

Chengdu, China, 8th - 12th October 2018

Agenda Item: 11.2.1.1

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Title: Considerations on 4-step RACH procedure for NR-U

Document for: Discussion and Decision

1 Introduction

In RAN2 #103 [1], the following agreement is reached:

- ⇒ R2 assumes that RACH may be enhanced by additional opportunities, e.g. in time or frequency domain, FFS which messages the additional opportunities apply to.
- ⇒ Will study the model of single-RACH procedure. FFS multiple parallel procedure model
- ⇒ Will study impact to *PREAMBLE_TRANSMISSION_COUNTER*, *PREAMBLE_POWER_RAMPING_COUNTER*, ra-ResponseWindow, ra-ContentionResolutionTimer

- ⇒ It is FFS if LBT failure knowledge would be used in MAC (if available), e.g. to decide whether to increments counters *PREAMBLE_POWER_RAMPING_COUNTER*, *PREAMBLE_TRANSMISSION_COUNTER*, or start stop of timers.

In RAN1 #94[2], the agreement on preamble transmission is reached as follows.

Agreement:

If preamble transmissions are dropped due to LBT failure, then

- From a RAN1 perspective, it is recommended that preamble power ramping is not performed and that the preamble transmission counter is not incremented

In this contribution, according to the agreements from the last RAN1 and RAN2, we will proceed to discuss some enhancements on 4-step RACH procedure, and provide our proposals.

2 Discussion

For NR-U, LBT needs to be performed before each step of transmitting message. Due to LBT failures, the channel access delay may be even worse, such that control plane requirement will not be met. Therefore, some enhancements are essential in order to reduce access delay. And in the last RAN2 meeting, it has reached an agreement that enhancements to 4-step RACH for additional opportunities should be studied for NR-U.

The following Enhancements schemes for RACH procedure are considered from the perspective of the model of RACH procedure and each message of RACH procedure.

2.1 RACH procedure

For the model of RACH procedure, two kinds of models of RACH procedure are considered: single RACH procedure with multiple RACH candidates and multiple parallel RACH procedures.

Single RACH procedure with multiple RACH candidates

For single RACH procedure with multiple RACH candidates, if multiple PRACH occasions in time domain are selected as multiple opportunities for transmitting preamble, multiple LBTs may need to be performed, which may increase access delay. Hence, multiple RACH candidates in frequency domain are considered as follows.

- ✓ **Option1:** UE may select one or multiple carriers/BWPs according to channel occupancy or LBT results, and perform LBT in candidate carriers/BWPs. Once a LBT succeeds, UE will transmit preamble in the corresponding carrier/BWP, and ongoing LBTs on other candidate carriers/BWPs will be terminated. The following Msg2 and Msg4 will be transmitted in DL BWP corresponding to UL BWP in which preamble is transmitted, and Msg3 will be transmitted in the same UL BWP as preamble transmission. An illustration of option 1 is shown as Figure 1.

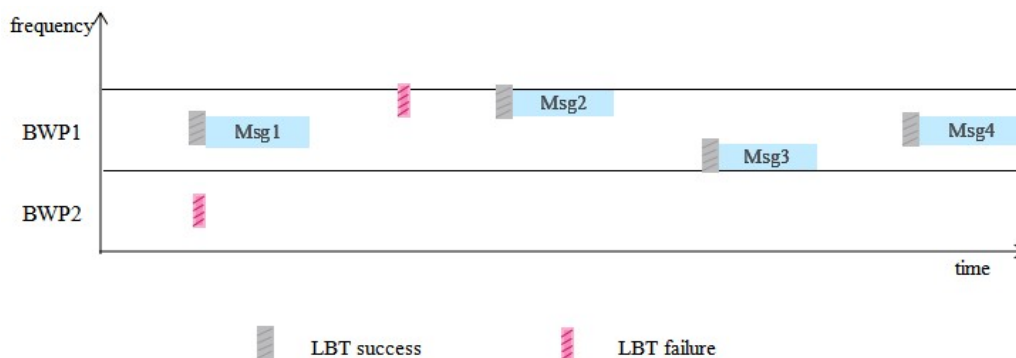


Figure 1 single RACH procedure in one selected BWP

- ✓ **Option2:** UE/gNB can select one or more carriers/BWPs according to channel occupancy or LBT results before transmitting each message in the RACH procedure, and then perform LBT on the candidate carriers/BWPs. Once a LBT succeeds, UE/gNB transmits the message in the corresponding carrier/BWP, and ongoing LBT on other candidate carriers/BWPs will be terminated. An illustration of option 2 is shown as Figure 2.

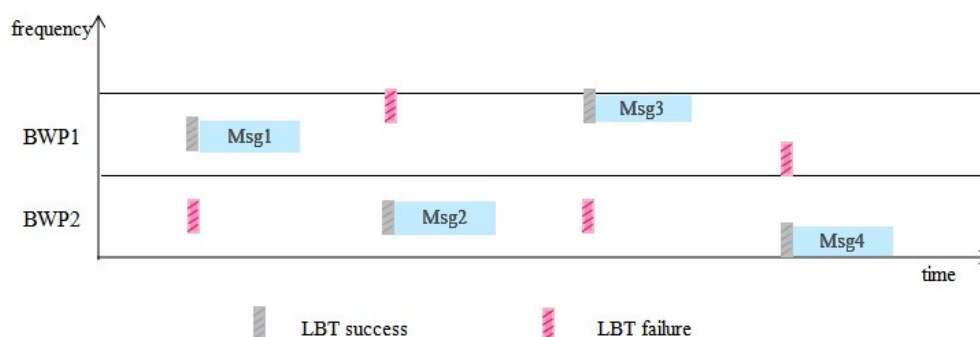


Figure 2 single RACH procedure in selected BWP based on LBT

For option1, RACH procedure is performed on the same carrier/BWP for both UL and DL once the preamble is transmitted on this carrier/BWP, and UE needs to monitor only one carrier/BWP without carrier switching or wideband monitoring. Therefore, blind detection across multiple carriers/BWPs is not needed and power consumption will be reduced.

For option 2, RACH procedure is performed across multiple carriers/BWPs. It increases transmission opportunities for each message during RACH procedure, and may reduce access latency. However, option 2 requires UE to do wideband blind detection across multiple carriers/BWPs, which consumes more power.

Based on the analysis above, both option 1 and option 2 have own benefits and disadvantages. Both should be studied.

Proposal 1: Single RACH procedure with multiple RACH candidates should be studied.

Multiple parallel RACH procedures

The scheme of multiple parallel RACH procedures can be applied in frequency or time domain or both.

- ✓ Option 1, multiple RACH occasions are configured in time domain. UE starts multiple RACH procedures at different time. Multiple independent RACH procedures may proceed in parallel.
- ✓ Option2, multiple RACH occasions are configured in frequency domain. One or more uplink and downlink carriers/BWPs are configured to UE. RACH configuration corresponding to each uplink carrier/BWPs is also configured to UE. UE performs multiple RACH procedures on different carriers/BWPs. Multiple independent RACH procedures may proceed in parallel. An illustration of option 2 is shown as Figure 3.

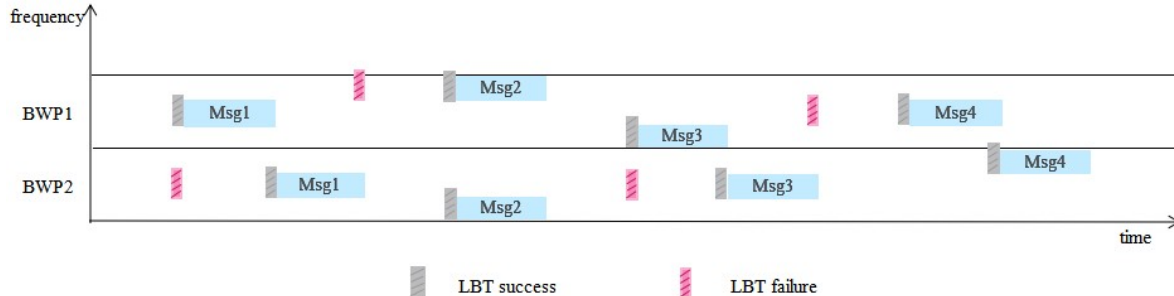


Figure 3 multiple parallel RACH procedures in multiple BWPs

For option1, multiple time domain RACH procedures are parallel. For option 2, multiple frequency domain RACH procedures are parallel performed. Since the multiple RACH procedures are parallel, when any one of the parallel RACH procedures succeeds, other ongoing RACH procedures can be terminated, which may reduce random access delay.

Therefore, multiple parallel RACH procedures in time domain and frequency domain should be studied.

Proposal 2: Multiple parallel RACH procedures should be studied.

2.2 Enhancement of each message transmission

In this section, from the perspective of the model of RACH procedure, we mainly take single RACH procedure with multiple candidates as an example to discuss the enhancements of each message transmission.

2.2.1 Preamble transmission

Preamble transmission failure

In the last RAN1 #94 meeting, the agreement on two counters related to preamble transmission is reached as follows.

If preamble transmissions are dropped due to LBT failure, then

From a RAN1 perspective, it is recommended that preamble power ramping is not performed and that the preamble transmission counter is not incremented

According to the agreement above, when preamble transmission fails due to LBT, both *PREAMBLE_POWER_RAMPING_COUNTER* and *PREAMBLE_TRANSMISSION_COUNTER* will not be incremented. From RAN2 perspective, we think that the two counters should not be incremented either, due to the fact that preamble transmission does not happen.

Observation 1: When preamble transmission is blocked due to LBT failure, both *PREAMBLE_POWER_RAMPING_COUNTER* and *PREAMBLE_TRANSMISSION_COUNTER* should not be incremented.

LBT feedback

In NR, MAC indicates lower layer to transmit preamble using the selected PRACH resource. Once MAC indicates the transmission, it will start *ra-ResponseWindow* at the first PDCCH occasion from the end of Random Access Preamble transmission. However, in NR-U, Preamble transmission can only happen when LBT succeeds. When LBT fails, there is no need for UE to start *ra-ResponseWindow* to wait for Random Access Response. Hence, when LBT fails, a LBT failure indication should be informed to MAC by the lower layer, such that MAC will not start *ra-ResponseWindow*, and will be able to re-select PRACH resource quickly.

In addition, when MAC receives LBT failure indication, preamble transmission counter and power ramping counter will not be incremented.

Proposal 3: LBT failure indication should be informed to MAC layer.

Preamble transmission termination

When preamble transmission is dropped due to LBT failure, *PREAMBLE_TRANSMISSION_COUNTER* will not be incremented. However, when channel is very busy, UE may have no chance to access the channel for a long time, then RACH procedure will never terminate since *PREAMBLE_TRANSMISSION_COUNTER* will not be incremented. In order to solve this problem, MAC may count LBT consecutive failure times. When consecutive LBT failure times exceed a certain value, UE may terminate the current RACH procedure and select other carrier, i.e. in this case, MAC should indicate random access failure to upper layer, and then upper layer initiates reestablishment procedure. Once a preamble transmission happens, LBT failure counter should be reset.

Proposal 4: When consecutive LBT failure times exceed a certain value, MAC terminates the current RACH procedure and indicates random access failure to upper layer.

Preamble transmission enhancement

Some enhancements on preamble transmission are considered, e.g. multiple time and/or frequency domain opportunities. For multiple frequency domain opportunities, when multiple carriers/BWPs are configured to UE, UE may attempt to perform LBTs in multiple carriers/BWPs. When any one of the LBTs succeeds, UE may perform preamble transmission in this carrier/BWP. For multiple time domain opportunities, if LBT fails in preamble transmission occasion, and it may attempt to perform LBT in the next preamble transmission occasion. Though multiple time domain opportunities may increase the access delay, it may also be an option in some cases.

Proposal 5: Multiple time and/or frequency domain opportunities may be considered for preamble transmission enhancements.

2.2.2 RAR/Msg4 transmission

Similar to preamble transmission enhancement, some enhancements on RAR/Msg4 can also be considered, e.g. multiple time and/or frequency domain opportunities.

Proposal 6: Multiple time and/or frequency domain opportunities may be considered for RAR/Msg4 transmission enhancements.

2.2.3 Msg3 transmission

Some enhancements on Msg3 are considered, e.g. multiple transmission opportunities, multiple repetition transmission. Multiple transmission opportunities or repetition need to be configured to UE. When UE receives MAC RAR or UL grant for Msg3 transmission/retransmission, it can attempt multiple LBTs until LBT succeeds in the candidate transmission resources.

Proposal 7: Some enhancements on Msg3 needs to be considered, e.g. multiple transmission opportunities, multiple repetition.

3 Conclusion

In this contribution, we discussed random access procedure in NR-U, and have made the following proposals.

Proposal 1: Single RACH procedure with multiple RACH candidates should be studied.

Proposal 2: Multiple parallel RACH procedures should be studied.

Observation 1: When preamble transmission is blocked due to LBT failure, both *PREAMBLE_TRANSMISSION_COUNTER* and *PREAMBLE_TRANSMISSION_COUNTER* should not be incremented.

Proposal 3: LBT failure indication should be informed to MAC.

Proposal 4: When consecutive LBT failure times exceed a certain value, MAC terminates the current RACH procedure and indicates random access failure to upper layer.

Proposal 5: Multiple time and/or frequency domain opportunities may be considered for preamble transmission enhancements.

Proposal 6: Multiple time and/or frequency domain opportunities may be considered for RAR/Msg4 transmission enhancements.

Proposal 7: Some enhancements on Msg3 need to be considered, e.g. multiple transmission opportunities, multiple repetition or non-adaptive retransmission.

4 Reference

[1] Draft_RAN2#103_Report_v1, Gothenburg, Sweden, 20th - 24th Aug 2018.

[2] Draft Report of 3GPP TSG RAN WG1 #94 v0.1.0, Gothenburg, Sweden, 20th – 24th August 2018