3GPP TSG-RAN WG2 Meeting #119bis Electronic draftR2-2210862

Elbonia, 10 – 19 October 2022

**Agenda item: 8.7.4**

**Source: Nokia, Nokia Shanghai Bell**

**Title: Report from [AT119bis-e][119][NR NTN Enh] HO enhancements (Nokia)**

**WID/SID: NR\_NTN\_enh – Rel-18**

**Document for: Discussion and Decision**

# 1 Introduction

This is to discuss the following:

* [AT119bis-e][119][NR NTN Enh] HO enhancements (Nokia)

Scope: Discuss possible CHO-based approach (p6 in [R2-2210353](file:///C:\Data\3GPP\Extracts\R2-2210353%20Further%20view%20on%20Idle-%20and%20Connected-mode%20NTN%20mobility%20in%20Rel-18.docx)) and “same PCI” approach (p5 in [R2-2210405](file:///C:\Data\3GPP\Extracts\R2-2210405%20Discussion%20on%20NTN%20mobility%20enhancements.doc)) for connected mode mobility enhancements in NTN

Initial intended outcome: Summary of the offline discussion with e.g.:

* List of proposals for agreement (if any)
* List of proposals that require online discussions
* List of proposals that should not be pursued (if any)

Initial deadline (for companies' feedback): Tuesday 2022-10-18 1600 UTC

Initial deadline (for rapporteur's summary in R2-2210862): Tuesday 2022-10-18 1800 UTC

In the next section we elaborate on CHO enhancements and on reusing the same PCI in quasi-Earth-fixed scenario.

# 2 Discussion

## 2.1 NTN-specific CHO enhancements

In [1] it is suggested to consider how to reduce the signalling overhead and allow the UE to keep the CHO commands even after HO execution. It is claimed that in NTN the sequence of next serving cells can be predicted with high probability (assuming the UE does not move significantly, compared to the satellite coverage, which should be the case in NTN). We would like to ask the companies if they agree with such statement.

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| **Question 1: Do you agree that in NTN the sequence of next serving cells can be predicted?** | | |
| **Company** | **Answer** | **Comments** |
| Huawei, HiSilicon | No | It requires UE is stationery or in low mobility, and cannot be located at cell edge, which is too restrictive. |
| CATT | No | We agree the next serving cell can be predicted in some way, but we think it is not feasible to predict multiple cell hops due to the UE movement. |
| MediaTek | Yes | We think it can be predicted if the UE’s mobility is negligible comparing to the satellite’s movement, which is often the case. |
| Xiaomi | Yes | We think the network could predict the sequence of next serving cells with the below restriction:   * UE is static or in low mobility; * Network has the UE location since the next serving cell may provide the different coverage from the current serving cell. |
| ITRI | Yes | We agree the sequence of next serving cells could be predicted if UE’s movement is negligible compared to the satellite’s. |
| OPPO | Maybe | If UE is stationary or in low mobility. |
| Samsung | Yes | If UE is static or low mobility, next serving cells that are going to serving the current serving cell area can be predicted. |
| vivo | No | Share the same view with CATT, it is not feasible to predict multiple cell hops due to UE movement. |
| Transsion Holding | Yes | For moving cell scenario, UEs are relative static or low mobility. |
| Apple | Yes | For the earth-moving cell scenario, if UE is stationary or in low mobility, the target cell of the subsequent handover is predictable. |
| Lenovo | Conditional yes | Besides the assumption of low mobility for the UE, it is also necessary to have the ephemeris of neighbour satellite (and maybe additionally its cell coverage information) to predict the next serving cell. |
| CMCC | Yes with comments | UE’s movement may be ignored compared to satellite, especially LEO case. Then with some assistance information, further candidate cells could be predicted. |
| NEC | Yes | With the assumption that UE does not move significantly. |
| Intel | No | From NW point of view, it can be predicted which satellite will serve current area; but for a moving UE, it would be not realistic to make this observation. |
| Qualcomm | Yes | This is certainly possible for network. Even in fixed, cell, network can know which satellite will provide service next in the area. |
| ZTE | No | We agree it is possible to predict to next serving cell in some cases but it is not feasible to predict the multiple cell hops. |
| Vodafone | No | It may not be able to predict the next serving cell in some scenarios |
| TTP | Yes | The orbit of the satellites are known and the relative motions of the UEs w.r.t. to satellites are negligible, therefore the next serving cell can be predicted |
| Sony | Yes | The orbits of satellites are known and UE speed is negligible compared to satellite speed. |
| Ericsson | Yes | In NTN, next serving cells can be predicted as satellites move along a predefined orbit, cell sizes are in the order of tenths of kilometres and satellite coverage may only last for a few tenths of seconds. Therefore, UEs can be considered either stationary or in low mobility. For UEs with low mobility not located close to the cell border, the next serving cell can likely be predicted with high probability. However, the accuracy of the prediction will of course be reduced for each subsequent handover. |
| Nokia | Yes | UE’s movement in comparison to satellite’s movement is rather negligible, even if the UE moves relatively fast. So, considering large footprints of the NTN cells the network may be able to prepare the UE with multiple cells in advance. |
| LGE | No | As RAN2 discusses general aspect of NTN, i.e., UE movement is not limited, predicting the sequence of next serving cells is not feasible. |

*Summary for Q1:*

If the approximate sequence of cells can be known in advance and as Conditional Handover (CHO) is a supported solution, [1] suggests to combine these two and allow preparing the UE for multiple cell hops in advance (i.e. enhancement compared to contemporary CHO standard, where the UE can be prepared just for the nearest cell change). UE would be provided in advance with cell-specific resources and configurations for one or more of the next serving cells (i.e. not only for the single cell change operation).

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| **Question 2: Do you support allowing the UE to be configured with CHO commands for multiple cell changes in advance and store some of these commands after CHO execution?** | | |
| **Company** | **Answer** | **Comments** |
| Huawei, HiSilicon | No | The gain is not clear to us.  Configuring multi-hop CHO candidates require multi-hop neighbour cells to reserve the resources to the UE in advance.  Besides, the UE complexity is increased. |
| CATT | No | We don’t see the benefit bring by configuring CHO command for multiple cell in advance. This mechanism seems has no help on reduce signalling overhead. And if the UE move away, the signalling used for preconfigured CHO command is wasted. |
| MediaTek | No | Agree with Huawei and CATT that this does not help in reducing signalling overhead and increases the UE complexity. |
| Xiaomi | No | We don’t think configuring CHO commands for multiple cell changes in advance at one time will reduce the signalling overhead. Moreover, as Huawei commented, it requires the multiple neighbour cells to reserve the resource and increase the UE complexity. |
| ITRI | No | The benefit in reducing signalling overhead is unclear. In addition, reconfiguration may be needed according to UE movement. |
| OPPO | No | Same view as above companies that this does not contribute much to signalling overhead reduction. Meanwhile, we are not sure whether sequential CHO is actually realistic in NTN since most likely the same gNB/cells will serve a specific location and we wonder whether there are really so many different next serving cells for the UE. |
| Samsung | Yes | CHO configuration for one or two (not a large number of) candidate cells that are going to serve area overlapping with the current serving cell’s coverage can be configured to be stored at UE, instead of release after CHO, so not too much resource needs to be reserved. |
| vivo | No | We think there seems no obvious reduction in configuration overhead compared to the legacy CHO configuration. Moreover, the configuration may be updated due to the movement of UE. |
| Transsion Holding | No | As our understanding, providing UE with cell-specific pre-configuration for multi cell hops which may need reserve resource of multi cells in advance. The benefit between pre-reserved resource and signaling reduction should be studied further. |
| Apple | Yes | With the assumption that the target cell of the subsequent handover and the configuration can be predictable, if one CHO command can cover multiple cell change, it is obvious that the signaling required for subsequent handover can be saved. In addition, we do not think that this will bring great UE complexity. |
| Lenovo | No | UE complexity will be increased, while its benefit is not clear. |
| CMCC | Pls. See comments | Considering that the actual problem needed to be resolved is HO signaling reduction, therefore the gain of the solution may be evaluated firstly. |
| NEC | See comments | We want to understand the gain and the impact to network:  will the UEs at different locations have different sequence of next serving cell?  what is the gain of sending multiple Conditional reconfigurations in one message instead of sending them one each time? |
| Intel | No | This enhancement requires NW to follow the configuration as the pre-configured one, and if one target cell changes current configuration, all the subsequent configurations have to be updated accordingly. So we think it’s not realistic to go this way. |
| Qualcomm | Yes | This has no gain in the cell where configuration was provided but definitely a lot of signaling overhead in the next cell.  Obviously to make it simple, this can be discussed whether to limit in the intra-gNB HO scenario. |
| ZTE | No | This is not beneficial in reducing the signalling overhead. |
| Vodafone | No | Not see much benefit |
| TTP | No | Unnecessary signalling load! |
| Sony | Yes | We think HO preparation signalling load is significant and should be addressed. Network can even further randomise this signalling while configuring CHO candidates during initial connection setup. |
| Ericsson | Yes | We have a similar view as Apple and Qualcomm. This might be especially beneficial for low mobility UEs located away from the cell edge, and/or the case of moving cells (due to the high satellite’s speed). Nonetheless, this concept alone cannot lead to signalling reduction, it needs to be combined with other optimizations such as e.g., delta signalling of target cell information. In addition, RAN2 has to consider that number of subsequent handovers would need to be limited to avoid an excess of pre-reserved network resources. Thus, this trade-off should be further studied. |
| Nokia | Yes | We are the proponent of this scheme.  We do not understand why some companies think this will cause signalling load. This is in fact to reduce the signalling overhead in the next prepared cells (the UE does not have to be prepared from scratch to perform subsequent HO/CHO).  We agree that for simplicity (to avoid inter-cell signalling), this could be initially limited to intra-gNB scenarios.  Regarding the excessive resource reservation at the NW side – we think this can be mitigated as in NTN we support (at least for some scenarios) the t-Service time, so that may be used for planning the resource reservations accordingly.  Please also note that a similar scheme may be defined as a part of Rel-18 mobility enhancements, where selective activation of cells is discussed. |
| LGE | No | We doubt the feasibility of predicting the sequence of the following serving cells. Furthermore, it is obvious to increase the signaling burden because the network contains more multiple target cell configurations as HO hop increases. |

*Summary for Q2:*

## 2.2 Reusing PCI after satellite changes

Another connected mobility enhancement is considered in [2]. It is proposed to address the quasi-Earth fixed scenario using the same gNB serving a particular area, even after the satellite changes. The authors of [2] claim the clear gain is that the UE will not have to handover and can continue using the same configuration. However, the authors of [2] indicate that the UE will have to anyway perform UL synchronization due to the changed position of the satellites. While the idea seems to be simple and promising in terms of the gains on the UE side, it is not clarified what is the expected impact/additional complexity on the NW side. In addition, the rapporteur wonders how would that co-exist with Rel-17 NTN mobility. Thus, we would like to ask the following:

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| **Question 3: Do you support the mobility scheme where PCI remains the same after switching of the satellites? Please provide the details on:**   1. **expected impact on the NW side** 2. **co-existence with Rel-17 NTN mobility** | | |
| **Company** | **Answer** | **Comments** |
| Huawei, HiSilicon | Yes | a) expected NW impacts  No impact. The NW only needs to broadcast a t-Service (which is already in R17), to inform the UE of satellite switching time.  b) co-existence  No co-existence problems.  For R17 UEs, the NW can simply configure intra-cell HO.  For R18 UEs, they can consider the PCI is unchanged, and only perform UL synchronization, so that HO command can be omitted. |
| CATT |  | We have similar view with HW.  NW can broadcast some information to indicate UE to perform UL sync but not HO, which is beneficial for signalling overhead reduction. |
| MediaTek | Yes | Agree with Huawei and CATT. |
| Xiaomi | Yes | The scheme also requires the network should keep the RRC configuration unchanged when the satellite is changed. |
| ITRI | Yes | Agree with Huawei and CATT. |
| OPPO | See comments | From RAN2’s perspective, we agree same PCI could be beneficial. However, it should be confirmed by RAN1 first whether this is feasible or not, e.g. whether same PCI has some interference issue. |
| vivo | Yes | Share same view with Huawei and CATT. The network can provide UE-common parameters on the target beam(s)/BWP(s) used for sync in the broadcast signalling or in the dedicated signalling; some condition can be defined to help UE perform DL/UL sync to the new satellites’ coverage. |
| Samsung |  | We don’t think this scenario requires HO, but it is similar to beam switch without PCI or serving cell configuration change. UE can perform PDCCH ordered RACH to synchronize to another satellite beam according to the new satellite assistance information. |
| Transsion Holding | Yes | Agree with Huawei and CATT. |
| Apple | Yes | Agree with Huawei and CATT. |
| Lenovo | Yes | Agree with Huawei, but wonder whether we shall specify NW to guarantee this. |
| CMCC | Yes | For a), in some case, there maybe just a little impact on NW side. For example, some system information needs update or some information needs negotiation between RAN nodes.  For b), from our perspective. There is no co-existence issue. |
| NEC | Yes  w/wo PCI changes | We support the mobility scheme (i.e., only uplink sync is required), regardless of whether the PCI changes or not after satellite switching (RAN1 may need to confirm feasibility of same PCI)   1. expected NW impacts   no/limit impact (e.g., may need trigger/indication), UL-synchronization will happen anyway no matter which solution we choose   1. co-existence with Rel-17 NTN mobility   agree with HW. Moreover, there would be not many rel17 UEs yet. |
| Intel | Yes | We assume there is some overlapped time when two satellites serve the same area with the same gNB, for the sake of service continuity. RAN2 could send an LS to RAN1, and ask RAN1 to check the feasibility, i.e., whether one cell can be served by two satellites with the same gNB |
| Qualcomm | No for soft satellite switch  Yes for hard satellite switch | If this is for soft switch, PCI overlapping in the same sync raster between two satellites parallelly, then we have to check with RAN1 for feasibility, this is huge UE complexity on detecting/decoding SSBs from two different satellites.  But if it for hard switch, i.e., at cell stop time, if network makes sure old satellite stops first and then only new satellite projects beam (transition can be quick and seamless in microseconds), then we think this can be considered and coexistence can be possible.  But network has to configure and provide sufficient interruption time for UE to synchronize with new satellite, probably with RACH. Until, RAN provides feedback, we cannot consider RACH-less here.  But what is the gain? It would be applicable only in the scenario of satellite switch with same feeder link, i.e. same gateway.  How about other scenarios? Group handover works for all scenarios. |
| ZTE |  | The feasibility should be analysed by RAN1 first. |
| Vodafone |  | The feasibility should be evaluated first. |
| TTP | Yes | It will be very helpful, from signalling load perspective if the PCI remained unchanged , however this means that the network has to assign the same Synch signals to both incoming and outgoing satellites |
| Sony |  | We agree with Samsung |
| Ericsson | No | Using the same PCI in the source cell and in the target cell after a satellite change was discussed in RAN2 in the beginning of Rel-17. This possibility was dismissed since it would have required L1 mobility and RAN1 involvement. In the proponent’s contribution, it is not entirely clear how these early concerns are addressed, what has changed after that to consider this possibility again, and what would be the impact on RAN1. Therefore, we suggest continuing where RAN2 stopped in Rel-17 and send an LS to RAN1 asking the possible consequences and impact. |
| Nokia |  | It sounds beneficial and simple, but we understand this still requires work in RAN1 to confirm if keeping the same PCI is possible. And the UE will anyway need to switch to a new beam. Agree with QC that it may be feasible for hard satellite switch only. And agree with Ericsson on the reference to Rel-17 discussion and its status. |
| LGE |  | It is beneficial for serving satellite change in quasi-earth fixed scenarios, where the satellites have the same gateway. Nevertheless, the feasibility should be evaluated first by RAN1. |

*Summary for Q3:*

# 3 Conclusion

This paper discussed selected mobility enhancements for Rel-18 NTN. The following proposals are made:

For agreement:

For further discussion:

# References

1. R2-2210353 Further view on Idle- and Connected-mode NTN mobility in Rel-18, 3GPP TSG RAN2 Meeting #119bis Electronic Meeting, Oct 10 - 19, 2022
2. R2-2210405 Discussion on NTN mobility enhancements, 3GPP TSG RAN2 Meeting #119bis Electronic Meeting, Oct 10 - 19, 2022