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| Proposed comments to 3GPP in relation to LAA | | |
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Abstract

This document contains draft comments for possible submission by IEEE 802 to 3GPP RAN1 in relation to the LAA specification

## IEEE 802 thanks 3GPP RAN for the opportunity to comment on LAA

During the 3GPP LAA Workshop in Beijing, China in August 2015, the RAN Chair committed to sending the LAA CRs to IEEE 802, Wi-Fi Alliance and other appropriate organisations for comment once they were approved by 3GPP RAN. The RAN Chair asked that any suggestions by IEEE 802 or Wi-Fi Alliance for substantive changes to the LAA CRs be made by April 2016, but noted that suggestions for parameter value changes could probably be made after April 2016. The RAN Chair further committed to 3GPP RAN seriously considering and responding to all IEEE 802 and Wi-Fi Alliance comments.

3GPP RAN subsequently approved the LAA CRs in December 2015, and fulfilled the RAN Chair’s first commitment by sending the following liaison to IEEE 802 and Wi-Fi Alliance in December 2015.

*3GPP TSG RAN would like to inform IEEE 802 LMSC and the Wi-Fi Alliance that it has approved the baseline CRs implementing the LAA feature in the 3GPP specs.*

*The CRs are provided in the attachment.*

*3GPP TSG RAN welcomes any further feedback from IEEE 802 LMSC and the Wi-Fi Alliance on LAA.*

*Potential corrections should be proposed directly to the relevant WGs (preferably with accompanying documents clearly articulating the motivation for the change).*

IEEE 802 thanks 3GPP RAN for allowing the participants of IEEE 802 the opportunity to comment on the LAA CRs. IEEE 802 looks forward to reviewing the responses to our comments and the resulting changes to the LAA specification.

IEEE 802 believes this process of collaboration between IEEE 802 and 3GPP RAN should result in an LAA specification that better supports fair sharing of unlicensed spectrum by both 802.11 and LAA equipment. Further, it should also result in a better LAA specification that leverages the long experience of IEEE 802 in defining effective and fair sharing protocols in unlicensed spectrum.

This document contains comments by participants in IEEE 802 particularly focused on CR\_R1\_157922, which contains specifications for “*Channel Access Procedures for LAA*”. While not all participants in IEEE 802 agree with every comment, the comments represent concerns and suggestions by a sufficient number of IEEE 802 participants. Other documents may contain comments on other aspects of the LAA CRs.

## IEEE 802 has numerous comments in relation to CR\_R1\_157922 (*Channel Access Procedures for LAA*)

The following pages contain a variety of comments related to the LAA specification, focusing on CR\_R1\_157922 (*Channel Access Procedures for LAA*), that have been highlighted by IEEE 802 participants. They are presented in no particular order.

* LAA should be modified to align it better with 802.11 EDCA in case of Ninit = 0
* LAA should be modified to align it better with 802.11 EDCA to avoid Td quanta
* LAA should be modified to align it better with 802.11 EDCA to avoid “head of line blocking
* LAA should be modified to align it better with 802.11 EDCA to avoid issues related to when the back off mechanism is executed
* The use of the Discovery Reference Signal in LAA should be clarified
* LAA should not transmit energy for the sole purpose of blocking access to the channel to others
* LAA should be modified to avoid inefficiencies from use of fixed length sub-frames
* The threshold driving the increase of CWp should be justified
* When lower and higher priority data can be included in a sub-frame that accesses a channel using a lower priority should be justified and clarified
* The adjustment of CWp should be described in an unambiguous manner
* LAA should be aligned with EN 301 893
* LAA should be modified to remove the slot in Tf
* LAA should use Tmcot = 6 ms for priority 3, 4

A common theme in these comments is that LAA has been underspecified and ambiguously specified. This approach is acceptable when there is a mechanism to resolve these issues after the specification stage. The Wi-Fi industry has traditionally resolved many such problems with the 802.11 specification at the plugfesting stage undertaken by the Wi-Fi Alliance. It is likely that the major operators have led equivalent processes in relation to licensed operation.

However, there are no equivalent processes in an environment with both LAA and Wi-Fi equipment. This highlights the importance of doing a very good job ensuring that the LAA (and 802.11 from now on) are fully specified and unambiguous.

### Suggestion: LAA should be modified to align it better with 802.11 EDCA in case of Ninit = 0

#### Situation: LAA defines a basic access method for an eNB

LAA defines a basic access method (in 5.1.1 of CR\_R1\_15792) for an eNB to access the channel for downlink traffic with priority level of p

1. *set N = Ninit, where Nint is a random number uniformly distributed between 0 and CWp ;*
2. *if N>0 and the eNB chooses to decrement the counter, set N=N-1;*
3. *sense the channel for an additional slot duration, and if the additional slot duration is idle, go to step 4; else, go to step 5;*
4. *if N=0, stop; else, go to step 2.*
5. *sense the channel during the slot durations of an additional defer duration Td ;*
6. *if the channel is sensed to be idle during the slot durations of the additional defer duration Td , go to step 2; else, go to step 5;*

#### Problem: The LAA access mechanism is more conservative than 802.11 accessing the medium in case of Ninit = 0

Now suppose Ninit = 0 for a particular access LAA attempt. The equivalent situation in 802.11 is that CW is randomly chosen to be 0.

In the case of 802.11 EDCA, the channel will be accessed after SIFS + 3 slots (or 43 µs) for normal priority traffic. In LAA, the channel will be accessed after Tf + (mp + 1) x Tsl (or 16 µs + 4 slots = 52 µs for equivalent priority 3 traffic). Step 3) in the LAA algorithm is the source of the extra slot delay before transmission.

This example demonstrates a problem in the LAA access mechanism. While this problem actually represents an advantage for 802.11 over LAA, it also highlights that the LAA access mechanism is generally underspecified. Other comments from IEEE 802 also emphasise this point

#### Solution: The LAA access mechanism should be better aligned with 802.11 EDCA

IEEE 802 suggests that the LAA access mechanism be defined so that it better aligned with the IEEE 802.11 EDCA access mechanism. The main advantage of doing so is that coexistence is more likely if both LAA and 802.11 use the same access mechanism. In this particular case, better alignment will result in LAA having earlier access to the medium.

### Suggestion: LAA should be modified to align it better with 802.11 EDCA to avoid Td quanta

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4. *if N=0, stop; else, go to step 2.*
5. *sense the channel during the slot durations of an additional defer duration Td ;*
6. *if the channel is sensed to be idle during the slot durations of the additional defer duration Td , go to step 2; else, go to step 5;*

#### Problem: The LAA access mechanism is more conservative than 802.11 accessing the medium by using Td quanta

In LAA, if a countdown is interrupted by a transmission, the access algorithm samples the medium in quanta of Td. This process is specified in step 5). In other words, if the medium is busy at any time during Td, another complete sensing period of length Td is required once the first Td is completed.

In contrast, 802.11 starts the equivalent to Td as soon as the medium is detected to be free. This means that LAA could take up to an extra 43 µs deferring (assuming, for example, that p = 3) compared to 802.11 before it resumes its countdown after an interruption.

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### Suggestion: LAA should be modified to align it better with 802.11 EDCA to avoid “head of line blocking”

#### Situation: LAA uses only a single access engine with priority driving parameter values

LAA appears to only define the use of a single access engine rather than an access engine per priority level. It further appears that the parameters used by access engine (mp, CWmin, p, CWmax,p, Tmcot, p, etc) ae determined at the time a sub-frame is queued for transmission. Given no alternative is described, it also appears that the access engine cannot be interrupted while access is being sought for a sub-frame at a particular priority.

#### Problem: The LAA access mechanism leads to “head of line blocking”

This mechanism will lead to a “head of line blocking” issue. “Head-of-line-blocking” is when a low priority sub-frame taking a significant period to access the channel blocks a high priority sub-frame in the same device.

This example demonstrates a problem in the LAA access mechanism. While this problem actually represents an advantage for 802.11 over LAA, it also highlights that the LAA access mechanism is generally underspecified. Other comments from IEEE 802 also emphasise this point

#### Solution: The LAA priority access mechanism should be better aligned with 802.11 EDCA

IEEE 802 suggests 3GPP modify LAA to avoid “head-of-line blocking”, possibly by aligning its priority mechanism with 802.11’s multi-engine priority access mechanism.

### Suggestion: LAA should be modified to align it better with 802.11 EDCA to avoid issues related to when the back off mechanism is executed

#### Situation: LAA defines a back off mechanism but is ambiguous about when the mechanism is used

The LAA specification defines a back off mechanism in clause 15.1.1. However, the LAA specification does not clearly define when the back off procedure is used.

#### Problem: The back off ambiguity results in a variety of inefficiencies and unfair behaviour

One interpretation is that a back off occurs every time a frame is queued for transmission. In this case, LAA will have a disadvantage compared to 802.11 because an 802.11 system can transmit on the next slot boundary as long as the medium is free after a previous post transmission back off.

It has been asserted by some LAA advocates that LAA also executes a post transmission back off like 802.11. While such an assertion might be true, it is not specified in an unambiguous manner. It also leads to a variety of additional problems:

* Assuming a post back off has completed, it appears that an LAA eNB can transmit after sensing the medium for Td. In contrast, an 802.11 system is supposed to transmit on a slot boundary. The LAA mechanism essentially converts a slotted ALOHA style system into an ALOHA style system. While this is a minor issue, it represents an unnecessary inefficiency with a negative impact on all stakeholders.
* Assuming a post back off has completed, it appears an LAA eNB takes at least Td (43 µs) to access the medium. In contrast an 802.11 system can access the medium at the next slot boundary (in practice, after about 13 µs). While this is a minor issue, and is a disadvantage for LAA compared to 802.11, it represents an unnecessary inefficiency.
* The LAA specification states that LAA can transmit after finding the channel to be free for a defer duration of Td, and suggests that it can keep searching for a defer duration. Alignment with 802.11 requires a full back off if the channel is determined not to be free when a frame is queued, but this is not specified. The lack of specification appears to give LAA a significant and unfair advantage over 802.11.

These problems highlight that the LAA access mechanism is generally underspecified. Other comments from IEEE 802 also emphasise this point.

#### Solution: The LAA priority access mechanism should be better aligned with 802.11 EDCA

IEEE 802 suggests 3GPP modify LAA to define when the back off mechanism is used, probably by aligning the LAA access mechanism with 802.11 EDCA. Any revised LAA specification should:

* Make it clearer that that a post transmission back off is required after every transmission.
* Specify that an LAA system can transmit immediately on any slot boundary after the post transmission back off, unless the channel is not free or is in a defer period; in these latter cases, LAA should specify the execution of a new back off procedure.

### Suggestion: The use of the Discovery Reference Signal in LAA should be clarified

#### Situation: LAA allows DRS special access to the medium

LAA specifies that a Discovery Reference Signal (without PDSCH) may be transmitted after sensing the medium is free for 25 µs, using an ED Threshold of 5 dB less than normal. This approach recognises the high importance of DRS signals in LTE and LAA.

#### Problem: It is not clear how often the special access for DRS will be used in practice

This specification should have limited adverse effect on 802.11/LAA coexistence if the DRS are transmitted by an eNB, as expected by many, every 40/80/160ms. However, it is also possible for an eNB to configure different DRS offsets for different UEs. Hence, while each UE may be receiving the DRS at a very low rate, the eNB may, in reality, be transmitting DRS much more often than once every 40 ms/80ms/160ms. In this case, 802.11 operations are likely to be adversely affected.

#### Solution: Clarify the limitations on the use of special access for DRS

IEEE 802 requests responses from 3GPP RAN to the following questions:

* Are all served UEs are expected to be configured with an identical DRS offset?
* How often is an eNB expected to transmit a DRS?

IEEE 802 also requests that the LAA be modified to include reasonable limits to the how often the channel may be accessed using the DRS mechanism. IEEE 802 would be happy to discuss appropriate limits with 3GPP RAN.

### Suggestion: LAA should not transmit energy for the sole purpose of blocking access to the channel to others

#### Situation: LAA needs to maintain control of medium between gaining access and transmitting data by sending energy

In LAA, there is normally a delay of 0-1 ms between gaining access to the channel and the start of the sub-frame, which is a result of LAA sub-frames always being aligned to 1 ms boundaries. The delay is 0-0.5 ms if partial sub-frames are used.

The only way for the LAA system to stop another system from accessing the channel during this delay is to transmit energy of some sort in the channel. This energy represents a form of interference because its sole purpose is to stop other systems from accessing the channel.

#### Problem: Transmitting energy for sole purpose of blocking others is contrary to best practice everywhere and possibly regulations in some domains

As noted during the IEEE 802 submission to the 3GPP LAA Workshop in August 2015, such interference is contrary to the well accepted principle in unlicensed spectrum to not cause unnecessary interference to others.

Such interference may also be against the regulations in some regulatory domains. For example, it is possible that a device transmitting unnecessary energy would not qualify as a ‘Radio Equipment’ under the RE-Directive (2014/53/EU) in Europe, which states, “*radio equipment shall only have intentional transmissions for the purpose of radio communications*”. Transmitting energy for the sole purpose of stopping another derives from transmitting is unlikely to be classified as “*radio communications*”.

#### Solution: LAA should be modified to avoid sending energy for the sole purpose of blocking access to the channel to others

IEEE 802 suggests that LAA be modified so that it never needs to transmit energy for the sole purpose of stopping another device (LAA or 802.11) from using the channel. Options to satisfy this request include:

* Allowing (partial) sub-frames to start immediately after channel access is obtained
* Deferring sending energy in a channel until the LAA device is ready to transmit

IEEE 802 understands that changes to LAA of the type suggested above are substantial and may take some time. An alternative approach might be to demonstrate by analysis and simulation that the transmission of energy by LAA for purpose of blocking access to the channel by other systems does not cause substantive harm to those systems. We are not aware of any such studies at this time.

### Suggestion: LAA should be modified to avoid inefficiencies from use of fixed length sub-frames

#### Situation: Use of LAA sub-frames is sometime inefficient

LAA transmits data in 1ms sub-frames, or 0.5ms partial sub-frames. In some cases, the sub-frames may only contain a very small amount of data compared to the capacity of the sub-frame. This represents a potential structural inefficiency.

#### Problem: There is no obvious upside to this structural inefficiency

It is a well-accepted principle in unlicensed spectrum that systems should attempt to make efficient use of the spectrum. Regulations also often highlight efficiency as an important goal. For example in Europe article 3.2 of RE-Directive (2014/53/EU) states, “*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*”.

Of course, this principle is sometimes traded off against other goals. For example LBT with exponential back off is not very efficient because time is wasted in contention and contention resolution, but is justified because it enables fair sharing between unrelated systems. Transmitting data at a low data rate is sometimes also not very efficient either, but it increases reliability.

However, it is not obvious that the use of fixed length sub-frames by LAA has any benefits for the “greater good”. Indeed, both 802.11 and LAA would have greater access to the medium for data transmission if LAA systems stopped transmission as soon as they had no more data to transmit.

#### Solution: LAA should be modified to avoid inefficiencies caused by use of fixed length sub-frames

IEEE 802 suggests that LAA be modified so that it avoids the inefficiencies that result from transmitting unfilled sub-frames. We understand from some 3GPP RAN1 participants that there is some possibility of such a feature in a future release of LAA. We suggest that this feature be brought forward to R13 or that LAA be delayed until the feature is ready.

IEEE 802 understands that changes to LAA of the type suggested above are disruptive to the planned completion of LAA. An alternative approach might be to demonstrate by analysis and simulation that the use of long sub-frames substantive does not cause harm to those systems. We are not aware of any such studies at this time.

Another alternative is to specify in LAA that sub-frames must be filled above a certain threshold. This approach provides at least some minimum level of efficiency. LAA can always use licensed spectrum to transmit data inefficiently.

### Suggestion: The threshold driving the increase of CWp should be justified

#### Situation: LAA uses a NACK threshold (Z) to drive increase of CWp

LAA specifies in clause 15.1.3 that CWp values are increased when 80% of acknowledgements (Z) are NACKs

#### Problem: The justification of Z is unclear

A high percentage means that collisions at many UEs will be ignored and thus those UEs and their neighbours will not benefit from the LAA back off mechanisms. This percentage intuitively seems to be very high, and the justification is unclear.

In addition, the details of the calculation of this percentage are not well understood by many IEEE 802 participants because of the use of unfamiliar LTE specific terminology

#### Solution: 3GPP is requested to justify the value of Z

IEEE 802 requests that 3GPP explain and justify the selection of the value of Z, and particularly why this value does not have an adverse effect on neighbouring 802.11 devices.

### Suggestion: When lower and higher priority data can be included in a sub-frame that accesses a channel using a lower priority should be justified and clarified

#### Situation: The LAA spec defines the transmission of data only one priority

Clause 15.1.1 specifies that, “mp*, CWmin,p and CWmax,p are based on channel access priority class associated with the eNB transmission*”. This suggests that each transmission of one or more contiguous sub-frames contains data of a single priority.

#### Problem: It seems that the intent is to allow the transmission of both higher and lower priority data in a single sub-frame

3GPP RAN1 participants in ETSI BRAN have noted that a single transmission (of one or more sub-frames) can actually contain data of multiple priorities. Specifically, it is asserted that it can contain data of any higher priority. It can also contain low priority traffic if there is spare space in the sub-frames. This perspective is contrary to what is actually written in clause 15.1.1.

The transmission of higher priority data in a sub-frame seems reasonable and is also allowed in 802.11. The transmission of lower priority traffic might also be reasonable if the transmission of such traffic does not increase the time the medium is used. This is what happens in 802.11.

Unfortunately, the transmission of lower priority traffic by LAA interacts adversely (from an 802.11 perspective) with the use by LAA of fixed length sub-frames. It appears from descriptions of LAA provided to ETSI BRAN that a single bit of high priority data in a LAA sub-frame allows the rest of sub-frame to be filled with low priority data. In contrast, 802.11 systems only allow the transmission of lower priority data only if the transmission of such data does not increase the length of the TxOP.

One justification provided for this behaviour is that the rest of the sub-frame would be wasted if it was not filled with lower priority data. While this is true, this is a justification for not using fixed length sub-frames in LAA given the adverse effect on 802.11 and other systems.

#### Solution: The LAA specification needs to be clarified to explain what data may be sent in a sub-frame accessing the channel at a particular priority

IEEE 802 request s that:

* The LAA specification is clarified to make it clear that a transmission of one or more sub-frames using a particular access priority may contain data of that priority and higher priorities.
* The LAA specification is clarified to make it clear that a transmission of one or more sub-frames using a particular access priority may contain lower priority data as long as that lower priority data does increase the duration of the transmission
* 3GPP RAN1 justify why filling the remainder of a sub-frame with lower priority data does not provide an unfair and unreasonable advantage to LAA systems over 802.11 systems, and why this is not a justification for not using fixed length sub-frames in LAA.

### Suggestion: The adjustment of CWp should be described in an unambiguous manner

#### Situation: LAA defines how CWp is adjusted

Clause 15.1.3 describes how CWp is adjusted when accessing the channel with priority class p as follows:

1. *For each priority class p ∈ {1,2,3,4} set CWp = CWmin,p*
2. *if at least Z = 80% of HARQ-ACK values corresponding to PDSCH transmission(s) in reference subframe k are determined as NACK, increase CWp for each priority class p ∈ {1,2,3,4} to the next higher allowed value; otherwise, go to step 1.*

#### Problem: The adjustment of CWp in LAA is ambiguous

One interpretation of this test is that all of CW1, CW2, CW3 and CW4 are increased in step 2. Another reasonable interpretation is that only the CWp associated with the priority p of the transmission is increased. The two interpretations could lead to quite different results when combined with other parts of the LAA specification.

A similar issue arises at the end of clause 15.1.3 in the text that describes resetting CWp after K uses of CWp,max. Is only on CWp reset or are all the CWp values reset?

#### Solution: LAA should describe the adjustment of CWp in an unambiguous manner

The LAA specification needs to be rewritten so that all text is clear and unambiguous. The texts cited in this comment are just examples of many ambiguities.

### Suggestion: LAA should be aligned with EN 301 893

#### Situation: LAA needs to satisfy EN 301 893 for operation in Europe

The LAA specification defines the access mechanism for eNBs. This specification will need to comply with the requirements documented in EN 301 893, which is currently being revised by ETSI BRAN, to enable operation in Europe.

#### Problem: It is unlikely or unclear that LAA satisfies EN 301 893

The definition of the LAA access mechanism is generally under specified and ambiguous. However, it appears unlikely any implementation of a reasonable interpretation of the LAA specification will satisfy the requirements in draft versions of EN 301 893.

Even it is possible for LAA satisfy the requirements of the draft version EN 301 893, it is not immediately obvious how this is done. This makes the use of the LAA specification a risk because LAA implementations may be rejected in the future.

#### Solution: LAA should be aligned with EN 301 893 (or 802.11 EDCA)

IEEE 802 suggests that the LAA access mechanism is rewritten to align much better with either 802.11 EDCA or the requirements documented in draft versions of EN 301 893. Alternatively, IEEE 802 suggests that 3GPP RAN1 document how LAA will satisfy EN 301 893

### Suggestion: LAA should be modified to remove the slot in Tf

#### Situation: Tf includes a slot

Clause 15.1.1 defines Tf as including “*an idle slot duration Tsl at the start of Tf*”

#### Problem: A slot in Tf is impractical and has an adverse effect on all systems

Tf is similar in many ways to SIFS in 802.11. However, SIFS does not include a slot at the start of the SIFS period. One reason for this is that it is impractical for a device to sense the medium during the transition from transmitter to receiver. Rather, 802.11 assume the medium is free during the whole of the SIFS. If this is not correct, the error will be detected during the sensing in the slots after SIFS.

The definition of Tf in LAA suggests that it cannot start until the turn around process is complete. This will not only disadvantage LAA relative to 802.11 in terms of access to the medium, it will also mean that slot alignment between 802.11 and LAA systems will be a function of how quickly each LAA implementation can transition from transmit to receive. Poor slot alignment converts a slotted ALOHA like system into an ALOHA like system, which has an adverse effect on all users of the channel.

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#### Solution: Remove the slot in Tf

LAA should remove the slot at the start of Tf.

### Suggestion: LAA should use Tmcot = 6 ms for priority 3, 4

#### Situation: LAA uses Tmcot = 8 ms for priority 3, 4

Table 15.1.1-1 specifies values of Tmcot,p for each priority level. The values for p = 3, 4 are 8ms in any band in which 802.11 can operate.

#### Problem: Tmcot = 8 ms has not been properly justified

It appears the value of 8ms has not been properly justified

* The vast majority of simulations undertaken by 3GPP participants during the study period used a Tmcot,3 of 4 ms, not 8ms. They mostly showed fair sharing was possible.
* While some simulations by 3GPP participants during the study period showed that a Tmcot,3 > 10ms also led to fair sharing, other simulations showed that these values caused fairness issues, particularly for Wi-Fi based voice traffic. Some regulators in Europe have emphasised a view that LAA should not adversely Wi-Fi voice under any circumstance, for competition reasons.
* At least one recent simulation undertaken by an ETSI BRAN participant appears to confirm that Tmcot,3 = 10 ms has an adverse effect on Wi-Fi voice. While other simulations did not show the same effect, it appears at least some of those simulations did not use realistic deployment scenarios.

#### Solution: LAA should use Tmcot = 6 ms for priority 3, 4 until justification for larger values is agreed

A very conservative approach would indicate that Tmcot,3 = 4 ms and Tmcot,4 = 4 ms, which are the values that IEEE 802 requested during the 3GPP LAA Workshop in August 2015. Rather than continuing to take this very conservative approach, IEEE 802 requests that the LAA specification define Tmcot,3 = 6 ms and Tmcot,4 = 6 ms, until it is agreed by all parties that higher values do not cause problems.