IEEE P802.11
Wireless LANs

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| Minutes for Task Group (TG) 802.11 beExtremely High ThroughputTelephone Conferences in October and November 2019 |
| Date: 2019-10-23 |
| Author(s): |
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Abstract

This document contains the meeting minutes for the 4 telephone conferences held in October and November 2019.

Revisions:

* Rev0: Added the telephone conference held the 10th of October.
* Rev1: Updated the participation list for 10th of October. Added minutes from telephone conference of October 17, 2019, as minuted by Matthew Fischer (Broadcom).
* Rev2: Added the telephone conference held the 31st of October.

**Thursday 10 October 2019, 10:00 – 12:30 ET**

**Introduction**

1. The Chair (Alfred Asterjadhi, Qualcomm) calls the meeting to order at 10:07. The Chair introduces himself and the Secretary, Dennis Sundman (Ericsson)
2. The Chair reminds that the agenda can be found in 11-19/1720r0. Today we will go through submissions related to multi-AP.
3. The Chair goes through the 802 and 802.11 IPR policy and procedures and asks if there is anyone that is aware of any potentially essential patents. Nobody speaks up.
4. The Chair reminds about attendance, send an e-mail to the Secretary. Based on the join.me app, it appears to be around 100 people in the call.

**Recorded attendance through the join.me app and/or reported attendance through e-mail:**
	* Akira Kishida (NTT)
	* AL Petrick
	* Albert Bredewoud
	* Alfred Asterjadhi (Qualcomm)
	* Andy Wang
	* Assaf Kasher
	* Boyce Bo Yang (Huawei)
	* Carl Kain (USDOT)
	* Cheng Chen (Intel)
	* Dandan Liang (Huawei)
	* David Kloper
	* David Lopez-Perez
	* Dmitry Akhmetov
	* Edward Au
	* Gaurav Patwardhan
	* George Calcev
	* Gongsu Gwak (KNUT)
	* Hanseul Hong (Yonsei Univ.)
	* Insun Jang
	* Jarkko Kneckt (Apple)
	* Jason Yuchen Guo
	* Jeongki Kim (LG)
	* Jia Jia
	* Jinmin Kim
	* Jinsoo Choi
	* John Son (WILUS)
	* Joseph Levy (InterDigital)
	* Junghoon Suh
	* Kazuto Yano (ATR)
	* Kosuke Aio (Sony)
	* Lei Wang
	* Lily Lyu
	* Lorenzo Galati Giordano (Nokia Bell Labs)
	* Namyeong Kim
	* Patrice Nezou
	* Ross Yu
	* Rui Yang
	* Ryuichi Hirata (Sony)
	* Sang Kim (LGE)
	* Sang Sun
	* Sebastian Max (Ericsson)
	* Sigurd Schelstraete (Quantenna)
	* Stephane Baron (Canon)
	* Steve Shellhammer (Qualcomm)
	* Sungjin Park (LGE)
	* Taewon Song
	* Thomas Handte (Sony)
	* Xin Zuo (Tencent)
	* Yan Xin
	* Yonggang
5. The Chair asks if there are any announcements. Nobody speaks up.
6. The Chair asks if there is any objection to continue with the agenda with the submission in the listed order. Nobody speaks up, agenda approved.

**Submissions**

1. **11-19/1554r1, “Data Sharing for Multi-AP Coordination” – Sungjin Park (LG)**

**Summary:** The authors consider data sharing for joint transmission using a wireless link. They introduce several methods: Method1: Unicast data sharing, Method2: Broadcast data sharing, and Method3: Multicast data sharing.

**Discussion:**
**C:** Slide4. Are STAs a and b associated with S-APs as well as the M-AP?
**A:** No.
**C:** In this scenario, if you need to share the data first. The STAs have already the opportunity to receive the data when it is shared to S-AP. Is there really a gain to use joint transmission in this case?
**A:** We can use more streams to the STA for the JT.
**C:** How would you deal with the case if the links from the M-AP to the S-AP has errors?
**A:** We haven’t considered errors at this point.
**C:** Do you believe the S-AP should be associated to the M-AP.
**A:** Yes.
**C:** Slide 7. Why do we need an announcement frame?
**A:** The announcement frame is needed for grouping the S-APs.
2. **11-19/1573, “Channel Info. Feedback Method 4 Multi-AP Coordation” – Dandan Liang (Huawei)**

**Summary:** The authors propose a scheme where STAs only reports BFR to APs if the channel is good enough. For the APs with poor channels, the STA either sends nothing or reports the CQI.

**Discussion:**
**C:** Can we do the same thing with RSSI? So that the STA selects APs before sounding procedure.
**A:** Yes, I think that may work.
**C:** In Option 2. If we are going to have CQI and not BFR information, is this really useful?
**A:** It is good to tell the AP so it knows how bad the channel is.
**C:** What is this information supposed to be used for? Joint transmission, coordinated beamforming…?
**A:** It could be any underlying method.
3. **11-19/1588r0, “Multi-AP backhaul analysis” – Sigurd Schelstraete (Quantenna)**

**Summary:** The authors provide some analysis on impact of backhaul rate. They consider in-channel and off-channel backhauls, where in-channel shares the resources with the primary transmission. In-channel backhaul on effective throughput evaluations suggest that all gains from joint transmissions is lost due to the backhaul. For off-channel backhaul, the authors look at two scenarios: using the same antennas (same antennas as main transmission) for backhaul, or separate antennas for the backhaul. For separate antennas in the backhaul, with high backhaul rate, we can see that the JT is useful. Note that off-channel transmission is not “free”, spectrum resources are being used that could have been used otherwise. The author’s conclusion is that the only backhaul option that seems practical is off-channel wireless with dedicated resources, or wired backhaul.

**Discussion:**
**C:** Are you assuming that the S-AP is receiving backhaul data and transmitting to the STA simultaneously? In the dedicated antenna case.
**A:** I assumed they could operate simultaneously.
**C:** Do you have any assumptions on the fronthaul? For example if the STA is very poorly placed so only very low data rate could be used.
**A:** I didn’t change any settings in the fronthaul. So, this could be studied further.
4. **11-19/1592r1, “Simulation Results for Coordinated OFDMA in multi-AP operation” – Jason Yuchen Guo (Huawei)**

**Summary:** The authors have performed coordinated OFDMA simulations on system level. The coordinated OFDMA chooses resources in a random manner, which may not be optimal. Although they don’t see much gain with coordinated OFDMA they encourage other people to perform simulations.

**Discussion:**
**C:** Slide3. What’s the assumption on the path loss model between the APs and STAs?
**A:** I used the model in simulation document in 802.11ax.
**C:** Why did you choose this scenario with bursty intervals?
**A:** I believe this is how data appears in practice.
**C:** How do you consider collision between APs?
**A:** There are some collisions between the two APs. Since they are competing on the same channel, they sometimes collide.
**C:** With probability p = 0, both BSSs can use the full 160 MHz? This does not really make sense to me. It would make more sense to allocate based on traffic. I think we should dynamically allocate the BW in cooperative OFDMA.
**A:** Good comment.
5. **11-19/1593r0, “Joint Sounding for Multi-AP Systems” – Jianhan Liu (MediaTek)**
**Summary:** The authors investigate different channel sounding techniques for multi-AP. They claim that a sequential sounding can not enable joint transmissions, so a joint feedback is required. They provide two options. Option 2a: global antenna indexing, so you potentially need a very large “P-matrix”. Option 2b: interleaving subcarriers from different APs to reduce size of P-matrix. The interleaved scheme seems to provide similar performance as the baseline (large P-matrix).

**Discussion:**
**C:** Slide3. Sequential channel sounding is not appropriate for several reasons, but you claim on this slide that you cannot use sequential channel sounding.
**A:** In sequential channel sounding, the STA will feedback the V1 matrix between the AP1 and STA1, then you will get the V2 from AP2 and STA1. When you want to do the encoding you put V1 and V2 together. It has to do with the compressing. What you need to do is to stack the H matrices together and then calculate one big V-matrix.
**C:** You mention that the large P matrix increases CFO estimation and correction.
**A:** I will go through the maths next time.
**C:** Which sequence did you use for LTF interleaving?
**A:** We took the .11ax 2x LTF.

**Concluding remarks**

1. **AoB.** Nobody speaks up.

**Adjourned.**

**Thursday 17 October 2019, 07:30 – 10:00 ET**

**Introduction**

1. The Chair (Alfred Asterjadhi, Qualcomm) calls the meeting to order at 07:33. The Chair introduces himself and the acting Secretary and vice chair, Matthew Fischer (Broadcom)
2. The Chair reminds the attendees that the agenda can be found in 11-19/1720r1. The agenda for today includes submissions related to joint transmission and other topics.
3. The Chair reviewed the 802 and 802.11 IPR policy and procedures and asks if there is anyone that is aware of any potentially essential patents. Nobody speaks up.
4. The Chair reminds attendees to note their attendance, by sending an e-mail to the Secretary. Based on the join.me app, there are 112 dialed lines, some of which might represent multiple participants.

**Recorded attendance through e-mail:**
	* Alfred Asterjadhi (Qualcomm)
	* Cheng Chen (Intel)
	* David Lopze Perez (Nokia)
	* Dmitry Akhmetov (Intel)
	* Jarkko Kneckt (Apple)
	* Kazuto Yano (ATR)
	* Lily Yunping Lyu (Huawei)
	* Liwen Chu (Marvell)
	* Matthew Fischer (Broadcom)
	* Ron Porat (Broadcom)
	* Sharan Naribole (Samsung)
	* Steve Shellhammer (Qualcomm)
	* Yongho Seok (Mediatek)
5. Chair asks for any announcements – none from the attendees, but the chair announces that a session slot for Tuesday PM3 of the November 2019 meeting is available and that he will ask for that slot for TGbe and send an updated schedule
6. The Chair asks if there is any objection to continue with the agenda with the submission in the listed order. Nobody speaks up, agenda approved.

**Submissions**

1. **11-19-1594-02-00be-coordinated-beamforming-null-steering-protocol-in-802-11be – David Lopez-Perez (Nokia)**

**Summary:** The authors review the major joint transmission/reception challenges, put forward coordinated beamforming/null steering as an appealing inter-AP coordination scheme, and sketch a protocol to efficiently realize the coordinated beamforming/null steering gains.

**Discussion:**
C: Slide 12 - Is null steering used for UL?
R: There is UL-UL scheduling.
C: so this is BF?
R: N, there are receive filters for UL at the AP
C: So the CSI is for DL
R: Y
C: slide 12 – trigger frames are not aligned, using SR parameters, for ACK, there is alignment, why different?
R: Null steering used for ACK transmissions by the APs, also could use for TFrame, could also use contention based, UL based
C: slide 7 – how does AP2 know which STAs to include for SR?
R: AP2 can use previous TX results to determine if interference is present and that SR could be beneficial
C: slide 9 – why AP1 has to receive FB from donnee AP2
R: so that AP1 can create a null
C: slide 12 – UL use case, AP2 TF is ok because of null with AP1, and why UL case?
R: yes – because of null, can do SR in any case, just started with UL because SR parameters are available in that case
C: receive nulls are shown, can you determine these through sounding FB?
R: N, for UL, through preamble, assuming you have spare atennnas
C: slide 12 – is AP2 TF using anything other than ordinary channel sensing?
R: no
2. **11-19-1595-00-00be-consideration-on-joint-transmission - Lily Yunping Lyu (Huawei Technologies Co. Ltd.))**

**Summary:** The authors suggest that the gain of JT is very attractive, while on the other hand, JT has stringent requirements. Following challenges have been mentioned in TGbe till now: Heavy load on backhaul and Stringent synchronization requirement. In this presentation, we analyze the feasibility to exploit JT in scenarios with wired backhaul, such as enterprise market, and some residential markets.

**Discussion:**
C: the scenarios indicated are cases that should be considered as valuable applications of JT and therefore, justify the inclusion of JT in TGbe
R: agree
C: slide 5 –architecture question, do these switches and coordinators need to be included in 802.11?
R: no, but if we allow a non-wired backhaul case, then we might need to include something in the 11be amendment
C: will JT be effective in a home scenario?
R: yes, for example, in China, each room has a port, so that a wired backhaul is possible
C: which AP will be the one with the coordinator and switch?
R: one of them
C: wireless backhaul should also be considered/included in TGbe scope of work for JT
R: agree, some scenarios might not have access to a wired backhaul
C: slide 7 – 300 Hz number – can you do better
R: this is from a paper – in our own results, we can do better
3. **11-19-1597-00-00be-jt-performance-with-multiple-impairments - Ron Porat (Broadcom)

Summary:** The authors update their JT results from [11-19-0799-01-00be-comparison-of-cbf-and-jt] (simulation configuration r1) to include the impact of additional impairments.

**Discussion:**
C: slide 3 – power difference is due to what?
R: between sounding and JT, slave and master powers might drift
C: other impairment numbers depend on estimation and SNR, right?
R: yes, but JT is better suited for higher SNR, so 0.5 ns seems ok, CFO depends on SNR as well and we think that the number used is ok for the case when JT is applicable
C: phase drift accumulates
R: worst case only for the entire reception applied to every symbol, reality will be better because we agree that it starts lower and then grows
C: residual CFO should be 20 Hz because it is +/-10 Hz
R: we assume a fixed 10 Hz, but yes, we assign each AP from a range of -4 degrees to +4 degrees
C: so that is +/- 10 Hz – did you apply residual CFO to both sounding and data?
R: no errors applied to sounding
C: would like to see the CFO applied to the sounding as well
R: we model errors on the SNR in the sounding, but not phase error, because the sounding is so short it will be a very tiny error
C: yes, but small errors are important in the sounding because they are multiplicative because they are the measurement frame – maybe 64 usec of duration
C: we simulated sounding phase error and it does have an impact on channel estimation error, but do not know the impact on JT
C: slide 4 first bullet v slide 3 first bullet – what is the difference?
R: phase error of channel estimation vs relative error between APs
4. **11-19-1616-01-00be-multi-ap-group-formation – Cheng Chen (Intel)

Summary:** Most EHT Multi-AP contributions so far have primarily focused on how to leverage the coordination within a Multi-AP group, assuming some APs act as Triggering APs and others serve as Triggered APs. In this presentation we study the fundamental framework of Multi-AP operations, i.e., the formation of a group of APs for various Multi-AP coordination functions. We focus on the management/control role of one AP among a group of APs that participate in Multi-AP coordination functions. We do not consider the sequence-trigger roles, i.e., who can send Multi-AP trigger frames etc. We will call the set of these APs as an EHT Multi-AP group. For simplicity, we use terminologies of the Coordinator AP and Coordinated APs in the management domain to differentiate it from the Master AP and Slave APs used in the domain of specific trigger operations as in most previous presentations

**Discussion:**
C: what is the role of the coordinator wrt group formation?
R: management and control
C: example?
R: long term scheduling coordination
C: master and slave are different from coordinator and coordinated?
R: yes, coordinator can define which AP can be a master and which are its slaves
C: coordinator/coorindated signalling wireless or wired?
R: no restriction
C: coorindator function can be in the wired DS which is not in the scope of 802.11
R: not saying that we have to define the coorindator functions as part of 802.11
C: but it could be either way – coordinator is present on 802.11 network or in wired, so I don’t know what you would include in 802.11
R: hooks to allow communication
C: group formation is good, I agree, slide 2 – if implementation specific then how do different vendors form a group?
R: user can decide how to assign coordinator function
C: coordinator to coordinated through wire or wireless?
R: no restriction
C: multi-AP has more than one joint TX mechanism, can this group be used for all of those mechanisms?
R: not discussed yet, but we could support that
C: JT could be dynamically coordinated without any group formation, except adhoc per TXOP
5. **11-19-1159-01-00be-multilink-operation-capability-announcement – Liwen Chu (Marvell)

Summary:** The capability to use multiple links by a multi-link logical entity should be announced. Whether a multi-link logical entity can do transmission while reception in more than one link

**Discussion:**
C: Audio problems occurred with presenter, so that the presentation was deferred
6. **11-19-1231-03-00be-multiband-and-multichannel-operation-in-ieee-802-11be –** Sai Shankar **(Cypress)

Summary:** New ways of operating in bands Efficient use of spectrum Leveraging underutilized spectrum Increased data rates Network load balancing Dynamic fast switching between bands/channels

**Discussion:**
C: the presenter was not present on the call, so the presentation was deferred
7. **11-19-1291-03-00be-performance-aspects-of-multi-link-operations –** Dmitry Akhmetov (Intel) **Summary:** An examination of the relative performance of three methods of multiple link medium access. SPC: Single Primary Channel with a PIFS medium condition check on the non primary to decide whether to transmit on the non-primary. MPC: Multiple Primary Channel and independent transmit and receive on the links. JMPC: Join Multiple Primary Channel, first backoff wins, with PIFS medium examination to decide whether to transmit on the other link.

**Discussion:**
C: slide 9 – the reported throughput for SPC vs the probability of two link access do not match up, using the 15% probability, the throughput should be 345 Mbps, not 600 Mbps
R: the network is not fully loaded, so all traffic can be delivered eventually, even though two links are active during only 15% of all TXOPs and 1 link active for 85% of all TXOPs

**Concluding remarks**

1. **The chair asks if there is any other business,** Nobody speaks up.

**22:01 Adjourned.**

**Thursday 31 October 2019, 10:00 – 12:30 ET**

**Introduction**

1. The Chair (Alfred Asterjadhi, Qualcomm), calls meeting to order. The Chair introduces himself and the Secretary, Dennis Sundman (Ericsson).
2. The Chair asks if anyone is aware of any potentially essential patents. Nobody speaks up.
3. The Chair reminds about attendance, send an e-mail to the Secretary. Based on the join.me app, it appears to be around 80 people in the call.

**Recorded attendance through the join.me app and/or reported attendance through e-mail:**
	* Dennis Sundman (Ericsson)
	* Abhishek Patil
	* Al Petrick
	* Albert Bredewoud
	* Alfred Asterjadhi (Qualcomm)
	* David Kloper (Cisco)
	* Dongguk Lim
	* Insun Jang (LGE)
	* Jason Yuchen Guo
	* Jinmin Kim (LGE)
	* Jinsoo Choi
	* Joseph Levy (InterDigital)
	* Junghoon Suh (Huawei)
	* Kazuto Yano (ATR)
	* Ley Wang
	* Liwen Chu
	* Mark Hamilton (Ruckus/CommScope)
	* Miguel Lopez (Ericsson)
	* Ming Gan (Huawei)
	* Namyeong Kim
	* Rojan Chitrakar (Panasonic)
	* Ruy Yang (InterDigital)
	* Sang Kim (LGE)
	* Srinivas Kandala
	* Sharan Naribole (Samsung)
	* Steve Shellhammer (Qualcomm)
	* Taewon Song
	* Yan Xin
	* Yonggang Fang
	* Yongsu Gwak
	* Young Hoon Kwon (Marvell)
	* Yunbo Li
	* Jarkko Kneckt (Apple)
	* Sebastian Max (Ericsson)
4. The Chair asks if there are any announcements. Nobody speaks up.

**Submissions**

1. **11-19/1405r1, “Multi-Link Channel Access Discussion – Sharan Naribole (Samsung)**
**Summary:** The authors study a multi-link simultaneous transmit and receive (STR) mechanism. They believe that the AP shall support STR, but the STAs may not support STR. The authors also discuss how backoffs may work unduer the multi-link setup: STR capable devices may have several backoffs running simultaneously on multiple links, but when receiving on one link, the other links pause their backoffs.

**Discussion:**C: If an AP is receiving from one STA, can it transmit to another STA on the other link?
A: Yes.
C: If there is a preamble on two links at the same time. Which one is the STR/non-STR STA receiving?
A: We are not considering multiple receiving links at this stage, but in principle you can receive both.
C: Slide 9, I think there may be an issue for multiple STAs that miss the preamble.
A: This can happen.
C: I believe it is reasonable that some APs are not STR.
A: Thanks for the comment. Let’s have offline discussion.
C: Slide 7, why should non-STR STA stop countdown?
A: Because packet on the other link may be to the non-STR STA.
C: Does the STAs countdown at ch B take into account OBSS/basic NAV on that channel?
A: Yes. This is all on top of these procedures.
2. **11-19/1505r1, “Multi-link TXOP Aggregation Considerations” – Sharan Naribole (Samsung)

Summary:** The authors propose to enable simultaneous multi-link TXOP reservation. The link in which the BO counter reaches 0 first dictates when channels on the aggregated links are accessed.

**Discussion:**
C: Slide 6. I am concerned with the fairness. There can be a single link STA also on link B. What happens then?
A: This should be dynamic.
C: Whomever has a secondary channel as their primary, already today we have a fairness issue. What is the difference here?
A: We have multiple-primary channel scenario here.
C: Slide 5 for example. It seems you can use one link to get unfair BO advantage on another link.
A: Yes, this can happen in principle.
3. **11-19/1509r1, “Discussion on Multi-link Setup” – Insun Jang (LGE)**
**Summary:** The authors discuss how to signal multi-link capabilities: what information should go where. They also provide an example of ML setup procedure.

**Discussion:**
C: We need to advertise this information somehow. In your setup procedure on slide 10, are you following the convention that the non-AP STA initiates the procedure or can the AP do it?
A: Both non-AP STA and AP STA may do that.
4. **11-19/1512r1, “Multi-Link Acknowledgment” – Rojan Chitrakar (Panasonic)**

**Summary:** The authors discuss how block ACK (BA) should work in multi-link. They propose that a single multi-link BA agreement is setup between two multi-link entities.

**Discussion:**
C: Is the BA agreement per link or for multiple-link.
A: For the setup I assume we can use a single setup.
C: We should try to minimize the number of new terms.
A: I am open to that.

**Concluding remarks**

1. The Chair asks if there is any other business. Notbody speaks up.
2. The Chair mentions that the next telephone conference meeting is to be held November 7th.

**Adjourned.**