

Agenda Item: 7.1.1

Source: Huawei

Title: Multiple Timing Advance Impact on RAN2

Document for: Discussion and Approval

1 Introduction

In reference [1][2], the feedback from RAN4 and RAN1 shows that it is possible to support multiple timing advance (TA) values for inter-band aggregated carriers under the scenario that frequency selective repeater is used. In last meeting, RAN2 has asked Operators to give some input on the requirement of multiple TA values for CA. In the meantime, RAN has also agreed a new WI for introducing Type-I relay in Rel-10 so we discuss if inband or outband relay could be used instead of a repeater for superior performance without additional TA advance complexity. In this paper, we analyze the impact of supporting multiple TA.

2 Discussion

2.1 Scenario Analysis

Based on the deployment scenarios with the highest priority for CA feasibility study listed in [3], four UL inter-band CA scenarios exist as showed in following table. At most three bands can be expected for inter-band UL CA. Accordingly, at most 3 TA values could be expected for one UE. For simplicity, the scenario7 will be taken as an example in the following description.

Scenario No.	Deployment Scenario	Transmission BWs of LTE-A carriers	No of LTE-A component carriers	Bands for LTE-A carriers	Duplex modes
7	Multi-band non-contiguous spec. alloc. @ Band 1, 3 and 7 for FDD	UL: 40 MHz DL: 40 MHz	UL/DL: Non-contiguous 10 MHz CC@Band 1 + 10 MHz CC@Band 3 + 20 MHz CC@Band 7	Band 3 (1.8 GHz) Band 1 (2.1 GHz) Band 7 (2.6 GHz)	FDD
8	Multi-band non-contiguous spec. alloc. @ Band 1 and Band 3 for FDD	30 MHz	Non-contiguous 1x15 + 1x15 MHz CCs	Band 1 (2.1 GHz) Band 3 (1.8GHz)	FDD
9	Multi-band non-contiguous spec. alloc. @ 800 MHz band and Band 8 for FDD	UL: 20 MHz DL: 20 MHz	UL/DL: Non-contiguous 10 MHz CC@UHF + 10 MHz CC@Band 8	800 MHz band Band 8 (900 MHz)	FDD
10	Multi-band non-contiguous spec. alloc. @ Band 39, 34, and 40 for TDD	90 MHz	Non-contiguous 2x20 + 10 + 2x20 MHz CCs	Band 39 (1.8GHz) Band 34 (2.1GHz) Band 40 (2.3GHz)	TDD

Generally, in presence of repeaters, the eNB can not know if two inter-band aggregated CCs will share identical timing advance as illustrated by two examples below:

- ✧ Case1: As showed in Fig.1, a UE is first served by CC1 which happens to be forwarded by a repeater. Later the eNB decides to add CC2 and CC3 for the UE. There are no repeaters in CC2 and CC3 so the eNB does not know whether the new CCs can share the same TA value with CC1.
- ✧ Case2: The UE in Fig.2, enters or leaves the coverage of a repeater. The movement of the UE results in the change TA among aggregated CCs.

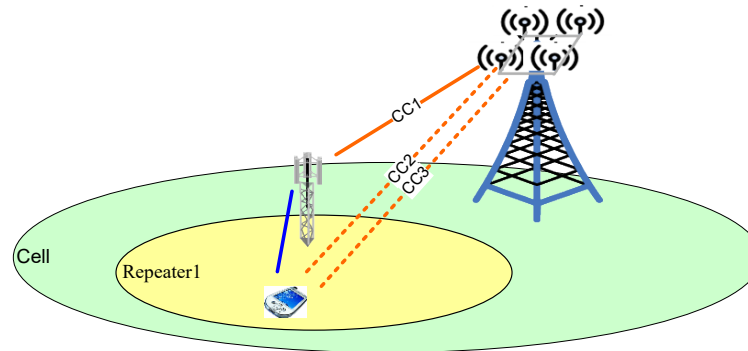


Fig.1 Multiple TA impact in the case of CC configuration

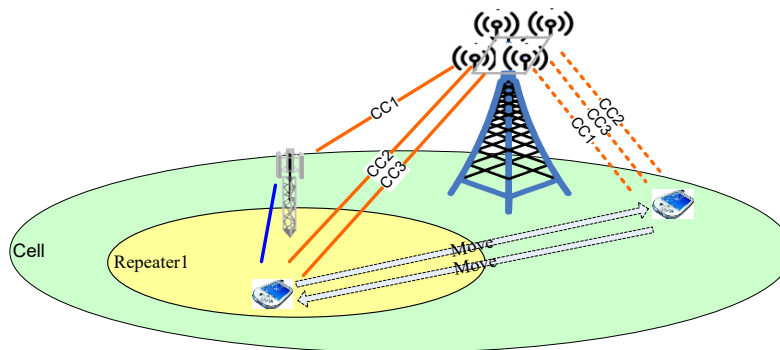


Fig.2 Multiple TA impact in the case of intra-cell mobility

One simple option is to maintain one TA for each band's UL aggregated CCs separately. However if repeaters are sparsely deployed, in most cases, the aggregated UL CCs will share identical TA value. That would cause a lot of unnecessary RACH operation and TA maintenance overhead. In order to reduce the above overhead, RAN2 could investigate methods to allow sharing a TA for inter-band aggregated CCs to support multiple TA, which increase the system complexity.

In the last RAN plenary meeting, it became clear that Type-I relays will be supported already in Release-10. Relays have superior performance than repeaters, and would require UEs no to maintain more than one timing advance in such cases.

Observation1: RAN2 should investigate the efficiency and complexity issues related to introducing multiple TA maintenance.

2.2 RACH Impact

RACH impact caused by multiple TA can be considered in following aspects:

- ✧ RRC connection establishment/reestablishment
- ✧ Inter-eNB Handover

- ✧ UL/DL data arrival RRC_CONNECTED requiring random access procedure
- ✧ RLF

2.2.1 Impact on RRC connection establishment/reestablishment

Since it has been agreed that there is no CA in idle mode, it is expected that there is no impact on RRC connection establishment caused by multiple TA. And it seems no strong motivation to initiate RRC connection reestablishment over multiple UL CCs.

Obeservation2: *for supporting multiple TA, no impact is expected on RACH for RRC connection establishment/reestablishment.*

2.2.2 Impact on the inter-eNB handover

It has been agreed in RAN2 that *at intra-LTE handover, multiple CCs can be included in the “handover command” for usage in the target cell*, in order to maintain high speed transmission during HO. When the UE receives one handover command including multiple CCs, they may require different timing advances, i.e. these CCs belong to the different bands where repeaters may be present (as showed in Fig.3). In order to acquire TA, one RACH per CC is needed. Concurrent RACH procedure operation may cause shorter access delay compared with performing RACH sequentially on each CC. However, simultaneous RACH operation is inconsistent with the previous agreement that “at most one random access procedure shall be ongoing at any time”. Hence we ake the following observation:

Obeservation3: *If multiple TA needs to be supported, RAN2 may need to revisit the conclusion “at most one random access procedure shall be ongoing at any time”.*

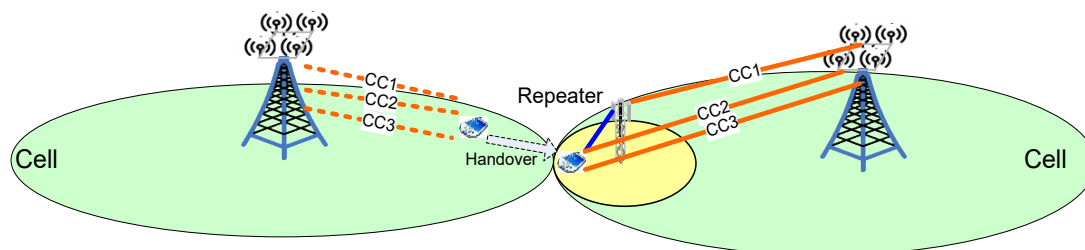


Fig.3 Multiple TA impact in the case of handover

2.2.3 Impact on UL/DL data arrival requiring RACH

If there is no PUCCH available for SR transmission when there is UL data arrival, as in Rel-8, UE needs to perform contention-based RACH to require UL grant. We see no motivation for simultaneously performing RACH over multiple CCs to request UL grant. So, there is no impact in this case.

When eNB needs to send DL data to UE in case of partial UL synchronization loss (i.e., part of the configured UL CCs lose synchronization), two ways can be used to request UE performing contention free RACH: 1) As in Rel-8, eNB send PDCCH order in one DL CC to trigger UE perform RACH over its paired UL CC; 2) eNB could also send the PDCCH order from one active CC to indicate the UE performing RACH over its unpaired UL CCs. And CC index (CIF) can be used to indicate which CC is required to perform RACH. These functions can be implemented based on legacy agreements. If all UL CCs in the different bands are out of synchronization, eNB can send the PDCCH order for each CC group with the identical TA value, and UE can perform the contention-free RACH simultaneously. Such impact is similar with simultaneous RACH required for inter-eNB handover.

So, we can conclude that there is little impact on UL/DL data arrival for supporting multiple TA.

Obeservation4: *for supporting multiple TA, little impact is expected on RACH for UL/DL data arrival.*

2.2.4 Impact on RLF

In Rel-8, UE only performs RACH on one UL CC. If UE reaches the maximum number of preamble transmission, MAC could trigger RLF report to RRC layer to initiate RRC reestablishment. For inter-band CA, since different band frequency may experience different large scale fading, so the simplest way is to choose one with lowest frequency to perform RACH if the inter-band aggregated CCs can share identical TA. If identical TA can not be shared among the inter-band aggregated CCs, RACH should be performed separately at least for each group of CCs with identical TA value. If UE reaches the maximum number of preamble transmission only for part of the groups, RLF should not be declared because UL communication can still continue over other group. So, we have following observation.

Observation5: *If multiple TAs exist, MAC RLF triggering will be performed when UE fails to access the network in every group of its aggregated CCs with identical TA.*

2.3 UE Impact on the Maintenance of Uplink Time Alignment

In active mode, the UE adjusts its uplink time alignment based on Timing Advance Command MAC PDU. From UE point of view, one timing advance command for the CCs with identical TA enough. If multiple TA command is assumed for the CCs with identical TA, it will result in additional signaling and UE operations.

For symmetric CA and asymmetric CA with #DL CCs > #UL CCs, each UL CC has a paired DL CC. The UE maintains its uplink time alignment based on the Timing Advance Command received from the paired DL CC. So the Timing Advanced Command can keep unchanged in such cases.

Another case is UE-specific asymmetric CA with #UL CCs > #DL CCs. As showed in Fig.1, CC1 is configured as unpaired UL CC, which can not share identical TA with CC2 and CC3. The Rel-8 TA command can only be used to maintain the time alignment of CC2 and CC3 but not for CC1 since it has no corresponding DL CC. If such case is considered, RAN2 should investigate how TA command needs to be enhanced.

Observation6: *RAN2 should discuss whether there is UE-specific asymmetric CA exist, which requires for TA command enhancement if multiple TA needs to be supported.*

3 Conclusion

In the contribution, we investigated the impact of multiple TAs on some RAN2 and observed the following:

Observation1: *RAN2 should investigate the efficiency and complexity issues for multiple TA maintenance.*

Obeservation2: *for supporting multiple TA, no impact can be expected on RACH for RRC connection establishment/reestablishment.*

Obeservation3: *If multiple TA needs to be supported, RAN2 should revisit the conclusion “at most one random access procedure shall be ongoing at any time”.*

Obeservation4: *for supporting multiple TA, little impact can be expected on RACH for UL/DL data arrival.*

Observation5: *If multiple TAs exist, MAC RLF triggering will be performed when UE fails to access the network in every group of its aggregated CCs with identical TA.*

Observation6: RAN2 should discuss whether there is UE-specific asymmetric CA exist, which requires for TA command enhancement if multiple TA needs to be supported.

4 References

- [1] R2-096267, LS on timing advance for carrier aggregation in LTE-A, Qualcomm
- [2] R2-097378, Reply LS on timing advance for carrier aggregation in LTE-A, Qualcomm
- [3] R4-091464, Prioritized Deployment Scenarios for LTE-Advanced studies, NTT DOCOMO, T-Mobile Intl., CMCC, Orange, Vodafone, Telecom Italia, TeliaSonera AB