

Agenda Item: 6.2.2.2

Source: InterDigital

Title: Handling UL LBT Failures in MAC

Document for: Discussion, Decision

1 Introduction

In RAN2#105bis, it was agreed that MAC will handle the detection and recover of a persistent UL LBT failure in MAC. Relevant agreements from RAN2 107 and 107bis are in Appendix A.

This contribution discusses remaining details for handling UL LBT failures in MAC, including a detection, recovery, and reporting behaviour.

2 Discussion

The unlicensed channel might not be symmetric for UL and DL directions, due to hidden nodes. A link maintenance and failure mechanism based on UL LBT failures is thus handled separately from RLM/RLF on the downlink, especially given that some MAC counters for UL procedures (e.g. RACH and SR) are not incremented when UL LBT fails, thus causing the UE to stall. For this reason, an additional failure reporting criterion that triggers when the UE fails to access the channel repeatedly is supported.

2.1 Detection of a consistent UL LBT Failure

As agreed in RAN2#107 as a baseline, the UE maintains a counter and timer to detect a consistent UL LBT failure, whereby the UE increments the counter and resets the detection timer at each UL LBT failure. The UE resets the counter upon timer expiry. Once the counter reaches a configured maximum threshold, the UE triggers a consistent UL LBT failure and performs recovery actions.

In addition to resetting the UL LBT counter upon expiry of the detection timer, the UE should reset the counter whenever the UE transmits on any UL channel after a successful UL LBT, given the channel is no longer *consistently* unavailable upon succeeding a single LBT. This can be achieved by resetting the *LBT counter* if no notification of UL LBT failure is received from PHY for an UL transmission expected to receive it in case of UL LBT failure. Relying solely on the expiry of the detection timer to reset the counter can cause false detection when the channel is sporadically not available rather than consistently not available, which is not the intent of this handling in MAC.

Proposal 1: MAC resets the *UL LBT counter* if UL LBT outcome is successful for any UL transmission.

2.2 Recovery from a consistent UL LBT Failure

Upon declaring a consistent UL LBT failure on the SpCell, the UE switches to another configured BWP with PRACH configured and initiates RACH. Once consistent LBT failure is declared on all BWPs with PRACH configured, the MAC indicates consistent LBT failure to upper layers. RRC layer then performs further recovery actions, including triggering RLF for failure detected on the PCell or informing the MN via the SCG failure information procedure for a failure detected on the PSCell.

It should be noted that the consistent UL LBT failure can be detected as part of a given random access procedure, in which case the UE will switch to another BWP with PRACH configured after detection. It's worthwhile to clarify that the UE should initiate a new RA procedure upon switching to another BWP, i.e. to

ensure the preamble counter and the power ramping counter are reset. Upon BWP switching caused by detection of consistent uplink LBT failures on SpCell, the MAC entity shall therefore stop the ongoing RA procedure -if any- and initiate a new RA procedure on the active BWP.

Proposal 2: After BWP switching caused by detection of consistent uplink LBT failures on SpCell, MAC shall stop any ongoing RA procedure and initiate a new RA procedure.

2.3 Reporting a consistent UL LBT Failure

Upon detecting a consistent UL LBT failure on the on an SCell, the UE reports a consistent UL LBT failure using a MAC CE to the gNB on the same cell group the SCell belongs to. As agreed in RAN2 107bis, UE can consider a grant valid for the transmission of the UL LBT failure reporting MAC CE if the grant is scheduled on a cell that belongs to the same cell group of the SCell on which consistent LBT failure was detected.

Observation 1: An UL-SCH resource is valid for multiplexing an LBT failure MAC CE if it is on a cell in the same cell group as the SCell on which consistent UL LBT failure was detected.

On top of observation 1, it is essential that the UE does not consider grants on the same cell and same BWP on which the consistent LBT failure was detected as valid for transmission of the MAC CE, and rather trigger a new SR. For example, the UE may have a configured grant on the same BWP on which the failure occurred, which should not be considered valid for the transmission of the MAC CE, especially given the failure might have been triggered by repeated LBT failures on that configured grant. Therefore, the UL-SCH resource should be on a different BWP than the one on which the consistent LBT failure was detected.

Proposal 3: The MAC entity considers an UL-SCH resource as valid for multiplexing an LBT failure MAC CE if it is on a different cell or a different BWP than the one on which consistent UL LBT failure was detected.

When the UE does not have a valid grant on the cell group on which the MAC CE needs to be transmitted, the UE should trigger a new SR. Such SR can be cancelled when the UE transmits a MAC CE that reflects the LBT failures detected on one or multiple SCells on the same cell group prior to PDU assembly.

Proposal 4: MAC triggers a new SR when it doesn't have a valid UL-SCH resource available to transmit the LBT failure MAC CE.

Proposal 5: MAC cancels a pending SR triggered by reporting an UL LBT failure upon transmission of a MAC PDU that contains an LBT failure MAC CE that reports triggered LBT failures detected on SCell prior to PDU assembly.

The MAC CE design can generally be similar to the MAC CE used to report a beam failure on an SCell. The MAC CE should contain information on the cell and the BWP on which the failure event was detected. The BWP information is vital for the gNB to know in order to perform BWP switching on the SCell, especially given the UE doesn't perform BWP switching on its own after detecting a consistent LBT failure on the SCell.

Proposal 6: The LBT failure MAC CE contains the cell and BWP indices on which consistent LBT failure was declared.

In the LCP procedure, the priority of multiplexing the LBT failure MAC CE into the TB should be higher than at least UL data. Given this MAC CE may be reported on a different cell, it makes sense to have the LCP priority of the MAC CE predefined as higher than UL data but lower than that the PHR MAC CE priority.

Proposal 7: The LBT failure MAC CE has higher multiplexing priority in LCP than UL data but lower priority than PHR MAC CEs.

3 Conclusion

In this contribution the following proposals and observations were made on handling UL LBT failures in MAC:

Proposal 1: MAC resets the *UL LBT counter* if UL LBT outcome is successful for any UL transmission.

- Proposal 2:** After BWP switching caused by detection of consistent uplink LBT failures on SpCell, MAC shall stop any ongoing RA procedure and initiate a new RA procedure.
- Observation 1:** An UL-SCH resource is valid for multiplexing an LBT failure MAC CE if it is on a cell in the same cell group as the SCell on which consistent UL LBT failure was detected.
- Proposal 3:** The MAC entity considers an UL-SCH resource as valid for multiplexing an LBT failure MAC CE if it is on a different cell or a different BWP than the one on which consistent UL LBT failure was detected.
- Proposal 4:** MAC triggers a new SR when it doesn't have a valid UL-SCH resource available to transmit the LBT failure MAC CE.
- Proposal 5:** MAC cancels a pending SR triggered by reporting an UL LBT failure upon transmission of a MAC PDU that contains an LBT failure MAC CE that reports triggered LBT failures detected on SCell prior to PDU assembly.
- Proposal 6:** The LBT failure MAC CE contains the cell and BWP indices on which consistent LBT failure was declared.
- Proposal 7:** The LBT failure MAC CE has higher multiplexing priority in LCP than UL data but lower priority than PHR MAC CEs.
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4 References

- [1] R2-1911512, Report from Break-Out Session, Vice-Chair (MediaTek)
 - [2] R2-1914134, Session minutes for NR-U, Power Savings, NTN and 2-step RACH, Session chair (InterDigital)
 - [3] RP-182878, "New WID on NR-based Access to Unlicensed Spectrum", Qualcomm.
 - [4] TR 38.889 v 16.0.0, "Study on NR-based access to unlicensed spectrum (Release 16)"
 - [5] 3GPP TS 38.321 V15.5.0, "NR; Medium Access Control (MAC) protocol specification (Release 15)"
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5 Past Relevant Agreements

In RAN2#105bis, the following was further agreed:

- ⇒ Adopt a mechanism in MAC spec to handle the UL LBT failure, where "consistent" UL LBT failures (at least for UL transmissions of SR, RACH, PUSCH) are used for problem detection

In RAN2#107, the following was further agreed [1]:

- ⇒ L2 LBT failure mechanism take into account any LBT failure regardless UL transmission type.
- ⇒ The UL LBT failure mechanism will have the same recovery mechanism for all failures regardless UL transmission type
- ⇒ UL LBT failures are detected per BWP
- ⇒ The UE will report the occurrence of consistent UL LBT failures on PSCell and SCells. The assumption is to reuse SCell failure reporting for BF
- ⇒ Baseline Mechanism, further enhancements not precluded:
- ⇒ A "threshold" for the maximum number of LBT failures which triggers the "consistent" LBT failure event will be used.
- ⇒ Both a timer and a counter are introduced, the counter is reset when timer expires and incremented when UL LBT failure happens
- ⇒ The timer is started/restarted when UL LBT failure occur.

In RAN2#107bis, the following was further agreed [2]:

1. MAC relies on reception of a notification of UL LBT failure from the physical layer to detect a consistent UL LBT failure.
2. The UE switches to another BWP and initiates RACH upon declaration of consistent LBT failure on PCell or PSCell if there is another BWP with configured RACH resources.
3. The UE shall perform RLF recovery if the consistent UL LBT failure was detected on the PCell and UL LBT failure was detected on “N” possible BWP. “
4. When consistent uplink LBT failures are detected on the PSCell, the UE informs MN via the SCG failure information procedure after detecting a consistent UL LBT failure on “N” BWPs.
5. “N” is the number of configured BWPs with configured PRACH resources. If N is larger than one it is up to the UE implementation which BWP the UE selects.
6. When consistent uplink LBT failures are detected on an SCell, a new MAC CE to report this to the node where SCell belongs to is used. FFS whether the MAC CE can be used to report failure on PCell