

IEEE 802
Local and Metropolitan Area Network Standards Committee

Paul Nikolich
Chairman, IEEE 802 LMSC



TO: Satoshi Nagata, 3GPP TSG RAN WG1 Chair, nagatas@nttdocomo.com

CC: Dino Flore, 3GPP TSG RAN Chair, oflore@qti.qualcomm.com
Susanna Kooistra, 3GPP Liaison Coordinator, susanna.kooistra@3gpp.org
John D'Ambrosia, IEEE 802 Recording Secretary, JAmbrosia@gmail.com
Steve Shellhammer, IEEE 802.19 Coexistence WG Chair, shellhammer@ieee.org

SUBJECT: Review of 3GPP LAA Specification Rel. 13

DATE: 01 August 2016

Dear Dino & Satoshi,

Thank you once again for supporting the ongoing cooperation over the last year or so between IEEE 802 and 3GPP RAN/RAN1 in relation to coexistence issues between LAA and 802.11 systems. This cooperation will hopefully ensure the various versions of LAA are designed in such a way that 802.11 and LAA systems will coexist fairly in unlicensed spectrum. IEEE 802 notes that the importance of fair coexistence to a wide diversity of stakeholders has been highlighted once again by a series of letters recently sent to 3GPP RAN, and copied to IEEE 802, by representatives of the cities of New York, Madison (Wisconsin), Leverett (Massachusetts), Independence (Oregon) and Monmouth (Oregon).

In IEEE 802's Liaison Statement to 3GPP RAN1 dated 21 May 2016 (EC-16-0082-00), IEEE 802 expressed a concern that any changes arising from IEEE 802's Liaison Statement to 3GPP RAN1 dated 18 March 2016 (802.19-16-0037-09, containing twelve important technical comments related to LAA Rel. 13) would be ineligible to be included in LAA Rel. 13 because of the delay in 3GPP RAN1 considering IEEE 802's comments and the subsequent inability for IEEE 802 to consider 3GPP RAN1's responses until IEEE 802's July 2016 face to face meeting. IEEE 802 was pleased to receive 3GPP RAN's confirmation in 3GPP RAN's Liaison Statement dated 19 June 2016 (RP-161228) that while LAA Rel. 13 was frozen at RAN#71 in March 2016, this does not preclude corrections to the channel access parameters or procedures. These are the topics likely to be of most relevance to any coexistence issues between LAA and 802.11 systems.

The recent interactions between 3GPP RAN/RAN1 and IEEE 802 in relation to LAA are based on the understanding from the 3GPP LAA Workshop in August 2015 that 3GPP RAN/RAN1 operates according to a consensus process and the agreement that IEEE 802, as an important stakeholder in the fair use of unlicensed spectrum, should be included in the consensus process. Since that time, IEEE 802 has sent a number of Liaison Statements to 3GPP RAN/RAN1 as part of our commitment to participate in the consensus process.

This Liaison Statement includes, in the appendix, commentary from IEEE 802 members on all of the responses included in 3GPP RAN1's Liaison Statement received by IEEE 802 on 7 June 2016 (R1-166040). The commentary suggests that some of the comments in IEEE 802's Liaison Statement to 3GPP RAN1 dated 18 March 2016 (802.19-16-0037-09) have been resolved satisfactorily. This represents a great success for the consensus process that started with the 3GPP LAA Workshop back in August 2015. However, there are a number of important outstanding issues, for which we request 3GPP RAN1 to continue to look for satisfactory compromises with IEEE 802 and other interested stakeholders.

The following table contains a summary of the status of the twelve comments on LAA Rel. 13 that were previously liaised by IEEE 802 to 3GPP RAN1. The status column is color coded to indicate the level of consensus on each issue. **Green** indicates “consensus” or “resolution”; **red** indicates “lack of consensus” or “no resolution”; **orange** indicates “progress towards consensus” or “progress towards resolution”.

#	Comment by IEEE 802 in Liaison Statement to 3GPP RAN1	Status
1	<i>Radio equipment in unlicensed spectrum should not transmit energy for the primary purpose of blocking access to the channel to others</i>	Possibility for consensus & resolution
2	<i>Transmission of Discovery Reference Signals should be clearly bounded to avoid excess airtime overhead on unlicensed spectrum</i>	Some consensus, but not fully resolved
3	<i>Radio equipment in unlicensed spectrum should detect neighboring networks with sufficient sensitivity to ensure fair coexistence</i>	No consensus, and not resolved
4	<i>LAA and IEEE 802.11 slot boundaries should align as accurately as possible to preserve spectral efficiency in unlicensed spectrum</i>	No consensus, and not resolved
5	<i>LAA and 802.11 multi-channel aggregation schemes should align</i>	No consensus, wait for measurements
6	<i>Radio equipment in unlicensed spectrum should stop transmission as soon as transmission of useful data is complete</i>	Possibility for consensus & resolution
7	<i>Channel access that is obtained using special access mechanisms for high priority data should not be used to transmit lower priority data</i>	Consensus but not fully resolved
8	<i>The maximum continuous transmission time should be limited to avoid blocking latency sensitive traffic on coexisting networks</i>	Consensus but not fully resolved
9	<i>Adjustment of channel access contention window should be based on comparable indicators of congestion to ensure fairness between technologies</i>	No consensus, wait for measurements
10	<i>Adjustment of channel access contention window should be clearly defined</i>	Consensus, and resolved
11	<i>The channel access state machine during channel sensing should be clearly defined</i>	Consensus, and resolved
12	<i>The use of the back off mechanism should be clearly defined</i>	Substantial consensus, but not fully resolved

IEEE 802 looks forward to a continued, productive interchange between our two organizations on these and other issues during the development of LAA Rel. 14.

The next two IEEE 802 meetings are on 11-16 September 2016 in Warsaw, Poland and 6-11 November 2016 in San Antonio, Texas, US.

Regards,

/s/ Paul Nikolich

Paul Nikolich, Chairman, IEEE 802 LAN/MAN Standards Executive Committee
IEEE Fellow
p.nikolich@ieee.org

Appendix: responses to 3GPP RAN1's Liaison Statement (R1-166041)

1. There is a possibility of future consensus and resolution of the issue, *Radio equipment in unlicensed spectrum should not transmit energy for the primary purpose of blocking access to the channel to others*

Response 1.1: RAN1's response to IEEE 802's comment suggests a possibility for consensus based on 3GPP RAN1's observation that LAA never needs to send reservation signals

IEEE 802's Liaison Statement to 3GPP RAN1 dated 18 March 2016 (IEEE 802 19-16-0037-09-0000-laa-comments.pdf) suggested in comment 1 that *LAA should be modified to avoid sending energy for the primary purpose of blocking access to the channel to others*. IEEE 802 documented two options for potential modifications. The basis for IEEE 802's suggestions was its understanding that *LAA needs to maintain control of medium between gaining access and transmitting synchronized data bursts by sending energy, but transmitting energy for sole purpose of blocking others is contrary to best practice everywhere and possibly regulations in some domains*.

3GPP RAN1's response to this comment was included in 3GPP RAN1's Liaison Statement dated 7 June 2016 (R1-166041). 3GPP RAN1 noted that LAA Rel. 13 *does not mandate transmitting any signals between the time the channel access is obtained and the subframe or slot boundary* and that any such signals are *an implementation choice* and not a matter for specification in LAA Rel. 13. 3GPP RAN1 provided four reasons why no changes are required in LAA Rel. 13 to address IEEE 802's concerns.

3GPP RAN1's response was discussed at a recent ETSI BRAN based on a submission (BRAN(16)000111r0) that undertook a detailed decomposition of 3GPP RAN1's response. This submission proposed a regulatory action in Europe that would ban the transmission of signals for the primary purpose of blocking other devices from using a channel. The basis of this proposal was that the four reasons provided by 3GPP RAN1 are either invalid or irrelevant to a conclusion that no change was necessary to LAA Rel. 13. Instead, it was asserted in the submission that the four reasons actually provide excellent support for a conclusion that LAA Rel. 13 systems should not transmit signals to reserve the channel between the time they gain access to a channel using the LBT mechanism and the time they are ready to transmit LAA Rel. 13 defined signals.

It is worth noting that the discussion on this proposal at the ETSI BRAN meeting was very contentious, with stakeholders from both the 3GPP and IEEE 802 communities participating, and that there was no consensus for the proposal for regulatory action. No doubt the issue will be discussed within ETSI BRAN again in the near future.

However, there was agreement at the ETSI BRAN meeting that regardless of what was regulated in Europe or included by 3GPP RAN1 in LAA Rel. 13, LAA Rel. 13 systems operating in Europe must satisfy RE-Directive 2014/53/EU, which requires radio equipment to make efficient use of spectrum and avoid harmful interference. In particular, this Directive:

- References article 2.2 (1) in Directive 2002/21/EC, which states in part that *'radio equipment' means an electrical or electronic product, which intentionally emits and/or receives radio waves for the purpose of radio communication and/or radiodetermination ...*
- States in article 3.2 that *radio equipment shall be so constructed that it both effectively uses and supports the efficient use of radio spectrum in order to avoid harmful interference*

A case was made at the ETSI BRAN meeting that that an LAA device transmitting signals primarily for the purpose of blocking other devices from accessing a channel would not satisfy the RE-Directive 2014/53/EU's definition of *radio equipment*. The specific problem was asserted to be that *radio communications* inherently requires both a transmitter and a receiver. A receiver function is missing in this case because no device needs to demodulate the signal that blocks other devices using the channel, noting that the LAA Rel. 13 does not contain any specification for the transmission or reception of such signals.

It was also asserted at the ETSI BRAN meeting that transmitting signals primarily for the purpose of blocking other devices from accessing the channel is contrary to the rule in Europe requiring efficient use of the medium because such transmissions make use of the channel but are actually unnecessary. The unnecessary nature of any such transmissions was highlighted by the 3GPP RAN1 Liaison Statement, which in the first reason related to comment 1 noted that fair coexistence between LAA and Wi-Fi was possible, and that LAA could operate with good performance, without the transmission of such signals. 3GPP RAN1's Liaison Statement specifically states in this regard that:

... deferring sending energy until a subframe boundary or partial subframe boundary, satisfied the criteria that the presence of an LAA network doesn't cause more degradation to 802.11 than the presence of another 802.11 network, and also provided good LAA performance, so it is considered a viable implementation option

It needs to be noted the discussion at the most recent ETSI BRAN meeting related to how the RE-Directive 2014/53/EU's rules should be interpreted in the context of the transmission of signals that block access to a channel was also very contentious and there was no consensus.

At this time, many IEEE 802 stakeholders believe that the issues highlighted in comment 1 in IEEE 802's Liaison Statement to 3GPP RAN1 dated 18 March 2016 remain unresolved. However, 3GPP RAN1's response to comment 1 suggests an opportunity for an acceptable compromise that should satisfy the needs of all stakeholders. The key insight highlighted by 3GPP RAN1 in their response is that *deferring sending energy until a subframe boundary or partial subframe boundary* does not cause any harm to the performance of LAA and supports fair sharing between LAA and Wi-Fi systems.

3GPP RAN1 is urged to seriously consider and accept the following IEEE 802 proposal to assist the closure of an issue that is very important to many IEEE 802 stakeholders.

This insight suggests that consensus can be achieved between all stakeholders. It is now recommended that 3GPP RAN1 include something similar to the following note in the LAA Rel. 13 specification:

Implementation note: LAA devices should not transmit any signals in a channel between the time a device obtains access to the channel using LBT Category 4 and the time of the next subframe or partial subframe boundary because transmitting such signals:

- *May violate rules in some regulatory domains*
- *Is contrary to the best practice that unnecessary transmissions are avoided in unlicensed spectrum*
- *Is unnecessary because LAA can achieve good performance without such signals*
- *Is unnecessary because LAA can achieve fair sharing with other technologies without such signals*

An acceptable alternative would be for 3GPP RAN1 to agree publically with the principles articulated by the proposed note. Under both alternatives, enforcement would need to be left to other authorities.

Response 1.2: IEEE 802 suggests an additional solution based on the definition of multiple sub-frame starting positions

IEEE 802's Liaison Statement to 3GPP RAN1 dated 18 March 2016 (IEEE 802 19-16-0037-09-0000-laa-comments.pdf) suggested in comment 1 that *LAA should be modified to avoid sending energy for the primary purpose of blocking access to the channel to others*. IEEE 802 provided two possible solutions for consideration by 3GPP RAN1 to resolve this problem. However, it has since been noted by an IEEE 802 participant that there is at least one additional solution that might be acceptable to all parties.

The goal of any solution is to minimise the time from when LAA gains access to the channel and the time it starts transmission of a sub-frame or partial sub-frame. Currently, LAA only supports two starting positions (0.5ms and 1ms boundaries i.e. 6/14 OFDM symbols) , which results in a difference between the time from when LAA gains access to the channel and the time it starts transmission of a sub-frame or partial sub-frame of up to 0.5ms or 1ms. It is contrary to regulations and/or best practice for an LAA system to transmit energy in such a long gap for the primary purpose of reserving the channel.

The additional possible solution is to reduce the duration of any reservation signal by increasing the number of possible starting positions of a partial sub-frame. IEEE 802 recognises that this may lead to increased complexity for the LAA eNB because LAA, not knowing in advance when the LBT may be successful, may need to keep Transport Blocks (TBs) compatible with all possible lengths of a partial sub-frame prepared in advance. However, doing so would just be a logical extension of what has to be done for two starting positions and will be worthwhile because it reduces the wastage of unlicensed resources.

IEEE 802 requests that 3GPP RAN consider defining additional partial sub-frame starting positions in LAA Rel. 13, so that the need to send reservation signals is minimized. IEEE 802 notes that 3GPP RAN is already considering shortened sub-frames (see RP-161299) because they help reduce latency in LTE and adapt it better for time critical applications (gaming, V2V and V2X communications etc.).

Further, IEEE 802 requests 3GPP RAN1 specify the use of this feature as a mandatory requirement for the eNB in LAA Rel. 13 rather than leaving it as an eNB recommendation as is the case currently.

Response 1.3: IEEE 802 requests 3GPP RAN1 confirm that HARQ operation is not related to comment 1

IEEE 802's Liaison Statement to 3GPP RAN1 dated 18 March 2016 (IEEE 802 19-16-0037-09-0000-laa-comments.pdf) suggested in comment 1 that *LAA should be modified to avoid sending energy for the primary purpose of blocking access to the channel to others*. Part of 3GPP RAN1's response to this comment included the following assertion, which IEEE 802 believes is incorrect:

The proposed changes would have an effect in making HARQ operation less efficient, since first transmission and retransmission would use different subframe lengths

IEEE 802 notes the following extract from 3GPP TS 36.321:

If the MAC entity receives a retransmission with a TB size different from the last valid TB size signalled for this TB, the UE behavior is left up to UE implementation.

In the context of this extract, IEEE 802 believes 3GPP RAN1 is asserting that if transmissions can happen in multiple time units (and not necessarily in one sub-frame), it is possible that the eNB will not be able to allocate the same TB size (the PHY data packet) for a first transmission and a retransmission. It appears 3GPP RAN1 is claiming that since the UE HARQ behaviour is left undefined, the UE may ignore the retransmission and hence the HARQ gain will be reduced.

However, IEEE 802 notes that different transmission time units don't necessarily force the eNB to use different TB sizes for retransmissions. HARQ efficiency depends on the TB size in bits and not on the transmission duration in time. The TB size depends upon the MCS used, the number of Physical Resource Blocks (PRBs or frequency resources) allocated and additionally (in case of partial sub-frames) the number of symbols in the subframe. It is possible to maintain the same TB size by adjusting these 3 parameters.

There may be cases when the eNB scheduler is not able to accommodate a retransmission in a certain partial subframe. In that case, the retransmission can be accommodated in a non-partial subframe and the partial subframe can be used for transmitting new data. Also, for retransmitting data that was initially transmitted in a partial subframe, it is possible to adjust number of PRBs and MCS and accommodate it in a non-partial subframe or a partial subframe of a different length.

IEEE 802 requests that 3GPP RAN1 clarifies IEEE 802's understanding in this case. IEEE 802 further requests that 3GPP RAN1 confirms that HARQ efficiency is not related to the issue raised in comment 1.

**2. There is a possibility of future consensus and resolution of the issue,
*Transmission of Discovery Reference Signals should be clearly bounded to avoid
excess airtime overhead on unlicensed spectrum***

Response 2.1: IEEE 802 requests 3GPP RAN1 impose additional constraints on DRS overheads

IEEE 802's Liaison Statement to 3GPP RAN1 dated 18 March 2016 (IEEE 802 19-16-0037-09-0000-laa-comments.pdf) suggested in comment 2 that the *LAA specification be modified to include reasonable limits on how often the channel may be accessed using the DRS mechanism.*

3GPP RAN1's response to this comment was included in 3GPP RAN1's Liaison Statement dated 7 June 2016 (R1-166041). 3GPP RAN1 agreed to limit the DRS overhead per eNB to 5%.

However, a DRS limit of 5% is still much higher than the typical transmission overhead of equivalent 802.11 transmissions. In 802.11, only the Traffic Indication Map (TIM) and Channel Switch Announcement (CSA) messages can be transmitted with 25us LBT similar to LAA DRS. The transmission of such messages is typically significantly less than 1% per AP.

IEEE 802 requests 3GPP RAN1 further reduce the DRS overhead for LAA Rel. 13 to a value closer to that resulting from 802.11 TIM and CSA overhead, which is significantly less than 1%. Alternatively, IEEE 802 requests that LAA Rel. 13 be specified to use 25us LBT for DRS transmissions up to 1% overhead and Category 4 LBT with EDCA parameters of AC_VO for DRS transmissions beyond 1%. IEEE 802 believes such a change will promote fair access to the medium for both LAA Rel. 13 and IEEE 802.11 systems.

3. There is not yet consensus or resolution of the issue, *Radio equipment in unlicensed spectrum should detect neighboring networks with sufficient sensitivity to ensure fair coexistence*

Response 3.1: IEEE 802 requests 3GPP RAN1 to consider the ED threshold based on a more realistic channel model

IEEE 802's Liaison Statement to 3GPP RAN1 dated 18 March 2016 (IEEE 802 19-16-0037-09-0000-laa-comments.pdf) suggested in comment 3 that the LAA specification be modified so that LAA system *detect 802.11 networks with a similar level of sensitivity to that with which current 802.11 devices can detect each other*. Alternatively, IEEE 802 requested that LAA Rel. 13 require *a base energy detection threshold of TH = -77dBm (20MHz), or preferably lower*.

3GPP RAN1's response to this comment was included in 3GPP RAN1's Liaison Statement dated 7 June 2016 (R1-166041). The response rejected IEEE 802's request based on 3GPP RAN1's opinion *that the agreed threshold levels will ensure fair coexistence as simulations based on the 3GPP indoor scenario have shown fair-coexistence when using the agreed CCA threshold*.

However, measurements of deployed 802.11 networks (such as R1-165927 and R1-162982 presented to 3GPP RAN1) show that in many deployments, the median RSSI over *all* Wi-Fi links is much lower than the median RSSI (= -48dBm) over *all* links in the 3GPP indoor model. Hence, any fair coexistence evaluations based on the 3GPP indoor model are not directly applicable to coexistence between LAA and 802.11 in deployments with low RSSI 802.11 links. The basis for 3GPP RAN1's response to IEEE 802 is therefore invalid.

IEEE 802 requests that 3GPP RAN1 consider the fairness of an LAA ED threshold of -72dBm on coexistence between LAA and 802.11 in a configuration that has a larger percentage of weak 802.11 links than what is currently assumed in the 3GPP indoor model. IEEE 802 suggests using the measurements from R1-165927 and R1-162982 as a basis for selection of simulation parameters IEEE 802 would prefer that this issue is resolved before any coexistence issues occur.

4. There is not consensus or resolution of the issue, *LAA and IEEE 802.11 slot boundaries should align as accurately as possible to preserve spectral efficiency in unlicensed spectrum*

Response 4.1: IEEE 802 requests that 3GPP RAN1 align LAA & 802.11 slots to preserve efficiency

IEEE 802's Liaison Statement to 3GPP RAN1 dated 18 March 2016 (IEEE 802.19-16-0037-09-0000-laa-comments.pdf) observed in comment 4 that the *LAA specification does not ensure time alignment of its slot boundary with IEEE 802.11 slot boundary*, with the effect that *large slot time offsets between LAA and 802.11 introduces more transmission collisions which reduce spectral efficiency and degrade both LAA and 802.11 performance*. IEEE 802 suggested that *LAA should time align its slot boundary with 802.11 slot boundary as accurately as possible*. 3GPP RAN1's response to this comment was included in 3GPP RAN1's Liaison Statement dated 7 June 2016 (R1-166041).

The first part of 3GPP RAN1's response focused on IEEE 802's proposed solution. The response noted that 3GPP RAN1 believes that *it would be (an) undue burden to require all LAA equipment to detect 802.11 PHY preamble and MAC NAV field*. IEEE 802 notes that it did not actually ask for LAA Rel. 13 to detect the MAC NAV field. Rather, it asked for LAA Rel. 13 to detect and transmit 802.11 PHY preambles. IEEE 802 agrees that this would be an additional burden but it has the benefit of enabling the alignment of LAA and 802.11 slots, which will enhance spectral efficiency. As an alternative, IEEE 802 suggested that LAA Rel. 13 include an improved energy detection mechanism that is more accurately able to detect the boundary at the end of an IEEE 802.11 transmission.

The second part of the response focused on the problem. 3GPP RAN1 asserted that the problem does not occur very often because *contending nodes using random backoff based LBT typically do not attempt data transmission within a few microseconds of each other*. This response is incorrect and represents a fundamental misunderstanding of the importance of slot synchronization in any LBT system. If LAA Rel. 13 has poor slot synchronization then the highlighted problem is guaranteed to occur one hundred percent of the time. The effect is that slotted ALOHA style access is converted into ALOHA style access; the efficiency of ALOHA is half of slotted ALOHA.

3GPP RAN1 also asserted that there is no problem because the simulations during the SI showed that *the presence of an LAA network doesn't cause more degradation to 802.11 than the presence of another 802.11 network*. IEEE 802 agrees that the SI simulations were very useful to show that an LBT Category 4 style scheme was the most appropriate access mechanism for LAA Rel. 13. However, the SI simulations cannot reasonably be used to draw any conclusions about the details of LAA Rel. 13 coexistence with IEEE 802.11 because:

- None of the SI simulations implemented the access method specified in LAA Rel. 13, except in very broad terms, and it is unclear how accurately they implemented the detail of IEEE 802.11 (or what version – both 802.11n and 802.11ac should have been simulated in recognition of the large number of currently deployed systems)
- The SI simulation scenarios were very limited in scope (e.g., the indoor scenario was a simple 4x2 matrix of APs), thus not representing the wide diversity of scenarios found in the real world
- Work presented to ETSI BRAN has established that the propagation models used in the 3GPP evaluations do not simulate common deployment scenarios sufficiently well

3GPP RAN1 finally asserted that the problem could be solved by relying on LBT backoff. IEEE 802 agrees that the LBT backoff mechanism will allow data to be transmitted eventually. However, the downside of a solution that more heavily relies on collisions and backoff is significantly reduced spectrum efficiency and quality of service with a consequent adverse effect on all users of the spectrum.

July 2016

IEEE 802 believes that there is not consensus on this issue and requests that 3GPP RAN1 reconsider its previous response based on the additional material above.

5. There is not consensus but resolution should be postponed on the issue, *LAA and 802.11 multi-channel aggregation schemes should align*

Response 5.1: IEEE 802 suggests resolution of the multi-channel aggregation issue be postponed until coexistence tests can be run

IEEE 802's Liaison Statement to 3GPP RAN1 dated 18 March 2016 (IEEE 802.19-16-0037-09-0000-laa-comments.pdf) observed in comment 5 that non-contiguous and/or differently aligned use of spectrum causes each LAA eNB to impact multiple 802.11 networks. IEEE 802 suggested that LAA should align its multi-channel aggregation scheme with 802.11.

3GPP RAN1's response to this comment was included in 3GPP RAN1's Liaison Statement dated 7 June 2016 (R1-166041). The response rejected IEEE 802's request on the basis that its adoption would reduce 802.11, as well as LAA, performance.

IEEE 802 disagrees with 3GPP RAN1's assertion that the LAA multi-carrier scheme will not adversely affect fair channel access probabilities for 802.11. This is because the 802.11 multi-carrier schemes follows channel bonding rules, while the LAA multi-carrier scheme can flexibly select any group of carriers for transmission. This additional channel access flexibility for LAA means that in certain multi-carrier configurations, LAA will gain higher channel access at the expense of co-channel 802.11. This has also been shown by simulations presented in 3GPP RAN1 (R1-160816, R1-157009, R1-155547) and ETSI-BRAN (BRAN(15)000188r3).

IEEE 802 believes there is not yet consensus in relation to this issue. However, it is not clear how consensus can be achieved at this time. IEEE 802 suggests that resolution of this issue be postponed until coexistence tests with real equipment can be run to demonstrate any adverse impact on 802.11. Any further comments on this issue by IEEE 802 are likely to be in the context of LAA Rel. 14.

6. There is possibility of consensus and resolution of the issue, *Radio equipment in unlicensed spectrum should stop transmission as soon as transmission of useful data is complete*

Response 6.1: IEEE 802 requests confirmation that it is mandatory to end transmissions at the shortest subframe boundary and further enhancements in LAA Rel. 14.

IEEE 802's Liaison Statement to 3GPP RAN1 dated 18 March 2016 (IEEE 802.19-16-0037-09-0000-laa-comments.pdf) observed in comment 6 that the use by LAA Rel. 13 of fixed length sub-frames *is sometimes inefficient*. IEEE 802 suggested that LAA Rel. 13 should be modified to avoid these inefficiencies.

3GPP RAN1's response to this comment was included in 3GPP RAN1's Liaison Statement dated 7 June 2016 (R1-166041). The response noted that *both beginning and end partial sub-frames are already specified in Release 13*, and that *end partial sub-frames can be 3/6/9/10/11/12 symbols in length*.

Based on 3GPP RAN1's response, it is now IEEE 802's understanding that LAA Rel. 13 already supports beginning sub-frames with 6/14 OFDM symbols and end sub-frames with 3/6/9/10/11/12/14 OFDM symbols, where each symbol has a duration of approximately 71 μ s. IEEE 802's request to 3GPP RAN is that LAA occupy the channel for the minimum time required to transmit data corresponding to the access channel priority class (or higher) used to win channel access and that LAA end the transmission as soon as possible (i.e. at the nearest partial subframe boundary) in the case there is no more data to transmit. IEEE 802 requests that 3GPP RAN1 confirm that LAA Rel. 13 systems are mandatorily required to end transmission at the shortest end partial sub-frame boundary when it has no more data to transmit of the appropriate channel access priority class(s).

Further, IEEE 802 notes that the minimum partial sub-frame duration in LAA Rel. 13 is 6 OFDM symbols for the beginning partial sub-frame and 3 OFDM symbols for the end partial sub-frame. This duration is approximately equal to 426 μ s and 213 μ s respectively which is about 106 or 53 times higher than a 4 μ s symbol quantum in which 802.11 can end its transmission if it doesn't have data to transmit of the appropriate channel access class. IEEE 802 requests that 3GPP RAN specify LAA Rel.14 to accommodate partial sub-frames of one OFDM symbol duration in order to minimize channel wastage resulting from coarse sub-frame granularity in LAA.

7. There is consensus but not full resolution of the issue, *channel access that is obtained using special access mechanisms for high priority data should not be used to transmit lower priority data*

7.1 IEEE 802 requests minimum duration be defined in LAA Rel. 13 and a subframe of one OFDM symbol be defined in LAA Rel. 14

IEEE 802's Liaison Statement to 3GPP RAN1 dated 18 March 2016 (IEEE 802.19-16-0037-09-0000-laa-comments.pdf) requested in comment 7 that 3GPP RAN1 update the LAA specification to clarify the requirements for transmitting traffic of a lower priority once the traffic at a higher priority has been transmitted, after a successful LBT.

3GPP RAN1's response to this comment was included in 3GPP RAN1's Liaison Statement dated 7 June 2016 (R1-166041). The response noted that the following text addresses the issue described in the IEEE 802 Liaison Statement: "*the transmission duration of the DL transmission burst shall not exceed the minimum duration needed to transmit all available buffered traffic corresponding to Channel Access Priority Class(es) $\leq P$* "

These requirements, for the most part, have been satisfied by the updates to LAA Rel. 13. However the value for "*minimum duration needed to transmit*" appears to be open to interpretation.

IEEE 802 requests that for LAA Rel. 13, the *minimum duration* be approximated to the next occurring (partial) sub-frame boundary (one of 3/6/9/10/11/12/14 OFDM symbols). Also, for future releases of LAA (starting with Rel. 14), 3GPP should define partial sub-frames with a finer granularity including the provision for a sub-frame with 1 OFDM symbol.

8. There is consensus but not full resolution of the issue, *the maximum continuous transmission time should be limited to avoid blocking latency sensitive traffic on coexisting networks*

8.1 IEEE 802 requests 3GPP RAN1 align LAA Rel. 13 with the agreement in ETSI BRAN

IEEE 802's Liaison Statement to 3GPP RAN1 dated 18 March 2016 (IEEE 802.19-16-0037-09-0000-laa-comments.pdf) requested in comment 8 that *"the LAA specification define $T_{\text{mcot},3} = 6 \text{ ms}$ and $T_{\text{mcot},4} = 6 \text{ ms}$, until it is agreed by all parties that higher values do not cause problems."*

3GPP RAN1's response to this comment was included in 3GPP RAN1's Liaison Statement dated 7 June 2016 (R1-166041). The response noted that *"There has been a continuing discussion in ETSI BRAN on the maximum allowed transmission time and the latest agreement in ETSI BRAN is actually to introduce a 10 ms T_{mcot} with contention window parameters that de-prioritize access (contention windows sizes of 31, 63, 127). RAN1 would also like to note that T_{mcot} is a maximum limit and does not mean that this is the typical transmission length. It is RAN1's understanding that 802.11 also allows a maximum limit that exceeds 4 ms."*

IEEE 802 requests that 3GPP ensure that the LAA Rel. 13 aligns with the agreement that was achieved at ETSI-BRAN (Table 8 section 4.2.7.3.2.4 of BRAN-0060015v009), where a maximum TXOP is 6 ms and this may be increased up to 8ms with a minimum pause of 100 μ s or up to 10 ms with a doubled contention window size.

9. There is not consensus but resolution should be postponed on the issue, *adjustment of channel access contention window should be based on comparable indicators of congestion to ensure fairness between technologies*

9.1: IEEE 802 suggests resolution of the *channel access contention window* issue be postponed until further tests and simulations have been completed

IEEE 802's liaison statement to 3GPP RAN1 dated 18 March 2016 (IEEE 802.19-16-0037-09-0000-laa-comments.pdf) included the request that *"3GPP explain and justify the selection of the 80% threshold for Z, and particularly why this value does not have an adverse effect on neighboring 802.11 devices."*

3GPP RAN1's response to this comment was included in 3GPP RAN1's Liaison Statement dated 7 June 2016 (R1-166041). The response noted that *"It is RAN1's understanding that the equivalent value of Z used by IEEE 802.11 is 100%".* IEEE 802 believes this comparison is invalid. 802.11 has no equivalent to Z. The lack of an immediate ACK always causes the contention window to expand immediately. In contrast, LAA ACKs/NACKs affect the contention window more than 4ms after possible collisions.

It is currently unproven whether contention style access between contending stations that have different contention window update delays is effective. Therefore, IEEE 802 recommends that extensive simulation and testing of LAA and 802.11 coexistence be conducted to determine whether fair sharing of the channel actually occurs in typical medium to high congestion environments. IEEE 802 is committed to work cooperatively with 3GPP RAN and other organizations in all necessary testing and simulation work.

10. There is consensus and resolution on the issue, *adjustment of channel access contention window should be clearly defined*

Response 10.1: IEEE 802 thanks 3GPP RAN1 for its clarification on CW_p adjustment

IEEE 802's Liaison Statement to 3GPP RAN1 dated 18 March 2016 (IEEE 802.19-16-0037-09-0000-laa-comments.pdf) asked in comment 10 for clarification on how the CW_p parameters are adjusted.

3GPP RAN1's response to this comment was included in 3GPP RAN1's Liaison Statement dated 7 June 2016 (R1-166041). The response explained that "*for each priority class $p \in \{1,2,3,4\}$* " means that CW_p is adjusted for every priority class, not only for the priority class(es) associated with the transmission in reference subframe k .

IEEE 802 thanks 3GPP RAN1 for the clarification. It is now our understanding that at any time, LAA will be contending for the channel using the channel access engine of only one priority class. The determination of which channel access engine to use will be made by the scheduler before the channel access. This is unlike 802.11, which has four parallel channel access engines that contend with each other. For this reason, in LAA, HARQ based CW updates will happen together for all four priority classes so that all channel access engines (whether active or not) can react to channel congestion and error. The exception to this rules is the contention window reset after K attempts at CW_{Max_p} for a given priority class p , which will happen only for the priority class that was used consecutively K times at CW_{Max_p} . IEEE 802 requests that 3GPP make any necessary corrections to IEEE 802's understanding on this issue.

11. There is consensus and resolution on the issue, *the channel access state machine during channel sensing should be clearly defined*

Response 11.1: IEEE 802's comment on quanta of channel sense has been resolved

IEEE 802's Liaison Statement to 3GPP RAN1 dated 18 March 2016 (IEEE 802 19-16-0037-09-0000-laa-comments.pdf) observed in comment 11 that the *LAA access mechanism is more conservative than 802.11 accessing the medium by using T_o quanta*, and suggested that this issue should be fixed by better aligning the LAA access mechanism with 802.11 EDCA.

3GPP RAN1's response to this comment was included in 3GPP RAN1's Liaison Statement dated 7 June 2016 (R1-166041). The response acknowledged the error and noted that a T_s quanta was intended. The correction the LAA Rel. 13 is included in R1-166022. This change resolves IEEE 802's comment 11.

12. There is substantial consensus but not yet full resolution of the issue, *the use of the back off mechanism should be clearly defined*

Response 12.1: Most of, but not all, IEEE 802's issues related to LAA Rel. 13's backoff mechanism have been resolved

IEEE 802's Liaison Statement to 3GPP RAN1 dated 18 March 2016 (IEEE 802 19-16-0037-09-0000-laa-comments.pdf) observed in comment 12 that the LAA Rel. 13 had a number of flaws that have the potential to adversely affect coexistence between LAA Rel. 13 and 802.11, or to adversely affect the performance of LAA Rel. 13.

3GPP RAN1's response to this comment was included in 3GPP RAN1's Liaison Statement dated 7 June 2016 (R1-166041). The response makes it unambiguous that a post backoff is always required after a transmission, aligned with the IEEE 802 request. More importantly, the response indicates that LAA Rel. 13 has been changed (see R1-163925) based on IEEE 802's comments to include an additional backoff, after the initial post backoff is complete, if the channel is busy when new information becomes ready to transmit. This change substantially resolves IEEE 802's comment 12.

However, there is one aspect of comment 12 that remains unresolved. IEEE 802 noted that the way LAA Rel. 13 is defined, the access mechanism is more like ALOHA than slotted ALOHA in the cases where the next transmission is ready after the post backoff is complete, with the subsequent loss of efficiency that is associated with ALOHA style mechanisms. This issue is most likely to have a measurable adverse affect at medium loads. At low loads, the LAA Rel. 13 mechanism is likely to result in lower delay. At high loads, LAA Rel. 13 transmissions will naturally occur on slot boundaries.

IEEE 802 suggests that LAA Rel. 13 is further refined to specify that transmissions normally occur on slot boundaries in all load scenarios, at least in the cases where LAA Rel. 13 uses 9us slots. This will align LAA Rel. 13 with 802.11 in most user environments. This alignment will maximise the use of slotted ALOHA style access and thus maximise efficiency to the benefit of all stakeholders. It may be acceptable for this change to be incorporated into LAA Rel. 14.

Response 12.2: IEEE 802 would appreciate clarification of a new backoff issue

An IEEE 802 member has noted an additional point that needs clarification/rewording in LAA Rel. 13 related to backoff. In 802.11, a station with a frame that becomes ready after a previous post transmission backoff is allowed to transmit at the next slot boundary only if the channel has been sensed to be idle continuously for a duration equal to the initial defer immediately preceding the transmission of the frame (see IEEE P802.11ac-2013 section 9.19.2.3, condition f).

IEEE 802 notes that 3GPP RAN1 has agreed to align LAA access behaviour to match that of 802.11. However, LAA Rel.13 is ambiguous on this point. In particular, 3GPP TS 36.213-V13.2.0 section 15.1.1 states:

If an eNB has not transmitted a transmission including PDSCH on a carrier on which LAA Scell(s) transmission(s) are performed after step 4 in the procedure above, the eNB may transmit a transmission including PDSCH on the carrier, if the channel is sensed to be idle at least in a slot duration T_s , when the eNB is ready to transmit PDSCH

The clause above leaves open the possibility that the eNB can transmit after completion of post-backoff, if the channel is sensed to be idle for only one slot when the eNB is ready to transmit, even if the channel has not been sensed to be idle for a continuous duration equal to the initial defer immediately before the transmission.

IEEE 802 requests that 3GPP RAN confirm intent of this clause and clarify/disambiguate the language in LAA Rel.13 or possibly LAA Rel. 14.