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| LAA – 802.11 coexistence status in 3GPP RAN1 |
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Abstract

This presentation discusses the status of the topics of interest to the coexistence between LAA and 802.11 as discussed in the latest 3GPP RAN1 meeting RAN1#91. The verbatim status can be found in section 6.2.2 of the report compiled by the RAN1 Chairman [1].

# Contention Window Size (CWS) adaptation procedure for LAA Autonomous Uplink

The salient contentious point in this topic was the CWS adjustment procedure in case the HARQ feedback (implicit or explicit) for LAA Autonomous UL transmission is not received by the UE in a given time frame.

Some companies wanted to elongate the time frame so that LAA can continue to use the unchanged Contention Window without considering error on the AUL transmissions for as long as possible. Having multiple (16/32) HARQ processes in LAA enables such transmission of packets while waiting for HARQ feedback in parallel for other packets. This also allows the LAA eNB to group together multiple HARQ feedbacks and reduce control messaging overhead.

However, from the perspective of fair coexistence, this means that there could potentially be 16/32 transmissions in LAA UL, each of 1ms duration, without updating the Contention Window, irrespective of the error status (ACK/NACK) of the transmissions. This is in contrast to 802.11 where a new transmission uses a Contention Window that considers the error status (ACK/NACK) of the previous transmission. So, when the two systems LAA and 802.11 coexist with each other and if there are errors in both due to collisions, LAA can use a stale and potentially smaller Contention Window for a number of subsequent transmissions while 802.11 will update and potentially double the Contention Window for each collision before attempting any subsequent transmission. If this happens, LAA will obtain much higher channel access relative to co-channel 802.11.

After a lot of discussion no agreements could be reached on what the maximum time frame for Contention Window update for LAA AUL should be. Given such disagreement, it was ensured that LAA will not have any AUL transmissions without adapting the Contention Window corresponding to a previous transmission. The agreement was captured as follows:

“ *RAN1 shall specify the CWS adjustment for the case of no A/N reception until which the UE is not allowed to perform Cat.4 LBT and transmit AUL in case of no A/N  or UL grant reception*.”

Further, provisions were added in the agreements for the future when AUL may be allowed to transmit without receiving any HARQ feedback or UL grant with procedures that subsequently get defined in 3GPP RAN1. Since, it is possible that LAA may start multiple AUL Cat 4 LBT transmissions without waiting for a previous feedback and therefore, it is possible to have multiple outstanding transmission bursts for which no feedback is received, there would be a provision to adapt the Contention Window based on feedback for all these outstanding transmissions. This agreement was captured as follows:

“*FFS: multiple reference subframes can be supported.*

*FFS: Handling of ACK/NACK or UL grant in case multiple consecutive recent Cat.4 LBT AUL bursts were transmitted without waiting for any AUL-DFI or UL grant*.”

# LBT priority class to traffic type map and traffic multiplexing rules to be followed by a UE for AUL transmissions within a COT won by the LAA eNB

It was proposed that if an AUL UE transmits with 25us LBT in a TXOP shared by the eNB, it must transmit traffic only of the appropriate traffic type within such a TXOP. This means that the data transmitted by the UE within the eNB TXOP should be of the same or higher priority class than the channel access priority class used by the eNB to win the TXOP. The above is also required by ETSI EN 301 893 and is followed by 802.11. While, companies in 3GPP agreed to the procedure in principle, they have a concern that implementing such an LBT priority class to traffic type map will require changes in the UE MAC specification which they feel will become intricate and complex. So, there are nascent proposals in RAN1 looking for a compromise where LAA agrees to equivalent rules for traffic multiplexing in order to avoid MAC specification changes. The topic is still under discussion and has been posted for further discussion over email.

# Number of 25us LBT attempts by a UE for scheduled UL transmissions within a TXOP shared by the eNB

In previous 3GPP RAN1 meetings, it had been agreed to add one more starting position within every subframe (at a slot i.e. 0.5 ms boundary) for scheduled LAA UL. The point of contention here (and which affects coexistence with Wi-Fi) was whether the existing principle of requiring only 25 us LBT for LAA UL transmissions should continue to apply to the additional starting position within a paused/shared TXOP. It was argued that paused/shared TXOP was allowed to overcome the limitation of LAA UL of having a single starting position per subframe and the grant-to-transmission delay in LAA scheduled UL. For a UL burst of X subframes length, legacy LAA UL can perform 25 us LBT and try to start transmitting ahead of every subframe, where each such LAA subframe starts at a 1ms time boundary. If the number of starting positions is increased to 2 per subframe due to UL transmission now being permitted at 0.5 ms boundaries, this would mean that LAA can get twice as many opportunities to occupy the channel with only 25 us LBT. It was argued that this is detrimental for fair coexistence with 802.11 and that the number of 25 us LBT opportunities should not double/change. Finally, the following was agreed which does not change the situation with respect to coexistence with 802.11:

“*If the UE is allowed Mode 1 UL partial subframe transmission, the number of possible Type 2 LBT attempts by the UE within the shared COT shall be limited to n+1, where n is the number of consecutively allocated UL subframes.*

*Note: This applies regardless of the type or number of grants that were used to schedule the consecutively allocated UL subframes and for cases where there maybe gaps of one symbol or less between the consecutively allocated subframes as in Rel-14*”

# UE sharing a TXOP with its eNB

Some companies in 3GPP RAN1 want an LAA eNB to be able to share with 25us LBT the TXOP won by any of its UEs. The proposal is to allow any UE to handover its TXOP to the eNB which can then use it to transmit in the DL to any UE. These companies claim the following:

* ETSI EN 301 893 already allows such UE-to-eNB TXOP sharing.
* 802.11 also allows it for Reverse Direction Protocol, PS-Poll, transmitting of ARQ feedback etc.

However, it was pointed out that LTE being a tightly scheduled system can misuse such a procedure in many ways to devise very aggressive channel access procedures that can be very unfair to co-channel 802.11.  For example, if an LAA eNB faces channel congestion around it that would otherwise have made it to increase its own Contention Window and wait longer, it can circumvent this procedure by making a UE that faces less congestion (the eNB is aware of the congestion observed by all its UEs and this information is communicated on the licensed channel) to win the channel with much higher probability and then hand over the COT to the eNB for transmission of any control message or data to any UE with only 25us LBT. This will be catastrophic for fair coexistence with 802.11 and can undo a lot of the fairness that has been built into the channel access procedures in LAA.

However, some companies were very keen on this feature and wanted to at least use this feature for transmission of control messages by the eNB with a proposal to later consider transmission of data.  However, no conclusion could be reached and the topic was posted to be discussed further over the RAN1 email reflector.

# Introduction of UL ending positions at symbol 3 and symbol 10 in a subframe

As per the agreements so far, LAA UL has ending positions at the end of symbols 6, 12 and 13, where each symbol has a duration of approximately 71us and transmission of symbol 0 starts at a 1ms boundary. Some companies have been proposing the end of symbols 3 and 10 as additional ending positions along with the corresponding arguments on how such positions will optimize efficiency and fairness.

* Increase in the number of end partial subframes will reduce the chances of the UE having to transmit lower priority data or padding in order align the end of the subframe to the available choices. This will also make LAA better match 802.11 that can end its transmission at the nearest 4us boundary once it exhausts data of the appropriate priority.
* Any reduction in COT wastage/transmission of lower priority data/transmission of padding and subsequent increase in spectral efficiency of LAA will make LAA coexist more fairly with another co-channel LAA or 802.11 node.

However, there is no consensus so far on inclusion of these positions.

# References

1. RAN1 Chairman’s Notes, 3GPP TSG RAN WG1 Meeting 901 (27th November – 1st December, 2017)