

Agenda item: 7.1.8

Source: Nokia Corporation, Nokia Siemens Networks

Title: RACH and carrier aggregation

Document for: Discussion and Decision

1 Introduction

Carrier aggregation has the potential to introduce additional complexity and changes to UE behaviour because a UE could be permitted to use RACH resources on more than one uplink CC. So far it has not been discussed whether UEs that are configured for carrier aggregation can be configured to use more than one RACH and, if so, the changes in UE behaviour that would be required. This Tdoc is intended to identify some of the issues that may need to be decided.

2 Discussion

For many of the uses of RACH, the UE behaviour relating to RACH could be expected to be similar to Rel-8.

For initial access and RRC connection re-establishment, the UE can be expected to be working with a single DL and UL carrier pair and will use the RACH parameters defined by system information. UE behaviour could be expected to be the same as in Rel-8.

Similarly, for handover, it is assumed here that the UE will use a single UL carrier and it's associated RACH to initiate communication with the target cell. The UL CC and RACH parameter would be indicated in the handover command. Even if multiple UL CCs in the target cell are indicated to the UE prior to handover execution, it seems likely that a specified single UL CC and RACH would be used for execution and, consequently, the UE behaviour in relation to RACH for handover could be the same as in Rel-8.

When, however, a UE is allocated more than one UL CC for carrier aggregation, there is the potential for the UE to have available to it more than one RACH. Each UL CC that it is assigned could support a RACH, and, in fact, where there are an asymmetric UL and DL numbers of carriers, e.g. two DL CC both paired to one UL CC, the UE could be assigned two sets of RACH parameters on the one UL CC when the RACH for each DL CC is mapped to the same UL CC by way of partitioning e.g. by time partitioning. It is assumed here that, if RACH resources on an UL CC are partitioned between two or more DL CCs these are seen as separate RACH entities by the UE.

It is currently not clear whether a UE will always operate with a single timing advance applicable to all UL CCs, or whether there can be configurations in which a UE would be required to operate with more than one independent timing advance chain. If a UE is assigned (groups of) UL CCs that have independent timing advance, it seems necessary that the UE must be assigned and able to support at least one RACH for each timing advance group in order to be able to implement timing correction via PDCCH order. The UE MAC must be able to distinguish between PDCCH orders signalled for each RACH and apply the timing advance to the UL CCs that are associated with that particular timing advance.

It is currently indicated in the stage 2 that a UE should only have one RACH procedure ongoing at a time. If this remains true for PDCCH order responses made for different timing advance groups then the eNB must avoid overlapping PDCCH orders for the two groups.

One question that RAN2 may wish to consider is whether a UE can/ should be expected to support more than one RACH per set of UL CCs that share a common timing advance. It seems likely that the UE will always be allocated RACH resources on the UL CC that is associated with its 'special cell' or 'primary carrier [1]' since these will have been available since cell entry or handover. It could be assigned, or detect from system information additional RACHs, e.g. RACHs associated with each of the DL CCs, which are configured or activated.

If the number of RACH is restricted to one the, except in the case of multiple timing advance groups, MAC operation should remain similar to Rel-8. On the other hand, if the UE has multiple RACH available there is the possibility to provide some distribution of RACH load and also to provide redundancy in the case of ‘out-of-sync’ failure on one or more DL CCs or failure of the RACH itself. However, it might also be questioned whether a UE that requires carrier aggregation, and therefore could be expected to have high activity, would make frequent use of RACH either for timing correction or BSR transmission.

It is therefore proposed to discuss whether:-

P1: If a UE supports CCs that have independent timing advance correction then at least one RACH is required for each group of UL CCs that have a common timing advance.

P2: How many RACH configurations is the UE required to support:-

1. UEs supporting carrier aggregation are required to support only a single RACH (per group of UL CCs that share a common timing advance).
 - The RACH is that associated with the ‘special cell’ or primary carrier [1] if the carrier is part of the group of CCs that apply the same timing advance.
2. UEs supporting carrier aggregation are required to support multiple RACH (per group of UL CCs that share a common timing advance).
 - Including that associated with the ‘special cell’ or primary carrier if the carrier is part of the group of CCs that apply the same timing advance.

If the UE is configured with multiple RACH then a follow up questions could be.

P3: Does the UE:-

1. By default, work with all of the RACHs that are provided by the DL/UL CC combination that is configured.
 - 1a. The UE must be able to utilise all of the RACHs.
 - 1b. The UE is free to select a subset of the RACHs, subject to a constraint that at least one RACH is known to the eNB for PDCCH order transmission e.g. the primary carrier RACH.
2. A subset of the RACHs that are available, the subset defined by the eNB via dedicated signalling.

P4: Is a RACH available if the associated DL and UL CCs are configured but not activated.

Following from decisions already made it is assumed that:-

P5: The UE receives RACH configuration information via dedicated signalling. A possible exception to this may be RACH associated with the ‘special cell’ or primary carrier which may be obtained from a UE receiving system information via Rel-8 procedures.

2.1 UE behaviour relating to RACH with carrier aggregation

As has been indicated above, it is assumed here that, in the case of RRC connection establishment, re-establishment and handover, UE behaviour relating to RACH may be essentially the same as in Rel-8 i.e. the UE uses a specific RACH. Therefore, if a connected state UE, configured for carrier aggregation, has available multiple RACHs the potential for UE behaviour change to accommodate multiple RACHs seems to apply to just two use cases, PDCCH order and RACH selected by MAC i.e. for BSR transmission. If the UE has only a single RACH then behaviour could be the same as in Re-8.

For PDCCH order with multiple RACHs:-

- Where the UE has UL CCs associated with more than one timing advance (should multiple timing advance be supported), it will be necessary for the RACHs to be partitioned between the timing advance groups. The MAC must be able to identify that the PDCCH order relates to a particular RACH and that the timing advance received relates to the particular group of UL CCs.
- The RACH procedure i.e. the receiving of the PDCCH order, the resulting signature transmission and receiving of the timing advance in the RAR could be the same as in Rel-8 e.g. the PDCCH order and the

RAR will be transmitted on the DL CC that is the DL pair for the UL CC that supports the RACH. Where the UE has more than one RACH associated with a timing advance group, then it is assumed that eNB could initiate the PDCCH order on any of these RACHs.

For random access initiated by MAC, i.e. contention based RACH access:-

- Where the UE has available more than one RACH designated for contention use, MAC may need to select between the RACHs i.e. if one is not designated for contention access by eNB. It is possible to identify a number of alternatives as the basis for selection e.g. selection at random or in sequence or taking account of some measured or broadcast parameter. If it is decided to allow UE selection between RACHs and to specify the method to be used in the standards, then stage 3 work would need to identify a method of selection.

It is assumed that the benefit of enabling the selecting from a set of available RACHs is a distribution of the load.

- Once a RACH has been selected a potentially simple way forward would be that the UE behaviour should conform to Rel-8 i.e. the transmission of signatures/ power ramping/ obeying of backoff/ monitoring for RA-RNTI/ transmission of Msg3/ Reception of Msg4 and contention resolution are based on the UL/DL CC pair that are associated with the RACH.

It could be argued that if there are multiple RACH available, a UE receiving a backoff delay should change RACH and continue the process using the alternative RACH parameters. In principle, the UE could either abort and restart the RACH process i.e. resetting the transmission counter and power ramping to the initial state, or simply change RACH resources part way through the sequence. However, changing RACH, if performed by all UEs, could simply move congestion from one RACH to another resulting in no gain. The behaviour of the UE in response to backoff in a multiple RACH scenario may need to be examined by stage 3 work.

A further topic where there is a potential for changed UE behaviour is the UE behaviour as a consequence of RACH failure i.e. the UE completes a maximum number of signature transmissions without success. In Rel-8 the MAC indicates RACH failure to RRC and RRC takes this as an indication of UL radio link failure and initiates RRC connection re-establishment. Where the UE has multiple UL CCs with RACH resources then, in principle, the UE may not be subject to a total radio link failure.

The criteria for declaring a radio link failure in these circumstances is outside of the scope of this Tdoc but in the case of RA triggered by MAC, the MAC could re-attempt the RACH access using an alternative UL CC RACH.

3 Conclusion

This Tdoc has been directed at identifying open issues that could result from the potential availability to a UE of multiple RACHs as a result of carrier aggregation. It is proposed that it should be reviewed whether the issues identified are correct. It is also proposed that RAN 2 consider whether any of the following options can be decided upon. Whether:-

P1: If a UE supports CCs that have independent timing advance correction then at least one RACH is required for each group of UL CCs that have a common timing advance.

P2: How many RACH configurations is the UE required to support, i.e.

1. UEs supporting carrier aggregation are required to support a single RACH (per group of UL CCs that share a common timing advance).
 - The RACH is that associated with the 'special cell' or primary carrier [1] if the carrier is part of the group of CCs that apply the same timing advance.
2. UEs supporting carrier aggregation are required to support multiple RACH (per group of UL CCs that share a common timing advance).
 - Including that associated with the 'special cell' or primary carrier if the carrier is part of the group of CCs that apply the same timing advance.

If the UE is assigned multiple RACH then:-

P3: Does the UE:-

1. By default, work with all of the RACHs that are provided by the DL/UL CC combination that it is configured.
 - 1a. The UE must be able to utilise all of the RACHs.
 - 1b. The UE is free to select a subset of the RACHs, subject to a constraint that at least one RACH is known to the eNB for PDCCH order transmission e.g. the primary carrier RACH.
2. A subset of the RACHs that are available, the subset defined by the eNB via dedicated signalling.

P4: Is a RACH available if the associated DL and UL CCs are configured but not activated.

Following from decisions already made it is assumed that:-

P5: The UE receives RACH configuration information via dedicated signalling. A possible exception to this may be RACH associated with the 'special cell' or primary carrier which may be obtained from a UE receiving system information via Rel-8 procedures.

References

- [1] R2-100054, *Primary Component Carrier*, Nokia Siemens Networks, Nokia Corporation