3GPP TSG-RAN WG2 Meeting #113bis-e draftR2-2104366

Elbonia, Online, 12 – 20th of April 2021

**Agenda item: 8.10.3.3**

**Source: Nokia, Nokia Shanghai Bell**

**Title: Report from [113bis-e][107][NTN] CHO aspects (Nokia)**

**WID/SID: NR\_NTN\_solutions-Core - Release 17**

**Document for: Discussion and Decision**

# 1 Brief scope of the paper

This document aims at collecting companies’ views regarding the Rel-17 NTN Conditional Handover (CHO):

* [AT113bis-e][107][NTN] CHO aspects (Nokia)

Initial scope: Discuss the proposals in [R2-2103335](file:///C%3A%5CData%5C3GPP%5CExtracts%5CR2-2103335%20On%20Connected%20mode%20mobility%20for%20NTN.docx)

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): Thursday 2021-04-15 18:00 UTC

Initial deadline (for rapporteur's summary in R2-2104366): Thursday 2021-04-15 22:00 UTC

Proposals marked "for agreement" in R2-2104366 not challenged until Friday 2021-04-16 10:00 UTC will be declared as agreed via email by the session chair.

For the rest the discussion will continue in a second round of the offline discussion until Monday 2021-04-19. Further details on the scope/intended outcome/exact deadlines to be announced by the session chair after Friday 2021-04-16 10:00 UTC.

The following sections elaborate on the topics listed in the scope above.

# 2 Discussion

In this section we discuss the aspects described in [1], as instructed in the scope of this e-mail discussion.

## 2.1 Time related aspects

In various TDocs submitted to RAN2#113bis-e, including [1], one can find the issue of how to actually use the timing information for CHO/measurement report triggering. First aspect to discuss is what the time information should indicate. Among the options considered we have:

1. Time since when the UE can access the candidate CHO target cell
2. Time until when the UE can access the candidate CHO target cell
3. Time until when the source cell provides coverage
4. Other

Companies are asked to express their views how the time information shall be defined.

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| **Question 1: What does the timing information actually describe in CHO triggering condition for NTN?** |
| **Company** | **Option** | **Motivation** |
| Samsung | d- other | Time as a trigger (specified in RRC Configuration for measurement triggering)= time elapsed since the reception of the RRC Reconfiguration message. Example: When this time exceeds a time threshold/timer AND RSRP of a neighbor cell exceeds an RSRP threshold, the UE sends a measurement report. This approach will use for both quasi-Earth-fixed beams and Earth-moving beams. The time/timer is not needed for Earth-fixed beams. Since the gNB knows about time-based coverage of its cells, it can determine a good UE-specific timer/time threshold value to get an early report from the UE to determine a good CHO Candidate List.We do not recommend the use of time/timer as a standalone trigger for traditional handover and CHO. Time/timer should be combined with other triggers (especially, RSRP). |
| MediaTek | Either a) or c) | Time information was discussed with respect to feeder link switch. So, we think option b) does not serve this purpose. In addition, time information needs to be combined with measurement based triggers. |
| Huawei, HiSilicon | A or b  | If our understanding is correct, option a is timer based solution, i.e. timer is started when CHO command is received by UE, and it expires UE performs CHO execution; and option b is UTC based solution, then it reaches configured UTC time, UE performs CHO execution. |
| Qualcomm | (a) | Same as legacy, what we just need is earliest time for CHO execution. |
| Lenovo | d) | How to describe the time information depends on the different cases e.g time only or time in combination with other condition e.g A3.If time only is configured for CHO, the timer can be configured as trigger condition.If time condition in combination with measurement-based condition is configured, time duration associated with evaluating measurement condition should be configured because TTT is included in measurement-based condition. |
| OPPO | A or c | Depending on different scenarios (e.g. soft/hard feeder link switch), two timers may need to be configured for serving cell and CHO target cell. |
| CMCC | d | The time condition should consider in combination with RSRP-based solution |
| BT | a) Or b) for CHO measurementsd) for CHO trigger | In our understanding both a) and b) have the same fundamental meaning, a specific reference time when UE can start its CHO measurements, unless as pointed by Huawei, option a) is a timer and not a reference time.CHO report triggering is discussed below. |
| Sony | a) | A timer defined for when CHO will be executed. |
| Spreadtrum | a | We prefer the timer solution because it is not necessary to equip UE with GPS module.  |
| ZTE | A+B | We understand a candidate cell would not be available forever considering the satellite movement, thus we prefer to configure an absolute time range with the UTC time as reference, in which the start time and expire time of the candidate cell would both be aware to UE. |
| Vodafone  |  a or b | a or b indicate the transiting time either from the start or from the end!  |
| Apple | d | We feel the timer based solution works in conjunction with other triggers and not alone. At the minimum we want this identified in this discussion. Given another condition, we would need some form of (b+c => at the minimum) or (a+b+c) for the UE to be able to execute the CHO. |
| Intel | a)  | We share the same view as Qualcomm. |

Another related aspects is how such timing information is implemented. In [1] and other papers it is mentioned to use the timer (typical NR/LTE functionality), absolute time or timer range (e.g. implemented via two timers). Obviously, each of these options has its pros and cons. Thus, companies are asked to express their view how the timing-information is used for CHO/measurement reporting in NTN. Please motivate your answer.

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| **Question 2: How is the timing information implemented (i.e. timer/timers, absolute time, etc.)** |
| **Company** | **Answer** | **Motivation** |
| Samsung | timer | Same as Answer 1.Time as a trigger (specified in RRC Configuration for measurement triggering)= time elapsed since the reception of the RRC Reconfiguration message. Example: When this time exceeds a time threshold/timer AND RSRP of a neighbor cell exceeds an RSRP threshold, the UE sends a measurement report. This approach will use for both quasi-Earth-fixed beams and Earth-moving beams. The time/timer is not needed for Earth-fixed beams. Since the Gnb knows about time-based coverage of its cells, it can determine a good UE-specific timer/time threshold value to get an early report from the UE to determine a good CHO Candidate List.We do not recommend the use of time/timer as a standalone trigger for traditional handover and CHO. Time/timer should be combined with other triggers (especially, RSRP). |
| MediaTek |  | Use a timer and trigger the event once the timer expires. |
| Huawei, HiSilicon | Timer or UTC time are both OK | It can be configured per candidate target cell as different cell may have different arriving time for a UE. |
| Qualcomm | Timer |  |
| Lenovo | timer range (2 timers) | In the legacy specification, TTT will be configured for measurement-based condition. The condition can be considered as ‘fulfilled’ only if the entering condition of the event e.g CondEvent A3 is met within TTT. When the timer expires, UE determine whether the entry condition of the measurement-based condition can be met during TTT (if configured). UE only determines whether the measurement-based condition is met or not at the time point of the timer expiry. If the measurement-based condition is not met at the time point of the timer expiry, the combined condition will not ever be met because the timer will not be restarted. We think a timer range can provide more robustness to the evaluation for execution conditions. This can be implemented by 2 timers: The first timer is used to set the starting time. E.g. starting when UE receives the execution condition.The second timer is used to set the length of time range. E.g. UE starts the second timer once the first timer expires, and evaluates whether the measurement-based condition is met or not when the second timer is running. |
| Oppo | UTC time | UTC time is simple and sufficient. |
| CMCC | Both are fine |  |
| BT | Both are valid | In order to trigger the CHO event, both are valid. For a known constellation, the satellite time arrival pattern is known and therefore an absolute time might be enough. In that case, UE power consumption can be reduced. On the other hand, in order to reuse Rel-16, a timer base can be used.A hybrid solution is an alternative option where an absolute time (option a) or b) of previous question) plus a timer where CHO conditions need to meet in order to trigger the event. |
| Sony | Timer | Timer based solution is straightforward. |
| Spreadtrum | timer | Time solution is simple to UE. |
| ZTE | Time range expressed by UTC time | If a relative time as a timer is configured, the transmission delay between UE and the network should be taken into consideration at network side, which is quite challenging as we can see from the discussion on SMTC and gap.With the above concern in mind, we prefer to configure a time range expressed as UTC time to make our lives easier.The following options can be considered to configure the time range:Option 1: Two UTC time to indicate the start and expire time of the candidate cell.Option 2: A start UTC time with a duration to indicate the valid time range of the candidate cell. |
| Vodafone  | Timer | Timer is simple as stated above but equally absolute UTC could work  |
| Apple | Timer or UTC either are fine | Either of the ways to indicate are fine. The UTC can also be expressed using SIB9.  |
| Intel | Timer |  |

## 2.2 Location related aspects

Another metric to be used in for CHO triggering is location. It is however unknown what the term “location” actually implies. It can be at least one of the following:

1. Distance between the UE and the satellite
2. Distance between the UE and the cell center (of either the serving cell or the target cell)
3. Difference in the distance between the UE and its serving cell center and the UE and its target cell’s center
4. Other

Companies are encouraged to choose the definition of the distance which suits them most and justify the selection.

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| **Question 3: What does the location information actually describe in CHO triggering condition for NTN?** |
| **Company** | **Answer** | **Motivation** |
| Samsung | a and b | We see value in both a and b. Due to the novelty of NR-based NTN deployments, we like to have more flexibility at the Gnb so that one or multiple combination triggers can be explored by the Gnb. This will mitigate any risks. |
| MediaTek | a) | Distance between UE and satellite seems an easier choice, as UE can calculate it using satellite ephemeris (e.g. PV information). |
| Huawei, HiSilicon | b | Although the beam coverage may not be a regular shape, e.g. a circle, but a coarse distance between UE and cell center can also provide assistance. |
| Qualcomm | (a) | In (a), the condition can be configured per candidate cell. |
| Lenovo | a) | Distance between UE and satellite is easy for implementation and can reuse existing calculation/derivation results e.g. service link delay from UE location and ephemeris. It also somehow reflects the possible receiving power considering LOS propagation. B) or c) requires additional indication of cell center information, and a UE that is close to cell center may not be close to the LEO satellite (transmitter). |
| OPPO | b | Distance between UE and satellite may not represent the UE’s location in the cell coverage. It is more straightforward to use the distance between UE and cell center. |
| CMCC | a | Opt. A is simple to implement. |
| BT | neutral | Some thoughts:* Without knowing the cell radius, we don’t see a real point to trigger the CHO based on a)
* At least with b) the UE can guess the radius.

For option c), the UE will need to constantly measure the distance with the target(s) only to trigger the CHO event. |
| Sony | a) |  |
| Spreadtrum | a | Distance between UE and satellite is simple without extra indication of cell center in SIB. |
| ZTE | 1. Or b)
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| Vodafone | a | Option a is simple to implementOption b due to flatness and undefined cell coverage , cell centre is difficult to define |
| Apple | At least (a) but  | This question is heavily related on the ephemeris discussion. Option (a) needs satellite co-ordinates to the UE to constantly calculate the distance. Option (b) needs information on the “cell center” and identification of serving cell and target cell centers in earth moving satellites would be tricky. (c) is a complicated variant of (b).  |
| Intel  | (a) | Distance between the UE and the satellite should be more accurate to consider link budget and it is easy if the UE knows the location of satellite.  |

In other papers, e.g. in [1], it is highlighted the use of instantaneous distance between the UE and cell center may lead to unnecessary HOs or RLFs. Instead, it is proposed to assess the distance change metric. One of the considered options is to use such distance change metric as an offset in radio measurement events (Ax). By doing so, the radio-based event has a notion of distance change and will be triggered sooner if the distance towards the target cell decreases.

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| **Question 4: Do you think the distance change should be considered in CHO/MR triggering, e.g. for modifying the offset used in Ax events?** |
| **Company** | **Answer** | **Motivation** |
| Samsung | No | Combination triggers (e.g., (distance AND RSRP) and (time AND RSRP)) would be more suitable in our view. |
| MediaTek | No |  |
| Huawei, HiSilicon | No | It’s a bit unnecessarily complicated, we prefer a straight solution. |
| Qualcomm | No | Agree with Samsung. |
| Lenovo | No | Combined triggers can handle. |
| OPPO | No |  |
| CMCC | No | Combination triggers are sufficient. |
| BT | No but | At this moment, it seems to overcomplicate the solution but we’re open to review it if someone presents a good justification.  |
| Sony | No |  |
| Spreadtrum | No | Agree with Samsung. |
| ZTE | No | Agree with Samsung |
| Vodafone  | No  |  |
| Apple  | No |  |
| Intel | No | The main motivation to use distance information is because the variance (difference) of RSRP is not big (i.e. between cell center UE and cell edge UE). Therefore, modifying offset doesn’t address this issue.  |

## 2.3 Combination of events

During the discussion in [2] there were lots of controversies on how the different events (location-based, time-based, radio-based) can be linked and whether radio-based measurement event needs to be always configured – for either MR or CHO triggering. As the motivation and use case for applying the location-based or time-based event alone remains vague, companies supporting such option are given the chance to explain how it shall work and what is the use case they have in mind for such standalone event.

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| **Question 5: Should the time- or location-based event for CHO/MR triggering in NTN always need to be configured with radio-based measurement event (Ax)?** |
| **Company** | **Answer** | **Motivation/use case for standalone use** |
| Samsung | Yes | For reliable and robust handover, we prefer combination triggers. For flexibility, we can determine allowed ranges of thresholds to be sufficiently wide/flexible. The use of new standalone triggers such as timer or distance can be highly risky; at the minimum, RSRP should be used in conjunction with a new trigger. The use of RSRP by itself would not provide robust handover due to similar RSRPs in large NTN cells. There has been an agreement on combination triggers (instead of standalone triggers) per prior RAN2 agreements. |
| MediaTek | Yes | Combination of triggers is needed to make sure that the cell UE is handed over is sufficiently strong (enough RSRP or RSRQ) level. |
| Huawei, HiSilicon | No | It can be left up to network implementation, we can support this flexibility when network think it’s enough to only use time/location metric for CHO. |
| Qualcomm | Yes | At least with A4 event (meaning to meet minimum RSRP criteria). |
| Lenovo | Depends | Combination of triggers can be used for common CHO case and guarantees CHO performance. For the feeder/service link switching case where the switch time is certain, radio-based measurement could be unnecessary and we may consider “OR” association. |
| OPPO | Yes | To make CHO more robust and reliable, combination of triggers is needed. |
| CMCC | Yes |  |
| BT | No | It should be left to network implementation if CHO trigger is done by events, time/timer + events, time/timer + location, etc. |
| Sony | No | In our understanding we are discussing network restrictions which are not needed. We think standalone timer or location based CHO triggers can work and should be left to nw implementation.  |
| Spreadtrum | Yes | A4 event could guarantee the RSRP criteria. If only time- or location-based event is configured, the HO robustness could be risky in some cases, for example, UE in fading. |
| ZTE | No | We support to have such flexibility. For the case when more than one event is configured, 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 time(r) based condition in NTN, can be configurable by the network and would be indicated to UE in CHO configuration.  |
| Vodafone  | No | Leave this to network implementation  |
| Apple | Yes |  |
| Intel | Yes | We prefer to combine location based CHO/MR triggering for A2 and A4.  |

In [1][2] there were also considerations on using time-based event with location-based event. Please share your opinion whether such combination shall be allowed.

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| **Question 6a: Can the location-based event be combined/configured with time-based event for NTN Rel-17?**  |
| **Company** | **Answer** | **Motivation**  |
| Samsung | Yes/No | We suggest using RSRP of the neighbor in a combination trigger. Within a combination trigger, we prefer “AND.” Furthermore, there could be multiple combination triggers for a UE and these triggers can be combined using OR and AND per Gnb implementation. |
| MediaTek | No | We do not see a need to make such combination of location and time based trigger events. Combining only with measurement triggers seems enough. |
| Huawei, HiSilicon | Yes | If the detail above of both of them are agreed, we can allow to enable them together and it’s up to network implementation. |
| Qualcomm | No | We also see no need for this.  |
| Lenovo | No | We see no use case for combination of location and time. Combination of location-measurement or time-measurement is sufficient. |
| OPPO | No | We also don’t see the need for this. |
| CMCC | No | No benefit is identified for this combination. |
| BT | Yes | This should be left to network implementation. |
| Sony | Yes | We don’t need to restrict this configuration and could leave it to network implementation. |
| Spreadtrum | No | This combination is not needed. |
| ZTE | - | We support to have such flexibility. For the case when more than one event is configured, 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 time(r) based condition in NTN, can be configurable by the network and would be indicated to UE in CHO configuration. |
| Vodafone  | Yes  | From operations perspective, we like to have the freedom to have both location and time base triggers |
| Apple | Yes |  |
| Intel | No | We are not sure if there is any additional gain.  |

If the answer to Question 6a is positive, companies are asked to express how such combination is used, i.e. with or without radio-based measurement:

1. Radio-based measurement event (Ax) always used in parallel to time and location events
2. Radio-based measurement event (Ax) used when other (time and/or location) event triggers
3. Radio-based measurement event (Ax) not used

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| **Question 6b: How the combination of location-based event and time-based event is configured? Please select one of the options listed above.**  |
| **Company** | **Answer** | **Motivation** |
| Samsung | Pl. see comments. | We suggest a flexible framework where multiple combination triggers are defined for a UE. RAN2 can first identify a set of quantity combinations that the contributors like. Then, define triggers for measurement reporting (and execution for CHO) using flexible OR and AND to combine trigger combinations. Define a single NTN event and include flexible combination triggers that companies prefer to cover all types of beams: Earth-fixed, quasi-Earth-fixed, and Earth-moving. |
| MediaTek | Not needed |  |
| Huawei, HiSilicon | c | We can have a separate indication to enable or disable measurement based CHO trigger.  |
| Lenovo | a) and b) | We prefer to keep the configuration flexible as both a) and b) could be used for time and location events. E.g. for combination of time and measurement events, as our comment for Q1, a first timer starts upon CHO configuration and expires when UE can initiate evaluation of measurement for a candidate cell, which is option b)-like. And the evaluation can be performed within a second timer running period, which is option a)-like. |
| BT |  | At this stage, we prefer to left this to network implementation where the network has the flexibility to configure a), b) or c) |
| Sony | c |  |
| Spreadtrum | b | Option a) means UE always performs radio-based measurement, which is power consuming for UE. So we prefer Option b). |
| Vodafone  |  | too early to discuss these as it should be left to the network implementation  |
| Apple |  | Agree with Samsung to have a flexible framework here for triggers.  |

## 2.4 Chain of Conditional Handovers

In [1], but also in some other papers submitted to RAN2#113 and RAN2#113bis, it is mentioned that the UE may retain the CHO configurations even after executing a CHO. The configurations to be kept are not the ones for other candidate cells evaluated in this CHO evaluation phase, but rather the configurations for future serving cells. As claimed in [1], in NTN the sequence of next serving cells can be predicted with high probability, which apparently may justify to equip the UE with the CHO configurations for future cells, i.e. not for the next handover execution only, but beyond that. Thus, companies are asked whether they see a benefit in enabling such option and would like to continue the related work.

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| **Question 7: Do you think providing the UE with CHO configurations for cells beyond the next cell change can be beneficial in NTN?** |
| **Company** | **Answer** | **Motivation** |
| Samsung | No | Since the measurement report needs to be obtained well in advance of an eventual handover, propagation delays are quite long, and RSRPs near the cell edge may be similar in an NTN, there would be a need for multiple CHO candidate cells. Note that resources in multiple CHO candidate cells are reserved but not actually used except by one cell at some point in future.In particular, we anticipate massive handover in an NTN due to movement of the NTN platforms. Hence, combination of a large number of handovers and need for CHO resource reservation in multiple cells mean that the resources available for user traffic can be significantly less. Because of these reasons, we think that RAN2 should try to accelerate CHO and reduce the resource reservation time.We suggest RAN2 to consider a UE indication of the selected CHO cell to the source cell before the UE leaves for the target CHO cell so that the resource reservation can be cancelled quickly, saving precious radio resources. |
| MediaTek | No | Such optimizations are not needed at this stage. We need to make a working solution first. |
| Huawei, HiSilicon | No | UE may move to another cell and even in the same cell different UEs may face different upcoming cells, so this solution may not work well in all cases. |
| Qualcomm | Yes | We think this is critical enhancement to reduce signaling overhead specially in case of handing over a large number of Ues from one cell to another and again to another. It is likely the predictable target cells are connected to same Gnb. Since time-based condition can be used for each candidate cell, resource utilization in candidate cells should not be issue. |
| Lenovo | No | This is an optimization that may not be necessary. We understand its intention of reducing signalling but as the time/location situation may change it is sufficient to let the current serving cell decide whether to configure CHO and the execution conditions. |
| OPPO | No | We should focus on the essential CHO features in NTN and not to do over-optimization. |
| CMCC | No | The cost is high due to large reserved resources of candidate target cells. |
| BT | Potentially  | In case the UE is restricted to a single satellite constellation, the fact that UE is configured with several neighbours will reduce the total overhead.  |
| Sony | Yes | Considering UE mobility is negligible compared to satellite movement, almost all UEs in the cell will need HO at the same time. Such pre-configuration of multiple potential target cells in future is needed in order to reduce the signalling overheads during handover preparation phase and receipts of HO commands in the UEs. We have already agreed timer based HO so target cells may reserve actual resources closer to the time when UEs will move in rather than well in advance and should be left to the node implementation. Relying on legacy HO mechanism will result in signalling storm. |
| Spreadtrum | Yes | For the UE with fixed location, the chain of conditional handover could be predicated actually. This mechanism could reduce a lot of signal, especially for large NTN cell. |
| ZTE | No | By configuring CHO, some resources would be reserved in the target side and wait for UE to use. With a CHO chain, more resources would be reserved and cannot be used by others. We do not see much benefits in having such enhancement. |
| Vodafone | no | In practice, the cells are 40-50 km wide and it is highly unlikely that the UE or the Network would handover to another cell further than the next cell.  |
| Apple | Maybe | This would help reduce some signaling load at the minimum. Also, this flexibility would help in the initial stages of LEO deployments where coverage would be primary concern.  |
| Intel | No | It was discussed in Rel-16 mobility WI, and has been excluded because the security and configuration (delta configuration) of CHO candidate cells are derived based on original source cell, and then security and configuration of CHO candidate cell cannot be used if source has been changed.  |

# 3 Conclusions

Based on the views expressed in the previous sections, we propose the following:

For e-mail agreement:

For online discussion:

# 4 List of referenced documents

[1] R2-2103335 *On connected mode mobility for NTN* 3GPP TSG-RAN WG2 Meeting #113bis Electronic Elbonia, 12 – 20 of April 2021

[2] R2-2102016 *Report of [AT113-e][106][NTN] CHO aspects (Ericsson)* 3GPP TSG-RAN WG2 Meeting #113 electronic Online, January 25th - February 5th, 2021

# Contact information

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