**3GPP TSG RAN WG1 #117 R1-240xxxx**

Fukuoka City, Fukuoka, Japan, May 20th – 24th, 2024

**Agenda Item: 8.1**

**Source: Moderator (Apple)**

**Title: Moderator Summary for Reply LS to R1-2403837 (LS on Reference Point for SSB-TimeOffset)**

**Document for: Discussion and Decision**

# Introduction

RAN2 sent an LS [1] on reference point for SSB-TimeOffset. In the LS, a question is raised on whether it is acceptable to set gNB as the reference point of SSB-TimeOffset.

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| In RAN2#125bis meeting, RAN2 is considering adopting the gNB as the reference point of ssb-TimeOffset. RAN2 would like to check with RAN4 and RAN1 whether this would be acceptable.**To RAN4, RAN1:****ACTION:** RAN2 respectfully asks RAN4 and RAN1 to take the above into consideration and come back if any issues are determined. |

In this contribution, we discuss the acceptability for setting gNB as the reference point of SSB-TimeOffset.

# Discussions

## Contribution summary

There are contributions from 8 companies, discussing the topic of acceptability for setting gNB as the reference point of SSB-TimeOffset. Companies’ views are summarized in the following table.

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|  | Acceptability | Proposals and Observations |
| ZTE [2] | Yes | Proposal 1: For satellite switch with resync procedure, it’s acceptable to adopt the gNB as the reference point of ssb-TimeOffset from RAN1 perspective. |
| Apple [3][4] | Yes | Proposal 1: It is acceptable to adopt gNB as the reference point of SSB-TimeOffset.  |
| CMCC [5] | Not preferred | Observation 1: If the reference point of ssb-TimeOffset is configured at the UL synchronization reference point as in current spec, UE only need to calculate the propagation delay difference between two satellites reusing the mechanism of TA estimation as defined in the specification. Observation 2: If the reference point of ssb-TimeOffset is changed to gNB, UE should further consider the propagation delay between UL sync reference point and gNB, e.g. by reusing the value of Kmac. And gNB should ensure the difference of Kmac values of two satellites is aligned with propagation delay difference for UE calculate the SSB position of 2nd satellite, which may put some restriction for gNB’s scheduling.Observation 3: The update of the reference point for ssb-TimeOffset seems overlapped with previous discussion in Rel-17 on the timing reference point. Proposal 1: The potential benefits should be clarified for the updates of the reference point from UL synchronization reference point to gNB.Proposal 2: It should be further discussed whether there is a need to clarify in the specification for UE to calculate propagation delay from gNB to the UE with the addition of Kmac values when the gNB is adopted as the reference point of ssb-TimeOffset and potential other specification impacts. |
| CATT [6] | No | RAN1 thinks the reference point of ssb-TimeOffset can be configured to UL uplink time synchronization reference point. Adopting the gNB as the reference point of ssb-TimeOffset will cause some technical issues. |
| OPPO [7] | Yes | Proposal: RAN1 confirms RAN2’s agreement by setting the reference point at gNB. |
| Ericsson [8] | Yes and must be | Observation 1: During a soft satellite switch with resync, there is one uplink time synchronization reference point (ULTSRP) defined for each satellite.Observation 2: The definition of ssb-TimeOffset in TS 38.331 is ambiguous since it does not specify in which ULTSRP it applies.Observation 3: If either ULTSRPsource or ULTSRPtarget is the reference point, it is not clear what it means that the time offset between the SSB from source and target satellite is ssb-TimeOffset at the reference point, since neither ULTSRPsource nor ULTSRPtarget is a point on the path of both SSBs.Observation 4: If gNB is the reference point, it is straightforward to derive the SSB time offset at the UE from ssb-TimeOffset.Proposal 1: RAN1 to reply to RAN2 with a recommendation to use gNB as the reference point for ssb-TimeOffset. |
| Qualcomm [9] | No | Using gNB as the reference point for SSB-TimeOffset does not allow UE to calculate the time offset between the SSBs from the two satellites. Without knowing the accurate time offset between the SSBs of the two satellites, a UE will have to search the SSB of the second satellite in the time domain after the acquisition of the SSB of the first satellite. |
| Huawei [10] | Yes | Observation 1: It is acceptable to adopt the gNB as the reference point of ssb-TimeOffset. Proposal 1: RAN1 informs RAN2 in a reply LS that it is acceptable to adopt gNB as the reference point of ssb-TimeOffset from RAN1 perspective. |

## Round 1 discussion

In the moderator’s understanding, companies’ views can be categorized in 4 different types:

* Must be at gNB (Ericsson)
	+ Neither ULTSRPsource nor ULTSRPtarget is a point on the path of both SSBs
* Acceptable at gNB (ZTE, Apple, OPPO, Huawei)
	+ Kmac is known to UE, which implies the reception timing difference between the SSB from the source satellite and the SSB from the target satellite can be known by the UE
	+ Although Kmac has a granularity of 1ms, the common TA can still be calculated correspondingly with good resolution
	+ gNB implementation can be simpler by adopting gNB as reference point for ssb-TimeOffset.
* Unacceptable at gNB (CATT, Qualcomm)
	+ When the UL synchronization reference point is not set at gNB, the SSB timing offset configuration will require additional efforts to consider timing difference of feeder link.
	+ When the UL synchronization reference point is set at the satellite, UE timing relationship is only related to satellite, and now it will have to consider the timing change of feeder link, including the K-mac maintaince.
* Preferred at UL time synchronization reference point (CMCC)
	+ May have potential specification impact
	+ May have restrictions of Kmac configuration

Regarding the technical issues mentioned by CATT, moderator thinks UE is able to calculate feeder link TA, based on common TA and Kmac. Hence, there is no technical issue for UE to derive the SSB reception time difference. It only increases UE complexity in the calculation.

Ericsson mentioned neither ULTSRPsource nor ULTSRPtarget is a point on the path of both SSBs. Moderator thinks the SSB time offset refers the time difference of SSB transmission time at ULTSRPsource and SSB transmission time at ULTSRPtarget, respectively. Since TA common and service link TA can be calculated by UE separately for both source satellite and target satellite, there is no problem for UE to determine the SSB reception time difference at UE side.

In moderator’s understanding, if the reference point of ssb-TimeOffset is set at gNB, then the SSB time offset calculated at UE side is given by

ssb-TimeOffset + $(K\_{mac, 1}+T\_{TA,1})/2$ - $(K\_{mac,2}+T\_{TA,2})/2$,

where $T\_{TA,1}$ is UE’s TA for the source satellite, $T\_{TA,2}$ is UE’s TA for the target satellite, $K\_{mac, 1}$ is the configured value for UE to estimate the RTT between gNB and source satellite uplink time synchronization reference point, and $K\_{mac, 2}$ is the configured value for UE to estimate the RTT between gNB and target satellite uplink time synchronization reference point. If the difference between $K\_{mac, 1}$ and $K\_{mac, 2}$ is configured to reflect the RTT difference between gNB and source satellite uplink time synchronization reference point and between gNB and target satellite uplink time synchronization reference point, then UE is able to calculate the time gap between to SSBs at UE side.

With the above discussions, the moderator would like to collect companies’ views on the feasibility of setting gNB as the reference point for ssb-TimeOffset.

*Question 1: Do you agree it is feasible to set gNB as the reference point for ssb-TimeOffset?*

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| --- | --- | --- |
| Company | Yes/No | Comments |
| Qualcomm | No | It is not feasible unless specification changes are made. |
| Nokia | Yes | Following the analysis of the moderator we agree that it should be feasible to use the gNB as the reference point for *ssb-TimeOffset*. |
| DCM | Yes |  |
| Ericsson | Yes | Please note that Ericsson tdoc R1-2404956 was revised into R1-2405343, where we conclude that it is possible using either the gNB or the ULTSRP as reference point. |
| vivo | Yes | In our understanding, if gNB is set as the reference point for *ssb-TimeOffset*, UE can derive the time gap between the SSBs based on common TA parameters and K\_mac, without significantly increasing complexity. Essentially, there is no difference between the two methods, except that the using gNB as the reference point requires considering the difference between the two K\_mac values. We also do not see any need for RAN1 specification change.  |
| CMCC | Yes and no | Theoretically, UE can use the Kmac value to compensate the propagation delay between RP and gNB. But as we mentioned in our contribution, this may put more limitation for gNB on the configuration of Kmac, since currently the only requirement for Kmac is to be larger than the propagation delay. From the perspective of UE, as UE is in the connected mode, the UE is maintaining the synchronization with the UL synchronization reference point. If we changes the reference point to gNB, then the UE has to use Kmac to calculate the RP of gNB and maintaining another reference point. And it should further clarify that the UE will use Kmac to calculate the reference point of gNB and which may have further specification impact and even RAN1 impact, which is not preferred at this stage. Theoretically, it is workable to use Kmac in additional to current specification to calculate and maintain the synchronization with the RP of gNB. Our concern is to the further specification impact of using Kmac to calculate a second uplink reference point and UE have to maintain it.  |

Some companies prefer to set uplink time synchronization RP as the reference point for ssb-TimeOffset. Hence, it is beneficial to compare the pros and cons of these two approaches. Please provide your views to the following question.

*Question 2: What are the advantages and disadvantages of setting gNB as the reference point for ssb-TimeOffset, comparing with setting uplink time synchronization RP as the reference point for ssb-TimeOffset?*

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| Company | Comments |
| DCM | At least in our understanding, there is no difference other than whether additional gNB implementation is needed or additional UE implementation is needed.  |
| Ericsson | A disadvantage of setting gNB as the reference point is that the uncertainty is larger of the SSB time offset calculated at UE side. $K\_{mac}$ has a granularity of 1 ms and can be configured to be ≥ the RTT between ULTSRP and gNB, and therefore the difference between $K\_{mac, 1}$ and $K\_{mac, 2}$ does not necessarily reflect exactly the RTT difference between gNB and source satellite ULTSRP and between gNB and target satellite ULTSRP. |
| CMCC | No advantage or necessity is observed for changing the RP from uplink reference point to gNB. Further concerns are on the limitation of Kmac values to ensure the calculation of the propagation delay difference matched with the case. It may have further specification impact to clarify how to calculate the reference point at the gNB and how to use the Kmac values in the specification for calculation of propagation delay, which is not preferred.  |

## Round 2 discussion

Based on the Round 1 discussion, 4 companies think it is feasible to set gNB as the reference point for ssb-TimeOffset, while 1 company thinks it is infeasible unless specification changes. To reflect the current situation, the moderator prepares two versions of possible responses. Companies please check which version is preferred, as well as the potential changes to each version.

*Proposal 1-a: It is feasible to adopt gNB as the reference point of ssb-TimeOffset, if the difference between* $K\_{mac, 1}$ and $K\_{mac, 2}$ *reflects the RTT difference between gNB and source satellite uplink synchronization reference point and between gNB and target satellite uplink synchronization reference point, where* $K\_{mac, 1}$ *and* $K\_{mac, 2}$ *are the configured values for source satellite and target satellite, respectively.*

*Proposal 1-b: Adopting the gNB as the reference point of ssb-TimeOffset will require additional specification change (e.g.,* $K\_{mac}$ *allows UE to calculate RTT between gNB and the uplink synchronization reference point).*

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| Company | Preferred version | Comments (including modifications or new version) |
| CMCC | 1-b | If changing the reference point of ssb-timeoffset to gNB, it requires further clarification on how to use the Kmac to calculate the reference point of gNB in the specification. And UE has to maintain two reference point in the connected mode. Both two changes are not preferred. We update the proposal as below in red.*Proposal 1-b: Adopting the gNB as the reference point of ssb-TimeOffset will require additional specification change (e.g.,* $K\_{mac}$ *allows UE to calculate RTT between gNB and the uplink synchronization reference point), and requiring the UE to maintain two uplink timing reference point in the connected mode, which is not preferred.* |

# Conclusion

TBD

# References

1. R1-2403837, “LS on reference point for SSB-TimeOffset,” Apr. 2024.
2. R1-2404209, Discussion on the reference point for SSB-TimeOffset ZTE
3. R1-2404266, Discussion on RAN2 LS on Reference Point for SSB-TimeOffset Apple
4. R1-2404267, Draft Reply LS to RAN2 on Reference Point for SSB-TimeOffset Apple
5. R1-2404443, Discussion on reference point for SSB-TimeOffset CMCC
6. R1-2404788, Discussion on reply LS on reference point for SSB-TimeOffset CATT
7. R1-2404851, Discussion on LS from RAN2 on SSB time offset OPPO
8. R1-2404956, Discussion of RAN2 LS on reference point for SSB-TimeOffset Ericsson
9. R1-2405132, Draft Reply to LS on reference point for SSB-TimeOffset Qualcomm Incorporated
10. R1-2405322, Discussion on the reply of LS on reference point for SSB-TimeOffset Huawei, HiSilicon