3GPP TSG-RAN WG1 Meeting #114e Tdoc R2-2106526

May 19th - 23rd 2021

Agenda: 8.10.3.3

Source: Ericsson

Title: Feature summary for 8.10.3.3

Document for: Discussion, Decision

# 1 Introduction

* [AT114-e][104][NTN] CHO aspects and service continuity (Ericsson)

Initial scope: Discuss the proposals from R2-2106489

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): Friday 2021-05-21 10:00 UTC

Initial deadline (for rapporteur's summary in R2-2106526): Friday 2021-05-21 14:00 UTC

Proposals marked "for agreement" in R2-210656 not challenged until Monday 2021-05-24 10:00 UTC will be declared as agreed via email by the session chair.

For the rest the discussion will continue online in the Monday CB session.

R2-2106526 [Offline 104] CHO aspects and service continuity Ericsson discussion Rel-17 NR\_NTN\_solutions-Core

This feature summary for 8.10.3.3 includes

1. include proposals to further progress on CHO

2. kickoff the discussion on TN/NTN service continuity

SMTC and measurement gap related discussion is not in this summary.

# 2 Conditional HO for NTN

### 2.1 CHO location trigger definition and RRM location event

Both CHO and RRM location reporting event trigger are discussed jointly as earlier concluded by RAN2. Related agreement from last meeting is:

Agreements:

3. The location in location-based CHO execution triggering for NTN describes the distance between the UE and the reference location of the cell (serving cell or the target cell). FFS what the reference location of the cell is (e.g cell center or other) and how this is provided to the UE

Here we attempt to progress on the FFSs within the previous agreement which is done based on related input within RAN2#114 contributions.

Definition of the reference location may be related to serving cell or candidate target cell or it may be a combination. Also, there is a suggestion to use UE’s (reference) location. When the reference location is either serving or candidate target cell reference location and a distance, the shape of the triggering threshold is s sphere. When, the threshold is combination of serving and candidate target, a line defines the triggering threshold and “cell shape” becomes a polygon.

*The distance between UE and reference point of the serving cell is used in location-based CHO condition.[11]*

*Location-based CHO execution triggers are based on distance from UE to serving cell center.[25]*

*Multiple location-based measurement events for NTN could be defined, and the distance in each of the location-based measurement events could be the distance to either a serving cell or a neighbor cell.[8]*

*Location-based CHO execution triggering describes a region in which UE is allowed to execute CHO to the candidate target cell.[25]*

*In location-based triggering condition, UE’s reference point for location is used to calculate the distance. FFS how to update UE’s reference point.[11]*

*Location based CHO triggering event can be configured based on a geographical area scope referring to the cell coverage information for satellite cells with irregular shape.[13]*

Based on the above, the below proposals are suggested for discussion.

1. Discuss whether shape of CHO trigger area is
   1. The distance between UE and the serving cell reference location
   2. The distance between UE and the candidate target cell reference location
   3. Combination of a) and b)

**Question 1 Which option is preferred?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Option** | **Comments** |
| Samsung | a with notes | Since the shape of the satellite beam on the Earth’s surface area is elliptical, we strongly recommend the use of an elliptical area instead of a circular area while deciding whether the UE is inside such inner area or not. If the UE is outside the elliptical area (with the serving beam’s center as the center of the ellipse (= serving cell reference location) and suitable major-axis and minor-axis), it can trigger a Measurement Report so that the gNB can determine a good set of CHO candidate cells. |
| CATT | A,b,c | This is simlar as RRM measurement event(A2, A4 and A3), so we think RAN2 should support all a, b and c. |
| Huawei, HiSilicon | B,c | B is like current event A4, and c is like current event A3. Option a is also useful, e.g. it can be used to determine when to start CHO evaluation, i.e. when UE is far away from the center of serving cell. |
| BT | A | We need to simplify the solution. A UE can execute the CHO based on its distance to the serving cells. Afterwards, the specific values are an engineering issue. |
| Nokia | b | In our understanding the distance between the UE and the target cell (reference location) shall matter primarily in deciding whether to trigger the CHO execution. And the location of this reference point is not on the satellite. |
| Sony | a | In our understanding, Option a is easy for UE to implement. |
| InterDigital | a | Technically all could work, however we think that distance from serving cell would be simplest. The same reference point would apply to all UEs within the cell allowing reduction of signalling overhead via broadcasting of the reference point. |
| MediaTek | b |  |
| Qualcomm | a | We also think we need “a” simple solution. We disagree providing beam information for all target cells. In (a), simply beam information of serving cell can be broadcast reducing size of HO command. |
| Lockheed Martin | b | Option b is more reliable to trigger timely HO. |
| ZTE | a and c |  |
| OPPO | a,b,c | We should support all these options. Option a is similar to RRM measurement event A2, option b is similar to RRM measurement event A4, and option c is similar to RRM measurement event A3/A5. |
| Apple | a, b | Option a is simple to implement , option b can add more value similar to existing “A” measurements. |
| Intel | a, b, c | Options a) and b) could be used by themselves but having a combination of them may also provide a more accurate trigger event e.g. if the distance to the cell boundary is not the same in all areas of the cell edge. Our understanding is that network could indicate the desirable trigger to be used by UE. |
| LG | A, b, c | Same view with CATT. |

1. Discuss whether UE’s reference location can be considered as an alternative for location based RRM event.

**Question 2 Whether UE’s reference location can be considered as an alternative for location based RRM event?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/no** | **Comments** |
| Samsung | No | Sorry- the question is a little unclear to us. The UE needs to evaluate measurement report triggers (e.g., traditional TN triggers and new NTN triggers). For other purposes (e.g., to detect country border crossing or TAC crossing within an NTN cell), the reporting of the UE position would be helpful. |
| CATT | No | For CHO, there is no need for UE to report the UE’s reference location infomation. |
| Huawei, HiSilicon | Yes | It’s ok to define a location based measurement event, as current CHO trigger is related to measurement event. |
| BT |  | Is the intention that an UE reports its reference location for CHO? |
| Nokia |  | Unclear what the question actually asks for…whether the event associated with reference location can be also used for RRM measurement reporting, i.e. not only for CHO triggering? If that is the case, then we are OK to have such reporting possibility. |
| Sony | Yes | Location based measurement report trigger should be supported. |
| InterDigital | - | Don’t entirely understand question either. If interpretation by Nokia is correct, then we agree as well. |
| MediaTek | no | No need for this at the momemt. |
| Question | - | We are also not clear on the question. If it is about using UE’s location for various purposes, like in RRM or location-based CHO, then yes we should use UE’s last calculated location (i.e., called UE’s reference location). Every time UE calculates new location, that becomes UE’s reference location. |
| Lockheed Martin | No | Having a consistent mechanism is better fort he system. Defining a location based RRM event is a better approach. |
| ZTE |  | Not sure what this proposal means. |
| OPPO |  | Not sure what this proposal means. |
| Apple | No | Do we need the UE to report this location or is there another way this happens? |
| Intel | - | The intention of the question is not clear. |
| LG | No | The question is not clear to us. Regarding location based RRM event, we do not think location based measurement triggering or measurement reporting triggering is needed. Existing cell quality-based measurement reporting is enough because UE’s location change is i |

Related to the definition of the reference location, the following proposals are presented

*For location-based measurement, cell center is considered as reference location and can be part of ephemeris.[1]*

*Location-based CHO execution triggers are based on distance from UE to serving cell center.[25]*

*The reference point of cell could be cell centre or a list of beam centres, and beam radius is also provided by network.[14]*

Based on the above, the below proposals are suggested for discussion.

1. Discuss whether the reference location is
   1. Center of a cell
   2. Center of a beam or beams

**Question 3 Which option is preferred?**

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| --- | --- | --- |
| **Company** | **Option** | **Comments** |
| Samsung | Pl. See comments | The use of the cell center would be simple and straightforward and applicable to one beam per PCI as well as multiple beams per PCI. If there is one beam per PCI, the cell center would be same as the beam center. If there are multiple beams per PCI, to detect that the UE is near the cell edge, the cell center would be more appropriate; otherwise, there would be a need to broadcast multiple beam centers without much gain. Once beam per PCI would likely simplify resource planning and maximize the capacity per unit area, as universal frequency reuse per beam can be realized in practice for the NTN. |
| CATT | a | Whether the cell consist of one beam or multiple beam, the center of a cell is enough. |
| Huawei, HiSilicon | A,b | Both options can work. But optin b is more accurate for a cell including multiple beams. |
| BT | a | Cell centre should be enough. Why do we intent to define here if the satellite will create a cell with one or more beams? |
| Nokia | b | We somewhat share Samsung’s view. That could be in principle a center of a beam, which would be simpler if there is a single beam per cell/PCI. However, the center of beam/cell implies a uniform shape (e.g. circular), while that may not be the case always. It needs to be discussed also what kind of accuracy is expected here (and what error margin is tolerated, when the shape is not regular, etc.). |
| Sony | a,b | Option a might be simpler to specify |
| InterDigital | a | Center of cell is simpler, and joint configuration with measurement-based trigger should provide additional redundancy in the case of non-regular shape. Accommodating for e.g. elipse may require increased signalling to describe/evaluate shape. We would prefer to keep it simple. |
| MediaTek | a | Handover is cell specific and not beam specific. In the case of 1beam per cell, a) and b) are equivalent. |
| Qualcomm | a | Network can choose a location that is close to center of cell regardless of multiple beam per cell operation. |
| Lockheed Martin | b | If we use center of beam, it will work for both one beam and multiple beams scenarios and it is more accurate than option a. |
| ZTE | a | We mainly consider cell level mobility in RAN2. |
| OPPO | a | We think it is simple and straightforward to use cell center for cell level mobility. |
| Apple | a,b | Given the size of the cells, b will be more accurate. However, a is simpler. |
| Intel | a with comments | For this discussion proposed, we can assume that reference location is cell center. However, we wonder whether there is any special handling required for moving cell. Moreover, from specification point of view, we wonder whether this reference location information is specified as a center of cell or is left up to network implementation (i.e. just having a reference location information configured to UE). |
| LG | a | Cell center is the simplest way. |

Other location CHO or RRM related proposals that may be selected for discussion if time allows.

*The location event includes hysteresis and TTT[23]*

*In NTN, serving cell centre coordinates are broadcast via system information.[25]*

*Reference location of the cell used for CHO execution triggering purposes should be given in RRC Reconfiguration (HO command).[3]*

*For at least LEO with earth moving cells, serving cell centre coordinates are periodically updated and associated with a timestamp. FFS periodicity of update.[25]*

*RAN2 is asked to confirm a reference location of the cell, used for location-based CHO execution triggering, indicates a location on Earth surface, within cell coverage.[3]*

For location based event reporting the following proposals were presented

*Location-based measurement and RSRP/RSRQ measurement can be reported in the same RRC message to the network, no matter which measurement event is triggered.[1]*

*UE is allowed to report (in measurement report) the distance to a cell in addition to the measured signaling strength of the cell.[8]*

*The UE location information report should be supported in NTN[19]*

*For UE location reporting to the network, the UE location information is piggybacked to the measurement report message.[19]*

*For UE location reporting, the network configures to include the UE location information in the measurement reporting configuration.[19]*

*Discuss what kind of NTN-specific UE location information can be included in the UE location reporting. Consider sending LS to other WG to define contents of the UE location information for NTN.[19]*

The aspect that network can configure location report to be piggybacked to the measurement report message is already supported. RAN2 can discuss whether measurement reports can be configured to be piggybacked when location based event triggers. Further the format of the location information should be discussed. It is possible to try to define a less granular and lighter location information suitable for NTN.

1. Discuss whether measurement reports can be configured to be piggybacked when location based event triggers

**Question 4 Whether measurement results can be piggybacked with location report?**

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| --- | --- | --- |
| **Company** | **Option** | **Comments** |
| Sasmsung | Yes with comment | To reduce the amount of signaling, we suggest the use of a compact UE location IE where only most critical and relevant fields (e.g., position coordinates) are conveyed instead of all the fields currently present in a typical location report. Such compact location IE can be conveyed in a variety of RRC meesages (e.g., RRC Reconfiguration Complete).  We can also consider the use of incremental coordinates instead of absolute coordinates (when possible) to further reduce the IE size.  We have not yet formally discussed in RAN2 the resource issues in an NTN. Per user resources in an NTN can be quite low ompared to that in a TN due to more users per cell (PCI) and low spectral efficiency (low CQIs) in an NTN. Hence, we should try to reduce the amount of dedicated signaling bits to the extent possible; every bit in a message counts because an individual message size would be multiplied by a massive number of users! |
| CATT | No |  |
| Huawei, HiSilicon | No | We see location based event can be defined as a CHO trigger, but no need to lead to a real measurement report. |
| BT |  | For regulatory reasons, the fact that a UE reports its location is not always possible therefore we need to find a solution that works without it. |
| Nokia | Yes | It would be preferable to have radio measurements reported (if UE was configured to do so) in the same message that is sent to the NW, when location-based event triggers. Perhaps we can reuse the principles defined for LTE UAVs and their events Hx. |
| Sony | No | We think location reporting should not always have measurement results. |
| InterDigital | Yes | Can be configurable option |
| MediaTek | Yes | Measurement results can be piggybacked with location report |
| Qualcomm | No | It should be the other way around. The location report is piggybacked by the existing measurement report.  First, we need to agree location-based measurement report trigger mechansim (this would be different from location-based CHO trigger). |
| ZTE | No | Since the section is mainly for CHO, we understand the location based event should be considered as CHO trigger only.  And whether to define location based triggering for measurement report is another discussion which seems to be out of the scope of this offline discussion. |
| OPPO | Yes | It would be helpful for gNB to make quick handover decision based on both location and measurement report, and may avoid too late handover. |
| Apple | No | Agree with BT. |
| Intel | Yes | It might indeed be beneficial for UE to indicate to the network when location based event triggered. FFS whether this indication may be in term of legacy measurement reporting or a simplifier kind of information. |
| LG | No | We think just piggybacking UE location reporting to the measurement reporting but location-based triggering is not needed. Existing cell quality-based triggering of measurement reporting is enough. |

1. Discuss the format of the location report
   1. Follow the existing format for location information
   2. Discuss if a less granular and lighter location information suitable for NTN is defined.

**Question 5 Preferred format for location report?**

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| --- | --- | --- |
| **Company** | **Option** | **Comments** |
| Samsung | None | We should report the full/most accurate GNSS-based position but avoid less important/less critical fields. Furthermore, in case the UE location needs to be sent before the security is activated, RAN2 can consider the use of transformed coordinates instead of true coordinates where the relationship between the true coordinates and the transformed coordinates is known to the UE and the network but not exchanged via UE-network signaling to ensure security. |
| CATT | None |  |
| Huawei, HiSilicon | None | Same comments as for Q4. |
| Nokia |  | Assuming this question is on CONNECTED mode (and not for e.g. PLMN selection), maybe a similar approach as decided for LTE V2X can be supported (i.e. locationInfo IE). |
| Sony | B | We think location information could be reported separately from measurement report. |
| MediaTek | a | Follow the existing format for location information |
| Qualcomm | a | Since there is already existing format available for location report to be carried in measurement report, we do not see why a new different format is needed. |
| ZTE | None | The need for location report has not been confirmed yet. |
| OPPO | None | The question is unclear to us. Is the intention to support UE to report UE location? If yes, we think there is no need to support UE location report for the purpose of handover. |
| Apple | None |  |
| Intel | b | We suggest trying to define a less granular and lighter location information suitable for NTN. |
| LG |  | Existing format in the measurement reporting is enough. |

Other location RRM related proposals.

*UE location information is provided to the RAN in order to allow the network to select a proper PLMN in accordance with UE’s physical location.[17]*

*UE location information is provided to network when it is in RRC\_CONNECTED in order to allow an NG handover in accordance with its physical location.[17]*

*RAN2 to discuss the feasibility of periodic location reporting as an addition to the event triggered based.[23]*

*Discuss whether explicit request by the network to immediately report UE location information is needed, in such as UEInformationReq message.[19]*

1. RAN2 to discuss whether periodic or request/response type of location reporting should be supported for NTN.

**Question 6 Whether periodic or request/response type of location reporting should be supported for NTN?**

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| --- | --- | --- |
| **Company** | **Opinion** | **Comments** |
| Samsung | New rule-based preferred but ok with periodic | Both options will increase the signaling overhead. The UE position should be event-based or rule-based (i.e., on a need basis) (Ex: when border crossing has occurred, TAC crossing has occurred, the UE has moved by a certain distance eriodic to the last reported location, and so on). |
| CATT | See comments | If the location reporting is for CHO trigger event, there is no need for UE to report the location information. If the location reporting is for HO trigger event, the report of location based RRM event need to report when it need to handover. If this location reporting is for UE accurate location information, it is not in this email scope. |
| Huawei, HiSilicon | Already supported? | This question is not quite clear to us. As locationInfo-r16 is already included in measure result, and it is triggered by includeCommonLocationInfo-r16 in both event config and eriodic reporting config. |
| Nokia | No for periodic | We believe event-based should be a primary choice. Request/Response type can be also enabled (as NW should be always able to request and obtain UE’s location). |
| Sony | Yes and comments | Agree with Huawei that it is already supported. We also think the enhancements proposed by Samsung make sense. |
| InterDigital | Up to network | We could support this being configurable option |
| MediaTek | No | We do not see any benefit of periodic triggers over event-based triggers. |
| Qualcomm | Existing periodic | Periodic measurement report can be configured.  The measurement report can include location information. |
| ZTE | No | The need for location report has not been confirmed yet. |
| OPPO | No | See our reply to Q5. |
| Apple | No |  |
| Intel | Yes, see comment | If UE is configured with location trigger event, periodic or request/response type may not be needed. Otherwise (i.e. UE is not configured with location trigger event), network may still want to rely on some form of location reporting. |
| LG | Yes | We think in some cases networks wants immediate UE location reporting. Thus, rather than configuring measurement reporting triggering condition, we think explicit request is needed. |

### 2.2 CHO time trigger definition

Related agreement from last meeting are:

Agreements:

1. Timing information in CHO execution triggering for NTN describes the time after which the UE is allowed to execute CHO to the candidate target cell.

2. Working assumption: the timing information for CHO execution triggering in NTN is defined in the form of a timer/timers. This can be revised and a solution based on UTC/system frame number can be considered if problems are found (e.g. if the timer lacks accuracy due to RTT in NTN).

In the Release-16 study item the issue of simultaneous RACH attempts to target cell was concluded to be an issue and time based CHO mechanism was recognised as one possible solutions for the situation. In worse case this may eliminate any access attempt to that cell when RACH issues accumulate. This was also recognized by some companies now

*RAN2 to discuss the solution for signalling storm created by frequent handovers of all connected UEs in an NTN cell.[16]*

*We suggest RAN2 to consider some solutions such as distributing UEs to access the same new cell(s) considering uplink signaling storms and access resources shortage due to a large number of UEs accessing the same new cell(s) almost simultaneously.[29]*

According to the agreement from the RAN2#113bis meeting, the timing information in the time/timer based CHO trigger event describes the time after which the UE is allowed to perform CHO to a given candidate target cell. This information is basically telling when it is worth for the UE to start detecting and measuring a given candidate target cell. As stated in the agreement, after this time the actual CHO event is evaluated which is then with current framework one or two events (MeasID) configured for that candidate target cell. Note that UE can be configured with up to 8 candidate target cells that may be same or different as per current signalling structure.

In the contributions submitted to RAN#114 the following proposals were presented:

*The trigger timer/timers can be configured based on the feeder/service link switch timing.[13]*

*The serving cell time information should also be considered in CHO execution triggering for NTN, e.g. time until when the source cell provides coverage.[2]*

*RAN2 to adopt absolute time based new CHO trigger, i.e. based on UTC or system frame number.[14]*

*The timing information for CHO execution triggering in NTN is defined in the form of UTC time.[22]*

*Define an event with the enter condition a time expressed as absolute time, or in system frame number, when the UE is to perform the CHO to the target cell.[23]*

*For soft feeder-link switch, a UTC time-based CHO execution trigger is introduced and combined with a low-threshold A4 trigger.[26]*

*Confirm the RAN2#113bis working assumption: the timing information for CHO execution triggering in NTN is defined in the form of a timer/timers.[3]*

*For general mobility case, confirm the following working assumption: the timing information for CHO execution triggering in NTN is defined in the form of a timer/timers.[26]*

*In time-based CHO condition, timer value is provided to UE with respect to a reference time.[11]*

*RAN2 confirms that the timing information for CHO execution triggering in NTN is defined in the form of a timer/timers.[21]*

*Timer-based condition is configured per prepared target cell i.e., it is within condExecutionCond. It is up to network implementation that the timer is linked to serving cell switch-off/leavingtime or neighbouring cell switch-on/coming up time.[24]*

*Timer-based condition can be ‘time range’. UE evaluates whether the measurement-based condition is met or not in the time range.[21]*

*Validity time of a CHO command is not needed.[11]*

*The timing information in CHO triggering condition consists of start time point and end time point. During the time period, the UE is allowed to execute CHO to the candidate cell. After the time period, the can stop the measurement until the next appearance.[19]*

*Two timers can be used to describe ‘time range’. UE evaluates whether the measurement-based condition is met or not when the first timer expires and the second timer is running. Namely, the first timer is the agreed time after which the UE is allowed to execute CHO to the candidate target cell.[21]*

*Timing information in CHO execution triggering for NTN also describes the time after which UE cannot access candidate target cell (i.e. the end time of a candidate target cell).[22]*

1. RAN2 to discuss how the time based CHO should work and what is the relevant information UE needs for efficient operation.

**Question 7 Please give your view on how the time based CHO should work and what is the relevant information UE needs for efficient operation?**

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| --- | --- | --- |
| **Company** | **Operation** | **UE information** |
| Samsung | Use (i) normal trigger that combines time related to the serving cell with neighbor cell RSRP and (ii) fallback trigger that defines a time and the fallback handover cell in case the normal trigger is not satisfied. | Different times are needed for two cases.  Case A. Quasi-Earth-fixed Beams and Feedr Link Switch. The UE compares remaining serving time with a threshold and if a neighbor RSRP can provide a good RSRP, the UE performs CHO. The gNB can distribute handover in time by specifying different thresholds to different Ues. If such (or another) execution trigger is not satisfied until (serving cell end time – time margin), the UE does a fallback handover to a fallback cell (e.g., the one that will have almost the same coverage as the current serving cell). We should designate a fallback handover cell because of similar RSRPs near the border and costly incorrect handovers.  Case B. Earth-moving beams.  If the total dwell time since last handover exceeds the serving time threshold and if a neighbor RSRP can provide a good RSRP, the UE can switch. If such (or another) trigger is not satisfied until (maximum serving time – time margin), the UE does a fallback handover to a fallback cell (e.g., the one that will have almost the same coverage as the current serving cell). |
| CATT | In earth-fixed Beams and feeder link switch, time info(e.g. stop time of serving cell and start time of neighbour cell) can be broadcasting in the SIB space. This information is applicable for measurement initiation for neighbour cell measurement. RRM measurement of target cell is started when the UE monitor the cell is about to stop service.  If the RSRP/RSRQ event is met, the UE can access to the target cell. | UE obtains the remaining service time of the serving cell via System Information. When the remaining time is insufficient, RRM measurement of the target cell should be triggered in advance. Then, if the RSRP/RSRQ event is met, the UE can access to the target cell.  The time information of serving cell should also be considered for NTN, e.g. time until when the source cell provides coverage. If the coverage time of serving cell is more than the coming time of the cell after next cell.  The stop time of serving cell may avoid the redundant handover. |
| Huawei, HiSilicon | UE can calculate the remaining serving time for each neighbour cell, when the remaining serving time of current serving cell is about to zero a CHO xecution can be triggered to the candidate target cell with the longest remaining serving time. | Besides ephemeris, beam centers and beam radius of serving cell and neighbour cells are also provided to UE. |
| BT | Depends on the satellite solution | We consider it will be desirable to discuss case by case. |
| Nokia | UE is configured with two execution conditions – one with a timer, another for radio measurements (e.g. Ax). When the timer expires, the UE evaluates the second condition (Ax). CHO is executed when the second condition (Ax) is met. This does not exclude the possibility to use another timer, controling for how long this execution is possible. | Two CHO execution conditions, timer (s) associated with each CHO candidate cell. |
| Sony | UE will execute CHO when the indicated timer of serving cell is expired.  We are also ok if timer is indicated per target cell. We think there are two options:  Option 1:  target cell #1 timer: 8 sec,  target cell #2: timer: 16 sec.  UE stores multiple target cell configurations and then execute based on the timer expiry.  Option 2:  Target cell#1 timer: 8 sec,  target cell#2: 9 secs  Due to predictable nature of cell movement even if their orbits overlap, we prefer option 1 | The time information of when the serving cell is going to stop service. |
| InterDigital | For general case agree with Nokia  For soft feeder-link switch, a UTC time-based CHO execution condition and combined with a low-threshold A4 trigger once A4 threshold is satisfied, UE may execute CHO at indicated time | For general case agree with Nokia.  For soft feeder-link switch, synchronized UTC time |
| MediaTek | Time based trigger should be based on Time since when the UE can access the candidate CHO target cell or Time until when the source cell provides coverage. In addition, time information needs to be combined with measurement based triggers. | UE needs information about the target cell and time since when it can access target cell or time until when it can access source cell. |
| Qualcomm | Only earliest time UE can execute CHO is sufficient.  After this time, UE follows legacy procedure to execute CHO using either CondEvent A3 or A4 or A5. | Each candidate cell can have different earliest time the CHO can be executed.  UE needs this time information per candidate cell and CondEvent. |
| ZTE | * Case 1: time based CHO is configured alone.   - The valid time range is configured for each candidate target cell, e.g. start UTC time + end UTC time.  - The candidate target cell becomes triggering cell when the start time is passed and the end time has not come yet.  - If there is more than one triggering cell, UE can select one from them in implementation, e.g. select one cell with the longest valid time.   * Case 2: time based CHO is configured together with radio measurement based event.   - The valid time range, e.g. start UTC time + end UTC time, together with a A3/A5 is configured for each candidate target cell.  -The candidate target cell becomes triggering cell when the start time is passed and the end time has not come yet and the A3/A5 is satisfied.  - If there is more than one triggering cell, UE can select one from them in implementation, e.g. select one cell with the longest valid time or the highest RSRP/RSRQ. | UE needs to know the start time and end time for each candidate target cell. |
| OPPO | The UE may be provided with a start time point for each candidate cell.  The UE is allowed to execute CHO to a candidate cell after the start time of the candidate cell which ensures availability. | a start time point for each candidate cell |
| Apple | Time based triggers provide the # time ticks up to when the CHO needs to be executed. The ticks can indicate either the time until when the source cell can continue to provide service or the target cell will start providing service. Service means when the satellite is in range ( > 10degrees elevation angle at a particular cell location). | Either a synchronized UTC time as Nokia mentions or simply ticks since last event (FFS) should be sufficient. Adding both the source and target times would be beneficial. |
| Intel | We understand that legacy operation is maintained, and time indicates the earliest time for CHO execution. We are ok to confirm the WA. |  |
| LG | For each CHO candidate cell, time duration is provided. During the time period, the UE performs measurement on the candidate cell and execute CHO when cell quality condition is met. Additional time condition can be configured – if remaining time duration is longer than a threshold, then UE is allowed to execute CHO to the candidate cell. | Start time point and end time point of time duration of each CHO candidate cell. |

1. RAN2 to discuss how to address the issue of RACH congestion in a target cell.

**Question 8 Please give your view on how to address the issue of RACH congestion in a target cell?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Operation** | **UE information** |
| Samsung | The gNB provides different time thresholds to different sets of Ues to distribute random access and handover signaling in time. | Time thresholds mentioned in our Proposal 7 reponse are adequate |
| CATT | Same as Q7. |  |
| Huawei, HiSilicon | Same as Q7. |  |
| BT | Same as Q7 |  |
| Nokia | This is a NW implementation aspect. NW provides each UE with a dedicated CHO configuration, so can consider RACH congestion when setting the configuration. |  |
| Sony | Multiple target cells are included in the RRC reconfiguration message after security and before a DRB is setup.  Also, RACH-less HO should be considered | Multiple target cell information |
| InterDigital | Biggest issue occurs during feeder-link switch. In this case, a UTC time-based CHO execution condition and combined with a low-threshold A4 condition. Once A4 threshold is satisfied, UE may execute CHO at indicated time  gNB may configure UTC times to be staggered, avoid RACH collision |  |
| MediaTek | (1) If the network can provide CFRA resources, then there will be no RACH storm. The different UEs will be spead out in time and frequency.  (2) If there is not enough CFRA resources, the network can provide an additional number with the CHO command. Prior to perfroming RACH, every UE will first back off a random time between 0 and the number provided. This will avoid the possible RACH congeston. | (1) UE will only need CFRA resources.  (2) UE needs a number from the network, which will indicate the maximum backoff value to spread out the RACH operatons. |
| Qualcomm | Simply use random backoff to initiate PRACH to target cell. | Either specifiy or provide maximum backoff value. |
| ZTE | NW can configure the start time and end time for each candidate target cell to distribute UE among these cells. |  |
| OPPO | Same as Q7. |  |
| Apple | UEs can be provided time ticks either as a range with a random seed to randomize RACHs or provided with accurate ticks based on the network load and conditions. | See proposal 7 responses. |
| Intel | The concern scenario should be clarified in relation to NTN deployments. We do not see the need for addressing this scenario with a new solution at this moment. |  |
| LG | Same as Q7. |  |

1. RAN2 to discuss whether information related to when candidate target cell becomes available is a timer, UTC, or a time range.

**Question 9 Please give your view on whether information related to when candidate target cell becomes available is a timer, UTC, or a time range?**

|  |  |  |
| --- | --- | --- |
| **Company** | **option** | **comment** |
| Samsung | No need at all for time availability of candidate cells: save precious bits | The gNB can simply update the neighbor list in a SIB to include good candidates at a given instant. These lists are not expected to be changing frequently. The neighbir list would need to be changed at times such as around feeder link switch or quasi-Earth-fixed beam cell change, because serving cell-neighbor relations should be quite redictable and statsic for all types of beams. |
| CATT | Absolute time, e.g. UTC time or SFN. | Absolute time, e.g. UTC time or SFN could be used to definitely indicate the stop time of the serving cell, it is much easier. |
| Huawei, HiSilicon | UTC is preferred | UE can further calculate the remaining serving time for each neighbour cell, so time range information is already known by UE. |
| BT | Final solution is dependant of the satellite implementation. | First, we should clarify that this solution applies to LEO with moving beams. LEO with semi-static beams and GEO can report neighbours following legacy procedures.  For LEO moving beams, a cell can be wide so UEs on one edge of the cell may have a completely different radio conditions that UEs on the opposite edge. For that reason, a broadcasted solution doesn’t seem a valid one. We incline to support time range assuming satellite constellations will be homogeneous with its inter-satellite distance on each orbit. |
| Nokia | There should be no such open question. We have a working assumption already to use a timer, so the question should be rather focused on showing the issues of a timer (if there are any) and arguing why UTC is better. Please do not start the discussion from scratch. |  |
| Sony | Timer or time range |  |
| InterDigital | Time Range, UTC time |  |
| MediaTek | Timer | Only one timer seems enough. |
| Qualcomm | Timer (confirm working assumption) | Signaling overhead of UTC is too high. |
| ZTE | The time range (start time + end time or start time + duration) of candidate target cell should be configured using UTC time. | * A light UTC time (e.g. UTC time with a lower accuracy) can be used to reduce the signaling overhead. * We understand having a time range would be beneficial to both UE and NW.   + UE can take it into consideration in implementation and select a cell with longer valid time when there are more than one triggering cell.   + From NW’s perspective, with the end time configured for each candidate target cell, NW would have more flexibility to distribute UE among cells for load balancing as well as reducing the HO rate. |
| OPPO | Absolute time | See our reply to Q7 |
| Apple | Timer | A time range would allow for staggered implementation of RACH but the range is still for a timer. |
| Intel | A timer or an UTC might be preferable depending on the NTN deployment (i.e. kind of satellite). |  |
| LG | Slight preference to UTC, but timer is also fine. | Start time point and end time point in UTC is provided. If timer is used, then the expiry of first timer and expiry of second timer represents start time point and end time point, respectively, of the time duration in which the UE is allowed to execute CHO to the candidate cell. |

### 2.3 CHO trigger combinations

Several companies have expressed their views on whether time or location trigger for CHO can be configured flexibly or whether those shall be mandated with RSRP trigger.

6 companies are supporting flexible trigger condition configurations

*CHO signalling should be flexible enough to support any combined conditions or standalone condition, it is left to network implementation to configure timer/location/radio condition alone or in combination.[24]*

*We suggest that RAN2 consider a flexible trigger framework that enables flexible combining of individual triggers to increase the reliability of handover in an NTN and to mitigate risks associated with new quantities and/or new type of deployment. One NTN-specific measurement event can suffice even when multiple trigger conditions are defined for flexibility.[27]*

*Down select from the following solutions to configure the timing information for CHO execution triggering in NTN:[22]*

*The relationship (i.e. “and” or “or”) among different CHO execution conditions, i.e. the R16 execution condition A3/A5, the newly introduced A4, location based condition, and timeI based condition in NTN, should be configurable by the network and should be indicated to UE in CHO configuration.[22]*

*A location-based measurement event could be configured independently, or be configured to combine with a radio-based measurement event by the network.[9]*

*It can be further discussed that the location-based measurement event can be configured to combine with all the existing radio-based measurement events.[9]*

*For the scenario of feeder/service link switch, time-based CHO triggering event can be configured without RSRP/RSRQ related event.[13]*

*Timer/location CHO trigger should be allowed to be configured independently.[16]*

8 companies to mandate the network to configure RSRP trigger together with time or location trigger. It is noted that since Rel 99 network can trigger HO without any RSRP measurements. Also DC secondary cell addition is possible without any RSRP measurements.

*Location-based event for CHO execution triggering is always configured with radio-based measurement event (e.g. Ax).[3]*

*Timer-based event for CHO execution is always configured with radio-based measurement event (e.g. Ax).[3]*

*Timer- or location-based events for NTN are either linked in the specification with radio measurements based events (e.g. Ax) or always configured jointly with radio measurements based events (e.g. Ax).[3]*

*Timer-based event cannot be combined with location-based event for the same CHO candidate cell evaluation criteria. Any of these shall be always linked with the radio measurement based events.[3]*

*Location-based condition, in combination with one of CondEvent A3, CondEvent A4, CondEvent A5, CondEvent A3& CondEvent A5 can be supported in CHO execution condition as follows.[21]*

*Timer-based condition, in combination with one of CondEvent A3, CondEvent A4, CondEvent A5, CondEvent A3& CondEvent A5 can be supported in CHO execution condition as follows.[21]*

*Time-based or location-based triggering shall be always combined with RSRQ/RSRP events (A4) for CHO triggering or measurement report triggering.[2]*

*Location-based event is always configured together with RSRP/RSRQ-based event, and CHO is executed when both events are fulfilled.[1]*

*For soft feeder-link switch, a UTC time-based CHO execution trigger is introduced and combined with a low-threshold A4 trigger.[26]*

*The time/location-based criterion is used as AND operation with either A4 or A3 or A5 event.[11]*

*In the NTN CHO configuration, cell quality condition should be mandatorily configured in the CHO triggering condition.[19]*

*In addition to the cell quality condition, time condition or location condition can be optionally configured.[19]*

*Location-based CHO execution triggering is always configured with a measurement-based trigger.[25]*

Two companies proposed to discuss and study which should RAN2 allow new triggers to work alone.

*RAN2 to discuss whether to allow new CHO trigger to work alone.[14]*

*We suggest that RAN2 evaluate the suitability of various candidate measurement quantities as standalone and/or combination triggers (e.g., RSRP, elevation angle, time since last handover, distance-to-the-cell center, and so on) for traditional handover and conditional handover in an NTN.[27]*

1. RAN2 to understand joint configuration of location and RSRP as well as time and RSRP triggers are supported.

**Question 10 Please give your view on whether joint configuration of location and RSRP as well as time and RSRP triggers should are supported?**

|  |  |  |
| --- | --- | --- |
| **Company** | **option** | **comment** |
| Samsung | Support (i) normal case combination triggers such as (a) UE location (Ex: UE outside the serving cell’s elliptical area) + neighbor cell RSRP and (b) time + neighbor cell RSRP and (ii) fallback handover case using time. | Multiple combination triggers can be defined. Ex: When either (a) is satisfied OR (b) is satisfied, HO occurs. |
| CATT | Combination of triggers.  (time+RSRP) and (location+RSRP) | We understand A4 should be the most essential event to trigger the CHO, while the time based info/location based info could be used as the assistance info.  The simplest way is to broadcast the time/location based info in the SI of each serving cell. UE could initiate the RRM measurement of the candidate neighbour cells according to the assistance info. When the A4 event is satisfied, CHO will be triggered.  That means, not necessary to define new triggering event, A4 is sufficient, and time/location based info could be broadcasted to UEs as the assistance info. |
| Huawei, HiSilicon | Trigger combination can be supported. | It’s also ok for us to have only location based or time based CHO trigger. |
| BT | First, we need to differentiate between LEO semi-static beams and LEO moving. | For LEO moving beams, which is the most complex case, time + RSRP is the most straight forward solution. |
| Nokia | What is the intention of this question? We have such agreement since November 2020 to support the combination of location/time + RSRP/RSRQ event. |  |
| Sony | Trigger combination is supported. |  |
| InterDigital | Same understanding as Nokia, i.e.  time+RSRP and location+RSRP are supported |  |
| MediaTek | Yes, location and time triggers should be combined with measurement (RSRP) triggers. | Combination of triggers is needed to make sure that the cell UE is handed over is detectable by the UE (enough RSRP or RSRQ). |
| Qualcomm | Time and location based condition should be combined with RSRP. | Time and location estimated to access the target cell is never accurate. So RSRP based condition is needed to make sure the target cell meets minimum signal quality threshold. |
| Lockheed Martin | Trigger combinations should be supported | Location only or Time/Timer only or (Location+RSRP ) and (Time/Timer+RSRP) |
| ZTE | We prefer the CHO signaling to be flexible enough to support any combined conditions or standalone condition, it is left to network implementation to configure timer/location/radio condition alone or in combination.  In this case, we do not need to spend a lot time discussing which standalone configuration or which combination is allowed and which is not allowed. |  |
| OPPO | Combination of triggers.  (time+RSRP) and (location+RSRP) | Location/time-based event is to mitigate the accuracy issue of RSRP/RSRQ measurement, and location measurement as such cannot reliably reflect the radio condition. If CHO execution is based on location/time-based event only, it may cause some performance issue, e.g. CHO failure. For better performance, we think location/time-based event should be always configured together with RSRP/RSRQ-based event. |
| Apple | Yes, combinations can be supported |  |
| Intel | Up to network configuration whether to enable one or both triggers (i.e. location and time) in a given UE with RSRP/RSRQ. |  |
| LG | (RSRP + time) or (RSRP+location), but RSRP is mandatory. | RSRP is mandatorily configured and time or location condition can be configured optionally. |

1. RAN2 to discuss whether RAN2 declines the options that the network configures location or time CHO trigger without measurement trigger.

**Question 11 Please give your view on whether RAN2 declines the options that the network configures location or time CHO trigger without measurement trigger? Reasoning is needed**

|  |  |  |
| --- | --- | --- |
| **Company** | **option** | **reasoning** |
| Samsung | Under normal circumstances, use combination triggers. For fallback handover case, use only time. | Under normal circumstances, combination triggers would work well. We should generally make sure that the neighbor cell can provide adequate RSRP. However, in case RSRPs at the border do not meet the combination criteria for handover, we would need a fallback handover because the serving cell will disappear if the UE does not perform handover in time! For fallback, we should use only time (while giving the UE adequate opportunities to find a neighbor with strong RSRP). |
| CATT | Decline standalone location and time trigger. | Same as Q10. |
| Huawei, HiSilicon | Ok to support location or time CHO trigger without measurement trigger | It depends on network implementation and realistic deployment. If in the early deployment stage, only one satellite exists, then it’s enough to only have location or time CHO trigger as there is no other candidate cell available. |
| BT | No | For LEO moving beams:  For a semi-static UE, it is expected a constellation is well-known in terms of time/distance between cells. Therefore, “forced” handovers due to moving cells will be predictable and can be simple configured with a timer. For UE power saving reasons we need to support this option. |
| Nokia | Time- or location-based event alone can be used for measurement report triggering, but not for CHO execution triggering, where radio-based event shall be also configured. | We wonder what is the exact NTN CHO use case, where just the time-/location-based event would make sense? We have asked that multiple times, nobody brought any solid scenario. Allowing full flexibility is not a credible motivation. |
| Sony | We think location or time CHO trigger without measurement should be supported. | 1. RSRP/RSRQ difference in NTN is not as obvious as in TN network e.g. the RSRP/RSRQ difference is more flat in NTN. So it is not straighforward to configure a proper threshold to trigger handover e.g. it would trigger CHO either too early or too late. 2. To configure timer/location independently will give network more flexibility to configure CHO. |
| InterDigital | Always configure with measurements | At minimum, configure with a low threshold A4 event to ensure that if UE initiates mobility it will not immediately experience RLF. |
| MediaTek | Yes, RAN2 should decline options that the network configures location or time CHO trigger without measurement trigger | Combination of triggers is needed to make sure that the cell UE is handed over is detectable by the UE (enough RSRP or RSRQ). |
| Qualcomm | Yes, time/location-based CHO without measurement trigger is possible. | Even today, there is no restriction specified and network can configure CHO to UE without receiving measurement report. |
| Lockheed Martin | We should support location only or timer/timer only as the CHO trigger | Since the difference between the source cell RSRP and target cell RSRP in NTN is going to be very small, combining RSRP measurement with location or time may not help. If all the options are provided, it gives deployment flexibility and also companies can test different options to better understand the NTN behavior. |
| ZTE | We prefer the CHO signaling to be flexible enough to support any combined conditions or standalone condition, it is left to network implementation to configure timer/location/radio condition alone or in combination.  In this case, we do not need to spend a lot time discussing which standalone configuration or which combination is allowed and which is not allowed. |  |
| OPPO | Decline standalone location and time trigger. | Same comment as Q10. |
| Apple | Measurement based should still be priority. The combination is just an augment to measurement. |  |
| Intel | We have slightly preference to keep RRM measurements in addition to location or time CHO trigger. |  |
| LG | Time or location condition cannot be configured without RSRP condition. (RSRP condition is mandatory) | Even if time or location condition is satisfied, minimum cell quality should be satisfied in order to check whether the cell is accessible, because NTN cells may easily be effected by whether (e.g. rainy or cloudy) |

There was one proposal related not configuring time and location together and no arguments why these should be considered together, thus

*Time-based and location-based conditions are not configured simultaneously for a candidate cell.[11]*

1. RAN2 not to consider further joint location and timer based trigger

**Question 12 Please give your view on whether RAN2 further discusses how to combine location and time trigger?**

|  |  |  |
| --- | --- | --- |
| **Company** | **option** | **reasoning** |
| Samsung | Support OR between (time+RSRP) and (location+RSRP). | Due to the novelty of NR-based NTN deployments, let‘s give the gNB full flexibility. If the gNB wants to configure one, it can do so. If the gNB wants to configure both, it can also do so. |
| CATT | Support OR between (time+RSRP) and (location+RSRP). | We think the combination of location and timer based trigger is essential.  UE can be configured the location and timer based conditions simultaneously for the same target cell. Whether (location+RSRP) or (time+RSRP) event is met, the CHO can be triggered.  That is because the two reasons of handover in NTN system are UE moving and satellite moving.  For example, in earth fixed scenario, when UE is moving out of the cell coverage, Handover should be trigger based on the location event rather than time info. When the cell is moving to cover another area, handover should be executed based on the time event rather than location info. And NW cannot know the reason for switch in advance. |
| Huawei, HiSilicon | No strong view | We could go for majority. |
| Nokia | Agree with P12. No clear use case and benefits. |  |
| Sony | No strong view |  |
| InterDigital | Not needed |  |
| MeidaTek | Yes, there is no need to combine location and time trigger | Time triggers are made for feederlin switch and is not dependent on location. |
| Qualcomm | UE does not need both. Time-based trigger can be prioritized over location-based. | Depending on signaling sructure, both time and location-configuration may be possible. |
| ZTE | We prefer the CHO signaling to be flexible enough to support any combined conditions or standalone condition, it is left to network implementation to configure timer/location/radio condition alone or in combination.  In this case, we do not need to spend a lot time discussing which standalone configuration or which combination is allowed and which is not allowed. |  |
| OPPO | Do not support to combine location and time trigger | Same comment as Q10 |
| Apple | Dont understand the question but there is no need to comnine location and time triggers. | Each of location and timer informations can be obtained in independent ways so independent triggers are sufficient. There is no need to combine them when individually they can serve the purpose. |
| Intel | We suppport OR between (time+RSRP) and (location+RSRP). | We think that time or location aim to provide similar kind of information therefore UE could trigger the event if either of them is met |
| LG | No for simultaneous configuration of time and location condition. | We think time condition is suitable for earth-fixed beam and location condition is suitable for earth-moving beam. So no co-existence is needed. |

RAN2 declines the options that the network configures location or time CHO trigger without measurement trigger

### 2.3 Other CHO related proposals or further details

On concatenated CHO. The idea here is that UE does not need to start all over the trigger evaluations and some companies also think the CHO configuration could be kept. However, as the target cell is responsible of the UE’s RRC configuration after the HO and that configuration including the possible CHO commands is given in the original CHO command.

*Stored conditional handover configurations is kept after conditional handover is executed.[16]*

*RAN2 is asked to support the mechanism, where the UE can be provided with CHO configurations for cells beyond the next cell change (future candidate cells). Details of the procedure can be left FFS.[3]*

*In time-based CHO condition, a candidate cell connecting to the same gateway/gNB with future execution time is stored even after successful CHO procedure.[11]*

1. RAN2 to discuss whether it is feasible that UE keeps part of another gNB/cell configuration after accessing the target cell.

**Question 13 Please give your view on whether it is feasible that UE keeps part of another gNB/cell configuration after accessing the target cell? Reasoning is needed**

|  |  |  |
| --- | --- | --- |
| **Company** | **option** | **reasoning** |
| Samsung | The UE does not keep any CHO configuration whatsoever after a successful CHO execution. | While we like the low signaling latency aspect of CHO, we have very serious concerns about huge resource consumption in CHO in an NTN. Per UE resources are already fewer in an NTN comapred to a TN. Additionally, precious radio resources would be reserved (but not used) for a relatively long time at mutiple cells for hundreds of or perhaps a couple of thouand users due to massive handover in the NTN. This will significnatly reduce the amount of radio resource available for user traffic. Indeed, to minimize resource reservation time and reduce the waste of precious radio resources, we suggest that RAN2 consider the mechanism where the UE informs the source cell about the selected CHO canddiate cell before doing initiating random access with the selected CHO target cell so that the source cell quickly release reserved resources at non-selected CHO candidate cells. |
| CATT | Same view with Samsung |  |
| Huawei, HiSilicon | No need to keep configuration after successful handover. | We can maintain current CHO mechanism, and no further enhancement is needed. |
| BT | Depends | Yes, if other cells/gNBs share any configuration parameter and shared parameters are feasible to be identified. In that case, it is worth that the UE keeps such configuration due to it will avoid the requirement to be transmitted again.  Other case, left to UE implementation which parameters it wants to keep. |
| Nokia | Yes, we think this could be beneficial, thanks to the predictable list of future cells. However, the details can be left FFS for now, let’s first decide on the more basic mobility aspects (we still struggle with the definition of time/location based events, etc.). |  |
| Sony | Yes, if we dont allow maintaining CHO config then we fail to realise the benefit of timer/location based triggers. | In NTN, as the approaching cells are predicable, we believe it is beneficial to keep the stored conditional handover configurations in order to reduce the control signalling overhead. |
| InterDigital | Support for LEO due to predictable movement of cells |  |
| MediaTek | No, there is no need at this time. | Such optimizations are not needed at this stage. We need to make a working solution first. |
| Qualcomm | Yes | If the cells belong to same gateway/gNB, then they may share same configuration and this is possible.  In any other case, network can always provide full configuration to each candidate cell with time-based trigger condition. |
| ZTE | No | Since the “another gNB/cell configuration ” is generated based on the configuration of original source cell and delta cofiguration may be used, the configuration provided in the CHO container of “another gNB/cell configuration ”seems not available anymore after UE accessing the target cell. |
| OPPO | No need to keep configuration after successful handover. | Current CHO mechanism is sufficient, no need to consider such enhancement. |
| Apple | Maybe with location. | The location based trigger can be maintained due tot he predictable nature oft he satellites. For timers however, the timer might need tob e updated based on discontinuous coverages meaning the previous configuration is not valid. The assumption here is that location and timer based triggers are never configured together. |
| Intel | Our preference is not to keep other/additional configurations. | Keeping extra configurations add a level of complexity considering the delta configuration supported in legacy operation, and is not clear to us whether would bring any signaling reduction. |
| LG | If some canddiate cell’s service time duration during which allowed to execute CHO is not started yet when the UE executes CHO, then the UE can maintain the CHO candidate cell. | Not all the CHO candidate cells need to be maintained, but some upcoming candidate cells can be maintained. |

1. RAN2 to discuss how to enhance the efficiency of the potential need to concatenate HOs in NTN. E.g. by UE not to discard filtered measurements after successful HO.

**Question 14 Please give your view on how to enhance the efficiency of the potential need to concatenate Hos in NTN. E.g. by UE not to discard filtered measurements after successful HO? Reasoning is needed**

|  |  |  |
| --- | --- | --- |
| **Company** | **opinion** | **reasoning** |
| Samsung | No concatenation, please. | Let’s use NTN for user traffic to the maximum extent possible to make NTN as efficient as possible. Let’s use (and not waste) precious NTN radio resources. Note that commercial nhance operate at 98% or even higher successful hanover rate. So, we should focus on making things better for 98%. And, we are not ignoring 2%...even when CHO fails, we still have a fallback mechanism in legacy R16; the UE will reestabish the RRC connection with the best available cell when a failure occurs. |
| CATT | No need in R17 | It is not essential part of CHO. R17 is an workable solution of NR NTN. Such optimization need deprioritize in this stage. |
| Huawei, HiSilicon | No concatenation is needed. | We can focus on essential nhancements first. |
| Nokia | As commented to Q13, let’s keep it FFS for now. |  |
| Sony | No strong view |  |
| InterDigital | Support further study of this. Agree with Nokia to keep it FFS |  |
| MediaTek | Not needed now. | We think such optimizations can be considered in later releases. We need to make a working solution first. |
| Qualcomm | Ok to further study this |  |
| ZTE | No |  |
| OPPO | No need in R17 |  |
| Apple | Not Needed |  |
| Intel | No needed in Rel-17 |  |
| LG | No strong view, but it seems reasonable. | Based on ephemeris information, we think the network could plan UE’s mobility based on upcoming LEO satellites. |

Signalling overhead. In below several different considerations regarding signalling overhead are presented

*What information to be provided in CHO configuration, system information etc need to await further progress in ephemeris discussions.[23]*

*The gain of signaling overhead reduction through the solution that broadcast handover signaling and information common to all the UEs may need to further evaluate due to the limited common signaling and information that can be extracted.[29]*

*To reduce HO signalling overhead, some common configurations, e.g. t304 and spCellConfigCommon, can be delivered to UEs in a broadcast manner.[1]*

*We suggest that RAN2 consider various signaling modes such as broadcast, multicast/groupcast, and unicast to efficiently and quickly exchange handover signaling with UEs.[27]*

*In order to decrease signaling overhead during the whole HO procedure, we could consider a handover scheme that the UE does not perceive, where all the information about UE, including UE context, protocol configuration, UE variables, constants and timers etc. could be interacted between source gNB and target gNB beforehand.[29]*

1. RAN2 to discuss whether there is a need to optimize signalling overhead for HO/CHO.

**Question 15 Please give your view on whether there is a need to optimize signalling overhead for HO/CHO? Reasoning is needed**

|  |  |  |
| --- | --- | --- |
| **Company** | **opinion** | **reasoning** |
| Samsung | Most definitely, we need to address the Tsunami of handover signaling. | We expect much higher amount of HO signaling in an NTN compared to a TN due to massive handover. We need to use every time-frequency resource as efficiently as possible. |
| CATT | No stong view |  |
| Huawei, HiSilicon | Not urgent | When feeder link switch happens, there could be handovers for all UEs in a cell. It depends network implementation how to group Ues and trigger handovers at different time. |
| Nokia | Signalling for HO/CHO shall be optimized. But we are a bit sceptical to push the dedicated message contents to SI blocks. |  |
| Sony | We think it is better to wait for details of ephemris information |  |
| MediaTek | Broadcast of common signalling parameters, as mentioned in [1], [27], [29] can be considered. | Broadcast signalling can reduce the signalling overhead. |
| Qualcomm | Yes | (1) CHO command can be carried by RRC that configures DRB. There is no tsunami issue for DRB configuration!  (2) In location-based CHO, the beam information should be associated with serving cell and broadcast as cell specific paramater (no need to carry in CHO command). |
| ZTE | Yes | For the case when HO command overrides a CHO command, one target cell indication (e.g. the candidate cell identity or index) can be included in the conventional HO command and UE should apply the corresponding condRRCReconfig provided earlier. |
| OPPO | To reduce HO signalling overhead in the LEO scenario, some common configurations can be delivered to UEs in a broadcast manner. | Even though CHO can resolve the signaling burst issue in the LEO scenario, it still does not reduce the overall signaling overhead for all UEs in the cell. Since some configurations (e.g. t304 and spCellConfigCommon) in HO command may be common to all UEs, these configurations can be signalled to the UE in a broadcast manner, i.e. to put them in SIB. For other configurations in the IE ReconfigurationWithSync, they are still carried in dedicated RRC signaling. In this way, the signaling overhead related to those common configurations in HO command can be reduced in dedicated RRC signaling. |
| Apple | Some common configuration messages are needed to reduce the signaling storms. Any UE specific configuration however should be initiated after a successful handover tot he target cell and application of common configuration. |  |
| Intel | This could be addressed during running stage-3 CR discussion e.g. broadcast of common parameters if the signaling reduction is considerable. |  |
| LG | No broadcast. | Broadcasting the handover-related parameters is not necessary. Each UE has different expected HO/CHO candidate cells, so cell-specific HO/CHO-related parameter is not workable. |

List of proposals that may be discussed if time allows

*Location-based CHO condition is configured per UE and time-based CHO condition is configured per candidate cell.[11]*

*Multiple target cells are included in the RRC reconfiguration message when AS security has been activated and SRB2 is setup and not suspended i.e DRB setup precondition is not required.[16]*

*AN2 discuss whether multiple conExecutionCond can be configured for one conRRCReconfig[24]*

*RAN2 to discuss how to select target cell when multiple triggered cells exist:[14]*

*If multiple cells within timing information satisfy CHO triggering condition, the UE triggers CHO to the candidate with longest remaining service time.[19]*

*UE can report neighbour cells related assistance information to help network select CHO candidate cells.[13]*

*To ensure seamless handover, the source gNB needs to pre-evaluate the HO timing to transmit all the information of UE to the target gNB in advance.[29]*

*RAN2 can consider supporting historical measurements to facilitate a predictive handover decision-making at the gNB to accelerate the overall handover.[27]*

*Support intra-handover user traffic transfer while the RA procedure for handover is ongoing to reduce the user traffic interruption in an NTN.[27]*

*We suggest that RAN2 consider the use of predictable satellite movements to create a compact Neighbor List and to introduce a cell movement-based offset in the measurement event criterion to enhance the reliability of handover in an NTN.[27]*

*The UE informs Source-gNB/cell about the selected Target gNB/cell before leaving the source cell so that radio resources in the source cell are not wasted. Furthermore, the Source-gNB can initiate an early HO CANCEL to non-selected gNBs to make more radio resources available in those gNBs. Additionally, the Source-gNB can do selective early status transfer & selective early packet forwarding to only one Target-gNB.[27]*

*UE will transmit assistance information when the difference between network’s configuration and UE’s own measurement is above a pre-defined threshold.[18]*

*Permission from UE is needed for the network to collect the UE location information for the purpose other than SON/MDT. If the UE location information is collected for other purpose, the UE consent for SON/MDT cannot be reused and a similar but independent procedure for permission should be considered.[19]*

*Measurement based CHO is prioritized over other mechanisms by RAN2 for NTN.[6]*

*If the network wants to trigger a conventional handover to one of the configured CHO candidate cells, one target cell indication (e.g. the candidate cell identity or index) can be included in the conventional HO command and UE should apply the corresponding condRRCReconfig.[22]*

*RAN2 consider CHO enhancement in NTN by introducing CHO activation command.[1]*

# 3 TN/NTN service continuity

### 3.1 Connected mode

The following proposals for service continuity were presented

*For NTN capable UE, both UE types shall be considered for NTN-TN mobility[5]*

*The UE capable of NTN shall support mobility between NTN and TN.[5]*

*No enhancements are needed for connected mode mobility from TN to NTN (hand-out) networks.[7]*

*Handovers from TN to NTN should use legacy events, e.g., A2. On the other hand, handovers from NTN to TN may require an additional trigger, e.g., UE location, apart from legacy events.[5]*

*Location-based triggers that are introduced for NTN connected mode mobility can be reused for NTN to TN (hand-in) mobility.[7]*

*The new trigger conditions for handover as described in TR 38.821 could also be considered for the NTN-TN service continuity.[30]*

Based on the above set of proposals the following discussion points are suggested

1. NTN capable UE shall support NTN-TN mobility

**Question 16 Please give your view on whether NTN capable UE shall support NTN-TN mobility**

|  |  |  |
| --- | --- | --- |
| **Company** | **opinion** | **reasoning** |
| Samsung | We have no strong view. We will go with the majority. | We expect a typical UE/smartphone to support such mobility. However, we do realize that some UEs (e.g., rural or hard-to-reach places) may never have to work with a TN. So, there could be some part of the NTN ecosystem that simply focuses on the NTN to cerate custom (and simplified) devices. Some low-cost IoT devices (e.g., sensors in farms or on bridges) may also be happy just communicating with an NTN. |
| CATT | Yes | We agree to further discuss the NTN-TN mobility. |
| Huawei, HiSilicon | Yes | A NTN UE is a R17 UE, so it should support all basic R15 functions. |
| BT | Yes | That is a key feature for our use cases. It is simply not acceptable that RAN2 precludes an intra-system mobility. There is no reason that a Rel-17 UE doesn’t support Rel-15 features. |
| Nokia | Similar view to Samsung. It would make sense, if the NTN UE can also support TN, but we understand there are some NTN use cases, where TN coverage is not expected, so UE’s capability for TN (and NTN-TN mobility) may not be essential. |  |
| Sony | Yes |  |
| InterDigital | Yes |  |
| MediaTek | We think it should be optional and not mandatory for NTN UEs. |  |
| Qualcomm | There needs to UE capability as this is inter-system handover. | There is always UE capability for inter-system handover, e.g., 5GC vs EPC.  Anyway, capability part should be discussed in the later phase. |
| Lockheed Martin | Yes | This is a very essential feature and there are many use cases where mobility between NTN and TN is needed. |
| ZTE | Ok from our side | Ok from our side. But it should be confirmed and supported by UE vendors. |
| Hughes/EchoStar | Yes | To achieve seamless interoperability between NTN and TN – for regulatory and commercial reasons |
| OPPO | We share the same view as Samsung and Nokia. | Normal NTN capable UEs should support NTN-TN mobility. If there are use cases that some devices are fixed in the regional area which would never access to TN, there may be no need to require these UEs to support NTN-TN mobility. |
| Apple | Yes |  |
| Intel | Yes |  |
| LG | Yes | We agreed that NTN-capable UE should be capable of TN. So NTN-TN mobility should be supported. If not, what is the alternative method? |

1. No limitations are specified for NTN-TN mobility thus same trigger conditions can be used within NTN and NTN-NT mobility

**Question 17 Please give your view on whether same trigger conditions can be used within NTN and NTN-NT mobility**

|  |  |  |
| --- | --- | --- |
| **Company** | **opinion** | **reasoning** |
| Samsung | The basic ramework would be reusable but some enhancements would be needed. | To enable the NTN ecosystem to flourish, we need full flexibility in business arrangements among operators and business ramework of operators. Prioritization of one network relative to another should not be one-way. Some NTN operator may want to hold onto their customers as far as possible. Similarly, a traditional TN operator with an agreement with an NTN operator may want to get its users on the TN as soon as possible. |
| CATT | Same view with Samsung. | NTN-TN mobility can reused the ramework agreed in NTN mobility. Maybe minor enhancenment is needed. |
| Huawei, HiSilicon | No fundamental enhancement is needed | For both cell reselection and handover mechanism, current designs can be reused. |
| BT | Enhancements are required | Mobility from TN to NTN can reuse legacy procedures.  For handovers from NTN to TN, we will need several enhancements to improve the UE power saving. E.g., a NTN UE in a fishing boat that won’t be under terrestrial network coverage area for hours or days. |
| Nokia | Yes, time/location-based events + legacy radio measurements should serve the purpose, if properly configured by the NW. |  |
| Sony | Yes | Network should make the UE aware of when to start performing the measurements on TN cells and not apply the serving cell criteria, when moving from an NTN cell towards a TN cell, from power saving point of view. |
| InterDigital | Agree with Samsung | If found to be beneficial |
| MediaTek | Yes, same trigger conditions can be used. |  |
| Qualcomm | Yes from NTN to TN. |  |
| Lockheed Martin | Yes, measurement, timer and location based HO should be reused. | Some enhancements maybe needed to handle service agreements between TN and NTN service providers. Enhancements for device power saving and any other optimization can be handled in R18. |
| ZTE | Yes. It can be left to NW to decide which one to configure. |  |
| Hughes/EchoStar | TN handovers and cell selection/reselection are based on RSRP and RSRQ measurements. For NTN, on top of RSRP/RSRQ, a different trigger may be required, e.g., the UE location | NTN cell size being so large, coverage can be endless with not much variation in RSRP/RSRQ |
| OPPO | Yes | We agree to use the same trigger conditions within NTN and NTN-NT mobility in Rel-17 for simplification. Enhancement for NTN-TN service continuity can be studied in later release. |
| Apple | We can use the same trigger conditions |  |
| Intel | Yes. RAN2 might need to discuss if those new triggers is applicable for both NTN-NT mobility cases (i.e. NTN to NT and NT to NTN) or only when moving from NTN to NT. |  |
| LG | We can use basic framework (e.g. cell reselection and handover) for NTN-TN mobility, and can study whether further enhancement is needed for some cases. | For now, it seems R16 cell reselection and handover mechanism is workable. |

### 3.2 Idle mode

As the capacity of NTN will be limited given the large cell size and considering the RSRP of NTN cells might be better than the RSRP of TN on the same area, the idle mode operation for service continuity need to be discussed.

*No enhancements are needed for Idle-mode mobility to address NTN-TN service continuity.[7]*

*Ping-pong between TN and NTN shall be avoided.[5]*

*RAN2 confirms that UE prioritises TN over NTN.[15]*

Based on the above set of proposals the following discussion points are suggested

1. NTN UE prioritises TN over NTN

**Question 18 Please give your view on whether Proposal 18 NTN UE prioritises TN over NTN?**

|  |  |  |
| --- | --- | --- |
| **Company** | **opinion** | **reasoning** |
| Samsung | We will go with the majority but we like vailabl prioritization. | Let the NTN ecosystem expand and let‘s not create artificial constraints. |
| CATT | No | This should be based on the operator policy, we don’t need to fix the prioritize of TN and NTN. |
| Huawei, HiSilicon | Yes | UE experience is better in TN than in NTN according to the system performance evaluation in TR38.821. So if TN is vailable, no strong reason to still make UE locate in NTN cell. |
| BT | No | Different operators may have different requirements. We don’t need to create an artificial constraint. |
| Nokia | No | This is a bit weird to introduce such fixed priority. Different use cases may require different configuration of priorities. |
| Sony | Yes | We think this should be the baseline if it supports both. |
| InterDigital | Agree with samsung |  |
| MediaTek | The network can configure the priorities so that TN can be prioritized over NTN. This is left to network implementation. Existing priority-based cell reselections will be sufficient [7] to address it. | It makes sense to reselect TN cells with higher priority. However, this should be left to operator strategies. As shown in [7], this could be done using existing priority-based cell reselections. |
| Qualcomm | Network may configure priority. | It makes sense UE may always want better user experience with TN. But it is network that configures the priority. |
| Lockheed Martin | Configurable | It should be configurable and which one is higher priority depends on the business model and service aggrements. |
| ZTE | - | We would prefer to have it configurable from NW’s perspective via SIB/RRC signaling/NAS signaling.  It is also fine if UE has some intra-UE prioritization for a certain NW type (NTN or TN). |
| Hughes/EchoStar | Must be above a certain threshold and depends on TN network capacity | Do not want to overload TN |
| OPPO | No | This should depend on the operator policy. |
| Apple | No | No need to fix this now. This depends on many different criteria including operator policies and use cases. |
| Intel | No | This can be controlled by network e.g. via cell reselection priorities |
| LG | No | It is expected that most cases TN cell’s cell quality is higher than NTN cell’s cell quality. So we think additional mechanism to force the UEs move on TN cell is not really necessary. The issues is that when the UE initiates the measurement on TN frequency. |

1. Discuss whether and what kind of idle mode enhancements are needed in order to realise the TN prioritization

**Question 19 Please give your view on whether and what kind of idle mode enhancements are needed in order to realise the TN prioritization**

|  |  |  |
| --- | --- | --- |
| **Company** | **opinion** | **reasoning** |
| Samsung | Brodcast NTN Type (Ex: GEO, MEO, LEO, HAPS) explicitly. | Spectrum sharing is an emerging trend. The same carrier frequency may be used by two ifferent operators. Also, the same operator (smae PLMN ID) may have both a TN and an NTN. |
| Huawei, HiSilicon | No further enhancement is needed | Network can set appropriate offset to prioritize TN. |
| BT | Check with RAN4 if NTN and TN spectrum sharing is an option. | We aren’t sure that satellite and terrestrial networks can reuse the same frequency specially in TDD bands. That will cause multiple problems that will difficult the NTN deployment specially if the same carrier frequency is used in the same territory by different TN and NTN operators. |
| Nokia | That should be possible with the existing cell reselection means + time/location based Idle mode mobility (currently discussed). |  |
| Sony | UE power consumption reduction for measuring high priority TN frequencies in a large NTN cell overlaid over TN cell. |  |
| InterDigital | Agree with Nokia |  |
| MediaTek | No enhancement is needed. As shown in [7], existing measurement-based cell reselections, based on priorities will be enough. | As shown in [7], this could be done using existing priority-based cell reselections. Using of additional information processing will result in additional power consumption, which is very important in idle mode. |
| Qualcomm | Check with RAN4 if TN and NTN freqeuncy can be shared without interference. | If it is the case operators manage interference or RAN4 studies interference on TN and NTN frequency sharing, then it is better to configure a priority.  Otherwise, frequency specific configuration is already possible. |
| ZTE | Yes, some idle mode enhancements can be considered to prioritize a certain NW type if NW or UE has any preference. |  |
| OPPO | Existing cell reselection priorities would be sufficient. |  |
| Apple | None needed. | Existing frequency based prioritization can be used for cell reselections (unless someone sees a scenarios of TN and NTN deployments in same frequencies !). For mixed coverage scenarios, we might have a TN with multiple NTN configurations (a GEO + LEO etc.), we would need some prioritization between the different NTN frequencies. |
| Intel | We understand that legacy cell reselection/priorities mechanism is sufficient from RAN2 point of view. | Our understanding is that different frequencies would be used for TN and NTN (even if same bands were used). We are also ok checking with RAN4 on RAN2 understanding/assumption. |
| LG | Up to network implementation. | In the NTN-TN boundary area, the network can set the TN frequencies as higher priority. |

### 3.3 UE battery consumption

The discussion for UE battery consumption is relevant for both connected and idle mode measurements. In the contributions submitted to RAN2#114 one proposal is for connected mode where certain measurements could be activated or deactivated. For idle mode, the proposal is to use parameter values to control when UE can relax with measurements.

*In order to save battery, it should be possible to activate/deactivate (trigger FFS) the survey of adjacent cells (measurements) for handover from NTN to TN (hand-in).[5]*

*RAN2 to discuss the need to specify a new parameter setting to initiate and to stop the UE measurements for handover from NTN to TN (hand-in).[5]*

*RAN2 to discuss the enhancement to avoid UE to measure TN neighbour cells when it is in NTN only area.[15]*

These proposals are a good starting point to gather further views how UE battery consumption could be considered in NTN and TN NTN power consumption.

### 3.4 Other

In regard of the following proposals it is suggested to discuss the nehancements first and then try to asses whether there is enough support for flexibility or further enhancements are needed.

*The network should provide enough flexibility to be capable of prioritizing between intra-system or an inter-system handover.[5]*

*For some cases, it should consider switching connection of the UE to a non-terrestrial cell or terrestrial cell, even if the quality of service in the current cell is still good depending on the operator’s policy.[30]*

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