**3GPP TSG RAN WG2 Meeting #121-bis-e**    **R2-230xxxx**

Electronic, 17th– 26th Apr, 2023

Agenda Item: 7.12.2.1

Source: Intel Corporation

Title: Summary of [AT121bis-e][015][eIAB] Beam handling RACH-less HO (Intel)

Document for: Discussion and Decision

# Introduction

This is the summary of post email discussion:

* [AT121bis-e][015][eIAB] Beam handling RACH-less HO (Intel)

      Scope: Continue the discussion based on R2-2304098 (and R2-2302784). Address the potential issue of beam handling in target cell at RACH less handover, determine to what extent a solution could be feasible it in the scope of eIAB Rel-18 WI. Can also document the resolutions to the other issues listed in R2-2304098 if they were found working. Pave the way for online Come-Back.

      Intended outcome: Report

      Deadline: Online CB Monday April 24

Following two phases are considered for this email discussion:

Phase 1: W1 Friday April 21st 1000 UTC

Phase 2: W2 Monday April 24th 1h before online CB

Companies providing input to this email discussion are invited to leave contact information below.

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| --- | --- | --- |
| **Company** | **Name** | **Email Address** |
| Intel | Ziyi Li | Ziyi.li@intel.com |
| Huawei | Yulong | Shiyulong5@huawei.com |
| Qualcomm | Georg Hampel | ghampel@qti.qualcomm.com |
| Apple | Peng Cheng | pcheng24@apple.com |
| Ericsson | Antonino Orsino | antonino.orsino@ericsson.com |
| NEC | Jinhui Wen | wenjinhui@labs.nec.cn |
| Xiaomi | Shukun Wang | Wangshukun3@xiaomi.com |
| KDDI | Hiroki TAKEDA | ho-takeda@kddi.com |
| ZTE | Lin Chen | chen.lin23@zte.com.cn |
| Nokia | Andrew Lappalainen | andrew.lappalainen@nokia.com |
| Lenovo | Yibin Zhuo | zhuoyb1@lenovo.com |
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# Discussion

## General assumption

During online discussion, following agreement was reached:

* RACH-less for mIAB scenario, if agreed in the end, will cover only the case of same-TA.

During online discussion, some companies pointed out that the two logical DUs can share the same beam configuration between two logical DUs. Recalling RAN2 previously agreed the two logical DU cells are seen by UE as different physical cells. There seems no limitation for these two cells using the same configuration (e.g. cell common and UE specific beam related configuration).

To help the discussion in the following sections, rapporteur thinks it might be helpful to first align on the assumption whether the two logical DUs can use the same beam related configurations or not.

Working assumption: RAN2 assumes the source and target logical DU use the same configuration (e.g. cell common and UE specific beam related configuration) during full migration.

**Q1: Do you agree with the above working assumption?**

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| **Company** | **Yes/No** | **Comments** |
| Huawei, HiSilicon | Yes, but | We should say “can use” if network considers it is possible and useful e.g. in RACH-less. Maybe it is not valid to mandate that they have to use the same config.  Then, if agreed, we should inform RAN3. |
| Qualcomm | No | This may unnecessarily constrain implementations. The cells are certainly different in that they use different PCIs and/or different frequencies. The HO command includes the new cell config, so there is no need to make this assumption. |
| Apple | No | Because the two logical DU are seen by UE as different physical cell, it is possible that the two physical cells have different beam configurations. Please note that RAN2 assume different transmit power can be used in source and target cell in CHO discussion.  And we think this WA is not useful because the beam used for one DL and UL transmission is generally indicated by DCI + MAC-CE (on top of RRC configuration). And our key issue is how to determine the beam used to transmit RRCReconfigurationComplete to target cell. So, even if same RRC configuration is same, it can't ensure the same beam is used by source cell and target cell. |
| Ericsson | No | The two DU uses different PCI, may use different frequencies, different BWP ID, etc. It is evident that the two configuration cannot be considered equal. |
| NEC | Yes, but | For our understanding, a beam is associated with a specific signal (e.g., SSB/CSI-RS). Take CSI-RS for example, since two logical DU cells are seen as different physical cells using separate physical resources, the resources and the number of CSI-RS are different for these 2 cells. So it’s hard to say that they can use the same beam configuration.  Instead, we suppose that UE maintains the latest beam information for the corresponding signal or channel (e.g., PUCCH, PUSCH, PDCCH or PDSCH) of source cell, and applies them in the target cell until new beam info is provided/determined. |
| Xiaomi | No | I wonder whether it is general deployment that two DU use the same configuration (e.g. cell common and UE specific beam related configuration)? In my understanding, the PCI is different at least. |
| KDDI | Yes | Share the view with Huawei, we “can use” if possible, but not mandate to use the same config always. |
| ZTE | No | Agree with Huawei that the same configuration may be used if possible. However, this does not preclude the cases where different beam configurations are used for the source and target logical DU. |
| Nokia | No | We share Ericsson’s view. |
| Lenovo | Yes | Agree with Huawei that source and target logical DU can use the same configuration.  As baseline, source and target logical DU use independent configuration as legacy. But in case of DU migration, the physical location between UE and IAB-DU doesn’t change, we may make some enhancement, e.g., source and target logical DU use the same configuration, to optimize the UE handover during DU migration. |
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## Beam handling

In [4098], it was questioned which beam will be used by the UE to perform first UL transmission or DL reception with the target cell, and how beam alignment between the UE and target cell works. In this section, we first focus on the beam open issue.

In [3503], it was observed that the beam configuration can be copied/shared from source DU to target DU, and the same beam can be continuously used by the UE. In [3112], a beam adjustment indication is proposed to indicate whether the beam information can be maintained.

In legacy handover, upon handover, the UE and the gNB performs initial beam detection procedure via RACH operation. Initial data transmission/reception can be handled with initial beam detection until the gNB and the UE perform further beam management process to use finer granularity of beams by using CSI-RS reporting.

It is observed by rapporteur that, since the two logical DUs are co-located at the mobile IAB-node, **the relative position between UE and the mobile IAB-node can be considered as unchanged** during its handover (**same assumption as we made for same TA**). In addition, it is unlikely that there will be **a change in channel condition** between the UE and the mobile IAB-node, the current beam can be still maintained. With the working assumption discussed in Q1, the same beam used by UE in the source logical DU can still possibly be continuously used for initial data transmission/reception in the target logical DU after its handover.

**Q2: Do you agree whether the same beam (the one UE used in source logical DU) can be used by the UE for its first UL transmission and/or DL reception with the target cell?**

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| **Company** | **Yes/No** | **Reasons for your response** |
| Huawei, HiSilicon | Yes, maybe | This may not be perfect as the UE measurement based beam selection. But, anyway, it is possible. If NW considers this as reliable, NW can indicate/use that in RACH-less (the worst case is BFR). |
| Qualcomm | No | The HO command should tell the UE which beam to use in the target cell.  Each of the two cells has its own set of logical beams. The two sets use different time/frequency resources. The two sets may use the same physical beam patterns, but this is up to implementation. We should therefore not assume that the mapping of beam-ID-to-beam-pattern is the same in both logical cells. |
| Apple | No | First, this proposal is confusing: what is “beam UE used in source logical DU”? As we explained in Q1, gNB typically dynamically indicates the UE to use different beams for its different DL/UL transmission via DCI + MAC-CE. So, there is no fixed beam used in source logical DU. At least, it should be clear which beam in which PUSCH of source logic DU.  Secondly, we agree with Qualcomm that the HO command can just notify the UE which beam to use in target cell. More pecifically, we think there are two cases:   1. If one-shot UL grant is provided in HO command, then a TCI can be also included to indicate the beam to transmit the UL grant. Note that existing RRC can also use TCI to indicate beam for one UL/DL transmission. 2. If periodic UL grant (i.e. CG type 1) is provided in HO command, then one TCI may not work because different CG occasions may use different beams. In this case, we can reuse the same solution of CG based SDT, i.e. a RSRP threshold and the associated SSB can be configured, which is similar to existing beam selection in RACH procedure.   Based on above analysis, we propose instead to make progress (details can be discussed in future meeting):  **Proposal: The beam used to transmit first PUSCH towards target logical DU is included as part of preconfigured uplink grant in HO command. FFS its details.** |
| Ericsson | No | In principle we can agree that the beam may be included in the handover command. However, how the beam is decided if the UE has done no measurements on the second DU.  The assumption so far is that the second logical DU is power up only when an inter-CU handover/migration is triggered and thus the UE may have no time to measure the second logial DU, without considering that may have no measurement configuration to do it.  In this case is not clear to us how the second logical DU can include a beam for the UE. |
| NEC | Yes, but | As we commented in Q1, we think UE should maintain the latest beam information for corresponding signal/channel before handover, and apply them in the target cell until new beam info is provided/determined.  Just like TA indication, we also think a beam indication could be provided to indicate whether UE should maintain the latest beam info. |
| Xiaomi | No | I share the same view as QC, apple and Ericsson, the TCI state can be included in HO command as UL grant. If the TCI state in HO command is absent, then UE can use the last serving beam in source.  Furthermore, I wonder the UL grant in HO command is similar with the CG for SDT and the CG selection means the beam selection? |
| KDDI | Yes | Share the view with Huawei, If NW considers this as reliable, NW can indicate/use that in RACH-less |
| ZTE | See comments | It is suggested to first clarify where the same beam denotes the same beam direction or the same beam indication/number information. Considering that the relative position of UE and mobile IAB node does not change, the same beam direction can be assumed. However, it is possible that the target cell may configure different number of beams and the beam indication may be changed based on the configuration of target cell. |
| Nokia | No | As commented in Q1, the logical DUs would not in general share the same configuration, so we cannot assume that the same beam can be used. Blindly re-using the old beam would lead to a sub-optimal solution. One the other hand, how to determine the appropriate beam for the target DU ahead of time could be quite complex. |
| Lenovo | Yes | Similar principle as commented in Q1, UE uses different beams for initial UL/DL to source and target DU as baseline. And UE can use same beam as an enhancement during DU migration. |
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## Other RACH-less

The other issues raised in [4098] is how UE will receive the UL grant for the first UL transmission to the new target cell.

It was discussed in [2784], based on the assumption of same cell configuration between two logical DUs, the UL grant can be provided by the target logical DU. Even UL grant is not configured, similar as LTE RACH-less handover, it is also possible for the served UEs to monitor the PDCCH of the 2nd logical DU based on the knowledge of the 1st logical DU PHY configuration. Both configured grant and dynamic grant can work.

Observation: Same as LTE RACH-less HO, the 2nd logical DU can provide UL grant to the served UE either via pre-allocation in RRC message or allow UE to monitor 2nd logical DU’s PDCCH.

Furthermore, except TA, beam and UL grant issues discussed online and in this email discussion, it was further discussed in [2784] and other contributions that following steps could also consider LTE RACH-less HO as baseline:

1. **Security key change**: mIAB served UEs can start to use new security key and trigger reconfiguration/ L2 reset, etc, upon applying the *RRCReconfiguration* message
2. **HO completion**: successful HO can be confirmed upon the completion of contention resolution

With that, rapporteur would like to propose:

During full migration, RACH-less handover with a security key change of the served UEs is supported. LTE RACH-less handover procedure (e.g. same TA, UL grant, security key change, HO completion) is considered as baseline for mobile IAB.

**Q3: Do you agree with above proposal? (note that beam related discussion will be merged/updated after phase 1)**

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| **Company** | **Yes/No** | **Comments** |
| Huawei, HiSilicon | No/Not needed | 1. “RACH-less handover with a security key change of the served UEs is supported.”  =>This is more like observation rather than proposal. Since any L3 HO can support security update. This is nothing new.  2. “HO completion” in LTE introduced the DL UE Contention Resolution Identity MAC CE, which is not needed in NR.  3. UL grant in NR is different from LTE. Maybe the question is about to support both CG and DG in RACH-less. For those, we are not sure. More analyses is needed. It is pre-mature to say they can be directly reused/baseline. We may need to consider the common design with LTM and NTN. |
| Qualcomm | No | Huawei’s point is valid in that using LTE as a baseline may lead to misunderstandings. Further, we should refer to “DU migration” and not “full migration”. We propose instead:  **Proposal: During DU migration, RACH-less handover with same TA is supported.** |
| Apple | No | Agree with QC's suggested proposal. |
| Ericsson | No | Since the CU is changed during DU migration, the security must be refreshed. Therefore, RACH-less without security key change cannot be supported.  For the TA, we see that the same TA is the only option we have for mobile IAB. This is different from NTN and LTM where in one the UE calculate the TA compensation by using SIB19 (NTN) and in the other the UE is provided with a TA before performing the cell switch (LTM).  For the grant, indeed this require more discussion and we cannot make a decision now without evaluating the options that are on the table. |
| NEC | Partially Yes. | We agree that LTE RACH-less handover procedure can be a baseline, at least for TA/security key change. But for UL grant and HO completion, some optimization can be considered.   1. For LTE RACH-less HO, UE shall send *RRCConnectionReconfigurationComplete* message to confirm the handover. Since the physical IAB-DU node is not changed and the TA is maintained during mobile IAB-node’s migration, we think that any PUSCH transmission on the pre-allocated uplink grant (which is UE-specific) can be used to confirm the handover.   By this way, the UL grant can accommodate more UL data (since no *RRCReconfigurationComplete* here), and gNB can indicate HO completion to UE more quickly, which is after CRC check rather than after decoding the *RRCReconfigurationComplete*.   1. For LTE RACH-less HO, upon reception of UE contention resolution identity MAC CE, UE shall consider HO complete and release the RACH-less HO configuration. However, even if there is no buffered DL data, the network needs to schedule a PDSCH resource for the MAC CE.   To overcome it, a mechanism like the response for BFR CFRA preamble can be used. If a PDCCH addressed to C-RNTI (rather than UE contention resolution identity MAC CE) is received (may be on a dedicated search space for RACH-less HO), UE can consider the HO is completed/successful. That is, successful HO can be confirmed upon the reception of a PDCCH addressed to C-RNTI. |
| Xiaomi | No | It is too early to say as proposal. We should discuss it one by one. Now only TA is clear and we can accept the proposal from QC. |
| KDDI |  | Maybe at this moment, we can agree that we can make LTE RACH-less handover procedure as a starting point for further discussions. |
| ZTE | Partially agree | We agree that the same TA and security key change can be assumed for RACH-less HO. However, the UL grant and HO completion requires further investigation. Similar to NTN WI, we may firstly agree that the LTE’s RACH-less handover procedure is considered as a baseline for mobile IAB. |
| Nokia | No | Although same TA might be okay in principle, we agree with other companies that LTE RACH-less HO may not be applicable here.  In general, we see RACH-less HO as an optimization rather than a feature to be prioritized for mobile IAB. Considering that RACH-less HO is already being worked on in other Rel-18 WIs, we prefer to avoid specifying a mobile IAB-specific RACH-less HO solution since the overall specification effort may be quite high relative to what is actually gained in terms of signalling offload (mIAB-specific RACH-less HO would only apply to on board Rel-18 UEs in RRC\_CONNECTED, which could be a relatively small number of users).  Furthermore, as argued by a few companies in [4],[5],[6], signalling storms can already be mitigated, either through the CHO options being discussed or even through legacy HO, so RACH resources would not be very constrained anyway. |
| Lenovo | No | Agree with Huawei’s concern on HO completion and UL grant.  But, anyway, we can leverage LTE RACH-less handover as the start point. |
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## LS to RAN1

**Q4: Companies are invited to comment on whether we should send a LS to RAN1, informing RAN1 our assumption during RACH-less handover (e.g. same TA and beam are used) and check if there’s any issue.**

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| **Company** | **Yes/No** | **Comments** |
| Huawei, HiSilion | No, but | RAN1 has no TU to discuss this. RAN2 can decide whether to support the whole RACH-less or not.  I guess the concern is not the feasibility from RAN1. The concern is whether RAN2 should spend huge TU on this RACH-less feature.  Therefore, the next step is the RAN2 final decision on this feature, by considering the agreeable solutions on TA, beam, UL grant, etc, if any.   * RACH-less for mIAB scenario, if agreed in the end, will cover only the case of same-TA. |
| Qualcomm | See comment | After we have converged on a design, we should inform RAN1 and ask if they see any issues. They can handle this as part of maintenance. Presently, we haven’t even converged on anything, so it is a little premature to send such an LS. |
| Apple | Inform RAN1 after convergence | Same view as Qualcomm.  In addition, with LTE RACH-less as baseline, we think its needed TU is manageable, especially considering mobile IAB WI is not busy (it seems no other open issue pending discussion in RAN2 for now). |
| Ericsson | Ok to send LS to RAN1 but is too early | Agree with Qualcomm.  RAN1 of course must be informed, but first we need to converge on how this RACH-less solution may work.  We also need to keep RAN3 in the loop. |
| NEC | Yes | If RACH-less HO is introduced, RAN1 may need to maintain TA and the latest beam info of source cell, and apply them in the target cell. So we think an LS to RAN1 is needed. |
| Xiaomi | No with comment | The RAN1 will be involved in the future regardless of the TU. But for now, we should make clear the whole picture of the RACH less HO and also consider LTM and NTN topic. RAN2 will output one RACH-less solution for mIAB, LTM and NTN. |
| KDDI | Yes | If we can converge the high-level principal and assumption, then we should send an LS to ask RAN1 to confirm RAN2 high-level principal and assumption. |
| ZTE | Yes | If RAN2 can reach some concensus on the TA and beam configuration for the support of RACH-less HO, then it is no harm to inform RAN1 and ask them if the our consideration on TA and beam are valid or not. |
| Nokia | Not yet | It is too early to send anything to RAN1 at this point since we have not yet reached any common understanding in RAN2. However, any critical assumptions RAN2 ends up making that fall within RAN1’s domain should of course be verified (not left to maintenance after the WI). |
| Lenovo | Perhaps Yes | Whether send LS to RAN1 may depend on the output of RAN2’s discussion on RACH-less handover. If we can achieve some initial agreement to support RACH-less handover for UE of the mobile IAB-node, we can send an LS to RAN1. |
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# References

[1] R2-2304098, Issues on supporting RACH-less for mobile IAB Ericsson

[2] R2-2303112, Discussion on mobility enhancements for mobile IAB NEC Corporation

[3] R2-2303503, Connected mode UE mobility enhancement for mobile IAB Huawei, HiSilicon

[4] R2-2302784, mobile IAB mobility enhancement for connected UEs Intel Corporation

[5] R2- 2302929, Mobile IAB connected mode issues and enhancements Nokia, Nokia Shanghai Bell

[6] R2- 2303852, On the need for connected mode mobility enhancements for mIAB LG Electronics Inc.