

Agenda item: 7.1.2
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Title: Primary Component Carrier
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1 Introduction

Carrier aggregation for LTE in Rel-10 is in some ways comparable to multi-carrier for GERAN in Rel-7 and multi-carrier for UTRAN introduced in Release 9 [1] [2]. An interesting difference between GERAN and UTRAN is the primary carrier concept. In multi-carrier for UTRAN, a primary carrier is used: it is the carrier that cannot be disabled and on which RLF and mobility measurements are based. In GERAN multi-carrier, there is no primary carrier concept and all resources are seen as equal: multi-carrier is a simple extension of the multi-slot mechanism. Because both approaches seem viable, this contribution discusses which one is best suited to LTE.

2 Primary Carrier Concept

A short overview of the two alternatives as we understand them for LTE is first given below:

- **One primary carrier:** a UE is assigned a primary component carrier (PCC) which it utilises much the same as for Rel-8 i.e. it performs PDCCH monitoring using DRX, it may have SR resources and it has RACH. The PCC corresponds to the “special” cell and can only be changed via handover. The UE can be configured with additional UL and DL CCs.
- **No primary carrier:** UE is configured/reconfigured with a number of DL and UL CCs. There is a “special” cell for the purpose of security and NAS mobility but at the lower level all CCs are equal.

In the following subclauses, the impacts the PCC has on handovers and radio link failure, scheduling requests, CC activation and DRX are investigated.

2.1 Handover and Radio Link Failure

With a PCC defined, the loss of the PCC alone triggers an RLF while without a PCC, it is in theory possible to avoid RLF as long as one CC is still available. In practise however, not only having a PCC should not increase the number of HO/RLF compared to Rel-8 (whenever a change of the P CC is needed, an HO would have happened in Rel-8 anyway), but also the scenario where a PCC is selected as the CC offering the smallest coverage of all CCs offered by the eNB is questionable. In the later case however, optimisations for the re-establishment procedure on CCs that belonged to the CC set before PCC loss could be studied.

Observation 1: defining a PCC does not increase RLF/HO compared to Rel-8.

Furthermore, limiting RLF monitoring (i.e. detection of physical layer problems in RRC_CONNECTED through wideband measurements) to the PCC reduces the need for measuring secondary component carriers (SCCs). Depending on which SCC measurements are agreed, this can be expected to reduce the power consumption of the UE.

Observation 2: limiting RLF monitoring (i.e. detection of physical layer problems in RRC_CONNECTED) to the PCC is expected to reduce the power consumption of the UE.

2.2 Scheduling Requests

It was agreed by RAN1 that scheduling requests can only be mapped onto one UE specific UL CC [3]. This decision obviously makes an UL carrier more important than others and also suggests that this CC should not be de-activated (assuming that an activation mechanism is agreed).

Observation 3: RAN1 decision on SR mapping points towards the adoption of a PCC.

2.3 CC Activation

Although the need for a separate CC activation (in addition to CC configuration) is still debated, it is important to understand the difference the adoption of a PCC makes in that context. Having a PCC defined ensures (as in UTRAN) that one CC can never be de-activated and thus guarantees a constant communication link between the UE and the eNB. Without a PCC defined, special care need to be taken with activation/de-activation.

Observation 4: defining a PCC simplifies CC activation/de-activation.

2.4 DRX

Although the details of DRX handling are still very much open, it is foreseen that adopting a PCC, on which the UE would always fallback after some triggers related to inactivity, would maximise the sleep opportunities for the UE whilst guaranteeing fixed opportunities in time for the UE and eNB to communicate.

Observation 5: defining a PCC as the carrier on which to fallback after periods of inactivity would maximise the “sleep” opportunities for the UE.

2.5 CMAS/ETWS

In principle, the monitoring of paging by UEs in connected state in order to detect CMAS/ETWS events could be extended to the set of configured CCs i.e. the eNB could page, and transmit the associated SIBs, on all DL CCs on which idle state UEs can camp and the connected state UE could select which to monitor itself (from amongst activated CCs). Provided that the UE is performing RLF detection on the chosen CC then this should be acceptable. If it detects RLF on the CC and re-establishment is not triggered, then the UE would have to select another suitable DL CC from amongst the activated CCs on which to receive paging. On the other hand, if there is a primary DL CC then it could be viewed as simplest to require that ETWS/CMAS capable UEs periodically monitor paging on the primary CC. If there is RLF on the primary then the UE would acquire a new primary (via re-establishment or other means) and start monitoring that CC instead. Even though both approaches seem feasible, defining a PCC that is used for CMAS/ETWS notifications does seem simpler and is aligned with Rel-9 behaviour.

Observation 6: defining a PCC as the carrier that is used for CMAS/ETWS notification seems simpler and is aligned with Rel-9 behaviour.

3 Conclusion

A primary component carrier (PCC) is a CC that is assigned to a UE and which it utilises much the same as for Rel-8: it is the CC that conveys SR, offers a RACH and governs RLF. The PCC corresponds to the “special” cell and can only be changed via handover. The UE can be configured with additional UL and DL CCs. Because there is a PCC, these additional CCs can be activated/deactivated by signalling. This contribution has investigated the impacts such a PCC would have in LTE and several observations were made:

Observation 1: defining a PCC does not increase RLF/HO compared to Rel-8.

Observation 2: limiting RLF monitoring (i.e. detection of physical layer problems in RRC_CONNECTED) to the PCC is expected to reduce the power consumption of the UE.

Observation 3: RAN1 decision on SR mapping points towards the adoption of a PCC.

Observation 4: defining a PCC simplifies CC activation/de-activation.

Observation 5: defining a PCC as the carrier on which to fallback after periods of inactivity would maximise the “sleep” opportunities for the UE.

Observation 6: defining a PCC as the carrier that is used for CMAS/ETWS notification seems simpler and is aligned with Rel-9 behaviour.

If the above observations are correct, having a PCC not only simplifies carrier aggregation but can also lead to better battery saving for the UE. In addition there seems to be a strong link to Rel-8 i.e. the UE is returned to Rel-8 behaviour when it does not need the higher capacity. Intuitively we therefore prefer the primary option to the non-primary and think that it probably provides an evolutionary way forward.

Proposal 1: adopt the concept of a Primary Component Carrier for LTE, where the PCC

- is the CC associated with the special cell;
- can only be changed via HO;
- is never deactivated (assuming that we have activation);
- supports SR, ACK/NACK (possibly for all DL CCs if a single uplink CC is configured) and RACH (maybe the only RACH);
- governs RLF (RLF on the UL/DL PCC is necessary and sufficient to trigger re-establishment);
- is used by the UE for CMAS/ETWS notifications.

References

- [1] [3GPP TR 45.912](#), *Feasibility study for evolved GSM/EDGE Radio Access Network (GERAN)*
- [2] [3GPP TS 25.308](#), *High Speed Downlink Packet Access (HSDPA); Overall description; Stage 2*
- [3] [R1-094960](#), *Uplink control signalling for carrier aggregation*
- [4] [R1-093918](#), *LTE-Advanced Autonomous CC selection results for dense urban*
- [5] [R1-094659](#), *Autonomous CC selection for heterogeneous environments*
- [6] [3GPP TS 36.912](#), *Feasibility study for Further Advancements for E-UTRA (LTE-Advanced)*
- [7] [3GPP TS 36.321](#), *Medium Access Control (MAC) protocol specification*
- [8] [3GPP TS 36.331](#), *Radio Resource Control (RRC); Protocol specification*