**3GPP TSG-RAN WG2 Meeting #122 R2-23xxxx**

**Incheon, Korea, May 22nd – 26th, 2023**

**Agenda item: 4.2.1**

**Source: MediaTek Inc.**

**Title: [Post122][102][IoT NTN] UTC reference point (Mediatek)**

**Document for: Discussion and Decision**

# 1 Introduction

This document is aimed at discussing on the UTC reference time and identify potential agreements for possible convergence.

* [Post122][102][IoT NTN] UTC reference point (Mediatek)

      Scope: Continue the discussion on CR4934

      Intended outcome: Agreeable CR in R2-2306668

      Deadline: June 2nd 10:00 UTC

# 2 Contact

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# 3 Discussion

In eMTC and NB-IoT, the UTC time info and reference time info were carried in the SIB16(-NB).

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| – *SystemInformationBlockType16*The IE *SystemInformationBlockType16* contains information related to GPS time and Coordinated Universal Time (UTC). The UE may use the parameters provided in this system information block to obtain the UTC, the GPS and the local time.NOTE: The UE may use the time information for numerous purposes, possibly involving upper layers e.g. to assist GPS initialisation, to synchronise the UE clock (a.o. to determine MBMS session start/ stop).***SystemInformationBlockType16* information element**-- ASN1STARTSystemInformationBlockType16-r11 ::= SEQUENCE { timeInfo-r11 SEQUENCE { timeInfoUTC-r11 INTEGER (0..549755813887), dayLightSavingTime-r11 BIT STRING (SIZE (2)) OPTIONAL, -- Need OR leapSeconds-r11 INTEGER (-127..128) OPTIONAL, -- Need OR localTimeOffset-r11 INTEGER (-63..64) OPTIONAL -- Need OR } OPTIONAL, -- Need OR lateNonCriticalExtension OCTET STRING OPTIONAL, ..., [[ timeReferenceInfo-r15 TimeReferenceInfo-r15 OPTIONAL -- Need OR ]]}-- ASN1STOP

| ***SystemInformationBlockType16* field descriptions** |
| --- |
| ***dayLightSavingTime***It indicates if and how daylight saving time (DST) is applied to obtain the local time. The semantics is the same as the semantics of the *Daylight Saving Time* IE in TS 24.301 [35] and TS 24.008 [49]. The first/leftmost bit of the bit string contains the b2 of octet 3, i.e. the value part of the *Daylight Saving Time* IE, and the second bit of the bit string contains b1 of octet 3. |
| ***leapSeconds***Number of leap seconds offset between GPS Time and UTC. UTC and GPS time are related i.e. GPS time -*leapSeconds* = UTC time. |
| ***localTimeOffset***Offset between UTC and local time in units of 15 minutes. Actual value = field value \* 15 minutes. Local time of the day is calculated as UTC time + *localTimeOffset*. |
| ***timeInfoUTC***Coordinated Universal Time corresponding to the SFN boundary at or immediately after the ending boundary of the SI-window in which *SystemInformationBlockType16* is transmitted. The field counts the number of UTC seconds in 10 ms units since 00:00:00 on Gregorian calendar date 1 January, 1900 (midnight between Sunday, December 31, 1899 and Monday, January 1, 1900). NOTE 1.This field is excluded when estimating changes in system information, i.e. changes of *timeInfoUTC* should neither result in system information change notifications nor in a modification of *systemInfoValueTag* in SIB1. |

NOTE 1: The UE may use this field together with the leapSeconds field to obtain GPS time as follows: GPS Time (in seconds) = timeInfoUTC (in seconds) - 2,524,953,600 (seconds) + leapSeconds, where 2,524,953,600 is the number of seconds between 00:00:00 on Gregorian calendar date 1 January, 1900 and 00:00:00 on Gregorian calendar date 6 January, 1980 (start of GPS time).– *TimeReferenceInfo****TimeReferenceInfo* information elements**-- ASN1STARTTimeReferenceInfo-r15 ::= SEQUENCE { time-r15 ReferenceTime-r15, uncertainty-r15 INTEGER (0..12) OPTIONAL, -- Need OR timeInfoType-r15 ENUMERATED {localClock} OPTIONAL, -- Need OR referenceSFN-r15 INTEGER (0..1023) OPTIONAL -- Cond TimeRef}ReferenceTime-r15 ::= SEQUENCE { refDays-r15 INTEGER (0..72999), refSeconds-r15 INTEGER (0..86399), refMilliSeconds-r15 INTEGER (0..999), refQuarterMicroSeconds-r15 INTEGER (0..3999)}-- ASN1STOP

| ***TimeReferenceInfo* field descriptions** |
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| ***referenceSFN***This field indicates the reference SFN for time reference information. The *time* field indicates the time at the ending boundary of the SFN indicated by *referenceSFN*. The UE considers the frame indicated by the *referenceSFN* nearest to the frame where the field is received.If the *time* field is included in *SystemInformationBlockType16* and the *referenceSFN* field is not included, the *time* field indicates the time at the SFN boundary at or immediately after the ending boundary of the SI-window in which *SystemInformationBlockType16* is transmitted. |
| ***time, timeInfoType***This field indicates time reference with 0.25 us granularity. The indicated time is referenced at the network, i.e., without compensating for RF propagation delay. The indicated time in 0.25 us unit from the origin is *refDays*\*86400\*1000\*4000 + *refSeconds*\*1000\*4000 + *refMilliSeconds*\*4000 + *refQuarterMicroSeconds*. The *refDays* field specifies the sequential number of days (with day count starting at 0) from the origin of the *time* field. If *timeInfoType* is not included, the origin of the *time* field is 00:00:00 on Gregorian calendar date 6 January, 1980 (start of GPS time). If *timeInfoType* is set to *localClock*, the interpretation of the origin of the *time* is unspecified and left up to upper layers.If *time* field is included in *SystemInformationBlockType16*, this field is excluded when estimating changes in system information, i.e. changes of *time* should neither result in system information change notifications nor in a modification of *systemInfoValueTag* in SIB1. |
| ***uncertainty***This field indicates the number of LSBs which may be inaccurate in the *refQuarterMicroSeconds* field. If *uncertainty* is absent, the uncertainty of *refQuarterMicroSeconds* is not specified. |
| **Conditional presence** | **Explanation** |
| *TimeRef* | The field is mandatory present if *TimeReferenceInfo* is included in *DLInformationTransfer* message; otherwise the field is not present. |

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When the UE acquires the network broadcasted SIB16(-NB), the absolute timing info carried in SIB16(-NB) is no longer correct due to the long propagation delay for IoT NTN. The propagation delay has to be compensated to get accurate timing. The network cannot compensate the propagation delay for broadcasted signalling, as the UEs are in different places. It has to be on the UE to do this compensation. This has been discussed briefly during RAN2# 122 (online and offline).

Some companies have raised concerns and confusion that there are also timing information in many radio resources (e.g., SPS, PUR) which corresponds to certain SFN. However, for SFN only, there is no issue as UE can just refer to that SFN. Network already takes into account the propagation delay when scheduling resources to UE. However, EpochTime and UTC timing information are carried in SIB and thus network has no way to compensate this information for each UE. Network composes the Ephemeris Info/UTC timing info at a timing point (RP timing), and UE receives it after a propagation delay. Hence, UE needs to know the starting point of the propagation delay (between RP and UE) for this compensation. It has been defined that the starting point (i.e., reference point) of epoch time in SIB31(-NB) is the uplink time synchronization reference point (i.e., RP).

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| *– SystemInformationBlockType31*The IE *SystemInformationBlockType31* contains satellite assistance information for the serving cell. *SystemInformationBlockType31* is only signalled in a NTN cell.*SystemInformationBlockType31* information element-- ASN1STARTSystemInformationBlockType31-r17 ::= SEQUENCE { servingSatelliteInfo-r17 ServingSatelliteInfo-r17, lateNonCriticalExtension OCTET STRING OPTIONAL, ...}ServingSatelliteInfo-r17 ::= SEQUENCE { ephemerisInfo-r17 CHOICE { stateVectors EphemerisStateVectors-r17, orbitalParameters EphemerisOrbitalParameters-r17 }, nta-CommonParameters-17 SEQUENCE { nta-Common-r17 INTEGER (0..8316827) OPTIONAL, -- Need OP nta-CommonDrift-r17 INTEGER (-261935..261935) OPTIONAL, -- Need OP nta-CommonDriftVariation-r17 INTEGER (0..29479) OPTIONAL -- Need OP }, ul-SyncValidityDuration-r17 ENUMERATED {s5, s10, s15, s20, s25, s30, s35, s40, s45, s50, s55, s60, s120, s180, s240, s900}, epochTime-r17 SEQUENCE { startSFN-r17 INTEGER (0..1023), startSubFrame-r17 INTEGER (0..9) } OPTIONAL, -- Need OP k-Offset-r17 INTEGER (0..1023), k-Mac-r17 INTEGER (1..512) OPTIONAL, -- Need OP ...}-- ASN1STOP

| *SystemInformationBlockType31* field descriptions |
| --- |
| ***epochTime***Epoch time of the satellite ephemeris data and common TA parameters, see TS 36.213 [23]. The reference point for epoch time of the serving satellite ephemeris and Common TA parameters is the uplink time synchronization reference point.*epochTime* is the starting time of a DL subframe indicated by *startSFN* and *startSubframe*. For serving cell, the *startSFN* indicates the current SFN or the next upcoming SFN after the frame where the message indicating the *epochTime* is received.If the field is absent, the UE uses the starting time of the DL subframe corresponding to the end of the SI window during which the SI message carrying SIB31 is transmitted.E-UTRAN always includes *epochTime* when *SystemInformationBlockType31* is provided through dedicated signalling.In case of handover or conditional handover, this field is based on the timing of the target cell, i.e. the *startSFN* and *startSubFrame* number indicated in this field refers to the SFN and sub-frame of the target cell, and UE considers the target cell epoch time (indicated by the *startSFN* and *startSubFrame* in this field) to be the frame nearest to the frame where *RRCConnectionReconfiguration* message is received. |
| ***k-Mac***Scheduling offset used when downlink and uplink frame timing are not aligned at the eNB, see TS 36.213 [23]. Unit in ms.If the field if absent, the UE uses the (default) value of 0. |
| ***k-Offset***Scheduling offset used in the timing relationships in NTN, see TS 36.213 [23]. Unit in ms. |
| ***nta-Common***Network-controlled common TA, see TS 36.213 [23]. Unit of μs.Step of 32.55208 ×10-3 μs. Actual value = field value \* 32.55208 ×10-3.If the field is absent, the UE uses the (default) value of 0. |
| ***nta-CommonDrift***Drift rate of the common TA, see TS 36.213 [23]. Unit of μs/s.Step of 0.2 ×10-3 μs/s. Actual value = field value \* 0.2 ×10-3.If the field is absent, the UE uses the (default) value of 0. |
| ***nta-CommonDriftVariation***Drift rate variation of the common TA, see TS 36.213 [23]. Unit of μs/s2.Step of 0.2 ×10-4 μs/s2. Actual value = field value \* 0.2 ×10-4.If the field is absent, the UE uses the (default) value of 0. |
| ***orbitalParameters***Instantaneous values of the satellite orbital parameters. The signalled values are only valid for the duration as defined by *ul-SyncValidityDuration* and *epochTime*. |
| ***stateVectors***Instantaneous values of the satellite state vectors. The signalled values are only valid for the duration as defined by *ul-SyncValidityDuration* and *epochTime*. |
| ***ul-SyncValidityDuration***Validity duration of the satellite ephemeris data and common TA parameters, i.e. maximum time duration (from *epochTime*) during which the UE can apply the satellite ephemeris without acquiring new satellite ephemeris, see TS 36.213 [23]. Unit in second.Value *s5* corresponds to 5 seconds, value *s10* corresponds to 10 seconds and so on. |

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Hence, for the timing info in SIB16(-NB), RAN2 should follow the same rule. The reference point of the propagation delay for timing info in SIB16(-NB) should also be the uplink time synchronization reference point (i.e., RP). After acquiring the SIB16(-NB), UE needs to compensate for the propagation delay between the UE and the RP. Based on this, the rapporteur asks the following question:

**Question 1: Do companies agree that the reference point of the propagation delay for timing info in SIB16(-NB) should be the uplink time synchronization reference point (i.e., RP)?**

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| **Company** | **Agree/Disagree** | **Comments** |
| Apple | Agree | It should be the same as EpochTime (referring to the reference point), otherwise UE needs to calculate the propagation delay differently.And, we think the same change should be made to NR spec as well. |
| ZTE | See comments | 1. Now we are not sure the following thing. Based on the following description of RP in 36.300:

*DL and UL are frame aligned at the uplink time synchronization reference point (RP) with an offset given by* $N\_{TA,offset} $*(see clause 8 of TS 36.211 [4]).*Can we RAN2 achieve a common understanding that: **In NTN**, the reference point for either UL frame or DL frame is RP? * If we cannot, we agree to clarify reference point for UTC time. But furthermore, we think we also need to clarify reference point for at least the DL frames (e.g., the DL frames in the SPS, PUR resources configuration etc).
* If we can, we think all the explicit definition for reference point are redundant or NOT needed, e.g., we don’t need this CR, we also need to remove the related description in epoch time:

*Epoch time of the satellite ephemeris data and common TA parameters, see TS 36.213 [23]. ~~The reference point for epoch time of the serving satellite ephemeris and Common TA parameters is the uplink time synchronization reference point.~~*1. Furthermore, we agree if change is needed for IoT NTN, NR should introduce similar change. But another different thing is, as NR has enhanced scheme for acquire more accurate timing, e.g, the PDC can be performance by either UE or NW, the exact way for modifying the NR NTN spec may be different.
2. We feel the current description of RP in TS 36.300 may be not so suitable since it may be not only applicable to uplink. So we give the following text suggestion:

23.21.2.1 Scheduling timingDL frame and UL frame are aligned at the time synchronization reference point (RP) with an offset given by $N\_{TA,offset} $(see clause 8 of TS 36.211 [4]). |
| Qualcomm | Agree | Agree with Apple.We are not sure what is meant by UL frame reference point but the uplink time synchronization reference point (RP) is for DL frame.Removing text from the epoch time field description is not ok.We do not think for other case like SR, PUR, reference point has to be specified because for example, the PUR start subframe works based on UE’s downlink timing (not RP). |
| CATT | See comments | We think we can discuss the issue of UTC separately, without touching the current description of concept, avoiding potential complex discussion. It is not necessary to introduce the concept of reference point for UTC time. Maybe just a note is enough, for example, adding Note 2 after the current Note1 in the field description of *SystemInformationBlockType16*:NOTE 1: The UE may use this field together with the leapSeconds field to obtain GPS time as follows: GPS Time (in seconds) = timeInfoUTC (in seconds) - 2,524,953,600 (seconds) + leapSeconds, where 2,524,953,600 is the number of seconds between 00:00:00 on Gregorian calendar date 1 January, 1900 and 00:00:00 on Gregorian calendar date 6 January, 1980 (start of GPS time).NOTE 2: In NTN cell, the UE should compensate the propagation delay of serving link and feeder link to get accurate timing via *timeInfoUTC*.In this way, the reference point of UTC can also be gNB, as the TN network.* If the *Kmac* is equal to the propagation delay between RP and gNB (according to the agreed CR R2-2306667, *Kmac* is approximately equal to the RTT between the RP and the gNB), the UE can compensate the feeder link propagation delay based on common TA and *Kmac,*which is broadcast.
* If the *Kmac* is not equal to the propagation delay between RP and gNB, the UE can also just compensate the feeder link propagation delay based on common TA and *Kmac,*whichis broadcast, but the gNB need to compensate the difference between the actual propagation delay between RP and gNB and the the broadcast K*mac*, when determine the value of *timeInfoUTC.*

If we want to change the reference point of UTC from gNB to RP, it is also unnecessary to introduce reference point for UTC, the following note can be used:NOTE 2: In NTN cell, the UE should compensate the propagation delay of serving link, and the propagation delay of satellite and RP, to get accurate timing via *timeInfoUTC*.In which, RP is not a specific concept of UTC, is alsouplink time synchronization reference point (RP), as described in current specification.  |
| ZTE2 | See comments | We have sympathy with CATT’s comments.That is, for all the **legacy** timing-related parameters, unless explicitly specified, otherwise, we should assume UE/NW would follow the legacy understanding as that in TN network. For example, for this UTC time, it refers to a certain SFN in eNB side. Based on this understanding, UE can do the corresponding compensation. In other word, even without any additional clarification, we don’t think confusion would exist, as the natural understanding would be following legacy understanding/processes in TN network.On the contrary, if we introduce this CR, e.g., a special clarification (a new understanding) for UTC time, it may trigger other discussion on whether we also need clarification for other existing timing-related parameters.Technically, without this CR and based on the assumption of following legacy understanding in TN network, we agree with CATT that “the UE should compensate the propagation delay of serving link and feeder link”. But if introducing this CR, both UE and gNB implementation may need to change, e.g., gNB should provide a "new" UTC time which refers to a SFN in RP, and UE still needs to do the compensation but just to apply a smaller compensation value.So even this CR is also workable, we see no need and no benefit for this CR.The *epochTime* can be seen as a special case as it’s a newly introduced one for only NTN network. It cannot be used as a mandatory reference to other existing timing-related parameters. |
| Ericsson | Agree  | We agree with Apple and QC that the same reference point shall be used for epochTime and for UTC. Some of the confusion comes from the fact that the reference point where UL and DL are frame aligned is a location in space (and the location is varying depending on the satellite movement and the Common TA parameters, but the propagation delay between RP and UE can be calculated from the parameters that are known to the UE). Because of the long distances, the propagation delay needs to be accounted for when absolute timing is used (such as for ephemeris and common TA parameters and UTC) this is done by defining a known timing at the location of the reference point. Thus, the addition In a NTN cell, the reference point for UTC time is the uplink time synchronization reference point.only defines the location for the already defined timing. It does **NOT** change the legacy timing definition in any way – it only says in NTN we specify the location where the legacy timing is valid. It is clear what RAN1 intended for epochTime, see these RAN1#106, RAN1#106bis and RAN1#107 agreements:**Agreement:**Serving satellite ephemeris Epoch time is implicitly known as a reference time defined by the starting time of a DL slot and/or frame.* FFS: Whether this starting time is given by predefined rule or it is indicated by the Network

**Agreement:**Common TA Epoch time is implicitly known as a reference time defined by the starting time of a DL slot and/or frame.* FFS: Whether this starting time is given by predefined rule or it is indicated by the Network
	+ Note: “implicitly known” means that UTC is not provided to define the Common TA epoch time.

**Agreement**The serving satellite ephemeris and common TA related parameters are signalled in the same SIB message and have the same epoch time.**Agreement**The reference point of the epoch time for assistance information (i.e. Serving satellite ephemeris and Common TA parameters) should be known by UE. * FFS: the definition of the reference point

**Agreement**Using indicated Higher-layer Common TA parameters, if configured, the UE can determine the one-way propagation time ( used for  calculation as follows:Where:* , and

* TACommon, TACommonDrift and TACommonDriftVariation are Common TA parameter defined in RAN1 Meeting #106-bis-e
* is the distance between the satellite and the uplink time synchronization reference point divided by the speed of light. DL and UL are frame aligned at the reference point with an offset given by **.**

* is derived by the UE based on to pre-compensate the two-way transmission delay between the uplink time reference point and the satellite.

**Agreement**The reference point for epoch time of the serving satellite ephemeris and Common TA parameters is the uplink time synchronization reference point.Addressing ZTE comments:It is already clear from RAN1 agreements that reference point is where UL and DL are frame aligned. This is correctly reflected in stage 2 “DL and UL are frame aligned at the uplink time synchronization reference point (RP) with an offset given by $N\_{TA,offset} $(see clause 8 of TS 36.211 [4]).” Thus, the absolute timing for epochTime shall not be removed from the RRC spec and stage 2 sentence shall not be changed. The SPS occasions are defined relative the subframe where it was activated and PUR is configured for a certain SFN+subframe – these are not affected by the definition of reference point (location) for things with absolute timing. Addressing CATT comments:Using the eNB as reference point (location) for UTC is not possible as the exact propagation delay between eNB and UE is unknown to the UE (Kmac is not sufficiently accurate with 1 ms resolution). Further, this is normative behaviour and cannot be specified in a NOTE.  |
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**Rapporteur Summary**

The CR [1] submitted in RAN2#122 has been revised to reflect some comments from companies during the previous discussion. The revised CR was put in the same folder as this discussion.

**Question 2: Do companies agree the revised CR?**

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| **Company** | **Agree/Disagree** | **Comments** |
| Apple | Agree generally | One thing is the timeReferenceInfo-r15 can be carried in DLInformationTransfer as well. Thus, in cover sheet, it should be explained that the change is not limited to SIB16. |
| ZTE | If RAN2 agree to correct or clarify something, we are fine to further discuss the CR | For CR itself:1. Agree with Apple’s comments, e.g., this modification is also applicable to the case of time provision via dedicated signalling. So the cover sheet needs to be updated.
2. Furthermore, we think this change would cause inter-operability issue. We need to mention that in the coversheet, if the UE is implemented the change and the network is not, or vice versa, the UE may have different time from NW.
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| Qualcomm | Agree | Ok coversheet can be updated. |
| CATT |  | We think further discussion is needed. |
| Ericsson | Agree with comment | Should say “In an NTN,…”, ok to update coversheet.  |
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**Rapporteur Summary**

# 4 Conclusion

**<To be Uploaded later>**

# 5 References

[1] R2-2306668 Clarify the reference point for UTC in SIB16 MediaTek Inc. CR Rel-17 36.331 17.4.0 4934 1 F LTE\_NBIOT\_eMTC\_NTN-Core