

Agenda Item: 6.2.2.2
Source: Huawei, HiSilicon
Title: Handling of UL LBT failure
Document for: Discussion, Decision

1 Introduction

In RAN2#107, the following agreement were made [1]:

RAN2#107 agreement

- ⇒ 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 agreement were made [1]:

RAN2#107bis agreement

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**

In this paper, we further discuss remaining issues on UL LBT failure based on the above agreements and provide our proposals.

2 UL LBT failure detection

2.1 Prevent counting too close failures

In last meeting, whether a counter should be introduced to prevent counting too close failures was discussed, however no agreement was made.

In unlicensed spectrum, the device is allowed to transmit the data within a COT obtained by a success of CAT4 LBT. The duration of COT can be several milliseconds. A UE will fail to perform transmission due to another device is performing transmission within its COT. For the NR-U UE, LBT will be consistently failed until another device ends the COT. In that case LBT failure recovery may be triggered unnecessarily when too close failure are counted during such COT of other device. One possible solution is a larger value of maximum number of UL LBT failure can be configured. However the triggering of failure recovery may be delayed due to a larger value is configured. . A trade-off solution may be a new counter is introduced to prevent counting too close failure.

Proposal 1: it is beneficial to introduce a counter to prevent counting too close UL LBT failure.

2.2 Suspending transmission due to LBT failure on SCells

For UL LBT failure on SCells, RAN2 agreed a MAC CE is used to report the UL LBT failure. The UE does not need to switch BWP to recovery from UL LBT failure. The following issues need to be discussed after detecting with UL LBT failure on SCells:

- 1) **Whether all ongoing transmissions including (PUSCH transmission, SRS transmission, PUCCH transmission, RACH transmission) on active BWP of SCell with UL LBT failure should be suspended immediately or not?**
- 2) **Whether type 2 configured grant should be cleared or not?**
- 3) **Whether type 1 configured grant should be suspended or not?**
- 4) **Whether BWP inactivity timer should be stopped or not?**

Considering the serving cell which has been detected with UL LBT failure could become unreliable, in order to save UE power, decrease load in unlicensed spectrum, all transmissions on the SCell detected with UL LBT failure should be suspended and all configured grants should be suspended, immediately. UE transmits the data on another serving cell without LBT failure. The UE may need to monitor the PDCCH for UL BWP switching indication after the network receives the MAC CE reporting UL LBT failure. For BWP inactivity timer, we think it should be stopped to avoid frequent BWP switching.

Proposal 2: After detecting with UL LBT failure on a SCell, the following actions should be performed.

- **All transmissions on the SCell should be suspended.**
- **Type 2 configured grant of the SCell is cleared, if configured.**
- **Type 1 configured grant of the SCell is suspended, if configured.**
- **BWP inactivity timer should be stopped.**

3 UL LBT failure recovery on PCell/PSCell

3.1 Random access for UL LBT failure recovery

RAN2 agreed that random access with BWP switching is used to recovery from UL LBT failure on PCell/PSCell, i.e. a new random access trigger is introduced. However it is still FFS which type of random access is used based on this new random access trigger among 2-step random and 4-step random access. For 4-step random access, we think it shall be supported. In WI of 2-step RACH, RAN2 agreed a BWP can be configured with 2-step RACH resource only. In that case the question

comes whether this BWP with 2-step RACH resource only can be used to recovery from LBT failure. We think it should be also supported to avoid early RLF.

Proposal 3: For UL LBT failure recovery by BWP switching, both 2-step RA and 4-step RA can be used.

3.2 LBT failure MAC CE for PCell

In last meeting, it was agreed to report LBT failure of SCells via MAC CE. However it is still FFS whether the MAC CE should report LBT failure of PCell. We think it is beneficial for network implementation, e.g. handover could be triggered, if the network is aware of LBT failure timely.

Proposal 4: MAC CE can be used to report UL LBT failure on PCell.

4 BWP switching for LBT failure recovery on PCell and PSCell

In Rel-15, multiple BWPs can be configured while only one BWP can be active. Different BWPs may be configured with different frequency ranges and BWP switching is supported for power saving and service, i.e. one BWP is active and the other BWP is deactivated. The active BWP can be switched from the current BWP to a new BWP. In NR-U, the above rules can be applied to NR-U. In Rel-15, the BWP switching is done by DCI/RRC and UE itself for random access.

In the previous meeting, we have agreed that LBT failure is detected per BWP, and both a counter and a timer are used to detect the UL LBT failure. Furthermore in case of UL LBT failure, the UE can switch the active BWP to a new BWP with RACH resource for recovery from UL LBT failure.

4.1 Handling of UL LBT failure related counter and timer

First question would be how to handle the UL LBT failure detection related variables (i.e. the counter and timer) when BWP switching is performed by UE itself or based on DCI. Since different BWPs will have different bandwidths and correspondingly, different LBT outcomes for uplink transmissions, we think the counter should be reset and timer should be stopped.

Proposal 5: Confirm that counter for UL LBT failure detection should be reset and timer for UL LBT failure detection should be stopped at BWP switching.

4.2 Handling of random access procedure

Secondly, the question comes whether the UE should perform a Random Access procedure initialization when the UE switches to a new BWP for random access to recovery from LBT failure. Considering the RACH configuration is configured per BWP, we think random access procedure initialization should be performed and new RACH configuration is applied when BWP is switched for UL LBT recovery.

Proposal 6: Random access initialization should be performed when BWP is switched for UL LBT recovery.

5 MAC CE for UL LBT failure

5.1 MAC CE restriction

After UL LBT failure occurs on any serving cell, the UE can send this MAC CE for UL LBT failure recovery via a grant. This grant may be received from serving cell with UL LBT failure or without UL LBT failure. We think it may be useful to have some rules to restrict the MAC CE to be transmitted

between LBT failure cells and non-failure cell. Considering the serving cell which has been detected with UL LBT failure would become unreliable, the serving cell without detected UL LBT failure should be prioritized for MAC CE transmission. If the UE puts the MAC CE into a serving cell with UL LBT failure, the MAC CE may be blocked due to LBT failure and not received by network.

Proposal 7: it is beneficial to have a rule to restrict the MAC CE to be transmitted on the serving cell without detected UL LBT failure.

5.2 Priority of UL LBT failure MAC CE

The prioritization rules are specified as following.

Logical channels shall be prioritised in accordance with the following order (highest priority listed first):

- C-RNTI MAC CE or data from UL-CCCH;
- Configured Grant Confirmation MAC CE;
- MAC CE for BSR, with exception of BSR included for padding;
- Single Entry PHR MAC CE or Multiple Entry PHR MAC CE;
- data from any Logical Channel, except data from UL-CCCH;
- MAC CE for Recommended bit rate query;
- MAC CE for BSR included for padding.

UL LBT failure MAC CE shall have a higher priority than BSR and UL data except CCCH and lower priority than C-RNTI MAC CE and data from CCCH.

Proposal 8: UL LBT failure MAC CE has higher priority than BSR MAC CE but lower priority than C-RNTI MAC CE and data from CCCH.

5.3 SR

When there is no UL resource for MAC CE transmission, the UE shall be able to transmit an SR signaling to request resource for this MAC CE. We think it should be supported for network to be aware of UL LBT failure timely.

Proposal 9: SR should be triggered to request resource for UL LBT failure MAC CE when the UE does not have any UL resource.

5.4 MAC CE Format

For improve resource efficient, two types of format can be introduced as showed below, i.e. short format and long format similar to SCell activation/deactivation MAC CE. Which type of format is used is based on how many SCell is configured.

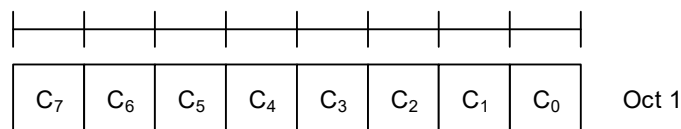


Figure 1: short format

C ₇	C ₆	C ₅	C ₄	C ₃	C ₂	C ₁	C ₀	Oct 1
C ₁₅	C ₁₄	C ₁₃	C ₁₂	C ₁₁	C ₁₀	C ₉	C ₈	Oct 2
C ₂₃	C ₂₂	C ₂₁	C ₂₀	C ₁₉	C ₁₈	C ₁₇	C ₁₆	Oct 3
C ₃₁	C ₃₀	C ₂₉	C ₂₈	C ₂₇	C ₂₆	C ₂₅	C ₂₄	Oct 4

Figure 2: long format

- C_i: this field indicates the UL failure status of the serving cell i. The C_i field is set to 1 to indicate that the serving cell i is detected with UL LBT failure.

Proposal 10: Both short and long MAC CE for UL LBT failure report can be used.

6 Conclusion

Based on the discussion we propose the following:

Proposal 1: it is beneficial to introduce a counter to prevent counting too close UL LBT failure.

Proposal 2: after detecting with UL LBT failure on a SCell, the following actions should be performed.

- All transmissions on the SCell should be suspended.
- Type 1 configured grant of the SCell is cleared, if configured.
- Type 2 configured grant of the SCell is suspended, if configured.
- BWP inactivity timer should be stopped.

Proposal 3: For UL LBT failure recovery by BWP switching, both 2-step RA and 4-step RA can be used.

Proposal 4: MAC CE can be used to report UL LBT failure on PCell.

Proposal 5: Confirm that counter for UL LBT failure detection should be reset and timer for UL LBT failure detection should be stopped at BWP switching.

Proposal 6: Random access initialization should be performed when BWP is switched for UL LBT recovery.

Proposal 7: It is beneficial to have a rule to restrict the MAC CE to be transmitted on the serving cell without detected UL LBT failure.

Proposal 8: UL LBT failure MAC CE has higher priority than BSR MAC CE but lower priority than C-RNTI MAC CE and data from CCCH.

Proposal 9: SR should be triggered to request resource for UL LBT failure MAC CE when the UE does not have any UL resource.

Proposal 10: Both short and long MAC CE for UL LBT failure report can be used.

7 References

- [1] RAN2#107 chairman note
- [2] RAN2#107bis chairman note