3GPP TSG-RAN WG2 Meeting #113-e R2-2102044

Electronic, Jan 25th – Feb 5th, 2021

Agenda Item: 8.10.3.1

Source: CMCC

Title: Summary of offline 104 - [NTN] TAC update

Document for: Discussion and Decision

# 1 Introduction

This document is for the following offline discussion, particularly for topics in 8.10.3.1:

* [AT113-e][104][NTN] TAC update (CMCC)-Phase II

Scope: Discuss TAC update procedure, based on [R2-2101607](file:///C:\C:\Data\3GPP\Extracts\R2-2101607%20Considerations%20on%20Soft%20TAI%20Update.docx), [R2-2100259](file:///C:\C:\Data\3GPP\Extracts\R2-2100259_TAU_NR-NTN_v2.0.docx), [R2-2100742](file:///C:\C:\Data\3GPP\Extracts\R2-2100742.doc), [R2-2100820](file:///C:\C:\Data\3GPP\Extracts\R2-2100820%20Fixed%20Tracking%20Area%20and%20the%20Tracking%20Area%20Code%20in%20NTN.docx), [R2-2101406](file:///C:\C:\Data\3GPP\RAN2\Docs\R2-2101406.zip)

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

Initial deadline (for companies' feedback): Monday 2021-02-01 11:00 UTC

Initial deadline (for rapporteur's summary in [R2-2102014](file:///C:\C:\Data\3GPP\RAN2\Inbox\R2-2102014.zip)[):](file:///C:\C:\Data\3GPP\archive\RAN2\RAN2%23112\Tdocs\R2-2010761.zip) Monday 2021-02-01 17:00 UTC

Updated scope: Discuss how to capture the proposal introducing soft TAU approach in a way that it's still possible to broadcast one TAC only, when this is sufficient

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

* + - List of proposals for agreement

Deadline (for companies' feedback): Wednesday 2021-02-03 18:00 UTC

Deadline (for rapporteur's summary in R2-2102044[):](file:///C:\C:\Data\3GPP\archive\RAN2\RAN2%23112\Tdocs\R2-2010761.zip) Thursday 2021-02-04 02:00 UTC

According to the comments from on line discussion, this document provides questions with respect to the how to capture the proposal introducing soft TAU approach in a way that it's still possible to broadcast one TAC only, when this is sufficient and companies are requested to provide their views on those. And the discussion part of Phase I are contained in section Annex.

# 2 Discussion

**Question 1: Do companies agree the proposal as “in NTN, the network can broadcast one or more than one TAI per PLMN a cell, which is to up to network configuration”？And please provide your suggestion or comments on the proposal wording.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comment / alternative proposal** |
| OPPO |  | in NTN, ~~the network~~ one cell can broadcast one or more than one TAI per PLMN ~~a cell~~, which is to up to network configuration |
| ZTE | No | Sorry for objection.  We would like to point out: With the fixed TA assumption, no matter hard or soft TA is used, NW has to update the broadcast TAC(s) when the coverage of a cell changes as the satellite moves in the earth moving cell case.  This was exactly something we were trying to avoid during the broadcast cell id discussion. And I hope NW vendors and operators can take this into consideration in this discussion.  Thus, we understand:   * whether the NW needs to broadcast TAC; and * how the NW would broadcast it with the fixed TA assumption (e.g. update the broadcast TAC when the cell coverage changes)   should be discussed and clarified first for both moving and fixed cell scenario before rushing into agreements on how many TACs we would like to broadcast.  In addition, there are also other proposals from companies which may also impact the broadcast of TAC, e.g. the VTA and UE determination of TA (i.e. no TAC needs to be broadcast in earth moving cell case). We would suggest to fully analyze the options on table with clear pros and cons compared. |
| MediaTek | Yes | As suggested by most of the companies during Phase 1, and mentioned in the respective reference Tdocs, Soft TAI update has the advantage over hard TAI in terms of signalling load associated with the TAU. |
| Xiaomi | Yes | For earth fixed beam scenario, one TAC broadcasted by network may be enough, for earth moving beam scenario, network can broadcast multiple TACs during the different TA border, and it could reduce UE power consuming and signalling overhead caused by TAU. |
| Qualcomm | Yes | PLMN-IdentityInfo ::= SEQUENCE {  plmn-IdentityList SEQUENCE (SIZE (1..maxPLMN)) OF PLMN-Identity,  trackingAreaCode TrackingAreaCode OPTIONAL, -- Need R  ranac RAN-AreaCode OPTIONAL, -- Need R  cellIdentity CellIdentity,  cellReservedForOperatorUse ENUMERATED {reserved, notReserved},  ...,  [[  iab-Support-r16 ENUMERATED {true} OPTIONAL, -- Need S  trackingAreaCode-r17 TrackingAreaCode OPTIONAL, -- Need R  ]]  }  It is up to network to decide what is TA boundary and when a cell enters to new TA. When cell enters new TA, the network adds new optional TAC.  So we have two (1) original existing TAC IE and (2) newly added TAC IE.  Since original TAC is still broadcast, network does not need to notify UE. However, there will be point in time (when cell leaves old TAC) when now cell replaces the existing TAC IE with new TAC IE and remove new TAC IE. Based on TA size, cell size, cell can broadcast time when this will happen.  The trackingAreaCode-r17 is optional. If network does not use it, then it is same as hard TAC update. |
| Lenovo | Yes | We support soft TAI update and think hard TAI update has already been supported by legacy NW implementation. There is no need to mention the support for broadcasting one TAI again:  In NTN, a cell **can** broadcast more than one TAIs per PLMN, which is to up to network configuration. |
| Panasonic | Yes | There is a missing ‘in’ in the proposed text: “in NTN, the network can broadcast one or more than one TAI per PLMN **in** a cell, which is to up to network configuration”. We also agree with other companies that perhaps we don’t need to mention specifically the ‘one TAI’ case, since supporting the soft TAI update approach doesn’t mean the legacy operation (i.e., hard TAI update approach) will be excluded. |
| BT | Yes | For quasi-Earth-fixed cells (fix beams on Earth) we don’t see the need to broadcast more than 1 TAC. For Earth-moving cells (moving beams) and based on network configuration, it is possible that one or more TAC are required. If more than 1 TAC is needed, for how long that is required will be up to how operators engineers the network. In that sense, hard TA can be seen as a subcase of soft TA.  We support Lenovo’s sentence. |
| Fraunhofer | Yes | We also support broadcasting multiple TAIs per cell. Our suggestion would be:  In NTN, a cell **shall be able to** broadcast more than one TAIs per PLMN, which is to up to network configuration. |
| Nokia | Yes | We support the proposal, even though we believe hard switch could be sufficient in most cases, if registration areas are properly designed. It is OK to leave the decision up to the network implementation if one or more than one TAC is broadcasted. |
| Samsung | No | We agree with ZTE. We should try our best not to force the cell/gNB to keep changing TAC to match the Earth-fixed TAs. We should consider pros and cons of hard TAC, soft TAC, virtual tracking area, and potentially other solutions (if proposed) and then make a decision. Perhaps, we can support multiple solutions and let the gNB decide whether it wants to implement Option A or Option B. If there are no viable options to soft TAC, we will certainly support soft TAC. Since we have not even evaluated multiple options in the Work Item phase, there is no need to compel UEs and especially gNBs to do lots of processing without a clear benefit of doing so. In practice, when limited # of TACs are broadcast by the gNB in a cell, there would most certainly be instances when SIB1 is sending a set of TACs that does not cover a TA that the cell is illuminating, leading to a “TAC Hole.” |
| Ericsson | Yes | It has been concluded during the SI both in RAN2 and RAN3 to rely on TAC and not to start defining geographical areas and use GNSS for UE registration, that is to redefine and design the whole tracking area concept and TAU.  RAN2 should fall back in discussing other ways ONLY if other WGs indicate hard or soft does not work. For those other ways suggested by ZTE and Samsung a study is needed in other WGs on the feasibility. |

**Question 2: do any other aspects not listed in phase I and phase II discussion?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comment / alternative proposal** |
| Samsung | Yes | We exhort RAN2 to consider proposals in addition to hard and soft TAC updates. Once proposals are made and pros and cons are evaluated, RAN2 can make a decision on supporting one or more effective options. |
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|  |  |  |

# 2 Annex- Phase I

To address this issue of frequent TAU procedure triggered by the satellite motion, the “fixed tracking area” concept is proposed and has been captured in TR 38.821 (section 7.3.1.3) [1], in which the tracking area code (TAC) is fixed on ground while the cells is sweeping on the ground. And it means that while the cells sweep on the ground, the tracking area code (i.e. TAC) broadcasted is changed when the cell arrives to the area of next planned earth fixed tracking area. Two approaches were discussed during the study item on how to effectively update the TACs that the cells/satellites are broadcasting they move across TAs, one is hard TAC update, another is soft TAC update, which is summarized in TR 38.821 [1] and previous email discussion [2] before RAN2#112 meeting:

**Hard TAI update** means that each cell can broadcast only on tracking area code. When this is combined with Earth fixed tracking area, it will create fluctuation at the border areas of these Earth fixed tracking areas, as depicted in Figure 1.



Figure 1 Tracking area update for Earth moving beams with hard TAI update



Figure 2 Tracking area update for Earth moving beams with soft TAI update

In [1][2][3][4][5][6][7], the pros and cons of the two approached are illustrated. In a summary, Soft TAI update solution can mitigate the increasing TAI update signaling with the problem of paging overhead, while the hard TAI update option has the problem of signaling overhead and boundary fluctuation, as shown in figure3. From another perspective, we could say that this issue mainly requires a compromise between paging load and signaling overhead actually.



Figure 3: TAC fluctuation at the border area

To progress the topic, this document provides questions with respect to the two approaches and companies are requested to provide their views on those.

As mentioned in [1][2][3][4][5], although there is the concern about the increasing paging load resulting from a cell broadcasting multiple TAIs. However, the satellite/cell will remove the old TAC once the satellite/cell cover the most geography area corresponding to the new TAC after it adds the new TAC in its system information in addition to the old one. And considering the short duration for the transition stage of the satellite passing over the boundary area, the increasing paging signaling only occurs in a short period. On the other hand, as VDF mentioned, how the MNOs and Satellite service providers jointly arrive at a suitable and practical Tracking Areas to suit their networks’ needs is up to deployment and implementation, not a standards issue.

**Question 1: Do companies assumes that in soft TAI update approach, the multiple TACs only broadcasted just during the transition stage of the satellite passing over the boundary area, or up to deployment and implementation? This means the paging load caused by multiple TACs broadcasted in one cell is limited and is under controlled.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comment / alternative proposal** |
| Panasonic | No | There is always a satellite/cell passing through the boundary of TAs at any time, and hence there is always a satellite/cell broadcasting multiple TACs and having increased paging overheads. Therefore, the impact is always there that impacts different satellite/cell at different time. |
| Huawei, HiSilicon | Yes | It depends on NW implementation to decide the size of one TAC, and for one satellite multiple TACs are only broadcasted during the transition stage. |
| OPPO | No | Agree with Panasonic. For a certain satellite, multiple TACs’ broadcasting applies to each satellite/cell passing through the TA boundary. |
| MediaTek | Yes | While this is left to implementation, we assume that multiple TACs are only broadcasted just during the transition stage of the satellite passing over the boundary area. This will limit the paging load caused by multiple TACs. |
| Samsung | Yes/No- pl. see comment | Each NTN cell that covers multiple TAIs at an instant needs to broadcast TAIs that are relevant at that instant.  A huge problem with the soft TAI approach is that an NTN beam and a TA boundary cannot be matched in practice. Large beams and beam overlap will necessitate sudden and aperiodic changes in SI, significantly degrading the reliability of SIB detection at the UE. The gNB processing load would increase due to the need to frequently change the TAI related SIB content to reflect the TAIs covered by the cell. If the SIB is not changed to reflect the covered TAIs, a UE may be in the “TAI hole” (like a coverage hole), where no cell is covering the geographic area of such UE. |
| Lenovo | Yes | For earth-fixed cell the transition stage can be the time when the current cell of a satellite is geographically across the boundary area, and for earth-moving cell the transition stage can be the time when the edge of a satellite cell is crossing the boundary area. This can be appropriately controlled by network e.g. satellite can adjust its beam to avoid too large cell near or in the boundary area. |
| Spreadtrum | Yes | The broadcast of TAC is due to gNB implementation. If multiple TACs are broadcasted only when the satellite passes over the boundary area, the paging load will not increase obviously. However, the modification of TAC information in SIB will introduce additional paging to RAN. |
| ZTE | See comments | We understand that both earth fixed and moving cell scenario should be taken into consideration with the general principle that TA is fixed on earth.  Also it is worthwhile to highlight that a TA usually refers to an area with a lot of cells deployed.   * For Earth fixed cell, as shown below, we understand NW can broadcast the same TAC even after the new satellite takes in charge, in which case there would be no TAU due to satellite movement when UE does not move. And in this case, we do not see need for broadcasting more than one TAC as the paging overhead will be increased while the NTN cell has already been quite large in size.  * For earth moving cell, we are actually wondering what is the difference between soft TAU (i.e. broadcasting more than one TAC per PLMN in SIB1) and broadcasting a TAC covering a larger area. As shown below, the frequency of TAU would be quite similar for the “soft TAU” and the “larger TA deployment” and NW does not need to broadcast extra TAC in SIB1. |
| APT | Yes | Up to NW implementation. Otherwise, it increases non-necessary paging load. |
| Xiaomi | Yes | We think it can be used for earth moving beam scenario, for earth fixed beam scenario, there may be no boundary areas and only broadcasting one TAC is enough. |
| NEC | No | Each satellite temporarily passing through a boundary of TAs broadcasts both TAs entirely. As Panasonic mentioned, this temporary phase happens any time a satellite is at a boundary, which may be very frequent, therefore it cannot be regarded as temporary |
| InterDigital | Yes | Up to NW implementation, but like MTK assume that multiple TACs only broadcast at boundary to minimize paging load. |
| Qualcomm | It depends | It depends on network deployment how fixed TA is realized. The fixed TA may be smaller than resulting cell size in case the beam coverage is extended due to earth curvature and antenna angle. |
| BT | Yes | Up to network implementation for fixed and moving cells. |
| Rakuten | Yes | Cell Coverage in known to NW/gNB.  TA Update in boundary area should be left to NW implementation. |
| Apple | Yes | Though this varies by deployment (of earth fixed or earth moving beams), we can leave this up to the network implementation. |
| Intel | No | We assume if the cell covers multiple TAC, it will broadcast multiple TAC but TAC will be updated based on satellite mobility. |
| Nokia | Maybe | It is up to NW implementation. With support of soft-TAI, the MNO can configure the area of multiple-TAC broadcast as needed case by case. |
| LG | Yes | The soft TAC update is more essential in moving beam scenario, but we do not need to differentiate the scenarios for this and how to broadcast TAC is up to NW implementation. |
| Thales | Yes | Up to deployment and implementation. |
| ITRI | No | Agree with Panasonic. For earth-fixed scenario the TAC would not change either soft or hard TAI update. It can be NW implementation to alleviate the changes of broadcast TAC in earth-moving case. |
| Ericsson | depends | How TACs are broadcasted is up to deployment and per implementation. |
| Vodafone | Yes | The Soft TAC is a good approach:  For a LEO Earth-Moving cell case: As the UE is stationary relative to the fast-moving satellite, it is up to the satellite to switch to from one Old TAC to the New TAC |
| CATT | Yes | It is up to NW implementation, e.g. if a TAC is associated to a small geographical area, one big NTN cell may always cover several TACs  Paging load is not the big issue for both soft update and hard update cases. UE’s history info, e.g. the last serving cell ID, the UE location info could be taken into account to minimize the signalling cost of paging for a particular UE. Then the paging cost of the whole system is minimized. This is under discussion of RAN3 |
| ETRI | Yes | Up to network implementations. |
| CMCC | Yes | It is up to NW implementation and deployment, and broadcasting multiple TACs at boundary is benefit for decreasing paging load of soft TAI update, and   * For ZTE’s view that the frequency of TAU would be quite similar for the “soft TAU” and the “larger TA deployment” and NW does not need to broadcast extra TAC in SIB1, we have different understanding, as shown in the following figure: |

***Summary of Question 1:***

*26 companies responded to the question. 19out of 26 companies generally agree that the paging load caused by multiple TACs broadcasted in one cell is up to network implementation and deployment, which is under control. In particular, opponents (5/26) think the phase of satellite/cell broadcasting multiple TACs happens any time a satellite is at a boundary or the cell will broadcast multiple TAC when it covers multiple TAC, which may be very frequent. One company think that the frequency of TAU would be quite similar for the “soft TAU” and the “larger TA deployment”. However, rapporteur has different understanding that the above view only applied to local TAs overlapping scenario, the frequency of TAU would be increasingly more than that of “soft TAU” in the global scenario. Additionally, one company express the view that a huge problem with the soft TAI approach is that an NTN beam and a TA boundary cannot be matched in practice, causing large beams and beam overlap will necessitate sudden and aperiodic changes in SI. However, as per the majority’s view, RAN2 can assume that:*

**Observation 1: RAN2 can assume that the paging load caused by multiple TACs broadcasted in one cell is up to network implementation and deployment, which is under control.**

**Regarding hard TAI update,** sinceonly one TAC per PLMN ID is broadcasted in SI, when gNB switches its TAC during satellite’s cell sweep on the ground, a stationary UE may need to perform TAU because of the different TAs at different timings, which results in signalling-intensive situation and increases the UE’s power consumption.

**Question 2: Do companies agree that hard TAI update will result in frequent TAU signalling overhead and increases the UE’s power consumption?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comment / alternative proposal** |
| Panasonic | Maybe | With some enhancements, such frequent TAU signaling overhead can be avoided even in the hard TAI update approach. For instance, the network can configure multiple TAs to the UE that is closed to the boundary of multiple TAs. Then this UE will not trigger TAI update even if the broadcasted TAC changes. For another instance, if we can prevent the satellite from performing paging (i.e., SI update procedure) due to the TAC update, such frequent TAU signaling overhead can be prevented as well. |
| Huawei, HiSilicon | Yes | For the UE on the TAC list edge, frequent TAU is inevitable. |
| OPPO | Yes | TAC update from network will lead to TAU signaling from lots of UEs. |
| MediaTek | Yes | If the UE is required to check Tracking Area changes, then there will be increase in TAU signalling load and UE’s power consumption. |
| Samsung | Yes |  |
| Lenovo | Yes | At least UE will experience frequency TAU. |
| Spreadtrum | Yes | If UE is located in the boundary area of TACs, the frequent TAU shall lead power consuming. |
| ZTE | See comments | * For Earth fixed cell, we understand NW can broadcast the same TAC even after the new satellite takes in charge, in which case there would be no TAU due to satellite movement when UE does not move. * For earth moving cell, as shown below, we are actually wondering what is the difference between soft TAU (i.e. broadcasting more than one TAC per PLMN in SIB1) and broadcasting a TAC covering a larger area. As shown below, the frequency of TAU would be quite similar for the “soft TAU” and the “larger TA deployment” and NW does not need to broadcast extra TAC in SIB1. |
| APT | Yes |  |
| Xiaomi | Yes |  |
| NEC | Yes, but | We agree that one of the main disadvantages of a hard TAI update will be those mentioned in this question. However, as explained in our TDoc [7] and as argued by Panasonic, configuring multiple TAs for UEs as part of a legacy Registration Area for boundary UEs would solve most TAU and battery consumption problems |
| InterDigital | Yes |  |
| Qualcomm | Yes | SI update procedure needs to be triggered once a cell updates its TAC as UEs need to be aware of the new TAC. SI update procedure will increase UE power consumption.  If a UE is not configured with (one or multiple) adjacent TAs, the UE will have to trigger registration updates frequently. If a UE is configured with multiple TAs to avoid frequent TAU, paging may be less efficient, though paging impact should be left to RAN3.  For the case extended radio cell coverage becoming than TA (see our answer to Q1), hard TAI update may not work. |
| BT | Maybe for moving beams.  No for fixed beams | For moving beams, seems that this is the case but not clear at this point on time a network optimization will mitigate this.  For fixed beams on Earth, one satellite/cell transmits a single TAC therefore, it’s never modified for the UE. |
| Rakuten | Yes |  |
| Apple | Yes |  |
| Intel | Yes |  |
| Nokia | Yes | UE has to perform TAU when UE is in TAC list boundary. |
| LG | Yes | The hard TAC update will bring frequent TAU especially mainly in moving beam case, but also earth fixed beam case will be affected because the beam may cover multiple tracking areas with same PLMN. |
| Thales | Yes | When the cell spans across border of 2 TA, all the UE in the cell were registered on TAC 1 will have to initiate the registration update (TAU) because TAC 1 is not anymore broadcasted by the cell. The UE will have to initiate TAU again when the cell leaves their geographic area and they are serve by a newly arriving satellite. This will happen every few minutes due to the satellite movement on Earth. Therefore, it generates the fluctuation at the border zone of all TA and high signalling load. |
| ITRI | No for earth-fixed  May be for earth-moving | It is not clear how NTN TA is implemented. NTN TAs may be allowed to overlap, or a UE near the TA boundary may reselect to a cell served by the succeeding satellite before hard TAI update for earth-moving scenario. Enhancements would be needed once frequent TAU is identified as an issue. |
| Ericsson | yes | HARD TAC update will cause TAC fluctuation from UE perspective and increase TAU. |
| Vodafone | Yes | the TA Update signaling load is significantly higher than in conventional paging load and it should be minimized as much as possible |
| CATT | No | For UE, TAI update is based on the Registration Area, i.e. a TA list. CN can configure the serving TA and surrounding TA(s) as the RA of the UE. In this case, UE may not appear at the boundary of RA and hard TAI update will not result in frequent TAU signalling overhead and increase the UE’s power consumption.  In the contrary, the soft update may result in more frequent TAI update of a cell, and frequent update of the SI may increase the UE’s power consumption. |
| ETRI | Yes | Frequent TAI update is expected when gNB changes its TAC. |
| CMCC | Yes | Frequent TAI update will result in signalling-intensive situation and increases the UE’s power consumption |

***Summary of Question 2:***

*26 companies responded to the question. 24out of 26 companies generally agree that the hard TAI update will result in frequent TAU signalling overhead and increases the UE’s power consumption. In particular, one company think that the frequency of TAU would be quite similar for the “soft TAU” and the “larger TA deployment”. Meanwhile, two companies point out that the issue can be addressed if enhancement allowed, e.g., configuring multiple TAs for UEs as part of a legacy Registration Area for boundary UEs. Therefore, as per the majority’s view, RAN2 can assume that:*

**Observation 2: RAN2 can assume that the hard TAI update will result in frequent TAU signalling overhead and increases the UE’s power consumption.**

In section 1, the pros and cons of the two approaches illustrated in [1][2][3][4][5][6][7] was summarized. Based on the comparison, companies are invited to answer this Question:

**Question 3: Do companies have a preference on supporting either hard or soft TAI update, or both?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comment / alternative proposal** |
| Panasonic | Both | We think both hard and soft TAI update approaches should be supported. More specifically. Hard TAI update is just the special case (i.e., subset) of the soft TAI update. |
| Huawei, HiSilicon | Yes | We prefer soft TAC update. |
| OPPO |  | We prefer soft TAC update. |
| MediaTek | Yes | Soft update is preferred |
| Samsung | New Proposal: Hybrid Hard and Soft TAI Update (“Virtual Tracking Area” Approach) | In our view, both the soft TAI update and the hard TAI update are challenging to implement in practice. We suggest combining the soft TAI approach and hard TAI approach to implement Earth-fixed Tracking Areas called Virtual Tracking Areas (VTAs). The proposed VTA approach transmits only one TAI in a cell like the hard TAI approach. Furthermore, the UE processes multiple TAIs to determine whether to perform a registration update or note like the soft TAI approach. We have summarized the key concept below. More details can be found in Section 2.3 of R2-2008915.  A VTA corresponds to an Earth-fixed Tracking Area. In the VTA approach, the gNB transmits a single TAI in a cell like R16 and this TAI does not change from one instant to another in the cell. The UE and the AMF are aware of the mapping between the VTA and TAIs in different time windows. Predictable platform movements (e.g., movement of LEO satellites) can be used to easily determine such mapping. The AMF registers the UE in a Virtual Registration Area (VRA) that consists of VTAs. The VRA is equivalent to the R16 TAI List. The UE compares the TAI broadcast in SIB1 with the applicable set of TAIs associated with the VRA at the current instant. The UE does not send a Registration Request (Update) to the AMF as long as the TAI broadcast in SIB1 is in the VRA.  We further observe that paging in multiple cells and beams would likely be required in any approach in case of Earth-moving cells and quasi-Earth-fixed cells, because the AMF would likely create a TAI list containing multiple TAIs due to cell overlap and cell mobility for low-delay and reliable paging. The AMF can use the location reported by the UE location to reduce the size of the TAI List. The good news is that the paging capacity is not a concern according to TR38.821. |
| Lenovo | Yes | We prefer soft TAC update. |
| Spreadtrum | Yes | Soft update is preferred.  The paging indication may be enhanced when the TAI update happens. |
| ZTE | / | As commented under Q1 and Q2, we are wondering what is the difference between soft TAU (i.e. broadcasting more than one TAC per PLMN in SIB1) and broadcasting a TAC covering a larger area.  The frequency of TAU would be quite similar for the “soft TAU” and the “larger TA deployment” and NW does not need to broadcast extra TAC in SIB1. And the drawback for both “soft TAU” and the “larger TA deployment” is the increased paging overhead.  Further enhancement, e.g. UE determine the current TA based on its own location and trigger TAU should be considered to address these drawbacks:   * Increased paging overhead. * Unnecessary TAU caused by satellite movement when UE does not move. |
| APT | Yes | Soft TAC update |
| Xiaomi | Yes | We prefer soft TAC update, but we think even if soft TAC is introduced, the network also can broadcast only one TAC based on network implementation. |
| NEC | Yes | We prefer hard TAI update |
| InterDigital | Yes | Prefer soft TAC update |
| Qualcomm | Yes | We prefer soft TAI update if SA2/CT has no concern. We also agree with Panasonic that supporting soft TAI update will allow hard TAI update as a special case. |
| BT | Both  Soft TAI update for moving beams.  Not sure for fix beams. | It is not clear that for fixed beams two TAC needs to be broadcasted. |
| Rakuten Mobile | Yes | Samsung’s suggested Virtual Area Concept can be discussed in more detail. |
| Apple | Yes | We agree with Panasonic and Qualcomm that Hard TAI is a special case of Soft TAI. We also prefer if Samsung’s suggested virtual area concept can also be discussed further. |
| Intel | Soft TAI update | We think that hard TAI has a lot of signaling overhead and it is not suitable for NTN. |
| Nokia | Both | It’s up to network implementation to balance between paging load and TAU signaling overhead considering the best option fitted to their scenarios. (e.g. geo-location, traffic density etc.) |
| LG | Both | We think soft TAC update should be supported. However, support of soft TAC update does not mean hard TAC update is excluded, because soft TAC update is just edition of hard TAC update. (single TAC to multiple TAC in ASN.1) |
| Thales | Both | Both hard and soft TAC update should be supported. Hard TAC update is only a special case of soft TAC update. |
| ITRI | Both | Both approaches need to handle the changes of broadcast TAC for earth moving scenario. |
| Ericsson |  | Soft TAC should be supported. Hard TAC is automatically supported as nothing forces network to implement soft TAC even a list would be supported in SI. |
| Vodafone | Both | agree with comments above for having both mechanisms as it is up to the satellite operators AND mobile operators to define Tracking Areas and the update mechanism |
| CATT | Yes | We prefer hard TAI update.  Soft TAI update need to extend the SIB content, and it need to update the SIB content more frequently than hard TAI update. When the satellite pass over the boundary of tracking area as the hard TAI update. A proper TA List configuration can avoid the problems described in Q2.  However, to make one step further, maybe we could compromise that, both hard and soft TAI update could be supported, pending to deployment of the NW. |
| ETRI | Both | We prefer soft TAI update. We agree that hard TAI update can be a special case of soft TAI update. |
| CMCC | Yes | We prefer the soft update approach. |

***Summary of Question 3:***

*26 companies responded to the question. It is observed that the majority of companies (25/26 ) agree to adopt at least soft TAU approach for moving beam. For fixed beams, from rapporteur point of view, it seems there is no need to update the TA due to satellite motion. In particular, 10 companies suggest allowing the hard TAI as well, as special case of soft TAI, 2 companies see the need of considering the virtual area concept in this topic. The soft TAU approach is also questioned by one company with the reason in Q1 and Q2, and is proposed to be replaced by further enhancement, e.g. UE determine the current TA based on its own location. Therefore, as per the majority’s view, the following proposal seems agreeable:*

**Proposal 1: it is proposed to adopt at least soft TAU approach for moving beam. FFS that the hard TAI can be allowed as well, as special case of soft TAI.**

Additionally, in NTN, to avoid having TAU performed frequently by the UE triggered by the satellite motion, as indicated in TR 38.821, the tracking area may be designed to be fixed on ground. As mentioned in [1][3][6], a relative issue is how does the UE determine the TA it is currently located, which can be categorized into two groups:

1. **current TA is determined based on the broadcasted radio coverage,**
2. **current TA is determined based on UE’s geographical location and satellite’s ephemeris’ information.**

**Question 4: which option is companies’ preference, option 1 or option 2?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comment / alternative proposal** |
| Panasonic | Option 1 | As mentioned in our paper R2-2100820, option 1 should be the baseline and option 2 can be considered later if time allows. |
| Huawei, HiSilicon | Partially option 1 | UE can determine the TA based on UE location and the broadcasted radio coverage.  For option 2, we don’t know how satellite ephemeris maps to geographical area. |
| OPPO | Option 1 | Option 1 is the existing approach, in our understanding. |
| MediaTek | Option 1 | This is aligned with TN behavior. |
| Samsung | None | Option 1 Challenge: The radio coverage overlap among neighboring cells and continuously changing cell coverage in Earth-moving beams make it difficult to reliably define the TAI coverage (“broadcast radio coverage”). The TAIs would not usually match with the elliptical beams. When the same beam covers multiple TAIs in the soft TAI approach, the UEs would not know the exact TAI it is in.  Option 2 Challenge: The UE’s location and satellite ephemeris are inadequate to determine the TAI. |
| Lenovo | Option 1 | Option 1 is legacy and baseline aligning with that in TN. Option 2 can be for further enhancement if necessary. |
| Spreadtrum | Option 1 | Option 1 is simple.  For option2, the mapping between geographical location and TA shall be preconfigured to UE. This pre-configuration information is complex, and difficult to update. |
| ZTE | Option 2 | As commented under Q1 and Q2, we are wondering what is the difference between soft TAU (i.e. broadcasting more than one TAC per PLMN in SIB1) and broadcasting a TAC covering a larger area.  The frequency of TAU would be quite similar for the “soft TAU” and the “larger TA deployment” and NW does not need to broadcast extra TAC in SIB1. And the drawback for both “soft TAU” and the “larger TA deployment” is the increased paging overhead.  Further enhancement, e.g. UE determine the current TA based on its own location and trigger TAU should be considered to address these drawbacks:   * Increased paging overhead. * Unnecessary TAU caused by satellite movement when UE does not move. |
| APT | Opton1 | Support legacy. |
| Xiaomi | Option 1 | Option 1 is the existing solution and is simple. |
| NEC | Option 1 | We prefer the existing approach |
| InterDigital | Option 1 | Support legacy |
| Qualcomm | May be Option 1 | With soft TAI update, we think the UE can determine to be in one of the TAs broadcast by the cell. We do not think the UE needs to know TA boundary. The implications of this to mobility support by the 5GCN (e.g. Registration) can be considered by SA2 and CT1 which is why we suggest an LS to get feedback.  If option 1 means existing solution i.e., broadcasting the TA the cell belongs to, then option 1 is sufficient. |
| BT | None | Agree with Samsung. |
| Rakuten Mobile | Option1 or Option2 | Option 1) it is challenging to predict exact cell shape and cell overlaps, however still possible with certain degree of error.  Option2) No viable mapping between Ephemeris and TA. |
| Apple | Option 1 | Network broadcasting aligns with current TN implementations. We however need to discuss further on Option 2 on what additional information maybe needed at UE to determine the TA so as to reduce any unnecessary scenarios of initiating TAUs esp. for earth moving scenarios. |
| Intel | Option 1 |  |
| Nokia | Option1 | For option2, we have concern on how it can work as ephemeris does not say anything about coverage on earth. Option 1 accounts for radio coverage, because the UE would not be able to receive the broadcasted message if it was not in coverage. |
| LG | Option 1 | Option 1 is simple approach, and it is not clear yet how to utilize the UE location information. |
| Thales | Option 1 | If the TAI list broadcast by the serving cell does not contain the TAI registered for the UE, the UE initiates TAU. |
| ITRI |  | We’d like to utilize UE GNSS capabilities to assist the determination of TAU.  If UE is served by the same NTN cell without moving away from the NTN TA(s) associated with UE GNSS location, UE needs not to perform TAU even the broadcast TAI(s) changed. |
| Ericsson | Option 1 |  |
| Vodafone | Option 1 | Tracking area is based on the Satellite’s beam coverage. Option 2 is impractical |
| CATT | Option 1 | Support legacy approach |
| ETRI | Option 1 |  |
| CMCC | Option1 | Legacy mechanism as the baseline, and option2 could be FFS. |

***Summary of Question 4:***

*26 companies responded to the question. It is observed that the majority of companies (21/26 ) agree to prefer option1, while two companies prefer option 2. Two companies express the concern on both options. One company is no strong view. Therefore, as per the majority’s view, the following proposal may be possible to be agreeable:*

**Proposal 2: the UE determine the TA based on the broadcasted radio coverage, as UE in terrestrial network.**

As mentioned in [3][6], in the soft TAI update scheme, it is beneficial to allow gNB to not trigger the SI update when the list of broadcast TACs changed, since it is not necessary for the UE staying in the same cell to know whether a new TAC is added or an existing TAC is deleted from the TAC list due to the satellite movement. UE will have to check the TAC list only when it just enters into a new cell. Moreover, if the option 2 in question 4 is adopted, it is straightforward that there is no necessity of SI update due to satellite motion.

**Question 5: do companies agree that such kind of TAC change in SI caused by satellite motion will not trigger paging for system information change?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comment / alternative proposal** |
| Panasonic | Yes | This is to avoid consuming UE’s power in acquiring SI due to the TAC change caused by the satellite motion, which might in turn consume more UE’s power in performing the TAU procedure. |
| Huawei, HiSilicon | Yes | Paging for system information change is not needed, as for one specific UE the key SI information is unchanged. |
| OPPO | Yes |  |
| MediaTek | Yes |  |
| Samsung | Yes | The TAC change in SI due to the platform’s movement should not trigger paging for SI change. |
| Lenovo | Yes |  |
| Spreadtrum | Yes | This paging shall not be triggered. |
| ZTE | / | * We would like to understand the difference between “soft TAU” and the “larger TA deployment” as well as the benefits of “soft TAI” first. * If soft TAI update is supported, NW has to update the broadcast TAC and UE should also be aware of the change to trigger TAU appropriately so that NW is aware of the latest RA of the UE and knows where to page UE. |
| APT | Yes | Good feature. |
| Xiaomi | Yes |  |
| NEC | Yes | The standard should take into account this specifity of NTN to preserve UE battery |
| InterDigital | Yes |  |
| Qualcomm | Yes if TA deletion times are provided | If a new TAC is added to the TACs broadcast by a cell, no paging is needed for SI change.  But if an existing TAC is deleted and if no other information is provided, paging is needed because some UEs may have to perform a TAU (if none of the remaining broadcast TACs are part of their registration areas).  To avoid paging when an existing TAC is deleted, a time indication can be broadcast for each TAC to indicate when that TAC will be deleted. This time can be known by a gNB in advance from cell and/or satellite OAM information. A UE which accesses a cell for the first time can then know at what time the cell will no longer support any of the TACs in the UE registration area. The UE can then plan ahead to change cell or look at the new set of TACs for the current cell at that time. |
| BT | Yes | It’s important to avoid to trigger a paging in this situation |
| Rakuten | Yes |  |
| Apple | Yes |  |
| Intel | Yes |  |
| Nokia | No | If NW can guarantee the TAC list change is not in the TAC boundary and UE is stationary, then it seems no need to let UE know the change. However, if the UE is also moving, then it would be important to know the up-to-date content of the TA list. |
| LG | Yes | It is up to network implementation how to provide the TAC in system information. Unnecessary paging should be avoided. |
| Thales | Yes | The triggering condition for initiating TAU is to be modified. Only if the TAI list does not contain the TAI registered for the UE, the UE initiates TAU. So also the Option 1 will not trigger paging for system information change. |
| ITRI | Yes |  |
| Ericsson | Needs more discussion | More discussion is needed. Is this not up to network? |
| Vodafone | Yes | Provided the Core network is notified of the ‘SOFT’ TAC change. |
| CATT | Yes |  |
| ETRI | Yes | We believe that it is beneficial not to trigger SI update by TAC changes because it occurs in a short period of time. |
| CMCC | Yes | It is necessary to improve paging load as well as UE power consumption. |

***Summary of Question 5:***

*26 companies responded to the question. It is observed that the majority of companies (23/26 ) agree to that such kind of TAC change in SI caused by satellite motion will not trigger paging for system information change, while three company question it. Therefore, as per the majority’s view, the following proposal may be possible to be agreeable:*

**Proposal 3: such kind of TAC change in SI caused by satellite motion will not trigger paging for system information change.**

In [5], the paper have pointed out that soft TAC update procedure has some NAS impact. For example, AS reports multiple TACs per PLMN to NAS for cell selection and NAS has to determine whether to trigger registration update based on reported multiple TACs per PLMN (unlike today where only one reported TAC per PLMN is used). The RAN can determine and report one TAC for a UE in the NG ULI as for TN.

Question 6: Do compaines agree that the soft TAC update has NAS impact and LS to CT1 and SA2 asking for any concern on soft TAC update mechanism is needed.

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comment / alternative proposal** |
| Panasonic | Yes | There could be NAS impact but it is not difficult to resolve. For instance, it can be further specified that once the registered TAC is still within the list of TACs reported from RRC, UE will not trigger the registration update. |
| Huawei, HiSilicon | No | UE can determine which TA it belongs to, as mentioned in Q4. Then as legacy only one TA is reported to NAS. In this way no LS is needed. |
| OPPO | Yes | We are ok to send LS to CT1/SA2. |
| MediaTek | Yes | During registration procedure the NAS should select one of the several broadcasted TACs for the UE. While this is left to implementation, it would make sense for the network to choose the TAC that the satellite is moving into. This is because a UE that has reselected to the new cell and performing the registration procedure is located at the leading edge of the cell. We are open to send an LS to SA2 for this. |
| Samsung | Pl. see “Comment” | It is premature to send an LS to other groups at this time. We request that RAN2 consider hard TAI approach, soft TAI approach, the VTA approach, and any other candidate solutions brought to RAN2’s attention to endure Earth-fixed Tracking Areas. Once we have settled on a specific approach, we can determine what LSs (if any) need to be sent to other groups. |
| Lenovo | Neutral | For now we see no severe issues. We can send an LS to inform CT1/SA2 after decision for TAC update is made, so they may see if there is NAS impact. |
| Spreadtrum | Yes | Based on the UE’s TA information, AMF determines the gNB list to trigger paging, so, if TAC information of gNB is updated, AMF shall be indicated as soon as possible. |
| ZTE | Yes, of course. | The condition to trigger TAU and related UE behavior has always been discussed and decided in SA2 and CT1and specified in their specs afterwards.  All RAN2 has done in R15 and R16 is to broadcast the TAC and ask UE AS layer to forward the received TAC to NAS layer. |
| APT | Yes | Support an LS after soft TAC update has been agreed. |
| Xiaomi | Yes | There may be the case that only part of TAC broadcasted by network is in the UE’s TAI list, this case should be discussed. |
| NEC | Yes | We are fine with sending an LS to CT1/SA2 |
| InterDigital | Yes | Okay to send LS to CT1/SA2 |
| Qualcomm | Yes | The potential NAS impact arises if a UE is not always aware of its TA since, in that case, a UE could enter a TA not in the UE registration area but not be aware. So it seems better to let SA2 and CT1 consider this and provide feedback. |
| BT | Yes | It’s better to inform CT1/SA2 |
| Rakuten |  | Agree with Samsung. Once the approach is finalized then other groups should be engaged. |
| Apple |  | Agree with Samsung. We can decide this once the approach is finalized. |
| Intel |  | Agree we don’t have to send LS at the moment. RAN2 should focus on solution first. |
| Nokia | No | UE can decide the actual TAC based on received cell information. Furthermore, isn’t it so that multiple TACs could be possible already today, if we rely on the registration area concept? |
| LG | No | We do not have any conclusion on this issue. After RAN2 makes common understanding about TAC broadcast, then we could inform or ask to other working groups. |
| Thales | Yes | We are ok to send LS to CT1/SA2. |
| ITRI | Yes | We support sending an LS to CT1/SA2. |
| Ericsson |  | We can send LS if we have clear content on question or RAN2 decision |
| Vodafone | Yes | there is an impact and the Core has to be notified, agree with LS |
| CATT | Neutral | It seems too early to send LS. The LS could be sent when we made some collusion on the TAC broadcasting. |
| ETRI |  | We agree that RAN2 should first make a decision on this topic and then can discuss if sending LS is needed. |
| CMCC | Yes | Okay to send LS to CT1/SA2 |

***Summary of Question 6:***

*26 companies responded to the question. It is observed that the majority of companies (12/26) agree to send LS to CT1/SA2 if needed, while (19/26) companies express their view that it is premature to send an LS to other groups at this time, and do it when we have settled on a specific approach. One company does not see the need of sending LS. Two companies are neutral on this. Therefore, as per the majority’s view, the following proposal may be possible to be agreeable:*

**Proposal 4: RAN2 need discussion on whether to send LS to CT1/SA2 to check the NAS impact at this moment or later.**

# **3 Summary**

***Summary of Question 1:***

*26 companies responded to the question. 19out of 26 companies generally agree that the paging load caused by multiple TACs broadcasted in one cell is up to network implementation and deployment, which is under control. In particular, opponents (5/26) think the phase of satellite/cell broadcasting multiple TACs happens any time a satellite is at a boundary or the cell will broadcast multiple TAC when it covers multiple TAC, which may be very frequent. One company think that the frequency of TAU would be quite similar for the “soft TAU” and the “larger TA deployment”. However, rapporteur has different understanding that the above view only applied to local TAs overlapping scenario, the frequency of TAU would be increasingly more than that of “soft TAU” in the global scenario. Additionally, one company express the view that a huge problem with the soft TAI approach is that an NTN beam and a TA boundary cannot be matched in practice, causing large beams and beam overlap will necessitate sudden and aperiodic changes in SI. However, as per the majority’s view, RAN2 can assume that:*

**Observation 1: RAN2 can assume that the paging load caused by multiple TACs broadcasted in one cell is up to network implementation and deployment, which is under control.**

***Summary of Question 2:***

*26 companies responded to the question. 24out of 26 companies generally agree that the hard TAI update will result in frequent TAU signalling overhead and increases the UE’s power consumption. In particular, one company think that the frequency of TAU would be quite similar for the “soft TAU” and the “larger TA deployment”. Meanwhile, two companies point out that the issue can be addressed if enhancement allowed, e.g., configuring multiple TAs for UEs as part of a legacy Registration Area for boundary UEs. Therefore, as per the majority’s view, RAN2 can assume that:*

**Observation 2: RAN2 can assume that the hard TAI update will result in frequent TAU signalling overhead and increases the UE’s power consumption.**

***Summary of Question 3:***

*26 companies responded to the question. It is observed that the majority of companies (25/26 ) agree to adopt at least soft TAU approach for moving beam. For fixed beams, from rapporteur point of view, it seems there is no need to update the TA due to satellite motion. In particular, 10 companies suggest allowing the hard TAI as well, as special case of soft TAI, 2 companies see the need of considering the virtual area concept in this topic. The soft TAU approach is also questioned by one company with the reason in Q1 and Q2, and is proposed to be replaced by further enhancement, e.g. UE determine the current TA based on its own location. Therefore, as per the majority’s view, the following proposal seems agreeable:*

**Proposal 1: it is proposed to adopt at least soft TAU approach for moving beam. FFS that the hard TAI can be allowed as well, as special case of soft TAI.**

***Summary of Question 4:***

*26 companies responded to the question. It is observed that the majority of companies (21/26 ) agree to prefer option1, while two companies prefer option 2. Two companies express the concern on both options. One company is no strong view. Therefore, as per the majority’s view, the following proposal may be possible to be agreeable:*

**Proposal 2: the UE determine the TA based on the broadcasted radio coverage, as UE in terrestrial network.**

***Summary of Question 5:***

*26 companies responded to the question. It is observed that the majority of companies (23/26 ) agree to that such kind of TAC change in SI caused by satellite motion will not trigger paging for system information change, while three company question it. Therefore, as per the majority’s view, the following proposal may be possible to be agreeable:*

**Proposal 3: such kind of TAC change in SI caused by satellite motion will not trigger paging for system information change.**

***Summary of Question 6:***

*26 companies responded to the question. It is observed that the majority of companies (12/26) agree to send LS to CT1/SA2 if needed, while (19/26) companies express their view that it is premature to send an LS to other groups at this time, and do it when we have settled on a specific approach. One company does not see the need of sending LS. Two companies are neutral on this. Therefore, as per the majority’s view, the following proposal may be possible to be agreeable:*

**Proposal 4: RAN2 need discussion on whether to send LS to CT1/SA2 to check the NAS impact at this moment or later.**

# **4 Conclusion**

**Observation 1: RAN2 can assume that the paging load caused by multiple TACs broadcasted in one cell is up to network implementation and deployment, which is under control.**

**Observation 2: RAN2 can assume that the hard TAI update will result in frequent TAU signalling overhead and increases the UE’s power consumption.**

**List of proposals for agreement (if any):**

**Proposal 1: it is proposed to adopt at least soft TAU approach for moving beam. FFS that the hard TAI can be allowed as well, as special case of soft TAI.**

**Proposal 2: the UE determine the TA based on the broadcasted radio coverage, as UE in terrestrial network.**

**Proposal 3: such kind of TAC change in SI caused by satellite motion will not trigger paging for system information change.**

**List of proposals that require online discussions:**

**Proposal 4: RAN2 need discussion on whether to send LS to CT1/SA2 to check the NAS impact at this moment or later.**

# 6 References

1. R2-2001627 Impact of CG/SPS with periodicities non dividing HF length Sequans Communications3GPP TR 38.821 Solutions for NR to support non-terrestrial networks (NTN), version 16.0.0
2. R2-209820, [POST111e][910][NTN] Impacts of earth fixed and moving beams (Ericsson)
3. R2-2101607 Considerations on Soft TAI Update CMCC discussion Rel-17
4. R2-2100259 Improving Tracking Area Updates in NR-NTN MediaTek Inc. discussion
5. R2-2100742 TAC update procedure Qualcomm Incorporated discussion Rel-17
6. R2-2100820 Fixed Tracking Area and the Tracking Area Code in NTN PANASONIC R&D Center Germany discussion R2-2009120
7. R2-2101406 TAI update for earth moving cell NEC Telecom MODUS Ltd. discussion