentation Support field indicates the level of HE fragmentation that is supported by a STA. The encoding of this field is described in Table 9-554ae (Fragmentation Support field encoding).

Table 9-554ae - Fragmentation Support field encoding

Fragmentation Support field value	Meaning
0	No support for HE Fragmentation
1	Support for fragments that are contained within a VHT single MPDU, no support for fragments within an A-MPDU
2	Support for up to one fragment per MSDU within a single A-MPDU
3	Support for multiple fragments per MSDU within an A-MPDU

The format of the PPE Thresholds field is defined in Figure 9-554ac (PPE Thresholds field format).

	B0 B1	B2 B3		
	NSS M1	RU Count	PPE Threshold Info	PPE Pad
Bits:	3	2	variable	variable

Figure 9-554ac -- PPE Thresholds field format

The NSS M1 subfield contains an unsigned integer that is equal to the number of NSS values minus one for which PPE threshold information is included in the PPE Thresholds field. For example, if the number of NSS values represented is 4, then the NSS M1 subfield contains the value 3.

The RU Count subfield contains an unsigned integer that is equal to the number of RU allocation values for which HE PPE threshold information is included in the PPE Thresholds field. The value of zero for this field is reserved. The value of three for this field is reserved.

The PPE Threshold Info field is (NSS M1 + 1) x RU Count x 6 bits in length. The format of the PPE Threshold Info field is defined in Figure 8-554ae (PPE Threshold Info field format).

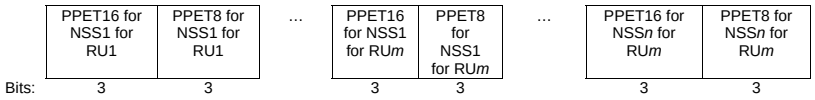


Figure 9-554ae - PPE Threshold Info field format

Each PPET8 for NSS*n* for RU*m* subfield contains a Constellation Index value.

Each PPET16 for NSS*n* for RU*m* subfield contains a Constellation Index value.

All the PPET8 for NSS*n* for RU*m* subfield and PPET16 for NSS*n* for RU*m* subfield values are combined to encode the minimum duration of the post-FEC padding and packet extension for HE PPDUs that are transmitted to the STA sending this field, for each value of NSS and RU specified by the field and implicitly, for values of NSS and RU not explicitly indicated in the field. The encoding is described in Table 9-554af (PPET8 and PPET16 encoding).

Table 9-554af - PPET8 and PPET16 encoding

Result of comparison of the constellation index *x* of an HE PPDU with NSS value *n* and RU value m to the value in the PPET8 for NSS*n* for RU*m* subfield	**Result of comparison of the constellation index of an HE PPDU with NSS value *n* and RU value m to the value in the PPET16 for NSS*n* for RU*m* subfield**	**Combined minimum total duration of the post-FEC padding and packet extension requirement for an HE PPDU transmitted to this STA using the constellation index = *x*, NSS = *n* and RU = *m***
X < PPET8 or PPET8 == NONE	X < PPET16 or PPET16 == NONE	0 µs
X > PPET8	X < PPET16 or PPET16 == NONE	8 µs
X > PPET8 or PPET8 == NONE	X > PPET16	16 µs
PPET8 == NONE	PPET16 == NONE	0 µs
PPET8 not present	PPET16 not present	0 µs

The RU Allocation Index encoding is indicated in Table 9-554ag (RU Allocation Index encoding).

Table 9-554ag - RU Allocation Index encoding

RU Allocation Index value	**RU allocation value**
0	2x996
1	996
2	484
3	242

The Constellation Index encoding is indicated in Table 9-554ah (Constellation Index encoding).

Table 9-554ah - Constellation Index encoding

Constellation Index value	**Corresponding Transmission Constellation**
0	BPSK
1	QPSK
2	16-QAM
3	64-QAM
4	256-QAM
5	1024-QAM

6	Reserved
7	NONE

The PPE Pad field contains all zeros. The number of bits in the PPE Pad field is the number of bits required to round the length of the PPE Thresholds field up to the next integer quantity of octets.

STA that declare support for HE trigger-based PPDU shall also declare whether they belong to class A or class B. Class A STAs that are high capability devices and Class B STAs are low capability devices.

9.4.2.214 HE Operation element

The operation of HE STAs in an HE BSS is controlled by the HT Operation element, the VHT Operation element and the HE Operation element. The format of the HE Operation element is defined in Figure 9-554ba (HE Operation element format).

	Element ID	Length	HE Operation Parameters
Octets:	1	1	2

Figure 9-554ba - HE Operation element format

The Element ID and Length fields are defined in 9.4.2.1 (General).

The format of the HE Operation Parameters field is defined in Figure 9-554bb (HE Operation Parameters field format).

	B0	B15
	BSS Color	Reserved
Bits:	TBD	TBD

Figure 9-554bb - HE Operation Parameters field format

The BSS Color field is an unsigned integer whose value is the BSS Color of the BSS corresponding to the AP which transmitted this element, except that a value of 0 in this field indicates that there is no BSS Color for this BSS.

9.4.3 Subelements

9.4.4 TLV encodings

9.4.5 Access network query protocol (ANQP) elements

9.4.6 Registered location query protocol (RLQP) elements

9.5 Fields used in Management and Extension frame bodies and Control frames

9.6 Action frame format details

9.7 Aggregate MPDU (A-MPDU)

9.7.3 A-MPDU contents

Change the first paragraph as follows:

In a non-DMG PPDU, an A-MPDU is a sequence of A-MPDU subframes carried in a single PPDU with one of the following combinations of RXVECTOR or TXVECTOR parameter values:

— The FORMAT parameter set to VHT

— The FORMAT parameter set to HT_MF or HT_GF and the AGGREGATION parameter set to 1

— The FORMAT parameter set to HE

Insert the following paragraph:

An A-MPDU carried in a HE MU PPDU may include MPDUs with different values of the TID field. Additional rules are TBD.

Insert the following three rows in Table 9-420 (A-MPDU Contexts):

Name of Context	Definition of Context	Table defining permitted content
Data Enabled Immediate Response with Multiple TID Support	The multiple TID A-MPDU is transmitted outside a PSMP sequence by a TXOP holder in DL/UL MU frame exchange or a STA in UL MU frame exchange sequence including potential immediate responses.	Table 9-426a (Multiple TID A-MPDU contents in the data enabled immediate response context)
Data Enabled No Immediate Response with Multiple TID Support	The multiple TID A-MPDU is transmitted outside a PSMP sequence by a TXOP holder in DL/UL MU frame exchange or a STA in UL MU frame exchange sequence that does not solicit immediate responses.	Table 8-426b (Multiple TID A-MPDU contents in the data enabled no immediate response context)
UL MU Context	An A-MPDU intended for a STA that is UL MU capable	Table 9-426c (A-MPDU content in the UL MU Context)

Insert the following two tables at the end of the subclause:

Table 9-426a - Multiple TID A-MPDU contents in the data enabled immediate response context

MPDU Description	Conditions	
Trigger frame	If the AP schedule resource for following UL MU transmission and HE A-Control field in data/management frames don't include trigger information.	
Ack frame	If the preceding PPDU contains an MPDU that requires an Ack frame response.	At most one of the MPDUs is present
BlockAck frame	If the preceding PPDU contains an implicit or explicit block ack request for a TID for which an HT-immediate block ack agreement exists, at most one BlockAck frame for this TID.	
Multi-STA BlockAck frame	If the preceding PPDU contains implicit or explicit block ack request for multiple TIDs for which an HT-immediate block ack agreement exists, at most one Multi-TID BA frame.	
Action No Ack	Action No Ack frames	
Data frames sent under an HTimmediate block ack agreement	QoS Data frames with the multiple TIDs, with TID being corresponding to an HT-immediate block ack agreement	
QoS Null MPDUs with Ack Policy set to No Acknowledgment	In an HE BSS, QoS Null MPDUs with Ack Policy set to No Acknowledgment.	
Action frame	At most one Action frame	
Data frame whith TID that has no block ack agreement and with Ack Policy set to Normal Ack	At most one data frame of the TID	
Immediate BlockAckReq frames	At most one data frame for one TID that there is no data frames sent under	

Table 9-426b – Multiple TID A-MPDU contents in the data enabled no immediate response context

MPDU Description	Conditions	
Trigger frame	If the AP schedule resource for following UL MU transmission and HE A-Control field in data/management frames don't include trigger information.	
Ack frame	If the preceding PPDU contains an MPDU that requires an Ack frame response.	

BlockAck frame	If the preceding PPDU contains an implicit or explicit block ack request for a TID for which an HT-immediate block ack agreement exists, at most one BlockAck frame for this TID.	At most one of the MPDUs is present
Multi-STA BlockAck frame	If the preceding PPDU contains implicit or explicit block ack request for multiple TIDs for which an HT-immediate block ack agreement exists, at most one Multi-TID BA frame.	
Action No Ack	Action No Ack frames	
Data frames without immediate block ack agreement and with Ack Policy set to No Ack	QoS Data frames with TIDs that does not correspond to a block ack agreement. These have the Ack Policy field equal to No Ack.	
QoS Null MPDUs with Ack Policy set to No Acknowledgment	In an HE BSS, QoS Null MPDUs with Ack Policy set to No Acknowledgment.	

Table 9-426c – A-MPDU content in the UL MU context

MPDU Description	Condition
A control frame of subtype Trigger	One or more Trigger frames can be included.
MPDU with trigger information in the MAC header	One or more MPDUs with trigger information in the MAC header may be included

10MAC sublayer functional description

10.1 Introduction

10.2 MAC architecture

10.3 DCF

10.3.1 General

Change as follows:

The virtual CS mechanism is achieved by distributing reservation information announcing the impending use of the medium. The exchange of RTS and CTS frames prior to the actual Data frame is one means of distribution of this medium reservation information. The RTS and CTS frames contain a Duration field that defines the period of time that the medium is to be reserved to transmit the actual Data frame and the returning Ack frame. A STA receiving either the RTS frame (sent by the originating STA) or the CTS frame (sent by the destination STA) shall process the medium reservation. Thus, a STA might be unable to receive from the originating STA and yet still know about the impending use of the medium to transmit a Data frame. The exchange of MU-RTS and simultaneous CTS responses by HE STAs prior to the actual Data frames as defined in 10.3.2.8a is one means of distribution of this medium reservation information.

10.3.2 Procedures common to the DCF and EDCAF

10.3.2.1 CS mechanism

Change as follows:

A virtual CS mechanism shall be provided by the MAC. This mechanism is referred to as the NAV. The NAV maintains a prediction of future traffic on the medium based on duration information that is announced in RTS/CTS frames by non-DMG STAs, MU-RTS/CTS by HE STAs as defined in 10.3.2.8a, and RTS/DMG CTS frames by DMG STAs prior to the actual exchange of data. The duration information is also available in the MAC headers of all frames sent during the CP other than PS-Poll frames, and during the BTI, the A-BFT, the ATI, the CBAP, and the SP. The mechanism for setting the NAV using RTS/CTS or MU-RTS/CTS or RTS/DMG CTS in the DCF is described in 10.3.2.4 (Setting and resetting the NAV),

use of the NAV in PCF is described in 10.4.3.3 (NAV operation during the CFP), and use of the NAV in HCF is described in 10.22.2.2 (EDCA backoff procedure) and 10.22.3.4 (NAV operation of a TXOP under HCCA). Additional details regarding NAV use appear in 10.3.2.5 (RTS/CTS with fragmentation), 10.3.2.13 (NAV distribution), 10.36.10 (Updating multiple NAV timers), and 10.26 (Protection mechanisms).

10.3.2.4 Setting and resetting the NAV

Insert the following at the end of 10.3.2.4:

An HE AP may use a TBD mechanism to configure the use of RTS/CTS initiated by non-AP STA.

Insert a new subclause following 10.3.2.8:

10.3.2.8a MU RTS/CTS procedure

The MU-RTS/CTS procedure allows an AP to protect MU transmission for HE STAs. An HE AP may transmit an MU-RTS frame to solicit simultaneous CTS responses from one or more HE STAs.

Figure 10-1 shows an example of the exchange of MU-RTS and simultaneous CTS responses to protect DL MU PPDU and acknowledgement responses.

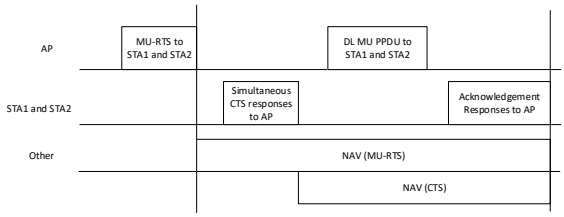


Figure 1 – Example of MU-RTS/CTS/DL MU PPDU/Acknowledgement Response and NAV setting

Figure 10-1 – Example of MU-RTS/CTS/DL MU PPDU/Acknowledgement Response and NAV setting

Figure 10-2 shows an example of the exchange of MU-RTS and simultaneous CTS responses to protect the scheduled HE trigger-based PPDU and Multi-STA BlockAck frame.

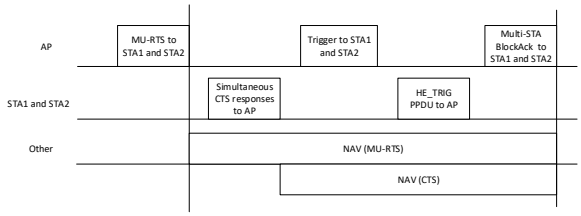


Figure 2 – Example of MU-RTS/CTS/Trigger/HE_TRIG PPDU/Multi-STA BlockAck and NAV setting

Figure 10-2 - Example of MU-RTS/CTS/Trigger/HE trigger-based PPDU/Multi-STA BlockAck and NAV setting

9.3.2.8a.1 MU-RTS procedure

An MU-RTS frame shall not request a STA to send CTS responses in any 20 MHz channel that is not occupied by the immediately preceding DL PPDU that contains an MU-RTS frame. In each 20 MHz channel occupied by the immediately preceding DL PPDU that contains an MU-RTS frame, there is at least one STA that is requested to send CTS responses on the 20 MHz channel.

If an MU-RTS frame requests a STA to send CTS responses in a non-HT or non-HT duplicate PPDU, the RU Allocation subfield in the Per-User Info field addressed to the STA shall be set to a value indicating either primary 20 MHz channel, primary 40 MHz channel, primary 80 MHz channel, 160 MHz channel, or 80+80 MHz channel. Other indications are TBD.

9.3.2.8a.2 CTS Repsonse to MU-RTS

If a HE STA receives an MU-RTS frame, the HE STA shall commence the transmission of a CTS response at the SIFS time boundary after the end of a received PPDU when all the following conditions are met:

— The MU-RTS frame has one of the Per-User Info fields addressed to the STA.

— The UL MU CS condition described in 25.5.2.4 (UL MU CS mechanism) indicates the medium is idle

— Other transmission conditions TBD are met.

HE STAs may transmit CTS responses to an MU-RTS frame in a non-HT or non-HT duplicate PPDU with frame format as defined in 9.3.1.3 based on the request in MU-RTS frame. The method of request is TBD.

The Scrambler Initialization in the SERVICE field of the CTS sent in response to an MU-RTS frame shall be copied from the Scrambler Initialization in the SERVICE field of the MU-RTS frame. The rate of the CTS response is defined in 10.7.6.

The CTS sent in response to an MU-RTS frame shall be transmitted on one or more 20 MHz channels.

If the CTS sent in response to an MU-RTS frame is transmitted in a non-HT or non-HT duplicate PPDU, then the CTS response shall be transmitted on the indicated 20 MHz channels identified in the RU Allocation subfield of the Per-User Info field.

Figure 10-3 shows an example of the exchange of MU-RTS and simultaneous CTS responses on primary 40 MHz channel. In this example, MU-RTS is transmitted in a 40 MHz non-HT duplicate PPDU on primary 40 MHz channel. Further, MU-RTS requests STA1 to transmit CTS response in a non-HT PPDU on primary 20 MHz channel and STA2 to transmit CTS response in a 40 MHz non-HT duplicate PPDU on primary 40 MHz channel.

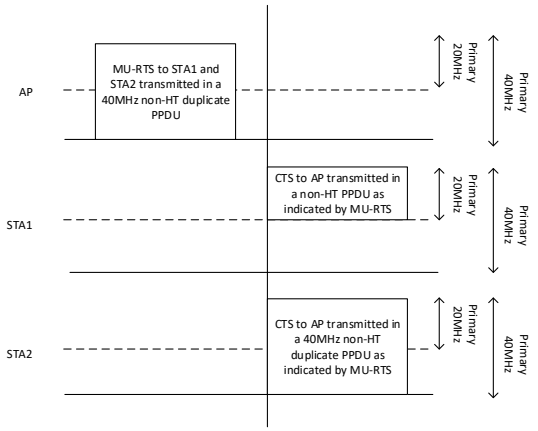


Figure 3 - Example of MU-RTS and CTS Responses on Primary 40MHz Channel

Figure 10-3 - Example of MU-RTS and CTS responses on the primary 40 MHz channel

10.3.2.11 MU acknowledgment procedure

Insert a new subclause heading before the first paragraph of 10.2.3.11:

10.3.2.11.1 General

Insert a new subclauses at the end of 10.2.3.11:

10.3.2.11.2 MU acknowledgement procedure for DL MU PPDU in SU format

The acknowledgment procedure performed by a STA that receives MPDUs that were transmitted within a VHT MU PPDU or an HE MU PPDU is the same as the acknowledgment procedure for MPDUs that were not transmitted within a VHT MU PPDU or an HE MU PPDU.

NOTE—All MPDUs transmitted within a VHT MU PPDU or an HE MU PPDU are contained within A-MPDUs, and the rules specified in 9.7.3 (A-MPDU contents) prevent an immediate response to more than one of the A-MPDUs.

Responses to A-MPDUs within a VHT MU PPDU or an HE MU PPDU that are not immediate responses to the VHT MU PPDU or the HE MU PPDU are transmitted in response to explicit BlockAckReq frames by the AP. Examples of VHT MU PPDU frame exchange sequences are shown in Figure 10-11 (An example of a TXOP containing a VHT MU PPDU transmission with an immediate acknowledgment to the VHT MU PPDU) and Figure 10-12 (An example of a TXOP containing a VHT MU PPDU transmission with no immediate acknowledgment to the VHT MU PPDU).

Recovery within the TXOP that contains a VHT MU PPDU or an HE MU PPDU can be performed according to the rules of 10.22.2.7 (Multiple frame transmission in an EDCA TXOP). BlockAckRequest frames related to A-MPDUs within a VHT MU PPDU or an HE MU PPDU can be transmitted in a TXOP separate from the one that contained the VHT MU PPDU or the HE MU PPDU.

NOTE 1—A BlockAck frame or an Ack frame is sent in immediate response to the BlockAckReq frame for HT-immediate or HT-delayed Block Ack, respectively. An Ack frame might be sent in immediate response to a VHT single MPDU in the VHT MU PPDU or the HE MU PPDU.

10.3.2.11.3 MU acknowledgement procedure for HE MU PPDU in MU format

A non-AP STA that is the recipient, within a HE MU PPDU, of an MPDU that solicits an immediate response with Ack Policy '01' in QoS Control field, shall send the immediate response according to the scheduling information defined by the UL trigger information that is carried either in the Trigger frame(s) or in MAC header. If no valid Trigger frame(s) or MAC header containing UL trigger information is received, then the STA shall not respond. An example of UL OFDMA acknowledgement to an HE MU PPDU is shown in Figure 10-4.

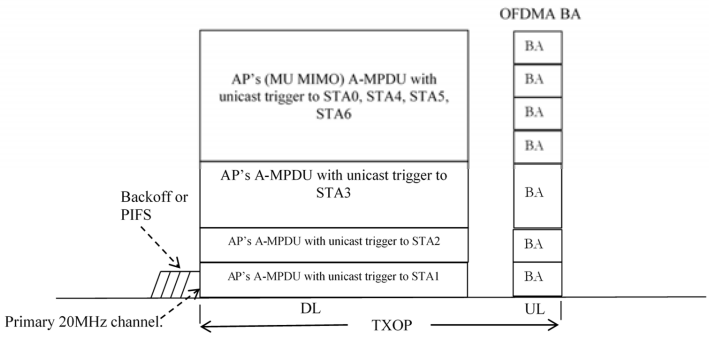


Figure 10-4 - An example of a TXOP containing an HE MU PPDU transmission with an immediate UL OFDMA acknowledgement

An AP shall not set Ack Policy to "01" in QoS Control field in MPDUs of HE MU PPDU if both UL MU OFDMA Capable subfield and UL MU MIMO Capable subfield of the HE Capabilities element of the receiver of the MPDUs are set to 0.

10.3.2.11.4 MU acknowledgement procedure for an UL MU transmission

When receiving multiple frames from more than one STA that are part of an UL MU transmission (Clause 9.42.2) and that require an immediate acknowledgement, an AP may send multiple BlockAck frames (or ACK frames) in an OFDMA HE MU PPDU or a Multi-STA BlockAck (M-BA) frame. Additional conditions to transmit multiple BlockAck frames (or ACK frames) in an OFDMA HE MU PPDU or Multi-STA BlockAck are TBD. After a successful reception of an UL frame requiring acknowledgment, transmission of the DL acknowledgement shall commence after a SIFS, without regard to the busy/idle state of the medium.

The example of DL OFDMA BA shown in Figure 10-5, and examples for Multi-STA BlockAck frame acknowledgement to a UL MU PPDU is given in Figure 10-6, Figure 10-7 and Figure 10-8.

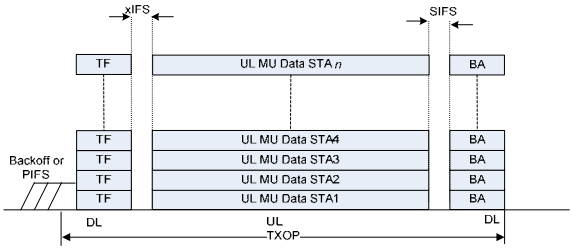


Figure 10-5 - An example of a TXOP containing an UL MU transmission with an immediate DL MU transmission containing unicast BlockAck frames acknowledging the frames received from the respective STAs

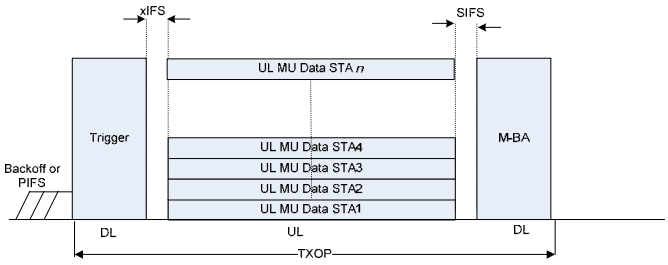


Figure 10-6 - An example of a TXOP containing UL MU transmissions with an immediate Multi-STA BlockAck (M-BA) frame acknowledging the MPDUs that were correctly received from each STA. The UL MU transmission may be OFDMA or MU-MIMO

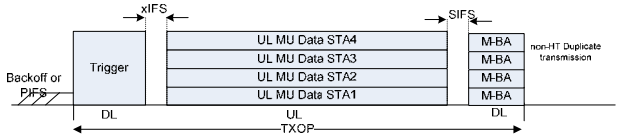


Figure 10-7 - An example of a TXOP containing UL MU transmissions with an immediate DL non-HT duplicate PPDU containing the M-BA frame. The UL MU transmissions may be OFDMA or MU-MIMO.

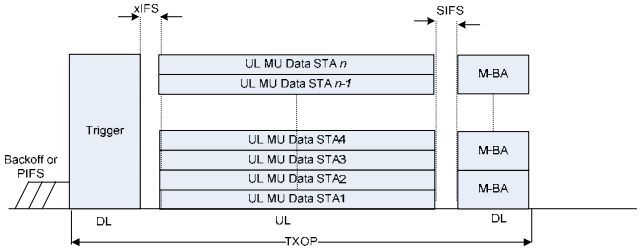


Figure 10-8 - An example of a TXOP containing UL MU transmissions with an immediate OFDMA HE MU PPDU containing Multi-STA BlockAck frames. The UL MU transmissions may be OFDMA or MU-MIMO.

10.7 Multirate support

10.7.6 Rate selection for Control frames

10.7.6.5 Rate selection for control response frames

10.7.6.5.2 Selection of a rate or MCS

Insert the following at the end of the subclause:

Within a MU RTS/CTS exchange, the simultaneous CTS shall be transmitted with the primary rate based on the rate or MCS of the MU-RTS frame that triggers the simultaneous CTS. The primary rate is defined to be the highest rate in the BSSBasicRateSet parameter that is less than or equal to the rate (or non-HT reference rate; see 10.7.10 (Non-HT basic rate calculation)) of the previous MU-RTS frame. If no rate in the BSSBasicRateSet parameter meets these conditions, the primary rate is defined to be the highest mandatory rate of the attached PHY that is less than or equal to the rate (or non-HT reference rate; see 10.7.10 (Non-HT basic rate calculation)) of the previous frame.

If a Multi-STA BlockAck frame or DL OFDMA ackowlegement frame is sent as an immediate response to an UL HE PPDU, the AP may ignore the <HE-MCS, NSS> tuples that are used for MPDUs in UL HE PPDU from non-AP STAs that elicits the DL acknowledgement.

A Multi-STA BlockAck frame is carried in a non-HT PPDU shall be transmitted by the AP using a rate supported by all the recipients.

A Multi-STA BlockAck frame is carried in an HT or VHT PPDU shall be transmitted by the AP using an HT-MCS or <VHT-MCS, NSS> tuple supported by all the recipients.

A Multi-STA BlockAck frame is carried in an HE PPDU shall be transmitted by the AP using an <HE-MCS, NSS> tuple supported by all the recipients.

10.9 HT Control field operation

If the value of dot11HTControlFieldSupported is true, a STA shall set the +HTC Support subfield of the HT Extended Capabilities field of the HT Capabilities element to 1 in HT Capabilities elements that it transmits. If the value of dot11VHTControlFieldOptionImplemented is true, a STA shall set the +HTC-VHT Support subfield of the VHT Capabilities Information field of the VHT Capabilities element to 1 in VHT Capabilities elements that it transmits. If the value of the dot11HEControlFieldOptionImplemented is true, a STA shall set the +HTC-HE Support subfield of the HE Capabilies Information field of the HE Capabilities element to 1 in HE Capabilities elements that it transmits.

A STA that has a value of true for at least one of dot11RDResponderOptionImplemented, dot11MCSFeedbackOptionImplemented, and dot11AlternateEDCAActivated shall set dot11HTControlFieldSupported or dot11VHTControlFieldOptionImplemented or both to true. A STA that has a value of true for at least one of dot11ULMUOFDMAOptionImplemented,

dot11MCSFeedbackOptionImplemented, and dot11ROMIOptionImplemented shall set the dot11HEControlFieldOptionImplemented to true.

An HT variant HT Control field shall not be present in a frame addressed to a STA unless that STA declares support for +HTC-HT in the HT Extended Capabilities field of its HT Capabilities element (see 9.4.2.55 (HT Capabilities element)).

A VHT variant HT Control field shall not be present in a frame addressed to a STA unless that STA declares support for +HTC-VHT in the VHT Capabilities Information field of its VHT Capabilities element.

NOTE—An HT STA that does not support +HTC (HT or VHT variant) that receives a +HTC frame addressed to another STA still performs the CRC on the actual length of the MPDU and uses the Duration/ID field to update the NAV, as described in **Error! Reference source not found.**.

An HE variant HT Control field shall not be present in a frame addressed to a STA unless that STA declares support for +HTC-HE in the HE Capabilities Information field of its HE Capabilities element. The HE variant HT Control field carried in the frame may contain aControl subfield supported by the intended receiver that has:

- A value of 0 in the Control ID subfield when the transmitting STA expects an UL MU PPDU that carries an immediate acknowledgement, as described in 9.42.2 (UL MU operation).
- A value of 1 in the Control ID subfield when the transmitting STA changes the receive operation mode, as described in 10.45.2 (Receive operating mode indication).
- A value of 2 in the Control ID subfield when the transmitting STA follows the HE link adaptation procedure, as described in 10.31.4 (Link adaptation using the HE variant HT Control field).
- ...

If the HT Control field is present in an MPDU aggregated in an A-MPDU, then all MPDUs of the same frame type (i.e., having the same value for the Type subfield of the Frame Control field) aggregated in the same A-MPDU shall contain an HT Control field. The HT Control field of all MPDUs containing the HT Control field aggregated in the same A-MPDU shall be set to the same value.

10.22HCF

10.22.2 HCF contention based channel access (EDCA)

10.22.2.9 Truncation of TXOP

Insert the following at the end of subclause 10.22.2.9:

An HE STA that receives a CF-End frame should not reset its NAV if:

- The CF-End did not originate from the STA's associated BSS or any BSS of a multi-BSSID set that the STA's associated BSS belongs to and the most recent NAV update was due to a PPDU originating from the STA's associated BSS or any BSS of a multi-BSSID set that the STA's associated BSS belongs to.
- The CF-End originated from the STA's associated BSS or any BSS of a multi-BSSID set that the STA's associated BSS belongs to and the most recent NAV update was not due to a PPDU originating from the STA's associated BSS or any BSS of a multi-BSSID set that the STA's associated BSS belongs to.

10.24Block acknowledgment (block ack)

10.24.10 GCR block ack

Insert the following sentences at the end of 2nd paragraph of section 10.24.10.3:

The originator may send a MU-BAR frame (MU-BAR Trigger variant of UL-Trigger Frame) to one or more of the HE STAs that have a GCR block ack agreement for this group address. Upon reception of the BlockAck frame, an originator may send a MU-BAR frame to other one or more HE STAs that have a block ack agreement for this group address, and this process may be repeated multiple times.

Insert the following sentences at the end of 4th paragraph of section 10.24.10.3:

When HE STA receives a MU-BAR frame with User identifier field set to the AID of the HE STA, the HE STA shall transmit BlockAck frame in the indicated resource unit SIFS after the Trigger frame. The BlockAck frames acknowledge the HE STA's reception status of the block of group addressed frames requested by the MU-BAR frame.

Insert the following sentences and a picture at the end of 5th paragraph of section 10.24.10.3:

Figure 10-9 (Example of a frame exchange with GCR block ack retransmission policy) shows another example of a frame exchange when the GCR block ack retransmission policy is used. The HE AP sends several A-MSDUs using the GCR block ack retransmission policy. The HE AP then sends a MU-BAR to group member 1 and 2 of the GCR group, waits for the BlockAck frames, and then sends a MU-BAR to group member 3. After receiving the BlockAck frame from GCR group member 3, the HE AP determines whether any A-MSDUs need to be retransmitted and sends additional A-MSDUs (some of which might be retransmissions of previous A-MSDUs) using the GCR block ack retransmission policy.

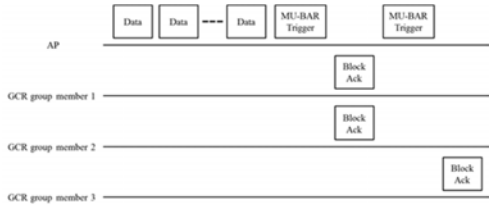


Figure 10-9 - Example of a frame exchange with GCR block ack retransmission policy

Change the following sentences in 6th paragraph of section 10.24.10.3:

After completing the BlockAckReq and BlockAck frame exchanges or the MU-BAR and BlockAck frame exchanges, the originator determines from the information provided in the BlockAck bitmap and from the missing BlockAck frames which, if any, A-MSDUs need to be retransmitted.

Change the following sentences in 7th paragraph of section 10.24.10.3

An originator adopting the GCR block ack retransmission policy for a GCR group address chooses a lifetime limit for the group address. The originator may vary the lifetime limit for the group address at any time and may use different lifetime limits for different GCR group addresses. The originator transmits and retries each A-MSDU until the appropriate lifetime limit is reached or until each one has been received by all group members to which a BlockAckReq frame or an MU-BAR frame has been sent, whichever occurs first.

Insert the following sentences at the end of 8th paragraph of section 10.24.10.3

An originator may also regularly send an MU-BAR frame with User identifier field set to AIDs of HE STAs that transmit the BlockAck frames and the Block Ack Starting Sequence Control subfield set to the Sequence Number field of the earliest A-MSDU of the GCR stream that has not been acknowledged by all group members and has not expired due to lifetime limits, in order to minimize buffering latency at receivers in the GCR group.

Change the following in 12th paragraph of section 10.24.10.3

If the beginning of such reception does not occur during the first slot time following a SIFS in case of a BlockAckReq frame or a [TBD IFS] in case of an MU-BAR, then the originator may perform error recovery

by retransmitting a BlockAckReq frame or an MU-BAR PIFS after the previous BlockAckReq frame or an MU-BAR frame when both of the following conditions are met:

— The carrier sense mechanism (see 10.3.2.1 (CS mechanism)) indicates that the medium is idle at the TxPIFS slot boundary (defined in 10.3.7 (DCF timing relations)) after the expected start of a BlockAck frame, and

— The remaining duration of the GCR TXOP is longer than the total time required to retransmit the GCR BlockAckReq frame or an MU-BAR frame plus one slot time.

10.44 Target wake time (TWT)

10.44.1 TWT overview

Change the 2nd paragraph of 9.44.1 as follows:

A TWT requesting STA communicates wake scheduling information to its TWT responding STA and the TWT responding STA devises a schedule and delivers TWT values to the TWT requesting STA when a TWT agreement has been established between them as described in 10.44.2 (Individual TWT agreements). When explicit TWT is employed, a TWT requesting STA wakes and performs a frame exchange and receives the next TWT information in a response from the TWT responding STA as described in 10.44.2.2 (Explicit TWT operation). When implicit TWT is used, the TWT requesting STA calculates the Next TWT by adding a fixed value to the current TWT value as described in 10.44.3 (Implicit TWT operation). An HE AP can additionally devise schedules and deliver TWT values to HE non-AP STAs without requiring that an individual TWT agreement has been established between them, as described in 10.44.4 (Broadcast TWT operation).

Insert a subclause heading after the 2nd paragraph of 10.44.1 (rest of dependent subclauses become dependent of this new subclause):

10.44.2 Individual TWT agreements

Change the 2 paragraphs (4th, 5th) of 9.44.1 as follows:

A STA with dot11TWTOptionActivated equal to true and that operates in the role of TWT requesting STA shall set the TWT Requester Support subfield to 1 in all S1G Capabilities or HE Capabilities elements that it transmits. A STA with dot11TWTOptionActivated equal to true and that operates in the role of TWT responding STA shall set the TWT Responder Support subfield to 1 in all S1G Capabilities or HE Capabilities elements that it transmits.

If the TWT Responder Support subfield of the S1G Capabilities or of the HE Capabilities element received from its associated AP is equal to 1, a non-AP STA with dot11TWTOptionActivated equal to true may transmit a TWT element to the AP with a value of Request TWT, Suggest TWT or Demand TWT in the TWT Command field and with the TWT Request field equal to 1.

Insert a new paragraph after the 9th paragraph as follows:

A STA that transmits a frame carrying a TWT element to an HE STA may set the Trigger subfield of the element to 1. Otherwise, the STA shall set the Trigger subfield to 0. In a TWT response, a Trigger field equal to 1 indicates a trigger-enabled TWT. The TWT responding STA of a trigger-enabled TWT agreement shall schedule for transmission a Trigger frame to the TWT requesting STA, as described in **Error! Reference source not found.** (UL MU operation), within each TWT SP for that TWT agreement. The TWT responding STA that intends to transmit additional Trigger frames during a trigger-enabled TWT SP shall set the Cascade Indicaion field of the Trigger frame to 1 to indicate that it will transmit another Trigger frame within the same TWT SP. Otherwise, it shall set the Cascade Indicaion field to 0.

Insert a sentence at the end of the 10th paragraph of 10.44.1 as follows:

An HE STA that transmits a TWT element to another HE STA shall set the Implicit subfield of the element to 1 and the NDP Paging Indicator subfield of the element to 0.

Insert a sentence at the end of the 12th paragraph of 10.44.1 as follows:

A TWT requesting STA transmits a frame during a trigger-enabled TWT SP in response to a Trigger frame (see 25.5.2 (UL MU operation)).

Change the last 2 paragraphs of 10.44.1 as follows:

The Flow Type field in the TWT response that successfully set up a TWT agreement indicates the type of interaction between the TWT requesting STA and the TWT responding STA within each TWT SP for that TWT agreement. Flow Type field equal to 0 indicates an announced TWT. The TWT responding STA of an announced TWT agreement shall not transmit a frame, except for a Trigger frame within a trigger-enabled TWT SP, to the TWT requesting STA within a TWT SP until it has successfully received a PS-Poll frame or APSD trigger frame (see 10.2.2.5 (Power management with APSD)) from the TWT requesting STA. Flow Type field equal to 1 indicates an unannounced TWT. The TWT responding STA of an unannounced TWT agreement may transmit a frame to the TWT requesting STA within a TWT SP before it has successfully received a frame from the TWT requesting STA.

An S1G TWT requesting STA indicates which single channel it desires to use as a temporary primary channel during a TWT SP by setting a single bit to 1 within the TWT Channel field of the TWT element, according to the mapping described for that field. An S1G TWT responding STA indicates which single channel the TWT requesting STA is permitted to use as a temporary primary channel during a TWT SP by setting a single bit to 1 within the TWT Channel field of the TWT element, according to the mapping described for that field. During a TWT SP, access to a channel which is not the primary channel of the BSS shall be performed according to the procedure described in 9.49 (Subchannel Selective Transmission (SST)). An HE STA indicates *TBD*.

10.44.3 Implicit TWT operation

Change the 3rd paragraph of 9.44.4 of as follows:

A TWT requesting STA awake for an implicit TWT SP may transition to the doze state after AdjustedMinimumTWTWakeDuration time has elapsed from the TWT SP start time as identified by the TWT requesting STA. A TWT requesting STA awake for a trigger-enabled TWT SP may transition to the doze state if it receives a Trigger frame from the TWT responding STA with a Cascade Indicaion field equal to 0 that is not intended to it.

Insert a sentence at the end of the 4rd paragraph of 10.44.4 as follows:

An HE STA shall not generate BAT, TACK, or STACK frames.

Insert a new subclause, and dependent subclauses, at the end of 10.44 as follows:

10.44.4 Broadcast TWT operation

10.44.4.1 General

A TWT scheduling STA is an HE AP with dot11TWTOptionActivated equal to true that includes a TWT element in the Beacon frame, and follows the rules described in 9.44.3.2 (Rules for TWT scheduling STA).

A TWT scheduled STA is an HE non-AP STA that:

- TBD: Declares support of being a TWT scheduled STA
- Receives a broadcast TWT element transmitted by an HE AP that is a TWT scheduling STA and,
- Has not negotiated any implicit TWT agreement with the HE AP as described in 10.44.2 (Individual TWT agreements).

A TWT scheduled STA follows the schedule provided by the TWT scheduling STA as described in **Error! Reference source not found.** (Rules for TWT scheduled STA). A TWT scheduled STA can negotiate the TBTT and listen interval for Beacon frames it intends to receive as described in 10.44.4.3 (Negotiation of TBTT and listen interval).

An example of broadcast TWT operation is shown in Figure 10-10 (Example of broadcast TWT operation), where the AP is the TWT scheduling STA and STA 1 and STA 2 are the TWT scheduled STAs.

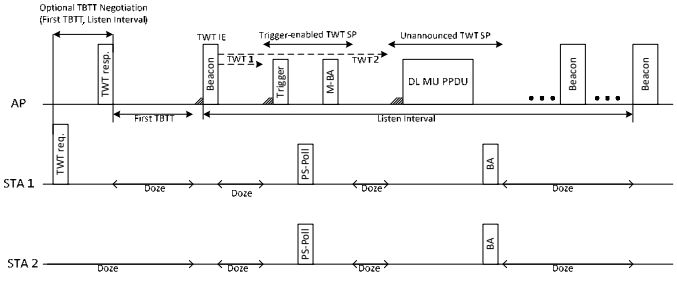


Figure 10-10 - Example of broadcast TWT operation

10.44.4.2 Rules for TWT scheduling STA

A TWT scheduling STA may include a TWT element in a Beacon frame scheduled at a TBTT (see 10.1.3.2 (Beacon generation in non-DMG infrastructure networks)). The TWT scheduling STA shall include one or more TWT parameter sets in the TWT element, and each TWT parameter set may indicate a periodic occurrence of TWTs. Each TWT parameter set specifies the TWT parameters of a broadcast TWT that are valid within a broadcast TWT SP.

The TWT scheduling STA sets the TWT parameters of each set as described below:

- The TWT scheduling STA shall set the Trigger field to 1 to indicate a trigger-enabled TWT. Otherwise, it shall set the Trigger field to 0. The TWT scheduling STA shall schedule for transmission a Trigger frame intended to one or more TWT scheduled STAs during a trigger-enabled TWT SP. The TWT scheduling STA that intends to transmit additional Trigger frames during a trigger-enabled TWT SP shall set the Cascade Indicaion field of the Trigger frame to 1 to indicate that it will transmit another Trigger frame within the same TWT SP. Otherwise, it shall set the Cascade Indicaion field to 0.
- The TWT scheduling STA shall set the TWT Flow Identifier field according to Table 8.248n1 (TWT Flow Identifier field for a broadcast TWT element). The TWT scheduling STA should only send frames that satisfy the TWT flow identifier recommendations listed in Table 8.248n1 (TWT Flow Identifier field for a broadcast TWT element) during the TWT SP(s).
- The TWT scheduling STA shall set the TWT field to the TSF[TBD X: TBD Y] time at which the first TWT is scheduled.
- The TWT scheduling STA shall include the value of the TWT wake interval in the TWT Wake Interval Exponent and TWT Wake Interval Mantissa fields for a periodic TWT. The TWT parameters are valid for each successive TWT of the periodic TWT.
- TBD

10.44.4.3 Negotiation of TBTT and listen interval

A TWT scheduled STA that intends to operate in power save mode (see 10.2.2.2 (STA Power Management modes)) may transmit a TWT request frame to the TWT scheduling STA that identifies the TBTT of the next Beacon frame the STA intends to receive and the interval between subsequent Beacon frames it intends to receive. The TWT request frame shall contain:

- The value of the requested first TBTT in the Target Wake Time field when the TWT Command field is Suggest TWT or Demand TWT.
- The value of the listen interval between consecutive TBTTs in the TWT Wake Interval Mantissa and TWT Wake Interval Exponent fields.

A TWT scheduling STA that receives a TWT request frame from a STA whose value of the TWT wake interval is equal to the STA's listen interval shall respond with a TWT response frame that contains either Accept TWT or Reject TWT in the TWT Command field and, in the case of an Accept TWT, it shall also contain:

- The value of the allocated first TBTT in the Target Wake Time field, and
- The value of the listen interval between consecutive TBTTs in the TWT Wake Interval Mantissa and TWT Wake Interval Exponent fields.

After successfully completing the negotiation, the TWT scheduled STA may go to doze state until its TSF matches the next negotiated TBTT provided that the STA is in power save mode, and no other condition requires the STA to remain awake. The TWT scheduled STA shall be in the awake state to listen to Beacon frames transmitted at negotiated TBTTs and shall operate as described in in **Error! Reference source not found.** (Rules for TWT scheduled STA).

Either STA can tear down an established negotiation following the tear down procedure described in 10.44.8 (TWT Teardown).

25High Efficiency (HE) MAC specification

25.1 Introduction

25.2 Channel access

25.2.1 Updating two NAVs

Mandatory or optional support of two NAVs is TBD.

For the two NAVs maintained by a HE STA, one is identified as Intra-BSS NAV, and the second one is identified as regular NAV.

A STA that receives at least one valid frame in a PSDU and identifies the frame as Intra-BSS can update its Intra-BSS NAV with the information from any valid Duration field in the PSDU.

A STA that receives at least one valid frame in a PSDU and identifies the frame as Inter-BSS can update its regular NAV with the information from any valid Duration field in the PSDU.

A STA that receives at least one valid frame in a PSDU and cannot identify the frame as Intra-BSS or Inter-BSS can update its regular NAV with the information from any valid Duration field in the PSDU.

A STA that receives a valid HE-SIG-A in a HE PPDU and identifies the HE-SIG-A as Intra-BSS can update its Intra-BSS NAV with the information from the TXOP Duration field in the HE-SIG-A.

A STA that receives a valid HE-SIG-A in a HE PPDU and identifies the HE-SIG-A as Inter-BSS can update its regular NAV with the information from the TXOP Duration field in the HE-SIG-A.

When the received frame's RA is equal to the STA's own MAC address, the STA shall not update its Intra-BSS NAV or regular NAV with the information from the Duration field.

When a STA receives both a valid HE-SIG-A in a HE PPDU and a valid frame in the PSDU of the HE PPDU, the STA shall not update its Intra-BSS NAV or regular NAV with the information from the TXOP Duration field in the HE-SIG-A.

For all other received frames that are identified by the STA as Intra-BSS, the STA shall update its Intra-BSS NAV when the received value of the Duration field is greater than the STA's current Intra-BSS NAV value.

For all other received frames that are identified by the STA as Inter-BSS or cannot be identified as Intra-BSS or Inter-BSS, the STA shall update its regular NAV when the received value of the Duration field is greater than the STA's current regular NAV value.

For all other received HE-SIG-As that are identified by the STA as Intra-BSS, the STA shall update its Intra-BSS NAV when the received value of the TXOP Duration field is greater than the STA's current Intra-BSS NAV value.

For all other received HE-SIG-As that are identified by the STA as Inter-BSS, the STA shall update its Inter-BSS NAV when the received value of the TXOP Duration field is greater than the STA's current regular NAV value.

25.3 Fragmentation

25.3.1 General

An HE STA can dynamically fragment individually addressed MSDUs or MMPDUs and defragment received MPDUs as defined in this subclause, and using the fragmentation/defragmentation processes defined in 10.2.7 (Fragmentation/defragmentation overview) without being subject to the rules defined in that subclause.

25.3.2 Procedure at the originator

A dynamic fragment is an MPDU, the payload of which carries a portion of an MSDU or MMPDU, which generation follows the rules defined in 9.5 (Fragmentation), except for:

- Reception of dynamic fragments is not mandatory. An HE STA declares its capability of receiving dynamic fragments by setting the HE Fragmentation Support field of the HE Capabilities element it transmits to a nonzero value as described below.
- The length of each fragment is not required to be equal for all fragments. The length of each fragment may be of any nonzero value. Other conditions may be TBD.

An HE STA may transmit to a receiver STA an individually addressed (A)-MPDU that contains:

- One dynamic fragment of an MSDU or MMPDU in a VHT single MPDU if the receiver STA has indicated a nonzero value in the HE Fragmentation Support field of its HE Capabilities element
    - The originator STA shall follow the rules defined in 9.13.8 (Transport of VHT single MPDUs) for generating the VHT single MPDU
- Up to one dynamic fragment for each MSDU in an A-MPDU if the receiver STA has indicated a value of 2 in the HE Fragmentation Support field of its HE Capabilities element
    - The originator STA shall follow the rules defined in in 9.24.7 (HT-immediate block ack extensions) for generating the A-MPDU
- Up to four dynamic fragments for each MSDU in an A-MPDU if the receiver STA has indicated a value of 3 in the HE Fragmentation Support field of its HE Capabilities element
    - The originator STA shall set the Fragment Number subfield of each MPDU to a value less than 4
    - The originator STA shall follow the rules defined in 10.24.7 (HT-immediate block ack extensions) for generating the A-MPDU with the following exceptions:

- The A-MPDU should contain MPDUs whose range of the Sequence Number subfields does not exceed 16. Other conditions may be TBD.

An HE STA shall not transmit a PSDU that contains dynamic fragments of an MSDU or MMPDU whose number is greater than the maximum number of fragments or that are carried in an A-MPDU format that is not supported by the receiver STA, as determined by the value of the HE Fragmentation Support field of the HE Capabilities element sent by the receiver STA.

25.3.3 Procedure at the receiver

An HE STA that transmits an HE Capabilities element with a nonzero value in the HE Fragmentation Support subfield shall set dot11DynamicFragmentation to true. Otherwise, the HE STA may set dot11DynamicFragmentation to false.

Defragmentation of dynamic fragments shall follow the rules defined in 10.6 (Defragmentation), except for:

— The receiver STA may support the concurrent reception of dynamic fragments of TBD number of MSDUs/MMPDUs under TBD conditions

NOTE— The receiver STA is still subject to the Receive Timer rules for each fo the MSDUs/MMPDUs as defined in 9.6 (Defragmentation).

Upon reception of a PSDU that carries one or more dynamic fragments, the receiver STA responds with:

— An Ack frame when the received fragment is contained in a VHT single MPDU that solicits the immediate response

  - The receiver STA shall follow the rules defined in 10.3.2.9 (Ack procedure) for generating the Ack frame

— A BlockAck frame when the received fragments, up to one fragment for each MSDU, are contained in the A-MPDU that solicits the immediate response and is sent by an HE STA whose HE Fragmentation Support subfield in its HE Capabilities element is 2

  - The receiver STA shall follow the rules defined in 10.24.7 (HT-immediate block ack extensions) for generating the BlockAck frame, except that the STA shall:
    - Set to 1 each bit of the Block Ack Bitmap field that corresponds to a Sequence Number subfield of a successfully received fragment contained in the soliciting A-MPDU
    - Update the corresponding block acknowledgement record when an MSDU that is received in fragments is successfully reconstructed (see 10.6 (Defragmentation)).

— A BlockAck frame when the received fragments, one or more fragments for each MSDU, are contained in an A-MPDU that solicits the immediate response and is sent by an HE STA whose HE Fragmentation Support subfield in its HE Capabilities element is 3

  - The receiver STA shall follow the rules in 10.24.7.5 (Generation and transmission of BlockAck frames by an HT STA or DMG STA) for generating the BlockAck frame, except that the STA shall:
    - Set to 1 the Fragment Number subfield in the Block Ack Starting Sequence Control subfield of the BlockAck frame
    - Set to 1 each bit in location *B* of the Block Ack Bitmap field that corresponds to a successfully received fragment and shall set it to 0 otherwise, with *B* calculated as:
      $B = SC - SSN$, where *SC* and *SSN* are treated as 14-bit unsigned integers
      SC is the value of the Sequence Control subfield of an MPDU containing the fragment for which the receive status is indicated

SSN is the value of the Starting Sequence Number subfield of the Block Ack Starting Sequence Control subfield of the BlockAck frame

- Update the corresponding block acknowledgement record when an MSDU that is received in fragments is successfully reconstructed (see 9.6 (Defragmentation)).

25.4 Block acknowledgement

25.4.1 Selection of BlockAck and BlockAckReq variants

An HE STA may send a Multi-STA BlockAck frame in response to an HE trigger-based PPDU. A Multi-STA BlockAck frame contains one or more BA Information fields with one or more AIDs and one or more different TIDs. A Multi-STA BlockAck frame with BA Information for multiple AIDs shall have RA field set to the broadcast address.

An HE STA that supports Multi-STA BA shall examine each received Mulit-STA sent by an STA with which it has a BA agreement. On receiving such a Multi-STA BlockAck frame a STA performs the following for each BA Information field with its AID:

— If the ACK type field is 1 then the BA Start Sequence Control, TID and BA Bitmap of the BA information field are processed according the procedure given in 10.24.7.

— If the ACK type field is 0, the field indicates an ACK of either a single MPDU or all MPDUs carried in the eliciting PPDU that was transmitted by the STA.

25.5 MU operation

25.5.1 HE DL MU operation

25.5.1.1 General

HE DL MU operation allows an AP to transmit simultaneously to one or more non-AP STAs in DL OFDMA, DL MU-MIMO or both.

An AP shall not transmit to a STA an HE MU PPDU with the HE-SIG-B allocating more than one RUs (see 25.3.9.8.3), unless the STA set the DL OFDMA Capable subfield of the HE Capabilities element to 1.

An AP shall not transmit to a STA a HE MU PPDU with the HE-SIG-B allocating spatial streams to more than one recipient STA, unless the STA set the DL MU MIMO Capable subfield of the HE Capabilities element to 1.

The transmission for all the STAs in an HE MU PPDU in either DL OFDMA or DL MU MIMO shall end at the same time, indicated by the L-SIG field as described in 26.3.9.5.

The padding procedure for each A-MPDU in an HE MU PPDU is the same as for an A-MPDU in a VHT PPDU and defined in 10.13.6 (A-MPDU padding for VHT PPDU).

25.5.1.2 HE MU PPDU payload

The content of each individual A-MPDU in an HE MU PPDU is based on the rules specified in 10.13.1 (A-MPDU contents).

The frame type and address type (unicast, groupcast) of MPDUs may be different across A-MPDUs within a same HE MU PPPDU.

A groupcast frame in a groupcast RU of an HE MU PPDU shall not include information intended for a STA that is identified as the recipient of another RU in the same HE MU PPDU.

25.5.2 UL MU operation

25.5.2.1 General

The UL MU operation allows an AP to solicit immediate simultaneous response frames from one or more non-AP STAs. Non-AP STAs transmit their response frames in HE trigger-based PPDU format, in either UL MU OFDMA UL MU-MIMO, or both.

An HE STA with dot11ULMUOFDMAOptionImplemented set to true shall set the UL MU OFDMA Capable subfield of the HE Calabilities element it transmits to 1; otherwise, the STA shall set it to 0.

An HE STA with dot11ULMUMIMOOptionImplemented set to true shall set the UL MU MIMO Capable subfield of the HE Calabilities element it transmits to 1; otherwise, the STA shall set it to 0.

A non-AP STA with dot11ULMUOFDMAOptionImplemented or dot11ULMUMIMOOptionImplemented equal to true is referred to as an UL MU capable STA.

25.5.2.2 Rules for soliciting UL MU frames

25.5.2.2.1 General

An AP shall not send to a STA a frame soliciting the transmission of a PPDU with the TXVECTOR parameter FORMAT set to HE_TRIG, unless the STA is UL MU Capable.

An AP may transmit a PPDU that elicits elicits an HE trigger-based PPDU from one or more UL MU capable STAs by including in the PPDU at least one of:

- A Trigger frame that includes one or more per-User Info field addressed to the recipient STA(s).
  - For recipient STAs that are associated with the AP, the per-User Info field is addressed to a recipient STA if the value of the AID subfield of the Per-User Info field is equal to the AID of the STA.
  - For recipient STAs that are not associated with the AP, TBD
- An “Trigger Information TBD contained in the MAC Header” of individually addressed MPDUs contained in the PPDU

The following two frames shall not be present at the same time in an A-MPDU

- A Trigger frame with a per-User Info field addressed to a STA
- an MPDU addressed to the same STA that includes “Trigger Information Field info in MAC header TBD”

If a Trigger frame is aggregsated with other frames in an A-MPDU, the Trigger frame shall be the first frame in the A-MPDU.

25.5.2.2.2 Allowed settings of the Trigger frame fields

If dot11MultiBSSIDActivated is true and at least two of the Trigger frame recipient STAs are associated with two different BSSIDs, then the TA shall be set to a common address TBD; in all other cases the TA shall be set to the BSSID of the AP to which all recipient STAs are associated.

An AP shall not set any subfields of the Commin Info field to a value that is not supported by all the recipient STAs of the Trigger frame.

An AP shall not set any subfields of a Per User Info field to a value that is not supported by the recipient STAs of the Per User Info field.

If a Trigger frame is transmitted in a broadcast RU of a HE MU PPDU, then the Trigger frame shall not include any Per User Info fields addressed to a STA that is identified as recipient of another RU or spatial stream of the same HE MU PPDU.

25.5.2.2.3 AP access procedures for UL MU operation

An UL OFDMA MPDU/A-MPDU is the acknowledgement of the Trigger frame. When the AP receives MPDU correctly from at least one STA indicated by trigger frame, the frame exchange initiated by the trigger frame is successful.

25.5.2.3 STA behavior

A STA shall not transmit an HE trigger-based PPDU unless is it explicitly enabled by an AP in one of the operation modes described in this section.

The inter frame space between a PPDU that contains a Trigger frame and the triggered HE trigger-based PPDU is SIFS.

A STA shall commence the transmission of an HE trigger-based PPDU at the SIFS time boundary after the end of a received PPDU, when all the following conditions are met

— The received PPDU contains a Trigger Frame with a Per User Info field addressed to the STA, or the PPDU contains an MPDU addressed to the STA which carries a "Trigger Information Field info in MAC header TBD". The Per User Info field is addressed to a STA if the AID subfield is equal to the AID of the STA, if the STA is associated with the AP. If the STA is not associated with the AP, TBD.

— The UL MU CS Condition described in 25.5.2.4 (UL MU CS mechanism) indicates the medium is idle, or the CS Required subfield in a Trigger frame is 0.

A STA transmitting an HE trigger-based PPDU shall set the TXVECTOR parameter as follows:

— The L_LENGTH parameter shall be set to the value indicated by the L-SIG Length field of the eliciting Trigger frame or of the "Trigger Information Field info in MAC header TBD".

— The CP_LTF_TYPE parameter shall be set to the value indicated by the CP-LTF subfield of the Common Info field of the eliciting Trigger frame

— The SIG-A_CONT parameter shall be set to the value indicated by the SIG-A subfield of the Common Info field of the eliciting Trigger frame [TBD, depending on how the TXVECTOR is defined we may spell out all the subfields of SIG-A]

— The DCM parameter shall be set to the value indicated by the DCM subfield of the per-User Info field of the eliciting Trigger frame

— The CODING_TYPE parameter shall be set to the value indicated by the Coding Type subfield of the Per User Info field of the eliciting Trigger frame

— The RU parameter shall be set to the value indicated by the RU Allocation field of the trigger frame

— The NSTS parameter shall be set to TBD

The MAC padding procedure is descried in 10.42.2.1.2

The content of each individual A-MPDU in an HE MU PPDU is based on the rules specified in 9.13.1 (A-MPDU contents) and the additional rules described in this clause.

If the Trigger Type value of a Trigger frame is not equal to 0, the STA shall include in the reponse A-MPDU at least one MPDU of the required type. If the STA does not have a frame of the required type, the STA should transmit QoS Null frame.

NOTE--The frame type of MPDUs may be different across A-MPDUs within a same HE trigger-based PPPDU

25.5.2.4 UL MU CS mechanism

The ED-based CCA and virtual CS functions are used to determine the state of the medium if CS is required before responding to a received Trigger frame. ED-based CCA is described in and virtual CS is defined in 10.3.2.1 (CS mechanism).

When two NAVs are supported by a STA, if one or both of the NAVs are considered and the considered NAV's counter is nonzero, then the virtual CS indicates busy. Otherwise, the virtual CS is idle.

When only one NAV is supported by a STA, if the NAV is considered and the NAV counter is nonzero, then virtual CS is busy. Otherwise, the virtual CS is idle.

Note that the previous sentence is only needed if support for two NAVs is optional. Mandatory or optional support for two NAVs is still TBD.

A NAV is considered in virtual CS for a STA that is polled from a Trigger frame for UL MU transmission unless one of the following conditions is met:

- The NAV was set by a frame originating from the AP sending the Trigger frame
- The response generated by the STA contains an Ack frame or a BlockAck frame and the duration of the HE trigger-based PPDU is less than a TBD value
- The NAV was set by a frame originating from an intra-BSS STA
- The CS Required subfield in the Trigger frame is 0
- Other condition TBD

If the CS Required subfield in a Trigger frame is set to 1, the STA shall consider the status of the CCA (using Energy Detect) and the virtual carrier sense (NAV) before UL MU transmission in response to the Trigger Frame. In this case, the STA shall sense the medium using energy-detect (ED) after receiving the PPDU that contains the Trigger frame (i.e. during the SIFS time), and it shall perform the energy-detect (ED) at least in the subchannel that contains the STA's UL allocation, where the sensed subchannel consists of either a single 20 MHz channel or multiple of 20 MHz channels. The STA may transmit an HE trigger-based PPDU when the 20 MHz channels containing the allocated UL RUs in the Trigger frame are considered idle; if the STA detects that the 20 MHz channels containing the allocated UL RUs are not all idle, then the STA shall not transmit anything in the allocated UL RUs.

If the CS Required subfield in a Trigger frame is set to 0, the STA may transmit an HE trigger-based PPDU without the carrier sense.

The AP shall set the CS Required subfield to 1 except under the following conditions:

- All HE trigger-based PPDU(s) solicited by the Trigger frame containing ACK/BA and the length of the HE trigger-based PPDU is below a TBD threshold.
- Other conditions are TBD.

25.5.2.5 HE buffer status feedback operation for UL MU

The buffer status report from HE STAs may be utilized to support the efficient UL MU operation. An AP may poll HE STAs for buffer status reports using the frame carrying the trigger information. The frame may be a broadcast Trigger frame, a unicast Trigger frame, a Trigger frame for random access, or a Data type of frame carrying the trigger information. An AP may request an HE STA to send its buffer status information by TBD indication in the Trigger frame or in the HE A-Control field in a Data type of frame. In this case, an AP may indicate TBD granularity of the Queue Size for an HE STA to report (signalling method TBD). Upon reception of the frame including the TBD indication in the Trigger frame or in the HE A-Control field, the HE STA may respond with the frame including the Queue Size subfield in a QoS Control field or TBD HE A-Control field. To report the buffer status for a given TID, an HE STA shall set the Queue Size subfield in a QoS Data or a QoS Null frame to the amount of queued traffic present in the output queue belonging to the TID.

25.5.2.6 UL OFDMA-based random access

UL OFDMA-based distributed random access is a random access mechanism for HE STAs that randomly select resource units (RUs) assigned by an AP for transmission of UL PPDUs. The HE AP indicates a TBD

parameter in the Trigger frame for HE STAs to initiate random access following the Trigger frame transmission.

25.5.2.6.1 Random access procedure

In this sub-section, the random access procedure is described with respect to UL OFDMA contention parameters. The procedure is also illustrated in Figure 25-1. An HE STA that uses the random access procedure maintains an internal counter termed as OBO counter. The OFDMA contention window (OCW) is an integer with an initial value of OCWmin. Other parameters for random access are TBD.

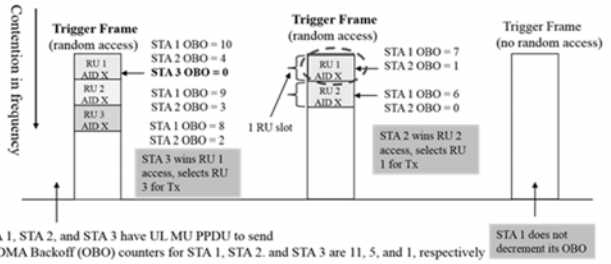


Figure 25-1 - Illustration of the UL OFDMA-based random access procedure

An HE AP indicates the value of OCWmin for the random access operation. The method of indication of the OCWmin value is TBD.

The random access procedure initiates with an HE STA receiving a Trigger frame for random access.

For an initial UL PPDU transmission, when an HE STA obtains the value of OCWmin from the HE AP, it shall set the value of OCW to the OCWmin and shall initialize its OBO counter to a random value in the range of 0 and OCWmin.

If the OBO counter for an HE STA is smaller than the number of RUs assigned to AID value TBD in a Trigger frame, then the HE STA shall decrement its OBO counter to zero. Otherwise, the HE STA decrements its OBO counter by a value equal to the number of RUs assigned to AID value TBD in a Trigger frame. For instance, as shown in Figure 25-1, HE STA 1 and HE STA 2 decrement their non-zero OBO counters by 1 in every RU assigned to AID value TBD for random access within the Trigger frame.

If the OBO counter for an HE STA is a zero value or if the OBO counter decrements to 0, it randomly selects any one of the assigned RUs for random access and transmits its UL PPDU in the selected RU. Otherwise, the STA resumes with its OBO counter in the next Trigger frame for random access.

25.5.3 HE MU cascading operation

A TXOP can include both DL MU and UL MU transmissions.

A HE AP can initiate a cascading sequence of MU PPDUs in a TXOP, allowing alternating HE MU PPDUs and HE trigger-based PPDUs starting with a DL MU PPDU in the same TXOP, as illustrated in Figure 25-2.

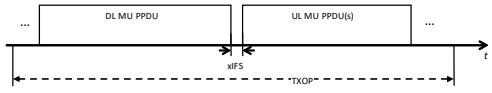


Figure 25-2 - An example of cascading sequence of MU PPDUs

The cascading sequence has only one DL transmitter. The cascading sequence may have different UL transmitters within each HE trigger-base PPDU. The cascading sequence may have a different set of transmitters in HE trigger-based PPDUs as compared to the DL HE MU PPDU that follows the HE trigger-based PPDUs within the same TXOP.

25.6 HE sounding protocol

The HE sounding protocol is initiated by an AP sending an NDP Announcement frame (TBD) followed by an HE NDP transmitted a SIFS after the end of the PPDU carrying the NDP Announcement (TBD).

An HE AP may use the Trigger frame to solicit HE beamforming feedback from a STA provided that the UL MU Capable field of the most recently received HE Capabilities element from that STA is 1 (see 25.5.2 (UL MU operation)).

An HE AP may solicit beamforming feedback from multiple STAs sequentially through SU transmission.

An example of the HE sounding protocol using MU operation to solicit feedback is shown in Figure 25-3.

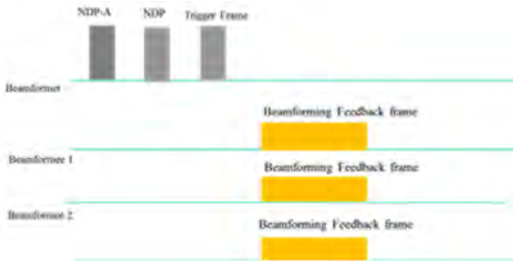


Figure 25-3 – An example of the HE sounding protocol using MU operation

25.7 TWT operation

25.8 Receive operating mode

25.8.1 General

An HE STA can change its operating mode setting either using the procedure described in 10.41 (Notificaion of operating mode changes), or the procedure describes in this subclause. Receive operating mode (ROM) indication is a procedure for a first HE STA to indicate the maximum operating channel width and the maximum number of spatial streams it can receive to a second HE STA.

When the first HE STA chooses to indicate its ROM setting, this can be signaled using the ROM subfield in the HE variant HT Control field sent in a frame of type Data. The ROM subfield is set to indicate that the first HE STA supports receiving frames with a bandwidth up to and including the value indicated by the Channel Width subfield and with a number of spatial streams up to and including the value indicated by the Rx NSS subfield (see [HE variant HT Control field]). The dot11ROMIOptionImplemented defines whether the HE AP implements the reception of the ROM setting and the AP transmits according to the ROM setting to the transmitter of the ROM setting. An HE AP shall set dot11ROMIOptionImplemented to true.

ROM indication allows an HE STA to adapt the maximum operating channel width or the maximum number of spatial streams it can receive. In doing so, an HE STA may save power by changing to a ROM setting that consumes less power, or by changing to a ROM setting that supports higher throughput operation. Unlike 11.41 (Notification of operating mode changes), ROM indication can be signaled in the MAC header of a Data frame as opposed to a management frame exchange. Hence, there is minimal impact on channel efficiency.

25.8.2 Rules for ROM indication

An HE STA may transmit an individually address frame of type Data that contains the ROM subfield to indicate that the transmitting HE STA supports receiving frames with a bandwidth up to and including the value indicated by the Channel Width subfield and with a number of spatial streams up to and including the value indicated by the Rx NSS subfield of the ROM subfield.

The transmitting HE STA shall support for receiving frames with a bandwidth up to and including the value indicated by the Channel Width subfield and with a number of spatial streams up to and including the value indicated by the Rx NSS subfield of the ROM subfield indicated in the eliciting frame immediately after receiving a successful acknowledgement from the responding HE STA.

If there is a change to the current maximum operating channel width or the maximum number of spatial streams, the transmitting HE shall adjust to the most recently sent ROM settings within a time TBD [Outage Time] following the receipt of an immediate acknowledgement response. The transmitting HE STA shall support receiving frames with a bandwidth up to and including the most recent value indicated by the Channel Width subfield and with a number of spatial streams up to and including the most recent value indicated by the Rx NSS subfield of the ROM subfield.

NOTE—In the event of transmission failures, the transmitting HE STA can attempt recovery procedure as defined in 9.19.2.4 (Multiple frame transmission in an EDCA TXOP), and can defer from changing to the new ROM settings indicated in the eliciting frame until a successful acknowledgement from the responding STA is received.

The responding HE STA shall use the value indicated by the Channel Width subfield most recently received from the transmitting HE STA as the current maximum operating channel width that the transmitting HE STA indicated as supported for receiving frames.

The responding HE STA shall use the value indicated by the Rx NSS subfield most recently received from the transmitting HE STA as the current maximum number of spatial streams that the transmitting HE STA indicated as supported for receiving frames.

The responding HE STA shall not transmit a subsequent PPDU to the transmitting HE STA that uses a bandwith or a number of spatial stream not indicated as currently supported by the transmitting HE STA.

If there is a change to the current maximum operating channel width or the maximum number of spatial stream that the transmistting STA is capable of receiving, the responding HE STA shall not sent any PPDU to the transmitting HE STA within a time TBD [Outage Time] following the transmission of an immediate acknowledgement response.

25.9 Spatial reuse operation

25.9.1 General

The objective of the HE spatial reuse operation is to improve the system level performance and the utilization of the spectrum resources in dense deployment scenarios by early identification of signals from overlapping basic service sets (OBSSs) and interference management.

25.9.2 Color code based CCA rules

An STA determines whether a detected frame is an inter-BSS or an intra-BSS frame by using BSS color or MAC address in the MAC header. The detected frame is intra-BSS frame if one of the following conditions is true:

— The BSS color in the detected PPDUis same as the BSS color announced by its associated AP,

— The RA or TA of the detected frame is same as the BSSID or its bandwidth signalling variant of its associated AP

— Its associated AP is identified by TBD Multiple BSSID element and the RA or TA of the detected frame is same as one of the BSSID or its bandwidth signalling variant defined by TBD Multiple BSSID element

If the detected frame is an inter-BSS frame, under TBD condition, uses TBD OBSS PD level that is greater than the minimum receives sensitivity level.

A STA should regard an inter-BSS PPDU with a valid PHY header and that has receiving power/RSSI below the OBSS PD level used by the receiving STA and that meets additional TBD conditions, as not having been received at all (e.g., should not update its NAV), except that the medium condition shall indicate BUSY during the period of time that is taken by the receiving STA to validate that the PPDU is from an inter-BSS, but not longer than the time indicated as the length of the PPDU payload.

A STA should revise the NAV depending on TBD conditions at the recipient of the ongoing OBSS frame.

25.9.3 Adaptive CCA and transmit power control

When the color code based CCA rule is used, as described in **Error! Reference source not found.**, an HE STA is allowed to adjust the OBSS_PD threshold in conjunction with transmit power control to improve the system level performance and the utilization of the spectrum resources.

To further improve the possibilities of spatial reuse, an STA is allowed to adjust the setting of one or more following parameters, CCA ED level, 802.11 signal detect CCA or TXPWR threshold values. The constraints on selecting threshold values are TBD.

25.10 A-MPDU operation

25.10.1 General

A-MPDU operation for an HE PPDU is as defined in 10.13 (A-MPDU operation), except for A-MPDU padding, which is defined in 25.10.2 and except for an A-MPDU that includes QoS Data frames from from two or more different TSs, the rules for which are defined in 25.10.3.

25.10.2 A-MPDU padding

The A-MPDU padding per each HE STA in an HE MU PPDU follows the same procedure as for VHT STA11ac procedure as defined in Section 10.13.6 (A-MPDU padding for VHT PPDU).

A non-AP STA that transmits an HE trigger-based PPDU shall construct the PSDU carried in the HE trigger-based PPDU as follows.

The STA computes the PSDU_LENGTH based on the TXVECTOR parameters.

The STA may add A-MPDU subframes to the A-MPDU contained in the PSDU provided that the following constraints are fullfilled:

— The A-MPDU content constraints (see 10.13.1 (A-MPDU contents)) for the intended recipient

— The Length limit constraints (see 9.7.1 (A-MPDU format) and 10.13.2 (A-MPDU length limit rules)) for the intended recipient

— The MPDU start spacing constraints (see 10.13.3 (Minimum MPDU Start Spacing field)) for the intended recipient

And provided that

— The A-MPDU subframes have a value greater than 0 in the MPDU Length field, or have a value 0 in the MPDU Length field and a value 0 in the EOF field.

— After incrementing the A-MPDU_Length with the length of each such added A-MPDU subframe, the relationship A-MPDU_Length ≤ PSDU_LENGTH is true.

Then, padding shall be added such that the resulting A-MPDU contains exactly PSDU_LENGTH octets as follows:

— First, while A-MPDU_Length < PSDU_LENGTH and A-MPDU_Length mod 4 != 0, add an octet to the final A-MPDU subframe's Padding subfield and increment A-MPDU_Length by 1.

— Then, while A-MPDU_Length + 4 < PSDU_LENGTH, add an EOF padding subframe to the EOF Padding Subframes field and increment A-MPDU_Length by 4.

— Finally, while A-MPDU_Length < PSDU_LENGTH, add an octet to the EOF Padding Octets subfield and increment A-MPDU_Length by 1.

The STA shall not add an A-MPDU subframe with EOF equal to 0 after any A-MPDU subframe with EOF set to 1. The STA shall not add an an A-MPDU subframe with EOF equal to 1 and with MPDU Length field equal to 0 before an A-MPDU subframe that contains a VHT single MPDU (see 10.13.7 (Setting the EOF field of the MPDU delimiter)).

25.10.3 A-MPDU with multiple TIDs

An HE STA with dot11AMPDUwithMultipleTIDOptionImplemented set to true shall set the A-MPDU with Multiple TIDs Capable subfield of the HE Calabilities element it transmits to 1; otherwise, the HE STA shall set it to 0.

An HE AP shall not send A-MPDU with multiple TIDs to an HE non-AP STA that associates with the AP, unless the HE non-AP STA is A-MPDU With Multiple TIDs capable.

An HE non-AP STA shall not send an A-MPDU with multiple TIDs to its associated HE AP, unless the HE AP is A-MPDU With Multiple TIDs capable.

In an HE MU PPDU, an HE STA may aggregate the frames in an A-MPDU with multiple TIDs as defined in Table 9-426a (Multiple TID A-MPDU contents in the data enabled immediate response context) or Table 9-426b (Multiple TID A-MPDU contents in the data enabled no immediate response context). An A-MPDU with multiple TIDs shall not be transmitted in an SU PPDU.

Multi-STA BlockAck frame shall be used to acknowledge the Multi-TID A-MPDU in MU PPDU. The value of TID field in Multi-STA BlockAck frame is TBD.

25.11 TXVECTOR parameters STA_ID_LIST, UPLINK_FLAG and BSS_COLOR for an HE PPDU

Each element of the TXVECTOR parameter STA_ID_LIST identifies the STA or group of STAs that is the recipient of an RU in the HE MU PPDU. If an RU is intended for a single STA, then the STA_ID_LIST element for that RU is set to the STA's AID. If an RU is intended for a group of STAs then the STA_ID_LIST element is set as follows:

— For a single BSS AP, if the RU is intended for all STAs in the BSS, the STA_ID_LIST element is set to 0;

— For a multiple BSS AP, if the RU is intended for all STAs in one of its BSSs, the STA_ID_LIST element is set to the group addressed AID assignment in the TIM according to the existing Multi-BSSID TIM operation;

— For a multiple BSS AP, if the RU is intended for all STAs on all its BSSs, the STA_ID_LIST element is set to 2047.

The Uplink Flag is carried in the TXVECTOR parameter UPLINK_FLAG of an HE SU PPDU, HE extended range SU PPDU, and HE MU PPDU and is set as follows:

— A STA transmitting an HE PPDU that is addressed to an AP shall set the TXVECTOR parameter UPLINK_FLAG to 1

— An AP transmitting an HE PPDU that is addressed to a non-AP STA shall set the TXVECTOR parameter UPLINK_FLAG to 0

— A STA transmitting an HE PPDU in a direct path to a (T)DLS peer STA, or to a member of an IBSS, shall set the TXVECTOR parameter UPLINK_FLAG to 0

NOTE—The (T) DLS peer STA or the member of an IBSS can identify that the HE PPDU is sent in a direct path from the To DS and From DS fields of the MAC header of its MPDU(s)

The TXVECTOR parameter UPLINK_FLAG is not present for HE trigger-based PPDUs.

The BSS Color is an identifier of the BSS and is used to assist a receiving STA in identifying the BSS from which a PPDU originates so that the STA can use the channel access rules as described in 9.X.Y (Spatial Reuse) or reduce power consumption as described in 25.13.1 (Intra-PPDU power save for HE non-AP STAs).

An HE AP shall select a value in the range 1 to TBD to include in the BSS Color subfield of the HE Operation elements that it transmits and shall maintain that single value of the BSS Color subfield for the duration of the existence of the BSS. An HE AP transmitting an HE PPDU shall set the TXVECTOR parameter BSS_COLOR to the value indicated in the BSS Color subfield of its HE Operation element.

A non-AP HE STA transmitting an HE PPDU shall set the TXVECTOR parameter BSS_COLOR to the value indicated in the BSS Color subfield of the HE Operation element received from the AP with which it is associated.

The virtual APs which are defined by TBD Multiple BSSID element shall select a same BSS Color.

25.12 HE PPDU post FEC padding and packet extension

An HE STA with dot11PPEThresholdsRequired set to false may set the PPE Thresholds Present subfield in HE Capabilities elements that it transmits to 0.

An HE STA with dot11PPEThresholdsRequired set to true shall set the PPE Thresholds Present subfield in HE Capabilities elements that it transmits to 1.

A STA that sets the PPE Thresholds Present subfield in HE Capabilities elements that it transmits to 1 shall indicate its minimum post-FEC padding and packet extension duration value per constellation, NSS and RU allocation by setting the subfields of the PPE Thresholds field according to 9.4.2.213 (HE Capabilities element) and using the corresponding values from dot11PPEThresholdsMappingTable.

A STA transmitting an HE PPDU to a receiving STA shall include a minimum post-FEC padding asetermined by the post-FEC padding a-factor (see 26.3.10 (Data field) and after including the post-FEC padding, the transmitting STA shall include a packet extension that yields a total post-FEC padding plus packet extension that corresponds to at least the value indicated in the HE Capabilities element received from the receiving STA.

25.13 Power management

25.13.1 Intra-PPDU power save for HE non-AP STAs

An HE non-AP STA that is in awake state (see 11.2.2.2 (STA Power Management modes)) and has dot11IntraPPDUPowerSaveOptionActivated equal to true operates in intra-PPDU power save mode.

An HE non-AP STA that is in intra-PPDU power save mode may enter the doze state until the end of a received PPDU when one of the following conditions is met:

— The PPDU is an HE MU PPDU with:

  o The value of the RXVECTOR parameter BSS_COLOR equal to the BSS color of the BSS with which the STA is associated and,

- The value of the RXVECTOR parameter UL_FLAG is equal to 0 and,
- The values obtained from the RXVECTOR parameter STA_ID_LIST do not match the identifier of the STA or the broadcast identifier(s) intended for the STA

— The PPDU is an HE MU PPDU, HE SU PPDU, or HE extended range SU PPDU with:

- The value of the RXVECTOR parameter BSS_COLOR equal to the BSS color of the BSS with which the STA is associated and,
- The value of the RXVECTOR parameter UL_FLAG is equal to 1

— The PPDU is an HE trigger-based PPDU with:

- The value of the RXVECTOR parameter BSS_COLOR equal to the BSS color of the BSS with which the STA is associated

An HE STA that is in intra-PPDU power save mode and has entered doze state shall continue to operate its NAV timer and consider the medium busy during doze state and shall transition into awake state at the end of the PPDU.

NOTE—The STA can contend for access to the medium immediately on the expiry of the NAV timer.

25.13.2 Power save with UL OFDMA-based random access

This section illustrates the power save mechanisms for HE STAs using random access procedure (see 25.5.2.6.1).

An HE AP may indicate values of one or multiple Trigger frame start time(s) for random access in the Beacon. The power save operation with the indication of one value of Trigger frame start time in a Beacon for random access is shown in Figure 25-4.

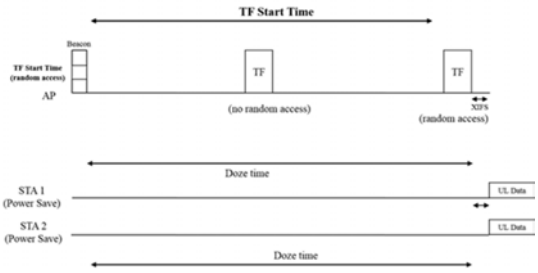


Figure 25-4 - Illustration of Trigger frame (TF) Start Time in Beacon frame for power save operation with random access operation

When an HE STA receives a Beacon with the value of Trigger frame start time for random access, it may enter the doze state till the expiration of the value indicated in the Beacon.

If random acces is enabled by a sequence of Trigger frames, then all the Trigger frames in the sequence shall have the Cascade Indication field set to 1, except for the last Trigger frame in the sequence that shall have the Cascade Indication field set to 0.

An HE STA may use the value indicated in the Cascade Indication field in a Trigger frame to enter the doze state. If the OBO counter decrements to a non-zero value with the random access procedure in a Trigger frame with Cascade Indication field set to 0, it may enter the doze state immediately. If the OBO counter decrements to a non-zero value with the random access procedure in a Trigger frame with Cascade Indication field set to 1, it may remain awake for random access in the cascaded Trigger frame.

26High Efficiency (HE) PHY specification

26.1 Introduction

26.1.1 Introduction to the HE PHY

Clause 26 specifies the PHY entity for a high efficiency (HE) orthogonal frequency division multiplexing (OFDM) system. In addition to the requirements in Clause 26, an HE STA shall be capable of transmitting and receiving PPDUs that are compliant with the mandatory PHY specifications defined in Clause 20 and Clause 22.

The HE PHY is based on the VHT PHY defined in Clause 22, which in turn is based on the HT PHY defined in Clause 20, which in turn is further based on the OFDM PHY defined in Clause 18. The HE PHY extends the maximum number of users supported for downlink multi-user MIMO (MU-MIMO) transmissions to eight and provides support for downlink and uplink orthogonal frequency divisional multiple access (OFDMA) as well as for uplink MU-MIMO. Both downlink and uplink MU-MIMO transmissions are supported on portions of the PPDU bandwidth (on resource units greater than or equal to 106 tones) and in an MU-MIMO resource unit, there is support for up to eight users with up to four space-time streams per user with the total number of space-time streams not exceeding eight.

NOTE—An HE SU PPDU includes individually addressed and group addressed transmissions.

The HE PHY provides support for 20 MHz, 40 MHz, 80 MHz and 160 MHz contiguous channel widths and support for 80+80 MHz non-contiguous channel width. Tones of one or more secondary channels in 80 MHz and 160 (80+80) MHz could be nulled when using OFDMA PPDU transmission. The modes of non-contiguous channel bonding are TBD. The non-contiguous channels within primary or secondary 80 MHz only exists at AP side.

The HE PHY provides support for 800 ns, 1600 ns, and 3200 ns guard interval durations.

The HE PHY provides support for 3.2 μs (1x LTF), 6.4 μs (2x LTF), and 12.8 μs (4x LTF) LTF symbol durations (symbol duration not including the guard interval).

The HE PHY data subcarriers are modulated using binary phase shift keying (BPSK), quadrature phase shift keying (QPSK), 16-quadrature amplitude modulation (16-QAM), 64-QAM, 256-QAM and 1024-QAM. Forward error correction (FEC) coding (convolutional or LDPC coding) is used with coding rates of 1/2, 2/3, 3/4 and 5/6.

An HE STA shall support the following Clause 26 features:

- Binary convolutional coding for RU sizes less than or equal to 242 tones (transmit and receive)
- LDPC as the only coding scheme for RU sizes of 484 tones, 996 tones (transmit and receive)
- LDPC when declaring support for at least one of HE 80/160/80+80 SU-PPDU bandwidths, or declaring support for more than 4 spatial streams (transmit and receive)
- A combination of 2x LTF with 0.8 μs GI duration on both LTF and data
- A combination of 2x LTF with 1.6 μs GI duration on both LTF and data
- A combination of 4x LTF with 3.2 μs GI duration on both LTF and data

An HE STA may support the following Clause 26 features:

- Other combinations of LTF durations and GI durations
- LDPC (transmit and receive) for RU sizes less than or equal to 242 tones
- LDPC (transmit and receive) when declaring support for less than or equal to 4 spatial streams
- Dual carrier modulation (transmit and receive)

NOTE--Once mandatory vs optional TBDs are decided, above text will have additions.

26.1.2 Scope

The services provided to the MAC by the HE PHY consist of the following protocol functions:

a) A function that defines a method of mapping the PSDUs into a framing format (PPDU) suitable for sending and receiving PSDUs between two or more STAs.

b) A function that defines the characteristics and method of transmitting and receiving data through a wireless medium between two or more STAs. Depending on the PPDU format, these STAs support a mixture of HE, Clause 22 (Very High Throughput (VHT) PHY specification), Clause 20 (High Throughput (HT) PHY specification) and Clause 18 (Orthogonal frequency division multiplexing (OFDM) PHY specification) PHYs.

26.1.3 HE PHY functions

26.1.3.1 General

The HE PHY contains two functional entities: the PHY function, and the physical layer management function (i.e., the PLME). Both of these functions are described in detail in 26.3 (HE PHY) and 26.4 (HE PLME). The HE PHY service is provided to the MAC through the PHY service primitives defined in Clause 7 (PHY service specification). The HE PHY service interface is described in 26.2 (HE PHY service interface).

26.1.3.2 PHY management entity (PLME)

The PLME performs management of the local PHY functions in conjunction with the MLME.

26.1.3.3 Service specification method

The models represented by figures and state diagrams are intended to be illustrations of the functions provided. It is important to distinguish between a model and a real implementation. The models are optimized for simplicity and clarity of presentation; the actual method of implementation is left to the discretion of the HE-PHY-compliant developer.

The service of a layer is the set of capabilities that it offers to a user in the next higher layer. Abstract services are specified here by describing the service primitives and parameters that characterize each service. This definition is independent of any particular implementation.

26.1.4 HE PPDU formats

The structure of the PPDU transmitted by an HE STA is determined by the TXVECTOR parameters as defined in Table 25-1 (TXVECTOR and RXVECTOR parameters).

The FORMAT parameter determines the overall structure of the PPDU:

— HE SU PPDU format (HE_SU) carries a single PSDU. With this format the HE-SIG-A field is not repeated. Support for the HE SU PPDU format is mandatory.

— HE MU PPDU format (HE_MU) carries one or more PSDUs to one or more users. It is similar to the SU format, except that an HE-SIG-B field is present. Support for the HE MU PPDU format is mandatory.

— HE extended range SU PPDU format (HE_EXT_SU) carries a single PSDU. It is similar to the SU format, except that the HE-SIG-A field is repeated. Support for the HE extended range SU PPDU format is TBD (mandatory or optional).

— HE trigger-based PPDU format (HE_TRIG) carries a single PSDU and is sent in response to a PPDU that carries a Trigger frame. The preamble format prior to the HE-STF field is identical to the HE SU PPDU. Support for the HE trigger-based PPDU format is TBD (mandatory or optional).

26.2 HE PHY service interace

26.2.1 Introduction

26.2.2 TXVECTOR and RXVECTOR parameters

The parameters in Table 26-1 (TXVECTOR and RXVECTOR parameters) are defined as part of the TXVECTOR parameter list in the PHY-TXSTART.request primitive and/or as part of the RXVECTOR parameter list in the PHY-RXSTART.indication primitive.

Table 26-1 - TXVECTOR and RXVECTOR parameters

Parameter	Condition	Value	TXVECTOR	RXVECTOR
FORMAT		Determines the format of the PPDU. Enumerated type: NON_HT indicates Clause 18 (Orthogonal frequency division multiplexing (OFDM) PHY specification) or non-HT duplicate PPDU format. In this case, the modulation is determined by the NON_HT_MODULATION parameter. HT_MF indicates HT-mixed format. HT_GF indicates HT-greenfield format. VHT indicates VHT format. HE_SU indicates HE SU PPDU format. HE_MU indicates HE MU PPDU format HE_EXT_SU indicates HE extended range SU PPDU format HE_TRIG indicates HE trigger-based PPDU format	Y	Y
PE_DURATION	FORMAT is HE_SU or HE_MU or HE_EXT_SU or HE_TRIG.	Determines the duration of PE field in an HE PPDU. Possible values are 0 μs, 4 μs, 8 μs, 12 μs and 16 μs.		
BEAM_CHANGE	FORMAT is HE_SU	Indicates beam change between pre-HE and HE modulated fields. 1 indicates that the beam is changed between the two portions. NOTE—BEAM_CHANGE shall be set to 1 if $N_{SS} > 2$ or the PPDU is the first PPDU in a TXOP.		
	Otherwise	Set to 1		

	(To be added)			
BSS_COLOR	FORMAT is HE_SU or HE_MU or HE_EXT_SU or HE_TRIG.	Set to a value of the AP's choosing within the range 0 to *TBD* (see 25.11 (STA ID, Uplink Flag and BSS Color in HE PPDUs)).	Y	Y
	Otherwise	Not present	N	N
UPLINK_FLAG	FORMAT is HE_SU or HE_MU or HE_EXT_SU	Set to 1 if the HE PPDU is addressed to an AP Set to 0 otherwise (see 25.11 (STA ID, Uplink Flag and BSS Color in HE PPDUs)).	Y	Y
	Otherwise	Not present	N	N
STA_ID_LIST	FORMAT is HE_MU	Indicates the list of STA IDs for an HE MU PPDU (see 25.11 (STA ID, Uplink Flag and BSS Color in HE PPDUs)).	MU	Y
	Otherwise	Not present	N	N

NOTE 1—In the "TXVECTOR" and "RXVECTOR" columns, the following apply:

Y = Present;

N = Not present;

O = Optional;

MU indicates that the parameter is present once for an HE SU PPDU, HE extended range SU PPDU and HE trigger-based PPDU and present per user for an HE MU PPDU. Parameters specified to be present per user are conceptually supplied as an array of values indexed by *u*, where *u* takes values 0 to NUM_USERS-1.

26.3 HE PHY

26.3.1 Introduction

26.3.2 HE PPDU formats

Four HE PPDU formats are defined: HE SU PPDU, HE MU PPDU, HE extended range SU PPDU and HE trigger-based PPDU.

The format of the HE SU PPDU is defined as in Figure 26-1. This PPDU is used for SU transmission and in this format the HE-SIG-A field is not repeated.

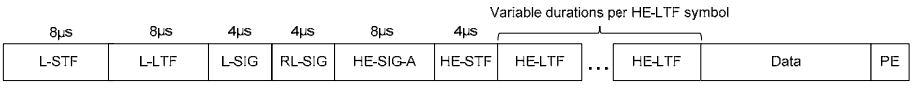


Figure 26-1 - HE SU PPDU format

The format of the HE MU PPDU is defined as in Figure 26-2. This format is used for MU transmission that is not a response of a Trigger frame. An HE-SIG-B field is present in this format.

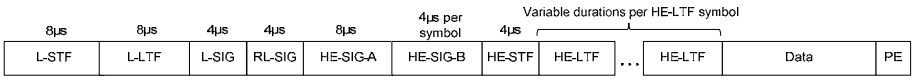


Figure 26-2 - HE MU PPDU format

The format of the HE extended range SU PPDU is defined as in Figure 26-3. This format is used for SU transmission and in this format the HE-SIG-A field is repeated.

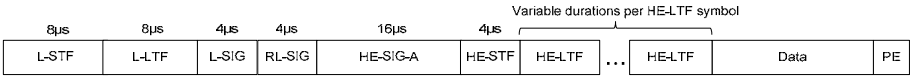


Figure 26-3 - HE extended range SU PPDU format

The format of the HE trigger-based PPDU is defined as in Figure 26-4. This format is used for a transmission that is a response to a Trigger frame. The HE trigger-based PPDU format is identical to the HE SU PPDU format for the L-STF, L-LTF, L-SIG, RL-SIG, HE-SIG-A fields. The duration of the HE-STF field is 8 μs.

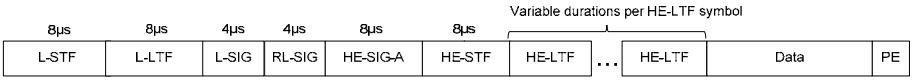


Figure 26-4 - HE trigger-based PPDU format

The fields of the HE PPDU formats are summarized in Table 26-2.

Table 26-2 - HE PPDU fields

Field	Description
L-STF	Non-HT Short Training field
L-LTF	Non-HT Long Training field
L-SIG	Non-HT SIGNAL field
RL-SIG	Repeated Non-HT SIGNAL field
HE-SIG-A	HE Signal A field
HE-SIG-B	HE Signal B field
HT-STF	HE Short Training field
HE-LTF	HE Long Training field
Data	The Data field carrying the PSDU(s)
PE	Packet Extension field

The RL-SIG, HE-SIG-A, HE-SIG-B, HE-STF, HE-LTF, and PE fields exist only in HE PPDUs. In the HE NDP PPDU the Data field is not present. The number of OFDM symbols in the HE-LTF field, $N_{HE\text{-}LTF}$, is 1, 2, 4, 6, or 8 and the duration of each symbol in the HE-LTF field is 3.2 μs, 6.4 μs, or 12.8 μs plus the GI duration. The HE-SIG-B field is present only in the HE MU PPDU. The duration of the PE field is determined by the TXVECTOR parameter PE_DURATION.

DL HE NDP is one DL HE sounding format.

The format of a HE NDP PPDU is shown in Figure 26-5.



Figure 26-5 - HE NDP PPDU format

NOTE 1—The number of HE-LTF OFDM symbols, $N_{HE\text{-}LTF}$ in the NDP is a function of the total number of space-time streams N_{STS} as shown in Table 26-6.

NOTE 2—The combination of HE-LTF modes and GI duration is indicated in HE-SIG-A field.

NOTE 3—The duration of each HE-LTF OFDM symbol, $T_{HE\text{-}LTF}$, is defined in Table 26-3.

NOTE 4—The presence and duration of PE are TBD.

The HE NDP PPDU has the following properties:

— It uses the HE SU PPDU format but without the Data field
— is an HE SU PPDU as implied by the value of L-Length field in L-SIG field

26.3.3 Transmitter block diagram

The generation of each field in a HE PPDU uses many of the following blocks:

a) pre-FEC PHY padding
b) Scrambler
c) FEC (BCC or LDPC) encoders
d) post-FEC PHY padding
e) Stream parser
f) Segment parser (for contiguous 160 MHz and noncontiguous 80+80 MHz transmissions)
g) BCC interleaver
h) Constellation mapper
i) DCM tone mapper
j) Pilot insertion
k) Replicate over multiple 20 MHz (if BW > 20 MHz)
l) Multiply by 1st column of P_{VHTLTF}
m) LDPC tone mapper
n) Segment deparser
o) Space time block code (STBC) encoder
p) Cyclic shift diversity (CSD) per STS insertion
q) Spatial mapper
r) Inverse discrete Fourier transform (IDFT)
s) Cyclic shift diversity (CSD) per chain insertion
t) Guard interval (GI) insertion
u) Windowing

Figure 26-6 to Figure 26-13 show example transmitter block diagrams. The actual structure of the transmitter is implementation dependent.

In particular, Figure 26-6 shows the transmit process for the L-SIG, RL-SIG, and HE-SIG-A fields of a HE PPDU using one frequency segment, when the Beam Change subfield in HE-SIG-A field is set to 1. These

transmit blocks are also used to generate the other pre-HE-SIG-B fields of the HE PPDU when the Beam Change subfield in HE-SIG-A field is set to 1, with the following exceptions applied:

— The BCC encoder and interleaver are not used when generating the L-STF and L-LTF fields.

— The BCC interleaver is not applied in the repeated HE-SIG-A symbols (i.e. the 2nd and the 4th OFDM symbols of HE-SIG-A field) in the HE extended range SU PPDU.

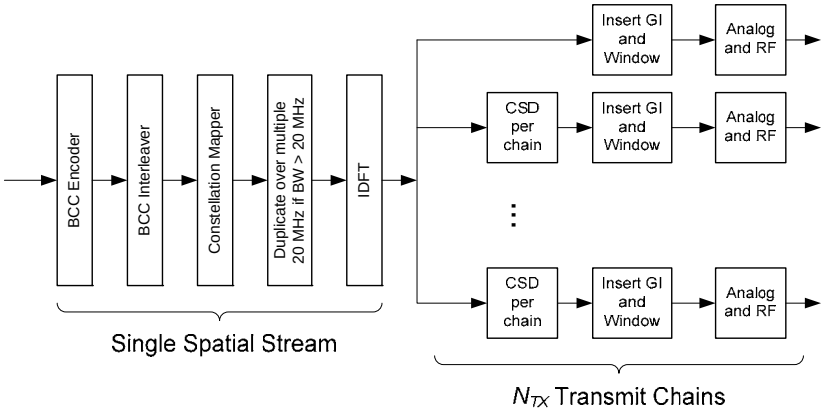


Figure 26-6 - Transmitter block diagram for the L-SIG, RL-SIG and HE-SIG-A fields when the Beam Change field is 1

Figure 26-7 shows the transmit process for the L-SIG, RL-SIG, and HE-SIG-A fields of a HE PPDU using one frequency segment, when the Beam Change subfield in HE-SIG-A field is set to 0. These transmit blocks are also used to generate the other pre-HE-SIG-B fields of the HE PPDU when the Beam Change subfield in HE-SIG-A field is set to 0, with the following exceptions:

— The BCC encoder and interleaver are not used when generating the L-STF and L-LTF fields.

— The BCC interleaver is not applied in the repeated HE-SIG-A field OFDM symbols (i.e., the 2nd and the 4th OFDM symbols of HE-SIG-A field) in the HE extended range SU PPDU.

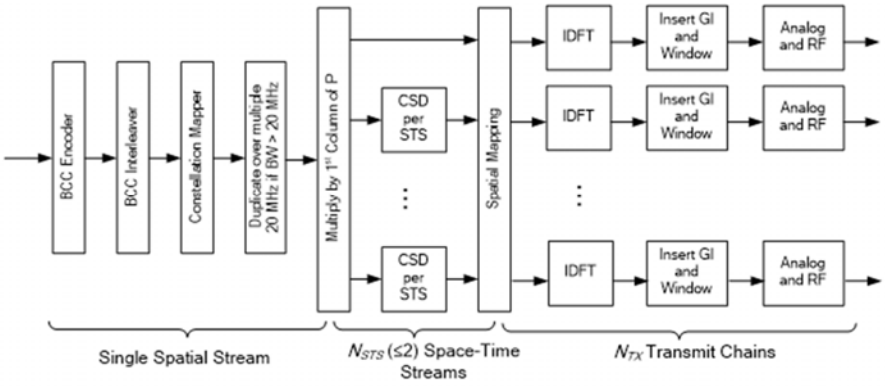


Figure 26-7 – Transmitter block diagram for the L-SIG, RL-SIG and HE-SIG-A fields when the Beam Change field is 0

Figure 26-8 shows the transmit process for the HE-SIG-B field of an HE MU PPDU using one frequency segment. This block diagram is for transmitting HE-SIG-B in one 20 MHz subchannel. Refer to 26.3.9.8.1 for the methods of transmitting HE-SIG-B in 40 MHz, 80 MHz and 160 MHz. The DCM tone mapper is applied only if the DCM indication in HE-SIG-A field is set to 1. (TBD: MCS0-DCM)

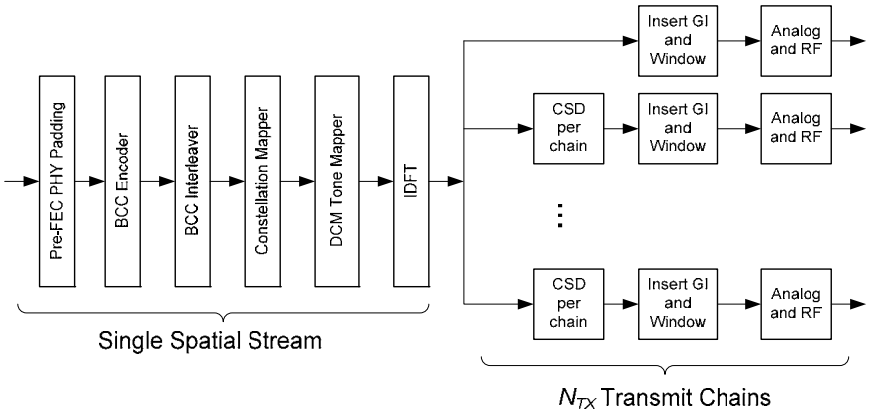


Figure 26-8 - Transmitter block diagram for the HE-SIG-B field

Figure 26-9 shows the transmitter blocks used to generate the Data field of a single user HE transmission within a 26-, 52-, 106-, or 242-RU with BCC encoding for a single frequency segment when the number of spatial stream is less than or equal to 4. This also includes the SU transmission in an RU that is part of a downlink or uplink OFDMA PPDU, and a transmission from one STA that is part of an UL MU-MIMO transmission in current RU. The STBC block may be applied only for single spatial stream and only when DCM is not applied. The DCM tone mapper is applied only when the DCM indication for the RU is set to 1. A subset of these transmitter blocks consisting of the constellation mapper and CSD blocks, as well as the blocks to the right of, and including, the spatial mapping block, are also used to generate the HE-LTF fields. This is illustrated in Figure 26-29. A subset of these transmitter blocks consisting of the constellation mapper and CSD blocks, as well as the blocks to the right of, and including, the spatial mapping block, are also used to generate the HE-STF field. (TBD: MCS0-DCM). This figure also applies to the data field with BCC encoding in a HE trigger-based PPDU.

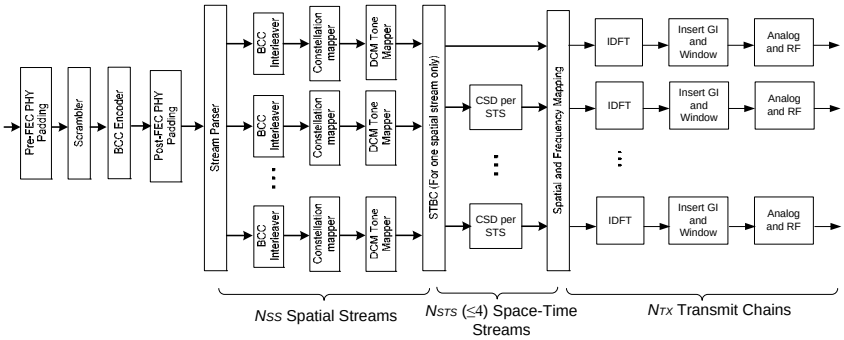


Figure 26-9 - Transmitter block diagram for the Data field of an HE SU transmission in a 26-, 52-, 106- or 242-RU with BCC encoding

Figure 26-10 shows the transmitter blocks used to generate the Data field of a single user HE transmission within a 26-, 52-, 106-, 242-, 484-, or 996-RU with LDPC encoding for a single frequency segment. This also includes the SU transmission in an RU that is part of a downlink or uplink OFDMA PPDU, and a transmission from one STA that is part of an UL MU-MIMO transmission in current RU. The STBC block may be applied only for single spatial stream and only when DCM is not applied. The DCM tone Mapper is applied only when the DCM indication for the RU is set to 1. (TBD: MCS0-DCM) This figure also applies to the data field with LDPC encoding in a HE trigger-based PPDU.

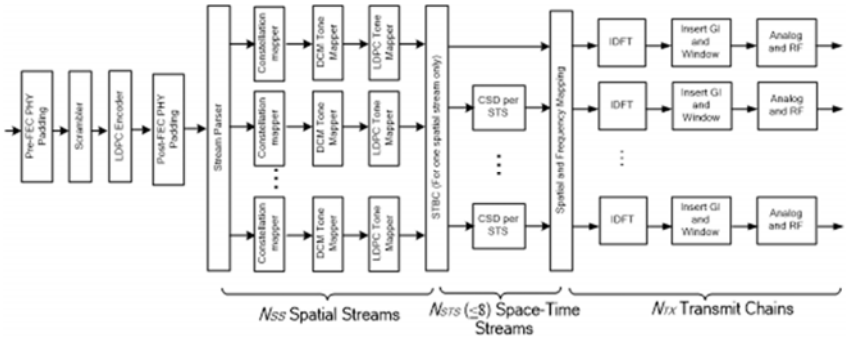


Figure 26-10 - Transmitter block diagram for the Data field of an HE SU transmission in 26-, 52-, 106-, 242-, 484- or 996-RU with LDPC encoding

Figure 26-11 shows the transmitter blocks used to generate the Data field of a HE downlink MU-MIMO transmission within a 106-, 242-, 484-, or 996-RU with LDPC encoding. This also includes the downlink MU-MIMO transmission in an RU that is part of a downlink or uplink OFDMA PPDU.

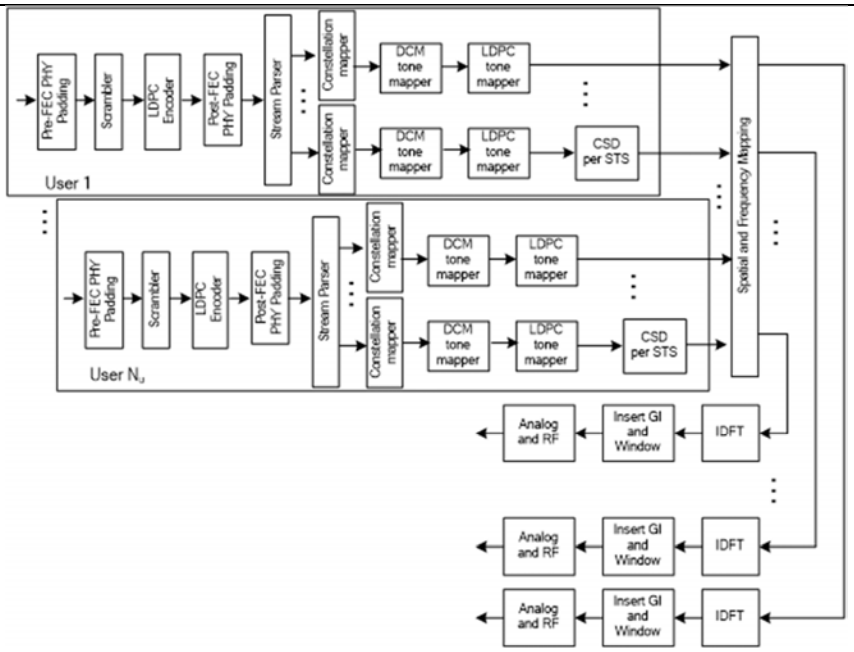


Figure 26-11 - Transmitter block diagram for the Data field of an HE downlink MU-MIMO transmission in 106-, 242-, 484- or 996-RU with LDPC encoding

Figure 26-12 shows the transmitter blocks used to generate the Data field of a single-user HE transmission in 160 MHz with LDPC encoding.

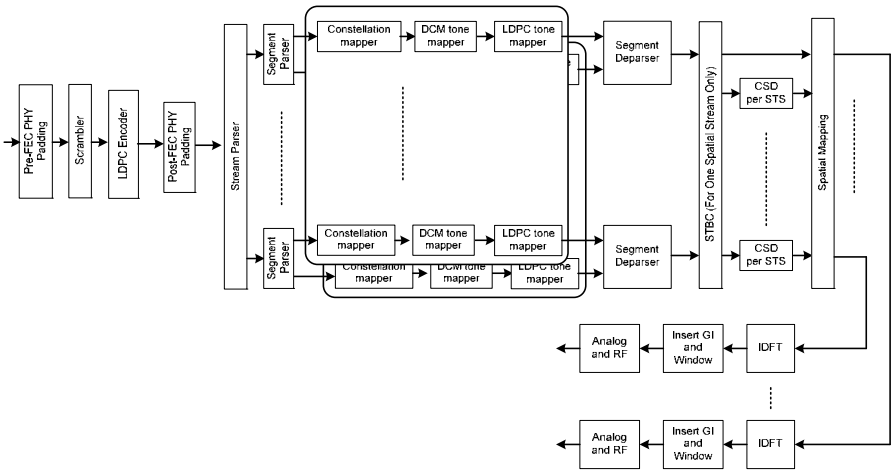


Figure 26-12 - Transmitter block diagram for the Data field of an HE SU PPDU in 160 MHz with LDPC encoding

Figure 26-13 shows the transmitter blocks used to generate the Data field of a single-user HE transmission in 80+80 MHz with LDPC encoding.

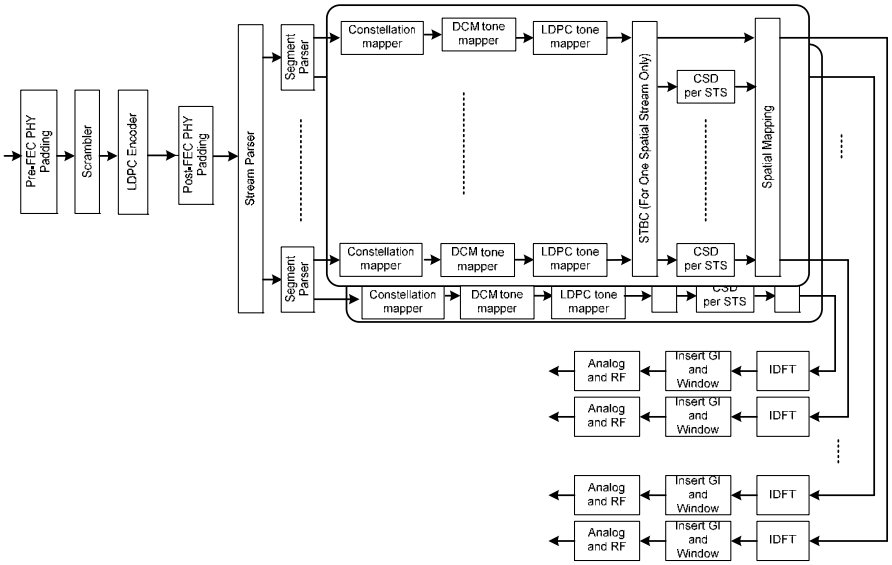


Figure 26-13 - Transmitter block diagram for the Data field of an HE SU PPDU in 80+80 MHz with LDPC encoding

26.3.4 Overview of the PPDU encoding process

26.3.5 HE modulation and coding schemes (HE-MCSs)

The HE-MCS is a value that determines the modulation and coding used in the HE-SIG-B field and the Data field of the PPDU. It is a compact representation that is carried in the HE-SIG-A field for the HE-SIG-B field in an HE MU PPDU and for the Data field in an HE SU PPDU and HE extended range SU PPDU and carried in the HE-SIG-B field for the Data field in an HE MU PPDU. Rate-dependent parameters for the full set of HE-MCSs are shown in Table 25-x (HE-MCSs for TBD mandatory/optional 26-tone RU, NSS = 1) to Table 25-y (HE-MCSs for optional non-OFDMA 160 MHz and 80+80 MHz, NSS = 8) (in 26.5 (Parameters for HE-MCSs)). These tables give rate-dependent parameters for HE-MCSs with indices 0 to 11, with number of spatial streams from 1 to 8, RU options of 26-tone, 52-tone, 106-tone, 242-tone, 484-tone and 996-tone, and bandwidth options of 20 MHz, 40 MHz, 80 MHz, and either 160 MHz or 80+80 MHz. HE-MCSs with indices 10 and 11 (1024-QAM) are optionally applied to the Data field of an HE PPDU with RUs equal to or larger than 242-tone. The HE extended range SU PPDU can only be transmitted with MCS0, MCS1, MCS2 and only with 1 spatial stream on the primary 20 MHz channel.

DCM is an optional modulation scheme used for the HE-SIG-B field and the Data field in an HE PPDU. It is indicated in the HE-SIG-A field for the HE-SIG-B field in an HE MU PPDU and for the Data field in HE SU PPDU, HE trigger-based PPDU and HE extended range SU PPDU and indicated in the HE-SIG-B field for the Data field in an HE MU PPDU. It is only applied for the HE-MCSs with indices 0, 1, 3 and 4.

26.3.6 Timing related parameters

Refer to Table 20-6 and Table 22-5 (Timing-related constants) for timing-related parameters for non-HE PPDU formats.

Table 26-3 defines the timing-related parameters for HE PPDU formats.

Table 26-3 – Timing related constants

Parameter	Values	Description
$\Delta_{F,\text{Pre-HE}}$	312.5 kHz	Subcarrier frequency spacing for the pre-HE portion.
$\Delta_{F,\text{HE}}$	78.125 kHz	Subcarrier frequency spacing for the HE portion.
$T_{DFT,Pre\text{-}HE}$	3.2 µs	IDFT/DFT period for the pre-HE portion.
$T_{DFT,HE}$	12.8 µs	IDFT/DFT period for the HE portion.
$T_{GI,Pre\text{-}HE}$	0.8 µs	Guard interval duration for the legacy preamble, RL-SIG, HE-SIG-A and HE-SIG-B
$T_{GI,HE\text{-}LTF}$	$T_{GI1,Data}$, $T_{GI2,Data}$ or $T_{GI4,Data}$ depending on the GI used for data	Guard interval duration for the HE-LTF field, same as $T_{GI,Data}$
$T_{GI,Data}$	$T_{GI1,Data}$, $T_{GI2,Data}$ or $T_{GI4,Data}$ depending on the GI used for data	Guard interval duration for the HE-Data field
$T_{GI1,Data}$	0.8 µs	Base guard interval duration for the HE-Data field.
$T_{GI2,Data}$	1.6 µs	Double guard interval duration for the HE-Data field.
$T_{GI4,Data}$	3.2 µs	Quadruple guard interval duration for the HE-Data field.
T_{SYM1}	13.6 µs = $T_{DFT,HE} + T_{GI1,Data} = 1.0625 \times T_{DFT,HE}$	Normal GI symbol interval
T_{SYM2}	14.4 µs = $T_{DFT,HE} + T_{GI2,Data} = 1.125 \times T_{DFT,HE}$	Double GI symbol interval
T_{SYM4}	16 µs = $T_{DFT,HE} + T_{GI4,Data} = 1.25 \times T_{DFT,HE}$	Quadruple GI symbol interval
T_{SYM}	T_{SYM1},T_{SYM2}, or T_{SYM4} depending on the GI used (see Table xx-x (Tone scaling factor and guard interval duration values for PHY fields))	Symbol interval
$T_{L\text{-}STF}$	8 µs = 10 x $T_{DFT,Pre\text{-}HE}$ /4	Non-HT Short Training field duration
$T_{L\text{-}LTF}$	8 µs = 2 x $T_{DFT,Pre\text{-}HE} + T_{GI2,Data}$	Non-HT Long Training field duration
$T_{L\text{-}SIG}$	4 µs	Non-HT SIGNAL field duration
$T_{RL\text{-}SIG}$	4 µs	Repeated non-HT SIGNAL field duration
$T_{HE\text{-}SIG\text{-}A}$	8 µs = 2 × 4 µs	HE-SIG-Afield duration in an HE SU PPDU, HE MU PPDU and HE trigger-based PPDU
$T_{HE\text{-}SIG\text{-}A\text{-}R}$	8 µs or 16 µs (TBD)	HE-SIG-A field duration in an HE extended range SU PPDU
$T_{HE\text{-}STF\text{-}T}$	8 µs = 5 × 1.6 µs	HE-STF field duration for an HE trigger-based PPDU
$T_{HE\text{-}STF\text{-}NT}$	4 µs = 5 × 0.8 µs	HE-STF field duration for an HE SU PPDU, HE extended range SU PPDU and HE MU PPDU
$T_{HE\text{-}LTF}$	$T_{HE\text{-}LTF\text{-}1X}$, $T_{HE\text{-}LTF\text{-}2X}$ or $T_{HE\text{-}LTF\text{-}4X}$ depending upon the LTF duration used	Duration of each HE-LTF field OFDM symbol without GI
$T_{HE\text{-}LTF\text{-}1X}$	3.2 µs	Duration of each 1x HE-LTF OFDM symbol without GI
$T_{HE\text{-}LTF\text{-}2X}$	6.4 µs	Duration of each 2x HE-LTF OFDM symbol without GI
$T_{HE\text{-}LTF\text{-}4X}$	12.8 µs	Duration of each 4x HE-LTF OFDM symbol without GI
$T_{HE\text{-}LTF,SYM}$	sum of $T_{HE\text{-}LTF}$ and $T_{GI,HE\text{-}LTF}$	Duration of each HE-LTF OFDM symbol including GI
$T_{HE\text{-}SIG\text{-}B}$	4 µs = $T_{DFT,Pre\text{-}HE} + T_{GI,Pre\text{-}HE}$	Duration of each HE-SIG-B field OFDM symbol
T_{PE}	0, 4 µs, 8 µs, 12 µs, 16 µs depending on actual extension duration used	Duration of the Packet Extension field
$N_{service}$	16	Number of bits in the SERVICE field
N_{tail}	6	Number of tail bits per BCC encoder
T_{SYML}	4 µs	Symbol duration including GI prior to the HE-STF field

Table 26-4 defines tone allocation related parameters for a non-OFDMA HE PPDU.

Table 26-4 - Tone allocation related constants for Data field in a non-OFDMA HE PPDU

Parameter	CBW20	CBW40	CBW80	CBW80+80	CBW160	Description
N_{SD}	234	468	980	980	1960	Number of complex data numbers per frequency segment
N_{SP}	8	16	16	16	32	Number of pilot values per frequency segment
N_{ST}	242	484	996	996	1992	Total number of subcarriers per frequency segment
N_{SR}	122	244	500	500	1012	Highest data subcarrier index per frequency segment
N_{Seg}	1	1	1	2	1	Number of frequency segments
N_{DC}	3	5	5	5	23	Number of null tones at DC per segment

Parameter	CBW20	CBW40	CBW80	CBW80+80	CBW160	Description
$N_{Guard,Left}$	6	12	12	12	12	Number of guard tones at the lower side of the spectrum
$N_{Guard,Right}$	5	11	11	11	11	Number of guard tones at the higher end of the spectrum
NOTE: $N_{ST} = N_{SD} + N_{SP}$						

Table 26-5 defines tone allocation related parameters for an OFDMA HE PPDU.

Table 26-5 - Tone allocation related constants for RUs in an OFDMA HE PPDU

Parameter	RU Size (Tones)						Description
	26	52	106	242	484	996	
N_{SD}	24	48	102	234	468	980	Number of complex data numbers per RU
N_{SP}	2	4	4	8	16	16	Number of pilot values per RU
N_{ST}	26	52	106	242	484	996	Total number of subcarriers per RU
NOTE: $N_{ST} = N_{SD} + N_{SP}$							

Table 26-6 defines parameters used frequently in Clause 26.

Table 26-6 - Frequently used parameters

Symbol	Explanation
N_{CBPS}, $N_{CBPS,r,u}$	Number of coded bits per symbol at r-th RU for user u, r = 0, …, N_{RU} – 1, u = 0, ..., $N_{user,r}$ – 1. For an HE SU PPDU, $N_{CBPS} = N_{CBPS,0,0}$ For an HE MU PPDU, N_{CBPS} is undefined
N_{CBPSS}, $N_{CBPSS,r,u}$	Number of coded bits per symbol per spatial stream. For the Data field, $N_{CBPSS,r,u}$ equals the number of coded bits per symbol per spatial stream at r-th RU for user u, r = 0, …, N_{RU}-1, u = 0, ..., $N_{user,r}$–1. For the Data field of an HE SU PPDU, $N_{CBPSS} = N_{CBPSS,0,0}$ For the Data field of an HE MU PPDU, N_{CBPSS} is undefined
N_{DBPS}, $N_{DBPS,r,u}$	Number of data bits per symbol at r-th RU for user u, r = 0, …, N_{RU} – 1, u = 0, ..., $N_{user,r}$ – 1. For an HE SU PPDU, $N_{DBPS} = N_{DBPS,0,0}$ For an HE MU PPDU, N_{DBPS} is undefined
N_{BPSCS}, $N_{BPSCS,r,u}$	Number of coded bits per subcarrier per spatial stream at r-th RU for user u, r = 0, …, N_{RU} – 1, u = 0, ..., $N_{user,r}$ – 1. For an HE SU PPDU, $N_{BPSCS} = N_{BPSCS,0,0}$ For an HE MU PPDU, N_{BPSCS} is undefined
N_{RX}	Number of receive chains
N_{RU}	For pre-HE modulated fields, N_{RU} = 1. For HE modulated fields, N_{RU} represents the number of RUs in the transmission (equal to the TXVECTOR parameter NUM_RUS).
$N_{user,r}$	For pre-HE modulated fields, $N_{user,r}$ = 1. For HE modulated fields, $N_{user,r}$ represents the number of users at r-th RU in the transmission (summing over all RUs equals to the TXVECTOR parameter NUM_USERS_TOTAL).
N_{user_total}	For pre-HE modulated fields, N_{user_total} = 1. For HE modulated fields, N_{user_total} represents the number of users in the transmission (equal to the TXVECTOR parameter NUM_USERS_TOTAL).
N_{STS}, $N_{STS,r,u}$	For pre-HE modulated fields, $N_{STS,r,u}$ = 1 (see NOTE 2). For HE modulated fields, $N_{STS,r,u}$ the number of space-time streams at r-th RU for user u, u = 0,…, $N_{user,r}$ – 1. In case of STBC, $N_{STS,r,u}$ = 2 For an HE SU PPDU, $N_{STS} = N_{STS,0,0}$

	For an HE MU PPDU, $N_{STS} = max_{r=0}^{N_{RU}-1} N_{STS,r,total}$
$N_{STS,r,total}$	For HE modulated fields, $N_{STS,r,total}$ is the total number of space-time streams at the r-th RU in a PPDU. $N_{STS,r,total} = \sum_{u=0}^{N_{user,r}-1} N_{STS,r,u}$ For pre-HE modulated fields, $N_{STS,r,total}$ is undefined. Note that $N_{STS,r,total} = N_{STS}$ for an HE SU PPDU.
N_{SS}, $N_{SS,r,u}$	Number of spatial streams. For the Data field, NSS,r,u is the number of spatial streams at r-th RU for user u, $u = 0,\ldots,N_{user,r} - 1$ For the Data field of an HE SU PPDU, $N_{SS} = N_{SS,0,0}$ For the Data field of an HE MU PPDU, $N_{SS} = max_{r=0}^{N_{RU}-1} N_{SS,r,total}$
$N_{SS,r,total}$	For HE modulated fields, $N_{SS,r,total}$ is the total number of spatial streams at r-th RU in a PPDU. $N_{SS,r,total} = \sum_{u=0}^{N_{user,r}-1} N_{SS,r,u}$ For pre-HE modulated fields, $N_{SS,r,total}$ is undefined. Note that $N_{SS,r,total} = N_{SS}$ for an HE SU PPDU.
N_{TX}	Number of transmit chains
N_{ES}, $N_{ES,r,u}$	The number of BCC encoders. This parameter should be 1 in all BCC cases in 11ax. For a Data field encoded using BCC, $N_{ES,r,u}$ is the number of BCC encoders at r-th RU for user u, $u = 0,\ldots, N_{user,r} - 1$. For the Data field encoded using LDPC, N_{ES}= 1 for an HE SU PPDU and $N_{ES,r,u}$ = 1 for an HE MU PPDU at r-th RU for user u, $u = 0, \ldots N_{user,r} - 1$. For the Data field of an HE SU PPDU, $N_{ES} = N_{ES,0,0}$ For the Data field of an HE MU PPDU, N_{ES} is undefined.
$N_{HE\text{-}LTF}$	The number of OFDM symbols in the HE-LTF field (see 26.3.9.10 (HE-LTF))
$N_{HE\text{-}SIG\text{-}B}$	The number of OFDM symbols in the HE-SIG-B field
K_r	Set of subcarrier indices in the r-th RU
R, $R_{r,u}$	$R_{r,u}$ is the coding rate at r-th RU for user u, $u = 0, ..., N_{user} - 1$. For an HE SU PPDU, $R = R_{0,0}$ For an HE MU PPDU, R is undefined
$M_{r,u}$	For pre-HE modulated fields, $M_{r,u} = 0$. For HE modulated fields, $M_{r,0} = 0$ for $u = 0$ and $M_{r,u} = \sum_{u'=0}^{u-1} N_{STS,r,u'}$ for $u = 1, \ldots N_{user,r} - 1$.
NOTE 1—Pre-HE modulated fields refer to the L-STF, L-LTF, L-SIG, RL-SIG, HE-SIG-A, HE-SIG-A-R, and HE-SIG-B fields, while HE modulated fields refer to the HE-STF, HE-LTF, and Data fields (see Timing boundaries for HE PPDU fields). NOTE 2—For pre-HE modulated fields, u and r are zeros only since $N_{user,r} = 1$ and $N_{RU} = 1$.	

1

26.3.7 OFDMA and SU tone allocation

Orthogonal Frequency Division Multiple Access (OFDMA) is the multi-user variant of the OFDM scheme where multiple-access is achieved by assigning subsets of subcarriers to different users, allowing simultaneous data transmission by several users. In OFDMA, the resources are allocated in two dimensional regions over time and frequency. In HE, the time region covers the entire data portion of an HE PPDU, and the frequency region includes a number of contiguous subcarriers with the exception of the RUs which straddle DC where nulls are placed in the middle of the band. The difference between OFDM and OFDMA is illustrated in Figure 26-14. Similar to OFDM, OFDMA employs multiple subcarriers, but the subcarriers are divided into several groups of subcarriers where each group is denoted as a resource unit (RU). The grouping of subcarriers into groups of resource units is referred to as subchannelization. In HE, the subcarriers that form a RU are physically adjacent (contiguous except at the middle of the band where nulls are placed at DC).

Subchannelization defines subchannels that can be allocated to stations depending on their channel conditions and service requirements. Using subchannelization, an OFDMA system can potentially allocate different transmit powers to different allocations.

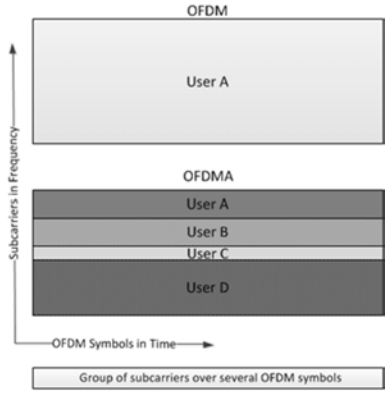


Figure 26-14 - Illustration of OFDM and OFDMA Concepts

OFDMA is a method to add multiple access in OFDM systems and has been adopted by other wireless standards, and the HE amendment introduces OFDMA into 802.11 WLAN networks. The OFDMA parameters in HE satisfy general design criteria for OFDM systems as follows:

$$T_{CP} \geq \tau_{RMS} \quad \text{(to prevent ISI due to delay spread)} \qquad \textbf{(26-1)}$$
$$T_{CP}\Delta f \gg 1 \quad \text{(for spectral efficiency improvement)}$$

In OFDMA, an OFDM symbol is constructed of subcarriers, the number of which is a function of the FFT size. There are several subcarrier types: 1) Data subcarriers which are used for data transmission; defined in section 25.3.7.1, 2) Pilot subcarriers which are utilized for phase information and parameter tracking; defined in section 25.3.7.3, and 3) unused subcarriers which are not used for data/pilot transmission. The unused subcarriers are the DC subcarrier (defined in section 23.3.7.1), the Guard band subcarriers at the band edges (defined in section 23.3.7.1), and the Null subcarriers (defined in section 25.3.7.2).

26.3.7.1 Resource unit, edge and DC tones

The OFDMA structure consists of a 26-subcarrier resource unit (RU), 52-subcarrier RU, 106-subcarrier RU, 242-subcarrier RU, 484-subcarrier RU and 996-subcarrier RU. Resource allocations for single user (SU) consist of a 242 subcarrier RU, 484-subcarrier RU, 996-subcarrier RU and 2x996-subcarrier RU.

The 26-subcarrier RU and 52-subcarrier RU are used in the 20 MHz, 40 MHz, 80 MHz, 160 MHz and 80+80 MHz OFDMA HE PPDU formats. The 106-subcarrier RU is used in the 20 MHz, 40 MHz, 80 MHz, 160 MHz and 80+80 MHz OFDMA and MU-MIMO HE PPDU formats. The 242-subcarrier RU is used in the 40 MHz, 80 MHz, 160 MHz and 80+80 MHz OFDMA and MU-MIMO HE PPDU formats. The 484-subcarrier RU is used in the 80 MHz, 160 MHz and 80+80 MHz OFDMA and MU-MIMO HE PPDU formats. The 996-subcarrier RU is used in the 160 MHz and 80+80 MHz OFDMA and MU-MIMO HE PPDU formats.

The 242-subcarrier and larger RUs are used in the HE SU PPDU and non-OFDMA, MU-MIMO HE PPDU formats. The 242-subcarrier RU is used in the 20 MHz HE SU PPDU and MU-MIMO HE PPDU formats. The 484-subcarrier RU is used in the 40 MHz HE SU PPDU and MU-MIMO HE PPDU formats. The 996-subcarrier RU is used in the 80 MHz HE SU PPDU and MU-MIMO HE PPDU formats. The 2x996-subcarrier RU is used in the 160 MHz and 80+80 MHz HE SU PPDU and MU-MIMO HE PPDUs.

The maximum numbers of RUs in the 20 MHz, 40 MHz, 80 MHz, 160 MHZ and 80+80 MHz HE PPDU formats are defined in Table 26-7. Cases of 1 RU indicate the HE SU and a HE MU-MIMO PPDU allocation.

Table 26-7 - Total number of RUs for BWs

RU type	CBW20	CBW40	CBW80	CBW160 and CBW80+80
26-subcarrier RU	9	18	37	74
52-subcarrier RU	4	8	16	32
106-subcarrier RU	2	4	8	16
242-subcarrier RU	1-SU/MU-MIMO	2	4	8
484-subcarrier RU	N/A	1-SU/MU-MIMO	2	4
996-subcarrier RU	N/A	N/A	1-SU/MU-MIMO	2
2x996 subcarrier RU	N/A	N/A	N/A	1-SU/MU-MIMO

An OFDMA HE PPDU can carry a mixture of 26-subcarrier, 52-subcarrier and 106-subcarrier RUs within any of the 242-subcarrier RU boundaries.

Table 26-8 - Subcarrier indices for RUs in a 20 MHz HE PPDU

RU type					
26-subcarrier	RU 1 [-121 : -96]	RU 2 [-95 : -70]	RU 3 [-68 : -43]	RU 4 [-42 : -17]	RU 5 [-16 : -4, 4 : 16]
	RU 6 [17 : 42]	RU 7 [43 : 68]	RU 8 [70 : 95]	RU 9 [96 : 121]	-
52-subcarrier	RU 1 [-121 : -70]	RU 2 [-68 : -17]	RU 3 [17: 68]	RU 4 [70 : 121]	-
106-subcarrier	RU 1 [-122 : -17]		RU 2 [17: 122]		-
242-subcarrier	RU 1 [-122 : -2, 2:122]				

Table 26-9 - Subcarrier indices for RUs in a 40 MHz HE PPDU

RU type					
26-subcarrier	RU 1 [-243 : -218]	RU 2 [-217 : -192]	RU 3 [-189 : -164]	RU 4 [-163 : -138]	RU 5 [-136 : -111]
	RU 6 [-109 : -84]	RU 7 [-83 : -58]	RU 8 [-55 : -30]	RU 9 [-29 : -4]	-

	RU 10 [4 : 29]	RU 11 [30 : 55]	RU 12 [58 : 83]	RU 13 [84: 109]	RU 14 [111 : 136]
	RU 15 [138 : 163]	RU 16 [164 : 189]	RU 17 [192 : 217]	RU 18 [218 : 243]	-
52-subcarrier	RU 1 [-243 : -192]	RU 2 [-189 : -138]	RU 3 [-109: -58]	RU 4 [-55: -4]	-
	RU 5 [4 : 55]	RU 6 [58 : 109]	RU 7 [138 : 189]	RU 8 [192 : 243]	-
106-subcarrier	RU 1 [-243:-138]	RU 2 [-109 : -4]	RU 3 [4 : 109]	RU 4 [138 : 243]	-
242-subcarrier	RU 1 [-244 : -3]			RU2 [3 : 244]	
484-subcarrier	RU 1 [-244 : -3, 3 : 244]				

Table 26-10 - Subcarrier indices for RUs in a 80 MHz HE PPDU

RU type					
26-subcarrier	RU 1 [-499 : -474]	RU 2 [-473 : -448]	RU 3 [-445 : -420]	RU 4 [-419 : -394]	RU 5 [-392 : -367]
	RU 6 [-365 : -340]	RU 7 [-339 : -314]	RU 8 [-311 : -286]	RU 9 [-285 : -260]	-
	RU 10 [-257 : -232]	RU 11 [-231 : -206]	RU 12 [-203 : -178]	RU 13 [-177 : -152]	RU 14 [-150 : -125]
	RU 15 [-123 : -98]	RU 16 [-97 : -72]	RU 17 [-69 : -44]	RU 18 [-43 : -18]	RU 19 [-16 : -4, 4:16]
	RU 20 [18 : 43]	RU 21 [44 : 69]	RU 22 [72 : 97]	RU 23 [98 : 123]	RU 24 [125 : 150]
	RU 25 [152 : 177]	RU 26 [178 : 203]	RU 27 [206 : 231]	RU28 [232 : 257]	-
	RU 29 [260 : 285]	RU 30 [286 : 311]	RU 31 [314 : 339]	RU 32 [340 : 365]	RU 33 [367 : 392]
	RU 34 [394 : 419]	RU 35 [420 : 445]	RU 36 [448 : 473]	RU37 [474 : 499]	-
52-subcarrier	RU 1 [-499: -448]	RU 2 [-445: -394]	RU 3 [-365: -314]	RU 4 [-311: -260]	-
	RU 5 [-257: -206]	RU 6 [-203: -152]	RU 7 [-123 : -72]	RU 8 [-69: -18]	-
	RU 9 [18: 69]	RU 10 [72: 123]	RU 11 [152: 203]	RU 12 [206: 257]	
	RU 13 [260: 311]	RU 14 [314: 365]	RU 15 [394: 445]	RU 16 [448: 499]	
106-subcarrier	RU 1 [-499 : -394]	RU 2 [-365 : -260]	RU 3 [-257 : -152]	RU 4 [-123 : -18]	-
	RU 5 [18 : 123]	RU 6 [152 : 257]	RU 7 [260 : 365]	RU 8 [394 : 499]	
242-subcarrier	RU 1 [-500: -259]	RU 2 [-258: -17]	RU 3 [17: 258]	RU 4 [259: 500]	
484-subcarrier	RU 1 [-500 : -17]		RU 2 [17 , 500]		
996-subcarrier	RU 1 [-500 : -3 , 3: 500]				

A 26-subcarrier RU consists of 24 data subcarriers and 2 pilot subcarriers. The position of the pilots for the 26-subcarrier RU is defined in 26.3.7.3. The location of the 26-subcarrier RUs are fixed as defined in Table 26-8 and shown in Figure 26-15, Figure 26-16 and Figure 26-17 for the 20 MHz, 40 MHz and 80 MHz OFDMA HE PPDU formats, respectively. The same structure as used for the 80 MHz OFDMA HE PPDU is used for each 80 MHz frequency segment of the 160 MHz and 80+80 MHz OFDMA HE PPDU. The

center 26-subcarrier RU in the 20 MHz and 80 MHz OFDMA HE PPDU (Figure 26-15 and Figure 26-17) is located on subcarriers [-16:-4, 4:16].

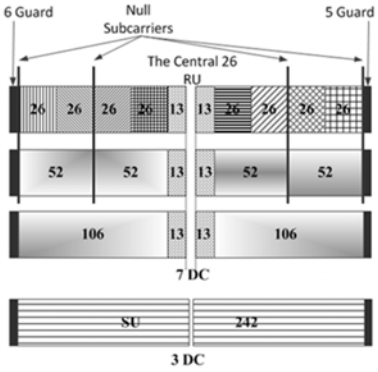


Figure 26-15 - RU locations in a 20 MHz HE PPDU

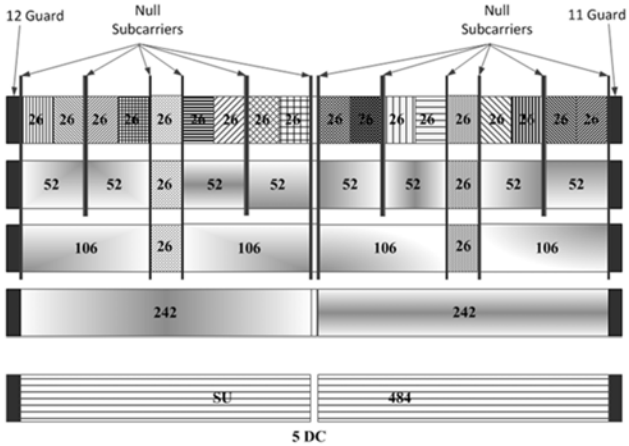


Figure 26-16 - RU locations in a 40 MHz HE PPDU

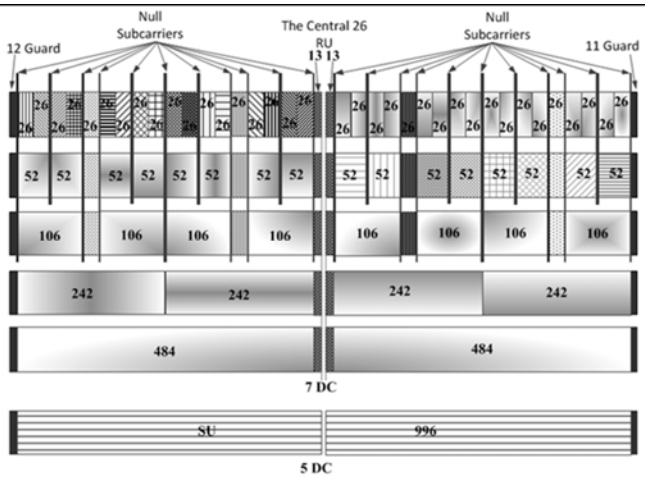


Figure 26-17 - RU locations in an 80 MHz HE PPDU

A 52-subcarrier RU consists of 48 data subcarriers and 4 pilot subcarriers. The position of the pilots for the 52-subcarrier RU is defined in 25.3.7.3. The locations of the 52-subcarrier RUs are fixed as defined in Table 26-8, Table 26-9 and Table 26-10 and illustrated in Figure 26-15, Figure 26-16 and Figure 26-17 for the 20 MHz, 40 MHz and 80 MHz OFDMA HE PPDU formats, respectively. The same structure as used in the 80 MHz OFDMA HE PPDU format is used for each 80 MHz frequency segment of the 160 MHz and 80+80 MHz OFDMA HE PPDU formats.

A 106-subcarrier RU consists of 102 data subcarriers and 4 pilot subcarriers. The position of the pilots for the 106-subcarrier RU is defined in 25.3.7.3. The locations of the 106-subcarrier RUs are fixed as defined in Table 26-8, Table 26-9 and Table 26-10 and illustrated in Figure 26-15, Figure 26-16 and Figure 26-17 for the 20 MHz, 40 MHz and 80 MHz OFDMA HE PPDU formats, respectively. The same structure as used in the 80 MHz OFDMA HE PPDU formats is used for each 80 MHz frequency segment of the 160 MHz and 80+80 MHz OFDMA HE PPDU formats.

A 242-subcarrier RU consists of 234 data subcarriers and 8 pilot subcarriers. The position of pilots for the 242-subcarrier RU is defined in 25.3.7.3. The locations of the 242-subcarrier RUs are fixed as defined in Table 26-9 and Table 26-10 and illustrated in Figure 26-16 and Figure 26-17 for the 40 MHz, 80 MHz OFDMA HE PPDU formats, respectively. The same structure as used in the 80 MHz OFDMA HE PPDU formats is used for each 80 MHz frequency segment of the 160 MHz and 80+80 MHz OFDMA HE PPDU formats. A 20 MHz HE SU PPDU and MU-MIMO HE PPDU with a 242-subcarrier RU is shown in Figure 26-15.

A 484-subcarrier RU consists of 468 data subcarriers and 16 pilot subcarriers. The position of the pilots for the 484-subcarrier RU is defined in 25.3.7.3. The locations of the 484-subcarrier RUs are fixed as defined in Table 26-10 and illustrated in Figure 26-17 for the 80 MHz HE PPDU. The same structure as used for the 80 MHz OFDMA HE PPDU is used for for each 80 MHz frequency segment of the 160 MHz and 80+80 MHz OFDMA HE PPDU. The 40 MHz HE SU PPDU and MU-MIMO HE PPDU with a 484-subcarrier RU is shown in Figure 26-16.

A 996-subcarrier RU consists of 980 data subcarriers and 16 pilot subcarriers. The position of the pilots for the 996-subcarrier RU is defined in 25.3.7.3. The locations of the 996-subcarrier RUs are fixed and located on subcarrier [-1012:-515, -509:-12] and [12:509, 515:1012] for each half of the BW, respectively, for 160/80+80 MHz HE OFDMA PPDUs.

The 20 MHz OFDMA HE PPDU has 7 DC subcarriers located at [-3:3]. The 20 MHz HE SU PPDU and 20 MHz MU-MIMO HE PPDU with a 242 subcarrier RU has 3 DC subcarriers located at [-1:1]. The 40 MHz OFDMA HE PPDU, HE SU PPDU and a HE MU-MIMO PPDU with 484 subcarries have 5 DC subcarriers located at [-2:2]. An 80 MHz HE OFDMA PPDU has 7 DC subcarriers located at [-3:3]. The 80 MHz HE SU PPDU and 80 MHz HE MU-MIMO PPDU with 996 a subcarrier allocation have 5 DC subcarriers located at [-2:2]. The same structure as used in the 80 MHz OFDMA HE PPDU is used for each 80 MHz frequency segment of the 160 MHz and 80+80 MHz OFDMA HE PPDU. The DC tones are located on subcarriers [-11:11]. The same structure as used in the 80 MHz HE SU PPDU is used for each 80 MHz frequency segment of the 160 MHz and 80+80 MHz OFDMA HE PPDU.

The 20 MHz HE PPDU format has 11 guard subcarriers (6, 5) located at [-128:-123] and [123:127] as shown in Figure 26-15. The 40 MHz HE PPDU has 23 guard subcarriers (12, 11) located at [-256:-245] and [245:255] as shown in Figure 26-16. The 80 MHz HE PPDU has 23 guard subcarriers (12, 11) located at [-512:-501] and [501:511] as shown in Figure 26-17. For 160 MHz and 80+80 MHz HE PPDUs, the same number of leftmost and rightmost guard subcarriers as 80 MHz are defined at each edge of the 160 MHz.

26.3.7.2 Null subcarriers

There are null subcarriers between the 26-, 52- and 106-subcarrier RU locations as illustrated in Figure 26-15, Figure 26-16 and Figure 26-17. The null subcarriers have zero energy. The indices of the null subcarrier are enumerated in Table 26-11.

Table 26-11 – Null subcarrier indices

Channel Width	RU size	Null Subcarrier Indices
20 MHz	26, 52	±69, ±122
	106	none
	242	none
40 MHz	26, 52	±3, ±56, ±57, ±110, ±137, ±190, ±191, ±244
	106	±3, ±110, ±137, ±244
	242, 484	none
80 MHz	26, 52	±17, ±70, ±71, ±124, ±151, ±204, ±205, ±258, ±259, ±312, ±313, ±366, ±393, ±446, ±447, ±500
	106	±17, ±124, ±151, ±258, ±259, ±366, ±393, ±500
	242, 484	none
	996	none

26.3.7.3 Pilot tones

If pilot tones are present in the HE-LTF field, the pilot tone locations in the HE-LTF field and Data field shall be the same. The pilot tone locations for 20 MHz, 40 MHz and 80 MHz bandwidth are as shown in Figure 26-18, Figure 26-19 and Figure 26-20, respectively. All pilot tones are at the even indices enumerated in Table 26-12.

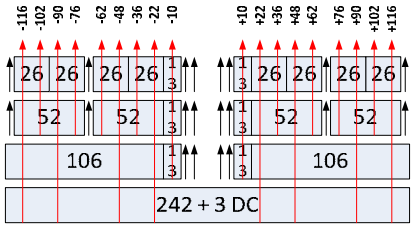


Figure 26-18 - Pilot tone locations for 20 MHz

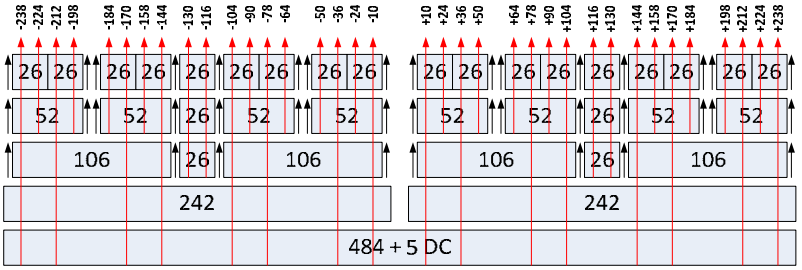


Figure 26-19 - Pilot tone locations for 40 MHz

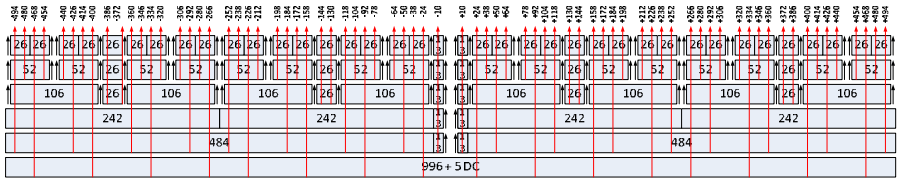


Figure 26-20 - Pilot tone locations for 80 MHz

Table 26-12 - Pilot tone indices

Channel Width	RU size	Pilot Tone Indices
20 MHz	26, 52	±10, ±22, ±36, ±48, ±62, ±76, ±90, ±102, ±116
	106, 242	±22, ±48, ±90, ±116
40 MHz	26, 52	±10, ±24, ±36, ±50, ±64, ±78, ±90, ±104, ±116, ±130, ±144, ±158, ±170, ±184, ±198, ±212, ±224, ±238
	106, 242, 484	±10, ±36, ±78, ±104, ±144, ±170, ±212, ±238
80 MHz	26, 52	±10, ±24, ±38, ±50, ±64, ±78, ±92, ±104, ±118, ±130, ±144, ±158, ±172, ±184, ±198, ±212, ±226, ±238, ±252, ±266, ±280, ±292, ±306, ±320, ±334, ±346, ±360, ±372, ±386, ±400, ±414, ±426, ±440, ±454, ±468, ±480, ±494
	106, 242, 484	±24, ±50, ±92, ±118, ±158, ±184, ±226, ±252, ±266, ±292, ±334, ±360, ±400, ±426, ±468, ±494
	996	±24, ±92, ±158, ±226, ±266, ±334, ±400, ±468

The pilot tones locations for 160 MHz or 80+80 MHz shall use the same 80 MHz locations for both 80 MHz.

26.3.8 Mathematical description of the signals

For a description of the conventions used for the mathematical description of the signals, see 18.3.2.5 (Mathematical conventions in the signal descriptions). In addition, the following notational conventions are used in Clause 25 (High Efficiency (HE) PHY specification):

$[Q]_{m,n}$ indicates the element in row m and column n of matrix , where $1 \leq m \leq N_{row}$, $1 \leq n \leq N_{col}$

N_{row} and N_{col} are the number of rows and columns, respectively, of the matrix Q.

$[Q]_{M:N}$ indicates a matrix consisting of columns M to N of matrix Q.

For a description on subcarrier indices over which the signal is transmitted for non-HT, HT and VHT PPDUs, see 22.3.7 (Mathematical description of signals).

For a 20 MHz HE Non-OFDMA PPDU transmission, the 20 MHz is divided into 256 subcarriers. The signal is transmitted on subcarriers –122 to –2 and 2 to 122, with 0 being the center (DC) subcarrier.

For a 20 MHz HE OFDMA PPDU transmission, the 20 MHz is divided into 256 subcarriers. The signal is transmitted on subcarriers –122 to –4 and 4 to 122, with 0 being the center (DC) subcarrier.

For a 40 MHz HE Non-OFDMA or OFDMA PPDU transmission, the 40 MHz is divided into 512 subcarriers. The signal is transmitted on subcarriers –244 to –3 and 3 to 244.

For an 80 MHz HE Non-OFDMA PPDU transmission, the 80 MHz is divided into 1024 subcarriers. The signal is transmitted on subcarriers –500 to –3 and 3 to 500.

For an 80 MHz HE OFDMA PPDU transmission, the 80 MHz is divided into 1024 subcarriers. The signal is transmitted on subcarriers –500 to –4 and 4 to 500.

For a 160 MHz HE PPDU transmission or a noncontiguous 80+80 MHz transmission, and each half 80 MHz bandwidth is divided into 1024 subcarriers, and the subcarriers on which the signal is transmitted in each 80 MHz bandwidth is identical to a 80 MHz HE PPDU transmission, depending on Non-OFDMA or OFDMA transmission within the correspond 80 MHz.

The transmitted signal is described in complex baseband signal notation. The actual transmitted signal is related to the complex baseband signal by the relation shown in Equation (26-2).

$$r_{RF}^{(i_{Seg},i_{TX})}(t) = \mathrm{Re}\left\{\frac{1}{\sqrt{N_{Seg}}} r_{PPDU}^{(i_{Seg},i_{TX})}(t)\exp\left(j2\pi f_c^{(i_{Seg})} t\right)\right\}, \quad i_{Seg} = 0,\ldots,N_{Seg}-1;\ i_{TX} = 1,\ldots,N_{TX} \tag{26-2}$$

where

N_{Seg} represents the number of frequency segments in the transmit signal, as defined in Table 26-3;

$r_{PPDU}^{(i_{Seg},i_{TX})}$ represents the complex baseband signal of frequency segment i_{Seg} and transmit chain i_{TX};

$f_c^{(i_{Seg})}$ represents the center frequency of the portion of the PPDU transmitted in frequency segment i_{Seg}.

The transmitted RF signal is derived by up-converting the complex baseband signal, which consists of several fields. The timing boundaries for the various fields are shown in Figure 26-21, where $N_{HE\text{-}LTF}$ is the number of HE-LTF symbols and is defined in Table 26-6, $N_{HE\text{-}SIG\text{-}B}$ is the number of symbols in the HE-SIG-B field, and N_{SYM} is the number of symbols in the Data field.

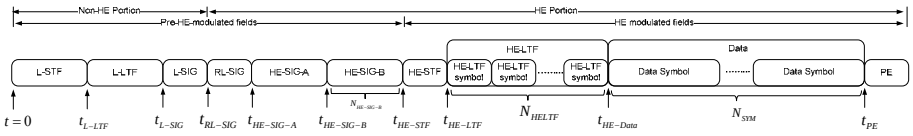


Figure 26-21 - TIming boundaries for HE PPDU fields

The time offset, t_{Field} , determines the starting time of the corresponding field relative to the start of L-STF (t = 0).

The signal transmitted on frequenct segment i_{Seg} of transmit chain i_{TX} shall be as shown in Equation (26-3).

$$
\begin{aligned}
r_{\text{PPDU}}^{(i_{Seg},i_{\text{TX}})}(t) = {} & r_{\text{L-STF}}^{(i_{Seg},i_{\text{TX}})}(t) + r_{\text{L-LTF}}^{(i_{Seg},i_{\text{TX}})}(t - t_{\text{L-LTF}}) \\
& + r_{\text{L-SIG}}^{(i_{Seg},i_{\text{TX}})}(t - t_{\text{L-SIG}}) + r_{\text{RL-SIG}}^{(i_{Seg},i_{\text{TX}})}(t - t_{\text{RL-SIG}}) \\
& + r_{\text{HE-SIG-A}}^{(i_{Seg},i_{\text{TX}})}(t - t_{\text{HE-SIG-A}}) + r_{\text{HE-SIG-B}}^{(i_{Seg},i_{\text{TX}})}(t - t_{\text{HE-SIG-B}}) \\
& + r_{\text{HE-STF}}^{(i_{Seg},i_{\text{TX}})}(t - t_{\text{HE-STF}}) + r_{\text{HE-LTF}}^{(i_{Seg},i_{\text{TX}})}(t - t_{\text{HE-LTF}}) \\
& + r_{\text{HE-Data}}^{(i_{Seg},i_{\text{TX}})}(t - t_{\text{HE-Data}}) + r_{\text{HE-PE}}^{(i_{Seg},i_{\text{TX}})}(t - t_{\text{HE-PE}})
\end{aligned}
\qquad \textbf{(26-3)}
$$

where

$0 \le i_{Seg} \le N_{Seg} - 1$

$1 \le i_{TX} \le N_{TX}$

$t_{L\text{-}LTF} = T_{L\text{-}STF}$

$t_{L\text{-}SIG} = t_{L\text{-}LTF} + T_{L\text{-}LTF}$

$t_{RL\text{-}SIG} = t_{L\text{-}SIG} + T_{L\text{-}SIG}$

$t_{HE\text{-}SIG\text{-}A} = t_{RL\text{-}SIG} + T_{RL\text{-}SIG}$

$$t_{HE\text{-}SIG\text{-}B} = \begin{cases} t_{HE\text{-}SIG\text{-}A} + T_{HE\text{-}SIG\text{-}A}, & \text{for an HE MU PPDU} \\ \textit{undefined}, & \text{otherwise} \end{cases}$$

$$t_{HE\text{-}STF} = \begin{cases} t_{HE\text{-}SIG\text{-}A} + T_{HE\text{-}SIG\text{-}A}, & \text{for an HE SU PPDU and HE trigger-based PPDU} \\ t_{HE\text{-}SIG\text{-}A} + T_{HE\text{-}SIG\text{-}A\text{-}R}, & \text{for an HE extended range SU PPDU} \\ t_{HE\text{-}SIG\text{-}B} + N_{HE\text{-}SIG\text{-}B} T_{HE\text{-}SIG\text{-}B}, & \text{for an HE MU PPDU} \end{cases}$$

where $N_{HE\text{-}SIG\text{-}B}$ is the number of OFDM symbols in the HE-SIG-B field

$$t_{HE\text{-}LTF} = \begin{cases} t_{HE\text{-}STF} + T_{HE\text{-}STF\text{-}T}, & \text{for an HE trigger-based PPDU} \\ t_{HE\text{-}STF} + T_{HE\text{-}STF\text{-}NT}, & \text{otherwise} \end{cases}$$

$$t_{HE\text{-}Data} = \begin{cases} t_{HE\text{-}LTF} + N_{HELTF} \cdot \left(T_{HE\text{-}LTF\text{-}1X} + T_{GI,HE\text{-}LTF}\right), & \text{for 1x HE-LTF} \\ t_{HE\text{-}LTF} + N_{HELTF} \cdot \left(T_{HE\text{-}LTF\text{-}2X} + T_{GI,HE\text{-}LTF}\right), & \text{for 2x HE-LTF} \\ t_{HE\text{-}LTF} + N_{HELTF} \cdot \left(T_{HE\text{-}LTF\text{-}4X} + T_{GI,HE\text{-}LTF}\right), & \text{for 4x HE-LTF} \end{cases}$$

$t_{PE} = t_{HE\text{-}Data} + N_{SYM} . T_{SYM}$

In an HE SU PPDU, HE MU PPDU and HE extended range SU PPDU, each field, $r_{Field}^{(i_{Seg},i_{\text{TX}})}(t)$, is defined as the summation of one or more subfields, where each subfield is defined to be an inverse discrete Fourier transform as specified in Equation (26-4).

$$r_{\text{Field}}^{(i_{Seg},i_{TX})}(t) = \eta_{\text{Field}} w_{T_{\text{Field}}}(t) \sum_{r=0}^{N_{RU}-1} \frac{\alpha_r \beta_r}{\sqrt{N_{Norm,r}}} \sum_{k\in K_r} \sum_{u=0}^{N_{user,r}-1} \sum_{m=1}^{N_{STS,r,u}} \left[Q_k^{(i_{Seg})} \right]_{i_{TX},(M_{r,u}+m)} \Upsilon_{k,\text{BW}} X_{k,r,u}^{(i_{Seg},m)} \exp\left(j2\pi k \Delta_{F,\text{Field}} (t - T_{GI,Field} - T_{CS,HE}(M_{r,u}+m)) \right) \quad \textbf{(26-4)}$$

In an HE trigger-based PPDU, transmitted by user-u in the r-th RU, each field, $r_{Field}^{(i_{Seg},i_{TX})}(t)$, is defined in Equation (26-5).

$$r_{\text{Field}}^{(i_{Seg},i_{TX})}(t) = \frac{\eta_{\text{Field}} \alpha_r \beta_r}{\sqrt{N_{Norm,r}}} w_{T_{\text{Field}}}(t) \sum_{k\in K_r} \sum_{m=1}^{N_{STS,r,u}} \left[Q_k^{(i_{Seg})} \right]_{i_{TX},(M_{r,u}+m)} \Upsilon_{k,\text{BW}} X_{k,r,u}^{(i_{Seg},m)} \exp\left(j2\pi k \Delta_{F,\text{Field}} (t - T_{GI,Field} - T_{CS,HE}(M_{r,u}+m)) \right) \quad \textbf{(26-5)}$$

In the remainder of this subclause, pre-HE modulated fields refer to the L-STF, L-LTF, L-SIG, RL-SIG, HE-SIG-A, and HE-SIG-B fields, while HE modulated fields refer to the HE-STF, HE-LTF, Data, and PE fields, as shown in Figure 26-21. The total power of the time domain HE modulated field signals summed over all transmit chains should not exceed the total power of the time domain pre-HE modulated field signals summed over all transmit chains. For notational simplicity, the parameter BW is omitted from some bandwidth dependent terms.

In Equation (26-4) the following notions are used:

N_{Field}^{Tone} Table 26-13 summarizes the various values of N_{Field}^{Tone} as a function of bandwidth per frequency segment. In the case of an HE OFDMA PPDU, the N_{Field}^{Tone} value of HE-STF, HE-LTF and HE-Data fields is variable, and is determined by which RUs of the current full bandwidth are transmitted in the PPDU.

Table 26-13 - Tone scaling factor and guard interval duration values for HE PPDU fields

Field	N_{Field}^{Tone} as a function of bandwidth, and RU size per frequency segment				Guard interval duration
	20 MHz	40 MHz	80 MHz	160 MHz	
L-STF	12	24	48	96	-
L-LTF	52	104	208	416	$T_{GI2,Data}$
L-SIG	56	112	224	448	$T_{GI,LegacyPreamble}$
RL-SIG	56	112	224	448	$T_{GI,LegacyPreamble}$
HE-SIG-A	56	112	224	448	$T_{GI,LegacyPreamble}$
HE-SIG-B	56	112	224	448	$T_{GI,LegacyPreamble}$
HE-STF not in HE_TRIG	14	30	62	126	-
HE-STF in HE_TRIG	30	60	124	248	-
HE-LTF 1x Duration	60	122	250	500	$T_{GI,HE-LTF1}$
HE-LTF 2x Duration	122	242	498	996	$T_{GI,HE-LTF2}$

HE-LTF 4x Duration	242	484	996	1992	$T_{GI,HE\text{-}LTF4}$
HE-Data	242	484	996	1992	$T_{GI,Data}$ or $T_{GI2,Data}$ or $T_{GI4,Data}$
NON_HT_DUP_ OFDM-Data	56	112	224	448	$T_{GI,LegacyPreamble}$
NOTE--in the case of an HE OFDMA PPDU, the N_{Field}^{Tone} value of HE-STF, HE-LTF and HE-Data fields is variable, and is determined by which RUs of the current full bandwidth are transmitted in the PPDU.					

$N_{\text{Norm},r}$ If the TXVECTOR parameter BEAM_CHANGE is 1, then for pre-HE modulated fields, $N_{\text{Norm},r} = N_{TX}$. If the TXVECTOR parameter BEAM_CHANGE is 0, then for pre-HE modulated fields $N_{\text{Norm},r} = N_{STS,r,total}$, where $N_{STS,r,total}$ is given in Table 26-6. For HE modulated fields $N_{\text{Norm},r} = N_{STS,r,total}$.

$w_{T_{\text{Field}}}(t)$ is a windowing function. An example function, $w_{T_{\text{Field}}}(t)$, is given in 18.3.2.5 (Mathematical conventions in the signal descriptions).

K_r For pre-HE modulated fields, K_r is the set of subcarriers indices from $-N_{SR}$ to N_{SR}. For HE modulated fields in a non-OFDMA HE PPDU, K_r is the set of subcarriers indices from $-N_{SR}$ to N_{SR}. For HE modulated fields in an OFDMA HE PPDU, K_r is the set of subcarrier indices for the tones in the r-th RU.

η_{Field} is the power boost factor per OFDM symbol, which is $\sqrt{2}$ for the L-STF and L-LTF fields in the HE extended range SU PPDU, and 1 otherwise.

α_r is the power boost factor for the r-th RU, where $\alpha_r \in [TBD_1, TBD_2]$

β_r is the per-RU power normalization factor and is defined in Equation (26-6)

$$\beta_r = \begin{cases} \dfrac{1}{\sqrt{N_{Field}^{Tone}}}, \text{ Pre-HE modulated Fields when BEAM\_CHANGE=1} \\ \sqrt{\dfrac{|K_r|}{|K_r^{Field}|}} \Big/ \sqrt{\sum_{r=1}^{N_{RU}} \alpha_r^2 |K_r|}, \text{ otherwise} \end{cases} \quad \textbf{(26-6)}$$

$|K_r|$ is the cardinality of the set of subcarriers K_r

K_r^{Field} is the set of subcarriers that have non-zero values within K_r in the HE-STF and Data fields, and defined in Equation (26-7) for the HE-LTF field.

$$K_r^{HELTF} = \begin{cases} |K_r|/4 & \text{for 1x HE-LTF} \\ |K_r|/2 & \text{for 2x HE-LTF} \\ |K_r| & \text{for 4x HE-LTF} \end{cases} \quad \textbf{(26-7)}$$

$Q_k^{(i_{Seg})}$ is the spatial mapping matrix for the subcarrier k in frequency segment i_{Seg}. For HE modulated fields, $Q_k^{(i_{Seg})}$ is a matrix with N_{TX} rows and $N_{STS,total}$ columns. If the TXVECTOR parameter

BEAM_CHANGE is 1, then for pre-HE modulated fields $Q_k^{(i_{Seg})}$ is a column vector with N_{TX} elements with element i_{TX} being $exp\left(-j2\pi k\Delta_{F,Pre-HE}T_{CS}^{i_{TX}}\right)$, where $T_{CS}^{i_{TX}}$ represents the cyclic shift for the transmitter chain whose values are TBD; otherwise it is identical to the spatial mapping $Q_k^{(i_{Seg})}$ for HE modulation fields.

$\Delta_{F,\text{Field}}$ is the subcarrier frequency spacing. For pre-HE modulated fields, $\Delta_{F,\text{Field}} = \Delta_{F,\text{Pre-HE}}$ given in Table 26-3. For HE modulated fields, $\Delta_{F,\text{Field}} = \Delta_{F,\text{HE}}$ given in Table 26-3.

$X_{k,r,u}^{(i_{Seg},m)}$ is the frequency-domain symbol in subcarrier k of user u in the r-th RU for frequency segment i_{Seg} of space-time stream m. Some of the $X_{k,u}^{(i_{Seg},m)}$ within $-N_{\text{SR}} \le k \le N_{\text{SR}}$ have a value of zero. Examples of such cases include the DC tones, guard tones on each side of the transmit spectrum, the leftover tones in an HE OFDMA PPDU, as well as the unmodulated tones of L-STF, HE-STF, and HE-LTF fields. Note that the multiplication matrices A_{HE-LTF}^{k} are included in the calculation of $X_{k,r,u}^{(i_{Seg},m)}$ for the HE-STF and HE-LTF fields. When the TXVECTOR parameter BEAM_CHANGE is 0, the first column of the multiplication matrices A_{HE-LTF}^{k} are included in the calculation of $X_{k,r,u}^{(i_{Seg},m)}$ for the pre-HE modulated fields.

$T_{GI,Field}$ is the guard interval duration used for each OFDM symbol in the field. The value for each field is as defined in Table 25-2 (Tone scaling factor and guard interval duration values for PHY fields).

$T_{CS,HE}(l)$ For pre-HE modulated fields, $T_{CS,HE}(l) = 0$. For HE modulated fields, $T_{CS,HE}(l)$ represents the cyclic shift per space-time stream, whose value is defined in Table 25-xx (Cyclic shift values for the HE modulated fields of a PPDU).

$\Upsilon_{k,\text{BW}}$ is used to represent a rotation of the tones. In HE modulated fields, $\Upsilon_{k,\text{BW}} = 1$ in all the subcarriers. In pre-HE modulated fields, BW in $\Upsilon_{k,\text{BW}}$ is determined by the TXVECTOR parameter CH_BANDWIDTH as defined in Table 26-14.

Table 26-14 - CH_BANDWIDTH and $\Upsilon_{k,\text{BW}}$ for pre-HE modulated fields

CH_BANDWIDTH	$\Upsilon_{k,\text{BW}}$
CBW20	$\Upsilon_{k,20}$
CBW40	$\Upsilon_{k,40}$
CBW80	$\Upsilon_{k,80}$
CBW160	$\Upsilon_{k,160}$
CBW80+80	$\Upsilon_{k,80}$ per frequency segments

For a 20 MHz PPDU transmission,

$$\Upsilon_{k,20} = 1 \quad \text{(26-8)}$$

For a 40 MHz PPDU transmission,

$$\Upsilon_{k,40} = \text{TBD} \quad \text{(26-9)}$$

For an 80 MHz PPDU transmission,

$$\Upsilon_{k,80} = \text{TBD} \quad \text{(26-10)}$$

For a noncontiguous 80+80 MHz PPDU transmission, each 80 MHz frequency segment shall use the phase rotation for 80 MHz PPDU transmissions as defined in Equation (26-10).

For a contiguous 160 MHz PPDU transmission,

$$\Upsilon_{k,160} = \text{TBD} \quad \text{(26-11)}$$

26.3.9 HE preamble

26.3.9.1 Introduction

The HE portion of HE format preamble consists of pre-HE modulated fields and HE modulated fields. The HE modulated fields consist of HE-STF and HE-LTF fields. The pre-HE modulated fields depend on the structure of the PPDU and consist of the following:

— RL-SIG and HE-SIG-A fields of an HE SU PPDU

— RL-SIG, HE-SIG-A and HE-SIG-B fields of an HE MU PPDU

— RL-SIG, HE-SIG-A and repeated HE-SIG-A fields of an HE Extended Range SU PPDU

— RL-SIG and HE-SIG-A fields of an HE Trigger-based PPDU

26.3.9.2 Cyclic shift for Pre-HE modulated fields

26.3.9.3 L-STF

If the TXVECTOR parameter BEAM_CHANGE is 1, the time domain representation of the L-STF field shall be as specified in Equation (26-12). The equation applies to all contiguous signals up to 160 MHz and non contiguous 80+80 MHz.

$$r_{\text{L-STF}}^{(i_{seg},i_{TX})}(t) = \frac{\eta}{\sqrt{N_{\text{TX}} \cdot N_{\text{L-STF}}^{\text{Tone}}}} w_{\text{T}_{\text{L-STF}}}(t) \sum_{i_{BW}=0}^{N_{20MHz}-1} \sum_{k=-26}^{26} \left(\Upsilon_{(k-K_{\text{Shift}}(i_{BW})),\text{BW}} S_{k,20} \cdot \exp\left(j2\pi \left(k - K_{\text{Shift}}(i_{\text{BW}}) \right) \Delta_{F,\text{Pre-HE}} \left(t - T_{GI,\text{LegacyPreamble}} - T_{CS}^{i_{TX}} \right) \right) \right) \quad \text{(26-12)}$$

where

η is an PPDU format dependent scaling factor, with the following value

$$\eta = \begin{cases} \sqrt{2}, & \text{HE extended range PPDU} \\ 1, & \text{otherwise} \end{cases} \quad \text{(26-13)}$$

N_{20MHz} is defined in 22.3.8.3.4 (L-SIG definition)

$K_{\text{Shift}}(i) = (N_{20\text{MHz}} - 1 - 2i) \cdot 32$

$T_{CS}^{i_{TX}}$ represents the cyclic shift for transmitter chain i_{TX} with a value given in 26.3.9.2 (Cyclic shift for Pre-HE modulated fields).

$\Gamma_{k,\text{BW}}$ is defined by Equation (22-14), Equation (22-15), Equation (22-16) and Equation (22-17).

$N_{\text{L-STF}}^{\text{Tone}}$ has the value given in Table 22-8 (Tone scaling factor and guard interval duration values for PHY fields(11ac)).

If the TXVECTOR parameter BEAM_CHANGE is 0, the time domain representation of the L-STF field of contiguous 20 MHz, 40 MHz, 80 MHz and 160 MHz transmission shall be as specified in Equation (26-14). The equation applies to all contiguous signals up to 160 MHz and non contiguous 80+80 MHz.

$$r_{\text{L-STF}}^{(i_{seg},i_{TX})}(t) = \frac{\eta}{\sqrt{N_{\text{TX}} \cdot N_{\text{L-STF}}^{\text{Tone}}}} w_{T_{\text{L-STF}}}(t) \sum_{i_{BW}=0}^{N_{20MHz}-1} \sum_{k=-26}^{26} \sum_{m=0}^{N_{STS,total}-1} \left(\begin{array}{l} \Upsilon_{(k-K_{\text{Shift}}(i_{BW})),\text{BW}} \left[Q_{4(k-K_{\text{Shift}}(i_{BW}))}^{(i_{seg})} \right]_{i_{TX},m} \left[A_{HELTF}^{4(k-K_{\text{Shift}}(i_{BW}))} \right]_{m,1} S_{k,20} \\ \cdot \exp\left(j2\pi \left(k - K_{\text{Shift}}(i_{\text{BW}}) \right) \Delta_{F,\text{Pre-HE}} \left(t - T_{GI,\text{LegacyPreamble}} - T_{CS}^{i_{TX}} \right) \right) \end{array} \right) \quad \textbf{(26-14)}$$

where

$T_{CS,\text{HE}}(n)$ is given in 26.3.9.2 (Cyclic shift for Pre-HE modulated fields).

$Q_k^{(i_{seg})}$ is defined in **Error! Reference source not found.**

A_{HELTF}^{k} is defined in Equation (26-57)

26.3.9.4 L-LTF

If the TXVECTOR parameter BEAM_CHANGE is 1, the time domain representation of the L-LTF field shall be as specified in Equation (26-15). The equation applies to all contiguous signals up to 160 MHz and non contiguous 80+80 MHz.

$$r_{\text{L-LTF}}^{(i_{seg},i_{TX})}(t) = \frac{\eta}{\sqrt{N_{\text{TX}} \cdot N_{\text{L-LTF}}^{\text{Tone}}}} w_{T_{\text{L-LTF}}}(t) \sum_{i_{BW}=0}^{N_{20MHz}-1} \sum_{k=-26}^{26} \left(\begin{array}{l} \Upsilon_{(k-K_{\text{Shift}}(i_{BW})),\text{BW}} L_{k,20} \\ \cdot \exp\left(j2\pi \left(k - K_{\text{Shift}}(i_{\text{BW}}) \right) \Delta_{F,\text{Pre-HE}} \left(t - T_{GI,\text{LegacyPreamble}} - T_{CS}^{i_{TX}} \right) \right) \end{array} \right) \quad \textbf{(26-15)}$$

where

η is an PPDU format dependent scaling factor, as defined in Equation (26-13).

$N_{20MHz}$is defined in 21.3.7.3 (Channel frequencies)

$K_{\text{Shift}}(i) = (N_{20\text{MHz}} - 1 - 2i) \cdot 32$

$T_{CS}^{i_{TX}}$ represents the cyclic shift for transmitter chain i_{TX} with a value given in 26.3.9.2 (Cyclic shift for Pre-HE modulated fields).

$\Gamma_{k,\text{BW}}$ is defined by Equation (22-14), Equation (22-15), Equation (22-16) and Equation (22-17).

$N_{\text{L-LTF}}^{\text{Tone}}$ has the value given in Table 22-8 (Tone scaling factor and guard interval duration values for PHY ields(11ac)).

If the TXVECTOR parameter BEAM_CHANGE is 0, the time domain representation of the L-LTF field of contiguous 20 MHz, 40 MHz, 80 MHz and 160 MHz transmission shall be as specified in Equation (26-16). The equation applies to all contiguous signals up to 160 MHz and non contiguous 80+80 MHz.

$$r_{\text{L-LTF}}^{(i_{seg},i_{TX})}(t)=\frac{\eta}{\sqrt{N_{\text{TX}}\cdot N_{\text{L-LTF}}^{\text{Tone}}}}w_{\text{T}_{\text{L-LTF}}}(t)$$
$$\sum_{i_{BW}=0}^{N_{20MHz}-1}\sum_{k=-26}^{26}\sum_{m=0}^{N_{STS,total}-1}\left(\begin{array}{l}\Upsilon_{(k-K_{\text{Shift}}(i_{BW})),\text{BW}}\left[Q_{4(k-K_{\text{Shift}}(i_{BW}))}^{(i_{seg})}\right]_{i_{TX},m}\left[A_{HELTF}^{4(k-K_{\text{Shift}}(i_{BW}))}\right]_{m,1}L_{k,20}\\ \cdot\exp\left(j2\pi\left(k-K_{\text{Shift}}(i_{\text{BW}})\right)\Delta_{F,\text{Pre-HE}}\left(t-T_{GI,\text{LegacyPreamble}}-T_{CS}^{i_{TX}}\right)\right)\end{array}\right) \quad \textbf{(26-16)}$$

where

$T_{CS,\text{HE}}(n)$ is given in 26.3.9.2 (Cyclic shift for Pre-HE modulated fields).

$Q_k^{(i_{seg})}$ is defined in **Error! Reference source not found.**

A_{HELTF}^{k} is defined in Equation (26-57)

26.3.9.5 L-SIG

The L-SIG field is used to communicate rate and length information. The structure of the L-SIG field is defined in Figure 18-5 (SIGNAL field bit assignment).

In a HE PPDU, the RATE field shall be set to the value representing 6 Mb/s in the 20 MHz channel spacing column of Table 18-6 (Contents of the SIGNAL field). In a non-HT duplicate PPDU, the RATE field is defined in 18.3.4.2 (RATE field) using the L_DATARATE parameter in the TXVECTOR.

The LENGTH field shall be set to the value given by Equation (26-17).

$$\text{Length}=\frac{\text{TXTIME}-20}{4}\times 3-3-m \quad \textbf{(26-17)}$$

where

TXTIME (in μs) is defined in 26.4.3 (TXTIME and PSDU_LENGTH calculation).

m is 1 for an HE MU PPDU and HE extended range SU PPDU, and 2 otherwise.

The LSB of the binary expression of the Length value shall be mapped to B5. In a non-HT duplicate PPDU, the LENGTH field is defined in 18.3.4.3 (LENGTH field) using the L_LENGTH parameter in the TXVECTOR.

The Reserved (R) field shall be set to 0.

The Parity (P) field has the even parity of bits 0-16.

The SIGNAL TAIL field shall be set to 0.

The L-SIG field shall be encoded, interleaved, and mapped following the steps described in 18.3.5.6 (Convolutional encoder), 18.3.5.7 (Data interleaving), and 18.3.5.8 (Subcarrier modulation mapping). The stream of 48 complex numbers generated by these steps is denoted by $d_k, k=0,\cdots,47$. Pilots shall be inserted as described in 18.3.5.9 (Pilot subcarriers). Extra 4 BPSK modulated tones are added, two at each edge of the subcarriers used by data and pilot tones. The 4 extra tones [-28, -27, 27, 28] of L-SIG in 20 MHz HE PPDU is [-1, -1, -1, 1].

If the TXVECTOR parameter BEAM_CHANGE is 1, the time domain waveform of the L-SIG field shall be as given by Equation (26-18).

$$r_{\text{L-SIG}}^{(i_{Seg},i_{TX})}(t)=\frac{1}{\sqrt{N_{L-SIG}^{\text{Tone}}N_{TX}}}w_{T_{L-SIG}}(t)\cdot\sum_{i_{BW}=0}^{N_{20MHz}-1}\sum_{k=-28}^{28}\left(\begin{array}{l}\Upsilon_{(k-K_{\text{Shift}}(i_{BW})),\text{BW}}\left(D_{k,20}+p_0P_k\right)\\ \cdot\exp\left(j2\pi\left(k-K_{\text{Shift}}\left(i_{\text{BW}}\right)\right)\Delta_{F,\text{Pre-HE}}\left(t-T_{GI,\text{LegacyPreamble}}-T_{CS}^{i_{TX}}\right)\right)\end{array}\right) \quad \textbf{(26-18)}$$

where

N_{20MHz} is defined in 21.3.7.3 (Channel frequencies)

$K_{\text{Shift}}(i) = (N_{20\text{MHz}} - 1 - 2i)\cdot 32$

$$D_{k,20}=\begin{cases}0, k=0,\pm7,\pm21\\ \pm1(TBD), k=\pm27,\pm28\\ d_{M_{20}^{r}(k)}, \text{otherwise}\end{cases}$$

$$M_{20}^{r}(k) = \begin{cases}k+26, -26\le k\le -22\\ k+25, -20\le k\le -8\\ k+24, -6\le k\le -1\\ k+23, 1\le k\le 6\\ k+22, 8\le k\le 20\\ k+21, 22\le k\le 26\end{cases}$$

P_k is defined in 18.3.5.10 (OFDM modulation)

p_0 is the first pilot value in the sequence defined in 18.3.5.10 (OFDM modulation)

$N_{\text{L-SIG}}^{\text{Tone}}$ has the value given in **Error! Reference source not found.**

$\Upsilon_{k,\text{BW}}$ is defined in Equation (26-8), Equation (26-9), Equation (26-10) and Equation (26-11).

$T_{CS}^{i_{TX}}$ represents the cyclic shift for transmitter chain i_{TX} with a value given in 26.3.9.2 (Cyclic shift for Pre-HE modulated fields)

NOTE—$M_{20}^{r}(k)$ is a "reverse" function of the function M(k) defined in 18.3.5.10 (OFDM modulation).

If the TXVECTOR parameter BEAM_CHANGE is 0, the time domain waveform of the L-SIG field shall be as given by Equation (26-19).

$$r_{L-SIG}^{(i_{seg},i_{TX})}(t)=\frac{1}{\sqrt{N_{\text{L-SIG}}^{\text{Tone}}N_{STS,total}}}w_{T_{L-SIG}}(t)\cdot\sum_{i_{BW}=0}^{N_{20MHz}-1}\sum_{k=-28}^{28}\sum_{m=0}^{N_{STS,total}-1}\left(\begin{array}{l}\left[Q_{4(k-K_{\text{Shift}}(i_{BW}))}^{(i_{seg})}\right]_{i_{TX},m}\left[A_{HELTF}^{4(k-K_{\text{Shift}}(i_{BW}))}\right]_{m,1}\left(D_{k,20}+p_0P_k\right)\\ \cdot\exp\left(j2\pi\left(k-K_{\text{Shift}}\left(i_{BW}\right)\right)\Delta_{F,\text{Pre-HE}}\left(t-T_{GI,\text{LegacyPreamble}}-T_{CS,HE}(m)\right)\right)\end{array}\right) \quad \textbf{(26-19)}$$

where

$T_{CS,\text{HE}}(n)$ is given in 26.3.9.2 (Cyclic shift for Pre-HE modulated fields)

$Q_k^{(i_{seg})}$ is defined in **Error! Reference source not found.**

A^{k}_{HELTF} is defined in **Error! Reference source not found.**

26.3.9.6 RL-SIG

The RL-SIG field is used to identify a HE PPDU.

The time domain waveform of the RL-SIG field is generated by repeating the time domain waveform of the L-SIG field, as defined in (26-20).

$$r^{(i_{Seg},i_{TX})}_{RL-SIG}(t) = r^{(i_{Seg},i_{TX})}_{L-SIG}(t) \quad \text{(26-20)}$$

26.3.9.7 HE-SIG-A

26.3.9.7.1 General

The HE-SIG-A field carries information required to interpret HE PPDUs. The structure of the HE-SIG-A field for the first part (HE-SIG-A1) and for the second part (HE-SIG-A2) is TBD.

26.3.9.7.2 Content

The HE-SIG-A field for an HE SU PPDU or an HE extended range SU PPDU contains the fields listed in Table 26-15.

Table 26-15 - Fields in the HE-SIG-A for an HE SU PPDU and HE extended range SU PPDU

Two Parts of HE-SIG-A	Bit	Field	Number of bits	Description
TBD	TBD	DL/UL	1	Indicates whether the PPDU is sent UL or DL. This field indicates DL for TDLS. NOTE—The TDLS peer can identify the TDLS frame by To DS and From DS fields in the MAC header of the MPDU.
	TBD	Format	1	Differentiate between an HE SU PPDU and an HE trigger-based PPDU or between an HE extended range SU PPDU and an HE trigger-based PPDU
	TBD	BSS Color	6	The BSS Color field is an identifier of the BSS
	TBD	Spatial Reuse	TBD	TBD
	TBD	TXOP Duration	TBD	Indicates the remaining time in the current TXOP. Details TBD.
	TBD	Bandwidth	2	Set to 0 for 20 MHz, 1 for 40 MHz, 2 for 80 MHz, 3 for 160 MHz and 80+80 MHz
	TBD	MCS	4	HE-MCS index
	TBD	CP+LTF Size	3	To indicate the CP length and HE-LTF size, the current combinations are 1x HE-LTF + 0.8 μs, 2x HE-LTF + 0.8 μs, 2x HE-LTF + 1.6 μs and 4x HE-LTF + 3.2 μs. Other combinations are TBD.
	TBD	Coding	2	Indication of BCC/LDPC and presence of the extra OFDM symbol for LDPC. Detailed indication is TBD.
	TBD	Nsts	3	Indicates the number of spatial streams: Set to 0 for 1 space time stream Set to 1 for 2 space time streams Set to 2 for 3 space time streams Set to 3 for 4 space time streams Set to 4 for 5 space time streams Set to 5 for 6 space time streams Set to 6 for 7 space time streams Set to 7 for 8 space time streams
	TBD	STBC	1	Set to 1 if space time block coding is used and set to 0 otherwise.

	TBD	TxBF	1	Set to 1 if a Beamforming steering matrix is applied to the waveform in an SU transmission, set to 0 otherwise.
	TBD	DCM	1	Set to 1 indicates that the payload of the SU PPDU is modulated with dual sub-carrier modulation for the MCS. Set to 0 indicates that the payload of the PPDU is not modulated with dual sub-carrier modulation for the MCS.
	TBD	Packet Extension	3	The first two bits indicate the "*a-factor*" and the third bit indicates the PE-Disambiguity.
	TBD	Beam Change	1	Set to 1 indicates that the pre-HE-STF portion of the SU PPDU is spatially mapped differently from HE-LTF1. Set to 0 indicates that the pre-HE-STF portion of the SU PPDU is spatially mapped the same way as HE-LTF1 on each tone.
	TBD	CRC	4	CRC of bits 0–41 in HT-SIG-A. See 22.3.9.7.1 (CRC calculation for HE-SIG-A). The first bit to be transmitted is bit C3 as explained in 20.3.9.7.1 (CRC calculation for HE-SIG).
	TBD	Tail	6	Used to terminate the trellis of the convolutional decoder. Set to 0.

NOTE—The HE-SIG-A field contents for the HE extended range SU PPDU may be subject to change.

The HE-SIG-A field of an HE MU PPDU contains the fields listed in Table 26-16.

Table 26-16 - Fields in the HE-SIG-A for a HE MU PPDU

Two Parts of HE-SIG-A	Bit	Field	Number of Bits	Description
TBD	TBD	DL/UL	1	Indicates whether the HE MU PPDU is UL or DL. This field indicates DL for TDLS. NOTE—The TDLS peer can identify the TDLS frame by To DS and From DS fields in the MAC header of the 11ax MPDU.
	TBD	BSS Color	6	The BSS Color field is an identifier of the BSS
	TBD	Spatial Reuse	TBD	TBD
	TBD	TXOP Duration	TBD	Indicates the remaining time in the current TXOP. Details TBD.
	TBD	Bandwidth	≥ 2	Set to 0 for 20 MHz, 1 for 40 MHz, 2 for 80 MHz, 3 for 160 MHz and 80+80 MHz
	TBD	SIGB MCS	3	Indication the MCS of HE-SIG-B. Set to 0 for MCS0 Set to 1 for MCS1 Set to 2 for MCS2 Set to 3 for MCS3 Set to 4 for MCS4 Set to 5 for MCS5
	TBD	SIGB DCM	1	Set to 1 indicates that the HE-SIG-B is modulated with dual sub-carrier modulation for the MCS. Set to 0 indicates that the HE-SIB-B is not modulated with dual sub-carrier modulation for the MCS.
	TBD	SIGB Number Of Symbols	4	Indciates the number of HE-SIG-B symbols.
	TBD	SIGB Compression	1	Set to 1 for full BW MU-MIMO. Set to 0 otherwise.
	TBD	Number of HE-LTF Symbols	3	Indicates the number of HE-LTF symbols.

	TBD	CP+LTF Size	3	To indicate the CP length and HE-LTF size, the current combinations are 1x HE-LTF + 0.8 μs, 2x HE-LTF + 0.8 μs, 2x HE-LTF + 1.6 μs and 4x HE-LTF + 3.2 μS. Other combinations are TBD.
	TBD	LPDC Extra Symbol	1	Indication of the presence of the extra OFDM symbol for LDPC.
	TBD	Packet Extension	3	The first two bits indicate the "a-factor" and the third bit indicates the PE-Disambiguity.
	TBD	CRC	4	CRC of bits 0–41 in HT-SIG-A. See 22.3.9.7.1 (CRC calculation for HE-SIG-A). The first bit to be transmitted is bit C3 as explained in 20.3.9.7.1 (CRC calculation for HE-SIG).
	TBD	Tail	6	Used to terminate the trellis of the convolutional decoder. Set to 0.

The HE-SIG-A field for an HE trigger-based PPDU contains the fields listed in Table 26-17.

Table 26-17 - HE Fields in the HE-SIG-A for a HE trigger-based PPDU

Two Parts of HE-SIG-A	Bit	Field	Number of Bits	Description
TBD	TBD	Format	1	Set to 0 for an HE SU PPDU Set to 1 for an HE trigger-based PPDU
	TBD	BSS Color	6	The BSS Color field is an identifier of the BSS
	TBD	Spatial Reuse	TBD	TBD
	TBD	TXOP Duration	TBD	Indicates the remaining time in the current TXOP. Details TBD.
	TBD	Bandwidth	TBD	TBD
	TBD	Reserved	TBD	TBD
	TBD	CRC	4	CRC of bits 0–41 in HT-SIG-A. See 22.3.9.7.1 (CRC calculation for HE-SIG-A). The first bit to be transmitted is bit C3 as explained in 20.3.9.7.1 (CRC calculation for HE-SIG).
	TBD	Tail	6	Used to terminate the trellis of the convolutional decoder. Set to 0.

26.3.9.7.3 CRC computation

The CRC computation defined in this subclause applies to HE-SIG-A, the Common field of HE-SIG-B and the User Specific field of HE-SIG-B.

The CRC protects bits 0–L of the HE-SIG (L=41 for HE-SIG-A, or L=x for each HE-SIG-B common block fields, or L=x for HE-SIG-B user specific fields). The value of the CRC field shall be the 1s complement of

$$crc(D) = \big(M(D) + I(D)\big)D^8 \; mod \; G(D)$$

where

$$M(D) = \sum_{i=0}^{L} m_{L-i} D^i$$

where

m_i is bit i in the field

$$I(D) = \sum_{i=L-7}^{L} D^i$$

$G(D)$ and $crc(D)$ are defined in Equation (20-18).

The CRC field is transmitted from c_5 to c_7 with c_7 first.

Figure 20-8 (HT-SIG CRC calculation) shows the operation of the CRC, where the serial input are from m_L to m_0, and the output is stopped at c_4.

26.3.9.7.4 Encoding and modulation

For an HE SU PPDU, HE MU PPDU and HE trigger-based PPDU, the HE-SIG-A field is composed of two parts, HE-SIG-A1 and HE-SIG-A2, each containing 26 data bits. HE-SIG-A1 is transmitted before HE-SIG-A2. The HE-SIG-A symbols shall be BCC encoded at rate, R = 1/2, interleaved, mapped to a BPSK constellation, and have pilots inserted following the steps described in 18.3.5.6 (Convolutional encoder), 18.3.5.7 (Data interleaving), 18.3.5.8 (Subcarrier modulation mapping), and 18.3.5.9 (Pilot subcarriers), respectively. The constellation mappings of HE-SIG-A in HE SU PPDU, HE MU PPDU and HE trigger-based PPDU are shown in Figure 26-22. The first and second half of the stream of 104 complex numbers generated by these steps (before pilot insertion) is divided into two groups of 52 complex numbers, where respectively, the first 52 complex numbers form the first symbol of HE-SIG-A and the second 52 complex numbers form the second symbol of HE-SIG-A. If the TXVECTOR parameter BEAM_CHANGE is 1, the time domain waveform for the HE-SIG-A field of an HE SU PPDU, HE MU PPDU and HE trigger-based PPDU shall be as specified in Equation (26-21).

$$r_{\text{HE-SIG-A}}^{(i_{\text{Seg}},i_{TX})}(t) = \frac{1}{\sqrt{N_{HE-SIG-A}^{\text{Tone}} N_{TX}}} \sum_{n=0}^{1} w_{T_{SYML}}(t - nT_{SYML}) \cdot \sum_{i_{BW}=0}^{N_{20MHz}-1} \sum_{k=-28}^{28} \left(\begin{array}{l} \Upsilon_{(k-K_{\text{Shift}}(i_{BW})),\text{BW}} \left(D_{k,n,BW} + p_{n+2} P_k \right) \\ \cdot \exp\left(j2\pi \left(k - K_{\text{Shift}}(i_{\text{BW}}) \right) \Delta_{F,\text{Pre-HE}} \left(t - nT_{SYML} - T_{GI,LEgacy\,Preamble} - T_{CS}^{i_{TX}} \right) \right) \end{array} \right) \quad \textbf{(26-21)}$$

where

N_{20MHz} is defined in 21.3.7.3 (Channel frequencies)

$K_{\text{Shift}}(i) = (N_{20\text{MHz}} - 1 - 2i) \cdot 32$

$$D_{k,n,20} = \begin{cases} 0, k = 0, \pm 7, \pm 21 \\ d_{M_{20}^{r'}(k),n}, \text{otherwise} \end{cases}$$

$$M_{20}^{r'}(k) = \begin{cases} k + 28, -28 \le k \le -22 \\ k + 25, -20 \le k \le -8 \\ k + 24, -6 \le k \le -1 \\ k + 23, 1 \le k \le 6 \\ k + 22, 8 \le k \le 20 \\ k + 21, 22 \le k \le 28 \end{cases}$$

P_k and p_n are defined in 18.3.5.10 (OFDM modulation).

$N_{HE-SIG-A}^{Tone}$ has the value given in **Error! Reference source not found.**

$\Upsilon_{k,\text{BW}}$ is defined in Equation (26-8), Equation (26-9), Equation (26-10) and Equation (26-11).

$T_{CS}^{i_{TX}}$ represents the cyclic shift for transmitter chain i_{TX} with a value given in 26.3.9.2 (Cyclic shift for Pre-HE modulated fields)

If the TXVECTOR parameter BEAM_CHANGE is 0, the time domain waveform of the HE-SIG-A field shall be as given by Equation (26-22).

$$r_{HE-SIG-A}^{(i_{seg},i_{TX})}(t)=\frac{1}{\sqrt{N_{\text{HE-SIG-A}}^{\text{Tone}}N_{STS,total}}}\sum_{n=0}^{1}w_{T_{SYML}}(t-nT_{SYML})$$
$$\cdot\sum_{i_{BW}=0}^{N_{20MHz}-1}\sum_{k=-28}^{28}\sum_{m=0}^{N_{STS,total}-1}\left(\begin{array}{l}\left[Q_{4(k-K_{\text{Shift}}(i_{BW}))}^{(i_{seg})}\right]_{i_{TX},m}\left[A_{HELTF}^{4(k-K_{\text{Shift}}(i_{BW}))}\right]_{m,1}(D_{k,20}+p_{n+2}P_k)\\ \cdot\exp\left(j2\pi(k-K_{\text{Shift}}(i_{BW}))\Delta_{F,\text{Pre-HE}}(t-nT_{SYML}-T_{GI,\text{LegacyPreamble}}-T_{CS,HE}(m))\right)\end{array}\right)$$
(26-22)

where

$T_{CS,\text{HE}}(n)$ is given in 26.3.9.2 (Cyclic shift for Pre-HE modulated fields)

$Q_k^{(i_{seg})}$ is defined in **Error! Reference source not found.**

A_{HELTF}^{k} is defined in Equation (26-57)

For an HE extended range SU PPDU, the HE-SIG-A field is composed of four parts, i.e. HE-SIG-A1, HE-SIG-A2, HE-SIG-A3 and HE-SIG-A4, each part containing 26 data bits. These four parts are transmitted sequentially from HE-SIG-A1 to HE-SIG-A4. HE-SIG-A1 and HE-SIG-A2 have the same data bits. HE-SIG-A3 and HE-SIG-A4 have same data bits. The data bits of HE-SIG-A1 and HE-SIG-A3 shall be BCC encoded at rate, R = 1/2, interleaved, mapped to a BPSK constellation, and have pilots inserted. HE-SIG-A2 shall be BCC encoded at rate, R=1/2, mapped to a QBPSK constellation and have pilots inserted. The constellation mappings of the HE-SIG-A field in an HE extended range SU PPDU is shown in Figure 26-22. QBPSK constellation on HE-SIG-A2 is used to differentiate between an HE extended range SU PPDU and an HE MU PPDU. HE-SIG-A4 shall be BCC encoded at rate, R=1/2, mapped to a BPSK constellation and have pilots inserted. BCC encoding, Data interleaving, constellation mapping and pilot insertion follow the steps described in 18.3.5.6 (Convolutional encoder), 18.3.5.7 (Data interleaving), 18.3.5.8 (Subcarrier modulation mapping), and 18.3.5.9 (Pilot subcarriers), respectively.

If the TXVECTOR parameter BEAM_CHANGE is 1, the time domain waveform for the HE-SIG-A field in an HE extended range SU PPDU, shall be as specified in Equation (26-23).

$$r_{\text{HE-SIG-A}}^{(i_{Seg},i_{TX})}(t)=\frac{1}{\sqrt{N_{HE-SIG-A}^{\text{Tone}}N_{TX}}}\sum_{n=0}^{3}w_{T_{SYML}}(t-nT_{SYML})$$
$$\cdot\sum_{i_{BW}=0}^{N_{20MHz}-1}\sum_{k=-28}^{28}\left(\begin{array}{l}\Upsilon_{(k-K_{\text{Shift}}(i_{BW})),\text{BW}}(R_nD_{k,n,BW}+p_{n+2}P_k)\\ \cdot\exp\left(j2\pi(k-K_{\text{Shift}}(i_{\text{BW}}))\Delta_{F,\text{Pre-HE}}(t-nT_{SYML}-T_{GI,LEgacy\,Preamble}-T_{CS}^{i_{TX}})\right)\end{array}\right)$$
(26-23)

where

R is a phase rotation vector defined as $[1, j, 1, 1]$.

If the TXVECTOR parameter BEAM_CHANGE is 0, the time domain waveform for the HE-SIG-A field in an HE extended range SU PPDU, shall be as specified in Equation (26-24).

$$r_{HE-SIG-A}^{(i_{seg},i_{TX})}(t)=\frac{1}{\sqrt{N_{\text{HE-SIG-A}}^{\text{Tone}}N_{STS,total}}}\sum_{n=0}^{3}w_{T_{SYML}}(t-nT_{SYML})$$
$$\cdot\sum_{i_{BW}=0}^{N_{20MHz}-1}\sum_{k=-28}^{28}\sum_{m=0}^{N_{STS,total}-1}\left(\begin{array}{l}\left[Q_{4(k-K_{\text{Shift}}(i_{BW}))}^{(i_{seg})}\right]_{i_{TX},m}\left[A_{HELTF}^{4(k-K_{\text{Shift}}(i_{BW}))}\right]_{m,1}(R_nD_{k,20}+p_{n+2}P_k)\\ \cdot\exp\left(j2\pi(k-K_{\text{Shift}}(i_{BW}))\Delta_{F,\text{Pre-HE}}(t-nT_{SYML}-T_{GI,\text{LegacyPreamble}}-T_{CS,HE}(m))\right)\end{array}\right)$$
(26-24)

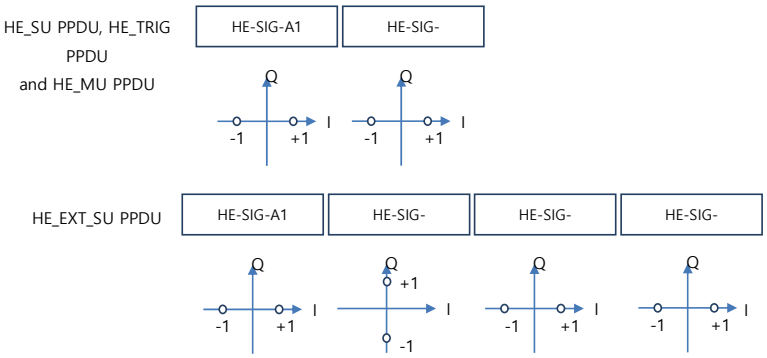


Figure 26-22 - Data tone constellation of HE-SIG-A symbols

26.3.9.8 HE-SIG-B

26.3.9.8.1 Encoding and modulation

The HE-SIG-B field is separately encoded on each 20 MHz band. The encoding structure in one such 20 MHz band is shown in Figure 26-23. It consists of a Common Block field followed by a User Specific field.

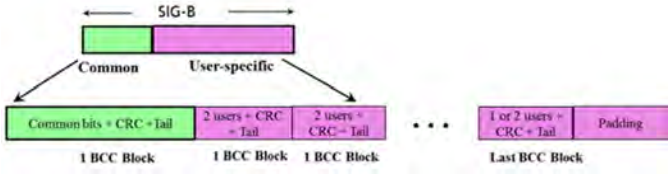


Figure 26-23 – HE-SIG-B field encoding structure in each 20 MHz

The Common Block field contains information regarding the resource unit allocation such as the RU arrangement in frequency domain, the RUs allocated for MU-MIMO and the number of users in MU-MIMO allocations. The Common Block field is described in detail in 25.3.9.2.5.2

The User Specific field consists of multiple User Block fields. Each User Block field contains information for two STAs to decode their payloads. The last User Block field may contain information for only one STA, if the number of user fields indicated by the RU allocation signaling in the common block is odd. See 25.3.9.2.5.3 for a description of the contents of the User Block field.

26.3.9.8.1.1 Frequency domain mapping

For 20 MHz and 40 MHz PPDUs, the Common Block field and the User field for a STA are transmitted in the same 20 MHz band as the STA's data as shown in Figure 26-24 and Figure 26-25.



Figure 26-24 HE-SIG-B content channel for a 20 MHz PPDU

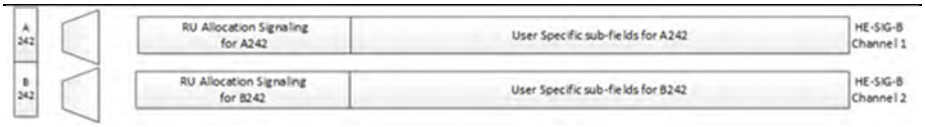


Figure 26-25 - HE-SIG-B content channels for a 40 MHz PPDU

For an 80 MHz PPDU, the default frequency mapping of the Common Block field and User Specific fields is shown in Figure 26-26. The HE-SIG-B field content in the 1st and 3rd 20 MHz bands from the top are identical. The information carried in either of these bands is called HE-SIG-B content channel 1. HE-SIG-B content channel 1 carries signaling information for all STAs whose payloads occupy some tones in A242 or C242. Similarly, the HE-SIG-B contents on the 2nd and 4th 20 MHz bands are identical. The information carried in either of these bands is called HE-SIG-B content channel 2. HE-SIG-B content channel 2 carries signaling information for all STAs whose payloads occupy some tones in B242 or D242.



Figure 26-26 - Default mapping of the two HE-SIG-B channels and their duplication in an 80 MHz PPDU

For a 160 MHz PPDU, the default frequency mapping of the Common Block field and User Specific fields is shown in Figure 26-27. The HE-SIG-B content in the 1st, 3rd, 5th and 7th 20 MHz bands from top are all identical. The information carried in any of these bands is called HE-SIG-B content channel 1. HE-SIG-B content channel 1 carries signaling information for all STAs whose payloads occupy some tones in A1-242 or C1-242 or A2-242 or C2-242. Similarly, the HE-SIG-B contents in the 2nd, 4th, 6th and 8th 20 MHz bands from top are identical. The information carried in any of these bands is called HE-SIG-B content channel 2. HE-SIG-B content channel 2 carries signaling information for all STAs whose payloads occupy some tones in B1-242 or D1-242 or B2-242 or D2-242.



Figure 26-27 - Default mapping of the two HE-SIG-B channels and their duplication in a 160 MHz PPDU

For MU-MIMO allocation of RU size > 20 MHz, the User Block subfields are dynamically split between the two HE-SIG-B content channels (1/2) and the split is decided by the AP (on a per case basis). See 25.3.9.2.5.2 and 25.3.9.2.5.3 for more details.

26.3.9.8.1.2 Time domain encoding

In each 20 MHz band, the bits in the Common Block field shall have CRC and tail bits added and then be BCC encoded at rate R = ½. Padding bits are not added after the common block.

In the User Specific field, in any 20 MHz band, the bits corresponding to two STAs (i.e. two User fields) are encoded together. Specifically, the STAs scheduled in the HE-MU-PPDU are split into groups of two. Each group of two User fields shall have CRC and tail bits added and then BCC encoded at rate R = ½ using the encoder described in 18.3.5.6. If the number of users is even, padding bits are added to round up the number of symbols to the nearest integer. If the number of users is odd, the User Block field corresponding to the last user, who is not grouped, is encoded after adding tail and CRC bits and only then are any padding bits added. The padding bits added ensure that both content channels have the same number of symbols. The specific method of generating padding bits is TBD. When the code rate is not equal to ½, the convolutional encoder output bits for each field (including padding bits) are concatenated, then the concatenated bit streams are punctured continuously as described in 18.3.5.6 (Convolutional encoder).

The number of data tones in each symbol is N_{SD} = 52. The coded bits are interleaved as in 22.3.10.8, with the parameter N_{col} = 13 (as in Table 22-17, for 20 MHz). The interleaved bits are mapped to constellation points from the MCS specified in HE-SIG-A and have pilots inserted following the steps described in 18.3.5.7 (Data Interleaving), 18.3.5.8 (Subcarrier modulation mapping) and 18.3.5.9 (Pilot subcarriers) respectively.

The cyclic prefix used for HE-SIG-B shall be 0.8 μs. The number of symbols in HE-SIG-B, denoted by $N_{SYM,HE\text{-}SIG\text{-}B}$, shall be signaled in HE-SIG-A in the default mode (see Section 25.3.9.2.4). For the cth content channel (c = 1 or 2), denote the sample on the kth subcarrier of the nth symbol by $d_{k,n,c}$. The time domain waveform for the HE-SIG-B follows Equation (26-25).

$$r_{HE-SIG-B}^{(i_{Seg},i_{Tx})}(t)=\frac{1}{\sqrt{N_{HE-SIG-B}^{Tone}N_{Tx}}}\sum_{n=0}^{N_{sym,HE-SIG-B}}w_{T_{HE-SIG-B}}(t-nT_{SYML})\sum_{i_{BW}=0}^{N_{20MHz}-1}\sum_{k=-N_{SR}}^{N_{SR}}\Upsilon_{(k-K_{shift}(i_{BW})),BW}$$
$$\left(D^{i_{Seg}}{}_{k,n,i_{BW}}+p_{n+4}P_k\right)\exp\left(j2\pi(k-K_{shift}(i_{BW}))\Delta_{F,Pre-HE}(t-nT_{SYML}-T_{GI,LEgacyPreamble}-T_{CS}^{i_{TX}})\right) \quad \textbf{(26-25)}$$

where

N_{20MHz} and $K_{shift}(i)$ are defined in 22.3.8.2.4 (L-SIG definition)

$$D_{k,n,i_{BW}}^{i_{Seg}}=\begin{cases}0,k=0,\pm7,\pm21\\ d_{M_{20}^{r}(k),n,(i_{BW}\bmod 2)+1},otherwise\end{cases}$$

$$M_{20}^{r}(k)=\begin{cases}k+28,-28\le k\le -22\\ k+27,-20\le k\le -8\\ k+26,-6\le k\le -1\\ k+25,1\le k\le 6\\ k+24,8\le k\le 20\\ k+23,22\le k\le 28\end{cases}$$

P_k and p_n are defined in 18.3.5.10 (OFDM modulation)

$\Upsilon_{k,BW}$ is defined in Equation (25-4), Equation (25-7), Equation (24-7) and Equation (24-8)

$N_{sym,HE-SIG-B}$ is the number of symbols in HE-SIG-B

26.3.9.8.2 HE-SIG-B common content

The Common block field in the HE-SIG-B carries RU allocation subfields. Depending on the PPDU bandwidth, the Common block field can contain multiple RU allocation subfields.

An RU allocation subfield in the Common block field of HE-SIG-B consists of 8 bits that indicates the following for a 20 MHz PPDU BW:

— The RU arrangement in the frequency domain: indexes the size of the RUs and their placement in the frequency domain.

— Number of user fields in each RU in the HE-SIG-B content channel: the number of users multiplexed in the RUs indicated by the arrangement; for RUs of size greater than or equal to 106 tones that support MU-MIMO, it indicates the number of users multiplexed using MU-MIMO.

The mapping of the 8-bit RU allocation subfield to the RU arrangement and the number of user fields per RU is defined in the Table 26-18. In the table, the number of entries column refers to the number of 8-bit indices that refer to the same RU arrangement in the frequency domain but differ in the number of users fields per RU. The RU arrangement and the number of user fields per RU together indicate the number of user-fields in the User specific field of HE-SIG-B. Signaling for the center 26 unit in 80 MHz is [TBD].

Table 26-18 - RU allocation signalling: Arrangement and number of MU-MIMO allocations

8 bits indices	#1	#2	#3	#4	#5	#6	#7	#8	#9	Number of entries
000 0 0000	26	26	26	26	26	26	26	26	26	1
000 0 0001	26	26	26	26	26	26	26	52		1
000 0 0010	26	26	26	26	26	52		26	26	1
000 0 0011	26	26	26	26	26	52		52		1
000 0 0100	26	26	52		26	26	26	26	26	1
000 0 0101	26	26	52		26	26	26	52		1
000 0 0110	26	26	52		26	52		26	26	1
000 0 0111	26	26	52		26	52		52		1
000 0 1000	52		26	26	26	26	26	26	26	1
000 0 1001	52		26	26	26	26	26	52		1
000 0 1010	52		26	26	26	52		26	26	1
000 0 1011	52		26	26	26	52		52		1
000 0 1100	52		52		26	26	26	26	26	1
000 0 1101	52		52		26	26	26	52		1
000 0 1110	52		52		26	52		26	26	1
000 0 1111	52		52		26	52		52		1
000 1 xxxx	Definition TBD									16
00100 yyy	26	26	26	26	26	106				8
00101 yyy	26	26	52		26	106				8
00110 yyy	52		26	26	26	106				8
00111 yyy	52		52		26	106				8
01000 yyy	106				26	26	26	26	26	8
01001 yyy	106				26	26	26	52		8
01010 yyy	106				26	52		26	26	8
01011 yyy	106				26	52		52		8
011 xxxxx	Definition TBD									32
10 yyy yyy	106				26	106				64
11 0 00yyy	242									8
11 0 01yyy	484									8
11 0 10yyy	996									8
11 0 11yyy	2*996									8
11 1 xxxxx	Definition TBD									32

NOTE: yyy' = 000~111 indicates number of STAs multiplexed in an RU. Binary vector yyy is indexed as $[y[3]y[2]y[1]]$ indicates $2^2 \times y[3] + 2^1 \times y[2] + y[1] + 1$ STAs multiplexed in the RU.

The definition for entries with 'x' bits is TBD.

The number of RU allocation subfields in the HE-SIG-B common block field depends on the total PPDU bandwidth

— In the default mode, for 20 MHz and 40 MHz PPDU, each HE-SIG-B content channel contains one RU allocation subfield followed by multiple user fields. The position of the user-field in the user-specific field together with the 8-bit RU allocation subfield indicates the RU assignment to the user.

— In the default mode for the 80 MHz PPDU, each HE-SIG-B content channel contains two RU allocation subfields for a total of 16 bits of RU allocation signaling, one each for the RUs in the two 20 MHz segments of the HE-SIG-B content channel. The user fields corresponding to the first RU allocation signaling field are followed by the user fields indicated by the second RU allocation signaling field in the user specific field.

In the default mode for the 160 MHz PPDU, each HE-SIG-B content channel contains four RU allocation signaling fields for a total of 32 bits of RU allocation signaling, one each for the RUs in the four 20 MHz segments of the HE-SIG-B content channel. The user fields for each of the 20 MHz segments in the content channel are arranged by the order in which their RU allocation signaling fields appear in the common field.

26.3.9.8.3 HE-SIG-B per-user content

The user-specific field consists of multiple user fields. The user fields follow the common block field of HE-SIG-B. The RU allocation subfield in the Common block field and the position of the user field in the HE-SIG-B user specific field together identify the RU used to transmit a STA's data. An example for the mapping of the 8-bit RU allocation subfield and the position of the user field to an STA's data is illustrated in Figure 26-28. The RU arrangement signaling indicates an arrangement of 106 tone RU followed by five 26-tone RUs and that the 106-tone RU contains three user-fields, i.e., the 106-tone RU supports multiplexing of three users using MU-MIMO. The eight user fields in the HE-SIG-B user-specific field thus map to the 6 RUs, with the first three user fields indicating MU-MIMO allocations in the first 106-tone RU followed by user fields corresponding to the each of the five 26-tone RUs.

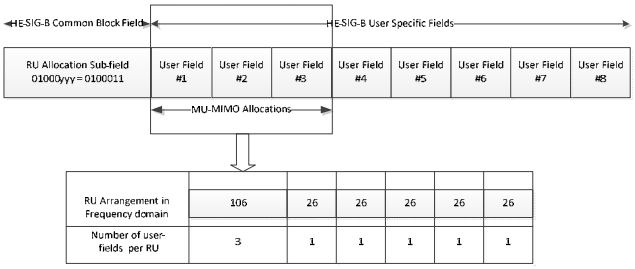


Figure 26-28 - Illustration for the mapping of the 8-bit RU allocation subfield and the position of the user-field to the STA's assignment

The contents of the user field differ based on whether the field addresses a single-STA in an RU or a STA in a MU-MIMO allocation in an RU. Irrespective of whether the allocation is for a STA in a SU or an MU-MIMO allocation, the size of the userfield is the same.

The HE-SIG-B user field for a SU allocation contain the subfields shown in Table 26-19.

Table 26-19 - Fields of the HE-SIG-B user field for a SU allocation

Bit	Subfield	Number of bits	Description
TBD	STA-ID	11	The STA identifier that addresses a STA – reference to MAC section(?). For RUs that carry a broadcast allocation: For single BSS AP, the STAID for Broadcast will be 0; For Multiple BSS AP, the STAID for Broadcast to a specific BSS will follow the group addressed AID assignment in the TIM according to the existing Multi-BSSID TIM operation; For Multiple BSS AP, the STAID for Broadcast to all BSS of the AP will have a special STAID value reserved.
TBD	NSTS	3	Number of spatial streams
TBD	Tx Beamforming	1	Use of transmit beamforming
TBD	MCS	4	Modulation and Coding Scheme
TBD	DCM	1	Indication for use of dual carrier modulation
TBD	Coding	1	Indication for use of LDPC

The HE-SIG-B user field for an STA in MU-MIMO allocation contain the subfields shown in Table 26-20.

Table 26-20 - Fields of the HE-SIG-B user field for a MU-MIMO allocation

Bit	Subfield	Number of bits	Description
TBD	STA-ID	11	The STA identifier that addresses an STA – reference to MAC section(?)
TBD	Spatial Configuration	4	Indication for the number of spatial streams for a STA in a MU-MIMO allocation. See Table 26-21.
TBD	MCS	4	Modulation and Coding Scheme
TBD	DCM	1	Use of dual carrier modulation
TBD	Coding	1	Use of LDPC

A user field for an MU-MIMO allocation includes a Spatial Configuration subfield consisting of 4 bits that indicates the number of spatial streams for each STA and the total number of spatial streams in the MU-MIMO allocation. The subfield shown in Table 26-21 is constructed by using the entries corresponding to the value of number of users (Nuser) multiplexed using MU-MIMO in an RU. When MU-MIMO is used in an RU of size ≤ 20 MHz, the number of users (Nuser) in an MU-MIMO allocation is equal to the number of user-fields per RU signalled for the RU in the RU allocation subfield of an HE-SIG-B Common block field. When MU-MIMO is used in RUs of size 20 MHz or greater, the number of users (Nuser) in an MU-MIMO allocation is computed as the sum of the number of user-fields per RU indicated for the RU by the 8-bit RU allocation subfield in each HE-SIG-B content channel. For a given value of Nuser, the four bits of the spatial configuration subfield are used as follows: A STA with a STA-ID that matches the 11-bit ID signalled in the user field for an MU-MIMO allocation derives the number of spatial streams allocated to it using the row corresponding to the signalled 4-bit spatial configuration subfield and the column corresponding to the position of the user-field in the user-specific field. The starting stream index for the STA is computed by summing the Nsts in the columns prior to the column indicated by the STA's user-field position. In the case of load balancing for RUs of size > 20 MHz where user fields corresponding to the same MU-MIMO allocations are split into two HE-SIG-B content channels, the user-field positions are logically continuous with the user-field in the second HE-SIG-B content channel updating its position (and therefore, column index) from that of the last user-field in the first HE-SIG-B content channel.

Table 26-21 - Spatial Configuration subfield encoding

Nuser	B0…B3	Nsts [1]	Nsts [2]	Nsts [3]	Nsts [4]	Nsts [5]	Nsts [6]	Nsts [7]	Nsts [8]	Total Nsts	Number of Entries
2	0000~0011	1~4	1							2~5	10
	0100~0110	2~4	2							4~6	
	0111~1000	3~4	3							6~7	

	1001	4	4							8	
3	0000~0011	1~4	1	1						3~6	13
	0100~0110	2~4	2	1						5~7	
	0111~1000	3~4	3	1						7~8	
	1001~1011	2~4	2	2						6~8	
	1100	3	3	2						8	
4	0000~0011	1~4	1	1	1					4~7	11
	0100~0110	2~4	2	1	1					6~8	
	0111	3	3	1	1					8	
	1000~1001	2~3	2	2	1					7~8	
	1010	2	2	2	2					8	
5	0000~0011	1~4	1	1	1	1				5~8	6
	0100~0101	2~3	2	1	1	1				7~8	
6	0000~0010	1~3	1	1	1	1	1			6~8	4
	0011	2	2	1	1	1	1			8	
7	0000~0001	1~2	1	1	1	1	1	1		7~8	2
8	0000	1	1	1	1	1	1	1	1	8	1

26.3.9.9 HE-STF

The main purpose of the HE-STF field is to improve automatic gain control estimation in a MIMO transmission. The duration of the HE-STF field for HE PPDUs except HE trigger-based PPDUs is $T_{HE\text{-}STF\text{-}NT}$ (peridiocity of 0.8 µs with 5 periods) and the duration of the HE-STF field for an HE trigger-based PPDU is $T_{HE\text{-}STF\text{-}T}$ (peridiocity of 1.6 µs with 5 periods). The tone indices for HE-STF field for HE PPDUs except HE trigger-based PPDUs is defined in Equation (26-26).

$$i_{STF} \bmod 16 = 0, \quad \lfloor N_{DC}/2 \rfloor < |i_{STF}| \le N_{SR} \qquad (25-1) \qquad \textbf{(26-26)}$$

i_{STF} : HE-STF tone index

The tone indices for HE-STF fields for an HE trigger-based PPDU are defined in Equation (26-27).

$$i_{STF} \bmod 8 = 0, \quad \lfloor N_{DC}/2 \rfloor < |i_{STF}| \le N_{SR} \qquad (25-2) \qquad \textbf{(26-27)}$$

i_{STF} : HE-STF tone index

For the HE-STF field, the *M* sequence is defined by Equation (26-28).

$$M = \{-1, -1, -1, 1, 1, 1, -1, 1, 1, 1, -1, 1, 1, -1, 1\} \qquad \textbf{(26-28)}$$

The HE-STF field is constructed from the *M* sequence(s) by multiplying integer coefficient(s) to each 20 MHz subchannel and inserting appropriate coefficients into tone indices which are null after mapping *M* sequences.

For a 20 MHz transmission, the frequency domain sequence for HE PPDUs except HE trigger-based PPDUs is given by Equation (26-29).

$$HES_{-112:16:112} = \{M\} \cdot (1+j)/\sqrt{2} \qquad (25-3)$$
$$HES_0 = 0$$ **(26-29)**

where $HES_{a:b:c}$ means coefficients of the HE-STF on every *b* tone indices from *a* to *c* tone indices and coefficients on other tone indices are set to zero.

For a 40 MHz transmission, the frequency domain sequence for HE PPDUs except HE trigger-based PPDUs is given by Equation (26-30).

$$HES_{-240:16:240} = \{M, 0, -M\} \cdot (1+j)/\sqrt{2} \qquad (25-4)$$ **(26-30)**

For an 80 MHz transmission, the frequency domain sequence for HE PPDUs except HE trigger-based PPDUs is given by Equation (26-31).

$$HES_{-496:16:496} = \{M, 1, -M, 0, -M, 1, -M\} \cdot (1+j)/\sqrt{2} \qquad (25-5)$$ **(26-31)**

For a 20 MHz transmission, the frequency domain sequence for HE trigger-based PPDUs is given by Equation (26-32).

$$HES_{-120:8:120} = \{M, 0, -M\} \cdot (1+j)/\sqrt{2} \qquad (25-6)$$ **(26-32)**

For a 40 MHz transmission, the frequency domain sequence for HE trigger-based PPDUs is given by Equation (26-33).

$$HES_{-248:8:248} = \{M, -1, -M, 0, M, -1, M\} \cdot (1+j)/\sqrt{2} \qquad (25-7)$$
$$HES_{\pm 248} = 0$$ **(26-33)**

For an 80 MHz transmission, the frequency domain sequence for HE trigger-based PPDUs is given by Equation (26-34).

$$HES_{-504:8:504} = \{M, -1, M, -1, -M, -1, M, 0, -M, 1, M, 1, -M, 1, -M\} \cdot (1+j)/\sqrt{2}$$ **(26-34)**
$$HES_{\pm 504} = 0 \qquad (25-8)$$

For an OFDMA transmission, the coefficients in Equation (25-3) to (25-8) are set to zero if those values are corresponding to tone indices on which no RUs defined in 25.3.7.1 are assigned.

The time domain representation of the signal for HE PPDUs except HE trigger-based PPDUs on frequency segment i_{Seg} of transmit chain i_{TX} shall be as specified in Equation (26-35).

$$r_{\text{HE-STF}}^{(i_{Seg}, i_{TX})}(t) = w_{T_{\text{HE-STF-NT}}}(t) \cdot \eta_{EXT} \cdot \sum_{r=0}^{N_{RU}-1} \frac{\alpha_r \beta_r}{\sqrt{N_{STS,r,total}}} \cdot \sum_{k \in K_r} \sum_{u=0}^{N_{user,r}-1} \sum_{m=1}^{N_{STS,r,u}} \left(\left[Q_k^{(i_{Seg})} \right]_{i_{TX},(M_{r,u}+m)} HES_k \cdot \exp\left(j2\pi k \Delta_{F,\text{HE}} \left(t - T_{\text{CS,HE}} \left(M_{r,u} + m \right) \right) \right) \right)$$ **(26-35)**

where

α_r is the power boost factor for the *r*-th RU, where $\alpha_r \in [TBD_1, TBD_2]$

η_{EXT} is an PPDU format dependent scaling factor, with the following value

$$\eta_{EXT} = \begin{cases} \sqrt{2}, & \text{HE extended range SU PPDU} \\ 1, & \text{otherwise} \end{cases}$$

β_r is the per-RU power normalization factor and defined by

$$\beta_r = \sqrt{\frac{|K_r|}{|K_r^{\text{HE-STF}}|}} \Big/ \sqrt{\sum_{r=1}^{N_{RU}} \alpha_r^2 |K_r|}$$

$|K_r|$ is the cardinality of the set of subcarriers K_r

$K_r^{\text{HE-STF}}$ is the set of subcarriers that have non-zero values within K_r in the HE-STF field

$T_{\text{CS,HE}}(n)$ is given in 26.3.9.2 (Cyclic shift for Pre-HE modulated fields)

$Q_k^{(i_{Seg})}$ is defined in 25.3.10.10.x (Transmission in HE format)

$w_{T_{\text{HE-STF-NT}}}(t)$ is the windowing function for HE-STF field in the non-HE trigger-based PPDU.

The time domain representation of the signal for HE trigger-based PPDUs on frequency segment i_{Seg} of transmit chain i_{TX} shall be as specified in Equation (26-36).

$$r_{\text{HE-STF}}^{(i_{Seg},i_{TX})}(t) = \frac{\alpha_r \beta_r}{\sqrt{N_{STS,r,total}}} w_{T_{\text{HE-STF-T}}}(t) \cdot \sum_{k \in K_r} \sum_{m=1}^{N_{STS,r,u}} \left(\left[Q_k^{(i_{Seg})} \right]_{i_{TX},(M_{r,u}+m)} HES_k \cdot \exp\left(j2\pi k \Delta_{F,\text{HE}} \left(t - T_{\text{CS,HE}}(M_{r,u}+m) \right) \right) \right) \quad \text{(26-36)}$$

where

$w_{T_{\text{HE-STF-T}}}(t)$ is the windowing function for HE-STF field in the HE trigger-based PPDU.

26.3.9.10 HE-LTF

The HE Long Training field (HE-LTF) field provides a means for the receiver to estimate the MIMO channel between the set of constellation mapper outputs (or, if STBC is applied, the STBC encoder outputs) and the receive chains. In an HE SU PPDU, HE MU PPDU or HE extended range SU PPDU, the transmitter provides training for $N_{STS,r,total}$ space-time streams (spatial mapper inputs) used for the transmission of the PSDU(s) in the r-th RU; in an HE trigger-based PPDU, the transmitter of user-u in the r-th RU provides training for $N_{STS,r,u}$ space-time streams used for the transmission of the PSDU. For each tone in the r-th RU, the MIMO channel that can be estimated is an $N_{RX} \times N_{STS,r,total}$ matrix. A HE transmission has a preamble that contains HE-LTF symbols, where the data tones of each HE-LTF symbol are multiplied by entries belonging to a matrix $P_{HE\text{-}LTF}$, to enable channel estimation at the receiver. The pilot tones of each HE-LTF symbol are multiplied by the entries of a matrix $R_{HE\text{-}LTF}$ defined in the following text. The multiplication of the pilot tones in the HE-LTF symbol by the $R_{HE\text{-}LTF}$ matrix instead of the $P_{HE\text{-}LTF}$ matrix allows receivers to track phase and frequency offset during MIMO channel estimation using the HE-LTF. In an HE SU PPDU and HE extended range SU PPDU, the number of HE-LTF symbols, $N_{HE\text{-}LTF}$, is a function of the total number of space-time streams N_{STS} as shown in **Error! Reference source not found.**. In an HE trigger-based PPDU, $N_{HE\text{-}LTF}$ is indicated in the Trigger frame that triggers the transmission of the PPDU. In an HE MU PPDU, $N_{HE\text{-}LTF}$ is indicated in the HE-SIG-A field. In an HE MU PPDU and HE trigger-based PPDU,

$N_{HE\text{-}LTF}$ is selected to be not smaller than the maximum value of the functions for each $N_{STS,r,total}$. As a result the HE-LTF field consists of one, two, four, six or eight symbols.

A HE PPDU supports 3 HE-LTF modes, which are 1x HE-LTF, 2x HE-LTF, and 4x HE-LTF. It is optional to support 1x HE-LTF in an HE SU PPDU, HE extended range SU PPDU and HE MU PPDU. In an HE SU PPDU, HE MU PPDU or HE extended range SU PPDU, the combination of HE-LTF modes and GI duration is indicated in HE-SIG-A field. In an HE trigger-based PPDU, the combination of HE-LTF modes and GI duration is indicated in the Trigger frame that triggers the transmission of the PPDU. The mandatory combinations of HE-LTF modes and GI duration are:

— *2x HE-LTF*, $T_{GI,Data}$
— *2x HE-LTF*, $T_{GI,Data2}$
— *4x HE-LTF*, $T_{GI,Data4}$

The optional combinations of HE-LTF mode and GI duration are:

— *1x HE-LTF*, $T_{GI,Data}$ in a HE SU PPDU or HE extended SU PPDU
— *1x HE-LTF*, $T_{GI,Data}$ in a non-OFDMA, MU-MIMO HE MU PPDU
— *1x HE-LTF*, $T_{GI,Data2}$ in a non-OFDMA, MU-MIMO HE trigger-based PPDU

The duration of each HE-LTF symbol is $T_{HE\text{-}LTF}$ is defined in Equation (26-37). In an HE SU PPDU, HE MU PPDU or HE extended range SU PPDU, the HE-LTF symbol duration is indicated in HE-SIG-A field. In an HE trigger-based PPDU, the HE-LTF symbol duration is indicated in the Trigger frame that triggers the transmission of the PPDU.

$$T_{HE-LTF} = \begin{cases} T_{HE-LTF-1X} & \text{if 1x HE-LTF} \\ T_{HE-LTF-2X} & \text{if 2x HE-LTF} \\ T_{HE-LTF-4X} & \text{if 4x HE-LTF} \end{cases} \quad (26\text{-}37)$$

where $T_{HE\text{-}LTF\text{-}1X}$, $T_{HE\text{-}LTF\text{-}2X}$, $T_{HE\text{-}LTF\text{-}4x}$ are defined in Table 26-3 (Timing related constants).

In a 20 MHz transmission, the 1x HE-LTF sequence transmitted is given by Equation **(26-38)**.

$HELTF_{-122,122}$ =

{0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, 0, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0} **(26-38)**

In a 20 MHz transmission, the 2x HE-LTF sequence transmitted is given by Equation (26-39).

$HELTF_{-122,122}$ =

{-1, 0, -1, 0, -1, 0, +1, 0, +1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -1, 0, +1, 0, -1, 0, -1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, +1, 0, +1, 0, -1, 0, +1, 0, -1, 0, +1, 0, -1, 0, -1, 0, +1, 0, +1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, -1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, +1, 0, +1, 0, +1, 0, -1, 0, -1, 0, +1, 0, 0, 0, +1, 0, -1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, -1, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, +1, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0, -1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0, -1, 0, -1, 0, +1, 0, +1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, -1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -1, 0, +1} (26-39)

In a 20 MHz transmission, the 4x HE-LTF sequence transmitted is given by Equation (26-40).

$HELTF_{-122, 122} =$
{-1, -1, +1, -1, +1, -1, +1, +1, +1, -1, +1, +1, +1, -1, -1, +1, -1, -1, -1, -1, -1, +1, +1, -1, -
1, -1, -1, +1, +1, -1, +1, -1, +1, +1, +1, +1, -1, +1, -1, -1, +1, +1, -1, +1, +1, +1, +1, -1, -
1, +1, -1, -1, -1, +1, +1, +1, +1, -1, +1, +1, -1, -1, -1, -1, +1, -1, -1, +1, +1, -1, +1, -1, -1,
-1, -1, +1, -1, +1, -1, -1, -1, -1, -1, -1, +1, +1, -1, -1, -1, -1, -1, +1, -1, -1, +1, +1, +1, -1,
+1, +1, +1, -1, +1, -1, +1, -1, -1, -1, -1, -1, +1, +1, +1, -1, -1, -1, +1, -1, +1, +1, +1, 0, 0,
0, -1, +1, -1, +1, -1, +1, +1, -1, +1, +1, +1, -1, -1, +1, -1, -1, +1, -1, +1, -1, +1, +1, +1, -1,
+1, +1, +1, -1, -1, +1, -1, -1, -1, -1, -1, +1, +1, -1, -1, -1, -1, -1, -1, +1, -1, +1, -1, -1, -1, -
1, +1, -1, +1, +1, -1, -1, +1, -1, -1, -1, -1, +1, +1, -1, +1, +1, +1, +1, +1, +1, +1, -1, +1,
+1, -1, -1, -1, -1, +1, -1, -1, +1, +1, -1, +1, -1, -1, -1, -1, +1, -1, +1, -1, -1, +1, +1, +1,
+1, -1, -1, +1, +1, +1, +1, +1, -1, +1, +1, -1, -1, -1, +1, -1, -1, -1, +1, -1, +1, -1, +1, +1} **(26-40)**

In a 40 MHz transmission, the 1x HE-LTF sequence transmitted is given by Equation **(26-41)**.

$HELTF_{-244,244} =$
{ +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0,
-1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1,
0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0,
0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0,
0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0,
+1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1,
0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0,
0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0,
0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1,
0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0,
0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0,
0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0,
+1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1,
0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0,
0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -
1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1,
0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1} **(26-41)**

In a 40 MHz transmission, the 2x HE-LTF sequence transmitted is given by Equation (26-42).

$HELTF_{-244,244} =$
{+1, 0, -1, 0, -1, 0, -1, 0, -1, 0, -1, 0, +1, 0, +1, 0, -1, 0, -1, 0, +1, 0, -1, 0, +1, 0, -1, 0, -1,
0, -1, 0, -1, 0, -1, 0, -1, 0, +1, 0, +1, 0, +1, 0, +1, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0, -1, 0, -
1, 0, -1, 0, -1, 0, -1, 0, +1, 0, +1, 0, -1, 0, -1, 0, +1, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1,
0, +1, 0, +1, 0, -1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, +1, 0,
+1, 0, -1, 0, +1, 0, -1, 0, -1, 0, +1, 0, -1, 0, +1, 0, -1, 0, -1, 0, +1, 0, +1, 0, +1, 0, +1, 0,
+1, 0, -1, 0, -1, 0, +1, 0, +1, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, +1, 0, +1, 0, +1, 0, -
1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, -1, 0, -1, 0, -1, 0, -1, 0, +1, 0,
+1, 0, -1, 0, -1, 0, +1, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, +1, 0, +1, 0, -1, 0, -1, 0, -1,
0, -1, 0, +1, 0, -1, 0, +1, 0, -1, 0, 0, 0, 0, 0, 0, -1, 0, -1, 0, -1, 0, -1, 0, -1, 0, +1, 0, +1, 0,
-1, 0, -1, 0, +1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1,
0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, +1, 0, +1, 0, +1, 0, +1, 0, -1, 0, -1, 0, +1, 0, +1, 0,
-1, 0, +1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0, -1, 0, +1,
0, -1, 0, +1, 0, +1, 0, +1, 0, +1, 0, +1, 0, +1, 0, +1, 0, -1, 0, -1, 0, +1, 0, +1, 0, -1, 0, +1, 0,
-1, 0, +1, 0, -1, 0, -1, 0, -1, 0, -1, 0, -1, 0, +1, 0, +1, 0, -1, 0, -1, 0, +1, 0, -1, 0, +1, 0, -1,
0, -1, 0, -1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0, -
1, 0, -1, 0, -1, 0, -1, 0, -1, 0, +1, 0, +1, 0, -1, 0, -1, 0, +1, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0,
+1, 0, +1, 0, +1, 0, -1, 0, +1, 0, -1, 0, -1, 0, +1, 0, -1, 0, +1, 0, -1, 0, +1} **(26-42)**

In a 40 MHz transmission, the 4x HE-LTF sequence transmitted is given by Equation (26-43).

$HELTF_{-244,244} =$
{+1, -1, -1, -1, -1, +1, -1, -1, +1, +1, -1, +1, -1, +1, -1, +1, +1, -1, +1, -1, -1, -1, +1, +1, -
1, -1, -1, -1, -1, -1, -1, +1, -1, -1, +1, +1, -1, +1, -1, -1, -1, -1, -1, +1, -1, +1, +1, +1, -1, - **(26-43)**

1, +1, +1, +1, -1, -1, +1, +1, +1, +1, -1, +1, +1, -1, -1, +1, -1, +1, -1, +1, -1, -1, +1, -1,
+1, +1, +1, -1, -1, +1, +1, +1, -1, -1, -1, -1, +1, -1, -1, +1, +1, -1, +1, -1, -1, -1, -1, -1, -1, +1,
-1, +1, +1, +1, +1, -1, -1, +1, +1, +1, +1, +1, +1, +1, +1, +1, -1, +1, +1, -1, -1, +1, -1, +1, +1, +1,
+1, +1, -1, +1, -1, -1, -1, +1, +1, -1, -1, -1, -1, -1, -1, -1, +1, -1, -1, +1, +1, -1, +1, -1,
+1, -1, +1, +1, -1, +1, -1, -1, -1, +1, +1, -1, -1, -1, -1, -1, -1, +1, -1, -1, +1, +1, -1, +1,
-1, -1, -1, -1, -1, +1, -1, +1, +1, +1, -1, -1, +1, +1, +1, -1, -1, -1, -1, -1, +1, -1, -1, +1,
+1, -1, +1, -1, -1, +1, -1, -1, +1, +1, -1, +1, -1, -1, -1, -1, +1, +1, -1, -1, -1, +1, +1, +1, -1, +1,
+1, -1, -1, +1, -1, +1, +1, +1, +1, +1, -1, +1, -1, -1, -1, +1, +1, -1, -1, -1, +1, 0, 0, 0, 0, 0,
-1, +1, +1, +1, +1, -1, +1, +1, -1, -1, +1, -1, +1, -1, +1, -1, -1, +1, -1, +1, +1, +1, -1, -1,
+1, +1, +1, +1, +1, +1, +1, -1, +1, +1, -1, -1, +1, -1, +1, +1, +1, +1, +1, -1, +1, -1, -1, -1,
+1, +1, -1, -1, -1, +1, +1, -1, -1, -1, -1, +1, -1, -1, +1, +1, -1, +1, -1, +1, -1, +1, +1, -1,
+1, -1, -1, -1, +1, +1, +1, -1, -1, -1, +1, +1, +1, +1, -1, +1, +1, -1, -1, +1, -1, +1, +1, +1, +1,
+1, -1, +1, -1, -1, -1, +1, +1, -1, -1, -1, +1, -1, -1, -1, -1, +1, -1, -1, -1, +1, -1, -1, +1,
-1, +1, +1, -1, +1, -1, -1, -1, +1, +1, -1, -1, -1, +1, -1, -1, -1, -1, +1, -1, -1, +1, +1, -1, +1,
-1, +1, -1, +1, +1, -1, +1, -1, -1, -1, +1, +1, -1, -1, -1, -1, -1, -1, +1, -1, -1, +1, +1, -1,
+1, -1, -1, -1, -1, +1, -1, +1, +1, +1, -1, -1, +1, +1, +1, -1, +1, -1, -1, -1, +1, +1, -1, -1,
+1, +1, -1, +1, -1, +1, -1, +1, +1, -1, +1, -1, -1, -1, +1, +1, -1, -1, -1, +1, +1, +1, +1, -1,
+1, +1, -1, -1, +1, -1, +1, +1, +1, +1, +1, -1, +1, -1, -1, -1, +1, +1, -1, -1, -1, -1}

1 In an 80 MHz transmission, the 1x HE-LTF sequence transmitted is given by Equation Equation (26-44).

$HELTF_{-500,500}$ =

{ -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -
1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1,
0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0,
0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0,
+1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1,
0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0,
0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0,
0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -
1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0,
0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0,
0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0,
+1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -
1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1,
0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0,
0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0,
0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, **(26-44)**
-1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1,
0, 0, 0, -1, 0, 0, 0, 0, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0,
0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0,
+1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0,
+1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1,
0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0,
0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0,
0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -
1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1,
0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0,
0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0,
+1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -
1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1,
0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0,
0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0,
0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0,
+1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -
1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1,
0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0,
0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0,
0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0,
+1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -
1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1,
0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0,
0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0,
0, -1, 0, 0, 0, +1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0,

-1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, -1,
0, 0, 0, -1, 0, 0, 0, -1, 0, 0, 0, +1, 0, 0, 0, +1}

1 In an 80 MHz transmission, the 2x HE-LTF sequence transmitted is given by Equation (26-45).

$HELTF_{-500,500}$ =
{+1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, +1, 0, -1, 0, -1, 0, -1, 0,
+1, 0, -1, 0, -1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, -1, 0, -1, 0, -1, 0, -1, 0, +1, 0, +1,
0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, -1, 0, +1, 0, -1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0,
+1, 0, +1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -1, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1,
0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -1, 0, -1, 0, +1, 0,
+1, 0, -1, 0, +1, 0, +1, 0, +1, 0, -1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, -1,
0, +1, 0, +1, 0, +1, 0, +1, 0, -1, 0, -1, 0, -1, 0, +1, 0, +1, 0, +1, 0, -1, 0, -1, 0, +1, 0, +1, 0,
+1, 0, -1, 0, +1, 0, +1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, +1,
0, -1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -
1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, -1, 0, -1, 0, +1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1,
0, -1, 0, +1, 0, -1, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, +1, 0,
-1, 0, -1, 0, -1, 0, +1, 0, -1, 0, -1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, -1, 0, -1, 0, -1,
0, -1, 0, +1, 0, +1, 0, +1, 0, -1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -1, 0,
+1, 0, +1, 0, +1, 0, -1, 0, -1, 0, +1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, -1, 0, +1, 0, -1, 0, -
1, 0, -1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, -1, 0,
+1, 0, +1, 0, -1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, +1, 0, +1, 0, +1, 0, +1, 0, -1, 0, +1, 0, -1,
0, -1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, -1, 0, +1, 0, +1, 0, +1, 0, +1, 0, -1, 0, -1, 0, -1, 0, **(26-45)**
+1, 0, +1, 0, +1, 0, 0, 0, 0, 0, 0, 0, +1, 0, -1, 0, -1, 0, +1, 0, +1, 0, -1, 0, +1, 0, -1, 0, -1, 0,
-1, 0, +1, 0, +1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, -1,
0, +1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, -1, 0, -1, 0, +1, 0, -1, 0, -1, 0, +1, 0, -1, 0, -1, 0,
+1, 0, -1, 0, +1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, +1, 0, -1, 0, +1, 0, -1, 0, -1, 0,
+1, 0, -1, 0, -1, 0, -1, 0, +1, 0, +1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, -1,
0, +1, 0, +1, 0, +1, 0, +1, 0, -1, 0, -1, 0, -1, 0, +1, 0, +1, 0, +1, 0, +1, 0, -1, 0, -1, 0, -1, 0,
+1, 0, -1, 0, -1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, -1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -1,
0, -1, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0, -1, 0, +1, 0, -1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0,
+1, 0, +1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -1, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, -1, 0, +1,
0, +1, 0, +1, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -1, 0, -
1, 0, -1, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, -1, 0, -1, 0, +1, 0, +1,
0, +1, 0, -1, 0, -1, 0, -1, 0, +1, 0, +1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, -1, 0, +1, 0,
-1, 0, -1, 0, -1, 0, -1, 0, +1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, -1, 0, -1, 0, +1, 0, -1, 0, -1,
0, -1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, -1, 0,
+1, 0, -1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, +1, 0, +1, 0, -1, 0, -1, 0, -1, 0, +1, 0, -1, 0, -1,
0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, +1, 0, -1, 0, -1, 0, -1, 0, -1, 0,
+1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1, 0, -1, 0, -1, 0, +1, 0, -1, 0, -1, 0, -1, 0, +1, 0, +1, 0,
+1, 0, +1, 0, -1, 0, +1, 0, +1, 0, +1, 0, -1, 0, +1, 0, +1}

2 In an 80 MHz transmission, the 4x HE-LTF sequence transmitted is given by Equation (26-46).

$HELTF_{-500,500}$ =
{+1, +1, -1, +1, -1, +1, -1, -1, -1, +1, -1, -1, -1, +1, +1, -1, +1, +1, +1, +1, +1, -1, -1, +1,
+1, +1, +1, -1, +1, -1, +1, -1, -1, +1, +1, -1, +1, +1, +1, -1, -1, +1, -1, -1, -1, -1, +1, +1,
+1, -1, -1, -1, -1, -1, -1, +1, +1, +1, +1, +1, +1, -1, +1, +1, +1, -1, +1, +1, -1, -1, -1, +1, -
1, +1, -1, -1, +1, +1, -1, +1, -1, +1, +1, +1, +1, +1, -1, -1, +1, +1, +1, -1, +1, +1, -1, -1, -
1, +1, -1, +1, +1, -1, +1, +1, -1, +1, -1, -1, +1, +1, +1, +1, -1, -1, +1, +1, +1, +1, +1, -1,
+1, +1, -1, -1, -1, +1, -1, -1, -1, +1, -1, +1, -1, +1, +1, -1, +1, -1, +1, -1, +1, +1, +1, -1,
+1, +1, +1, -1, -1, +1, -1, -1, -1, -1, -1, +1, +1, -1, -1, -1, -1, +1, -1, +1, -1, +1, +1, -1, -1, **(26-46)**
+1, -1, -1, -1, +1, +1, -1, +1, +1, +1, +1, -1, -1, -1, +1, +1, +1, +1, -1, +1, +1, +1, +1, +1,
+1, +1, -1, +1, +1, +1, -1, +1, +1, -1, -1, -1, +1, -1, +1, -1, -1, +1, +1, -1, +1, -1, +1, +1,
+1, +1, +1, -1, -1, +1, +1, +1, -1, +1, +1, -1, -1, -1, +1, -1, +1, +1, -1, +1, +1, -1, +1, -1, -
1, +1, -1, +1, -1, +1, -1, +1, +1, +1, -1, +1, +1, +1, -1, -1, +1, -1, -1, -1, -1, -1, +1, +1, -1,
-1, -1, -1, +1, -1, +1, -1, +1, +1, -1, -1, +1, -1, -1, -1, +1, +1, -1, +1, +1, +1, +1, -1, -1, -1,
+1, +1, +1, +1, -1, +1, -1, -1, -1, -1, -1, -1, +1, -1, -1, -1, +1, -1, -1, +1, +1, +1, -1, +1, -1,
+1, +1, -1, -1, +1, -1, +1, -1, -1, -1, -1, -1, +1, +1, -1, -1, -1, +1, -1, -1, +1, +1, +1, -1, +1,
-1, -1, +1, -1, -1, +1, -1, +1, +1, +1, +1, +1, +1, -1, -1, +1, +1, +1, +1, +1, -1, +1, +1, -1, -

1, -1, +1, -1, -1, -1, +1, -1, +1, -1, +1, +1, -1, +1, -1, +1, -1, +1, +1, +1, -1, +1, +1, +1, -1,
-1, +1, -1, -1, -1, -1, -1, +1, +1, -1, -1, -1, -1, +1, -1, +1, -1, +1, +1, -1, -1, +1, -1, -1, -1,
+1, +1, -1, +1, +1, +1, +1, -1, -1, -1, +1, +1, +1, +1, -1, -1, +1, +1, +1, +1, +1, +1, -1, +1,
+1, +1, -1, +1, +1, -1, -1, -1, +1, -1, +1, -1, -1, +1, +1, -1, +1, -1, +1, +1, +1, +1, +1, -1, -
1, +1, +1, +1, -1, +1, +1, -1, -1, -1, +1, -1, +1, +1, -1, +1, +1, -1, +1, -1, -1, -1, +1, -1, +1,
-1, -1, -1, -1, +1, +1, +1, -1, -1, +1, 0, 0, 0, 0, 0, +1, -1, -1, -1, -1, -1, -1, +1, -1, +1, +1, -
1, -1, +1, +1, -1, +1, -1, +1, +1, -1, -1, +1, -1, +1, -1, -1, -1, +1, +1, -1, +1, +1, +1, -1, +1,
+1, +1, +1, +1, +1, +1, -1, +1, -1, -1, +1, -1, -1, +1, -1, +1, +1, +1, -1, -1, +1, -1, -1, -1,
+1, +1, -1, -1, -1, -1, -1, +1, -1, -1, -1, -1, -1, +1, +1, -1, -1, -1, -1, -1, +1, -1, -1, +1, +1,
+1, -1, +1, +1, +1, -1, +1, -1, +1, -1, -1, -1, -1, -1, +1, +1, +1, -1, -1, -1, -1, +1, -1, -1, +1,
+1, +1, -1, +1, +1, -1, -1, +1, -1, +1, -1, -1, -1, -1, -1, -1, -1, +1, +1, -1, -1, -1, +1, -1, -1,
+1, +1, +1, -1, +1, -1, -1, +1, -1, -1, +1, -1, +1, +1, +1, -1, +1, -1, -1, +1, +1, -1, +1, -1,
+1, +1, +1, -1, -1, +1, -1, -1, -1, +1, -1, -1, -1, -1, -1, -1, -1, +1, -1, +1, +1, -1, +1, +1, -1,
+1, -1, -1, -1, +1, +1, -1, +1, +1, +1, -1, -1, +1, +1, +1, +1, +1, -1, +1, -1, -1, -1, -1, +1,
+1, -1, -1, -1, -1, -1, +1, -1, -1, +1, +1, +1, -1, +1, +1, +1, -1, +1, -1, +1, -1, -1, -1, -1, -1,
+1, +1, +1, -1, -1, -1, -1, +1, -1, -1, +1, +1, +1, -1, +1, +1, -1, -1, +1, -1, +1, -1, +1, +1,
+1, -1, +1, -1, -1, +1, +1, -1, +1, -1, +1, +1, +1, -1, -1, +1, -1, -1, -1, +1, -1, -1, -1, -1, -1,
-1, -1, +1, -1, +1, +1, -1, +1, +1, -1, +1, -1, -1, -1, +1, +1, -1, +1, +1, +1, -1, -1, +1, +1,
+1, +1, +1, -1, +1, +1, +1, +1, +1, -1, -1, +1, +1, +1, +1, +1, -1, +1, +1, -1, -1, -1, +1, -1,
-1, -1, +1, -1, +1, -1, +1, +1, +1, +1, +1, -1, -1, -1, +1, +1, +1, +1, -1, +1, +1, -1, -1, -1,
+1, -1, -1, +1, +1, -1, +1, -1, +1, -1, -1, -1, -1, -1, -1, +1, +1, -1, -1, -1, +1, -1, -1, +1, +1,
+1, -1, +1, -1, -1, +1, -1, -1, +1, -1, +1, -1, +1, -1, +1, -1, -1, +1, +1, -1, +1, -1, +1, +1,
+1, -1, -1, +1, -1, -1, -1, +1, -1, -1, -1, -1, -1, -1, -1, +1, -1, +1, +1, -1, +1, +1, -1, +1, -1, -
1, -1, +1, +1, -1, +1, +1, +1, -1, -1, +1, +1, +1, +1, +1, -1, +1, -1, -1, -1, -1, +1, +1, -1, -1,
-1, -1, -1, +1, -1, -1, +1, +1, +1, -1, +1, +1, +1, -1, +1, -1, +1, -1, -1, -1, -1, -1, +1, +1,
+1, -1, -1, -1, -1, +1, -1, -1, +1, +1, +1, -1, +1, +1, -1, -1, +1, -1, +1, -1, +1}

In a 160 MHz transmission, the 1x HE-LTF sequence transmitted is given by Equation (26-47).

$$HELTF_{-1012,1012} = \{\ 1\text{x LTF}_{80\text{MHz_primary}},\ \text{zeros}(1,23),\ 1\text{x LTF}_{80\text{MHz_secondary}}\ \} \quad \textbf{(26-47)}$$

where 1x $\text{LTF}_{80\text{MHz_primary}}$ = {L-$\text{LTF}_{80\text{MHz_1x}}$, 0, R-$\text{LTF}_{80\text{MHz_1x}}$}, 1x $\text{LTF}_{80\text{MHz_ secondary}}$ = {L-$\text{LTF}_{80\text{MHz_1x}}$, 0, (-1)*R-$\text{LTF}_{80\text{MHz_1x}}$}.

In a 160 MHz transmission, the 2x HE-LTF sequence transmitted is given by Equation (26-48).

$$HELTF_{-1012,1012} = \{\ 2\text{x LTF}_{80\text{MHz_primary}},\ \text{zeros}(1,23),\ 2\text{x LTF}_{80\text{MHz_secondary}}\ \} \quad \textbf{(26-48)}$$

where

2x $\text{LTF}_{80\text{MHz_primary}}$ =
{ {1st 242-RU}, {2nd 242-RU}, {central 26-RU}, {3rd 242-RU}, {4th 242-RU} } **(26-49)**

2x $\text{LTF}_{80\text{MHz_secondary}}$ =
{ {1st 242-RU}, (-1)*{2nd 242-RU}, {central 26-RU}, {3rd 242-RU}, (-1)*{4th 242-RU} } **(26-50)**

In a 160 MHz transmission, the 4x HE-LTF sequence transmitted is given by Equation (26-51).

$$HELTF_{-1012,1012} = \{\ 4\text{x LTF}_{80\text{MHz_primary}},\ \text{zeros}(1,23),\ 4\text{x LTF}_{80\text{MHz_secondary}}\ \} \quad \textbf{(26-51)}$$

where

$$4\text{x LTF}_{80\text{MHz_primary}} = \{\text{L-LTF}_{80\text{MHz_4x}},\ 0,\ \text{R-LTF}_{80\text{MHz_4x}}\} \quad \textbf{(26-52)}$$

$$4\text{x LTF}_{80\text{MHz_ secondary}} = \{\text{L-LTF}_{80\text{MHz_4x}},\ 0,\ (-1)*\text{R-LTF}_{80\text{MHz_4x}}\} \quad \textbf{(26-53)}$$

For a noncontiguous 80+80 MHz transmission, the 1x HE-LTF sequence is given by Equation (26-54).

$HELTF_{80+80MHz}$ = { 1x $LTF_{80MHz\_primary}$, 1x $LTF_{80MHz\_secondary}$ } **(26-54)**

For a noncontiguous 80+80 MHz transmission, the 2x HE-LTF sequence is given by Equation (26-55).

$HELTF_{80+80MHz}$ = { 2x $LTF_{80MHz\_primary}$, 2x $LTF_{80MHz\_secondary}$ } **(26-55)**

For a noncontiguous 80+80 MHz transmission, the 4x HE-LTF sequence is given by Equation (26-56).

$HELTF_{80+80MHz}$ = { 4x $LTF_{80MHz\_primary}$, 4x $LTF_{80MHz\_secondary}$ } **(26-56)**

The generation of the time domain HE-LTF symbols per frequency segment in an HE SU PPDU, HE MU PPDU, HE extended range SU PPDU, HE trigger-based PPDU using single stream pilots is shown in Figure 26-29 where A^k_{HELTF} is given by Equation (26-57).

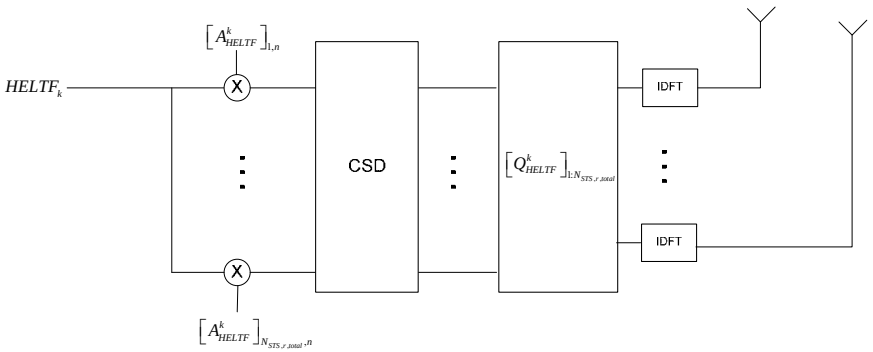


Figure 26-29 – Generation of HE-LTF symbols per frequency segment in an HE SU PPDU, HE MU PPDU, HE extended range SU PPDU, and HE trigger-based PPDU using single stream pilots

The generation of time domain symbol of 1x HE-LTF is equivalent to modulating every 4 tones in an OFDM symbol of 12.8 μs excluding GI, and then only transmit the first ¼ of the OFDM symbol in the time domain, as shown in Figure 26-30.

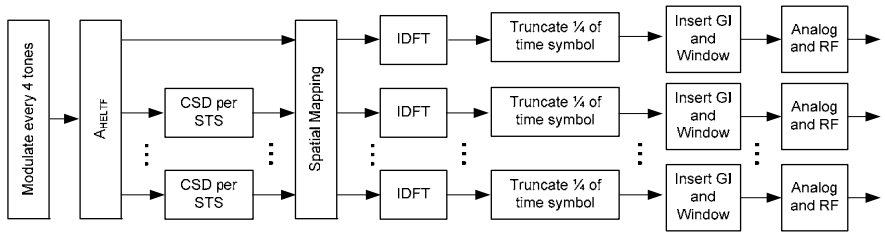


Figure 26-30 - Generation of 1x HE-LTF symbols per frequency segment

The generation of time domain symbol of 2x HE-LTF is equivalent to modulating every other tone in an OFDM symbol of 12.8 μs excluding GI, and then only transmit the first half of the OFDM symbol in time domain, as shown in Figure 26-31.

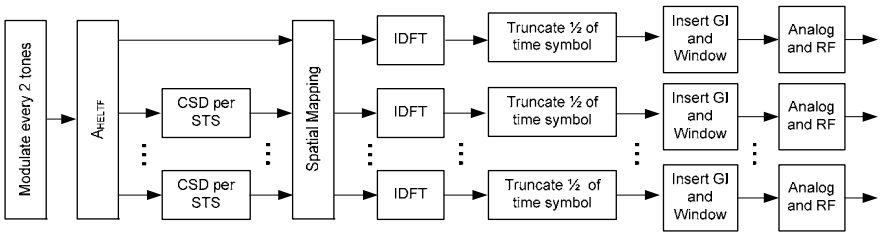


Figure 26-31 - Generation of 2x HE-LTF symbols per frequency segment

A^k_{HELTF} is given by Equation (26-57).

$$A^k_{HELTF} = \begin{cases} R_{HELTF}, & \text{if } k \in K_{\text{Pilot}} \\ P_{HELTF}, & \text{otherwise} \end{cases} \quad \textbf{(26-57)}$$

where K_{Pilot} is the set of subcarrier indices for the pilot tones as defined in 25.x (xx).

R_{HELTF} is a $N_{HELTF} \times N_{HELTF}$ matrix whose elements are defined in Equation (26-58).

$$\left[R_{HELTF}\right]_{m,n} = \left[P_{HELTF}\right]_{1,n},\ 1 \le m,n \le N_{HELTF} \quad \textbf{(26-58)}$$

P_{HELTF} is defined in (26-59).

$$P_{HELTF} = \begin{cases} P_{4\times4}, N_{HELTF} \le 4 \\ P_{6\times6}, N_{HELTF} = 6 \\ P_{8\times8}, N_{HELTF} = 8 \end{cases} \quad \textbf{(26-59)}$$

where $P_{4\times4}$ is defined in Equation (20-17), $P_{6\times6}$ is defined in Equation (22-45), and $P_{8\times8}$ is defined in Equation (22-46).

In an HE SU PPDU, HE MU PPDU, HE extended range SU PPDU and HE trigger-based PPDU using single stream pilots, the time domain representation of the waveform transmitted on frequency segment i_{Seg} of transmit chain i_{TX} shall be as described by Equation (26-60).

$$r^{(i_{seg},i_{TX})}_{HE-LTF}(t) = \frac{\eta_{HE-LTF}\cdot\eta_{EXT}}{\sqrt{\sum_{r=1}^{N_{RU}}\alpha_r^2|K_r|}} \sum_{n=0}^{N_{HELTF}-1} w_{T_{HE-LTF}}\left(t-nT_{HE-LTF}\right)\sum_{r=0}^{N_{RU}-1}\frac{\alpha_r}{\sqrt{N_{STS,r,total}}}$$
$$\cdot\sum_{k\in K_r}\sum_{u=0}^{N_{user,r}-1}\sum_{m=1}^{N_{STS,r,u}}\left(\begin{array}{l}\left[Q_k^{(i_{seg})}\right]_{i_{TX},(M_{r,u}+m)}\left[A^k_{HELTF}\right]_{(M_{r,u}+m),(n+1)}HELTF_k \\ \cdot\exp\left(j2\pi k\Delta_{F,HE}\left(t-nT_{HE-LTF}-T_{GI}-T_{CS,HE}\left(M_{r,u}+m\right)\right)\right)\end{array}\right) \quad \textbf{(26-60)}$$

Field Code Changed

where

α_r is the power boost factor for the r-th RU, where $\alpha_r \in [TBD_1, TBD_2]$

η_{EXT} is an PPDU format dependent scaling factor, with the following value

$$\eta_{EXT} = \begin{cases} \sqrt{2}, & \text{HE extended range SU PPDU} \\ 1, & \text{otherwise} \end{cases}$$

$N_{\text{HE-LTF}}^{\text{Tone}}$ has the value given in Table 25-xx (Tone scaling factor and guard interval duration values for PHY fields)

$T_{CS,\text{HE}}(n)$ is given in 26.3.9.2 (Cyclic shift for Pre-HE modulated fields)

$Q_k^{(i_{seg})}$ is defined in 25.xx (Transmission in HE format)

A_{HELTF}^k is defined in Equation (26-57)

K_r is the set of subcarrier indices for the tones in the *r*-th RU as defined in 25.x.

η_{HELTF} is the power scaling factor as defined in (25-xx)

$$\eta_{HE-LTF} = \begin{cases} 2 & \text{for 1x HE-LTF} \\ \sqrt{2} & \text{for 2x HE-LTF} \\ 1 & \text{for 4x HE-LTF} \end{cases}$$

26.3.10 Data field

26.3.10.1 General

The number of OFDM symbols in the Data field is determined by the Length field in L-SIG (see Equation (25-x)), the preamble duration and the setting of the CP+LTF Size field in HE-SIG-A (see 25.3.9.2.4.x HE-SIG-A definition). Data symbols in an HE PPDU shall use a DFT period of 12.8 µs and subcarrier spacing of 78.125 kHz. Data symbols in an HE PPDU shall support guard interval durations of 0.8 µs, 1.6 µs and 3.2 µs. HE PPDUs shall have single stream pilots in the Data field. In UL MU-MIMO transmissions, all streams use the same pilot sequence. The Data field in UL MU transmissions shall immediately follow the HE-LTF section.

When BCC encoding is used, the Data field shall consist of the SERVICE field, the PSDU, the tail bits, the post-FEC padding bits and the packet extension (bits for SU and bits for each user u in MU). When LDPC encoding is used, the Data field shall consist of the SERVICE field, the PSDU, the post-FEC padding bits and the packet extension. No tail bits are present when LDPC encoding is used.

The Data field of the HE PPDU contains data for one or more users.

26.3.10.1.1 Pre-FEC encoding process

A two-step padding process is applied on all HE PPDUs. A pre-FEC padding with both MAC and PHY padding is applied before conducting FEC coding, and a post-FEC PHY padding is applied on the FEC encoded bits.

The pre-FEC padding may pad torward 4 possible boundaries in the last one (in the case of non STBC), or two (in the case of STBC) OFDM symbols of a HE PPDU, the 4 possible boundaries participate the FEC output bit stream of the last OFDM symbol(s) into 4 symbol segments. The 4 possible boundaries are represented by a parameter *a*, called *a-factor*.

Figure 26-32 illustrates these 4 possible symbol segments in the last OFDM symbol of a non STBC case, and the general padding process assuming the desired pre-FEC padding boundary, *a-factor*, is 1. In the case of STBC, the FEC output bits and post-FEC padding bits as shown in Figure 26-33, are modulated into the last two OFDM symbols by STBC encoding, each with the same number of effective symbol segments, *a-factor,* being 1.

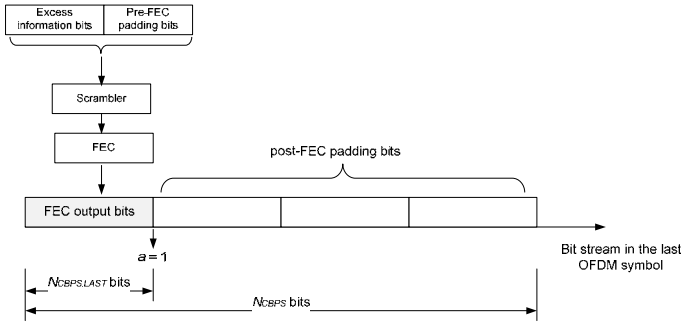


Figure 26-32 - HE PPDU padding process in the last OFDM symbol (non STBC) when *a* = 1

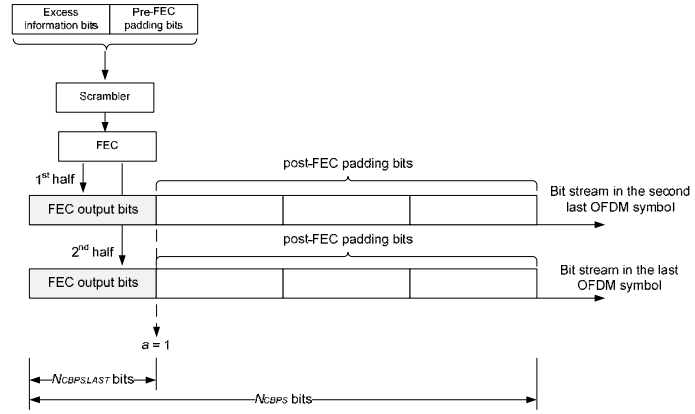


Figure 26-33 – HE PPDU padding process in the last OFDM symbol (STBC) when *a* = 1

The pre-FEC padding process is described in this subclause, and the encoding and post-FEC padding process are described in 26.3.10.3. While this subclause describes the pre-FEC padding processing of an SU transmission, its extension to MU transmission is described in 25.3.10.3.4 (Encoding Process for HE MU PPDUs).

In an HE SU PPDU transmission, the transmitter first computes the number of excess bits in the last OFDM symbol(s). Specifically, for HE SU PPDU with BCC encoding, the number of excess bits is calculated based on Equation (26-61).

$$N_{\text{Excess}} = \text{mod}\left(8.\text{APEP\_LENGTH} + N_{Tail} + N_{service},\ m_{STBC}.N_{DBPS}\right) \quad \textbf{(26-61)}$$

where

m_{STBC} is 2 when STBC is used, and 1 otherwise;

APEP_LENGTH is the TXVECTOR parameter APEP_LENGTH.

For a HE SU PPDU with LDPC encoding, the number of excess bits is calculated based on Equation (26-62):

$$N_{\text{Excess}} = \text{mod}\left(8.\text{APEP\_LENGTH} + N_{service},\ m_{STBC}.N_{DBPS}\right) \quad \textbf{(26-62)}$$

Then based on N_{Excess}, compute the initial number of symbol segments in the last OFDM symbol(s), *a-factor* value or a_{init}, as shown in Equation (26-63):

$$a_{init} = \begin{cases} 4 & \text{if } N_{\text{EXCESS}} = 0 \\ \left\lceil \dfrac{N_{\text{Excess}}}{m_{STBC} \cdot N_{DBPS,SHORT}} \right\rceil & \text{otherwise} \end{cases} \quad \textbf{(26-63)}$$

where

$N_{DBPS.SHORT} = N_{CBPS.SHORT}.R$, in which R is the coding rate, and

$N_{CBPS.SHORT} = N_{SD.SHORT}.N_{SS}.N_{BPSCS}$;

The parameter $N_{SD.SHORT}$ values for different RU sizes are as shown in Table 26-22.

Table 26-22 - $N_{SD.SHORT}$ values

RU Size	$N_{SD.SHORT}$	
	DCM = 0	***DCM = 1***
26	6	2 (TBD)
52	12	6 (TBD)
106	24	12 (TBD)
242	60	30 (TBD)
484	120	60 (TBD)
996	240	120 (TBD)
996x2	492	246 (TBD)

Given the a_{init} values, the initial number of data bits per symbol and the initial number of coded bits per symbol in the last OFDM symbol(s) are defined in Equation (26-64):

$$N_{DBPS.LAST.init} = \begin{cases} a_{init}.N_{DBPS.SHORT}, & \text{if } a_{init} < 4 \\ N_{DBPS,} & \text{if } a_{init} = 4 \end{cases}$$
$$N_{CBPS.LAST.init} = \begin{cases} a_{init}.N_{CBPS.SHORT}, & \text{if } a_{init} < 4 \\ N_{CBPS,} & \text{if } a_{init} = 4 \end{cases} \quad \textbf{(26-64)}$$

For a HE SU PPDU with BCC encoding, the number of pre-FEC pad bits is calculated using Equation (26-65).

$$N_{PAD,PRE-FEC} = (N_{SYM.init} - m_{STBC}).N_{DBPS} + m_{STBC}.N_{DBPS.Last.init} - 8.APEP\_LENGTH - N_{Tail} - N_{service} \quad \textbf{(26-65)}$$

where $N_{SYM.init}$ is defined as in Equation (26-68) for BCC encoding, and Equation (26-73) for LDPC encoding.

For a HE SU PPDU with LDPC encoding, the number of pre-FEC pad bits is calculated using Equation (26-66).

$$N_{PAD,PRE-FEC} = (N_{SYM.init} - m_{STBC}).N_{DBPS} + m_{STBC}.N_{DBPS.Last.init} - 8.APEP\_LENGTH - N_{service} \quad \textbf{(26-66)}$$

Among the pre-FEC padding bits, the MAC delivers a PSDU that fills the available octets in the Data field of the HE PPDU, toward the desired pre-FEC padding boundary, represented by a_{init} value, in the the last OFDM symbol(s). The PHY then determines the number of pad bits to add and appends them to the PSDU. The number of pre-FEC pad bits added by PHY will always be 0 to 7. The procedure is defined in Equation (26-67).

$$N_{PAD,PRE-FEC,MAC} = \left\lfloor \frac{N_{PAD,PRE-FEC}}{8} \right\rfloor \cdot 8 \qquad \text{(26-67)}$$

$$N_{PAD,PRE-FEC,PHY} = N_{PAD,PRE-FEC} \bmod 8$$

26.3.10.2 SERVICE field

The SERVICE field of HE PPDU is as shown in Table 26-23.

Table 26-23 – SERVICE field

Bits	Field	Description
B0-B6	Scrambler Initialization	Set to 0
B7-B15	Reserved	Set to 0

26.3.10.3 Coding

The Data field shall be encoded using either the binary convolutional code (BCC) defined in 26.3.10.3.1 or the low density parity check (LDPC) code defined in 25.3.10.3.2 (LDPC coding). The encoder is selected by the Coding field in HE-SIG-A in an HE SU PPDU or an HE extended range SU PPDU, or HE-SIG-B per-user subfield(s) in a HE MU PPDU, as defined in 26.3.9.7 and 26.3.9.8 respectively.

When conducting BCC FEC encoding for an HE PPDU, the number of encoders is always 1.

LDPC is the only FEC coding scheme in the HE PPDU Data field for a 484-RU, a 996-RU or a 996x2-RU. Support of BCC code is limited to less than or equal to four spatial streams (per user in case of MU-MIMO), and is mandatory (for both transmit and receive) for RU sizes less than or equal to a 242-RU. Support of LDPC code (for both transmit and receive) is mandatory for HE STAs declaring support for at least one of HE 40/80/160/80+80 SU PPDU bandwidths, or for HE STAs declaring support for more than 4 spatial streams, according to HE capabilities field as defined in clause 8.4.2.1 (HE Capabilities Element). Otherwise, support of LDPC code for either transmit or receive is optional.

26.3.10.3.1 Binary convolutional coding and puncturing

The information bits and pre-FEC padding bits of user *u* are encoded by a rate R = ½ convolutional encoder defined in 18.3.5.6 (Convolutional encoder). After encoding, the encoded data is punctured by the method defined in 18.3.5.6 (Convolutional encoder) (except for rate 5/6), to achieve the rate selected by the modulation and coding scheme. In the case that rate 5/6 coding is selected, the puncturing scheme will be the same as described in 20.3.11.6 (Binary convolutional coding and puncturing).

The initial number of OFDM symbols in the Data field with BCC encoding in a HE SU PPDU is calculated as in Equation (26-68),

$$N_{SYM.init} = m_{STBC} \cdot \left\lceil \frac{8.APEP\_LENGTH + N_{Tail}.N_{ES} + N_{service}}{m_{STBC}.N_{DBPS}} \right\rceil \qquad \text{(26-68)}$$

For a HE SU PPDU with BCC encoding,

$$N_{SYM} = N_{SYM.init} \qquad \text{(26-69)}$$

and

$$a = a_{init} \quad \text{(26-70)}$$

The number of coded bits per symbol in the last OFDM symbol(s) of a HE SU PPDU is

$$N_{CBPS.LAST} = \begin{cases} a \cdot N_{CBPS.SHORT}, & \text{if } a < 4 \\ N_{CBPS,} & \text{if } a = 4 \end{cases} \quad \text{(26-71)}$$

26.3.10.3.2 LDPC coding

For a HE SU PPDU using LDPC coding to encode the Data field, the LDPC code and encoding process described in 20.3.11.7 (LDPC codes) shall be used with the following modifications. First, all bits in the Data field including the scrambled SERVICE, PSDU, and pre-FEC pad bits are encoded. Thus, N_{pld} for HE PPDUs shall be computed using Equation (26-72) instead of Equation (20-35).

$$N_{pld} = (N_{SYM.init} - m_{STBC}).N_{DBPS} + m_{STBC}.N_{DBPS.LAST.init} \quad \text{(26-72)}$$

where

$N_{SYM.init}$ is given by Equation (26-73):

$$N_{SYM.init} = m_{STBC} \cdot \left\lceil \frac{8.APEP\_LENGTH + N_{service}}{m_{STBC}.N_{DBPS}} \right\rceil \quad \text{(26-73)}$$

Following the calculation of N_{pld}, N_{avbits} shall be computed using (26-74) instead of Equation (20-36).

$$N_{avbits} = (N_{SYM.init} - m_{STBC}).N_{CBPS} + m_{STBC}.N_{CBPS.LAST.init} \quad \text{(26-74)}$$

In addition, in step d) of LDPC encoding process as described in clause 20.3.11.7.5 (LDPC PPDU encoding process) , if the following condition is met:

$\left(\left(N_{punc} > 0.1 \times N_{CW} \times L_{LDPC} \times (1-R)\right) \text{ AND } \left(N_{shrt} < 1.2 \times N_{punc} \times \frac{R}{1-R}\right)\right)$ is true OR if

$\left(N_{punc} > 0.3 \times N_{CW} \times L_{LDPC} \times (1-R)\right)$ is true,

then the LDPC Extra OFDM Symbol field of HE-SIG-A shall be set to 1, and increment *Navbits* by the following Equation (26-75) instead of Equations (20-39), followed by recomputing N_{punc} as in Equation (20-40):

$$N_{avbits} = \begin{cases} N_{avbits} + m_{STBC} \cdot \left(N_{CBPS} - 3.N_{CBPS.SHORT}\right), & \text{if } a_{init} = 3 \\ N_{avbits} + m_{STBC}.N_{CBPS.SHORT}, & \text{otherwise} \end{cases} \quad \text{(26-75)}$$

and then update a and N_{SYM} values by the following Equation (26-76):

$$\begin{cases} N_{SYM} = N_{SYM.init} + m_{STBC}, \text{ and } a = 1, & \text{if } a_{init} = 4 \\ N_{SYM} = N_{SYM.init}, \text{ and } a = a_{init} + 1, & \text{otherwise} \end{cases} \quad \text{(26-76)}$$

If in step d) of LDPC encoding process as described in clause 20.3.11.7.5 (LDPC PPDU encoding process), the above mentioned condition is not met, then the LDPC Extra OFDM Symbol field of HE-SIG-A shall be set to 0, and:

$$a = a_{init},\ N_{SYM} = N_{SYM.init} \quad \textbf{(26-77)}$$

With the final *a-factor* value *a*, update the N_{CBPS} of the last symbol as:

$$N_{CBPS.LAST} = \begin{cases} a \cdot N_{CBPS.SHORT}, & \text{if } a < 4 \\ N_{CBPS,} & \text{if } a = 4 \end{cases} \quad \textbf{(26-78)}$$

LDPC codes used in HE MU PPDUs shall also follow the definitions in 20.3.11.7 (LDPC codes). Refer to 25.3.10.3.4 (Encoding process for HE MU PPDUs) for a description of the LDPC encoding process for HE MU PPDUs.

26.3.10.3.3 Post-FEC padding

The number of post-FEC padding bits in each of the last m_{STBC} symbol(s) is computed by:

$$N_{PAD,POST-FEC} = N_{CBPS} - N_{CBPS.LAST} \quad \textbf{(26-79)}$$

$N_{PAD.POST-FEC}$ bits with arbitrary 0 or 1 values (TBD) are appended after the FEC output bits in each of the last m_{STBC}OFDM symbols.

26.3.10.3.4 Encoding process for an HE MU PPDU

For an HE MU PPDU, all the users shall use a common *a-factor* value and a common N_{SYM} value. The padding process is described as follows:

First compute initial *a-factor* value ($a_{init,u}$) for each user *u* using Equation (26-63), and the initial number of OFDM symbols ($N_{init,u}$) for each user *u* using Equation (26-68) if user *u* is BCC encoded, or Equation (26-73) if user *u* is LDPC encoded. Among all the users, derive the user index with the longest encoded packet duration, as in Equation (26-80):

$$u_{\max} = \arg\max_{u=0}^{N_U-1}(N_{SYM.init.u} - m_{STBC} + 0.25.m_{STBC}.a_{init.u}) \quad \textbf{(26-80)}$$

where m_{STBC} is the common STBC setting among all the users, as described in 26.3.10.8.

Then the common a_{init} and N_{init} values among all the users are derived by Equation (26-81):

$$N_{SYM.init} = N_{SYM.init.u_{\max}}$$
$$a_{init} = a_{init.u_{\max}} \quad \textbf{(26-81)}$$

Update each user's initial number of coded bits in its last symbol as below:

$$N_{DBPS.LAST.init.u} = \begin{cases} a_{init}.N_{DBPS.SHORT.u}, & \text{if } a_{init} < 4 \\ N_{DBPS.u,} & \text{if } a_{init} = 4 \end{cases}$$
$$N_{CBPS.LAST.init.u} = \begin{cases} a_{init}.N_{CBPS.SHORT.u}, & \text{if } a_{init} < 4 \\ N_{CBPS.u,} & \text{if } a_{init} = 4 \end{cases} \quad \textbf{(26-82)}$$

For each user with LDPC encoding, the number of pre-FEC padding bits is computed as in Equation (26-83):

$$N_{PAD,PRE-FEC,u} = (N_{SYM.init} - m_{STBC}).N_{DBPS.u} + m_{STBC}.N_{DBPS.LAST.init.u} - 8APEP\_LENGTH_u - N_{service} \quad \textbf{(26-83)}$$

For each user with LDPC encoding, the parameters $N_{pld,u}$ and $N_{avbits,u}$ are computed using Equations (26-84) and (26-85) respectively:

$$N_{pld,u} = (N_{SYM.init} - m_{STBC}).N_{DBPS,u} + m_{STBC}.N_{DBPS.LAST.init,u} \quad \textbf{(26-84)}$$

$$N_{avbits,u} = (N_{SYM.init} - m_{STBC}).N_{CBPS,u} + m_{STBC}.N_{CBPS.LAST.init,u} \quad \textbf{(26-85)}$$

Each user with LDPC encoding continue LDPC encoding process as in clause 20.3.11.7.5 (LDPC PPDU encoding process) starting with the parameters $N_{pld,u}$ and $N_{avbits,u}$. If there is at least one user with LDPC encoding, where step d) of its LDPC encoding process of clause 20.3.11.7.5 (LDPC PPDU encoding process), meets the following condition:

$\left(\left(N_{punc,u} > 0.1\times N_{CW,u}\times L_{LDPC,u}\times(1-R_u)\right) \text{ AND } \left(N_{shrt,u} < 1.2\times N_{punc,u}\times\frac{R_u}{1-R_u}\right)\right)$ is true OR if $\left(N_{punc,u} > 0.3\times N_{CW,u}\times L_{LDPC,u}\times(1-R_u)\right)$ is true, where $N_{punc,u}$, $N_{CW,u}$, $L_{LDPC,u}$, $N_{shrt,u}$ are the LDPC encoding paraters for user u, as defined in 20.3.11.7.5 (LDPC PPDU encoding process), and R_u is the coding rate of user u, then the LDPC Extra symbol bit in HE-SIG-A shall be set to 1, and all the users with LDPC encoding shall increment *Navbits* and recomputed N_{punc}, by the following two equations once:

$$N_{avbits,u} = \begin{cases} N_{avbits,u} + m_{STBC}\cdot\left(N_{CBPS,u} - 3.N_{CBPS.SHORT,u}\right), & \text{if } a_{init} = 3 \\ N_{avbits,u} + m_{STBC}.N_{CBPS.SHORT,u}, & \text{otherwise} \end{cases} \quad \textbf{(26-86)}$$

$$N_{punc,u} = \max\left(0,\ (N_{CW,u}\times L_{LDPC,u}) - N_{avbits,u} - N_{shrt,u}\right) \quad \textbf{(26-87)}$$

Update the common *a-factor* and N_{SYM} values for all users by the following equation:

$$\begin{cases} N_{SYM} = N_{SYM.init} + m_{STBC}, \text{ and } a = 1, & \text{if } a_{init} = 4 \\ N_{SYM} = N_{SYM.init}, \text{ and } a = a_{init} + 1, & \text{otherwise} \end{cases} \quad \textbf{(26-88)}$$

Note that users with BCC encoding shall also use the common N_{SYM} and a parameters as in Equation (26-76).

If among all the users with LDPC encoding, in step d) of clause 20.3.11.7.5 (LDPC PPDU encoding process), the above mentioned condition is not met, or if all the users in the HE MU PPDU are BCC encoded, then the LDPC Extra symbol bit in HE-SIG-A shall be set to 0, and:

$$a = a_{init},\ N_{SYM} = N_{SYM.init} \quad \textbf{(26-89)}$$

Update the N_{CBPS} and N_{DBPS} of the last symbol for each user as:

$$N_{DBPS.LAST.u} = \begin{cases} a.N_{DBPS.SHORT.u}, & \text{if } a < 4 \\ N_{CBPS.u,} & \text{if } a = 4 \end{cases}$$
$$N_{CBPS.LAST.u} = \begin{cases} a.N_{CBPS.SHORT.u}, & \text{if } a < 4 \\ N_{CBPS.u,} & \text{if } a = 4 \end{cases} \quad \textbf{(26-90)}$$

For the users with BCC encoding, the number of pre-FEC padding bits is shown in Equation (26-91).

$$N_{PAD,PRE-FEC,u} = (N_{SYM} - m_{STBC}).N_{DBPS.u} + m_{STBC}.N_{DBPS.LAST.u} - 8APEP\_LENGTH_u - N_{Tail} - N_{service} \quad \textbf{(26-91)}$$

For each user with either LDPC or BCC encoding, the number of post-FEC padding bits in each of the last m_{STBC} symbol(s) is computed as in Equation (26-92):

$$N_{PAD,POST-FEC,u} = m_{STBC}.(N_{CBPS,u} - N_{CBPS.LAST,u}) \quad \textbf{(26-92)}$$

26.3.10.3.5 Encoding process for an HE trigger-based PPDU

The AP indicates the common N_{SYM}, *a-factor*, STBC indication and LDPC Extra Symbol in the Trigger frame.

For an HE trigger-based PPDU with BCC encoding, follow the HE SU PPDU padding and encoding process as introduced in clause 25.3.10.1.1 (pre-FEC padding process), clause 25.3.10.3.1 (Binary convolutional coding and puncturing), and 25.3.10.3.3 (Post-FEC Padding), with initial parameters setting to $N_{SYM.init} = N_{SYM}$, and $a_{init} = a$, where N_{SYM} and a are the common number of symbols and *a-factor* parameters indicated in the Trigger frame, respectively.

For an HE trigger-based PPDU with LDPC encoding, follow the HE SU PPDU padding and encoding process as introduced in 26.3.10.1.1 (pre-FEC encoding process), 26.3.10.3.2 (LDPC coding), and 26.3.10.3.3 (Post-FEC padding), with the following exceptions:

When the Trigger frame indicates LDPC Extra Symbol = 1, set the initial parameters following Equation (26-93):

$$\begin{cases} a_{init} = 4,\ N_{SYM.init} = N_{SYM} - m_{STBC}, & \text{if } a = 1 \\ a_{init} = a - 1,\ N_{SYM.init} = N_{SYM}, & \text{otherwise} \end{cases} \quad \textbf{(26-93)}$$

where N_{SYM} and a are the common number of symbols and *a-factor* parameters indicated in the Trigger frame respectively, and m_{STBC} is 2 if the Trigger frame indicates STBC and 1 otherwise. Then continue with the LDPC encoding process as in clause 20.3.11.7.5 (LDPC PPDU encoding process), during which in step d) of clause 20.3.11.7.5 (LDPC PPDU encoding process), always increment *Navbits* as in Equation (26-75), and always recompute N_{punc} as in Equation (20-40), followed by updating *a = ainit + 1 if* a_{init}*<4, or a=1 if* a_{init}*=4*.

When the Trigger frame indicates LDPC Extra Symbol = 0, set initial parameters to $N_{SYM.init} = N_{SYM}$, and $a_{init} = a$, where N_{SYM} and a are the common number of symbols and *a-factor* parameters indicated in the Trigger frame respectively. Then continue with the LDPC encoding process as in clause 20.3.11.7.5 (LDPC PPDU encoding process), during which in step d) of clause 20.3.11.7.5 (LDPC PPDU encoding process), *Navbits* and N_{punc} are not changed, and $a = a_{init}$.

26.3.10.4 Stream parser

After coding, puncturing and post-FEC padding, the data bit streams at the output of the FEC encoder are processed in groups of N_{CBPS} bits. Each of these groups is re-arranged into N_{SS} blocks of N_{CBPSS} bits ($N_{SS,u}$

blocks of $N_{CBPSS,u}$ bits in the case of a HE MU transmission). This operation is referred to as "stream parsing" and is described in this section.

The description is given in terms of an SU transmission. For MU transmissions, the rearrangements are carried out in the same way per user.

The number of bits assigned to a single axis (real or imaginary) in a constellation point in a spatial stream is denoted by Equation (26-94).

$$s = \max\left\{1, \frac{N_{BPSCS}}{2}\right\} \quad \textbf{(26-94)}$$

The sum of these over all streams is $S = N_{SS}.s$.

Consecutive blocks of s bits are assigned to different spatial streams in a round robin fashion.

Let

$$N_{\text{Block}} = \left\lfloor \frac{N_{CBPS}}{S} \right\rfloor \quad \textbf{(26-95)}$$

For the $N_{\text{Block}}.S$ bits of each OFDM symbol, S bits from the output of the encoder are divided among all spatial streams, s bits per stream.

Note that in all the different RU sizes, $N_{CBPS} = N_{\text{Block}}.S$, therefore the coded bits of each OFDM symbol are always evenly allocated to *Nss* spatial streams.

The following equations are an equivalent description to the above procedure. Bit i at the output of the encoder is assigned to input bit k of spatial stream i_{SS} where

$$i = (i_{SS} - 1)s + S \cdot \left\lfloor \frac{k}{s} \right\rfloor + k \bmod s, \quad k = 0,1,\ldots, N_{Block} \cdot s - 1$$

where

$i_{SS} = 1,\ 2,\ \ldots,\ N_{SS}$

$i = 0,\ 1,\ \ldots,\ N_{CBPS} - 1$

$k = 0,\ 1,\ \ldots,\ N_{CBPS} - 1$

26.3.10.5 Segment parser

For a 160 MHz and 80+80 MHz HE SU PPDU, a 160 MHz and 80+80 MHz HE MU PPDU, and a HE trigger-based PPDU with the RU spanning the entire PPDU bandwidth, the output bits of each stream parser are segment parsed as specified in 22.3.10.7.

26.3.10.6 BCC interleavers

There is some duplication here. I think we need to delete the Table 25-24 and its reference sentence.

The BCC interleaver parameters are defined in Table 26-24.

Table 26-24 - BCC interleaver and LDPC tone mapper parameters

RU size (tones)	BCC		LDPC
	N_{col}	N_{rot}	D_{TM}
26	8	2	1
52	16	11	3
106	17	29	6
242	26	58	9
484	-	-	12
996	-	-	20

For ease of explanation, the operation of the interleaver is described only for the SU case. For user *u* in the *r*-th RU of an MU transmission, the interleaver operates in the same way on the output bits for the user from the stream parser by replacing N_{SS}, N_{CBPSS}, N_{CBPSSI}, and N_{BPSCS} with $N_{SS,r,u}$, $N_{CBPSS,r,u}$, $N_{CBPSSI,r,u}$, and $N_{BPSCS,r,u}$, respectively. That is, the operation of the interleaver is the same as if the transmission were an SU one, consisting of bits from only that user.

The BCC interleaver operation is specified in 22.3.10.8 (BCC interleaver). The values of the interleaver parameters, N_{COL}, N_{ROW}, and N_{ROT} are selected based on the RU size of the user, and are given in Table 26-25.

Table 26-25 - BCC interleaver parameters

Parameter	RU Size (tones)			
	26	52	106	242
N_{COL}	8	16	17	26
N_{ROW}	$3 \times N_{BPSCS}$	$3 \times N_{BPSCS}$	$6 \times N_{BPSCS}$	$9 \times N_{BPSCS}$
N_{ROT} ($N_{SS} \leq 4$)	2	11	29	58

26.3.10.7 Constellation mapping

The mapping between the input bits of the constellation mapper and complex constellation points for BPSK, QPSK, 16-QAM, 64-QAM and 256-QAM is as defined in 22.3.10.9 (constellation mapping).

1024-QAM is used as an optional feature for SU and MU using resource units equal to or larger than 242 tones in 11ax. For 1024-QAM, the constellation mapping is TBD.

Dual sub-carrier modulation (DCM) is an optional modulation scheme for the HE-SIG-B and Data fields. DCM is only applied to BPSK, QPSK and 16-QAM modulations.

When DCM is employed, bit sequences are mapped to a pair symbols $(d_k, d_{q(k)})$ where k is in the range of $0 \leq k \leq \frac{N_{SD}}{2} - 1$ and $q(k)$ is in the range of $\frac{N_{SD}}{2} \leq k \leq N_{SD} - 1$ in order to exploit frequency diversity.

To maximize the frequency diversity, the indices of a pair of DCM subcarriers $(k, q(k))$ is $q(k) = k + \frac{N_{SD}}{2}$.

For QPSK modulation with DCM, the input stream is broken into groups of N_{CBPS} *or* $N_{CBPS,ru}$ bits $(B_0, B_1, \cdots, B_{N_{CBPS,ru}-1})$. Each pair of bits (B_{2k}, B_{2k+1}) is QPSK modulated to a symbol d_k. This generates the constellation points for the lower half the data subcarriers in the RU. For the upper half of the data sub-carriers in the RU, $d_{q(k)} = conj(d_k)$.

For BPSK and 16-QAM modulation with DCM, the constellation mapping is TBD.

26.3.10.8 Space-time block coding

This subclause defines a set of optional robust transmission techniques that are applicable only when using STBC coding. For an HE PPDU, STBC is allowed only with single spatial stream and two space-time streams, and its application is as indicated by the STBC bit in HE-SIG-A (TBD: undecided whether in HE-SIG-A for HE_MU). In an HE MU PPDU, STBC coding is used in all RUs or not used in any of the RUs. If in an RU, DL MU-MIMO is applied, STBC shall not be used in any RU in the HE MU PPDU.

The STBC encoding process is as described in clause 22.3.10.9.4 (Space-time block coding), with $N_{SS,0} = 1$ and $N_{STS,0} = 2$.

26.3.10.9 LDPC tone mapper

The LDPC tone mapper parameters are defined in Table 26-24.

The LDPC tone mapping shall be performed on all LDPC encoded streams mapped in a RU as described in this subclause. LDPC tone mapping shall not be performed on streams that are encoded using BCC. When DCM is applied to LDPC encoded streams, D_{TM_DCM} shall be applied on both the lower half data subcarriers in a RU and the upper half data subcarriers of the RU. The LDPC tone-mapping distance parameter D_{TM} and D_{TM_DCM} are constant for each RU size and the values for different RU sizes are given in Table 26-26.

Table 26-26 – LDPC tone mapping distance for each RU size

Parameter	RU Size (tones)						
	26	52	106	242	484	996	2x996
D_{TM}	1	3	6	9	12	20	20
D_{TM_DCM}	1	1	3	9	9	14	20

For an HE PPDU without DCM, the LDPC tone mapping for the LDPC encoded stream for user u in the r-th RU is done by permuting the stream of complex numbers generated by the constellation mappers (see 26.3.10.7) to

$$d''_{t(k),i,n,l,r,u} = d'_{k,i,n,l,r,u};\ k = 0,1,...,N_{SD}-1 \text{ for a RU of 26, 52, 106, 242, 484, and 996 tones}$$
$$k = 0,1,...,\frac{N_{SD}}{2}-1 \text{ for a RU of } 996\times 2 \text{ tones}$$
$$i = 1,\ldots,N_{SS,r,u}$$
$$n = 0,1,\ldots,N_{SYM}-1 \qquad \text{(26-96)}$$
$$l = 0 \text{ for a RU of 26, 52, 106, 242, 494, and 996 tones}$$
$$l = 0,1 \text{ for a RU of } 996\times 2 \text{ tones}$$
$$u = 0,\ldots,N_{user,r}-1$$
$$r = 0,\ldots,N_{RU}-1$$

where N_{SD} is the number of data tones in the r-th RU.

$$t(k) = \begin{cases} D_{TM}\left(k \bmod \frac{N_{SD}}{D_{TM}}\right) + \left\lfloor \frac{k\cdot D_{TM}}{N_{SD}} \right\rfloor, & \text{for a RU of 26, 52, 106, 242, 484, and 996 tones} \\ D_{TM}\left(k \bmod \frac{N_{SD}/2}{D_{TM}}\right) + \left\lfloor \frac{k\cdot D_{TM}}{N_{SD}/2} \right\rfloor, & \text{for a RU of } 996\times 2 \text{ tones} \end{cases} \qquad \text{(26-97)}$$

For a HE PPDU with DCM, the LDPC tone mapping for the LDPC encoded stream corresponding to user u in the r-th RU is done by permuting the stream of complex numbers generated by the constellation mappers (see 25.3.10.7) to

$$d''_{t(k),i,n,l,r,u} = \begin{cases} d'_{k,i,n,l,r,u}; \\ d'_{k',i,n,l,r,u}; \end{cases} \qquad \text{(26-98)}$$

where

$k = 0,1,...,\frac{N_{SD}}{2} - 1$

$k^{'} = k - \frac{N_{SD}}{2}$, *for* $k = \frac{N_{SD}}{2}, \frac{N_{SD}}{2} + 1,..., N_{SD}\text{-}1$

$i = 1,\ldots, N_{SS,r,u}$

$n = 0,1,\ldots, N_{SYM} - 1$

$l = 0$ for a RU of 26, 52, 106, 242, 494, and 996 tones

$l = 0,1$ for a RU of 996×2 tones

$u = 0,\ldots, N_{user,r} - 1$

$r = 0,\ldots, N_{RU} - 1$

N_{SD} is the number of data tones in the *r*-th RU and

$$t(k) = \begin{cases} D_{TM\_DCM}\left(k \bmod \frac{N_{SD}/2}{D_{TM\_DCM}}\right) + \left\lfloor \frac{k \cdot D_{TM\_DCM}}{N_{SD}/2} \right\rfloor, & \text{for a RU of 26, 52, 106, 242, 484, and 996 tones} \\ D_{TM\_DCM}\left(k^{'} \bmod \frac{N_{SD}/2}{D_{TM\_DCM}}\right) + \left\lfloor \frac{k^{'} \cdot D_{TM\_DCM}}{N_{SD}/2} \right\rfloor + \frac{N_{SD}}{2}, & \text{for a RU of 26, 52, 106, 242, 484, and 996 tones} \\ D_{TM\_DCM}\left(k \bmod \frac{N_{SD}/2}{D_{TM\_DCM}}\right) + \left\lfloor \frac{k \cdot D_{TM\_DCM}}{N_{SD}/2} \right\rfloor, & \text{for a RU of } 996 \times 2 \text{ tones} \end{cases} \quad \textbf{(26-99)}$$

D_{TM_DCM} is the LDPC tone mapping distance for the *r*-th RU when DCM is applied.

NOTE—LDPC tone mapper for a 26-, 52-, 106-, 242-, 484- and 996-tone RU is defined as one segement. LDPC tone mapping is performed separately for the upper and lower 80 MHz frequency segments of a 2x996-tone RU as indicated by the frequency subblock index l in Error! Reference source not found. and Error! Reference source not found.

Since LDPC tone apping is not performed on BCC-coded streams, for BCC-coded streams, the following applies:

$$d''_{k,i,n,l,r,u} = d'_{k,i,n,l,r,u};\ k = 0,1,...,N_{SD} - 1 \text{ for a RU of 26, 52, 106, 242, 484, and 996 tones}$$
$$k = 0,1,...,\frac{N_{SD}}{2} - 1 \text{ for a RU of } 996 \times 2 \text{ tones}$$
$$i = 1,\ldots, N_{SS,r,u}$$
$$n = 0,1,\ldots, N_{SYM} - 1 \quad \textbf{(26-100)}$$
$$l = 0 \text{ for a RU of 26, 52, 106, 242, 494, and 996 tones}$$
$$l = 0,1 \text{ for a RU of } 996 \times 2 \text{ tones}$$
$$u = 0,\ldots, N_{user,r} - 1$$
$$r = 0,\ldots, N_{RU} - 1$$

26.3.10.10 Segment deparser

In a transmission over a RU of 26, 52, 106, 242, 484 and 996 subcarriers, the segment deparsing is not performed (see Equation (22-90)).

For a 160 MHz HE SU PPDU, or a 160 MHz HE MU PPDU or HE trigger-based PPDU with the RU spanning the entire PPDU bandwidth, the two frequency subblocks at the output of the LDPC tone mapper are combined into one frequency segment as specified in Equation (22-89).

In an 80+80 MHz HE PPDU transmission, the segment deparsing is not performed (see Equation (22-91)).

26.3.10.11 Pilot subcarriers

For a user transmitting on the *i*-th 26-tone RU in a given PPDU BW, two pilot tones shall be inserted in subcarriers $k \in K_{R26_i}$, where K_{R26_i} is given by *i*-th pilot index set in the row of given PPDU BW of Table 26-27.

Table 26-27 - Pilot indices for 26-tone RU transmission

PPDU BW	K_{R26_i}
20 MHz, i=1:9	-116/-102, -90/-76, -62/-48, -36/-22, -10/10, 22/36, 48/62, 76/90, 102/116
40 MHz, i=1:18	-238/-224, -212/-198, -184/-170, -158/-144, -130/-116, -104/-90, -78/-64, -50/-36, -24/-10, 10/24, 36/50, 64/78, 90/104, 116/130, 144/158, 170/184, 198/212, 224/238
80 MHz, i=1:37	-494/-480, -468/-454, -440/-426, -414/-400, -386/-372, -360/-346, -334/-320, -306/-292, -280/-266, -252/-238, -226/-212, -198/-184, -172/-158, -144/-130, -118/-104, -92/-78, -64/-50, -38/-24, -10/10, 24/38, 50/64, 78/92, 104/118, 130/144, 158/172, 184/198, 212/226, 238/252, 266/280, 292/306, 320/334, 346/360, 372/386, 400/414, 426/440, 454/468, 480/494
160 MHz, i=1:74	{pilot tone indices in 80 MHz -512, pilot tone indices in 80 MHz +512}

The pilot mapping $\boldsymbol{P_n^k}$ for subcarrier *k* for symbol *n* shall be as specified in Equation (26-101).

$$P_n^{K_{R26_i}} = \{\Psi_{i,n \bmod 2}, \Psi_{i,(n+1) \bmod 2}\}$$
$$P_n^{k \notin K_{R26_i}} = 0 \quad \textbf{(26-101)}$$

where

$\Psi_{i,m}$ is TBD for Pilot values for *i*-th 26-tone RU in a given PPDU BW.

For a user transmitting on the *i*-th 52-tone RU in a given PPDU BW, four pilot tones shall be inserted in subcarriers $k \in K_{R52_i}$, where K_{R52_i} is given by *i*-th pilot index set in the row of given PPDU BW of Table 26-28.

Table 26-28 - Pilot indices for 52-tone RU transmission

PPDU BW	K_{R52_i}
20 MHz, i=1:4	-116/-102/-90/-76, -62/-48/-36/-22, 22/36/48/62, 76/90/102/116
40 MHz, i=1:8	-238/-224/-212/-198, -184/-170/-158/-144, -104/-90/-78/-64, -50/-36/-24/-10, 10/24/36/50, 64/78/90/104, 144/158/170/184, 198/212/224/238
80 MHz, i=1:16	-494/-480/-468/-454, -440/-426/-414/-400, -360/-346/-334/-320, -306/-292/-280/-266, -252/-238/-226/-212, -198/-184/-172/-158, -118/-104/-92/-78, -64/-50/-38/-24, 24/38/50/64, 78/92/104/118, 158/172/184/198, 212/226/238/252, 266/280/292/306, 320/334/346/360, 400/414/426/440, 454/468/480/494
160 MHz, i=1:32	{pilot tone indices in 80 MHz -512, pilot tone indices in 80 MHz +512}

The pilot mapping $\boldsymbol{P_n^k}$ for subcarrier *k* for symbol *n* shall be as specified in Equation (26-102).

$$P_n^{K_{R52_i}} = \{\Psi_{i,n \bmod 4}, \Psi_{i,(n+1) \bmod 4}, \Psi_{i,(n+2) \bmod 4}, \Psi_{i,(n+3) \bmod 4}\}$$
$$P_n^{k \notin K_{R52_i}} = 0 \quad \textbf{(26-102)}$$

where

$\Psi_{i,m}$ is TBD for Pilot values for *i*-th 52-tone RU in a given PPDU BW.

For a user transmitting on the *i*-th 106-tone RU in a given PPDU BW, four pilot tones shall be inserted in subcarriers $k \in K_{R106_i}$, where K_{R106_i} is given by *i*-th pilot index set in the row of given PPDU BW of Table 26-29.

Table 26-29 - Pilot indices for 106-tone RU transmission

PPDU BW	K_{R106_i}
20 MHz, i=1:2	-116/-90/-48/-22, 22/48/90/116
40 MHz, i=1:4	-238/-212/-170/-144, -104/-78/-36/-10, 10/36/78/104, 144/170/212/238
80 MHz, i=1:8	-494/-468/-426/-400, -360/-334/-292/-266, -252/-226/-184/-158, -118/-92/-50/-24, 24/50/92/118, 158/184/226/252, 266/292/334/360, 400/426/468/494
160 MHz, i=1:16	{pilot tone indices in 80MHz -512, pilot tone indices in 80MHz +512}

The pilot mapping $\boldsymbol{P_n^k}$ for subcarrier k for symbol n shall be as specified in Equation (26-103).

$$P_n^{K_{\mathrm{R106}_i}} = \{\Psi_{i,n \bmod 4}, \Psi_{i,(n+1) \bmod 4}, \Psi_{i,(n+2) \bmod 4}, \Psi_{i,(n+3) \bmod 4}\}\}$$
$$P_n^{k \notin K_{\mathrm{R106}_i}} = 0 \quad \textbf{(26-103)}$$

where

$\Psi_{i,m}$ is TBD for Pilot values for i-th 106-tone RU in a given PPDU BW.

For a user transmitting on the i-th 242-tone RU in a given PPDU BW, eight pilot tones shall be inserted in subcarriers $k \in K_{R242_i}$, where K_{R242_i} is given by i-th pilot index set in the row of given PPDU BW of Table 26-30.

Table 26-30 - Pilot indices for 242-tone RU transmission

PPDU BW	K_{R242_i}
20 MHz, i=1	-116/-90/-48/-22/22/48/90/116
40 MHz, i=1:2	-238/-212/-170/-144/-104/-78/-36/-10, 10/36/78/104/144/170/212/238
80 MHz, i=1:4	-494/-468/-426/-400/-360/-334/-292/-266,-252/-226/-184/-158/-118/-92/-50/-24, 24/50/92/118/158/184/226/252, 266/292/334/360/ 400/426/468/494
160 MHz, i=1:8	{pilot tone indices in 80 MHz -512, pilot tone indices in 80 MHz +512}

The pilot mapping $\boldsymbol{P_n^k}$ for subcarrier k for symbol n shall be as specified in Equation (26-104).

$$P_n^{K_{\mathrm{R242}_i}} = \{\Psi_{i,n \bmod 8}, \Psi_{i,(n+1) \bmod 8}, \Psi_{i,(n+2) \bmod 8}, \Psi_{i,(n+3) \bmod 8}, \Psi_{i,(n+4) \bmod 8}, \Psi_{i,(n+5) \bmod 8}, \Psi_{i,(n+6) \bmod 8}, \Psi_{i,(n+7) \bmod 8}\}$$
$$P_n^{k \notin K_{\mathrm{R242}_i}} = 0 \quad \textbf{(26-104)}$$

where

$\Psi_{i,m}$ is TBD for Pilot values for i-th 242-tone RU in a given PPDU BW.

For a user transmitting on the i-th 484-tone RU in a given PPDU BW, sixteen pilot tones shall be inserted in subcarriers $k \in K_{R484_i}$, where K_{R484_i} is given by i-th pilot index set in the row of given PPDU BW of Table 26-31.

Table 26-31 - Pilot indices for 484-tone RU transmission

PPDU BW	K_{R484_i}
20 MHz	N/A
40 MHz, i=1	-238/-212/-170/-144/-104/-78/-36/-10/10/36/78/104/144/170/212/238
80 MHz, i=1:2	-494/-468/-426/-400/-360/-334/-292/-266/-252/-226/-184/-158/-118/-92/-50/-24, 24/50/92/118/158/184/226/252/266/292/334/360/400/426/468/494
160 MHz, i=1:4	{pilot tone indices in 80 MHz -512, pilot tone indices in 80 MHz +512}

The pilot mapping $\boldsymbol{P_n^k}$ for subcarrier k for symbol n shall be as specified in Equation (26-105).

$$P_n^{K_{R484_i}} = \{\Psi_{i,n \bmod 8}, \Psi_{i,(n+1) \bmod 8}, \Psi_{i,(n+2) \bmod 8}, \Psi_{i,(n+3) \bmod 8}, \Psi_{i,(n+4) \bmod 8}, \Psi_{i,(n+5) \bmod 8}, \Psi_{i,(n+6) \bmod 8}, \Psi_{i,(n+7) \bmod 8}, \cdots$$
$$\Psi_{i,(n+8) \bmod 8}, \Psi_{i,(n+9) \bmod 8}, \Psi_{i,(n+10) \bmod 8}, \Psi_{i,(n+11) \bmod 8}, \Psi_{i,(n+12) \bmod 8}, \Psi_{i,(n+13) \bmod 8}, \Psi_{i,(n+14) \bmod 8}, \Psi_{i,(n+15) \bmod 8}\} \quad \textbf{(26-105)}$$
$$P_n^{k \notin K_{R484_i}} = 0$$

where

$\Psi_{i,m}$ is TBD for Pilot values for *i*-th 484-tone RU in a given PPDU BW.

For a user transmitting on the *i*-th 996-tone RU in a given PPDU BW, sixteen pilot tones shall be inserted in subcarriers $k \in K_{R996_i}$, where K_{R996_i} is given by *i*-th pilot index set in the row of given PPDU BW of Table 26-32.

Table 26-32 - Pilot indices for 996-tone RU transmission

PPDU BW	K_{R996_i}
20 MHz	N/A
40 MHz	N/A
80 MHz, i=1	-468/-400/-334/-266/-226/-158/-92/-24/24/92/158/226/266/334/400/468
160 MHz, i=1:2	{pilot tone indices in 80 MHz -512, pilot tone indices in 80 MHz +512}: -980/-912/-846/-778/-738/-670/-604/-536/-488/-420/-354/-286/-246/-178/-112/-44, 44/112/178/246/286/354/420/488/536/604/670/738/778/846/912/980

The pilot mapping $\boldsymbol{P_n^k}$ for subcarrier *k* for symbol *n* shall be as specified in Equation (26-106).

$$P_n^{K_{R996_i}} = \{\Psi_{i,n \bmod 8}, \Psi_{i,(n+1) \bmod 8}, \Psi_{i,(n+2) \bmod 8}, \Psi_{i,(n+3) \bmod 8}, \Psi_{i,(n+4) \bmod 8}, \Psi_{i,(n+5) \bmod 8}, \Psi_{i,(n+6) \bmod 8}, \Psi_{i,(n+7) \bmod 8}, \cdots$$
$$\Psi_{i,(n+8) \bmod 8}, \Psi_{i,(n+9) \bmod 8}, \Psi_{i,(n+10) \bmod 8}, \Psi_{i,(n+11) \bmod 8}, \Psi_{i,(n+12) \bmod 8}, \Psi_{i,(n+13) \bmod 8}, \Psi_{i,(n+14) \bmod 8}, \Psi_{i,(n+15) \bmod 8}\} \quad \textbf{(26-106)}$$
$$P_n^{k \notin K_{R996_i}} = 0$$

where

$\Psi_{i,m}$ is TBD for Pilot values for 996-tone RU in 80 MHz PPDU BW.

For a 160 MHz transmission, the 80 MHz pilot mapping is replicated in the two 80 MHz subchannels of the 160 MHz transmission. Specifically, thirty-two pilot tones shall be inserted in subcarriers $k \in K_{R2x996}$, where $K_{R2\times996}$ is given by {-980, -912, -846, -778, -738, -670, -604, -536, -488, -420, -354, -286, -246, -178, -112, -44, 44, 112, 178, 246, 286, 354, 420, 488, 536, 604, 670, 738, 778, 846, 912, 980}. The pilot mapping $\boldsymbol{P_n^k}$ for subcarrier *k* for symbol *n* shall be as specified in Equation (26-107) .

$$P_n^{K_{R2x996}} = \{\Psi_{i,n \bmod 8}, \Psi_{i,(n+1) \bmod 8}, \Psi_{i,(n+2) \bmod 8}, \Psi_{i,(n+3) \bmod 8}, \Psi_{i,(n+4) \bmod 8}, \Psi_{i,(n+5) \bmod 8}, \Psi_{i,(n+6) \bmod 8}, \Psi_{i,(n+7) \bmod 8}, \cdots$$
$$\Psi_{i,(n+8) \bmod 8}, \Psi_{i,(n+9) \bmod 8}, \Psi_{i,(n+10) \bmod 8}, \Psi_{i,(n+11) \bmod 8}, \Psi_{i,(n+12) \bmod 8}, \Psi_{i,(n+13) \bmod 8}, \Psi_{i,(n+14) \bmod 8}, \Psi_{i,(n+15) \bmod 8}, \cdots \quad \textbf{(26-107)}$$
$$\Psi_{i,n \bmod 8}, \Psi_{i,(n+1) \bmod 8}, \Psi_{i,(n+2) \bmod 8}, \Psi_{i,(n+3) \bmod 8}, \Psi_{i,(n+4) \bmod 8}, \Psi_{i,(n+5) \bmod 8}, \Psi_{i,(n+6) \bmod 8}, \Psi_{i,(n+7) \bmod 8}, \cdots$$
$$\Psi_{i,(n+8) \bmod 8}, \Psi_{i,(n+9) \bmod 8}, \Psi_{i,(n+10) \bmod 8}, \Psi_{i,(n+11) \bmod 8}, \Psi_{i,(n+12) \bmod 8}, \Psi_{i,(n+13) \bmod 8}, \Psi_{i,(n+14) \bmod 8}, \Psi_{i,(n+15) \bmod 8}\}$$
$$P_n^{k \notin K_{R2x996}} = 0$$

where

$\Psi_{i,m}$ is TBD for Pilot values for 996-tone RU in 80 MHz PPDU BW.

For a noncontiguous 80+80 MHz transmission, each frequency segment shall follow the 80 MHz pilot tone allocation and values defined for 996-tone RU in 80 MHz transmission as specified in Equation (26-106) and TBD Pilot values for 996-tone RU in 80 MHz PPDU BW.

The above pilot mapping shall be copied to all space-time streams before the space-time stream cyclic shifts are applied.

26.3.10.12 OFDM Modulation

The time domain waveform of the Data field of an HE PPDU that is not an HE trigger-based PPDU, from transmit chain i_{TX}, $1 \le i_{TX} \le N_{TX}$, shall be as defined in Equation (26-108).

$$r_{\text{HE-Data}}^{(i_{seg},i_{TX})}(t) = \frac{1}{\sqrt{\sum_{r=1}^{N_{RU}} \alpha_r^2 |K_r|}} \sum_{n=0}^{N_{SYM}-1} w_{T_{HE-Data}}(t - nT_{SYM}) \sum_{r=0}^{N_{RU}-1} \frac{\alpha_r}{\sqrt{N_{STS,r,total}}} \cdot \sum_{k \in K_r} \sum_{u=0}^{N_{user,r}-1} \sum_{m=1}^{N_{STS,r,u}} \left(\begin{array}{l} \left[Q_k^{(i_{seg})} \right]_{i_{TX},(M_{r,u}+m)} \left(\tilde{D}_{k,m,n,r}^{(i_{seg},u)} + p_{n+2+N_{HE-SIG-A}+N_{HE-SIG-B}} P_n^k \right) \\ \cdot \exp\left(j2\pi k \Delta_{F,HE} \left(t - nT_{SYM} - T_{\text{GI,Data}} - T_{CS,HE}(M_{r,u}+m) \right) \right) \end{array} \right) \quad \textbf{(26-108)}$$

where

p_n is defined in 18.3.5.10 (OFDM modulation)

P_n^k is defined in **Error! Reference source not found.**

$\tilde{D}_{k,m,n,BW}^{(i_{Seg},r,u)}$ is the transmitted constellation for user u in the r-th RU at subcarrier k, space-time stream m, and Data field OFDM symbol n and is defined in **Error! Reference source not found.**.

$N_{\text{HE-Data}}^{\text{Tone}}$ has the value given in **Error! Reference source not found.**

$T_{CS,HE}(n)$ is given in 26.3.9.2 (Cyclic shift for Pre-HE modulated fields)

$T_{\text{GI, Data}}$ is the guard interval duration as defined in Table 25-xxx (Timing related constants) of 25.3.6 (Timing related parameters).

$$\tilde{D}_{k,m,n,r}^{(i_{Seg},u)} = \begin{cases} 0, k \in K_{\text{Pilot}} \\ \tilde{d}_{M_r(k),m,n,r,u}^{(i_{Seg})}, \text{otherwise} \end{cases} \quad \textbf{(26-109)}$$

where

K_{Pilot} is the set of subcarrier indices of pilot tones, as defined in 25.3.7.3 (Pilot tones).

$M_r(k)$ is defined in Equation (26-110).

$$M_r(k) = k - K_{r,\min} - \left| \left\{ k' : K_{r,\min} \le k' < k \right\} \cap K_{\text{Pilot}} \right| \quad \textbf{(26-110)}$$

where

$K_{r,\min}$ is the minimum value of the set K_r;

$|\Phi|$ is the cardinality of a set Φ.

NOTE – $M_r(k)$ translates a subcarrier index k ($-N_{SR} \le k \le N_{SR}$) into the index of data symbols in a transmission over a RU ($0 \le M_r(k) \le N_{SD,r}$). The subcarrier index k for the data tone is first offset by the minimum value of subcarrier index $K_{r,min}$ (for the lower edge tone) in this RU, and then subtracted by the number of pilot tones falling in between the data tone and the edge tone.

In a noncontiguous 80+80 MHz transmission, each frequency segment shall follow the 80 MHz HE subcarrier mapping as specified in 26.3.7 (OFDMA and SU tone allocation).

The time domain waveform of the Data field of an HE trigger-based PPDU for user u in the r-th RU from transmit chain i_{TX}, $1 \le i_{TX} \le N_{TX}$ shall be as defined in Equation (26-111).

$$r_{\text{HE-Data}}^{(i_{seg},i_{TX})}(t) = \frac{\alpha_r}{\sqrt{\sum_{r=1}^{N_{RU}} \alpha_r^2 |K_r|}} \sum_{n=0}^{N_{SYM}-1} w_{T_{HE-Data}}(t - nT_{SYM}) \frac{1}{\sqrt{N_{STS,r,total}}} \cdot \sum_{k \in K_r} \sum_{m=1}^{N_{STS,r,u}} \left(\left[Q_k^{(i_{seg})} \right]_{i_{TX},(M_{r,u}+m)} \left(\tilde{D}_{k,m,n,r}^{(i_{Seg},u)} + p_{n+4} P_n^k \right) \cdot \exp\left(j2\pi k \Delta_{F,HE} \left(t - nT_{SYM} - T_{\text{GI,Data}} - T_{CS,HE} \left(M_{r,u} + m \right) \right) \right) \right) \quad \text{(26-111)}$$

where

$Q_k^{(i_{Seg})}$ is a spatial mapping/steering matrix with N_{TX} rows and $N_{STS,r,total}$ columns for subcarrier k in frequency segment i_{Seg}. $Q_k^{(i_{Seg})}$ may be frequency dependent, and the dimension may be variant in each RU. Refer to the descriptions in 22.3.10.11.1 (Transmission in VHT format) for examples of $Q_k^{(i_{Seg})}$.

26.3.10.13 Dual carrier modulation

Dual sub-carrier modulation (DCM) modulates the same information on a pair of sub-carriers. DCM is an optional modulation scheme for the HE-SIG-B and Data fields. DCM is only applied to BPSK, QPSK and 16-QAM modulations.

The constellation mapper for DCM is defined in 25.3.10.6. The DCM tone mapper is TBD.

26.3.10.14 Packet extension

A HE PPDU may have a Packet Extension (PE) field appended at the end of the PPDU, with possible durations being 0 µs, 4 µs, 8 µs, 12 µs, or 16 µs. The PE field, when present, shall be transmitted with the same average power as the Data field, and its content is arbitrary (PE content TBD).

The PE field is applied for the recipient of the PPDU to obtain longer processing time at the end of a HE PPDU, and its duration is determined by both the *a-factor* value in the last OFDM symbol(s) of the Data field, and the maximum PE duration requested by the recipient for the signal bandwidth (or RU size), the number of spatial streams, and the constellation size of the current PPDU, which is based on the Maximum PE capabilities as defined in HE capabilities field (8.4.2.1 (HE Capabilities Element)).

For a HE PPDU, the maximum PE durations as defined by the Maximum PE capabilities in HE capabilities (8.4.2.1 (HE Capabilities Element)) are 0 µs, 8 µs and 16 µs.

— A 0 µs maximum PE duration means no PE is present.

— A 8 µs maximum PE duration means that a PE field of 0 µs, 0 µs, 4 µs, and 8 µs are appended at the end of the PPDU, corresponding to *a-factor* being 1, 2, 3 and 4, respectively, as shown in Figure 25.3.10.9-1 (PE field when maximum PE duration is 8 µs (non STBC)).

— A 16 µs maximum PE duration means that a PE field of 4 µs, 8 µs, 12 µs, and 16 µs are appended at the end of the PPDU, corresponding to *a-factor* being 1, 2, 3 and 4, respectively, as shown in Figure 25.3.10.9-2 (PE field when maximum PE duration is 16 µs (non STBC)).

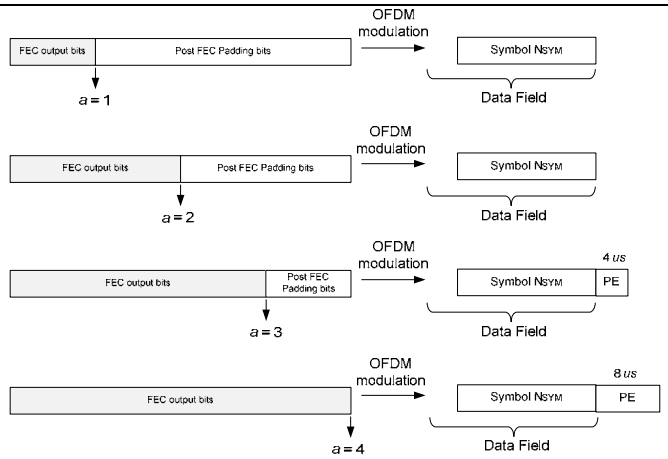


Figure 26-34 - PE field when maximum PE duration is 8 µs (non STBC)

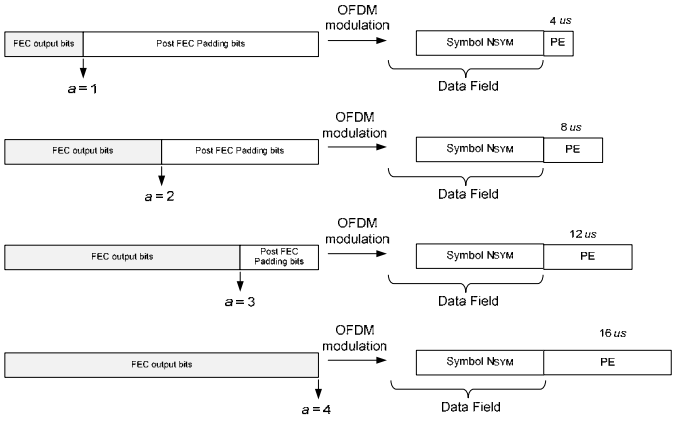


Figure 26-35 - PE field when maximum PE duration is 16 µs (non STBC)

For an HE MU PPDU, the AP computes the PE duration, $T_{PE,u}$, for each user u, according to the common *a-factor* value among all users as described in 26.3.10.3.4, the Maximum PE Duration capabilities, the RU size, the number of spatial streams and constellation size for user u. The AP shall choose the largest PE duration among all the users as the common PE duration of the current HE MU PPDU as:

$$T_{PE} = \max_{u}\left(T_{PE,u}\right) \quad \textbf{(26-112)}$$

and then append the PE field at the end of the current HE MU PPDU, with duration T_{PE}.

For an HE trigger-based PPDU, the AP indicates the common PE duration, T_{PE}, for all the users in the Trigger frame. Each user, when responding the Trigger frame with an HE trigger-based PPDU, shall append PE field at the end of the current HE trigger-based PPDU, with a duration T_{PE}. The value of T_{PE} is TBD.

Should the HE-SIG-A bits definition below be moved into 25.3.9.2.4 (HE-SIG-A)?

The 3-bit Packet Extension field in HE-SIG-A are defined as in Table 26-33.

Table 26-33 - Packet Extension field in HE-SIG-A

Name	bits	Definition
a-factor	b0-b1	Indicates a-factor value of current PPDU
PE Disambiguity	b2	Indicates PE disambiguity

The a-factor subfield of the Packet Extension field is encoded as shown in Table 26-34.

Table 26-34 - a-factor subfield encoding

a-factor value	a-factor subfield encoding
1	b01
2	b10
3	b11
4	b00

The PE Disabmbituity subfield of the Packet Extension field shall be set to 1 if the condition in Equation (26-113) is met, otherwise it shall be set to 0.

$$T_{PE} + 4 \times \left(\left\lceil \frac{TXTIME - 20}{4} \right\rceil - \left(\frac{TXTIME - 20}{4} \right) \right) \geq T_{SYM} \quad \text{(26-113)}$$

where

T_{PE} is the PE field duration

T_{SYM} is the symbol duration of the Data field as defined in 26.3.6 (Timing related parameters)

TXTIME (in µs) is defined in 26.4.3.

Based on PE disambiguity field and a-factor field, the recipient shall compute N_{SYM} and T_{PE} listed in 26.3.15.

26.3.11 Non-HT Duplicate Transmission

When the TXVECTOR parameter FORMAT is NON_HT and the TXVECTOR parameter NON_HT_MODULATION is NON_HT_DUP_OFDM, the transmitted PPDU is a non-HT duplicate. Non-HT duplicate transmission is used to transmit to non-HT OFDM STAs, HT STAs, VHT STAs, HE STAs that may be present in a part of a 40 MHz, 80 MHz, or 160 MHz channel (see **Error! Reference source not found.**). The RL-SIG, HE-SIG-A, HE-SIG-B, HE-STF, and HE-LTF fields are not transmitted. The L-STF, L-LTF, and L-SIG fields shall be transmitted in the same way as in the HE transmission when the TXVECTOR parameter BEAM_CHANGE is 0, with the exceptions for the Rate and Length fields which shall follow 18.3.4 (SIGNAL field).

In a 40 MHz non-HT duplicate transmission, the Data field shall be as defined by Equation (20-61).

For 80 MHz and 160 MHz non-HT duplicate transmissions, the Data field shall be as defined by **Error! Reference source not found.**.

In a noncontiguous 80+80 MHz non-HT duplicate transmission, data transmission in each frequency segment shall be as defined for an 80 MHz non-HT duplicate transmission in **Error! Reference source not found.**.

26.3.12 MU-MIMO

26.3.12.1 Introduction

DL MU MIMO is specified in 22.3.11 for full band transmission. In this amendment, MU-MIMO is also applicable on a subset of active RUs within PPDU bandwidth in both DL and UL. The non-AP STAs in the

same MU-MIMO group are allocated the same resource unit. The combination of SU-MIMO and MU-MIMO on different RU for different non-AP STA in one PPDU is supported.

26.3.12.2 Minimum RU size in MU MIMO transmission

Both DL and UL MU MIMO shall transmit on the RU of at least 106 tones.

26.3.12.3 DL MU-MIMO

26.3.12.3.1 Introduction

For DL MU-MIMO beamforming in RU r, the receive signal vector in subcarrier k (where subcarrier k is one of the subcarriers in RU r, $k \in K_r$) at beamformee u, $\boldsymbol{y}_{k,u} = \left[y_{k,0}, y_{k,1}, \cdots, y_{k,N_{RX_u}-1}\right]^T$, is shown in Equation (26-114), where $\boldsymbol{x}_k = \left[\boldsymbol{x}_{k,0}^T, \boldsymbol{x}_{k,1}^T, \cdots, \boldsymbol{x}_{k,N_{user,r}-1}^T\right]^T$ denotes the transmit signal vector in subcarrier k for all N_{user} beamformees, with $\boldsymbol{x}_{k,u} = \left[x_{k,0}, x_{k,1}, \cdots, x_{k,N_{STS,r,u}-1}\right]^T$ being the transmit signal for beamformee u.

$$\boldsymbol{y}_{k,u} = \boldsymbol{H}_{k,u} \times \left[Q_{k,0}, Q_{k,1}, \cdots, Q_{k,N_{user}-1}\right] \times \boldsymbol{x}_k + \boldsymbol{n} \quad \textbf{(26-114)}$$

where

$\boldsymbol{H}_{k,u}$ is the channel matrix from the beamformer to beamformee u in subcarrier k with dimensions $N_{RX_u} \times N_{TX}$

N_{RX_u} is the number of receive antennas at beamformee u

$Q_{k,u}$ is a steering matrix for beamformee u in subcarrier k with dimensions $N_{TX} \times N_{STS,r,u}$

$N_{user,r}$ is the number of HE MU PPDU recipients in RU r (see Table 26-6)

$\boldsymbol{n}$ is a vector of additive noise and may include interference

The DL MU-MIMO steering matrix $Q_k = \left[Q_{k,0}, Q_{k,1}, \cdots, Q_{k,N_{user,r}-1}\right]$ can be determined by the beamformer using the beamforming feedback for subcarrier k from beamformee u, where $u = 0,1,\cdots,N_{user,r}-1$. The feedback report format is TBD. The steering matrix that is computed (or updated) using new beamforming feedback from some or all of participating beamformees might replace the existing steering matrix Q_k for the next DL MU-MIMO data transmission. The beamformee group for the DL MU transmission is signaled in HE-SIG-B (see 26.3.9.8.3 and 26.3.12.3.4).

26.3.12.3.2 Beamforming feedback

TBD

26.3.12.3.3 Maximum number of total spatial streams in a VHT MU PPDU

A DL MU-MIMO capable STA shall support reception of DL MU PPDUs with the total number of space-time streams across the N_user users being less than or equal to its DL MU-MIMO STS Capability in the HE Capabilities.

26.3.12.3.4 Resource indication and STA self identification

AP shall transmit HE MU PPDU. The UL/DL field in the HE-SIG-A shall be set TBD (for DL). If the value of SIGB Compression field in HE-SIG-A is 0, the RU allocation signaling in the HE-SIG-B common field indicates the combination of RUs in current PPDU bandwidth and the number of STAs on each RU for SU/MU MIMO transmission. The number of users in RU r for MU-MIMO transmission, $N_{user,r}$ is indicated together with the RU allocation as defined in Table 26-18. If the value of SIGB Compression field in HE-SIG-A is 1, there is no RU allocation signaling in HE-SIG-B common field. The number of STAs in the

MU MIMO group is indicated in the TBD field in HE-SIG-A. the number of spatial streams $N_{ss,r,u}$ is indicated by NSTS field in user specific block as defined in Table 26-19 and Table 26-20.The allocated spatial streams for a designated MU MIMO user and the total number of spatial streams on the RU are indicated in spatial configuration field of user specific block containing the STA ID of designated MU MIMO STA as defined in Table 26-21.

When processing the HE-SIG-B, a STA will look at information of each RU to find out its Membership Status, i.e., if it belongs to a beamformee group in a certain RU. If $N_{user,r}$ STAs are scheduled in RU r, there are $N_{user,r}$ user specific blocks for RU r. Each user specific block has an 11-bit field indicating the STA ID. A STA identifies itself as a member in the beamformee group in the RU, if its STA ID matches one of the STA IDs. The user position is indicated by the block index. From a multiplexing information lookup table for $N_{user,r}$, the ordered number of spatial streams for all members in the beamformee group in RU r, $N_{ss,r,u}$, u=1,…, $N_{users,u}$, could be obtained. The spatial streams of different users are ordered in accordance to user position values, i.e., the spatial streams for the user in user position 0 come first, followed by the spatial streams for the user in position 1, followed by the spatial streams for the user in position 2, and followed by the spatial streams for the user in position 3, and so on.

A STA is also able to identify the space-time streams intended for other STAs that act as interference. HE-LTF symbols in the HE DL MU PPDU are used to measure the channel for the space-time streams intended for the STA and can also be used to measure the channel for the interfering space-time streams. To successfully demodulate the space-time streams intended for the STA, it is recommended that the STA uses the channel knowledge for all space-time streams to reduce the effect of interfering space-time streams.

If a STA finds that it is a member of the beamformee group in RU r, its corresponding $N_{STS,r,u}$ interpreted from the HE-SIG-B user specific blocks shall not be zero for the STA in the PPDU. If a STA finds that it is not a member of the beamformee group in RU r, then the STA may elect not to process RU r in the remainder of the PPDU.

26.3.12.4 UL MU-MIMO

26.3.12.4.1 Introduction

UL MU-MIMO is a technique to allow multiple STAs to transmit simultaneously over the same frequency resource to the receiver. The concept is very similar to SU-MIMO where multiple space-time streams are transmitted simultaneously over the same frequency resource utilizing spatial multiplexing through multiple antennas at the transmitter and receiver. The key difference from SU-MIMO is that in UL MU-MIMO, the transmitted streams originate at multiple transmitters.

For UL MU-MIMO transmissions, support for both single stream pilots and the masking the LTF sequence of each spatial stream by a distinct orthogonal code is mandatory at the transmitter side (non-AP STA).

26.3.12.4.2 Resource Indication and STA Self Identification

UL MU-MIMO transmissions are preceded by a Trigger frame from the AP. Similar as UL OFDMA cases, the Trigger frame indicates the transmitting STAs in the common part about when to transmit the UL MU-MIMO PPDUs, the duration of the payload, and packet-extension. The CP length for UL OFDMA/MU-MIMO transmissions shall also be explicitly indicated by AP in the Trigger frame. The value of CP length for all users addressed by the Trigger frame shall be the same. The Trigger frame shall use 1 bit to indicate whether the UL MU-MIMO transmission following it uses single stream pilots or a mask on each spatial stream of the LTF sequence by a distinct orthogonal code. When single stream pilot is used, no masking is applied to the HE LTF. The allocated RU and spatial streams are carried in the fields of RU allocation info and SS allocation of Per User Info field, where Address field is set as the AID of designated MU MIMO STA. Details TBD.

If a STA finds that there is no Per User Info field in Trigger frame carrying the STA's AID in the Address field, then the STA will not transmit in the following HE trigger-based PPDU.

26.3.12.4.3 Pre-corrections in UL MU-MIMO

Since multiple transmitters take part in an UL MU-MIMO transmission, it requires time, frequency, sampling clock and power pre-correction by the participating STAs to mitigate the synchronization related issues at the AP. Frequency and sampling clock pre-corrections are needed to prevent inter-carrier interference. Power pre-correction is done through power control described in **Error! Reference source not found.**. The Trigger frame serves as a reference DL frame for the STAs to do the aforementioned pre-corrections to the UL PPDUs. The accuracy requirements on these pre-corrections are specified in section x.x.x.

26.3.12.4.4 Power control in UL MU-MIMO

TBD

26.3.12.4.5 Maximum number of spatial streams in UL MU-MIMO PPDUs

An UL MU-MIMO capable STA shall support transmission of UL MU PPDUs with the number of space-time streams being less than or equal to its UL MU-MIMO STS Capability in HE Capabilities.

26.3.12.4.6 Requirements for STAs transmitting HE trigger-based PPDUs

A STA that transmits an HE trigger-based PPDU shall support per chain max(*P*-32, -10 dBm) as the minimum transmit power, with *P* the maximum power the STA can transmit at the antenna connector of that chain using MCS0 while meeting the TX EVM and spectral mask requirements. A STA transmitting at and above the minimum power shall support the EVM requirements for MCS7 (TBD whether support for higher MCS).

A STA that transmits an HE trigger-based PPDU shall support the absolute transmit power requirements and the RSSI measurement accuracy requirements defined in Table 26-35.

Table 26-35 - Transmit power and RSSI measurement accuracy

Parameter	Minimum Requirement		Comments
	Class A	Class B	
Absolute transmit power accuracy	±3 dB	±9 dB	Accuracy of achieving a specified transmit power
RSSI measurement accuracy	±2 dB	±5 dB	Difference between the actual RSSI and the measured RSSI Requirements are valid from minimum Rx to maximum Rx input power

A STA that transmits an HE trigger-based PPDU shall pre-compensate for carrier frequency offset (CFO) error and timing drift. After compensation, the absolute value of residual CFO error with respect to the PPDU carrying the associated Trigger frame shall not exceed 350 Hz for data subcarriers when measured as the 10% point of CCDF of CFO errors in AWGN at a received power of -60 dBm in the primary 20MHz. The residual CFO error measurement shall be made on the HE trigger-based PPDU following the HE-SIG-A field.

A STA that transmits an HE trigger-based PPDU shall have timing accuracy of ±0.4 μs relative to the PPDU carrying the Trigger frame. This requirement does not include round trip delay.

26.3.13 Transmit specification

26.3.13.1 Transmit spectral mask

26.3.13.2 Spectral flatness

26.3.13.3 Transmit center frequency and symbol clock frequency tolerance

Transmit center frequency and the symbol clock frequency for all transmit antennas and frequency segments shall be derived from the same reference oscillator.

26.3.13.4 Modulation accuracy

26.3.13.4.1 Introduction to modulation accuracy tests

26.3.13.4.2 Transmit center frequency leakage

The TX LO leakage requirement for all transmission modes shall be the following. The power measured at the location of the RF LO using resolution BW 78.125 kHz shall not exceed the maximum of –32 dB relative to the total transmit power and −20 dBm, or equivalently max(P−32, −20), where P is the transmit power per antenna in dBm. The transmit center frequency leakage is specified per antenna.

26.3.13.4.3 Transmitter constellation error

26.3.14 HE transmit procedure

TBD

26.3.15 HE receive procedure

TBD

26.4 HE PLME

26.4.1 PLME_SAP sublayer management primitives

Table 25-1 (HE PHY MIB attributes (11ax)) lists the MIB attributes that may be accessed by the PHY entities and the intralayer of higher level LMEs. These attributes are accessed via the PLME-GET, PLME-SET, PLME-RESET, and PLME-CHARACTERISTICS primitives defined in 6.5 (PLME SAP interface).

26.4.2 PHY MIB

TBD

26.4.3 TXTIME and PSDU_LENGTH calculation

The value of the TXTIME parameter returned by the PLME-TXTIME.confirm primitive shall be calculated for a HE PPDU using Equation (26-115) for an HE SU PPDU and HE trigger-based PPDU, Equation (26-116) for an HE MU PPDU and Equation (26-117) for an HE extended range SU PPDU.

$$\mathrm{TXTIME} = T_{LEG\_PREAMBLE} + T_{L-SIG} + T_{RL-SIG} + T_{HE-SIG-A} + T_{HE\_PREAMBLE} + N_{SYM} T_{SYM} + T_{PE} \quad \textbf{(26-115)}$$

$$\mathrm{TXTIME} = T_{LEG\_PREAMBLE} + T_{L-SIG} + T_{RL-SIG} + T_{HE-SIG-A} + N_{HE-SIG-B} T_{HE-SIG-B} + T_{HE\_PREAMBLE} + N_{SYM} T_{SYM} + T_{PE} \quad \textbf{(26-116)}$$

$$\mathrm{TXTIME} = T_{LEG\_PREAMBLE} + T_{L-SIG} + T_{RL-SIG} + T_{HE-SIG-A} + T_{HE-SIG-A-R} + T_{HE\_PREAMBLE} + N_{SYM} T_{SYM} + T_{PE} \quad \textbf{(26-117)}$$

where

$T_{\text{LEG\_PREAMBLE}} = T_{\text{L-STF}} + T_{\text{L-LTF}}$

$$T_{\text{HE\_PREAMBLE}} = \begin{cases} T_{\text{HE-STF}-T} + N_{HELTF} T_{\text{HE-LTF,SYM}}, & \text{for the HE\_TRIG} \\ T_{\text{HE-STF}-NT} + N_{HELTF} T_{\text{HE-LTF,SYM}}, & \text{Otherwise} \end{cases}$$

$T_{\text{L-STF}}$, $T_{\text{L-LTF}}$, $T_{\text{HE-STF}-T}$, $T_{\text{HE-STF}-NT}$, $T_{\text{HE-LTF,SYM}}$, $T_{\text{L-SIG}}$, $T_{\text{RL-SIG}}$, $T_{\text{HE-SIG-A}}$, $T_{\text{HE-SIG-A-R}}$, $T_{\text{HE-SIG-B}}$ and T_{SYM} are defined in Table 26-3 (Timing-related constants)

$N_{HE-SIG-B}$ and N_{HE-LTF} are defined in Table 26-6 (Frequently used parameters)

For an HE NDP PPDU, there is no Data field and $N_{SYM} = 0$.

For an HE SU PPDU and HE extended range SU PPDU using BCC encoding, the total number of OFDM symbols in the Data field is given by Equation (26-118).

$$N_{SYM} = m_{\text{STBC}} \times \left\lceil \frac{8 \cdot \text{APEP\_LENGTH} + N_{service} + N_{tail} \cdot N_{ES}}{m_{\text{STBC}} \cdot N_{DBPS}} \right\rceil \quad \textbf{(26-118)}$$

where

m_{STBC} is equal to 2 when STBC is used, and 1 otherwise.

For an HE SU PPDU and HE extended range SU PPDU using LDPC encoding, the total number of OFDM symbols in the Data field, N_{SYM}, is given in 26.3.10.3.2 (LDPC coding).

For an HE MU PPDU (including both MU-MIMO and OFDMA), the total number of OFDM symbols in the Data field, N_{SYM}, is given in 26.3.10.3.4 (Encoding process for an HE MU PPDU).

For an HE trigger-based PPDU, the total number of OFDM symbols in the Data field, N_{SYM}, is given in 26.3.10.3.5 (Encoding process for an HE trigger-based PPDU).

T_{PE} is given by Equation (26-112).

The value of the PSDU_LENGTH parameter returned in the PLME-TXTIME.confirm primitive for an HE SU PPDU and HE extended range SU PPDU is calculated using Equation (26-119).

$$\text{PSDU\_LENGTH} = \begin{cases} \left\lfloor \frac{(N_{SYM.init} - m_{STBC}).N_{DBPS} + m_{STBC}.N_{DBPS.Last.init} - N_{service} - N_{tail} \cdot N_{ES}}{8} \right\rfloor & \text{for BCC encoding} \\ \left\lfloor \frac{(N_{SYM.init} - m_{STBC}).N_{DBPS} + m_{STBC}.N_{DBPS.Last.init} - N_{service}}{8} \right\rfloor & \text{for LDPC encoding} \end{cases} \quad \textbf{(26-119)}$$

where

$N_{SYM.init}$ is given by Equation (26-68) for BCC encoding and by Equation (26-73) for LDPC encoding;

m_{STBC} is 2 when STBC is used, and 1 otherwise;

N_{DBPS} is given in 26.5 (Parameters for HE-MCSs);

$N_{DBPS.Last.init}$ is given by Equation (26-64)

The value of the PSDU_LENGTH parameter for user *u* returned in the PLME-TXTIME.confirm primitive and in the RXVECTOR for a HE MU PPDU is calculated using Equation (26-120).

$$\text{PSDU\_LENGTH}_u = \begin{cases} \left\lfloor \frac{(N_{SYM.init} - m_{STBC}).N_{DBPS.u} + m_{STBC}.N_{DBPS.LAST.u} - N_{service} - N_{tail} \cdot N_{ES}}{8} \right\rfloor & \text{when BCC is used for user } u \\ \left\lfloor \frac{(N_{SYM.init} - m_{STBC}).N_{DBPS.u} + m_{STBC}.N_{DBPS.LAST.init.u} - N_{service.}}{8} \right\rfloor & \text{when LDPC is used for user } u \end{cases} \quad \textbf{(26-120)}$$

where

$N_{SYM.init}$ is given by Equation (26-81)

$N_{DBPS.Last.init}$ is given by Equation (26-82)

The value of the PSDU_LENGTH parameter returned in the PLME-TXTIME.confirm primitive for an HE NDP PPDU is 0.

26.4.4 HE PHY

The static HE PHY characteristics, provided through the PLME-CHARACTERISTICS service primitive, shall be as shown in Table 20-25 (HT PHY characteristics) unless otherwise listed in Table 26-36. The definitions for these characteristics are given in 6.5 (PLME SAP interface).

Table 26-36 - HE PHY characteristics

Characteristics	Value
aTxPHYDelay	Implementation dependent
aRxPHYDelay	Implementation dependent
aCCAMidTime	25 µs
aPPDUMaxTime	5.484 ms
aPSDUMaxLength	TBD

26.5 Parameters for HE-MCSs

The rate-dependent parameters for 26-tone RU, 52-tone RU, 106-tone RU, 242-tone RU and non-OFDMA 20 MHz, 484-tone RU and non-OFDMA 40 MHz, 996-tone RU and non-OFDMA 80 MHz, non-OFDMA 160 MHz and 80+80 MHz N_{SS} = 1, …, 8 are given in Table 26-85 through Table 26-92. Support for HE-MCS 8, 9, 10, and 11 (when valid) is optional in all cases. HE-MCS 10 and 11 (1024-QAM) are applicable only to RU sizes equal to or larger than 242 tones.

Dual sub-carrier modulation (DCM) is an optional modulation scheme for any OFDMA and non OFDMA transmissions. DCM is only applicable to MCS 0, 1, 3 and 4 with up to TBD number of streams and for TBD RU sizes. A HE STA shall support single spatial stream HE-MCSs within the range HE-MCS 0 to HE-MCS 7 for all channel widths for which it has indicated support regardless of the Tx or Rx Highest Supported Long GI Data Rate subfield values in the Supported HE-MCS and NSS Set field. When more than one spatial stream is supported, the Tx or Rx Highest Supported Long GI Data Rate subfield values in the Supported HE-MCS and NSS Set field may result in a reduced HE-MCS range (cut-off) for N_{SS} = 2, …, 8. Support for OFDMA 26-tone RU, 52-tone RU, 106-tone RU, 242-tone RU, and 996-tone RU with N_{SS} = 1 is TBD mandatory/optional. Support for non-OFDMA 20 MHz, 40 MHz, and 80 MHz with N_{SS} =1 is mandatory. Support for more than one spatial stream is optional in all cases. Support for OFDMA and non-OFDMA 160 MHz and 80+80 MHz with N_{SS} = 1, …, 8 is optional. N_{ES} values were chosen to yield an integer number of punctured blocks for each BCC encoder per OFDM symbol.

Table 26-37 to Table 26-92 define HE-MCSs not only for SU transmission but also for user u at r-th RU of an MU transmission. In the case of HE-MCSs for MU transmissions, the parameters, N_{SS}, R, N_{BPSCS}, N_{CBPS}, N_{DBPS}, and N_{ES} are replaced with $N_{SS,r,u}$, $R_{r,u}$, $N_{BPSCS,r,u}$, $N_{CBPS,r,u}$, $N_{DBPS,r,u}$, and $N_{ES,r,u}$, respectively.

In the tables below, the number of streams and RU sizes that DCM is applicable to are TBD.

Table 26-37 - HE-MCSs for TBD mandatory/optional 26-tone RU, NSS = 1

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	24	2	24	6	1	0.4	0.4	0.4
0	0		1/2	1			24	12	1	0.9	0.8	0.8
1	1	QPSK	1/4	2			48	12	1	0.9	0.8	0.8
1	0		1/2	2			48	24	1	1.8	1.7	1.5
2	N/A		3/4	2			48	36	1	2.6	2.5	2.3
3	1	16-QAM	1/4	4			96	24	1	1.8	1.7	1.5
3	0		1/2	4			96	48	1	3.5	3.3	3.0
4	1		3/8	4			96	36	1	2.6	2.5	2.3
4	0		3/4	4			96	72	1	5.3	5.0	4.5
5	N/A	64-QAM	2/3	6			144	96	1	7.1	6.7	6.0
6			3/4	6			144	108	1	7.9	7.5	6.8
7			5/6	6			144	120	1	8.8	8.3	7.5
8		256-QAM	3/4	8			192	144	1	10.6	10.0	9.0
9			5/6	8			192	160	1	11.8	11.1	10.0

Table 26-38 HE-MCSs for TBD mandatory/optional 26-tone RU, NSS = 2

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	24	2	48	12	1	0.9	0.8	0.8
0	0		1/2	1			48	24	1	1.8	1.7	1.5
1	1	QPSK	1/4	2			96	24	1	1.8	1.7	1.5
1	0		1/2	2			96	48	1	3.5	3.3	3.0
2	N/A		3/4	2			96	72	1	5.3	5.0	4.5
3	1	16-QAM	1/4	4			192	48	1	3.5	3.3	3.0
3	0		1/2	4			192	96	1	7.1	6.7	6.0
4	1		3/8	4			192	72	1	5.3	5.0	4.5
4	0		3/4	4			192	144	1	10.6	10.0	9.0
5	N/A	64-QAM	2/3	6			288	192	1	14.1	13.3	12.0
6			3/4	6			288	216	1	15.9	15.0	13.5
7			5/6	6			288	240	1	17.6	16.7	15.0
8		256-QAM	3/4	8			384	288	1	21.2	20.0	18.0
9			5/6	8			384	320	1	23.5	22.2	20.0

Table 26-39 HE-MCSs for TBD mandatory/optional 26-tone RU, Nss = 3

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	24	2	72	18	1	1.3	1.3	1.1
0	0		1/2	1			72	36	1	2.6	2.5	2.3
1	1	QPSK	1/4	2			144	36	1	2.6	2.5	2.3
1	0		1/2	2			144	72	1	5.3	5.0	4.5
2	N/A		3/4	2			144	108	1	7.9	7.5	6.8
3	1	16-QAM	1/4	4			288	72	1	5.3	5.0	4.5
3	0		1/2	4			288	144	1	10.6	10.0	9.0
4	1		3/8	4			288	108	1	7.9	7.5	6.8
4	0		3/4	4			288	216	1	15.9	15.0	13.5
5	N/A	64-QAM	2/3	6			432	288	1	21.2	20.0	18.0
6			3/4	6			432	324	1	23.8	22.5	20.3
7			5/6	6			432	360	1	26.5	25.0	22.5
8		256-QAM	3/4	8			576	432	1	31.8	30.0	27.0
9			5/6	8			576	480	1	35.3	33.3	30.0

Table 26-40 HE-MCSs for TBD mandatory/optional 26-tone RU, Nss = 4

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	24	2	96	24	1	1.8	1.7	1.5
0	0		1/2	1			96	48	1	3.5	3.3	3.0
1	1	QPSK	1/4	2			192	48	1	3.5	3.3	3.0
1	0		1/2	2			192	96	1	7.1	6.7	6.0
2	N/A		3/4	2			192	144	1	10.6	10.0	9.0
3	1	16-QAM	1/4	4			384	96	1	7.1	6.7	6.0
3	0		1/2	4			384	192	1	14.1	13.3	12.0
4	1		3/8	4			384	144	1	10.6	10.0	9.0
4	0		3/4	4			384	288	1	21.2	20.0	18.0
5	N/A	64-QAM	2/3	6			576	384	1	28.2	26.7	24.0
6			3/4	6			576	432	1	31.8	30.0	27.0
7			5/6	6			576	480	1	35.3	33.3	30.0
8		256-QAM	3/4	8			768	576	1	42.4	40.0	36.0
9			5/6	8			768	640	1	47.1	44.4	40.0

Table 26-41 HE-MCSs for TBD mandatory/optional 26-tone RU, Nss = 5

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	24	2	120	30	1	2.2	2.1	1.9
0	0		1/2	1			120	60	1	4.4	4.2	3.8
1	1	QPSK	1/4	2			240	60	1	4.4	4.2	3.8
1	0		1/2	2			240	120	1	8.8	8.3	7.5
2	N/A		3/4	2			240	180	1	13.2	12.5	11.3
3	1	16-QAM	1/4	4			480	120	1	8.8	8.3	7.5
3	0		1/2	4			480	240	1	17.6	16.7	15.0
4	1		3/8	4			480	180	1	13.2	12.5	11.3
4	0		3/4	4			480	360	1	26.5	25.0	22.5
5	N/A	64-QAM	2/3	6			720	480	1	35.3	33.3	30.0
6			3/4	6			720	540	1	39.7	37.5	33.8
7			5/6	6			720	600	1	44.1	41.7	37.5
8		256-QAM	3/4	8			960	720	1	52.9	50.0	45.0
9			5/6	8			960	800	1	58.8	55.6	50.0

Table 26-42 HE-MCSs for TBD mandatory/optional 26-tone RU, NSS = 6

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	24	2	144	36	1	2.6	2.5	2.3
0	0		1/2	1			144	72	1	5.3	5.0	4.5
1	1	QPSK	1/4	2			288	72	1	5.3	5.0	4.5
1	0		1/2	2			288	144	1	10.6	10.0	9.0
2	N/A		3/4	2			288	216	1	15.9	15.0	13.5
3	1	16-QAM	1/4	4			576	144	1	10.6	10.0	9.0
3	0		1/2	4			576	288	1	21.2	20.0	18.0
4	1		3/8	4			576	216	1	15.9	15.0	13.5
4	0		3/4	4			576	432	1	31.8	30.0	27.0
5	N/A	64-QAM	2/3	6			864	576	1	42.4	40.0	36.0
6			3/4	6			864	648	1	47.6	45.0	40.5
7			5/6	6			864	720	1	52.9	50.0	45.0
8		256-QAM	3/4	8			1152	864	1	63.5	60.0	54.0
9			5/6	8			1152	960	1	70.6	66.7	60.0

Table 26-43 HE-MCSs for TBD mandatory/optional 26-tone RU, NSS = 7

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	24	2	168	42	1	3.1	2.9	2.6
0	0		1/2	1			168	84	1	6.2	5.8	5.3
1	1	QPSK	1/4	2			336	84	1	6.2	5.8	5.3
1	0		1/2	2			336	168	1	12.4	11.7	10.5
2	N/A		3/4	2			336	252	1	18.5	17.5	15.8
3	1	16-QAM	1/4	4			672	168	1	12.4	11.7	10.5
3	0		1/2	4			672	336	1	24.7	23.3	21.0
4	1		3/8	4			672	252	1	18.5	17.5	15.8
4	0		3/4	4			672	504	1	37.1	35.0	31.5
5	N/A	64-QAM	2/3	6			1008	672	1	49.4	46.7	42.0
6			3/4	6			1008	756	1	55.6	52.5	47.3
7			5/6	6			1008	840	1	61.8	58.3	52.5
8		256-QAM	3/4	8			1344	1008	1	74.1	70.0	63.0
9			5/6	8			1344	1120	1	82.4	77.8	70.0

Table 26-44 HE-MCSs for TBD mandatory/optional 26-tone RU, Nss = 8

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	24	2	192	48	1	3.5	3.3	3.0
0	0		1/2	1			192	96	1	7.1	6.7	6.0
1	1	QPSK	1/4	2			384	96	1	7.1	6.7	6.0
1	0		1/2	2			384	192	1	14.1	13.3	12.0
2	N/A		3/4	2			384	288	1	21.2	20.0	18.0
3	1	16-QAM	1/4	4			768	192	1	14.1	13.3	12.0
3	0		1/2	4			768	384	1	28.2	26.7	24.0
4	1		3/8	4			768	288	1	21.2	20.0	18.0
4	0		3/4	4			768	576	1	42.4	40.0	36.0
5	N/A	64-QAM	2/3	6			1152	768	1	56.5	53.3	48.0
6			3/4	6			1152	864	1	63.5	60.0	54.0
7			5/6	6			1152	960	1	70.6	66.7	60.0
8		256-QAM	3/4	8			1536	1152	1	84.7	80.0	72.0
9			5/6	8			1536	1280	1	94.1	88.9	80.0

Table 26-45 HE-MCSs for TBD mandatory/optional 52-tone RU, Nss = 1

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	48	4	48	12	1	0.9	0.8	0.8
0	0		1/2	1			48	24	1	1.8	1.7	1.5
1	1	QPSK	1/4	2			96	24	1	1.8	1.7	1.5
1	0		1/2	2			96	48	1	3.5	3.3	3.0
2	N/A		3/4	2			96	72	1	5.3	5.0	4.5
3	1	16-QAM	1/4	4			192	48	1	3.5	3.3	3.0
3	0		1/2	4			192	96	1	7.1	6.7	6.0
4	1		3/8	4			192	72	1	5.3	5.0	4.5
4	0		3/4	4			192	144	1	10.6	10.0	9.0
5	N/A	64-QAM	2/3	6			288	192	1	14.1	13.3	12.0
6			3/4	6			288	216	1	15.9	15.0	13.5
7			5/6	6			288	240	1	17.6	16.7	15.0
8		256-QAM	3/4	8			384	288	1	21.2	20.0	18.0
9			5/6	8			384	320	1	23.5	22.2	20.0

Table 26-46 HE-MCSs for TBD mandatory/optional 52-tone RU, Nss = 2

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	48	4	96	24	1	1.8	1.7	1.5
0	0		1/2	1			96	48	1	3.5	3.3	3.0
1	1	QPSK	1/4	2			192	48	1	3.5	3.3	3.0
1	0		1/2	2			192	96	1	7.1	6.7	6.0
2	N/A		3/4	2			192	144	1	10.6	10.0	9.0
3	1	16-QAM	1/4	4			384	96	1	7.1	6.7	6.0
3	0		1/2	4			384	192	1	14.1	13.3	12.0
4	1		3/8	4			384	144	1	10.6	10.0	9.0
4	0		3/4	4			384	288	1	21.2	20.0	18.0
5	N/A	64-QAM	2/3	6			576	384	1	28.2	26.7	24.0
6			3/4	6			576	432	1	31.8	30.0	27.0
7			5/6	6			576	480	1	35.3	33.3	30.0
8		256-QAM	3/4	8			768	576	1	42.4	40.0	36.0
9			5/6	8			768	640	1	47.1	44.4	40.0

Table 26-47 HE-MCSs for TBD mandatory/optional 52-tone RU, Nss = 3

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	48	4	144	36	1	2.6	2.5	2.3
0	0		1/2	1			144	72	1	5.3	5.0	4.5
1	1	QPSK	1/4	2			288	72	1	5.3	5.0	4.5
1	0		1/2	2			288	144	1	10.6	10.0	9.0
2	N/A		3/4	2			288	216	1	15.9	15.0	13.5
3	1	16-QAM	1/4	4			576	144	1	10.6	10.0	9.0
3	0		1/2	4			576	288	1	21.2	20.0	18.0
4	1		3/8	4			576	216	1	15.9	15.0	13.5
4	0		3/4	4			576	432	1	31.8	30.0	27.0
5	N/A	64-QAM	2/3	6			864	576	1	42.4	40.0	36.0
6			3/4	6			864	648	1	47.6	45.0	40.5
7			5/6	6			864	720	1	52.9	50.0	45.0
8		256-QAM	3/4	8			1152	864	1	63.5	60.0	54.0
9			5/6	8			1152	960	1	70.6	66.7	60.0

Table 26-48 HE-MCSs for TBD mandatory/optional 52-tone RU, Nss = 4

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	48	4	192	48	1	3.5	3.3	3.0
0	0		1/2	1			192	96	1	7.1	6.7	6.0
1	1	QPSK	1/4	2			384	96	1	7.1	6.7	6.0
1	0		1/2	2			384	192	1	14.1	13.3	12.0
2	N/A		3/4	2			384	288	1	21.2	20.0	18.0
3	1	16-QAM	1/4	4			768	192	1	14.1	13.3	12.0
3	0		1/2	4			768	384	1	28.2	26.7	24.0
4	1		3/8	4			768	288	1	21.2	20.0	18.0
4	0		3/4	4			768	576	1	42.4	40.0	36.0
5	N/A	64-QAM	2/3	6			1152	768	1	56.5	53.3	48.0
6			3/4	6			1152	864	1	63.5	60.0	54.0
7			5/6	6			1152	960	1	70.6	66.7	60.0
8		256-QAM	3/4	8			1536	1152	1	84.7	80.0	72.0
9			5/6	8			1536	1280	1	94.1	88.9	80.0

Table 26-49 HE-MCSs for TBD mandatory/optional 52-tone RU, Nss = 5

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	48	4	240	60	1	4.4	4.2	3.8
0	0		1/2	1			240	120	1	8.8	8.3	7.5
1	1	QPSK	1/4	2			480	120	1	8.8	8.3	7.5
1	0		1/2	2			480	240	1	17.6	16.7	15.0
2	N/A		3/4	2			480	360	1	26.5	25.0	22.5
3	1	16-QAM	1/4	4			960	240	1	17.6	16.7	15.0
3	0		1/2	4			960	480	1	35.3	33.3	30.0
4	1		3/8	4			960	360	1	26.5	25.0	22.5
4	0		3/4	4			960	720	1	52.9	50.0	45.0
5	N/A	64-QAM	2/3	6			1440	960	1	70.6	66.7	60.0
6			3/4	6			1440	1080	1	79.4	75.0	67.5
7			5/6	6			1440	1200	1	88.2	83.3	75.0
8		256-QAM	3/4	8			1920	1440	1	105.9	100.0	90.0
9			5/6	8			1920	1600	1	117.6	111.1	100.0

Table 26-50 HE-MCSs for TBD mandatory/optional 52-tone RU, Nss = 6

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	48	4	288	72	1	5.3	5.0	4.5
0	0		1/2	1			288	144	1	10.6	10.0	9.0
1	1	QPSK	1/4	2			576	144	1	10.6	10.0	9.0
1	0		1/2	2			576	288	1	21.2	20.0	18.0
2	N/A		3/4	2			576	432	1	31.8	30.0	27.0
3	1	16-QAM	1/4	4			1152	288	1	21.2	20.0	18.0
3	0		1/2	4			1152	576	1	42.4	40.0	36.0
4	1		3/8	4			1152	432	1	31.8	30.0	27.0
4	0		3/4	4			1152	864	1	63.5	60.0	54.0
5	N/A	64-QAM	2/3	6			1728	1152	1	84.7	80.0	72.0
6			3/4	6			1728	1296	1	95.3	90.0	81.0
7			5/6	6			1728	1440	1	105.9	100.0	90.0
8		256-QAM	3/4	8			2304	1728	1	127.1	120.0	108.0
9			5/6	8			2304	1920	1	141.2	133.3	120.0

Table 26-51 HE-MCSs for TBD mandatory/optional 52-tone RU, Nss = 7

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	48	4	336	84	1	6.2	5.8	5.3
0	0		1/2	1			336	168	1	12.4	11.7	10.5
1	1	QPSK	1/4	2			672	168	1	12.4	11.7	10.5
1	0		1/2	2			672	336	1	24.7	23.3	21.0
2	N/A		3/4	2			672	504	1	37.1	35.0	31.5
3	1	16-QAM	1/4	4			1344	336	1	24.7	23.3	21.0
3	0		1/2	4			1344	672	1	49.4	46.7	42.0
4	1		3/8	4			1344	504	1	37.1	35.0	31.5
4	0		3/4	4			1344	1008	1	74.1	70.0	63.0
5	N/A	64-QAM	2/3	6			2016	1344	1	98.8	93.3	84.0
6			3/4	6			2016	1512	1	111.2	105.0	94.5
7			5/6	6			2016	1680	1	123.5	116.7	105.0
8		256-QAM	3/4	8			2688	2016	1	148.2	140.0	126.0
9			5/6	8			2688	2240	1	164.7	155.6	140.0

Table 26-52 HE-MCSs for TBD mandatory/optional 52-tone RU, Nss = 8

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	48	4	384	96	1	7.1	6.7	6.0
0	0		1/2	1			384	192	1	14.1	13.3	12.0
1	1	QPSK	1/4	2			768	192	1	14.1	13.3	12.0
1	0		1/2	2			768	384	1	28.2	26.7	24.0
2	N/A		3/4	2			768	576	1	42.4	40.0	36.0
3	1	16-QAM	1/4	4			1536	384	1	28.2	26.7	24.0
3	0		1/2	4			1536	768	1	56.5	53.3	48.0
4	1		3/8	4			1536	576	1	42.4	40.0	36.0
4	0		3/4	4			1536	1152	1	84.7	80.0	72.0
5	N/A	64-QAM	2/3	6			2304	1536	1	112.9	106.7	96.0
6			3/4	6			2304	1728	1	127.1	120.0	108.0
7			5/6	6			2304	1920	1	141.2	133.3	120.0
8		256-QAM	3/4	8			3072	2304	1	169.4	160.0	144.0
9			5/6	8			3072	2560	1	188.2	177.8	160.0

Table 26-53 HE-MCSs for TBD mandatory/optional 106-tone RU, Nss = 1

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	102	4	102	25	1	1.8	1.7	1.6
0	0		1/2	1			102	51	1	3.8	3.5	3.2
1	1	QPSK	1/4	2			204	51	1	3.8	3.5	3.2
1	0		1/2	2			204	102	1	7.5	7.1	6.4
2	N/A		3/4	2			204	153	1	11.3	10.6	9.6
3	1	16-QAM	1/4	4			408	102	1	7.5	7.1	6.4
3	0		1/2	4			408	204	1	15.0	14.2	12.8
4	1		3/8	4			408	153	1	11.3	10.6	9.6
4	0		3/4	4			408	306	1	22.5	21.3	19.1
5	N/A	64-QAM	2/3	6			612	408	1	30.0	28.3	25.5
6			3/4	6			612	459	1	33.8	31.9	28.7
7			5/6	6			612	510	1	37.5	35.4	31.9
8		256-QAM	3/4	8			816	612	1	45.0	42.5	38.3
9			5/6	8			816	680	1	50.0	47.2	42.5

Table 26-54 HE-MCSs for TBD mandatory/optional 106-tone RU, Nss = 2

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	102	4	204	51	1	3.8	3.5	3.2
0	0		1/2	1			204	102	1	7.5	7.1	6.4
1	1	QPSK	1/4	2			408	102	1	7.5	7.1	6.4
1	0		1/2	2			408	204	1	15.0	14.2	12.8
2	N/A		3/4	2			408	306	1	22.5	21.3	19.1
3	1	16-QAM	1/4	4			816	204	1	15.0	14.2	12.8
3	0		1/2	4			816	408	1	30.0	28.3	25.5
4	1		3/8	4			816	306	1	22.5	21.3	19.1
4	0		3/4	4			816	612	1	45.0	42.5	38.3
5	N/A	64-QAM	2/3	6			1224	816	1	60.0	56.7	51.0
6			3/4	6			1224	918	1	67.5	63.8	57.4
7			5/6	6			1224	1,020	1	75.0	70.8	63.8
8		256-QAM	3/4	8			1632	1,224	1	90.0	85.0	76.5
9			5/6	8			1632	1,360	1	100.0	94.4	85.0

Table 26-55 HE-MCSs for TBD mandatory/optional 106-tone RU, Nss = 3

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	102	4	306	76	1	5.6	5.3	4.8
0	0		1/2	1			306	153	1	11.3	10.6	9.6
1	1	QPSK	1/4	2			612	153	1	11.3	10.6	9.6
1	0		1/2	2			612	306	1	22.5	21.3	19.1
2	N/A		3/4	2			612	459	1	33.8	31.9	28.7
3	1	16-QAM	1/4	4			1224	306	1	22.5	21.3	19.1
3	0		1/2	4			1224	612	1	45.0	42.5	38.3
4	1		3/8	4			1224	459	1	33.8	31.9	28.7
4	0		3/4	4			1224	918	1	67.5	63.8	57.4
5	N/A	64-QAM	2/3	6			1836	1,224	1	90.0	85.0	76.5
6			3/4	6			1836	1,377	1	101.3	95.6	86.1
7			5/6	6			1836	1,530	1	112.5	106.3	95.6
8		256-QAM	3/4	8			2448	1,836	1	135.0	127.5	114.8
9			5/6	8			2448	2,040	1	150.0	141.7	127.5

Table 26-56 HE-MCSs for TBD mandatory/optional 106-tone RU, Nss = 4

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	102	4	408	102	1	7.5	7.1	6.4
0	0		1/2	1			408	204	1	15.0	14.2	12.8
1	1	QPSK	1/4	2			816	204	1	15.0	14.2	12.8
1	0		1/2	2			816	408	1	30.0	28.3	25.5
2	N/A		3/4	2			816	612	1	45.0	42.5	38.3
3	1	16-QAM	1/4	4			1632	408	1	30.0	28.3	25.5
3	0		1/2	4			1632	816	1	60.0	56.7	51.0
4	1		3/8	4			1632	612	1	45.0	42.5	38.3
4	0		3/4	4			1632	1,224	1	90.0	85.0	76.5
5	N/A	64-QAM	2/3	6			2448	1,632	1	120.0	113.3	102.0
6			3/4	6			2448	1,836	1	135.0	127.5	114.8
7			5/6	6			2448	2,040	1	150.0	141.7	127.5
8		256-QAM	3/4	8			3264	2,448	1	180.0	170.0	153.0
9			5/6	8			3264	2,720	1	200.0	188.9	170.0

Table 26-57 HE-MCSs for TBD mandatory/optional 106-tone RU, Nss = 5

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	102	4	510	127	1	9.3	8.8	7.9
0	0		1/2	1			510	255	1	18.8	17.7	15.9
1	1	QPSK	1/4	2			1020	255	1	18.8	17.7	15.9
1	0		1/2	2			1020	510	1	37.5	35.4	31.9
2	N/A		3/4	2			1020	765	1	56.3	53.1	47.8
3	1	16-QAM	1/4	4			2040	510	1	37.5	35.4	31.9
3	0		1/2	4			2040	1,020	1	75.0	70.8	63.8
4	1		3/8	4			2040	765	1	56.3	53.1	47.8
4	0		3/4	4			2040	1,530	1	112.5	106.3	95.6
5	N/A	64-QAM	2/3	6			3060	2,040	1	150.0	141.7	127.5
6			3/4	6			3060	2,295	1	168.8	159.4	143.4
7			5/6	6			3060	2,550	1	187.5	177.1	159.4
8		256-QAM	3/4	8			4080	3,060	1	225.0	212.5	191.3
9			5/6	8			4080	3,400	1	250.0	236.1	212.5

Table 26-58 HE-MCSs for TBD mandatory/optional 106-tone RU, Nss = 6

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	102	4	612	153	1	11.3	10.6	9.6
0	0		1/2	1			612	306	1	22.5	21.3	19.1
1	1	QPSK	1/4	2			1224	306	1	22.5	21.3	19.1
1	0		1/2	2			1224	612	1	45.0	42.5	38.3
2	N/A		3/4	2			1224	918	1	67.5	63.8	57.4
3	1	16-QAM	1/4	4			2448	612	1	45.0	42.5	38.3
3	0		1/2	4			2448	1,224	1	90.0	85.0	76.5
4	1		3/8	4			2448	918	1	67.5	63.8	57.4
4	0		3/4	4			2448	1,836	1	135.0	127.5	114.8
5	N/A	64-QAM	2/3	6			3672	2,448	1	180.0	170.0	153.0
6			3/4	6			3672	2,754	1	202.5	191.3	172.1
7			5/6	6			3672	3,060	1	225.0	212.5	191.3
8		256-QAM	3/4	8			4896	3,672	1	270.0	255.0	229.5
9			5/6	8			4896	4,080	1	300.0	283.3	255.0

Table 26-59 HE-MCSs for TBD mandatory/optional 106-tone RU, Nss = 7

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	102	4	714	178	1	13.1	12.4	11.1
0	0		1/2	1			714	357	1	26.3	24.8	22.3
1	1	QPSK	1/4	2			1428	357	1	26.3	24.8	22.3
1	0		1/2	2			1428	714	1	52.5	49.6	44.6
2	N/A		3/4	2			1428	1,071	1	78.8	74.4	66.9
3	1	16-QAM	1/4	4			2856	714	1	52.5	49.6	44.6
3	0		1/2	4			2856	1,428	1	105.0	99.2	89.3
4	1		3/8	4			2856	1,071	1	78.8	74.4	66.9
4	0		3/4	4			2856	2,142	1	157.5	148.8	133.9
5	N/A	64-QAM	2/3	6			4284	2,856	1	210.0	198.3	178.5
6			3/4	6			4284	3,213	1	236.3	223.1	200.8
7			5/6	6			4284	3,570	1	262.5	247.9	223.1
8		256-QAM	3/4	8			5712	4,284	1	315.0	297.5	267.8
9			5/6	8			5712	4,760	1	350.0	330.6	297.5

Table 26-60 HE-MCSs for TBD mandatory/optional 106-tone RU, Nss = 8

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	102	4	816	204	1	15.0	14.2	12.8
0	0		1/2	1			816	408	1	30.0	28.3	25.5
1	1	QPSK	1/4	2			1632	408	1	30.0	28.3	25.5
1	0		1/2	2			1632	816	1	60.0	56.7	51.0
2	N/A		3/4	2			1632	1,224	1	90.0	85.0	76.5
3	1	16-QAM	1/4	4			3264	816	1	60.0	56.7	51.0
3	0		1/2	4			3264	1,632	1	120.0	113.3	102.0
4	1		3/8	4			3264	1,224	1	90.0	85.0	76.5
4	0		3/4	4			3264	2,448	1	180.0	170.0	153.0
5	N/A	64-QAM	2/3	6			4896	3,264	1	240.0	226.7	204.0
6			3/4	6			4896	3,672	1	270.0	255.0	229.5
7			5/6	6			4896	4,080	1	300.0	283.3	255.0
8		256-QAM	3/4	8			6528	4,896	1	360.0	340.0	306.0
9			5/6	8			6528	5,440	1	400.0	377.8	340.0

Table 26-61 HE-MCSs for TBD mandatory/optional 242-tone RU and mandatory non-OFDMA 20MHz, Nss = 1

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	234	8	234	58	1	4.3	4.0	3.6
0	0		1/2	1			234	117	1	8.6	8.1	7.3
1	1	QPSK	1/4	2			468	117	1	8.6	8.1	7.3
1	0		1/2	2			468	234	1	17.2	16.3	14.6
2	N/A		3/4	2			468	351	1	25.8	24.4	21.9
3	1	16-QAM	1/4	4			936	234	1	17.2	16.3	14.6
3	0		1/2	4			936	468	1	34.4	32.5	29.3
4	1		3/8	4			936	351	1	25.8	24.4	21.9
4	0		3/4	4			936	702	1	51.6	48.8	43.9
5	N/A	64-QAM	2/3	6			1404	936	1	68.8	65.0	58.5
6			3/4	6			1404	1,053	1	77.4	73.1	65.8
7			5/6	6			1404	1,170	1	86.0	81.3	73.1
8		256-QAM	3/4	8			1872	1,404	1	103.2	97.5	87.8
9			5/6	8			1872	1,560	1	114.7	108.3	97.5
10		1024-QAM	3/4	10			2340	1,755	1	129.0	121.9	109.7
11			5/6	10			2340	1,950	1	143.4	135.4	121.9

Table 26-62 HE-MCSs for TBD mandatory/optional 242-tone RU and mandatory non-OFDMA 20MHz, Nss = 2

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	234	8	468	117	1	8.6	8.1	7.3
0	0		1/2	1			468	234	1	17.2	16.3	14.6
1	1	QPSK	1/4	2			936	234	1	17.2	16.3	14.6
1	0		1/2	2			936	468	1	34.4	32.5	29.3
2	N/A		3/4	2			936	702	1	51.6	48.8	43.9
3	1	16-QAM	1/4	4			1872	468	1	34.4	32.5	29.3
3	0		1/2	4			1872	936	1	68.8	65.0	58.5
4	1		3/8	4			1872	702	1	51.6	48.8	43.9
4	0		3/4	4			1872	1,404	1	103.2	97.5	87.8
5	N/A	64-QAM	2/3	6			2808	1,872	1	137.6	130.0	117.0
6			3/4	6			2808	2,106	1	154.9	146.3	131.6
7			5/6	6			2808	2,340	1	172.1	162.5	146.3
8		256-QAM	3/4	8			3744	2,808	1	206.5	195.0	175.5
9			5/6	8			3744	3,120	1	229.4	216.7	195.0
10		1024-QAM	3/4	10			4680	3,510	1	258.1	243.8	219.4
11			5/6	10			4680	3,900	1	286.8	270.8	243.8

Table 26-63 HE-MCSs for TBD mandatory/optional 242-tone RU and mandatory non-OFDMA 20MHz, Nss = 3

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	234	8	702	175	1	12.9	12.2	10.9
0	0		1/2	1			702	351	1	25.8	24.4	21.9
1	1	QPSK	1/4	2			1404	351	1	25.8	24.4	21.9
1	0		1/2	2			1404	702	1	51.6	48.8	43.9
2	N/A		3/4	2			1404	1,053	1	77.4	73.1	65.8
3	1	16-QAM	1/4	4			2808	702	1	51.6	48.8	43.9
3	0		1/2	4			2808	1,404	1	103.2	97.5	87.8
4	1		3/8	4			2808	1,053	1	77.4	73.1	65.8
4	0		3/4	4			2808	2,106	1	154.9	146.3	131.6
5	N/A	64-QAM	2/3	6			4212	2,808	1	206.5	195.0	175.5
6			3/4	6			4212	3,159	1	232.3	219.4	197.4
7			5/6	6			4212	3,510	1	258.1	243.8	219.4
8		256-QAM	3/4	8			5616	4,212	1	309.7	292.5	263.3
9			5/6	8			5616	4,680	1	344.1	325.0	292.5
10		1024-QAM	3/4	10			7020	5,265	1	387.1	365.6	329.1
11			5/6	10			7020	5,850	1	430.1	406.3	365.6

Table 26-64 HE-MCSs for TBD mandatory/optional 242-tone RU and mandatory non-OFDMA 20MHz, Nss = 4

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	234	8	936	234	1	17.2	16.3	14.6
0	0		1/2	1			936	468	1	34.4	32.5	29.3
1	1	QPSK	1/4	2			1872	468	1	34.4	32.5	29.3
1	0		1/2	2			1872	936	1	68.8	65.0	58.5
2	N/A		3/4	2			1872	1,404	1	103.2	97.5	87.8
3	1	16-QAM	1/4	4			3744	936	1	68.8	65.0	58.5
3	0		1/2	4			3744	1,872	1	137.6	130.0	117.0
4	1		3/8	4			3744	1,404	1	103.2	97.5	87.8
4	0		3/4	4			3744	2,808	1	206.5	195.0	175.5
5	N/A	64-QAM	2/3	6			5616	3,744	1	275.3	260.0	234.0
6			3/4	6			5616	4,212	1	309.7	292.5	263.3
7			5/6	6			5616	4,680	1	344.1	325.0	292.5
8		256-QAM	3/4	8			7488	5,616	1	412.9	390.0	351.0
9			5/6	8			7488	6,240	1	458.8	433.3	390.0
10		1024-QAM	3/4	10			9360	7,020	1	516.2	487.5	438.8
11			5/6	10			9360	7,800	1	573.5	541.7	487.5

Table 26-65 HE-MCSs for TBD mandatory/optional 242-tone RU and mandatory non-OFDMA 20MHz, Nss = 5

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	234	8	1170	292	1	21.5	20.3	18.3
0	0		1/2	1			1170	585	1	43.0	40.6	36.6
1	1	QPSK	1/4	2			2340	585	1	43.0	40.6	36.6
1	0		1/2	2			2340	1,170	1	86.0	81.3	73.1
2	N/A		3/4	2			2340	1,755	1	129.0	121.9	109.7
3	1	16-QAM	1/4	4			4680	1,170	1	86.0	81.3	73.1
3	0		1/2	4			4680	2,340	1	172.1	162.5	146.3
4	1		3/8	4			4680	1,755	1	129.0	121.9	109.7
4	0		3/4	4			4680	3,510	1	258.1	243.8	219.4
5	N/A	64-QAM	2/3	6			7020	4,680	1	344.1	325.0	292.5
6			3/4	6			7020	5,265	1	387.1	365.6	329.1
7			5/6	6			7020	5,850	1	430.1	406.3	365.6
8		256-QAM	3/4	8			9360	7,020	1	516.2	487.5	438.8
9			5/6	8			9360	7,800	1	573.5	541.7	487.5
10		1024-QAM	3/4	10			11700	8,775	1	645.2	609.4	548.4
11			5/6	10			11700	9,750	1	716.9	677.1	609.4

Table 26-66 HE-MCSs for TBD mandatory/optional 242-tone RU and mandatory non-OFDMA 20MHz, Nss = 6

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	234	8	1404	351	1	25.8	24.4	21.9
0	0		1/2	1			1404	702	1	51.6	48.8	43.9
1	1	QPSK	1/4	2			2808	702	1	51.6	48.8	43.9
1	0		1/2	2			2808	1,404	1	103.2	97.5	87.8
2	N/A		3/4	2			2808	2,106	1	154.9	146.3	131.6
3	1	16-QAM	1/4	4			5616	1,404	1	103.2	97.5	87.8
3	0		1/2	4			5616	2,808	1	206.5	195.0	175.5
4	1		3/8	4			5616	2,106	1	154.9	146.3	131.6
4	0		3/4	4			5616	4,212	1	309.7	292.5	263.3
5	N/A	64-QAM	2/3	6			8424	5,616	1	412.9	390.0	351.0
6			3/4	6			8424	6,318	1	464.6	438.8	394.9
7			5/6	6			8424	7,020	1	516.2	487.5	438.8
8		256-QAM	3/4	8			11232	8,424	1	619.4	585.0	526.5
9			5/6	8			11232	9,360	1	688.2	650.0	585.0
10		1024-QAM	3/4	10			14040	10,530	1	774.3	731.3	658.1
11			5/6	10			14040	11,700	1	860.3	812.5	731.3

Table 26-67 HE-MCSs for TBD mandatory/optional 242-tone RU and mandatory non-OFDMA 20MHz, Nss = 7

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	234	8	1638	409	1	30.1	28.4	25.6
0	0		1/2	1			1638	819	1	60.2	56.9	51.2
1	1	QPSK	1/4	2			3276	819	1	60.2	56.9	51.2
1	0		1/2	2			3276	1,638	1	120.4	113.8	102.4
2	N/A		3/4	2			3276	2,457	1	180.7	170.6	153.6
3	1	16-QAM	1/4	4			6552	1,638	1	120.4	113.8	102.4
3	0		1/2	4			6552	3,276	1	240.9	227.5	204.8
4	1		3/8	4			6552	2,457	1	180.7	170.6	153.6
4	0		3/4	4			6552	4,914	1	361.3	341.3	307.1
5	N/A	64-QAM	2/3	6			9828	6,552	1	481.8	455.0	409.5
6			3/4	6			9828	7,371	1	542.0	511.9	460.7
7			5/6	6			9828	8,190	1	602.2	568.8	511.9
8		256-QAM	3/4	8			13104	9,828	1	722.6	682.5	614.3
9			5/6	8			13104	10,920	1	802.9	758.3	682.5
10		1024-QAM	3/4	10			16380	12,285	1	903.3	853.1	767.8
11			5/6	10			16380	13,650	1	1,003.7	947.9	853.1

Table 26-68 HE-MCSs for TBD mandatory/optional 242-tone RU and mandatory non-OFDMA 20MHz, Nss = 8

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	234	8	1872	468	1	34.4	32.5	29.3
0	0		1/2	1			1872	936	1	68.8	65.0	58.5
1	1	QPSK	1/4	2			3744	936	1	68.8	65.0	58.5
1	0		1/2	2			3744	1,872	1	137.6	130.0	117.0
2	N/A		3/4	2			3744	2,808	1	206.5	195.0	175.5
3	1	16-QAM	1/4	4			7488	1,872	1	137.6	130.0	117.0
3	0		1/2	4			7488	3,744	1	275.3	260.0	234.0
4	1		3/8	4			7488	2,808	1	206.5	195.0	175.5
4	0		3/4	4			7488	5,616	1	412.9	390.0	351.0
5	N/A	64-QAM	2/3	6			11232	7,488	1	550.6	520.0	468.0
6			3/4	6			11232	8,424	1	619.4	585.0	526.5
7			5/6	6			11232	9,360	1	688.2	650.0	585.0
8		256-QAM	3/4	8			14976	11,232	1	825.9	780.0	702.0
9			5/6	8			14976	12,480	1	917.6	866.7	780.0
10		1024-QAM	3/4	10			18720	14,040	1	1,032.4	975.0	877.5
11			5/6	10			18720	15,600	1	1,147.1	1,083.3	975.0

Table 26-69 HE-MCSs for TBD mandatory/optional 484-tone RU and mandatory non-OFDMA 40MHz, Nss = 1

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	468	16	468	117	1	8.6	8.1	7.3
0	0		1/2	1			468	234	1	17.2	16.3	14.6
1	1	QPSK	1/4	2			936	234	1	17.2	16.3	14.6
1	0		1/2	2			936	468	1	34.4	32.5	29.3
2	N/A		3/4	2			936	702	1	51.6	48.8	43.9
3	1	16-QAM	1/4	4			1872	468	1	34.4	32.5	29.3
3	0		1/2	4			1872	936	1	68.8	65.0	58.5
4	1		3/8	4			1872	702	1	51.6	48.8	43.9
4	0		3/4	4			1872	1,404	1	103.2	97.5	87.8
5	N/A	64-QAM	2/3	6			2808	1,872	1	137.6	130.0	117.0
6			3/4	6			2808	2,106	1	154.9	146.3	131.6
7			5/6	6			2808	2,340	1	172.1	162.5	146.3
8		256-QAM	3/4	8			3744	2,808	1	206.5	195.0	175.5
9			5/6	8			3744	3,120	1	229.4	216.7	195.0
10		1024-QAM	3/4	10			4680	3,510	1	258.1	243.8	219.4
11			5/6	10			4680	3,900	1	286.8	270.8	243.8

Table 26-70 HE-MCSs for TBD mandatory/optional 484-tone RU and mandatory non-OFDMA 40MHz, Nss = 2

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	468	16	936	234	1	17.2	16.3	14.6
0	0		1/2	1			936	468	1	34.4	32.5	29.3
1	1	QPSK	1/4	2			1872	468	1	34.4	32.5	29.3
1	0		1/2	2			1872	936	1	68.8	65.0	58.5
2	N/A		3/4	2			1872	1,404	1	103.2	97.5	87.8
3	1	16-QAM	1/4	4			3744	936	1	68.8	65.0	58.5
3	0		1/2	4			3744	1,872	1	137.6	130.0	117.0
4	1		3/8	4			3744	1,404	1	103.2	97.5	87.8
4	0		3/4	4			3744	2,808	1	206.5	195.0	175.5
5	N/A	64-QAM	2/3	6			5616	3,744	1	275.3	260.0	234.0
6			3/4	6			5616	4,212	1	309.7	292.5	263.3
7			5/6	6			5616	4,680	1	344.1	325.0	292.5
8		256-QAM	3/4	8			7488	5,616	1	412.9	390.0	351.0
9			5/6	8			7488	6,240	1	458.8	433.3	390.0
10		1024-QAM	3/4	10			9360	7,020	1	516.2	487.5	438.8
11			5/6	10			9360	7,800	1	573.5	541.7	487.5

Table 26-71 HE-MCSs for TBD mandatory/optional 484-tone RU and mandatory non-OFDMA 40MHz, Nss = 3

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	468	16	1404	351	1	25.8	24.4	21.9
0	0		1/2	1			1404	702	1	51.6	48.8	43.9
1	1	QPSK	1/4	2			2808	702	1	51.6	48.8	43.9
1	0		1/2	2			2808	1,404	1	103.2	97.5	87.8
2	N/A		3/4	2			2808	2,106	1	154.9	146.3	131.6
3	1	16-QAM	1/4	4			5616	1,404	1	103.2	97.5	87.8
3	0		1/2	4			5616	2,808	1	206.5	195.0	175.5
4	1		3/8	4			5616	2,106	1	154.9	146.3	131.6
4	0		3/4	4			5616	4,212	1	309.7	292.5	263.3
5	N/A	64-QAM	2/3	6			8424	5,616	1	412.9	390.0	351.0
6			3/4	6			8424	6,318	1	464.6	438.8	394.9
7			5/6	6			8424	7,020	1	516.2	487.5	438.8
8		256-QAM	3/4	8			11232	8,424	1	619.4	585.0	526.5
9			5/6	8			11232	9,360	1	688.2	650.0	585.0
10		1024-QAM	3/4	10			14040	10,530	1	774.3	731.3	658.1
11			5/6	10			14040	11,700	1	860.3	812.5	731.3

Table 26-72 HE-MCSs for TBD mandatory/optional 484-tone RU and mandatory non-OFDMA 40MHz, Nss = 4

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	468	16	1872	468	1	34.4	32.5	29.3
0	0		1/2	1			1872	936	1	68.8	65.0	58.5
1	1	QPSK	1/4	2			3744	936	1	68.8	65.0	58.5
1	0		1/2	2			3744	1,872	1	137.6	130.0	117.0
2	N/A		3/4	2			3744	2,808	1	206.5	195.0	175.5
3	1	16-QAM	1/4	4			7488	1,872	1	137.6	130.0	117.0
3	0		1/2	4			7488	3,744	1	275.3	260.0	234.0
4	1		3/8	4			7488	2,808	1	206.5	195.0	175.5
4	0		3/4	4			7488	5,616	1	412.9	390.0	351.0
5	N/A	64-QAM	2/3	6			11232	7,488	1	550.6	520.0	468.0
6			3/4	6			11232	8,424	1	619.4	585.0	526.5
7			5/6	6			11232	9,360	1	688.2	650.0	585.0
8		256-QAM	3/4	8			14976	11,232	1	825.9	780.0	702.0
9			5/6	8			14976	12,480	1	917.6	866.7	780.0
10		1024-QAM	3/4	10			18720	14,040	1	1,032.4	975.0	877.5
11			5/6	10			18720	15,600	1	1,147.1	1,083.3	975.0

Table 26-73 HE-MCSs for TBD mandatory/optional 484-tone RU and mandatory non-OFDMA 40MHz, Nss = 5

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	468	16	2340	585	1	43.0	40.6	36.6
0	0		1/2	1			2340	1,170	1	86.0	81.3	73.1
1	1	QPSK	1/4	2			4680	1,170	1	86.0	81.3	73.1
1	0		1/2	2			4680	2,340	1	172.1	162.5	146.3
2	N/A		3/4	2			4680	3,510	1	258.1	243.8	219.4
3	1	16-QAM	1/4	4			9360	2,340	1	172.1	162.5	146.3
3	0		1/2	4			9360	4,680	1	344.1	325.0	292.5
4	1		3/8	4			9360	3,510	1	258.1	243.8	219.4
4	0		3/4	4			9360	7,020	1	516.2	487.5	438.8
5	N/A	64-QAM	2/3	6			14040	9,360	1	688.2	650.0	585.0
6			3/4	6			14040	10,530	1	774.3	731.3	658.1
7			5/6	6			14040	11,700	1	860.3	812.5	731.3
8		256-QAM	3/4	8			18720	14,040	1	1,032.4	975.0	877.5
9			5/6	8			18720	15,600	1	1,147.1	1,083.3	975.0
10		1024-QAM	3/4	10			23400	17,550	1	1,290.4	1,218.8	1,096.9
11			5/6	10			23400	19,500	1	1,433.8	1,354.2	1,218.8

Table 26-74 HE-MCSs for TBD mandatory/optional 484-tone RU and mandatory non-OFDMA 40MHz, Nss = 6

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	468	16	2808	702	1	51.6	48.8	43.9
0	0		1/2	1			2808	1,404	1	103.2	97.5	87.8
1	1	QPSK	1/4	2			5616	1,404	1	103.2	97.5	87.8
1	0		1/2	2			5616	2,808	1	206.5	195.0	175.5
2	N/A		3/4	2			5616	4,212	1	309.7	292.5	263.3
3	1	16-QAM	1/4	4			11232	2,808	1	206.5	195.0	175.5
3	0		1/2	4			11232	5,616	1	412.9	390.0	351.0
4	1		3/8	4			11232	4,212	1	309.7	292.5	263.3
4	0		3/4	4			11232	8,424	1	619.4	585.0	526.5
5	N/A	64-QAM	2/3	6			16848	11,232	1	825.9	780.0	702.0
6			3/4	6			16848	12,636	1	929.1	877.5	789.8
7			5/6	6			16848	14,040	1	1,032.4	975.0	877.5
8		256-QAM	3/4	8			22464	16,848	1	1,238.8	1,170.0	1,053.0
9			5/6	8			22464	18,720	1	1,376.5	1,300.0	1,170.0
10		1024-QAM	3/4	10			28080	21,060	1	1,548.5	1,462.5	1,316.3
11			5/6	10			28080	23,400	1	1,720.6	1,625.0	1,462.5

Table 26-75 HE-MCSs for TBD mandatory/optional 484-tone RU and mandatory non-OFDMA 40MHz, Nss = 7

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	468	16	3276	819	1	60.2	56.9	51.2
0	0		1/2	1			3276	1,638	1	120.4	113.8	102.4
1	1	QPSK	1/4	2			6552	1,638	1	120.4	113.8	102.4
1	0		1/2	2			6552	3,276	1	240.9	227.5	204.8
2	N/A		3/4	2			6552	4,914	1	361.3	341.3	307.1
3	1	16-QAM	1/4	4			13104	3,276	1	240.9	227.5	204.8
3	0		1/2	4			13104	6,552	1	481.8	455.0	409.5
4	1		3/8	4			13104	4,914	1	361.3	341.3	307.1
4	0		3/4	4			13104	9,828	1	722.6	682.5	614.3
5	N/A	64-QAM	2/3	6			19656	13,104	1	963.5	910.0	819.0
6			3/4	6			19656	14,742	1	1,084.0	1,023.8	921.4
7			5/6	6			19656	16,380	1	1,204.4	1,137.5	1,023.8
8		256-QAM	3/4	8			26208	19,656	1	1,445.3	1,365.0	1,228.5
9			5/6	8			26208	21,840	1	1,605.9	1,516.7	1,365.0
10		1024-QAM	3/4	10			32760	24,570	1	1,806.6	1,706.3	1,535.6
11			5/6	10			32760	27,300	1	2,007.4	1,895.8	1,706.3

Table 26-76 HE-MCSs for TBD mandatory/optional 484-tone RU and mandatory non-OFDMA 40MHz, Nss = 8

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	468	16	3744	936	1	68.8	65.0	58.5
0	0		1/2	1			3744	1,872	1	137.6	130.0	117.0
1	1	QPSK	1/4	2			7488	1,872	1	137.6	130.0	117.0
1	0		1/2	2			7488	3,744	1	275.3	260.0	234.0
2	N/A		3/4	2			7488	5,616	1	412.9	390.0	351.0
3	1	16-QAM	1/4	4			14976	3,744	1	275.3	260.0	234.0
3	0		1/2	4			14976	7,488	1	550.6	520.0	468.0
4	1		3/8	4			14976	5,616	1	412.9	390.0	351.0
4	0		3/4	4			14976	11,232	1	825.9	780.0	702.0
5	N/A	64-QAM	2/3	6			22464	14,976	1	1,101.2	1,040.0	936.0
6			3/4	6			22464	16,848	1	1,238.8	1,170.0	1,053.0
7			5/6	6			22464	18,720	1	1,376.5	1,300.0	1,170.0
8		256-QAM	3/4	8			29952	22,464	1	1,651.8	1,560.0	1,404.0
9			5/6	8			29952	24,960	1	1,835.3	1,733.3	1,560.0
10		1024-QAM	3/4	10			37440	28,080	1	2,064.7	1,950.0	1,755.0
11			5/6	10			37440	31,200	1	2,294.1	2,166.7	1,950.0

Table 26-77 HE-MCSs for TBD mandatory/optional 996-tone RU and mandatory non-OFDMA 80MHz, Nss = 1

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	980	16	980	245	1	18.0	17.0	15.3
0	0		1/2	1			980	490	1	36.0	34.0	30.6
1	1	QPSK	1/4	2			1960	490	1	36.0	34.0	30.6
1	0		1/2	2			1960	980	1	72.1	68.1	61.3
2	N/A		3/4	2			1960	1,470	1	108.1	102.1	91.9
3	1	16-QAM	1/4	4			3920	980	1	72.1	68.1	61.3
3	0		1/2	4			3920	1,960	1	144.1	136.1	122.5
4	1		3/8	4			3920	1,470	1	108.1	102.1	91.9
4	0		3/4	4			3920	2,940	1	216.2	204.2	183.8
5	N/A	64-QAM	2/3	6			5880	3,920	1	288.2	272.2	245.0
6			3/4	6			5880	4,410	1	324.3	306.3	275.6
7			5/6	6			5880	4,900	1	360.3	340.3	306.3
8		256-QAM	3/4	8			7840	5,880	1	432.4	408.3	367.5
9			5/6	8			7840	6,533	1	480.4	453.7	408.3
10		1024-QAM	3/4	10			9800	7,350	1	540.4	510.4	459.4
11			5/6	10			9800	8,166	1	600.4	567.1	510.4

Table 26-78 HE-MCSs for TBD mandatory/optional 996-tone RU and mandatory non-OFDMA 80MHz, Nss = 2

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	980	16	1960	490	1	36.0	34.0	30.6
0	0		1/2	1			1960	980	1	72.1	68.1	61.3
1	1	QPSK	1/4	2			3920	980	1	72.1	68.1	61.3
1	0		1/2	2			3920	1,960	1	144.1	136.1	122.5
2	N/A		3/4	2			3920	2,940	1	216.2	204.2	183.8
3	1	16-QAM	1/4	4			7840	1,960	1	144.1	136.1	122.5
3	0		1/2	4			7840	3,920	1	288.2	272.2	245.0
4	1		3/8	4			7840	2,940	1	216.2	204.2	183.8
4	0		3/4	4			7840	5,880	1	432.4	408.3	367.5
5	N/A	64-QAM	2/3	6			11760	7,840	1	576.5	544.4	490.0
6			3/4	6			11760	8,820	1	648.5	612.5	551.3
7			5/6	6			11760	9,800	1	720.6	680.6	612.5
8		256-QAM	3/4	8			15680	11,760	1	864.7	816.7	735.0
9			5/6	8			15680	13,066	1	960.7	907.4	816.6
10		1024-QAM	3/4	10			19600	14,700	1	1,080.9	1,020.8	918.8
11			5/6	10			19600	16,333	1	1,201.0	1,134.2	1,020.8

Table 26-79 HE-MCSs for TBD mandatory/optional 996-tone RU and mandatory non-OFDMA 80MHz, Nss = 3

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	980	16	2940	735	1	54.0	51.0	45.9
0	0		1/2	1			2940	1,470	1	108.1	102.1	91.9
1	1	QPSK	1/4	2			5880	1,470	1	108.1	102.1	91.9
1	0		1/2	2			5880	2,940	1	216.2	204.2	183.8
2	N/A		3/4	2			5880	4,410	1	324.3	306.3	275.6
3	1	16-QAM	1/4	4			11760	2,940	1	216.2	204.2	183.8
3	0		1/2	4			11760	5,880	1	432.4	408.3	367.5
4	1		3/8	4			11760	4,410	1	324.3	306.3	275.6
4	0		3/4	4			11760	8,820	1	648.5	612.5	551.3
5	N/A	64-QAM	2/3	6			17640	11,760	1	864.7	816.7	735.0
6			3/4	6			17640	13,230	1	972.8	918.8	826.9
7			5/6	6			17640	14,700	1	1,080.9	1,020.8	918.8
8		256-QAM	3/4	8			23520	17,640	1	1,297.1	1,225.0	1,102.5
9			5/6	8			23520	19,600	1	1,441.2	1,361.1	1,225.0
10		1024-QAM	3/4	10			29400	22,050	1	1,621.3	1,531.3	1,378.1
11			5/6	10			29400	24,500	1	1,801.5	1,701.4	1,531.3

Table 26-80 HE-MCSs for TBD mandatory/optional 996-tone RU and mandatory non-OFDMA 80MHz, Nss = 4

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	980	16	3920	980	1	72.1	68.1	61.3
0	0		1/2	1			3920	1,960	1	144.1	136.1	122.5
1	1	QPSK	1/4	2			7840	1,960	1	144.1	136.1	122.5
1	0		1/2	2			7840	3,920	1	288.2	272.2	245.0
2	N/A		3/4	2			7840	5,880	1	432.4	408.3	367.5
3	1	16-QAM	1/4	4			15680	3,920	1	288.2	272.2	245.0
3	0		1/2	4			15680	7,840	1	576.5	544.4	490.0
4	1		3/8	4			15680	5,880	1	432.4	408.3	367.5
4	0		3/4	4			15680	11,760	1	864.7	816.7	735.0
5	N/A	64-QAM	2/3	6			23520	15,680	1	1,152.9	1,088.9	980.0
6			3/4	6			23520	17,640	1	1,297.1	1,225.0	1,102.5
7			5/6	6			23520	19,600	1	1,441.2	1,361.1	1,225.0
8		256-QAM	3/4	8			31360	23,520	1	1,729.4	1,633.3	1,470.0
9			5/6	8			31360	26,133	1	1,921.5	1,814.8	1,633.3
10		1024-QAM	3/4	10			39200	29,400	1	2,161.8	2,041.7	1,837.5
11			5/6	10			39200	32,666	1	2,401.9	2,268.5	2,041.6

Table 26-81 HE-MCSs for TBD mandatory/optional 996-tone RU and mandatory non-OFDMA 80MHz, Nss = 5

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	980	16	4900	1,225	1	90.1	85.1	76.6
0	0		1/2	1			4900	2,450	1	180.1	170.1	153.1
1	1	QPSK	1/4	2			9800	2,450	1	180.1	170.1	153.1
1	0		1/2	2			9800	4,900	1	360.3	340.3	306.3
2	N/A		3/4	2			9800	7,350	1	540.4	510.4	459.4
3	1	16-QAM	1/4	4			19600	4,900	1	360.3	340.3	306.3
3	0		1/2	4			19600	9,800	1	720.6	680.6	612.5
4	1		3/8	4			19600	7,350	1	540.4	510.4	459.4
4	0		3/4	4			19600	14,700	1	1,080.9	1,020.8	918.8
5	N/A	64-QAM	2/3	6			29400	19,600	1	1,441.2	1,361.1	1,225.0
6			3/4	6			29400	22,050	1	1,621.3	1,531.3	1,378.1
7			5/6	6			29400	24,500	1	1,801.5	1,701.4	1,531.3
8		256-QAM	3/4	8			39200	29,400	1	2,161.8	2,041.7	1,837.5
9			5/6	8			39200	32,666	1	2,401.9	2,268.5	2,041.6
10		1024-QAM	3/4	10			49000	36,750	1	2,702.2	2,552.1	2,296.9
11			5/6	10			49000	40,833	1	3,002.4	2,835.6	2,552.1

Table 26-82 HE-MCSs for TBD mandatory/optional 996-tone RU and mandatory non-OFDMA 80MHz, Nss = 6

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	980	16	5880	1,470	1	108.1	102.1	91.9
0	0		1/2	1			5880	2,940	1	216.2	204.2	183.8
1	1	QPSK	1/4	2			11760	2,940	1	216.2	204.2	183.8
1	0		1/2	2			11760	5,880	1	432.4	408.3	367.5
2	N/A		3/4	2			11760	8,820	1	648.5	612.5	551.3
3	1	16-QAM	1/4	4			23520	5,880	1	432.4	408.3	367.5
3	0		1/2	4			23520	11,760	1	864.7	816.7	735.0
4	1		3/8	4			23520	8,820	1	648.5	612.5	551.3
4	0		3/4	4			23520	17,640	1	1,297.1	1,225.0	1,102.5
5	N/A	64-QAM	2/3	6			35280	23,520	1	1,729.4	1,633.3	1,470.0
6			3/4	6			35280	26,460	1	1,945.6	1,837.5	1,653.8
7			5/6	6			35280	29,400	1	2,161.8	2,041.7	1,837.5
8		256-QAM	3/4	8			47040	35,280	1	2,594.1	2,450.0	2,205.0
9			5/6	8			47040	39,200	1	2,882.4	2,722.2	2,450.0
10		1024-QAM	3/4	10			58800	44,100	1	3,242.6	3,062.5	2,756.3
11			5/6	10			58800	49,000	1	3,602.9	3,402.8	3,062.5

Table 26-83 HE-MCSs for TBD mandatory/optional 996-tone RU and mandatory non-OFDMA 80MHz, Nss = 7

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	980	16	6860	1,715	1	126.1	119.1	107.2
0	0		1/2	1			6860	3,430	1	252.2	238.2	214.4
1	1	QPSK	1/4	2			13720	3,430	1	252.2	238.2	214.4
1	0		1/2	2			13720	6,860	1	504.4	476.4	428.8
2	N/A		3/4	2			13720	10,290	1	756.6	714.6	643.1
3	1	16-QAM	1/4	4			27440	6,860	1	504.4	476.4	428.8
3	0		1/2	4			27440	13,720	1	1,008.8	952.8	857.5
4	1		3/8	4			27440	10,290	1	756.6	714.6	643.1
4	0		3/4	4			27440	20,580	1	1,513.2	1,429.2	1,286.3
5	N/A	64-QAM	2/3	6			41160	27,440	1	2,017.6	1,905.6	1,715.0
6			3/4	6			41160	30,870	1	2,269.9	2,143.8	1,929.4
7			5/6	6			41160	34,300	1	2,522.1	2,381.9	2,143.8
8		256-QAM	3/4	8			54880	41,160	1	3,026.5	2,858.3	2,572.5
9			5/6	8			54880	45,733	1	3,362.7	3,175.9	2,858.3
10		1024-QAM	3/4	10			68600	51,450	1	3,783.1	3,572.9	3,215.6
11			5/6	10			68600	57,166	1	4,203.4	3,969.9	3,572.9

Table 26-84 HE-MCSs for TBD mandatory/optional 996-tone RU and mandatory non-OFDMA 80MHz, Nss = 8

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	980	16	7840	1,960	1	144.1	136.1	122.5
0	0		1/2	1			7840	3,920	1	288.2	272.2	245.0
1	1	QPSK	1/4	2			15680	3,920	1	288.2	272.2	245.0
1	0		1/2	2			15680	7,840	1	576.5	544.4	490.0
2	N/A		3/4	2			15680	11,760	1	864.7	816.7	735.0
3	1	16-QAM	1/4	4			31360	7,840	1	576.5	544.4	490.0
3	0		1/2	4			31360	15,680	1	1,152.9	1,088.9	980.0
4	1		3/8	4			31360	11,760	1	864.7	816.7	735.0
4	0		3/4	4			31360	23,520	1	1,729.4	1,633.3	1,470.0
5	N/A	64-QAM	2/3	6			47040	31,360	1	2,305.9	2,177.8	1,960.0
6			3/4	6			47040	35,280	1	2,594.1	2,450.0	2,205.0
7			5/6	6			47040	39,200	1	2,882.4	2,722.2	2,450.0
8		256-QAM	3/4	8			62720	47,040	1	3,458.8	3,266.7	2,940.0
9			5/6	8			62720	52,266	1	3,843.1	3,629.6	3,266.6
10		1024-QAM	3/4	10			78400	58,800	1	4,323.5	4,083.3	3,675.0
11			5/6	10			78400	65,333	1	4,803.9	4,537.0	4,083.3

Table 26-85 HE-MCSs for optional non-OFDMA 160/80+80MHz, Nss = 1

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	1960	32	1960	490	1	36.0	34.0	30.6
0	0		1/2	1			1960	980	1	72.1	68.1	61.3
1	1	QPSK	1/4	2			3920	980	1	72.1	68.1	61.3
1	0		1/2	2			3920	1,960	1	144.1	136.1	122.5
2	N/A		3/4	2			3920	2,940	1	216.2	204.2	183.8
3	1	16-QAM	1/4	4			7840	1,960	1	144.1	136.1	122.5
3	0		1/2	4			7840	3,920	1	288.2	272.2	245.0
4	1		3/8	4			7840	2,940	1	216.2	204.2	183.8
4	0		3/4	4			7840	5,880	1	432.4	408.3	367.5
5	N/A	64-QAM	2/3	6			11760	7,840	1	576.5	544.4	490.0
6			3/4	6			11760	8,820	1	648.5	612.5	551.3
7			5/6	6			11760	9,800	1	720.6	680.6	612.5
8		256-QAM	3/4	8			15680	11,760	1	864.7	816.7	735.0
9			5/6	8			15680	13,066	1	960.7	907.4	816.6
10		1024-QAM	3/4	10			19600	14,700	1	1,080.9	1,020.8	918.8
11			5/6	10			19600	16,333	1	1,201.0	1,134.2	1,020.8

Table 26-86 HE-MCSs for optional non-OFDMA 160/80+80MHz, NSS = 2

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	1960	32	3920	980	1	72.1	68.1	61.3
0	0		1/2	1			3920	1,960	1	144.1	136.1	122.5
1	1	QPSK	1/4	2			7840	1,960	1	144.1	136.1	122.5
1	0		1/2	2			7840	3,920	1	288.2	272.2	245.0
2	N/A		3/4	2			7840	5,880	1	432.4	408.3	367.5
3	1	16-QAM	1/4	4			15680	3,920	1	288.2	272.2	245.0
3	0		1/2	4			15680	7,840	1	576.5	544.4	490.0
4	1		3/8	4			15680	5,880	1	432.4	408.3	367.5
4	0		3/4	4			15680	11,760	1	864.7	816.7	735.0
5	N/A	64-QAM	2/3	6			23520	15,680	1	1,152.9	1,088.9	980.0
6			3/4	6			23520	17,640	1	1,297.1	1,225.0	1,102.5
7			5/6	6			23520	19,600	1	1,441.2	1,361.1	1,225.0
8		256-QAM	3/4	8			31360	23,520	1	1,729.4	1,633.3	1,470.0
9			5/6	8			31360	26,133	1	1,921.5	1,814.8	1,633.3
10		1024-QAM	3/4	10			39200	29,400	1	2,161.8	2,041.7	1,837.5
11			5/6	10			39200	32,666	1	2,401.9	2,268.5	2,041.6

Table 26-87 HE-MCSs for optional non-OFDMA 160/80+80MHz, NSS = 3

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	1960	32	5880	1,470	1	108.1	102.1	91.9
0	0		1/2	1			5880	2,940	1	216.2	204.2	183.8
1	1	QPSK	1/4	2			11760	2,940	1	216.2	204.2	183.8
1	0		1/2	2			11760	5,880	1	432.4	408.3	367.5
2	N/A		3/4	2			11760	8,820	1	648.5	612.5	551.3
3	1	16-QAM	1/4	4			23520	5,880	1	432.4	408.3	367.5
3	0		1/2	4			23520	11,760	1	864.7	816.7	735.0
4	1		3/8	4			23520	8,820	1	648.5	612.5	551.3
4	0		3/4	4			23520	17,640	1	1,297.1	1,225.0	1,102.5
5	N/A	64-QAM	2/3	6			35280	23,520	1	1,729.4	1,633.3	1,470.0
6			3/4	6			35280	26,460	1	1,945.6	1,837.5	1,653.8
7			5/6	6			35280	29,400	1	2,161.8	2,041.7	1,837.5
8		256-QAM	3/4	8			47040	35,280	1	2,594.1	2,450.0	2,205.0
9			5/6	8			47040	39,200	1	2,882.4	2,722.2	2,450.0
10		1024-QAM	3/4	10			58800	44,100	1	3,242.6	3,062.5	2,756.3
11			5/6	10			58800	49,000	1	3,602.9	3,402.8	3,062.5

Table 26-88 HE-MCSs for optional non-OFDMA 160/80+80MHz, Nss = 4

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	1960	32	7840	1,960	1	144.1	136.1	122.5
0	0		1/2	1			7840	3,920	1	288.2	272.2	245.0
1	1	QPSK	1/4	2			15680	3,920	1	288.2	272.2	245.0
1	0		1/2	2			15680	7,840	1	576.5	544.4	490.0
2	N/A		3/4	2			15680	11,760	1	864.7	816.7	735.0
3	1	16-QAM	1/4	4			31360	7,840	1	576.5	544.4	490.0
3	0		1/2	4			31360	15,680	1	1,152.9	1,088.9	980.0
4	1		3/8	4			31360	11,760	1	864.7	816.7	735.0
4	0		3/4	4			31360	23,520	1	1,729.4	1,633.3	1,470.0
5	N/A	64-QAM	2/3	6			47040	31,360	1	2,305.9	2,177.8	1,960.0
6			3/4	6			47040	35,280	1	2,594.1	2,450.0	2,205.0
7			5/6	6			47040	39,200	1	2,882.4	2,722.2	2,450.0
8		256-QAM	3/4	8			62720	47,040	1	3,458.8	3,266.7	2,940.0
9			5/6	8			62720	52,266	1	3,843.1	3,629.6	3,266.6
10		1024-QAM	3/4	10			78400	58,800	1	4,323.5	4,083.3	3,675.0
11			5/6	10			78400	65,333	1	4,803.9	4,537.0	4,083.3

Table 26-89 HE-MCSs for optional non-OFDMA 160/80+80MHz, Nss = 5

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	1960	32	9800	2,450	1	180.1	170.1	153.1
0	0		1/2	1			9800	4,900	1	360.3	340.3	306.3
1	1	QPSK	1/4	2			19600	4,900	1	360.3	340.3	306.3
1	0		1/2	2			19600	9,800	1	720.6	680.6	612.5
2	N/A		3/4	2			19600	14,700	1	1,080.9	1,020.8	918.8
3	1	16-QAM	1/4	4			39200	9,800	1	720.6	680.6	612.5
3	0		1/2	4			39200	19,600	1	1,441.2	1,361.1	1,225.0
4	1		3/8	4			39200	14,700	1	1,080.9	1,020.8	918.8
4	0		3/4	4			39200	29,400	1	2,161.8	2,041.7	1,837.5
5	N/A	64-QAM	2/3	6			58800	39,200	1	2,882.4	2,722.2	2,450.0
6			3/4	6			58800	44,100	1	3,242.6	3,062.5	2,756.3
7			5/6	6			58800	49,000	1	3,602.9	3,402.8	3,062.5
8		256-QAM	3/4	8			78400	58,800	1	4,323.5	4,083.3	3,675.0
9			5/6	8			78400	65,333	1	4,803.9	4,537.0	4,083.3
10		1024-QAM	3/4	10			98000	73,500	1	5,404.4	5,104.2	4,593.8
11			5/6	10			98000	81,666	1	6,004.9	5,671.3	5,104.1

Table 26-90 HE-MCSs for optional non-OFDMA 160/80+80MHz, Nss = 6

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	1960	32	11760	2,940	1	216.2	204.2	183.8
0	0		1/2	1			11760	5,880	1	432.4	408.3	367.5
1	1	QPSK	1/4	2			23520	5,880	1	432.4	408.3	367.5
1	0		1/2	2			23520	11,760	1	864.7	816.7	735.0
2	N/A		3/4	2			23520	17,640	1	1,297.1	1,225.0	1,102.5
3	1	16-QAM	1/4	4			47040	11,760	1	864.7	816.7	735.0
3	0		1/2	4			47040	23,520	1	1,729.4	1,633.3	1,470.0
4	1		3/8	4			47040	17,640	1	1,297.1	1,225.0	1,102.5
4	0		3/4	4			47040	35,280	1	2,594.1	2,450.0	2,205.0
5	N/A	64-QAM	2/3	6			70560	47,040	1	3,458.8	3,266.7	2,940.0
6			3/4	6			70560	52,920	1	3,891.2	3,675.0	3,307.5
7			5/6	6			70560	58,800	1	4,323.5	4,083.3	3,675.0
8		256-QAM	3/4	8			94080	70,560	1	5,188.2	4,900.0	4,410.0
9			5/6	8			94080	78,400	1	5,764.7	5,444.4	4,900.0
10		1024-QAM	3/4	10			117600	88,200	1	6,485.3	6,125.0	5,512.5
11			5/6	10			117600	98,000	1	7,205.9	6,805.6	6,125.0

Table 26-91 HE-MCSs for optional non-OFDMA 160/80+80MHz, Nss = 7

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	1960	32	13720	3,430	1	252.2	238.2	214.4
0	0		1/2	1			13720	6,860	1	504.4	476.4	428.8
1	1	QPSK	1/4	2			27440	6,860	1	504.4	476.4	428.8
1	0		1/2	2			27440	13,720	1	1,008.8	952.8	857.5
2	N/A		3/4	2			27440	20,580	1	1,513.2	1,429.2	1,286.3
3	1	16-QAM	1/4	4			54880	13,720	1	1,008.8	952.8	857.5
3	0		1/2	4			54880	27,440	1	2,017.6	1,905.6	1,715.0
4	1		3/8	4			54880	20,580	1	1,513.2	1,429.2	1,286.3
4	0		3/4	4			54880	41,160	1	3,026.5	2,858.3	2,572.5
5	N/A	64-QAM	2/3	6			82320	54,880	1	4,035.3	3,811.1	3,430.0
6			3/4	6			82320	61,740	1	4,539.7	4,287.5	3,858.8
7			5/6	6			82320	68,600	1	5,044.1	4,763.9	4,287.5
8		256-QAM	3/4	8			109760	82,320	1	6,052.9	5,716.7	5,145.0
9			5/6	8			109760	91,466	1	6,725.4	6,351.8	5,716.6
10		1024-QAM	3/4	10			137200	102,900	1	7,566.2	7,145.8	6,431.3
11			5/6	10			137200	114,333	1	8,406.8	7,939.8	7,145.8

Table 26-92 HE-MCSs for optional non-OFDMA 160/80+80MHz, NSS = 8

HE-MCS Index	DCM	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)		
										0.8 usec GI	1.6 usec GI	3.2 usec GI
0	1	BPSK	1/4	1	1960	32	15680	3,920	1	288.2	272.2	245.0
0	0		1/2	1			15680	7,840	1	576.5	544.4	490.0
1	1	QPSK	1/4	2			31360	7,840	1	576.5	544.4	490.0
1	0		1/2	2			31360	15,680	1	1,152.9	1,088.9	980.0
2	N/A		3/4	2			31360	23,520	1	1,729.4	1,633.3	1,470.0
3	1	16-QAM	1/4	4			62720	15,680	1	1,152.9	1,088.9	980.0
3	0		1/2	4			62720	31,360	1	2,305.9	2,177.8	1,960.0
4	1		3/8	4			62720	23,520	1	1,729.4	1,633.3	1,470.0
4	0		3/4	4			62720	47,040	1	3,458.8	3,266.7	2,940.0
5	N/A	64-QAM	2/3	6			94080	62,720	1	4,611.8	4,355.6	3,920.0
6			3/4	6			94080	70,560	1	5,188.2	4,900.0	4,410.0
7			5/6	6			94080	78,400	1	5,764.7	5,444.4	4,900.0
8		256-QAM	3/4	8			125440	94,080	1	6,917.6	6,533.3	5,880.0
9			5/6	8			125440	104,533	1	7,686.3	7,259.2	6,533.3
10		1024-QAM	3/4	10			156800	117,600	1	8,647.1	8,166.7	7,350.0
11			5/6	10			156800	130,666	1	9,607.8	9,074.0	8,166.6

Annex C

26.6 C.3 MIB Detail

Insert the following (after getting some sucker to validate MIB compilation, etc.):

```
dot11PPEThresholdsRequired OBJECT-TYPE
     SYNTAX TruthValue
     MAX-ACCESS read-only
     STATUS current
     DESCRIPTION
          "This is a capability variable.
          Its value is determined by device capabilities.
          This attribute, when true, indicates that Post-FEC
          Padding and Packet Extension Thresholds exist and are
          provided in the dot11PPEThresholdsTable MIB."
     DEFVAL { false }
     ::= { dot11StationConfigEntry <ANA> }

--------------------------------------------------------------------
------
--
--------------------------------------------------------------------
------
-- * dot11PPEThresholdsMappings TABLE
--
--------------------------------------------------------------------
------
dot11PPEThresholdsMappingsTable OBJECT-TYPE
     SYNTAX SEQUENCE OF Dot11PPEThresholdsMappingsEntry
     MAX-ACCESS not-accessible
     STATUS current
     DESCRIPTION
          "Conceptual table for PPE Thresholds Mappings. The MIB
          supports the ability to share separate PPE Thresholds
          for each NSS/RU pair. The Thresholds Mappings Table
          contains one entry for each NSS/RU pair and contains
          two fields for each entry: PPET8 and PPET16. The PPE
          Thresholds mappings are logically WRITE-ONLY. Attempts
          to read the entries in this table return unsuccessful
          status and values of null or 0. The default value for
          all PPET8 fields is NONE."
     REFERENCE "IEEE Std 802.11-<year>, 9.47 (HE Post-FEC
Padding and Packet Extension)"
     ::= { dot11smt 4 }

dot11PPEThresholdsMappingsEntry OBJECT-TYPE
     SYNTAX Dot11PPEThresholdsMappingsEntry
```

```
     MAX-ACCESS not-accessible
     STATUS current
     DESCRIPTION
          "An Entry (conceptual row) in the PPE Thresholds
          Mappings Table. ifIndex - Each IEEE Std 802.11
          interface is represented by an ifEntry. Interface
          tables in this MIB module are indexed by ifIndex."
     INDEX { ifIndex, dot11PPEThresholdsMappingIndex }
     ::= { dot11PPEThresholdsMappingsTable 1 }

Dot11PPEThresholdsMappingsEntry ::=
     SEQUENCE {
          dot11PPEThresholdsMappingIndex           Unsigned32,
          dot11PPEThresholdsMappingNSS                Integer,
          dot11PPEThresholdsMappingRUIndex            Integer,
          dot11PPEThresholdsMappingPPET8              Integer,
          dot11PPEThresholdsMappingPPET16             Integer,
          dot11PPEThresholdsMappingStatus          RowStatus }

dot11PPEThresholdsMappingIndex OBJECT-TYPE
     SYNTAX Unsigned32
     MAX-ACCESS not-accessible
     STATUS current
     DESCRIPTION
               "The auxiliary variable used to identify
               instances of the columnar objects in the PPE
               Thresholds Mappings Table."
          ::= { dot11PPEThresholdsMappingsEntry 1 }

dot11PPEThresholdsMappingNSS OBJECT-TYPE
     SYNTAX Integer
     MAX-ACCESS read-create
     STATUS current
     DESCRIPTION
          "The NSS value portion of the NSS/RU pair for which
          the values from this Thresholds mapping entry are to
          be used."
     ::= { dot11PPEThresholdsMappingsEntry 2 }

dot11PPEThresholdsMappingRUIndex OBJECT-TYPE
     SYNTAX Integer
     MAX-ACCESS read-create
     STATUS current
     DESCRIPTION
          "The index of the RU value portion of the NSS/RU pair
          for which the values from this Thresholds mapping
          entry are to be used. The index values map to an RU as
          follows: RU Index of 0 is 996 tones, 1 is 448 tones, 2
          is TBD tones, 3 is reserved."
     ::= { dot11PPEThresholdsMappingsEntry 3 }
```

```
1
2   dot11PPEThresholdsMappingPPET8 OBJECT-TYPE
3        SYNTAX TruthValue
4        MAX-ACCESS read-create
5        STATUS current
6        DESCRIPTION
7             "An index that determines a constellation value at or
8             above which a Post FEC Padding and Packet Extension
9             value of at least 8 us is required for the given
10            NSS/RU pair corresponding to the row of the entry. The
11            index values are mapped as follows: 0 is BPSK, 1 is
12            QPSK, 2 is 16QAM, 3 is 64QAM, 4 is 256QAM, 5 is
13            1024QAM, 6 is reserved, 7 is the special value of
14            NONE."
15       ::= { dot11PPEThresholdsMappingsEntry 4 }
16
17
18  dot11PPEThresholdsMappingPPET16 OBJECT-TYPE
19       SYNTAX TruthValue
20       MAX-ACCESS read-create
21       STATUS current
22       DESCRIPTION
23            "An index that determines a constellation value at or
24            above which a Post FEC Padding and Packet Extension
25            value of 16 us is required for the given NSS/RU pair
26            corresponding to the row of the entry. The index
27            values are mapped as follows: 0 is BPSK, 1 is QPSK, 2
28            is 16QAM, 3 is 64QAM, 4 is 256QAM, 5 is 1024QAM, 6 is
29            reserved, 7 is the special value of NONE."
30       ::= { dot11PPEThresholdsMappingsEntry 5 }
31
32  dot11PPEThresholdsMappingStatus OBJECT-TYPE
33       SYNTAX RowStatus
34       MAX-ACCESS read-create
35       STATUS current
36       DESCRIPTION
37            "The status column used for creating, modifying, and
38            deleting instances of the columnar objects in the PPE
39            Thresholds mapping Table."
40  DEFVAL { active }
41       ::= { dot11PPEThresholdsMappingsEntry 6 }
42
43  ----------------------------------------------------------------
44  ------
45  -- * End of dot11PPEThresholdsMappings TABLE
46  --
47  ----------------------------------------------------------------
48  ------
```

APPENDIX K

The Beacon

Wi-Fi® 2015: The top-10 list

by Craig Mathias

With 2015 now here (what, already?), it's time for the annual Top-10 lists to hit the airwaves. And what could be more interesting or important than a look at what's really going to matter in Wi-Fi® over the next year? Sure, many already take Wi-Fi for granted as a mature fixture in networking, and that's actually a good thing. Wi-Fi has indeed become ubiquitous to the point that it's achieved the networking nirvana of (however inelegant this may sound) *plumbing*. That's right, Wi-Fi *just works*. It's right up there with Ethernet and LTE as an *essential* networking and communications technology that few – *very, very few*, and, regardless, no one I know – could live without.

But that doesn't mean that the folks at the Patent Office can relax – the rate of innovation in Wi-Fi remains at a significant pace, and new developments continue to enable advanced applications that will yield far-reaching benefits. So what follows is a look at what I think will be the most important advances in Wi-Fi technologies, and more, for 2015 – and, as we'll allude below, about which there will be plenty of talk about in the outyears. I've listed my Top-10 in no particular order, with no prioritization or relative importance implied. With Wi-Fi, again, now so important across so many applications, it would be tough to say which of the following is truly Number One.

802.11ac takes off

But let's start with what's usually top-of-mind today, *802.11ac*. As we forecast about two years ago, 2015 will be *the* year in which sales of 802.11ac-based products exceed those of 802.11n. This is not to say that 802.11n is obsolete; indeed, sales of .11n-based products will continue and we still don't see any large-scale de-commissioning of 802.11n installations occurring before 2018 (and even then, 802.11ac will still provide backwards compatibility for the many still-in-service 802.11n clients). But the rate-vs.-range performance of .11ac, thanks primarily to beamforming and clever vendor implementations, and the improvement in overall capacity inherent in 802.11ac, thanks to increased channel bandwidths, will bring even the most skeptical IT managers and residential buyers into the 802.11ac fold in 2015. Sure, vendors are leading with the amazing throughput numbers enabled by 802.11ac, with four-stream products offering in excess of 3 Gbps aggregate throughput now available, but most deployments will really be all about improved *range, reliability, management*, and the *capacity* to support multiple, simultaneous, and demanding users, devices, and applications ranging from streaming video to the Internet of Things.

WiGig® on the move

802.11ad, or WiGig, will also gain a good deal of steam in 2015. Many have not yet even heard of 802.11ad, perhaps because it's getting lost in the alphabet soup (see the final item, below) of WLAN standards, and the fact is that few products are available today. But 802.11ad is no afterthought, and it won't be to .11ac like 802.11a was to 802.11g, a powerful but underutilized also-ran. 802.11ad is best thought of as a *complement* to 802.11ac, designed for *very* (very!) high throughput over more limited range. 802.11ad operates in the 60 GHz bands, where's there's a *vast* amount of available spectrum, and can reach close to 7 Gbps. OK, you say; so can 802.11ac - but that's possible only in an 8x8 MIMO configuration, and such won't be common in 2015, if ever. But, again you say, the 5 GHz. of 802.11ac propagates more efficiently, and 60 GHz really doesn't go through walls. True – but in open offices, for in-room full-speed HD video links, high-performance virtual reality and medical applications, and many more, however – let's just say that *a lot* more people will appreciate what 802.11ad can really do by the end of 2015. And with Wi-Fi Alliance® hard at work on a certification program here, many of these folks will soon have direct experience with just how amazing 802.11ad really is. Stay tuned – *this is going to be big*.

Passpoint™: Cellular-like connectivity comes to Wi-Fi

Passpoint is one of the most important innovations ever to come out of Wi-Fi Alliance, ranking right up with WPA™, the brilliant solution that addressed the fundamental flaws in WEP that at the time threatened to derail the momentum that was just beginning to build behind wireless LANs. Just like WPA, Passpoint is simple and elegant, and designed to make authenticating with Wi-Fi hotspots as easy and as transparent as handsets connecting to a cellular network. In other words, the same seamless authentication experience that is essential to cellular will become *common* in Wi-Fi based hotspots and beyond in 2015 – momentum is building, and the flexibility inherent in Passpoint leaves few opportunities for either objections or alternatives – a done deal, in other words.

Wi-Fi and the cloud – In more ways than one

Which leads us to the future of information systems and IT overall as the continuous connectivity enabled by Wi-Fi becomes commonplace. I'm of the opinion that the Cloud, not apps, wins in the long run. Why? Because modern organizational computing centers on large (make that *vast*) amounts of data, sufficient server processing power to deal with all that data, and real-time, anytime/anywhere communication and collaboration. The argument about needing to be productive when offline is now moot: *no one can really be productive without access to the network*. Wi-Fi – *real mobile broadband networking* – is going to be available almost everywhere (it'll be rare to be on a flight that doesn't offer Wi-Fi, for example), and often the *first* choice for this essential connectivity (see the next item). Look for HTML5-based applications, desktop virtualization, all manner of network and other operational management services, and, really, all cloud services available at the end of a Wi-Fi connection to *define* IT from 2015 onwards. And remember - *only* Wi-Fi offers the combination of throughput, capacity, and cost-effectiveness that truly makes the cloud mobile.

Wi-Fi is critical to the success of - *Cellular*

Going hand-in-hand with (and also augmented by) Passpoint is the emerging momentum towards *cellular offload*. I've argued for some time that Wi-Fi is *fundamental – essential,* really – to the future of wide-area wireless communications because cellular networks are so limited in terms of available spectrum. Sure, the trend towards small cells and LTE-Advanced will help here, but more spectrum is always king in wireless. With vast amounts of spectrum available on an unlicensed basis, and rapid reuse of this spectrum due to both efficient sharing mechanisms and limited transmit power, Wi-Fi is an *ideal* complement to cellular, especially indoors and in high-population-density, high-demand areas. In fact, all that abundant spectrum and 802.11ac-equipped clients will likely drive the nascent *"Wi-Fi First"* movement that's just coming onto radar screens. And such exciting developments as the increasing availability of Wi-Fi in cars as both mobile hotspots and as a core element in intelligent vehicles and highways, the increasing application of voice over Wi-Fi, and even mobile unified communications (landlines? remember those?), and more – exciting just doesn't begin to describe it!

Wi-Fi and the enterprise: Two key developments

Just as is the case in the residence, enterprises are now provisioning Wi-Fi as not just their primary or preferred networks, but rather as their *only* access for essentially *everyone*, from staff to contractors to guests. As a consequence, wired networks in organizations are now taking on a supporting role, providing connectivity, power (over Ethernet), and backhaul for the ever-increasingly dense population of APs. This means that *unified wired/wireless management* is gaining steam, as IT staffs always pressed to improve productivity seek to optimize Wi-Fi performance end-to-end and minimize operational expense, and the rise of big-data *analytics* to help spot performance and potential security and integrity issues before these can have an impact.

Wi-Fi maintains its leading role in location-based services

One of the most interesting applications (again, almost everywhere) going forward will be *location-based services* and, at least in some cases, Wi-Fi-based *tracking* in the interests of enhancing these services and a number of dimensions of security. Many in the press are ga-ga about beacons based on Bluetooth Low Energy (BLE), but let's face it: these have limited range and are broadcast-only – meaning another wireless technology is required to close the loop. And that technology is – well, I think you know… And Wi-Fi can also be used for the location and tracking of unmodified clients, with excellent range, accuracy, and convenience. We'll see the launch of new location-based services and applications across a broad range of market opportunities. Even the obvious privacy concerns can be addressed – such represent, after all, a *political*, and not technical, challenge.

Wi-Fi dominates in IoT applications

2015, as I **recently wrote**, will see the dramatically increased application of Wi-Fi in M2M/IoT/IoE. The real beauty of Wi-Fi in the Internet of Things world is that Wi-Fi already speaks IP natively, and new applications can in many cases leverage a robust, broadband infrastructure that's already in place. Everything required is in fact here today – security, authentication, and even low-cost, low-power (I recently reviewed, for example, a Wi-Fi *camera* that can run for up to 90 days on a single USB charge!) implementations suitable for anything that needs to be done in the residence, or the enterprise. Wi-Fi is a very serious alternative to other M2M/IoT/IoE radio technologies, and I expect Wi-Fi will even *dominate* many IoT applications going forward. And let's not forget the many potential beneifts of Wi-Fi Direct® here as well.

Service discovery: Convenience and value

Just announced by Wi-Fi Alliance, Wi-Fi Aware™ is an exciting advance in the vital service-discovery space. The idea here is for devices and users to learn about potential services, applications, information, and beyond *before* connecting to a given Wi-Fi network. The implications here are huge: looking for a printer? How about being notified about an item on your shopping list being not just available nearby, but also on sale? Think of service discovery as social networking that runs in the background on mobile devices. The real power of service discovery will be unlocked when application developers discover all that's here – but it's going to be exciting (there's that word again!) nonetheless, and, yes, in 2015.

And the innovation continues: We're not done yet

OK, most of these extend well beyond 2015, but you'll see many new products based on the continuing innovation coming out of IEEE 802.11 Working Groups in 2015 and beyond. A few notable examples here include work on 802.11ax, which could reach (around 2018, I think) the magical 10 Gbps level of throughput; 802.11ah, for additional M2M/IoT opportunities in the sub-1 GHz. bands; 802.11ai, for improved connect times (this is a/k/a Fast Link Setup); and 802.11aq, or Pre-Association Discovery – which should fit nicely with the Wi-Fi Aware effort noted above (and, once again, Wi-Fi Alliance is well ahead of the formal standards process). While Wi-Fi Alliance has yet to announce

plans in many of these areas, the ongoing high levels of activity and innovation in wireless LANs point to a future that will yield numerous additional benefits for us all.

So you see what I mean: Wi-Fi is indeed *everywhere* and has achieved the status of an *essential* technology - it's right up there with electricity, the Internet, and, yes, indoor plumbing as a universal requisite for effective business, education, government, health and healthcare, entertainment - and much, much more.

Happy New Year – *and an innovative 2015* – to all!

Add new comment

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Submitted by Anonymous on Fri, 03/13/2015 - 14:46

Permalink

this is one of the world best

this is one of the world best application

Reply

Submitted by Vinod Vyas on Sun, 10/25/2015 - 06:55

Permalink

Whats the latest update, we are in Q4 2015

Good article Craig. Whats the update. We are in Q4 2015. How do you see WiFi now after lots of changes in technology and recent acquisition of Aruba by HP and Meru by Fortinet.

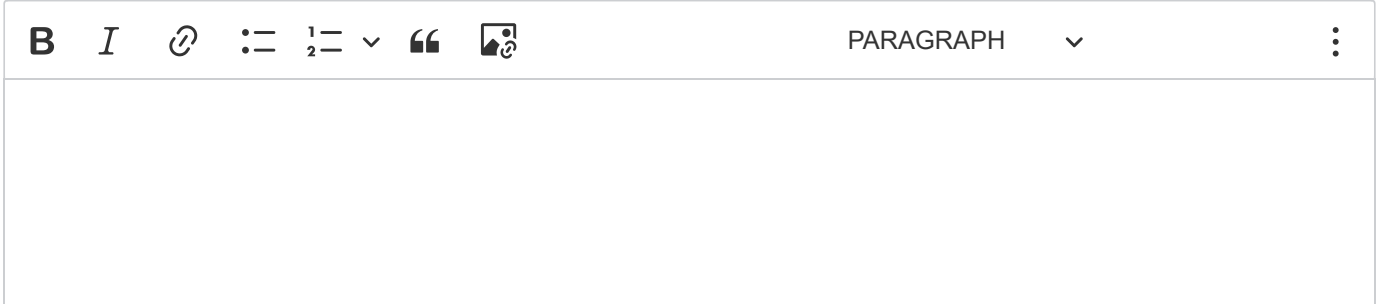
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SAVE PREVIEW



Craig Mathias

Farpoint Group

Craig J. Mathias is a Principal with Farpoint Group, an advisory firm specializing in wireless networking and mobile computing. Founded in 1991, Farpoint Group works with technology developers, manufacturers, carriers and operators, enterprises, and the financial community. Craig is an internationally-recognized industry and technology analyst, consultant, conference speaker, author, columnist, and blogger. He regularly writes for *Network World, CIO.com,* and *TechTarget*. Craig holds an Sc.B. degree in Computer Science from Brown University, and is a member of the Society of Sigma Xi and the IEEE.

Follow Craig Mathias at:

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APPENDIX L

IEEE Spectrum

NEWS TELECOMMUNICATIONS

What's Next After 25 Years of Wi-Fi? › The 25th anniversary of the IEEE 802.11 wireless standard provides a chance to glimpse next-gen Wi-Fi

BY JEREMY HSU

10 SEP 2015



PHOTO: ISTOCKPHOTO

IN 1997, THE FIRST VERSION OF WI-FI APPEARED. (The same year saw a bout half of U.S. homes using AOL as their Internet Service Provider, Netscape with the most web browser users, and Microsoft rescuing Apple from the verge of bankruptcy.) Today, the the Wi-Fi standard known as IEEE 802.11 celebrates its 25th anniversary in a world where many people take Wi-Fi access for granted while streaming high-definition video and checking in on social media through their smartphones and laptops.

The IEEE 802.11 wireless technology standard has come a long way since it first originated from a working group meeting in September 1990. Early Wi-Fi supported data rates of just 2 megabits per second. By comparison, the latest Wi-Fi standard supports 3,500 times faster data rates, ranging up to 7 gigabits per second. *IEEE Spectrum* spoke with Dorothy Stanley, a vice chair of the IEEE 802.11 Working Group and senior standards architect at Aruba Networks, about what to expect from the next generation of Wi-Fi.

This interview has been edited and condensed for clarity.

IEEE Spectrum: How have the goals of the 802.11 Working Group evolved since it first met 25 years ago?

Dorothy Stanley: At a high level, the goal of the group that first met is very similar to the goal of the group we have today, which is to incorporate technology into the 802.11 standard that improves throughput and capacity and capability. And the technology we have to work with today is obviously much more advanced. Standards have gone from rates of 1 to 2 megabits per second—which at the time was very respectable—to 11 Mb/s, then 54 Mb/s, then hundreds of Mb/s and now into the gigabit range. The impact of the technology has exceeded anyone's crystal ball predictions.

IEEE Spectrum: What do you see as the biggest impacts of Wi-Fi on society?

Dorothy Stanley: Today, 802.11 technology is global and it's almost an expected infrastructure utility in many places. I think the generation growing up now and anyone who is 30 years or younger expects Wi-Fi to be there. Since their cell phone data plans are limited, they look for Wi-Fi and they value Wi-Fi.

I think the 802.11 standard is a prime example of how

technology has made it possible for people to access data and information in a very cost-effective way. 802.11 was the first case of making wireless technology effectively available to the masses. Any person could set up a wireless network. They didn't have to get a license, go through an operator, or get someone else to get it done. You empower individuals and corporations to use the technology and experiment with it and improve productivity in a very cost-effective way.

IEEE Spectrum: What can we expect next-generation Wi-Fi standards to deliver?

Dorothy Stanley: The 802.11ad amendment deals with 60 gigahertz wireless operations. The technical challenges of building radios in 60 GHz are much more difficult than in the 2-4 GHz or 5 GHz ranges. Those products are going to be later to market; I expect they'll be more prevalent in 2016, 2017 and beyond. 60 GHz will be another spectrum band that will be available for very low range applications such as those within a room; primarily docking applications and video applications. The current 60 GHz standard provides data rates of up to 7 Gb/s. The next-gen 60 GHz standard, 802.11ay, will go up to 20 Gb/s. You'll get very high throughput.

Another amendment is the 802.11ax amendment for high-

efficiency wireless local area networks. That looks for efficiency in dense deployments such as stadiums, shopping malls, and subways where you have a lot of people accessing the Wi-Fi system.

There is also work going on with the next-generation 802.11az amendment, which is designed for new positioning applications designed to run on wireless networks. It's about more efficient positioning and location finding that can augment GPS for indoor locations.

IEEE Spectrum: Have there been big challenges in the next-generation 802.11ah standard being developed for the Internet of Things (IoT)?

Dorothy Stanley: The Internet of Things is a little different from Internet access applications, because you're not interested so much in high Internet throughput, but you're interested in longer range and higher power efficiency. 802.11ah provides protocols and definitions for operating in the sub-one-gigahertz band (900 megahertz). In the sub-one-gigahertz spectrum, there is much less spectrum available. The spectrum that is available is different in different countries; it's not like the 2.4 gigahertz band where you had virtually all channels available globally. Work is underway with regulators,

particularly in Europe, to get additional spectrum allocated.

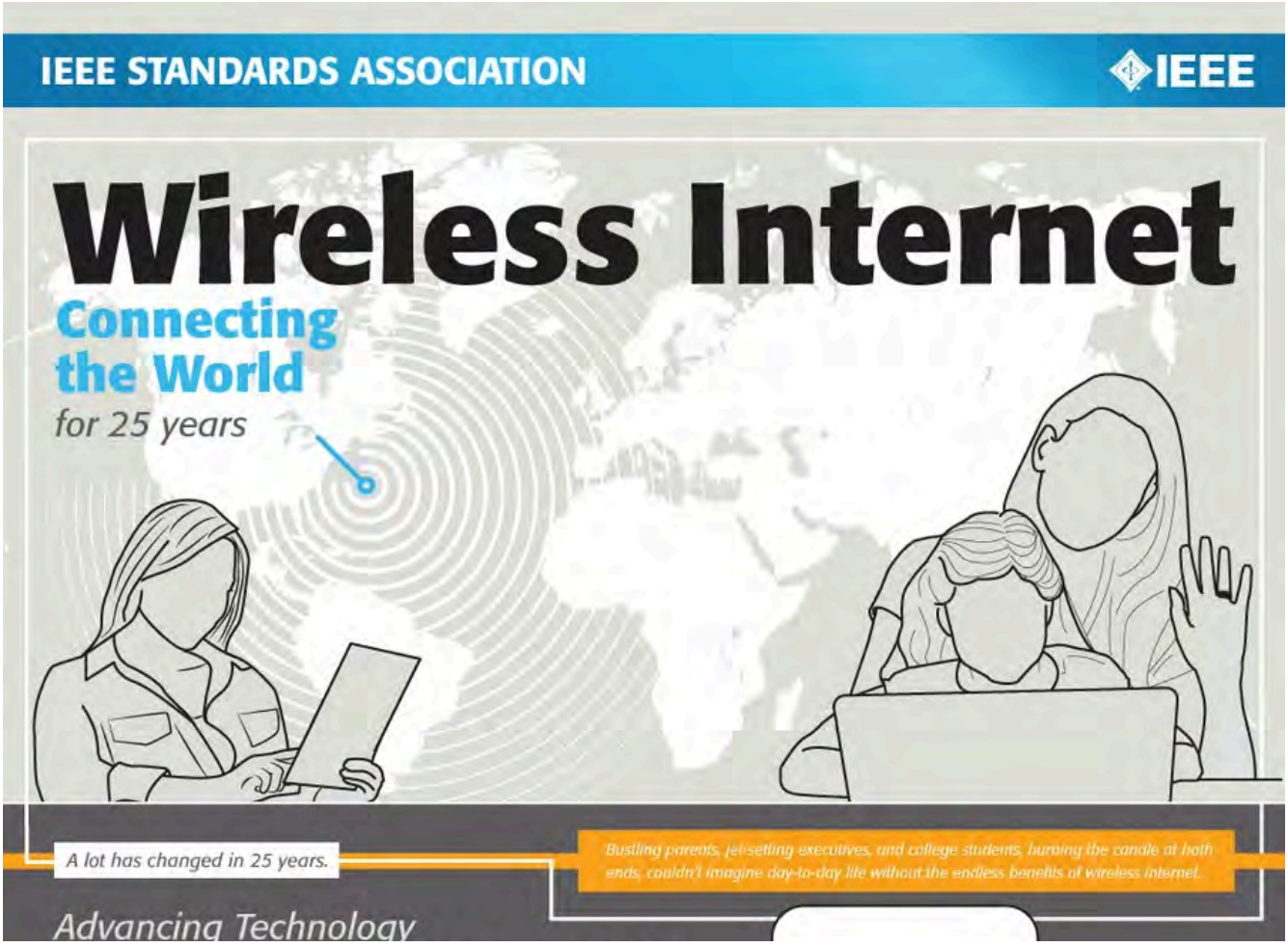
Here, the data rates are in the hundreds of kilobits range rather than in the hundreds of megabits range. But because you're operating at sub-one-gigahertz, the range is longer. The transmission range is up to a kilometer. For most smart grid or Internet of Things applications, a kilometer is more than adequate. A lot of the consumer applications that have been identified as use cases would be 802.11ah-enabled appliances, such as water softeners down in the basement, the furnace, or the lighting around the house.

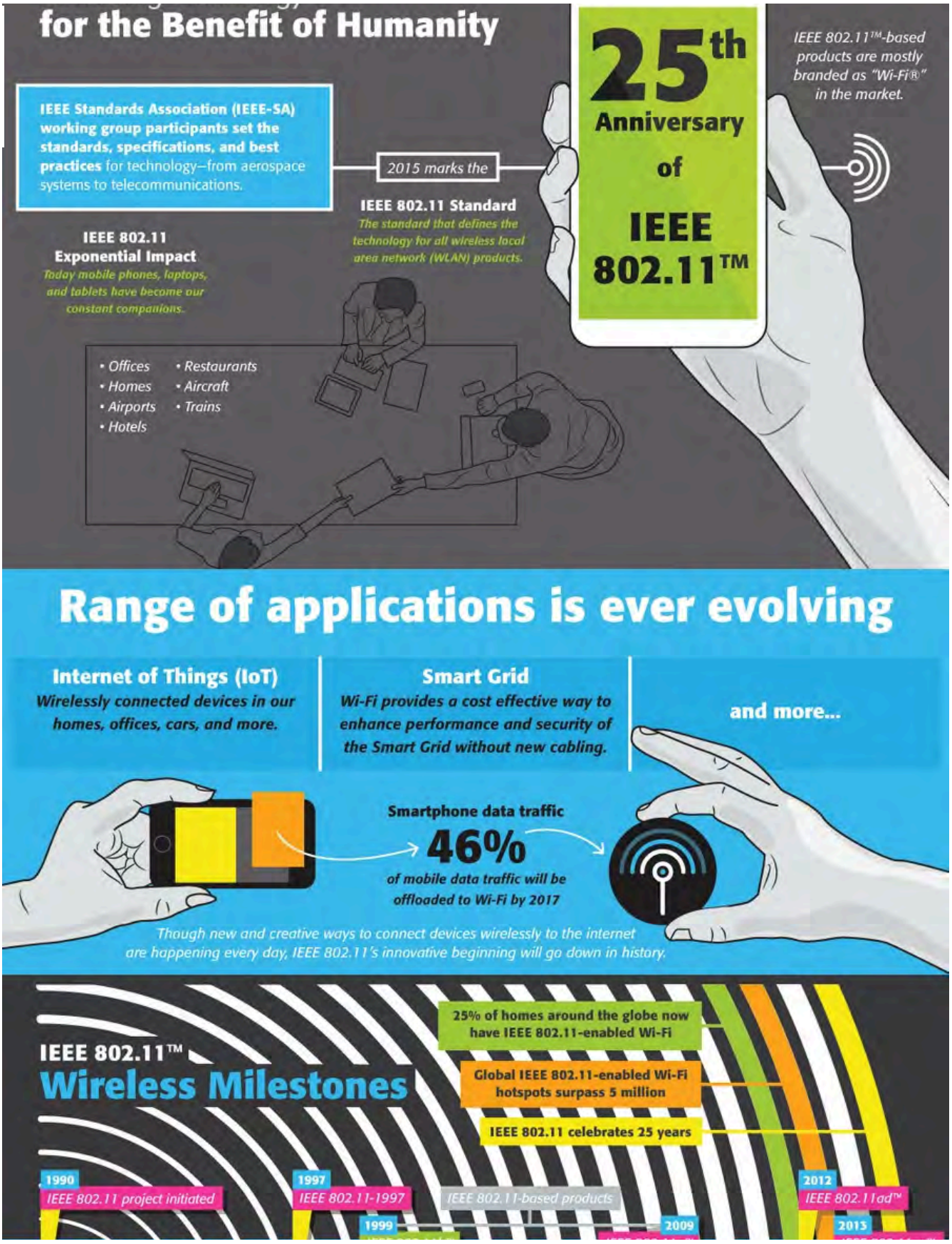
IEEE Spectrum: Why do you think the IEEE 802.11 Working Group process has been successful over the past 25 years? And do you expect the process to continue working well in the future?

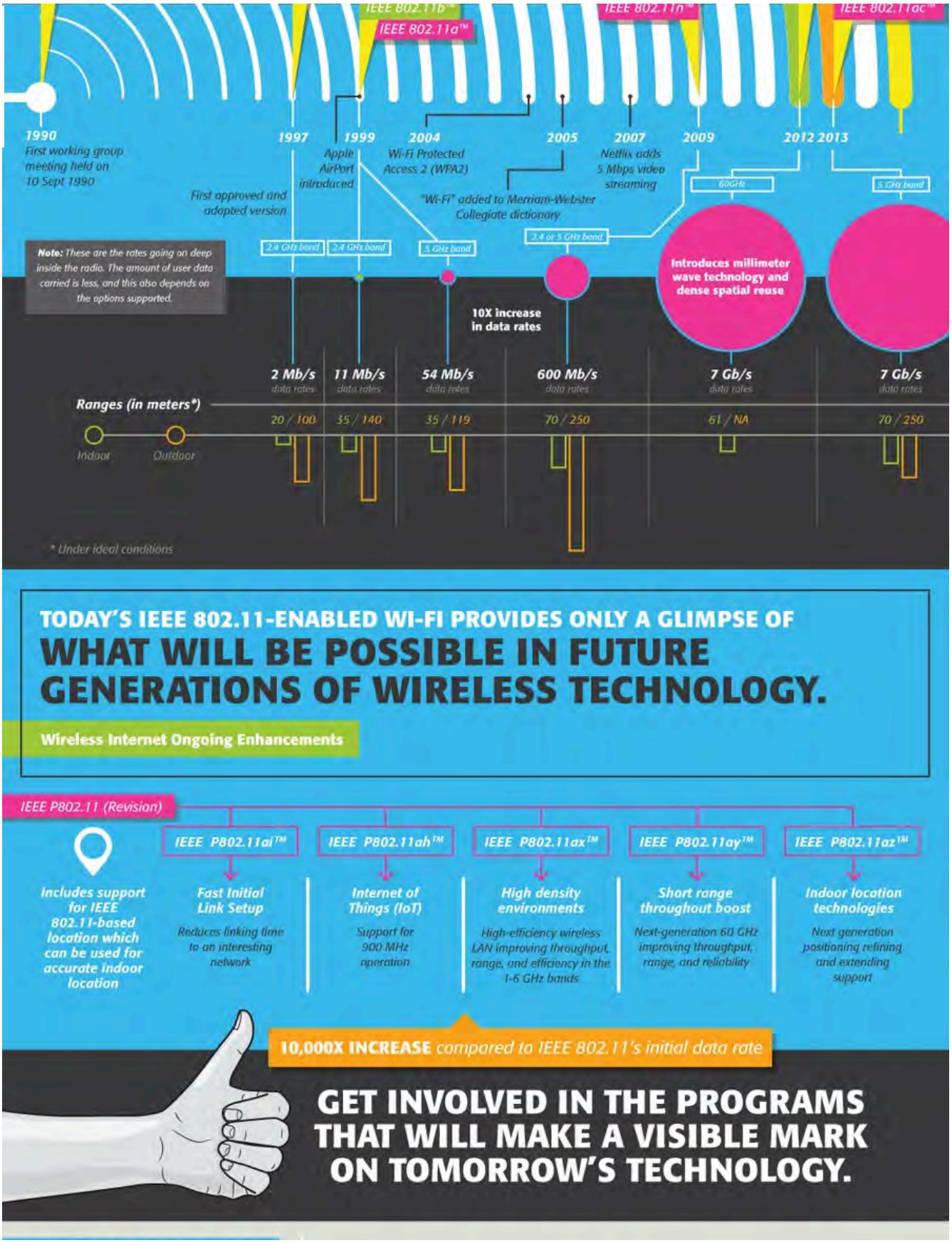
Dorothy Stanley: There is a very open, global and collaborative consensus process in place. The benefit is that you can have any people come who have technology or information to contribute. You don't have to be associated with a government; people come from new companies, established companies and academia to provide contributions. The success of the 802.11 standard is really due to not just the folks who developed the standard, but also due to the engineers in all the companies who built products based on the standard, and to

companies who built products based on the standard, and to the customers who bought those products.

It's not just companies supporting us in going to the Wi-Fi standard, but also end consumers and the world in general accessing the Internet. My kids and the college generation expect Wi-Fi to be there. Our goal is to make sure the 802.11 standards are there in the future to provide an efficient technology that people can use and improve their lives with.




for the Benefit of Humanity
IEEE Standards Association (IEEE-SA) working group participants set the standards, specifications, and best practices for technology—from aerospace systems to telecommunications.
2015 marks the
IEEE 802.11 Standard
The standard that defines the technology for all wireless local area network (WLAN) products.
25th Anniversary of IEEE 802.11™
IEEE 802.11™-based products are mostly branded as "Wi-Fi®" in the market.
IEEE 802.11 Exponential Impact
Today mobile phones, laptops, and tablets have become our constant companions.
• Offices
• Homes
• Airports
• Hotels
• Restaurants
• Aircraft
• Trains
Range of applications is ever evolving
Internet of Things (IoT)
Wirelessly connected devices in our homes, offices, cars, and more.
Smart Grid
Wi-Fi provides a cost effective way to enhance performance and security of the Smart Grid without new cabling.
and more...
Smartphone data traffic
46%
of mobile data traffic will be offloaded to Wi-Fi by 2017
Though new and creative ways to connect devices wirelessly to the internet are happening every day, IEEE 802.11's innovative beginning will go down in history.
IEEE 802.11™
Wireless Milestones
25% of homes around the globe now have IEEE 802.11-enabled Wi-Fi
Global IEEE 802.11-enabled Wi-Fi hotspots surpass 5 million
IEEE 802.11 celebrates 25 years
1990
IEEE 802.11 project initiated
1997
IEEE 802.11-1997
1999
IEEE 802.11-based products
2009
2012
IEEE 802.11ad™
2013


IEEE 802.11b™
IEEE 802.11a™
IEEE 802.11n™
IEEE 802.11ac™
1990
First working group meeting held on 10 Sept 1990
1997
First approved and adopted version
1999
Apple AirPort introduced
2004
Wi-Fi Protected Access 2 (WPA2)
2005
"Wi-Fi" added to Merriam-Webster Collegiate dictionary
2007
Netflix adds 5 Mbps video streaming
2009
2012
2013
60GHz
5 GHz band
2.4 GHz band
2.4 GHz band
5 GHz band
2.4 or 5 GHz band
Note: These are the rates going on deep inside the radio. The amount of user data carried is less, and this also depends on the options supported.
10X increase in data rates
Introduces millimeter wave technology and dense spatial reuse
2 Mb/s data rates
11 Mb/s data rates
54 Mb/s data rates
600 Mb/s data rates
7 Gb/s data rates
7 Gb/s data rates
Ranges (in meters*)
20 / 100
35 / 140
35 / 119
70 / 250
61 / NA
70 / 250
Indoor
Outdoor
* Under ideal conditions
TODAY'S IEEE 802.11-ENABLED WI-FI PROVIDES ONLY A GLIMPSE OF
WHAT WILL BE POSSIBLE IN FUTURE GENERATIONS OF WIRELESS TECHNOLOGY.
Wireless Internet Ongoing Enhancements
IEEE P802.11 (Revision)
IEEE P802.11ai™
IEEE P802.11ah™
IEEE P802.11ax™
IEEE P802.11ay™
IEEE P802.11az™
Includes support for IEEE 802.11-based location which can be used for accurate indoor location
Fast Initial Link Setup
Reduces linking time to an interesting network
Internet of Things (IoT)
Support for 900 MHz operation
High density environments
High-efficiency wireless LAN improving throughput, range, and efficiency in the 1-6 GHz bands
Short range throughout boost
Next-generation 60 GHz improving throughput, range, and reliability
Indoor location technologies
Next generation positioning refining and extending support
10,000X INCREASE compared to IEEE 802.11's initial data rate
GET INVOLVED IN THE PROGRAMS THAT WILL MAKE A VISIBLE MARK ON TOMORROW'S TECHNOLOGY.



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open-stand.org | searchnetworking.techtarget.com | standards.ieee.org | wi-fi.org

APPENDIX M

ACCEPTED FROM OPEN CALL

IEEE 802.11AX: HIGH-EFFICIENCY WLANS

BORIS BELLALTA

ABSTRACT

IEEE 802.11ax-2019 will replace both IEEE 802.11n-2009 and IEEE 802.11ac-2013 as the next high-throughput WLAN amendment. In this article, we review the expected future WLAN scenarios and use cases that justify the push for a new PHY/MAC IEEE 802.11 amendment. After that, we overview a set of new technical features that may be included in the IEEE 802.11ax-2019 amendment, and describe both their advantages and drawbacks. Finally, we discuss some of the network-level functionalities that are required to fully improve the user experience in next-generation WLANs and note their relation with other ongoing IEEE 802.11 amendments.

INTRODUCTION

IEEE 802.11 wireless local area networks (WLANs) [1] are a cost-efficient solution for wireless Internet access that can satisfy most current communication requirements in domestic, public, and business scenarios.

Similar to other wireless technologies, WLANs have evolved by integrating the latest technological advances in the field as soon as they have become sufficiently mature, aiming to continuously improve spectrum utilization and raw WLAN performance. IEEE 802.11n-2009 adopted single-user multiple-input multiple-output (SU-MIMO), channel bonding, and packet aggregation. Those mechanisms were further extended in IEEE 802.11ac-2013, which also introduced downlink multi-user (MU) MIMO transmissions. In addition, new amendments such as IEEE 802.11af-2013 and IEEE 802.11ah-2016 are further expanding the application scenarios of WLANs, which include cognitive radio, long-range communication, advanced power saving mechanisms, and support for machine-to-machine (M2M) devices.

Partly because of their own success, next-generation WLANs face two main challenges. First, they must address dense scenarios, which is motivated by the continuous deployment of new access points (APs) to cover new areas and provide higher transmission rates. Second, the current evolution of Internet usage toward real-time high-definition audio and video content will also significantly increase users' throughput needs in the coming years.

To address those challenges, the High-Efficiency WLAN (HEW) Task Group [2] is currently working on a new high-throughput amendment named IEEE 802.11ax-2019. This new amendment will develop new physical (PHY) and medium access control (MAC) layer enhancements to further improve the WLAN performance, with a focus on the throughput and battery duration. This article overviews some of those new enhancements, and describes the potential benefits and drawbacks of each one. We have grouped these enhancements into four main categories: spatial reuse, temporal efficiency, spectrum sharing, and multiple-antenna technologies. Moreover, we also discuss several key system-level improvements for next-generation WLANs, as in addition to the IEEE 802.11ax-2019 amendment, they will likely implement other in-progress amendments such as IEEE 802.11aq-2016 (pre-association discovery of services), IEEE 802.11ak-2017 (bridged networks), and IEEE 802.11ai-2016 (fast initial link setup time) to satisfy the created expectations.

SCENARIOS, USE CASES, AND REQUIREMENTS

The forecast number of devices and networks, and traffic characteristics and user demands for the 2020–2030 decade motivate the development of a new PHY/MAC IEEE 802.11 amendment to cope with the new challenges and usages WLANs will face [2].

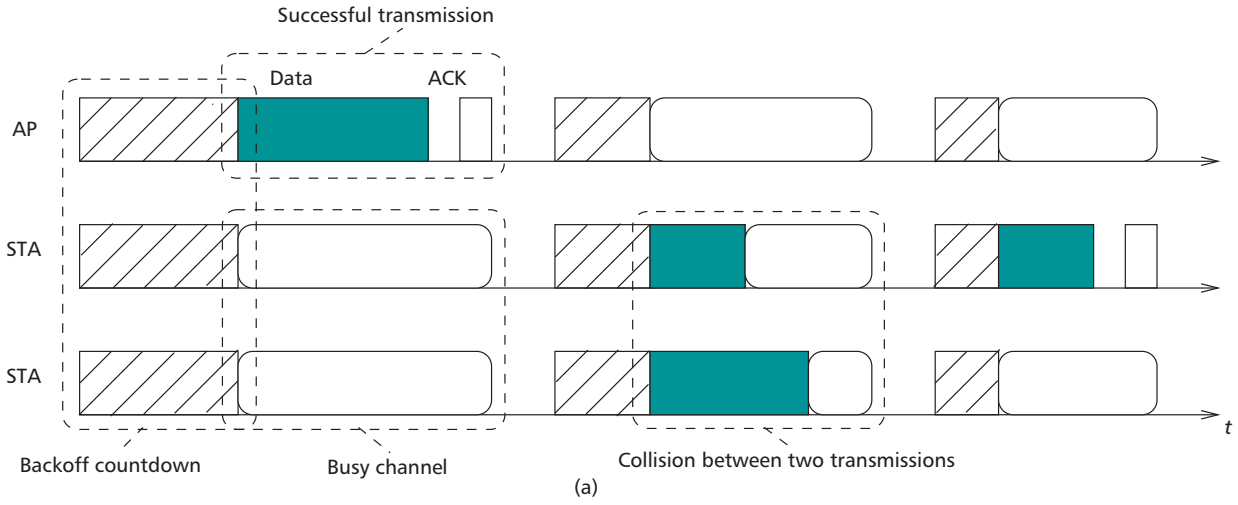
One of the most representative characteristics of WLANs is the use of carrier sense multiple access with collision avoidance (CSMA/CA) as the MAC protocol. It offers a reasonable trade-off between performance, robustness, and implementation costs. Using CSMA/CA, when a node has a packet ready for transmission, it listens to the channel. Once the channel has been detected as free (i.e., the energy level on the channel is lower than the clear channel assessment, CCA, threshold), the node starts the backoff procedure by selecting a random initial value for the backoff counter. The node then starts decreasing the backoff counter while sensing the channel. Whenever a transmission, either from other nodes within the same WLAN or belonging to other WLANs, is detected on the channel, the backoff counter is paused until the channel is detected to be free again, at which point the countdown is resumed. When the backoff counter reaches zero, the node starts transmitting. Figure 1a shows an example of CSMA/CA operation.

DENSE WLAN SCENARIOS

Providing high data rates in scenarios where the density of WLAN users is very high (e.g., 1 user/m^2) requires the deployment of many APs

The author is with Universitat Pompeu Fabra, Barcelona

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Scenario (area, m²)	APs	STAs	Description
Stadium (~12,500 m²)	> 1000	> 50,000	Large events that require many APs to provide a satisfactory connectivity service able to support video uploading/downloading.
Train (~600 m²)	< 10	> 1000	Full coverage inside a train to provide both work and entertainment services.
Apartment building — 4 floors, 6 apartments/ floor (~2400 m ²)	> 120	< 480	Several short-range APs deployed in each apartment, offering full coverage and high data rates for bandwidth hungry entertainment applications, as well as connectivity for house appliances. Community APs may also be deployed in the corridors and shared spaces.

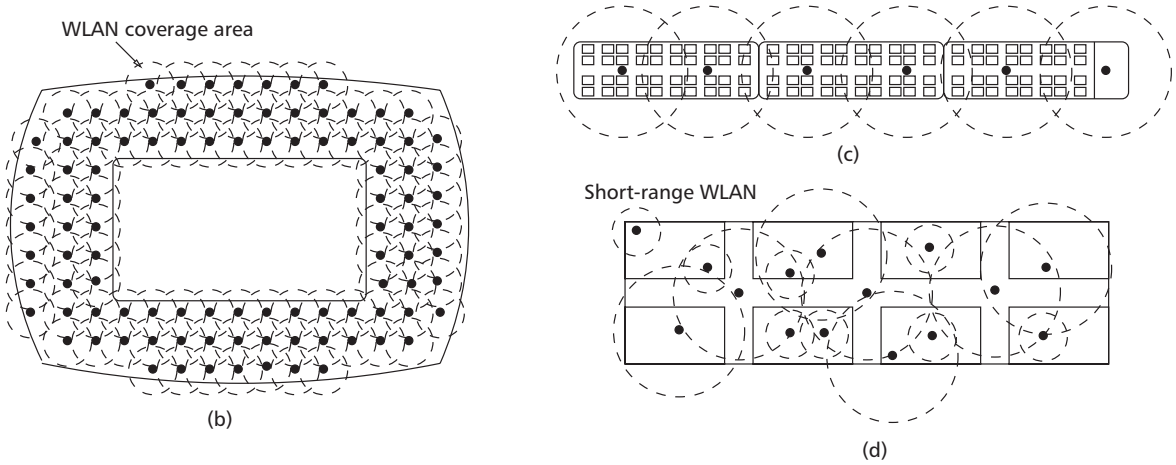


Figure 1. Key scenarios in next-generation WLANs: a) example of CSMA/CA temporal evolution with one AP and two STAs; b) stadium; c) train; d) floor of a building with several apartments.

placed close to each other (e.g., within 5–10 m of one another). Figure 1 depicts and describes three of those scenarios: a stadium, a train, and an apartment building. In these dense scenarios, most relevant challenges are related to interference issues, which increase the packet error rate and reduce the number of concurrent transmissions in a given area by preventing neighboring WLANs from accessing the channel. Additionally, the presence of many stations (STAs) in the same area increases the chances that the backoff counters of two or more STAs reach zero simultaneously, which results in a collision.

In the stadium scenario, many people are concentrated in small areas because of a fair, a conference, or a sporting event. The presence of many people results in a high density of STAs and the necessity of deploying many APs to offer satisfactory service. A fundamental challenge in these scenarios is to deploy, optimize, and coordinate such a large number of APs and STAs.

Public transport is also a key scenario for next-generation WLANs because trains, buses, and planes will offer broadband Internet access. In these scenarios, the user density may be notably high, with several people per square meter. Then smart AP coordination can help improve spatial reuse, and the use of an efficient medium

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Interactive and high-definition video applications are predicted to dominate future Internet usage. Two examples of applications that require throughputs of several gigabits per second are high-definition multi-party video conferences in business environments, and virtual reality entertainment applications at home, which include culture, films, and games.

access protocol may help support many simultaneous contenders.

Finally, in an apartment building, we can find multiple autonomous and heterogeneous WLANs overlapping, including short-range WLANs that offer high transmission rates in small spaces [3]. In this scenario, each WLAN is primarily configured independent of the others, where the channel selection, channel width, and transmission power are randomly set or are simply the preset values. Therefore, autonomous WLANs must be able to implement smart decentralized self-configuration and self-adaptation mechanisms to minimize the interference among them.

WLANs must also coexist with other wireless networks that operate in the industrial, scientific, and medical (ISM) band, such as wireless sensor networks and personal area networks. In addition, Long Term Evolution (LTE) operators are currently considering deploying LTE networks in the ISM band [4], which is known as LTE-Unlicensed, thus opening further coexistence challenges for WLANs.

Future WLAN Usages

Interactive and high-definition video applications are predicted to dominate future Internet usage. Two examples of applications that require throughputs of several gigabits per second are high-definition multi-party video conferences in business environments, which can help avoid unnecessary travel and meetings, and virtual reality entertainment applications at home, which include culture, films, and games. Additionally, web surfing is moving further toward a multimedia experience, where rich text, images, audio, and video content interact. Furthermore, file storage, management, and synchronization in the cloud are becoming the standard in terms of content management and generation. Those applications are bandwidth-demanding, and require both reliability and limited delay.

Requirements

Based on the aforementioned scenarios and expected use cases, there are four key requirements for the IEEE 802.11ax-2019 amendment.

Coexistence: WLANs operate as unlicensed devices in the ISM bands. Therefore, the IEEE 802.11ax-2019 amendment has to include the required mechanisms to coexist with both the other wireless networks that operate there and the licensed devices.

Higher Throughput: Improving both the system and user throughput requires the improved use of channel resources. IEEE 802.11ax-2019 aims for a four-fold throughput increase compared to IEEE 802.11ac-2013. To achieve this goal, some new wireless technologies such as dynamic CCA, OFDMA (orthogonal frequency-division multiple access), and advanced multiple-antenna techniques may be used.

Energy Efficiency: The target in IEEE 802.11ax-2019 is, at least, to not consume more energy than the previous amendments, considering the aforementioned four-fold throughput increase, which requires both new low-power hardware architectures [5] and new low-power PHY/MAC functionalities.

Backward Compatibility: Because WLANs implementing IEEE 802.11ax-2019 must also support devices using any previous IEEE 802.11 PHY/MAC amendments, mechanisms must also be implemented to make it backward compatible (i.e., common frame headers and transmission rates), although it is a clear source of inefficiency.

New Features and Concepts

The IEEE 802.11ax-2019 amendment may include some new technical features compared to the IEEE 802.11ac-2013 amendment. We introduce them in this section, providing insight into their potential performance gains and limitations. All numerical results presented in this section are obtained using the analytical model and parameters from [6], unless otherwise stated.

Spatial Reuse

In dense scenarios, the combined use of CSMA/CA, a conservative CCA, and a high transmit power level may result in scenarios with limited spatial reuse. A conservative configuration of both the CCA and transmit power levels minimizes the interference among the WLANs, which supports higher transmission rates. However, the number of concurrent transmissions is reduced, which may decrease the achievable area throughput. The alternatives that can be used to reach an optimal trade-off between individual transmission rates and the number of concurrent transmissions that maximize the area throughput include dynamically adapting the transmit power level, the CCA level, and the use of directional transmissions based on the observed network performance.

Figure 2a shows three neighboring WLANs. The channels that each WLAN uses are shown in Fig. 2b. Because WLANs A and C, and B and C partially share their channels, they overlap. The three APs are inside the carrier sense range of the others, as shown in Fig. 2a, which pauses their backoff if either of the other two transmits. Although WLAN C uses the widest channel, it achieves the lowest throughput because it overlaps with WLANs A and B, which are independent of each other (Fig. 2c).

Dynamic Adaptation of the Transmit Power and CCA Levels: Reducing the used transmission power in a WLAN reduces its influence area, which benefits the spatial reuse. However, it may result in a larger number of packet errors and lower transmission rates, as well as an increased number of hidden nodes.

Alternatively, to reduce the area of influence of neighboring WLANs and increase each WLAN's chances to transmit, the nodes in a WLAN may increase their CCA level, hence requiring a higher energy level in the channel to consider it as occupied and pause the backoff countdown. In [7], significant throughput gains are achieved by tuning the CCA level in a multicell WLAN scenario. The downside of increasing the CCA level is again the higher interference that a node may suffer, which could be detrimental in some cases.

Beamforming: Omnidirectional transmissions homogeneously spread the transmitted energy in all directions, which fills the channel with energy

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in areas where it is not required. Concentrating the energy toward the desired destination improves the spatial reuse because the devices that are placed in other directions will observe the channel as being empty and, therefore start their own transmissions concurrently. However, similar to the previous case, those nodes outside the energy beam may also become hidden nodes.

Temporal Efficiency

The backoff countdown, packet headers, interframe spaces, collisions, and retransmissions are an intrinsic part of the CSMA/CA channel access scheme, but they significantly decrease the effective time that a node spends transmitting data every time it accesses the channel. IEEE 802.11ax-2019 may include several solutions to mitigate such overheads.

Control Packets: The time consumed by the exchange of control packets may result in large overheads, particularly because they are usually transmitted at a low rate. Common control packet exchanges between the AP and STAs include the request to send/clear to send (RTS/CTS) exchange to avoid hidden nodes and ACKs to acknowledge the reception of data packets.

Additionally, some of the new technical features described in the next sections that enable multi-user transmissions may require frequent exchange of control packets to synchronize all involved STAs, hence also increasing the control packets' overheads.

Packet Headers, Aggregation, and Piggy-Backing: Packet aggregation was introduced in IEEE 802.11n-2009 to reduce temporal overheads by combining short packets into a longer one. Using packet aggregation, multiple packets can be transmitted with a single backoff, distributed inter-frame space (DIFS), short inter-frame space (SIFS), PHY header, and ACK.

The packet header overheads can be reduced by supporting variable size headers and using only the minimum required fields for every packet. Additionally, the use of shorter identifiers instead of the full MAC address is considered.

Moreover, the piggybacking of ACKs with DATA will improve the efficiency, although some changes in the current setting of the network allocation vector (NAV) are required because the full transmission duration is unknown to the transmission initiator.

Efficient Retransmissions: Packet errors are also a source of overhead because they currently require full retransmission of the data packet. Further work about the use of incremental redundancy-based automatic repeat requests (ARQs) can reduce the time spent in retransmissions, although it implies some extra complexity in both transmitter and receiver firmware.

Simultaneous Transmit and Receive: By allowing the AP and a STA to simultaneously transmit and receive (STR), which is commonly known as full-duplex communication, the channel capacity can be theoretically doubled [8]. Using CSMA/CA, the only way they can have full-duplex communication is if they finish their backoff countdown simultaneously. Otherwise, one will start transmitting before the other, causing the latter to pause its backoff until the former finishes its transmission. Only when the number of active STAs is low do they have bidirectional and saturated traffic flows, and use a small backoff contention window; here, the use of STR can result in significant gains. Therefore, specific channel access mechanisms should be considered in the IEEE 802.11ax-2019 amendment in case the STR capability is finally considered. Alternatively, the STR capability can allow WLANs to replace the CA feature of CSMA/CA with collision detection (CD), because collisions can be promptly detected and resolved.

Collision-Free MAC Protocols: Collisions represent an important waste of channel resources

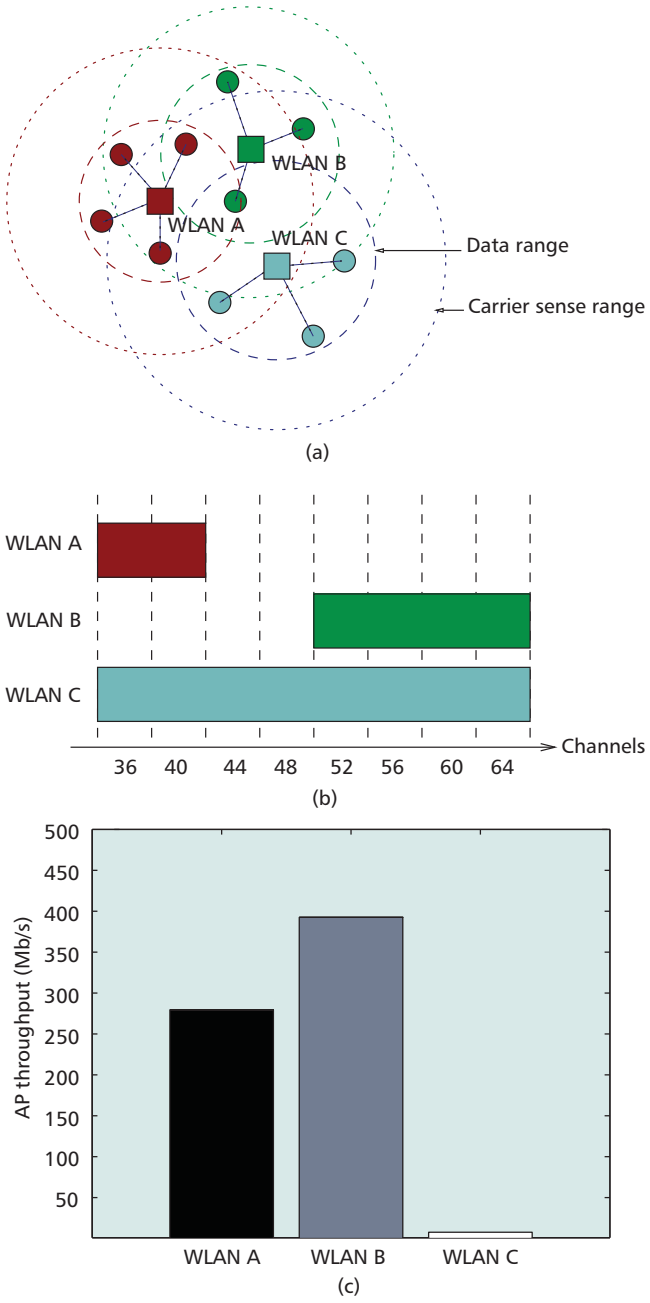


Figure 2. Throughput unfairness between overlapping WLANs: a) three overlapping WLANs; b) channel used by each WLAN; c) throughput achieved by each WLAN.

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An unplanned deployment of WLANs results in chaotic and fragmented spectrum occupancy, which causes many inefficiencies and undesirable interactions among neighboring WLANs. To improve the spectrum usage efficiency, two main approaches can be considered in IEEE 802.11ax-2019: dynamic channel bonding and OFDMA.

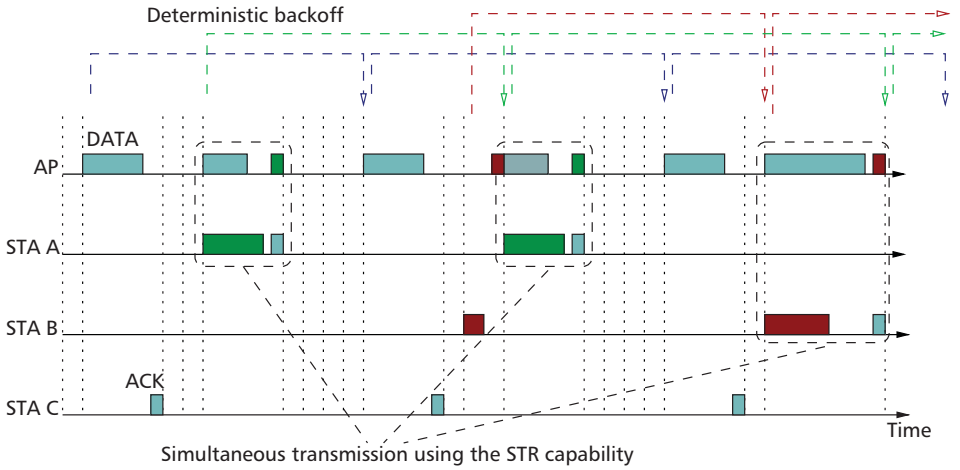


Figure 3. CSMA/ECA operation. It can be observed how the use of a deterministic backoff allows prediction of when a node will transmit again after successful transmission.

in WLANs. IEEE 802.11ax-2019 may consider enhancing or changing the underlying CSMA/CA protocol to minimize collisions. There are two possibilities: moving to a centralized solution or enhancing the current CSMA/CA protocol. Because centralized options such as hybrid coordination function controlled channel access (HCCA) were never adopted in WLANs, a focus on enhancing CSMA/CA appears more plausible. CSMA with enhanced CA (CSMA/ECA) is a particularly good candidate to replace CSMA/CA because it is backward compatible, is easily implemented, and outperforms CSMA/CA in all cases [9].

Figure 3 shows the basic operation of CSMA/ECA with STR. Compared to CSMA/CA, the main difference observed for CSMA/ECA is its use of a deterministic backoff after successful transmissions. This deterministic backoff guarantees that after some time, a collision-free schedule can be achieved. In addition, because the AP can learn when the STAs will transmit, the use of STR can provide huge performance gains.

Spectrum Sharing

An unplanned deployment of WLANs results in a chaotic and fragmented spectrum occupancy, which causes many inefficiencies and undesirable interactions among neighboring WLANs [6]. To improve the spectrum usage efficiency, two main approaches can be considered in IEEE 802.11ax-2019: dynamic channel bonding and OFDMA.

Dynamic Channel Bonding: To adapt to the instantaneous channel occupancy, IEEE 802.11ax-2019 may consider extending the dynamic bandwidth channel access (DBCA) scheme introduced in the IEEE 802.11ac-2013 amendment [10]. Using DBCA, only the available channel width is used at each transmission, which allows WLANs to adapt to the instantaneous spectrum occupancy. This mechanism helps fill most spectrum gaps and share them fairly among neighboring WLANs.

OFDMA: The use of orthogonal frequency-division multiple access (OFDMA) adds a new degree of flexibility to the use of spectrum resources by dividing the channel width into multiple narrow channels. Then these narrow channels can be used to transmit to multiple users in parallel [11]. A basic implementation of OFDMA in WLANs may simply consider the use of multiple independent 20 MHz channels. This approach is shown in Fig. 4: when channel bonding is used, each 20 MHz subchannel can be independently allocated to a different user. The RTS packet has been extended to announce the subchannels allocation to the STAs. Additionally, OFDMA may enable the use of non-contiguous channel bonding and remove the requirement to use only 20 MHz consecutive channels.

Figure 4a shows an example where dynamic channel bonding and OFDMA operate together. The upper part of Fig. 4a shows a snapshot of the spectrum occupancy for a group of neighboring WLANs. The lower part of Fig. 4a shows two transmissions: a node in the target WLAN transmits to a single user via a bonded channel of 40 MHz (left), and a node uses a bonded channel of 80 MHz and OFDMA to transmit to three different users (right). Figure 4b shows the AP throughput when OFDMA is used to split a 160 MHz channel into multiple subchannels. The parallelization of temporal overheads clearly improves the throughput.

Multiple Antennas

Spatial multiplexing using multiple antennas at both APs and STAs remains one of the key technologies to achieve high throughput in WLANs. IEEE 802.11ax-2019 will continue implementing both SU-MIMO and downlink MU-MIMO, as in IEEE 802.11ac-2013. However, it may also include or provide support for uplink MU-MIMO, massive MIMO, and network MIMO, as well as distributed antenna solutions.

Multi-User MIMO: Multi-user MIMO enables multiple simultaneous transmissions to different STAs from the AP in the downlink, and from multiple STAs to the AP in the uplink. A survey of MU-MIMO MAC protocols for WLANs is presented in [12], where the challenges and requirements to design an MU-MIMO MAC

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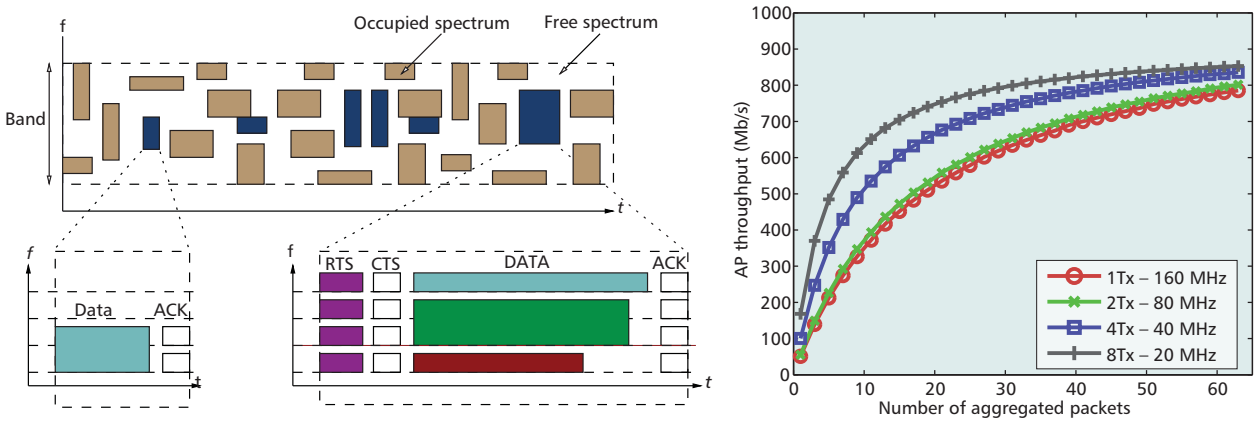


Figure 4. Dynamic spectrum access with and without OFDMA: a) dynamic channel bonding and OFDMA; b) achievable downlink throughput using a channel width of 160 MHz and OFDMA. The RTS size is $120 + 56 \cdot N_{tx}$ bits, with N_{tx} the number of OFDMA subchannels.

protocol are introduced, and several uplink and downlink MAC proposals are reviewed.

In the downlink, a challenge for IEEE 802.11ax-2019 is to reduce the channel sounding overheads given the same explicit approach as in IEEE 802.11ac-2013 is considered. The overhead caused by the explicit channel sounding protocol implemented depends on the channel sounding rate and number of sounded STAs, which can result in an unacceptable overhead in scenarios with many STAs. Solutions to reduce such a large overhead, apart from replacing the current channel sounding protocol with a more efficient solution, will require the use of smart schedulers that consider the current traffic patterns and the quality of service (QoS) demands of users to decide when the channel state information (CSI) has to be requested, and from which STAs.

To support MU-MIMO transmissions in the uplink, IEEE 802.11ax-2019 must also detail how the uplink CSI from each STA is obtained by the AP, introduce a mechanism to signal a group of STAs to simultaneously start a transmission, and include techniques to overcome channel calibration and timing issues in order to efficiently decode all the simultaneously received packets at the AP.

In both cases, using the collected CSI, the AP has to select the specific STAs that will take part in the next MU-MIMO transmission. Therefore, the design of an efficient mechanism to create groups of STAs with low spatial channel correlation and similar channel quality is still an open challenge. Failing to properly create those groups may prevent next-generation WLANs from fully benefiting from MU-MIMO technology.

Figure 5a shows an AP with three STAs. On the left, we have three downlink MU-MIMO transmissions. The ones directed to STAs A, B, and C contain four, two, and one SU-MIMO spatial streams, respectively. To start a downlink transmission, the AP omnidirectionally sends the PHY header with information about the group of selected STAs and the number of spatial streams that are transmitted to each STA in SU-MIMO mode. On the right, we show an uplink MU-MIMO transmission. In IEEE 802.11ax-2019, because several STAs are unlikely to finish their backoff countdowns at the same time, uplink MU-MIMO transmissions may be started by the AP using a special RTS″ packet containing information about the STAs that can transmit in parallel. Then the selected STAs will simply start transmitting at the same time and wait to receive the corresponding ACKs. This approach allows all selected STAs to be synchronized, but requires knowledge of the STAs's buffer occupancy by the AP, which can be provided by the same STAs as in previous transmissions. Figure 5b shows the throughput achieved by the AP in two downlink MU-MIMO configurations (cases 16:4:4 and 16:16:1). The obtained throughput values are compared with the case where a single spatial stream is transmitted to only one destination (case 1:1:1).

Massive MIMO: Massive MIMO refers to the case where the AP has many more antennas than STAs and uses them to create a nearly identical number of point-to-point links as the number of active STAs [13]. In addition to the cost of APs, the extra processing complexity, and higher energy consumption, other open challenges for massive MIMO include obtaining the CSI information; WLANs may require switching to an implicit channel feedback approach.

Network MIMO: In coordinated WLAN deployments, network MIMO can be used to minimize the interference among simultaneous transmissions from different APs. The idea behind network MIMO is that different APs can coordinate the transmissions as if they were a large array of antennas, which reduces the inter-transmission interference and increases the spatial reuse [14]. However, effectively solving the tight synchronization requirements among the APs remains an open challenge.

WLAN-Level Improvements

The user experience in next-generation WLANs will not be simply enhanced by increasing the achievable network and user throughput as previous technical features do. To achieve that goal, apart from the IEEE 802.11ax-2019 amendment, there are other IEEE 802.11 amendments in progress. Figure 6 shows the most significant ones, including the new features they are targeting.

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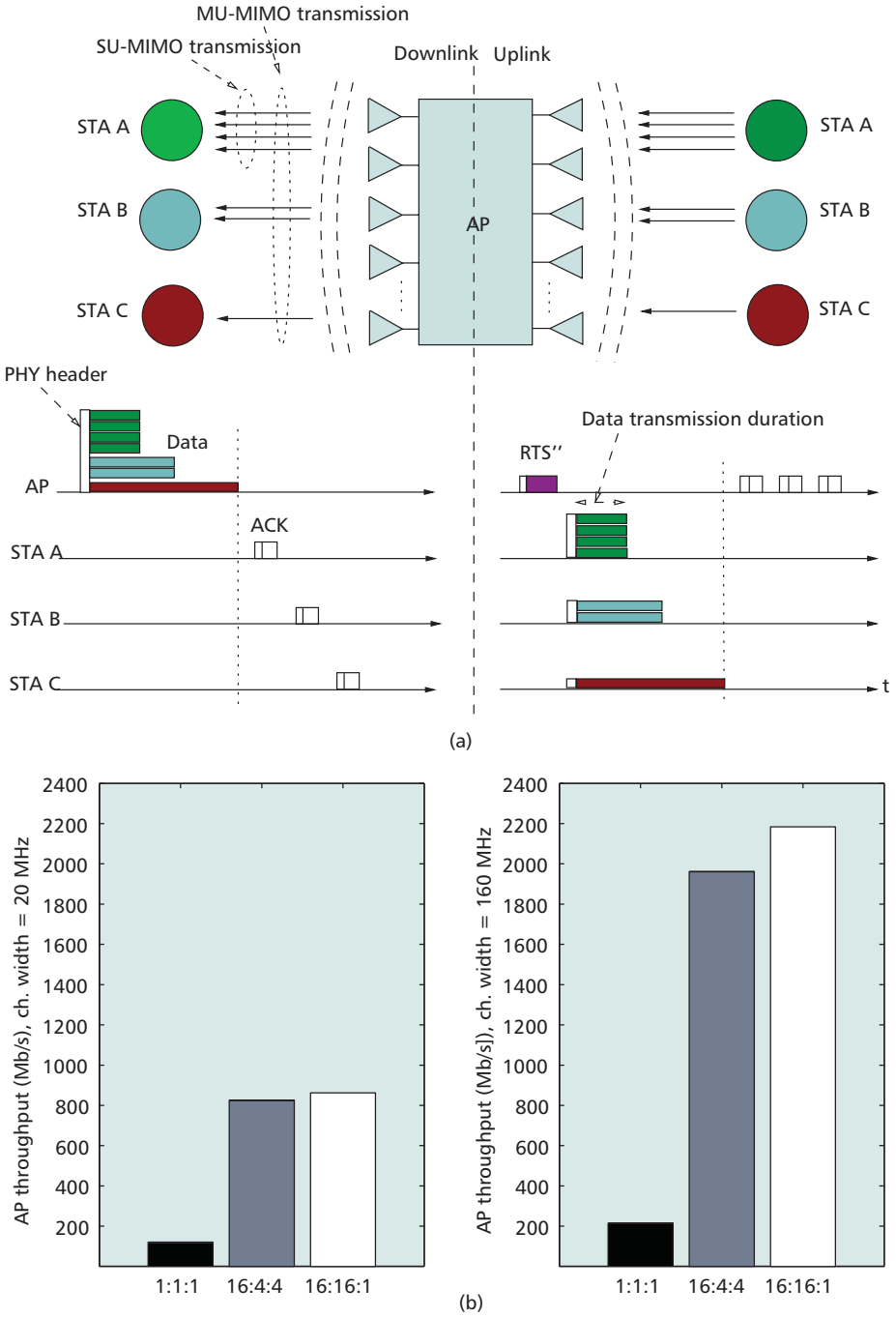
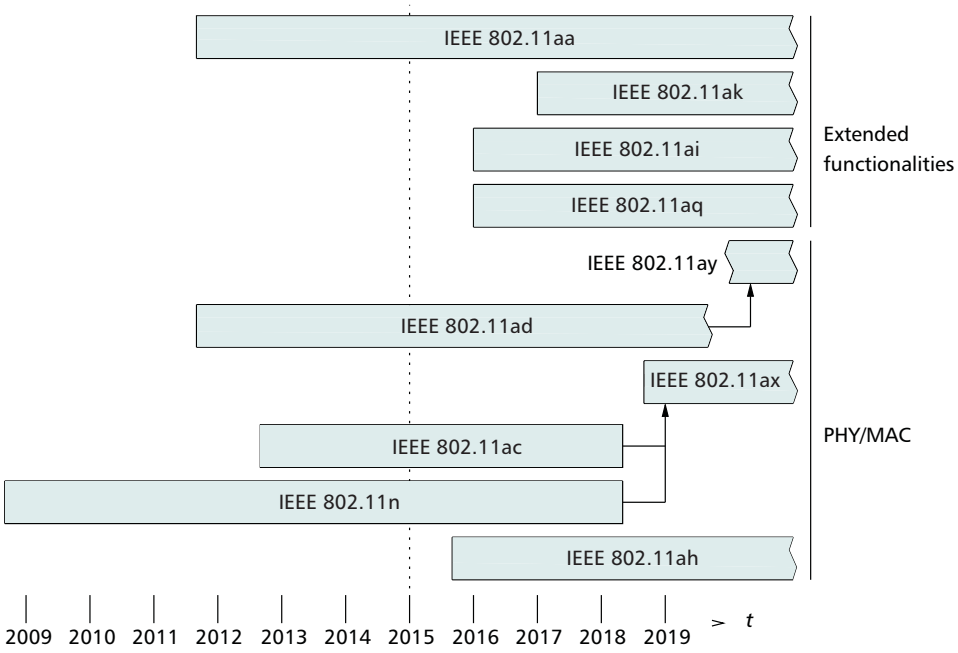


Figure 5. Multi-user spatial multiplexing: a) downlink and uplink MU-MIMO transmissions in WLANs; b) downlink throughput. The AP is equipped with 16 antennas. Each configuration is identified by the code x:y:z, where x refers to the total number of transmitted spatial streams, y the number of destinations, and z the number of streams transmitted to each destination.

In scenarios where multiple APs are used to offer a large coverage area and higher data rates by deploying multiple WLANs nearby, a mechanism that enables fast handoff among the APs is required because the current large delays when a STA switches to a new AP are unacceptable. The IEEE 802.11ai-2016 amendment targets this challenge. It aims to provide a handoff duration below 100 ms by implementing preemptive channel sensing and user authentication. Alternatives based on network virtualization and software defined networks are also an interesting option as they are able to centralize all decisions, including the handoff between overlapping APs. Future IEEE amendments will probably consider such an approach.

Device-to-device (D2D) communications, which are also known as WiFi Direct in the IEEE WLAN context, will also be a key element in next-generation WLANs [15]. Examples of D2D communications are file synchronization

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Feature	Amendment	Objective
Fast handoff between APs	IEEE 802.11ai-2016	Handoff duration below 100 ms by implementing preemptive channel sensing and user authentication.
D2D/WiFi Direct	WiFi Alliance feature	STAs with D2D capability can decide to create their own WLAN to communicate directly.
Multi-technology APs and bridging capabilities	IEEE 802.11ak-2017	Interconnection of multiple WLANs.
Video traffic differentiation	IEEE 8v02.11aa-2012	Stream prioritization and groupcast mechanisms.
AP/service selection	IEEE 802.11aq-2018	APs provide pre-association information about the services offered to help STAs to choose between multiple APs

Figure 6. Upcoming IEEE 802.11 amendments.

The use of D2D communications will reduce the amount of airtime required for each transmission by allowing higher data rates and avoiding the use of the AP as a relay. Beamforming is an interesting feature for D2D communication because it may allow concurrent transmissions inside the same WLAN by different groups of nodes.

IEEE 802.11ax-2019 aims to operate in the 2.4 and 5 GHz bands by superseding and integrating the IEEE 802.11n-2009 and IEEE 802.11ac-2013 amendments. In a few years, every single AP will most likely implement two IEEE 802.11ax-2019 instances that independently operate at 2.4 and 5 GHz, with a IEEE 802.11ah-2016 instance at 1 GHz for M2M and long-range communications, and one IEEE 802.11ad-2012 (or the future IEEE 802.11ay-202x) at 60 GHz for very fast millimeter-wave communications. In this situation, the STAs of any of those networks should be able to communicate with the STAs in any of the other WLANs. This is the aim of the IEEE 802.11ak-2017 amendment, which focuses on adding bridging capabilities to WLANs.

Finally, next-generation WLANs will use traffic differentiation, flow admission control, and groupcast mechanisms from the IEEE 802.11e-2007, IEEE 802.11ae-2012 and IEEE 802.11aa-2012 amendments to support multimedia traffic with the required QoS. Also, further advances in power saving mechanisms are expected to keep WLAN energy consumption as low as possible.

Conclusion

We have reviewed some technological options that could be included in the IEEE 802.11ax-2019 amendment for next-generation WLANs. Individually, all those solutions offer some per-

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In addition to the higher achievable throughput provided by IEEE 802.11ax-2019 PHY/MAC features, we believe that the most disruptive performance and user experience improvements in next-generation WLANs will also be related to the development and implementation of the other recently approved or ongoing amendments.

formance gains by improving the spatial reuse and spectrum utilization. However, the analysis of the actual performance gains when several of those solutions are combined and used simultaneously is still an open challenge requiring significant research efforts in the next years. For instance, for a given transmission power, multiplexing different users in a single transmission using channel bonding and spatial multiplexing reduces the received power per Hertz and user, which may require the selection of lower-order modulation schemes and coding rates, and the theoretical gain in throughput obtained by the combined use of spatial multiplexing and channel bonding may be lost by the larger transmission delay.

Finally, in addition to the higher achievable throughput provided by IEEE 802.11ax-2019 PHY/MAC features, we believe that the most disruptive performance and user experience improvements in next-generation WLANs will also be related to the development and implementation of the other recently approved or ongoing amendments, and by developing efficient and smart mechanisms to improve the coexistence and cooperation among WLANs.

Acknowledgments

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Biography

Boris Bellalta is an associate professor in the Deparment of Information and Communication Technologies at University Pompeu Fabra (UPF), where he leads the Wireless Networking research group. He obtained his degree in telecommunications engineering from Universitat Politecnica de Catalunya in 2002 and his Ph.D. in information and communication technologies from UPF in 2007. His research interests are in the area of wireless networks, with emphasis on the design and performance evaluation of PHY/MAC protocols and network architectures.

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APPENDIX N

OFFICIAL IEEE 802.11 WORKING GROUP PROJECT TIMELINES - 2025-04-23

IN PROCESS - Standards, Amendments, and Recommended Practices

IEEE Project and Final Document	Final Doc Type	Project Authorization Request (PAR)	Task Group and Activity	Documentation: Session End Snapshot Format & Version	Documentation: Session End Snapshot Incorporated Baselines	Current Status	PAR Approved, Modified, or Extended [Expires]	WG Letter Ballots: Draft Initial	WG Letter Ballots: Date Predicted	WG Letter Ballots: Result Recirc	Form Standards Association (SA) Ballot Pool / Reform	MEC / MDR Done	IEEE SA Ballots: Draft Initial	IEEE SA Ballots: Date Predicted	IEEE SA Ballots: Result Recirc	Final 802.11 WG Approval	Final or Conditional 802 LMSC Approval	RevCom & Standards Board Final or Continuous Process Approval	ANSI Approved	Sup Wit Sta B
IEEE Std P802.11bq	A	Integrated Millimeter Wave	TGbq		802.11-2020 802.11ax-2021 802.11ay-2021 802.11ba-2021 802.11-2020/Cor1-2022 802.11az-2022 802.11bd-2022 802.11bb-2023 802.11bc-2023 802.11-2020/Cor2-2024 802.11me 802.11bh 802.11be 802.11bk 802.11bf 802.11bi 802.11mf 802.11bn 802.11bp	Actual	2024-12-11													
						Predicted	C												N/A	
IEEE Std P802.11mf	A	802.11 Accumulated Maintenance Changes	TGmf		802.11-2020 802.11ax-2021 802.11ay-2021 802.11ba-2021 802.11-2020/Cor1-2022 802.11az-2022 802.11bd-2022 802.11bb-2023 802.11bc-2023 802.11-2020/Cor2-2024 802.11me 802.11bh 802.11be 802.11bk 802.11bf 802.11bi	Actual	2024-11-12													
						Predicted	C	May 2025		Jan 2026	Oct 2026	Oct 2026	Jan 2027		Jul 2027	Nov 2027	Nov 2027	Feb 2028	N/A	
IEEE Std P802.11bp	A	Ambient Power Communication	TGbp		802.11-2020 802.11ax-2021 802.11ay-2021 802.11ba-2021 802.11-2020/Cor1-2022 802.11az-2022 802.11bd-2022 802.11bb-2023 802.11bc-2023 802.11-2020/Cor2-2024 802.11me 802.11bh 802.11be 802.11bk 802.11bf 802.11bi 802.11mf 802.11bn	Actual	2024-03-19 [2028-12-31]													
						Predicted	C	Feb 2026		Nov 2026	Mar 2027	Oct 2027	Aug 2027		Oct 2027	Jan 2028	Mar 2028	May 2028	N/A	
IEEE Std P802.11bn	A	Ultra High Reliability	TGbn	D0.20	802.11-2020 802.11ax-2021 802.11ay-2021 802.11ba-2021 802.11-2020/Cor1-2022 802.11az-2022 802.11bd-2022 802.11bb-2023 802.11bc-2023 802.11-2020/Cor2-2024 802.11me 802.11bh 802.11be 802.11bk 802.11bf 802.11bi 802.11mf	Actual	2023-09-21 [2027-12-31]													
						Predicted	C	May 2025		May 2026	Mar 2027	May 2027	May 2027		Jul 2027	Mar 2028	Mar 2028	May 2028	N/A	
IEEE Std P802.11bk	A	320 MHz Positioning	TGbk	PDF D5.00	802.11-2020 802.11ax-2021 802.11ay-2021 802.11ba-2021 802.11-2020/Cor1-2022 802.11az-2022 802.11bd-	Actual	2022-12-03	D1.0 D2.0 D3.0	2023-12-28 2024-04-26 2024-08-15	95% 97% 98%	2024-05-01	2024-06-01	D3.0 D4.0 D5.0	2024-11-10 2025-02-07 2025-03-30	94% 97% 98%	2025-03-12	2025-03-14			

IEEE Project and Final Document	Final Doc Type	Project Authorization Request (PAR)	Task Group and Activity	Documentation Session End Snapshot Format & Version	Documentation Session End Snapshot Incorporated Baselines	Current Status	PAR Approved, Modified, or Extended [Expires]	WG Letter Ballots Draft Predicted Initial	WG Letter Ballots Date Predicted Recirc	WG Letter Ballots Result	Form Standards Association (SA) Ballot Pool / Reform	MEC / MDR Done	IEEE SA Ballots Draft Predicted Initial	IEEE SA Ballots Date Predicted Recirc	IEEE SA Ballots Result	Final 802.11 WG Approval	Final or Conditional 802 LMSC Approval	RevCom & Standards Board Final or Continuous Process Approval	ANSI Approved	Sup Wit Sta B
					2022 802.11bb-2023 802.11bc-2023 802.11-2020/Cor2-2024 802.11me 802.11bh 802.11be	Predicted	C	C	C		C	C	C	C		C	C	Sep 2025	N/A	
IEEE Std P802.11bi	A	Enhanced Data Privacy	TGbi	PDF D1.10	802.11-2020 802.11ax-2021 802.11ay-2021 802.11ba-2021 802.11-2020/Cor1-2022 802.11az-2022 802.11bd-2022 802.11bb-2023 802.11bc-2023 802.11-2020/Cor2-2024 802.11me 802.11bh 802.11be 802.11bk 802.11bf	Actual	2021-02-10 [2025-12-31]	D1.0	2025-02-27	89%										
						Predicted	C	C	Jul 2025		Sep 2025	Jul 2025	Jan 2026	Mar 2026		May 2026	May 2026	Jul 2026	N/A	
IEEE Std P802.11me	A	802.11 Accumulated Maintenance Changes	TGme	PDF D7.00	802.11-2020 802.11ax-2021 802.11ay-2021 802.11ba-2021 802.11-2020/Cor1-2022 802.11az-2022 802.11bd-2022 802.11bb-2023 802.11bc-2023 802.11-2020/Cor2-2024	Actual	2021-02-10 [2025-12-31]	D1.0 D2.0 D3.0 D4.0	2022-01-10 2022-11-11 2023-05-07 2023-08-30	84% 87% 93% 96%	2023-05-01	2023-07-01	D4.0 D5.0 D6.0 D7.0	2023-10-10 2024-03-05 2024-07-02 2024-08-08	85% 84% 93% 98%	2024-07-01	2024-07-01			
						Predicted	C	C	C		C	C	C	C		C	C	Sep 2024	N/A	
IEEE Std P802.11bh	A	Randomized and Changing MAC Addresses	TGbh	PDF D6.00	802.11-2020 802.11ax-2021 802.11ay-2021 802.11ba-2021 802.11-2020/Cor1-2022 802.11az-2022 802.11bd-2022 802.11bb-2023 802.11bc-2023 802.11-2020/Cor2-2024 802.11me	Actual	2021-02-10 [2025-12-31]	D1.0 D2.0 D3.0 D4.0	2023-07-01 2024-01-05 2024-02-24 2024-04-06	92% 94% 98% 99%	2024-02-01	2024-03-01	D4.0 D5.0 D6.0	2024-05-09 2024-07-13 2024-08-15	91% 92% 98%	2024-07-01	2024-07-01			
						Predicted	C	C	C		C	C	C	C		C	C	Sep 2024	N/A	
IEEE Std P802.11bf	A	WLAN Sensing	TGbf	PDF D8.00	802.11-2020 802.11ax-2021 802.11ay-2021 802.11ba-2021 802.11-2020/Cor1-2022 802.11az-2022 802.11bd-2022 802.11bb-2023 802.11bc-2023 802.11-2020/Cor2-2024 802.11me 802.11bh 802.11be 802.11bk	Actual	2020-09-25 [2026-12-31]	D1.0 D2.0 D3.0 D4.0	2023-03-02 2023-08-20 2024-01-04 2024-04-26	78% 86% 93% 96%	2024-04-01	2024-03-01	D4.0 D5.0 D6.0 D7.0 D8.0	2024-06-12 2024-10-23 2024-12-11 2025-01-16 2025-04-04	90% 96% 97% 98% 98%	2025-03-12	2025-03-14			
						Predicted	C	C	C		C	C	C	C		C	C	Jun 2025	N/A	
IEEE Std P802.11be	A	Extremely High Throughput	TGbe	PDF D7.00	802.11-2020 802.11ax-2021 802.11ay-2021 802.11ba-2021 802.11-2020/Cor1-2022 802.11az-2022 802.11bd-2022 802.11bb-2023 802.11bc-2023 802.11-2020/Cor2-2024 802.11me 802.11bh	Actual	2019-03-21 [2025-12-31]	D2.0 D3.0 D4.0 D5.0	2022-07-04 2023-03-02 2023-08-13 2023-12-16	64% 80% 90% 95%	2023-10-01	2023-09-01	D5.0 D6.0 D7.0	2024-02-02 2024-05-31 2024-08-10	82% 93% 97%	2024-07-01	2024-07-01			
						Predicted	C	C	C		C	C	C	C		C	C	Sep 2024	N/A	

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IEEE Std P802.11-2020/Cor2-2024	COR	Correct 802.11bc identifer of EBCS ANQP element	WG Tech Ed	PDF D1.00	802.11-2020 802.11ax-2021 802.11ay-2021 802.11ba-2021 802.11-2020/Cor1-2022 802.11az-2022 802.11bd-2022 802.11bb-2023 802.11bc-2023	Actual	2023-07-20 [2024-07-20]	D1.0	2023-10-25	100%	2023-10-01	2023-11-01	D1.0	2023-12-28	100%	2023-11-17	2024-01-09	2024-01-01		20
IEEE Std P802.11bc-2023	A	Enhanced Broadcast Service	TGbc	PDF D7.00	802.11-2020 802.11ax-2021 802.11ay-2021 802.11ba-2021 802.11-2020/Cor1-2022 802.11az-2022 802.11bd-2022 802.11bb-2023	Actual	2018-12-05 [2022-12-31]	D1.0 D2.0 D3.0 D4.0	2020-12-20 2021-10-28 2022-04-28 2022-08-25	83% 90% 92% 95%	2022-09-01	2022-07-01	D4.0 D5.0 D6.0 D7.0	2022-11-04 2023-01-13 2023-02-21 2023-03-13	92% 97% 100% 100%	2023-03-01	2023-03-01	2023-06-01		20
IEEE Std P802.11bb-2023	A	Light Communications	TGbb	PDF D7.00	802.11-2020 802.11ax-2021 802.11ay-2021 802.11ba-2021 802.11-2020/Cor1-2022 802.11az-2022 802.11bd-2022	Actual	2018-03-09 [2022-12-31]	D1.0 D2.0 D3.0 D4.0	2022-01-12 2022-04-22 2022-08-31 2022-10-01	87% 94% 95% 99%	2022-03-01	2022-03-01	D4.1 D5.0 D6.0 D7.0	2022-11-07 2023-01-14 2023-02-21 2023-03-14	91% 92% 96% 100%	2023-03-01	2023-03-01	2023-06-01		20
IEEE Std P802.11bd-2022	A	Enhancements for Next Generation V2X	TGbd	PDF D8.00	802.11-2020 802.11ax-2021 802.11ay-2021 802.11ba-2021 802.11-2020/Cor1-2022 802.11az-2022	Actual	2018-12-05 [2022-12-31]	D1.0 D2.0 D3.0 D4.0	2020-11-18 2021-08-01 2021-12-16 2022-03-30	82% 88% 94% 99%	2021-12-02	2022-03-01	D4.0 D5.0 D6.0 D7.0 D8.0	2022-05-09 2022-07-05 2022-08-30 2022-09-30 2022-10-14	92% 93% 95% 97% 97%	2022-09-16	2022-10-04	2022-12-01		20
IEEE Std P802.11az-2022	A	Next Generation Positioning	TGaz	PDF D7.00	802.11-2020 802.11ax-2021 802.11ay-2021 802.11ba-2021 802.11-2020/Cor1-2022	Actual	2015-09-03 [2023-12-31]	D1.0 D2.0 D3.0 D4.0 D4.0	2019-03-09 2020-01-03 2021-02-10 2021-09-07 2021-10-01	79% 87% 88% 95% 98%	2021-08-01	2021-07-01	D4.0 D5.0 D6.0 D7.0	2021-11-05 2022-06-09 2022-09-07 2022-09-29	93% 94% 99% 100%	2022-09-16	2022-10-04	2022-12-01		20
IEEE Std P802.11-2020/Cor1-2022	COR	Correct 802.11ay Assignment of Protected Announce Support Bit	WG Tech Ed	PDF D2.10	802.11-2020 802.11ax-2021 802.11ay-2021 802.11ba-2021	Actual	2022-02-23 [2026-12-31]	D1.0 D2.1	2022-04-14 2022-06-01	99% 100%	2022-05-01	2022-06-01	D2.1	2022-07-08	100%	2022-07-01	2022-07-01	2022-09-21		20
IEEE Std P802.11ba-2021	A	Wake Up Radio	TGba	PDF D8.00	802.11-2020 802.11ax-2021 802.11ay-2021	Actual	2016-12-07 [2020-12-31]	D1.0 D2.0 D3.0 D4.0 D5.0 D6.0	2018-10-24 2019-03-03 2019-06-18 2019-10-15 2019-12-17 2020-02-01	72% 82% 84% 90% 96% 99%	2019-08-01	2019-11-01	D6.0 D7.0 D8.0	2020-03-18 2020-10-01 2020-12-21	91% 95% 98%	2020-11-01	2020-11-01	2021-03-01		20
IEEE Std P802.11ay-2021	A	Next Generation 60GHz	TGay	PDF D7.00	802.11-2020 802.11ax-2021	Actual	2015-03-26 [2021-12-31]	D1.0 D2.0 D3.0 D4.0 D5.0	2018-01-07 2018-08-31 2019-02-28 2019-07-08 2019-11-08	74% 93% 93% 98% 99%	2019-06-01	2019-07-16	D5.0 D6.0 D7.0	2020-01-09 2020-09-29 2020-12-20	89% 92% 98%	2020-11-01	2020-11-01	2021-03-01		20
IEEE Std P802.11ax-2021	A	High Efficiency WLAN	TGax	PDF D8.00	802.11-2020	Actual	2014-03-27 [2020-12-31]	D1.0 D2.0 D3.0 D4.0 D5.0 D6.0	2017-01-08 2017-11-04 2018-07-01 2019-02-25 2019-10-24 2019-12-11	58% 63% 87% 92% 94% 97%	2019-09-01	2019-05-01	D6.0 D7.0 D8.0	2020-01-24 2020-09-17 2020-11-27	82% 88% 95%	2020-09-01	2020-11-01	2021-02-01		20
IEEE Std P802.11-2020	STD	802.11 Accumulated Maintenance Changes	TGmd	PDF D5.00	802.11-2016	Actual	2017-03-23 [2021-12-31]	D1.0 D2.0 D3.0	2018-03-17 2019-01-10 2019-10-30	85% 93% 96%	2019-09-01	2019-05-01	D3.0 D4.0 D5.0 D7.0	2019-12-15 2020-09-04 2020-10-04 2024-08-08	83% 91% 97% 98%	2020-09-01	2020-10-01	2020-12-01		20

SUPERSEDED OR WITHDRAWN - Standards, Amendments, and Recommended Practices

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IEEE Std P802.11aq-2018	A	Pre-Association Discovery	TGaq	PDF D14.00	802.11-2016 802.11ai-2016 802.11-2020 802.11ah-2016 802.11aj-2018 802.11ak-2018	Actual	2012-12-05 [2018-12-31]	D1.0 D3.0 D4.0 D5.0 D6.0 D7.0	2015-03-04 2015-11-07 2016-04-21 2016-07-19 2016-08-19 2016-09-25	73% 93% 93% 93% 96% 97%	2016-08-01	2016-06-01	D7.0 D8.0 D9.0 D10.0 D12.0 D13.0 D14.0 D14.0	2016-11-04 2017-03-18 2017-06-23 2017-07-29 2017-10-01 2017-10-30 2018-01-04 2018-01-31	88% 91% 94% 98% 97% 97% 98% 99%	2018-03-07	2018-03-09	2018-06-14		2
IEEE Std P802.11ak-2018	A	General Link	TGak	PDF D6.00	802.11-2016 802.11ai-2016 802.11-2020 802.11ah-2016 802.11aj-2018	Actual	2012-12-05 [2018-12-31]	D1.0 D2.0 D3.0 D4.0	2015-05-06 2016-03-10 2017-01-10 2017-03-30	85% 91% 94% 95%	2016-11-01	2016-11-01	D4.0 D5.0 D6.0	2017-05-11 2017-11-09 2018-01-01	90% 93% 97%	2018-01-19	2018-01-31	2018-03-08		2
IEEE Std P802.11aj-2018	A	China Millimeter Wave	TGaj	PDF D9.00	802.11-2016 802.11ai-2016 802.11-2020 802.11ah-2016	Actual	2012-08-01 [2018-12-31]	D1.0 D2.0 D3.0 D4.0 D5.0	2016-01-20 2016-06-30 2016-08-30 2016-12-21 2017-03-04	88% 89% 89% 92% 95%	2017-01-01	2016-11-01	D6.0 D7.0 D8.0 D9.0 D14.0	2017-06-25 2017-08-04 2017-08-24 2017-12-17 2018-01-04	98% 100% 100% 100% 98%	2017-11-10	2017-11-10	2018-01-24		2
IEEE Std P802.11-2016	STD	802.11 Accumulated Maintenance Changes	TGmc	PDF D8.00	802.11-2012 802.11ae-2012 802.11aa-2012 802.11ad-	Actual	2012-08-30 [2016-12-31]	D1.0 D2.0 D3.0 D4.0 D4.0	2013-03-02 2013-10-23 2014-06-23 2015-02-17 2015-03-26	88% 90% 90% 94% 96%	2014-09-01	2014-07-01	D4.0 D5.0 D6.0 D7.0 D8.0	2015-04-26 2016-01-26 2016-06-30 2016-08-20 2016-09-08	88% 90% 93% 97% 99%	2016-09-01	2016-10-01	2016-12-07		2

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					2012 802.11ac-2013 802.11af-2013															
IEEE Std P802.11ah-2016	A	Sub 1 GHz	TGah	PDF D10.00	802.11-2016 802.11ai-2016 802.11-2020	Actual	2010-10-04 [2016-12-31]	D1.0 D2.0 D3.0 D4.0 D5.0 D5.0	2013-11-04 2014-07-05 2014-10-25 2015-02-14 2015-04-16 2015-10-03	73% 83% 90% 93% 93% 98%	2015-04-01	2016-02-01	D5.0 D6.0 D7.0 D8.0 D9.0 D10.0	2015-11-05 2016-03-02 2016-04-14 2016-05-17 2016-09-09 2016-09-30	91% 91% 92% 95% 95% 96%	2016-09-01	2016-10-01	2016-12-07		2
IEEE Std P802.11ai-2016	A	Fast Initial Link Setup	TGai	PDF D11.00	802.11-2016	Actual	2010-12-08 [2016-12-31]	D1.0 D2.0 D3.0 D4.0 D5.0 D6.0	2013-09-12 2014-05-07 2014-10-14 2015-02-24 2015-06-26 2015-07-31	74% 85% 88% 90% 92% 97%	2015-03-01	2014-11-01	D6.0 D7.0 D8.0 D9.0 D9.0 D11.0	2015-09-15 2016-03-30 2016-07-13 2016-08-06 2016-09-09 2016-09-30	90% 89% 93% 95% 97% 95%	2016-09-01	2016-10-01	2016-12-07		2
IEEE Std P802.11af-2013	A	TV White Spaces	TGaf	PDF D6.00	802.11-2012 802.11ae-2012 802.11aa-2012 802.11ad-2012 802.11ac-2013	Actual	2009-12-09 [2013-12-31]	D1.0 D2.0 D3.0 D4.0 D5.0 D5.0	2011-02-24 2012-08-19 2013-02-08 2013-04-17 2013-06-14 2013-08-01	62% 79% 87% 92% 94% 99%	2013-06-01	2013-11-01	D5.0 D6.0 D6.0	2013-09-11 2013-10-19 2013-10-30	97% 99% 99%	2013-11-01	2013-11-01	2013-12-11		2
IEEE Std P802.11ac-2013	A	Very High Throughput 6GHz	TGac	PDF D7.00	802.11-2012 802.11ae-2012 802.11aa-2012 802.11ad-2012	Actual	2008-09-26 [2012-12-31]	D1.0 D2.0 D3.0 D4.0 D5.0 D5.0	2011-06-25 2012-02-18 2012-06-25 2012-11-01 2013-02-01 2013-04-04	74% 89% 91% 94% 95% 96%	2013-01-01	2013-01-01	D5.0 D6.0 D7.0	2013-05-05 2013-08-03 2013-10-23	93% 97% 99%	2013-11-01	2013-11-01	2013-12-09		2
IEEE Std P802.11ad-2012	A	Very High Throughput 60GHz	TGad	PDF D9.00	802.11-2012 802.11ae-2012 802.11aa-2012	Actual	2008-12-10 [2012-12-31]	D1.0 D2.0 D3.0 D4.0 D5.0 D5.0	2010-10-24 2011-04-05 2011-06-01 2011-08-09 2011-10-06 2011-11-24	87% 88% 92% 95% 94% 95%	2011-09-01	2011-07-01	D5.0 D6.0 D7.0 D8.0 D9.0 D9.0	2012-01-05 2012-03-30 2012-05-11 2012-06-16 2012-07-28 2012-08-12	86% 90% 95% 97% 98% 98%	2012-07-01	2012-07-01	2012-10-23		2
IEEE Std P802.11aa-2012	A	Video Transport Streams	TGaa	Word / PDF D9.00	802.11-2012 802.11ae-2012	Actual	2008-03-27 [2012-12-31]	D1.0 D2.0 D3.0 D4.0 D5.0 D6.0 D6.0	2010-07-10 2010-12-08 2011-02-24 2011-04-09 2011-06-17 2011-08-09 2011-08-31	78% 79% 81% 85% 90% 94% 95%	2011-06-30	2011-06-16	D6.0 D7.0 D8.0 D9.0	2011-10-12 2011-11-26 2012-01-02 2012-01-27	93% 96% 99% 100%	2012-01-28	2012-02-17	2012-06-01		2
IEEE Std P802.11ae-2012	A	Prioritization of Management Frames	TGae	PDF D8.00	802.11-2012	Actual	2009-12-09 [2010-10-15]	D1.0 D2.0 D3.0 D4.0 D5.0	2010-10-27 2011-02-18 2011-04-26 2011-06-18 2011-08-04	81% 86% 89% 96% 96%	2011-07-01	2011-05-01	D5.0 D6.0 D7.0 D8.0	2011-09-09 2011-10-29 2011-12-13 2012-01-04	95% 96% 100% 100%	2012-01-20	2012-02-17	2012-03-01		2
IEEE Std P802.11-2012	STD	802.11 Accumulated Maintenance Changes	TGmb	Frame / PDF D9.01	802.11-2007 802.11k-2008 802.11r-2008 802.11y-2008 802.11w-2009 802.11n-2009 802.11p-2010 802.11z-2010 802.11v-2011 802.11u-2011 802.11s-2011	Actual	2007-03-22 [2011-12-31]	D1.0 D2.0 D3.0 D4.0 D5.0	2009-06-27 2010-01-08 2010-04-25 2010-06-25 2010-08-19	87% 89% 89% 89% 92%	2010-09-14	2010-09-01	D6.0 D7.0 D8.0 D9.0 D10.0 D11.0 D12.0	2010-11-05 2011-02-18 2011-04-14 2011-06-22 2011-09-07 2011-10-22 2011-11-13	87% 90% 92% 93% 92% 94% 97%	2011-11-11	2011-11-11	2012-03-01		2
IEEE Std P802.11s-2011	A	Mesh Networking	TGs	PDF	802.11-2007 802.11k-2008 802.11r-2008 802.11y-2008 802.11w-2009 802.11n-2009 802.11p-2010 802.11z-2010 802.11v-2011 802.11u-2011	Actual	2004-05-13 [2010-12-31]	D1.0 D2.0 D3.0 D4.0 D5.0 D6.0 D7.0	2007-01-06 2008-05-03 2009-05-04 2010-01-08 2010-04-15 2010-06-28 2010-08-13	48% 61% 79% 85% 89% 89% 95%	2010-09-12	2010-09-29	D7.0 D8.0 D9.0 D10.0 D11.0	2010-11-01 2011-01-10 2011-03-05 2011-04-05 2011-05-07	95% 96% 95% 97% 97%	2011-07-01	2011-07-01	2011-08-01		2
IEEE Std P802.11u-2011	A	InterWorking with External Networks	TGu	Frame / PDF D13.00	802.11-2007 802.11k-2008 802.11r-2008 802.11y-2008 802.11w-2009 802.11n-2009 802.11p-2010 802.11z-2010 802.11v-2011	Actual	2004-12-08 (02/05/2008) [2010-12-31]	D1.0 D2.0 D3.0 D4.0 D5.0 D6.0 D7.0 D8.0	2007-07-08 2008-03-15 2008-07-12 2008-10-08 2009-02-20 2009-04-24 2009-06-19 2009-08-18	64% 70% 77% 78% 82% 90% 88% 93%	2009-06-01	2009-07-12	D8.0 D9.0 D10.0 D11.0 D12.0 D13.0	2009-11-07 2010-04-23 2010-07-08 2010-08-13 2010-09-12 2010-11-21	90% 92% 94% 96% 98% 99%	2010-11-01	2010-11-01	2011-02-25		2
IEEE Std P802.11v-2011	A	Wireless Network Management	TGv	Frame / PDF D16.00	802.11-2007 802.11k-2008 802.11r-2008 802.11y-2008 802.11w-2009 802.11n-2009 802.11p-2010 802.11z-2010	Actual	2004-12-08 [2010-12-31]	D1.0 D2.0 D3.0 D4.0 D5.0 D6.0 D7.0	2007-08-30 2008-03-15 2008-07-13 2008-12-19 2009-04-04 2009-06-12 2009-08-07	63% 67% 69% 81% 83% 90% 92%	2009-06-01	2009-07-12	D7.0 D9.0 D10.0 D11.0 D12.0 D13.0 D14.0 D15.0 D15.0 D16.0	2009-11-07 2010-02-17 2010-04-13 2010-06-10 2010-07-07 2010-07-28 2010-08-25 2010-10-18 2010-09-30 2010-11-15	81% 84% 87% 92% 94% 98% 98% 98% 98% 98%	2010-11-01	2010-11-01	2011-02-09		2
IEEE Std P802.11z-2010	A	Extensions to Direct Link Setup	TGz	Word / PDF D13.00	802.11-2007 802.11k-2008 802.11r-2008 802.11y-2008 802.11w-2009 802.11n-2009 802.11p-2010	Actual	2007-08-22	D1.0 D2.0 D3.0 D4.0 D5.0 D6.0	2008-05-03 2008-08-20 2008-12-18 2009-03-05 2009-06-23 2009-08-26	64% 66% 84% 88% 92% 96%	2009-06-01	2009-06-18	D6.0 D7.0 D8.0 D9.0 D11.0 D13.0	2009-11-07 2010-02-27 2010-05-04 2010-06-10 2010-08-04 2010-08-29	87% 87% 94% 95% 95% 98%	C	C	2010-10-01		2
IEEE Std P802.11p-2010	A	Wireless Access for the Vehicular Environment	TGp	N/A	802.11-2007 802.11k-2008 802.11r-2008 802.11y-2008 802.11w-2009 802.11n-2009	Actual	2004-09-23	D1.0 D2.0 D3.0 D4.0 D5.0 D6.0 D7.0 D8.0 D9.0	2006-04-11 2007-01-05 2007-09-12 2008-05-03 2008-12-05 2009-03-31 2009-06-13 2009-08-05 2009-10-10	59% 67% 74% 79% 85% 89% 85% 89% 93%	2009-06-01	2008-06-19	D9.0 D10.0 D11.0	2009-11-22 2010-02-16 2010-04-07	93% 96% 99%	C	C	2010-07-15		2
IEEE Std P802.11w-2009	A	Protected Management Frames	TGw	N/A	802.11-2007 802.11k-2008 802.11r-2008 802.11y-2008	Actual	2005-03-20	D1.0 D2.0 D3.0 D4.0 D5.0 D6.0	2006-11-19 2007-05-02 2007-10-19 2008-01-05 2008-02-20 2008-04-18	86% 89% 92% 92% 95% 97%	2007-11-13		D6.0 D7.0 D9.0 D10.0 D11.0	2008-09-24 2009-01-18 2009-05-23 2009-06-14 2009-06-28	86% 88% 92% 93% 95%	C	C	2009-09-11		2
IEEE Std P802.11n-2009	A	High Throughput	TGn		802.11-2007 802.11k-2008 802.11r-2008 802.11y-2008 802.11w-2009	Actual	2003-09-11 [2007-09-27]	D1.0 D2.0 D3.0 D4.0 D5.0 D6.0 D7.0 D7.0	2006-04-29 2007-03-09 2007-10-27 2008-04-12 2008-06-12 2008-08-05 2008-09-30 2008-12-02	47% 83% 85% 88% 90% 91% 94% 95%	2008-12-11	2008-12-11	D7.0 D8.0 D9.0 D10.0 D11.0 D11.0	2009-01-10 2009-03-06 2009-04-04 2009-05-30 2009-07-03 2009-06-20	78% 80% 81% 88% 91% 90%	C	C	2009-09-11		2
IEEE Std P802.11y-2008	A	3650-3700 MHz Operation in USA	TGy	N/A	802.11-2007 802.11k-2008 802.11r-2008	Actual	2006-03-16	D1.0 D2.0 D3.0 D4.0 D5.0 D6.0	2007-01-07 2007-05-05 2007-06-20 2007-08-21 2007-10-13 2007-12-08	76% 84% 91% 94% 96% 99%	2007-06-20	2007-07-28	D7.0 D8.0 D9.0 D10.0 D11.0	2008-01-30 2008-03-08 2008-03-27 2008-03-18 2008-06-20	93% 93% 96% 97% 97%	C	C	2008-11-06		2
IEEE Std P802.11r-2008	A	Fast Roaming	TGr	N/A	802.11-2007 802.11k-2008	Actual	2006-05-25	D1.0 D2.0 D3.0 D4.0 D5.0 D6.0	2006-01-04 2006-04-04 2006-10-14 2006-12-04 2007-04-04 2007-06-13	81% 88% 86% 92% 95% 97%		2007-04-11	D7.0 D8.0 D9.0 D9.0	2007-08-30 2007-10-07 2008-02-01 2008-01-17	86% 90% 97% 96%	C	C	2008-05-09		2
IEEE Std P802.11k-	A	Radio Resource	TGk	N/A	802.11-2007	Actual	2002-12-11		2007-09-11 2008-01-05	90% 100%		2007-04-10	D8.0 D9.0	2007-08-13 2007-10-04	90% 89%	C	C	2008-05-09		2

IEEE Project and Final Document	Final Doc Type	Project Authorization Request (PAR)	Task Group and Activity	Documentation: Session End Snapshot Format & Version	Documentation: Session End Snapshot Incorporated Baselines	Current Status	PAR Approved, Modified, or Extended [Expires]	WG Letter Ballots: Draft Predicted Initial	WG Letter Ballots: Date Predicted Recirc	WG Letter Ballots: Result	Form SA Ballot Pool / Reform	MEC / MDR Done	IEEE SA Ballots: Draft Predicted Initial	IEEE SA Ballots: Date Predicted Recirc	IEEE SA Ballots: Result	Final 802.11 WG Approval	Final or Conditional 802 LMSC Approval	RevCom & Standards Board Final or Continuous Process Approval	ANSI Approved	S W S
2008		Measurement						D1.0 D2.0 D3.0 D4.0 D5.0 D6.0 D7.0 D7.0	2004-09-11 2005-03-15 2005-11-12 2006-03-31 2006-09-16 2006-11-16 2007-02-13 2007-05-05	95% 86% 80% 81% 85% 91% 92% 93%			D10.0 D11.0 D12.0 D12.0 D13.0	2007-12-08 2008-01-17 2008-02-14 2008-02-01 2008-03-18	91% 95% 95% 95% 97%					
IEEE Std P802.11-2007	STD	802.11 Standard Maintenance Revision	TGma	N/A	802.11-1999 802.11c 802.11a-1999 802.11b-1999 802.11b Cor1-2001 802.11d-2001 802.11g-2003 802.11h-2003 802.11i-2004 802.11j-2004 802.11e-2005	Actual	2003-03-20 [2003-03-20]	D1.0 D2.0 D3.0 D4.0	2005-05-08 2005-07-17 2005-08-19 2005-09-19	91% 94% 95% 96%	2005-08-21	2005-08-21	D5.0 D6.0 D7.0 D8.0 D9.0	2005-11-20 2006-05-10 2006-07-11 2006-09-09 2006-11-07	86% 90% 91% 96% 96%	2006-11-08	2006-11-08	2007-03-08		2
IEEE Std P802.11.2	RP	Wireless Performance	TGt			Actual	2008-12-31	D1.0	2007-05-16	76%										2
IEEE Std P802.11e-2005	A	MAC Enhancements QoS	TGe	N/A	802.11-1999 802.11c 802.11a-1999 802.11b-1999 802.11b Cor1-2001 802.11d-2001 802.11g-2003 802.11h-2003 802.11i-2004 802.11j-2004	Actual	2000-03-30	D4.0 D5.0 D6.0 D7.0 D8.0	2001-05-15 2002-01-16 2002-07-02 2003-01-08 2003-08-22 2003-12-20 2004-02-15 2004-03-10	0% 55% 49% 83% 97% 89% 93% 94%			D8.0 D9.0 D10.0 D11.0 D12.0 D13.0 D13.0	2004-05-30 2004-08-31 2004-10-08 2004-11-11 2004-12-23 2005-04-16 2005-02-18	85% 87% 92% 95% 96% 99% 96%	2005-07-22	2005-07-22	2005-09-22		2
IEEE Std P802.11j-2004	A	4.9 GHz-5 GHz Operation in Japan	TGj	N/A	802.11-1999 802.11c 802.11a-1999 802.11b-1999 802.11b Cor1-2001 802.11d-2001 802.11g-2003 802.11h-2003 802.11i-2004	Actual	2002-12-11	D1.0 D1.2 D1.3 D1.4	2003-05-12 2004-01-14 2004-03-11 2004-04-20	68% 89% 94% 95%	2004-05-13		D1.5 D1.6	2004-07-02 2004-08-14	88% 96%	C	C	2004-09-23	2005-02-02	2
IEEE Std P802.11i-2004	A	MAC Security Enhancements	TGi	N/A	802.11-1999 802.11c 802.11a-1999 802.11b-1999 802.11b Cor1-2001 802.11d-2001 802.11g-2003 802.11h-2003	Actual	2001-05-30	D3.0 D4.0 D5.0 D6.0 D7.0	2002-05-04 2003-01-12 2003-06-06 2003-08-19 2003-10-09 2003-11-04	77% 76% 78% 87% 92% 95%	2003-08-10		D7.0 D8.0 D9.0 D10.0	2003-12-20 2004-03-12 2004-04-10 2004-05-08	89% 92% 98% 98%	C	C	2004-06-24	2005-02-14	2
IEEE Std P802.11h-2003	A	Spectrum and Transmit Power Management Extensions in the 5 GHz Band in Europe	TGh	N/A	802.11-1999 802.11c 802.11a-1999 802.11b-1999 802.11b Cor1-2001 802.11d-2001 802.11g-2003	Actual	2000-12-07	D2.2	2001-09-03 2002-05-05 2002-09-01 2002-11-01	0% 76% 90% 97%	2002-07-25		D3.0 D3.11 D3.6	2003-02-06 2003-06-26 2003-04-30	92% 98% 96%	C	C	2003-09-11	2003-12-29	2
IEEE Std P802.11g-2003	A	Further Higher Data Rate Extension in the 2.4 GHz Band	TGg	N/A	802.11-1999 802.11c 802.11a-1999 802.11b-1999 802.11b Cor1-2001 802.11d-2001	Actual	2000-09-21	D5.0 D4.0 D6.1	2002-03-11 2002-09-01 2003-01-08 2002-11-01 2003-02-04	45% 83% 88% 87% 89%	2002-07-25		D6.2 D7.1 D8.2	2003-03-09 2003-04-08 2003-05-14	84% 85% 96%	C	C	2003-06-12	2003-10-20	2
IEEE Std P802.11b Cor1-2001	COR	Corrigenda to IEEE 802.11b-1999	TGb-Cor1		802.11-1999 802.11c 802.11a-1999	Actual	1999-11-27						D1.5	2001-04-13	98%	C	C	2001-10-10	2002-01-30	2
IEEE Std P802.11d-2001	A	Operation in Additional Regulatory Domains	TGd	N/A	802.11-1999 802.11c 802.11a-1999 802.11b-1999 802.11b Cor1-2001	Actual	1999-06-26		2000-04-04 2000-06-26	0% 0%	2001-11-29		D2.0 D3.0	2001-03-01 2001-04-13	93% 100%	C	C	2001-06-14	2001-10-25	2
IEEE Std P802.11b-1999	A	Higher Speed PHY Extension in the 2.4 GHz Band	TGb	N/A	802.11-1999 802.11c 802.11a-1999	Actual	1997-12-09		1998-11-09	0%						C	C	1999-09-16		2
IEEE Std P802.11a-1999	A	Higher Speed PHY Extension in the 5GHz Band	TGa	N/A	802.11-1999	Actual	1997-09-16									C	C	1999-09-16	2000-02-04	2
IEEE Std P802.11f-2003	RP	Inter-Access Point Protocol Across Distribution Systems Supporting IEEE 802.11 Operation	TGf	N/A		Actual	2000-03-30		2001-05-15 2001-09-03 2002-03-10 2002-06-16	0% 0% 82% 96%	2002-07-27		D4.0 D4.1 D5.0 D6.0	2002-10-28 2002-12-19 2003-02-17 2003-04-08	88% 95% 97% 98%	C	C	2003-06-12		2
IEEE Std P802.11-1999	STD	Part II Wireless LAN Medium Access Control MAC and Physical Layer PHY Specifications	MAC/PHY	N/A		Actual	1997-12-09							2003-01-07 2003-04-09 2003-02-02	99% 99% 99%	C	C	1999-03-18	1999-07-15	2
IEEE Std P802.11-1997	STD	IEEE Standard for Wireless LAN Medium Access Control MAC and Physical Layer PHY Specifications	MAC/PHY	N/A		Actual	1991-03-21									C	C	1997-06-26		1
IEEE Std P802.11c	A	Media Access Control MAC Bridges - Supplement for Support by IEEE 802.11 [Rolled into IEEE 802.1D]	TGc	N/A	802.11-1999	Actual	1997-12-09													

Timeline Chart Notes:

C = Stage Completed or Currently In-Process
A / COR = Amendment / Corrigendum
Predicted = Current Date Estimate
Date = Actual or Start Date
LB = Letter Ballot

N/A = Not Applicable
RP = Recommended Practice
SB = SA Ballot
STD = Standard and/or Revision
TG = Task Group

MEC = IEEE-SA Mandatory Editorial Coordination
Final 802.11 WG = Approval by 802.11 WG - Current WG Calendar
Final or Conditional 802 LMSC = Approval by 802 LMSC at Plenary Session - Current 802 LMSC Plenary Calendar
RevCom/Standards Board = Approval of RevCom / IEEE-SA Standards Board in Normal Session - Current IEEE-SA Calendar
ANSI = American National Standards Institute

MDR = 802.11 WG Mandatory Draft Review

This page is maintained by Stephen McCann . Comments are welcome.

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APPENDIX O

The Wayback Machine - https://web.archive.org/web/20140702154806/http://www.ieee802.org/11/Reports/802.11_Timelines.htm

OFFICIAL IEEE 802.11 WORKING GROUP PROJECT TIMELINES - 2014-06-02

IN PROCESS - Standards, Amendments, and Recommended Practices

IEEE Project and Final Document	Final Doc Type	Project Authorization Request (PAR)	Task Group and Activity	Documentation: Format & Version	Documentation: Session End Snapshot Incorporated Baselines	Current Status	PAR Approved, Modified, or Extended [Expires]	WG Letter Ballots: Draft Predicted Initial	WG Letter Ballots: Date Predicted Recirc	WG Letter Ballots: Result	WG Letter Ballots: Form Sponsor Ballot Pool / Reform	WG Letter Ballots: MEC / MDR Done	IEEE-SA Sponsor Ballots: Draft Predicted Initial	IEEE-SA Sponsor Ballots: Date Predicted Recirc	IEEE-SA Sponsor Ballots: Result	Final 802.11 WG Approval	Final or Conditional 802 EC Approval	RevCom & Standards Board Final or Continuous Process Approval	ANSI Approved
IEEE Std P802.11ax	A	High Efficiency WLAN	TGax	None	802.11REVmc 802.11ai 802.11ah 802.11ak 802.11aq 802.11aj	Actual	2014-03-25												
						Predicted	C	Jul 2016			Jan 2018	Jan 2018	May 2018			Jan 2019	Mar 2019	Mar 2019	N/A
IEEE Std P802.11ak	A	General Link	TGak	None	802.11REVmc 802.11ai 802.11ah	Actual	2012-12-05 [2016-12-31]												
						Predicted	C	Jul 2014	Nov 2014		May 2015	Sep 2015	Nov 2015	Jan 2016		May 2016	May 2016	May 2016	N/A
IEEE Std P802.11aq	A	Pre-association Discovery	TGaq	None	802.11REVmc 802.11ai 802.11ah 802.11ak	Actual	2012-12-05 [2016-12-31]												
						Predicted	C	Nov 2014	Mar 2015		Jul 2015	Jul 2015	Nov 2015	Mar 2016		Jul 2016	Jul 2016	Jul 2016	N/A
IEEE Std P802.11aj	A	China Millimeter Wave	TGaj	PDF D0.01	802.11REVmc 802.11ai 802.11ah 802.11ak 802.11aq	Actual	2012-08-01												
						Predicted	C	Mar 2015	Jul 2015		Jul 2015	Sep 2015	Sep 2015	Jan 2016		May 2016	May 2016	Jun 2016	N/A
IEEE Std P802.11REVmc	STD	Maintenance	TGmc	PDF D2.70	802.11-2012 802.11ae-2012 802.11aa-2012 802.11ad-2012 802.11ac-2013 802.11af-2013	Actual	2012-07-20	D1.0 D2.0	2013-03-02 2013-10-23	88% 90%									
						Predicted	C	C		C	Aug 2014	Jul 2014	Nov 2014	Mar 2015		Jul 2015	Jul 2015	Dec 2015	Dec 2015
IEEE Std P802.11ai	A	Fast Initial Link Setup	TGai	PDF D1.30	802.11REVmc	Actual	2010-12-08 [2014-12-31]	D1.0 D2.0	2013-09-12 2014-05-07	74% 85%									
						Predicted	C	C		Sep 2014	Mar 2015	Nov 2014	Jul 2015	Sep 2015		Nov 2015	Nov 2015	Mar 2016	N/A
IEEE Std P802.11ah	A	Sub 1 GHz	TGah	PDF D1.20	802.11REVmc 802.11ai	Actual	2010-10-04 [2013-12-31]	D1.0	2013-11-04	73%									
						Predicted	C	C		Sep 2014	Nov 2014	Nov 2014	Feb 2015	Nov 2015		Jan 2016	Jan 2016	Mar 2016	N/A

PUBLISHED - Standards, Amendments, and Recommended Practices

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IEEE Std P802.11af-2013	A	TV White Spaces	TGaf	PDF D6.00	802.11-2012 802.11ae-2012 802.11aa-2012 802.11ad-2012 802.11ac-2013	Actual	2009-12-09 [2013-12-31]	D1.0 D2.0 D3.0 D4.0 D5.0 D5.0	2011-02-24 2012-08-19 2013-02-08 2013-04-17 2013-06-14 2013-08-01	62% 79% 87% 92% 94% 99%	2013-06-01	2013-11-01	D5.0 D6.0 D6.0	2013-09-11 2013-10-19 2013-10-30	97% 99% 99%	2013-11-01	2013-11-01	2013-12-11	2013-12-11
IEEE Std P802.11ac-2013	A	Very High Throughput 6GHz	TGac	PDF D7.00	802.11-2012 802.11ae-2012 802.11aa-2012 802.11ad-2012	Actual	2008-09-26 [2012-12-31]	D1.0 D2.0 D3.0 D4.0 D5.0 D5.0	2011-06-25 2012-02-18 2012-06-25 2012-11-01 2013-02-01 2013-04-04	74% 89% 91% 94% 95% 96%	2013-01-01	2013-01-01	D5.0 D6.0 D7.0	2013-05-05 2013-08-03 2013-10-23	93% 97% 99%	2013-11-01	2013-11-01	2013-12-09	2013-12-11
IEEE Std P802.11ad-2012	A	Very High Throughput 60GHz	TGad	PDF D9.00	802.11-2012 802.11ae-2012 802.11aa-2012	Actual	2008-12-10 [2012-12-31]	D1.0 D2.0 D3.0 D4.0 D5.0 D5.0	2010-10-24 2011-04-05 2011-06-01 2011-08-09 2011-10-06 2011-11-24	87% 88% 92% 95% 94% 95%	2011-09-01	2011-07-01	D5.0 D6.0 D7.0 D8.0 D9.0 D9.0	2012-01-05 2012-03-30 2012-05-11 2012-06-16 2012-07-28 2012-08-12	86% 90% 95% 97% 98% 98%	2012-07-01	2012-07-01	2012-10-23	2012-12-28
IEEE Std P802.11aa-2012	A	Video Transport Streams	TGaa	Word / PDF D9.00	802.11-2012 802.11ae-2012	Actual	2008-03-27 [2012-12-31]	D1.0 D2.0 D3.0 D4.0 D5.0 D6.0 D6.0	2010-07-10 2010-12-08 2011-02-24 2011-04-09 2011-06-17 2011-08-09 2011-08-31	78% 79% 81% 85% 90% 94% 95%	2011-06-30	2011-06-16	D6.0 D7.0 D8.0 D9.0	2011-10-12 2011-11-26 2012-01-02 2012-01-27	93% 96% 99% 100%	2012-01-28	2012-02-17	2012-06-01	2012-05-29
IEEE Std P802.11ae-2012	A	Prioritization of Management Frames	TGae	PDF D8.00	802.11-2012	Actual	2009-12-09 [2010-10-15]	D1.0 D2.0 D3.0 D4.0 D5.0	2010-10-27 2011-02-18 2011-04-26 2011-06-18 2011-08-04	81% 86% 89% 96% 96%	2011-07-01	2011-05-01	D5.0 D6.0 D7.0 D8.0	2011-09-09 2011-10-29 2011-12-13 2012-01-04	95% 96% 100% 100%	2012-01-20	2012-02-17	2012-03-01	2012-03-31
IEEE Std P802.11-2012	STD	802.11 Accumulated Maintenance Changes	TGmb	Frame / PDF D9.01	802.11-2007 802.11k-2008 802.11r-2008 802.11y-2008 802.11w-2009 802.11n-2009 802.11p-2010 802.11z-2010 802.11v-2011 802.11u-2011 802.11s-2011	Actual	2007-03-22 [2011-12-31]	D1.0 D2.0 D3.0 D4.0 D5.0	2009-06-27 2010-01-08 2010-04-25 2010-06-25 2010-08-19	87% 89% 89% 89% 92%	2010-09-14	2010-09-01	D6.0 D7.0 D8.0 D9.0 D10.0 D11.0 D12.0	2010-11-05 2011-02-18 2011-04-14 2011-06-22 2011-09-07 2011-10-22 2011-11-13	87% 90% 92% 93% 92% 94% 97%	2011-11-11	2011-11-11	2012-03-01	2012-05-13

SUPERSEDED OR WITHDRAWN - Standards, Amendments, and Recommended Practices

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IEEE Std P802.11s-2011	A	Mesh Networking	TGs	PDF	802.11-2007 802.11k-2008 802.11r-2008 802.11y-2008	Actual	2004-05-13 [2010-12-31]	D1.0 D2.0 D3.0 D4.0	2007-01-06 2008-05-03 2009-05-04 2010-01-08	48% 61% 79% 85%	2010-09-12	2010-09-29	D7.0 D8.0 D9.0	2010-11-01 2011-01-10 2011-03-05	95% 96% 95%	2011-07-01	2011-07-01	2011-08-01	

IEEE Project and Final Document	Final Doc Type	Project Authorization Request (PAR)	Task Group and Activity	Documentation: Session End Snapshot: Format & Version	Documentation: Session End Snapshot: Incorporated Baselines	Current Status	PAR Approved, Modified, or Extended [Expires]	WG Letter Ballots: Draft: Predicted Initial	WG Letter Ballots: Date: Predicted Recirc	WG Letter Ballots: Result	Form Sponsor Ballot Pool / Reform	MEC / MDR Done	IEEE-SA Sponsor Ballots: Draft: Predicted Initial	IEEE-SA Sponsor Ballots: Date: Predicted Recirc	IEEE-SA Sponsor Ballots: Result	Final 802.11 WG Approval	Final or Conditional 802 EC Approval	RevCom & Standards Board Final or Continuous Process Approval	ANSI Approved	Su W S
					802.11w-2009 802.11n-2009 802.11p-2010 802.11z-2010 802.11v-2011 802.11u-2011			D5.0 D6.0 D7.0	2010-04-15 2010-06-28 2010-08-13	89% 89% 95%			D10.0 D11.0	2011-04-09 2011-05-07	97% 97%					
IEEE Std P802.11u-2011	A	InterWorking with External Networks	TGu	Frame / PDF D13.00	802.11-2007 802.11k-2008 802.11r-2008 802.11y-2008 802.11w-2009 802.11n-2009 802.11p-2010 802.11z-2010 802.11v-2011	Actual	2004-12-08 (02/05/2008) [2010-12-31]	D1.0 D2.0 D3.0 D4.0 D5.0 D6.0 D7.0 D8.0	2007-07-08 2008-03-15 2008-07-12 2008-10-08 2009-02-20 2009-04-24 2009-06-19 2009-08-18	64% 70% 77% 78% 82% 90% 88% 93%	2009-06-01	2009-07-12	D8.0 D9.0 D10.0 D11.0 D12.0 D13.0	2009-11-07 2010-04-23 2010-07-08 2010-08-13 2010-09-12 2010-11-21	90% 92% 94% 96% 98% 99%	2010-11-01	2010-11-01	2011-02-25		2
IEEE Std P802.11v-2011	A	Wireless Network Management	TGv	Frame / PDF D16.00	802.11-2007 802.11k-2008 802.11r-2008 802.11y-2008 802.11w-2009 802.11n-2009 802.11p-2010 802.11z-2010	Actual	2004-12-08 [2010-12-31]	D1.0 D2.0 D3.0 D4.0 D5.0 D6.0 D7.0	2007-08-30 2008-03-15 2008-07-13 2008-12-19 2009-04-04 2009-06-12 2009-08-07	63% 67% 69% 81% 83% 90% 92%	2009-06-01	2009-07-12	D7.0 D9.0 D10.0 D11.0 D12.0 D13.0 D14.0 D15.0 D15.0 D16.0	2009-11-07 2010-02-17 2010-04-13 2010-06-10 2010-07-07 2010-07-28 2010-08-25 2010-10-18 2010-09-30 2010-11-15	81% 84% 87% 92% 94% 98% 98% 98% 98% 98%	2010-11-01	2010-11-01	2011-02-09		2
IEEE Std P802.11z-2010	A	Extensions to Direct Link Setup	TGz	Word / PDF D13.00	802.11-2007 802.11k-2008 802.11r-2008 802.11y-2008 802.11w-2009 802.11n-2009 802.11p-2010	Actual	2007-08-22	D1.0 D2.0 D3.0 D4.0 D5.0 D6.0	2008-05-03 2008-08-20 2008-12-18 2009-03-05 2009-06-23 2009-08-26	64% 66% 84% 88% 92% 96%	2009-06-01	2009-06-18	D6.0 D7.0 D8.0 D9.0 D11.0 D13.0	2009-11-07 2010-02-27 2010-05-04 2010-06-10 2010-08-04 2010-08-29	87% 87% 94% 95% 95% 98%	C	C	2010-10-01		2
IEEE Std P802.11p-2010	A	Wireless Access for the Vehicular Environment	TGp	N/A	802.11-2007 802.11k-2008 802.11r-2008 802.11y-2008 802.11w-2009 802.11n-2009	Actual	2004-09-23	D1.0 D2.0 D3.0 D4.0 D5.0 D6.0 D7.0 D8.0 D9.0	2006-04-11 2007-01-05 2007-09-12 2008-05-03 2008-12-05 2009-03-31 2009-06-13 2009-08-05 2009-10-10	59% 67% 74% 79% 85% 89% 85% 89% 93%	2009-06-01	2008-06-19	D9.0 D10.0 D11.0	2009-11-22 2010-02-16 2010-04-07	93% 96% 99%	C	C	2010-07-15		2
IEEE Std P802.11w-2009	A	Protected Management Frames	TGw	N/A	802.11-2007 802.11k-2008 802.11r-2008 802.11y-2008	Actual	2005-03-20	D1.0 D2.0 D3.0 D4.0 D5.0 D6.0	2006-11-19 2007-05-02 2007-10-19 2008-01-05 2008-02-20 2008-04-18	86% 89% 92% 92% 95% 97%	2007-11-13		D6.0 D7.0 D9.0 D10.0 D11.0	2008-09-24 2009-01-18 2009-05-23 2009-06-14 2009-06-28	86% 88% 92% 93% 95%	C	C	2009-09-11		2
IEEE Std P802.11n-2009	A	High Throughput	TGn		802.11-2007 802.11k-2008 802.11r-2008 802.11y-2008 802.11w-2009	Actual	2003-09-11 [2007-09-27]	D1.0 D2.0 D3.0 D4.0 D5.0 D6.0 D7.0 D7.0	2006-04-29 2007-03-09 2007-10-27 2008-04-12 2008-06-12 2008-08-05 2008-09-30 2008-12-02	47% 83% 85% 88% 90% 91% 94% 95%	2008-12-11	2008-12-11	D7.0 D8.0 D9.0 D10.0 D11.0 D11.0	2009-01-10 2009-03-06 2009-04-04 2009-05-30 2009-07-03 2009-06-20	78% 80% 81% 88% 91% 90%	C	C	2009-09-11		2
IEEE Std P802.11y-2008	A	3650-3700 MHz Operation in USA	TGy	N/A	802.11-2007 802.11k-2008 802.11r-2008	Actual	2008-12-31	D1.0 D2.0 D3.0 D4.0 D5.0 D6.0	2007-01-07 2007-05-05 2007-06-20 2007-08-21 2007-10-13 2007-12-08	76% 84% 91% 94% 96% 99%	2007-06-20	2007-07-28	D7.0 D8.0 D9.0 D10.0 D11.0	2008-01-30 2008-03-08 2008-03-27 2008-03-18 2008-06-20	93% 93% 96% 97% 97%	C	C	2008-11-06		2
IEEE Std P802.11r-2008	A	Fast Roaming	TGr	N/A	802.11-2007 802.11k-2008	Actual	2008-12-31	D1.0 D2.0 D3.0 D4.0 D5.0 D6.0	2006-01-04 2006-04-04 2006-10-14 2006-12-04 2007-04-04 2007-06-13	81% 88% 86% 92% 95% 97%		2007-04-11	D7.0 D8.0 D9.0 D9.0	2007-08-30 2007-10-07 2008-02-01 2008-01-17	86% 90% 97% 96%	C	C	2008-05-09		2
IEEE Std P802.11k-2008	A	Radio Resource Measurement	TGk	N/A	802.11-2007	Actual	2002-12-11	D1.0 D2.0 D3.0 D4.0 D5.0 D6.0 D7.0 D7.0	2007-09-11 2008-01-05 2004-09-11 2005-03-15 2005-11-12 2006-03-31 2006-09-16 2006-11-16 2007-02-13 2007-05-05	90% 100% 95% 86% 80% 81% 85% 91% 92% 93%		2007-04-10	D8.0 D9.0 D10.0 D11.0 D12.0 D12.0 D13.0	2007-08-13 2007-10-04 2007-12-08 2008-01-17 2008-02-14 2008-02-01 2008-03-18	90% 89% 91% 95% 95% 95% 97%	C	C	2008-05-09		2
IEEE Std P802.11-2007	STD	802.11 Standard Maintenance Revision	TGma	N/A	802.11-1999 802.11c 802.11a-1999 802.11b-1999 802.11b Cor1-2001 802.11d-2001 802.11g-2003 802.11h-2003 802.11i-2004 802.11j-2004 802.11e-2005	Actual	2003-03-20 [2003-03-20]	D1.0 D2.0 D3.0 D4.0	2005-05-08 2005-07-17 2005-08-19 2005-09-19	91% 94% 95% 96%	2005-08-21	2005-08-21	D5.0 D6.0 D7.0 D8.0 D9.0	2005-11-20 2006-05-10 2006-07-11 2006-09-09 2006-11-07	86% 90% 91% 96% 96%	2006-11-08	2006-11-08	2007-03-08		2
IEEE Std P802.11.2	RP	Wireless Performance	TGt			Actual	2008-12-31	D1.0	2007-05-16	76%										2
IEEE Std P802.11e-2005	A	MAC Enhancements QoS	TGe	N/A	802.11-1999 802.11c 802.11a-1999 802.11b-1999 802.11b Cor1-2001 802.11d-2001 802.11g-2003 802.11h-2003 802.11i-2004 802.11j-2004	Actual	2000-03-30	D4.0 D5.0 D6.0 D7.0 D8.0	2001-05-15 2002-01-16 2002-07-02 2003-01-08 2003-08-22 2003-12-20 2004-02-15 2004-03-10	0% 55% 49% 83% 97% 89% 93% 94%			D8.0 D9.0 D10.0 D11.0 D12.0 D13.0 D13.0	2004-05-30 2004-08-31 2004-10-08 2004-11-11 2004-12-23 2005-04-16 2005-02-18	85% 87% 92% 95% 96% 99% 96%	2005-07-22	2005-07-22	2005-09-22		2
IEEE Std P802.11j-2004	A	4.9 GHz-5 GHz Operation in Japan	TGj	N/A	802.11-1999 802.11c 802.11a-1999 802.11b-1999 802.11b Cor1-2001 802.11d-2001 802.11g-2003 802.11h-2003 802.11i-2004	Actual	2002-12-11	D1.0 D1.2 D1.3 D1.4	2003-05-12 2004-01-14 2004-03-11 2004-04-20	68% 89% 94% 95%	2004-05-13		D1.5 D1.6	2004-07-02 2004-08-14	88% 96%	C	C	2004-09-23	2005-02-02	2
IEEE Std P802.11i-2004	A	MAC Security Enhancements	TGi	N/A	802.11-1999 802.11c 802.11a-1999 802.11b-1999 802.11b Cor1-2001 802.11d-2001 802.11g-2003 802.11h-2003	Actual	2001-05-30	D3.0 D4.0 D5.0 D6.0 D7.0	2002-05-04 2003-01-12 2003-06-06 2003-08-19 2003-10-09 2003-11-04	77% 76% 78% 87% 92% 95%	2003-08-10		D7.0 D8.0 D9.0 D10.0	2003-12-20 2004-03-12 2004-04-10 2004-05-08	89% 92% 98% 98%	C	C	2004-06-24	2005-02-14	2
IEEE Std P802.11h-2003	A	Spectrum and Transmit Power Management Extensions in the 5 GHz Band in Europe	TGh	N/A	802.11-1999 802.11c 802.11a-1999 802.11b-1999 802.11b Cor1-2001 802.11d-2001 802.11g-2003	Actual	2000-12-07	D2.2	2001-09-03 2002-05-05 2002-09-01 2002-11-01	0% 76% 90% 97%	2002-07-25		D3.0 D3.11 D3.6	2003-02-06 2003-06-26 2003-04-30	92% 98% 96%	C	C	2003-09-11	2003-12-29	2
IEEE Std P802.11g-2003	A	Further Higher Data Rate Extension in	TGg	N/A	802.11-1999 802.11c 802.11a-1999 802.11b-1999	Actual	2000-09-21	D5.0	2002-03-11 2002-09-01 2003-01-08	45% 83% 88%	2002-07-25		D6.2 D7.1 D8.2	2003-03-09 2003-04-08 2003-05-14	84% 85% 96%	C	C	2003-06-12	2003-10-20	2

IEEE Project and Final Document	Final Doc Type	Project Authorization Request (PAR)	Task Group and Activity	Documentation: Session End Snapshot Format & Version	Documentation: Session End Snapshot Incorporated Baselines	Current Status	PAR Approved, Modified, or Extended [Expires]	WG Letter Ballots: Draft Predicted Initial	WG Letter Ballots: Date Predicted Initial	WG Letter Ballots: Result Predicted Initial	WG Letter Ballots: Date Predicted Recirc	WG Letter Ballots: Result Predicted Recirc	Form Sponsor Ballot Pool / Reform	MEC / MDR Done	IEEE-SA Sponsor Ballots: Draft Predicted Initial	IEEE-SA Sponsor Ballots: Date Predicted Initial	IEEE-SA Sponsor Ballots: Result Predicted Initial	IEEE-SA Sponsor Ballots: Date Predicted Recirc	IEEE-SA Sponsor Ballots: Result Predicted Recirc	Final 802.11 WG Approval	Final or Conditional 802 EC Approval	RevCom & Standards Board Final or Continuous Process Approval	ANSI Approved	Su W S
		the 2.4 GHz Band			802.11b Cor1-2001 802.11d-2001			D4.0 D6.1			2002-11-01 2003-02-04	87% 89%												
IEEE Std P802.11b Cor1-2001	COR	Corrigenda to IEEE 802.11b-1999	TGb-Cor1		802.11-1999 802.11c 802.11a-1999	Actual	1999-11-27								D1.5	2001-04-13	98%	C	C	2001-10-10	2002-01-30	2
IEEE Std P802.11d-2001	A	Operation in Additional Regulatory Domains	TGd	N/A	802.11-1999 802.11c 802.11a-1999 802.11b-1999 802.11b Cor1-2001	Actual	1999-06-26				2000-04-04 2000-06-26	0% 0%	2001-11-29		D2.0 D3.0	2001-03-01 2001-04-13	93% 100%	C	C	2001-06-14	2001-10-25	2
IEEE Std P802.11b-1999	A	Higher Speed PHY Extension in the 2.4 GHz Band	TGb	N/A	802.11-1999 802.11c 802.11a-1999	Actual	1997-12-09				1998-11-09	0%						C	C	1999-09-16		2
IEEE Std P802.11a-1999	A	Higher Speed PHY Extension in the 5GHz Band	TGa	N/A	802.11-1999	Actual	1997-09-16											C	C	1999-09-16	2000-02-04	2
IEEE Std P802.11f-2003	RP	Inter-Access Point Protocol Across Distribution Systems Supporting IEEE 802.11 Operation	TGf	N/A		Actual	2000-03-30				2001-05-15 2001-09-03 2002-03-10 2002-06-16	0% 0% 82% 96%	2002-07-27		D4.0 D4.1 D5.0 D6.0	2002-10-28 2002-12-19 2003-02-17 2003-04-08	88% 95% 97% 98%	C	C	2003-06-12		2
IEEE Std P802.11-1999	STD	Part II Wireless LAN Medium Access Control MAC and Physical Layer PHY Specifications	MAC/PHY	N/A		Actual	1997-12-09									2003-01-07 2003-04-09 2003-02-02	99% 99% 99%	C	C	1999-03-18	1999-07-15	2
IEEE Std P802.11c	A	Media Access Control MAC Bridges - Supplement for Support by IEEE 802.11	TGc	N/A	802.11-1999	Actual	1997-12-09															2
IEEE Std P802.11-1997	STD	IEEE Standard for Wireless LAN Medium Access Control MAC and Physical Layer PHY Specifications	MAC/PHY	N/A		Actual	1991-03-21											C	C	1997-06-26		1

Timeline Chart Notes:

C = Stage Completed or Currently In-Process
A / COR = Amendment / Corrigendum
Predicted = Current Date Estimate
Date = Actual or Start Date
LB = Letter Ballot

N/A = Not Applicable
RP = Recommended Practice
SB = Sponsor Ballot
STD = Standard and/or Revision
TG = Task Group

MEC = IEEE-SA Mandatory Editorial Coordination
Final 802.11 WG = Approval by 802.11 WG - Current WG Calendar
Final or Conditional 802 EC = Approval by 802 EC at Plenary Session - Current 802 EC Plenary Calendar
RevCom/Standards Board = Approval of RevCom / IEEE-SA Standards Board in Normal Session - Current IEEE-SA Calendar
ANSI = American National Standards Institute

MDR = 802.11 WG Mandatory Draft Review

This page is maintained by Stephen McCann and Alex Ashley . Comments are welcome.

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    - Software & Systems Engineering Groups (S2ESC)
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- IEEE 802.15 Wireless Speciality Network (WSN) Working Group
- IEEE 802.16 Working Group on Broadband Wireless Access
- IEEE 802.18 Radio Regulatory Technical Advisory Group
- IEEE 802.19 Wireless Coexistence WG
- IEEE 802.21 Handover Services WG
- IEEE 802.22 WRAN WG
- IEEE 802 Whitespace SG(not an active group - archive)
- IEEE 802.23 Emergency Services Working Group(not an active group - archive)
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APPENDIX R

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Created (ET) ▼	Year	DCN	Rev	Group	Title	Author (Affiliation)	Uploaded (ET)	Actions
28-Apr-2025 ET	2025	255	3	TGm	P2P TWT Harmonization	Brian Hart (Cisco Systems)	28-Apr-2025 13:34:11 ET	Download
28-Apr-2025 ET	2024	1925	6	TGm	REVmf Motions	Michael Montemurro (Huawei)	28-Apr-2025 12:17:19 ET	Download
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28-Apr-2025 ET	2025	371	1	TGm	NR-IE_6GHz_Bits	Abhishek Patil (Qualcomm)	28-Apr-2025 11:33:33 ET	Download
28-Apr-2025 ET	2025	345	5	TGm	PASN ID for MLO	Yan Li(ZTE)	28-Apr-2025 09:42:37 ET	Download
28-Apr-2025 ET	2025	676	1	TGbn	CC50 CR for CID3866	Bo Cao (ZTE)	28-Apr-2025 09:37:41 ET	Download
28-Apr-2025 ET	2025	638	2	TGbn	CRs for CID related to definitions in MAPC scheme	Chun Huang (ZTE)	28-Apr-2025 08:18:13 ET	Download
28-Apr-2025 ET	2024	2080	1	TGbn	High-Capability Protection in DPS Follow Up	Maolin Zhang (Huawei)	28-Apr-2025 06:32:10 ET	Download
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28-Apr-2025 ET	2025	5	3	TGbn	MAP discovery follow up	Jay Yang(ZTE)	28-Apr-2025 03:46:33 ET	Download
28-Apr-2025 ET	2025	576	3	TGbq	TGbg April 2025 Teleconference Call Meeting Minutes	Jonghoe Koo (Samsung Electronics)	28-Apr-2025 02:10:27 ET	Download
28-Apr-2025 ET	2025	673	3	TGbn	CR for CC50 on subclause 37.x.x.x.x Allowed settings	Hong Won Lee(LG Electronics Inc.)	28-Apr-2025 01:26:53 ET	Download
28-Apr-2025 ET	2025	727	1	TGbk	Minutes for telecons in March-APril2025	Dibakar Das (Intel)	28-Apr-2025 01:04:27 ET	Download
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27-Apr-2025 ET	2025	723	1	TGm	802.11REVmf Editor's Report	Po-Kai Huang (Intel)	27-Apr-2025 21:29:07 ET	Download
27-Apr-2025 ET	2025	707	1	TGbn	CC50 CR for clause 6 part 2	Yan Li(ZTE)	27-Apr-2025 21:15:57 ET	Download
27-Apr-2025 ET	2024	1919	3	TGm	Protecting TSF values in Beacon frames	Henry Ptasinski (Morse Micro)	27-Apr-2025 14:18:24 ET	Download
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27-Apr-2025 ET	2025	726	0	TGbn	Transmit and Receive Specifications for New MCS Follow-Up	Alice Chen (Qualcomm)	27-Apr-2025 02:02:47 ET	Download
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26-Apr-2025 ET	2025	345	4	TGm	PASN ID for MLO	Yan Li(ZTE)	26-Apr-2025 22:58:57 ET	Download
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25-Apr-2025 ET	2025	600	6	TGbn	PDT MAC Co-RTWT Signaling and Protocol Aspects	Giovanni Chisci, Qualcomm Technologies Inc.	25-Apr-2025 21:01:02 ET	Download
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25-Apr-2025 ET	2025	681	5	TGbn	PDT-CRs-Joint-sounding-procedure	You-Wei Chen (MediaTek)	25-Apr-2025 13:04:02 ET	Download
25-Apr-2025 ET	2025	719	0	PQC SG	PQC SG 21 April 2025 Teleconference Meeting Minutes	Alex LUNGU (Samsung)	25-Apr-2025 12:40:41 ET	Download
25-Apr-2025 ET	2025	717	0	TGbn	PDT JOINT Abbreviations and Acronyms	Akira Kishida (NTT)	25-Apr-2025 04:59:30 ET	Download
25-Apr-2025 ET	2025	715	0	TGbn	Discussion on Time Synchronization in MAP Framework	Qingwei Fu (TP-Link Systems Inc.)	28-Apr-2025 06:45:08 ET	Download
24-Apr-2025 ET	2024	209	14	TGbn	Specification Framework for TGbn	Ross Jian Yu (Huawei)	24-Apr-2025 23:19:58 ET	Download
24-Apr-2025 ET	2025	570	4	TGbn	CC50 CR for 38.3.4 Transmission of DRU	Eunsung Park (LG Electronics)	24-Apr-2025 19:40:18 ET	Download
24-Apr-2025 ET	2025	504	14	TGbn	mar-may-tgbn-teleconference-agenda	Alfred Asterjadhi (Qualcomm Technologies Inc.)	24-Apr-2025 18:08:24 ET	Download
24-Apr-2025 ET	2025	14	16	TGbn	tgbn-motions-list-part-2	Alfred Asterjadhi (Qualcomm Technologies Inc.)	24-Apr-2025 16:00:39 ET	Download
24-Apr-2025 ET	2025	712	0	TGbn	CC50 Section 9.4.2.aa2.3 PHYcap CIDs	Eugene Baik (Qualcomm)	25-Apr-2025 12:23:25 ET	Download
24-Apr-2025 ET	2025	711	0	TGbn	CC50 Section 38.3.1 phyintro CID	Eugene Baik (Qualcomm)	25-Apr-2025 12:20:47 ET	Download
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24-Apr-2025 ET	2025	638	1	TGbn	CRs for CID related to definitions in MAPC scheme	Chun Huang (ZTE)	24-Apr-2025 01:54:10 ET	Download
24-Apr-2025 ET	2025	550	1	TGbn	CC50 CR for 38.3.15.11.3	Dongguk Lim (LG Electronics)	24-Apr-2025 01:36:00 ET	Download

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18-May-2015 ET	2015	565	3	TGm	REVmc SB MAC comments	Mark Hamilton (Ruckus)	18-May-2015 14:05:19 ET	Download
18-May-2015 ET	2015	704	0	802.11 WG	May 2015 China Interim Opening Report	Jon Rosdahl (CSR)	18-May-2015 16:01:13 ET	Download
18-May-2015 ET	2014	1091	4	TGaj	TGaj Editor Report for CC20	Jiamin Chen (Huawei/HiSilicon)	18-May-2015 12:46:04 ET	Download
18-May-2015 ET	2015	703	0	TGaj	Proposed Resolutions to CID 1, 3, 4, 7, 13, 52, 64, 74, 84, 85 and 88 on TGaj D0.5 in CC20	Dejian Li (Huawei/HiSilicon)	19-May-2015 04:43:28 ET	Download
18-May-2015 ET	2015	702	0	802.11 WG	May 2015 WG China iInterim Agenda	Jon Rosdahl (CSR)	18-May-2015 15:57:45 ET	Download
18-May-2015 ET	2011	1149	44	802.11 WG	Draft Number Alignment Tool	Adrian Stephens (Intel Corporation)	18-May-2015 10:08:14 ET	Download
18-May-2015 ET	2014	1082	3	TGaj	PPDU Format for IEEE 802.11aj(45GHz)	SEU	18-May-2015 09:27:23 ET	Download
17-May-2015 ET	2014	1082	2	TGaj	PPDU Format for IEEE 802.11aj(45GHz)	SEU	17-May-2015 23:37:39 ET	Download
17-May-2015 ET	2015	701	0	TGaj	Physical Channel Encoding for 45Ghz	Liguang Li (ZTE corporation)	17-May-2015 21:31:21 ET	Download

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15-May-2015 ET	2014	1082	1	TGaj	PPDU Format for IEEE 802.11aj(45GHz)	SEU	15-May-2015 22:00:06 ET	Download
15-May-2015 ET	2015	700	0	PUB SC	minutes-may-2015	Stephen McCann (BlackBerry)	15-May-2015 16:06:09 ET	Download
15-May-2015 ET	2015	482	4	802.11 WG	May 2015 WG Agenda	Adrian Stephens (Intel Corporation)	15-May-2015 13:20:25 ET	Download
15-May-2015 ET	2015	513	3	802.11 WG	May 2015 WG Motions	Dorothy Stanley (Aruba Networks)	15-May-2015 13:13:36 ET	Download
15-May-2015 ET	2015	521	2	802.11 WG	1st Vice Chair Report May 2015 Vancouver	Jon Rosdahl (CSR)	15-May-2015 12:43:37 ET	Download
15-May-2015 ET	2015	699	0	NGP SG	NGP overview May 2015	Jonathan Segev (Intel)	15-May-2015 11:32:50 ET	Download
15-May-2015 ET	2015	682	2	REG SC	Draft Response FCC PN DA 15-516	Carolyn Heide (Ruckus)	15-May-2015 11:01:45 ET	Download
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15-May-2015 ET	2015	697	0	TGaq	TGaq Meeting Minutes - May 2015 Session	Yunsong Yang (Huawei Technologies)	15-May-2015 02:28:02 ET	Download
14-May-2015 ET	2015	482	3	802.11 WG	May 2015 WG Agenda	Adrian Stephens (Intel Corporation)	14-May-2015 23:41:38 ET	Download
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Draft

Created (ET) ▼	Year	DCN	Rev	Group	Title	Author (Affiliation)	Uploaded (ET)	Actions
03-Dec-2020 ET	2020	1771	7	TGax	P802.11ax Report to EC on Conditional Approval to forward draft to RevCom	Osama Aboul-Magd (Huawei Technologies)	03-Dec-2020 13:41:02 ET	Download
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05-Nov-2020 ET	2020	1771	2	TGax	P802.11ax Report to EC on Conditional Approval to forward draft to RevCom	Osama Aboul-Magd (Huawei Technologies)	05-Nov-2020 07:12:43 ET	Download
03-Nov-2020 ET	2020	1771	1	TGax	P802.11ax Report to EC on Conditional Approval to forward draft to RevCom	Osama Aboul-Magd (Huawei Technologies)	03-Nov-2020 17:13:56 ET	Download
03-Nov-2020 ET	2020	1771	0	TGax	P802.11ax Report to EC on Conditional Approval to forward draft to RevCom	Osama Aboul-Magd (Huawei Technologies)	03-Nov-2020 06:54:11 ET	Download
30-Oct-2020 ET	2020	1647	5	TGax	MAC CR on Fragmentation for Draft 7.0	Ming Gan (Huawei)	30-Oct-2020 11:42:45 ET	Download
30-Oct-2020 ET	2020	1647	4	TGax	MAC CR on Fragmentation for Draft 7.0	Ming Gan (Huawei)	30-Oct-2020 05:43:20 ET	Download
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20-Aug-2020 ET	2020	980	4	TGax	Mac CR on MU Cascading for Draft 6.0	Ming Gan (Huawei)	20-Aug-2020 22:00:51 ET	Download
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02-Apr-2020 ET	2020	514	2	TGax	11ax Draft 6.0 PHY Comment Resolutions	Yan Zhang (NXP)	02-Apr-2020 22:28:46 ET	Download
25-Mar-2020 ET	2020	514	1	TGax	11ax Draft 6.0 PHY Comment Resolutions	Yan Zhang (NXP)	25-Mar-2020 18:05:17 ET	Download
19-Mar-2020 ET	2020	514	0	TGax	11ax Draft 6.0 PHY Comment Resolutions	Yan Zhang (NXP)	23-Mar-2020 17:47:29 ET	Download
14-Nov-2019 ET	2019	1986	2	TGax	Sounding CRs 11ax Draft 5.0	Menzo Wentink (Qualcomm)	14-Nov-2019 18:26:35 ET	Download
11-Nov-2019 ET	2019	1986	1	TGax	Sounding CRs 11ax Draft 5.0	Menzo Wentink (Qualcomm)	11-Nov-2019 11:39:53 ET	Download
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16-Jan-2017 ET	2017	77	1	TGax	Proposed changes to Draft 1.0	Xiaogang Chen (Intel)	16-Jan-2017 11:20:26 ET	Download
16-Jan-2017 ET	2017	106	0	TGax	LB255_comments_IDCC_Draft_1_0	Kome Oteri (InterDigital)	16-Jan-2017 10:36:05 ET	Download
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02-Mar-2016 ET	2016	24	1	TGax	Proposed draft specification	Robert Stacey (Intel)	02-Mar-2016 23:56:10 ET	Download
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