3GPP SA WG2 Meeting #160-Ad Hoc-e
E-meeting, January 22 - 29, 2024

S2-2400199

Discussion on the support of Network Timing Synchronization Status Reporting

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Background (1/2)

- Requirements: Upon the reception of the clock quality detail level and clock quality acceptance criteria (if applicable) in the AF request, the TSCTSF needs to be subscribed to NG-RAN timing synchronization status updates at the NG-RAN nodes that may provision access stratum time distribution information to the target UE, see clause 4.15.9.5 of TS 23.502, v 18.4.0:

#---excerpt from clause 4.15.9.5 of TS 23.502---

0. The AF requests creation or modification of ASTI or PTP based time synchronization service as described in clauses 4.15.9.4 and 4.15.9.3 including clock quality detail level and clock quality acceptance criteria (if applicable) in the request.

   If the request is received at the NEF, it checks whether the AF is authorized to send the request and forwards the request to the TSCTSF.

   If network timing synchronization status reports are provisioned using node-level signalling via control plane, the TSCTSF determines the serving AMF(s) and the UPF/NW-TT nodes (if applicable) for the UE(s) that needs to initiate network timing synchronization status monitoring.

   Otherwise, if network timing synchronizations status reports are provisioned via OAM, steps 1-3 and 5-7 are skipped.

1-2. (When the procedure is triggered by the AF request to influence the 5G access stratum time distribution or by PTP instance activation, modification):

   Upon the reception of the clock quality detail level and clock quality acceptance criteria (if applicable) in the AF request in step 0, the TSCTSF needs to be subscribed to NG-RAN timing synchronization status updates at the NG-RAN nodes that may provision access stratum time distribution information to the target UE. NG-RAN timing synchronization status updates provisioning may be configured via AMF (with node level signalling as illustrated in steps 1-2).

   The TSCTSF sends Namf_Communication_NonUeN2InfoSubscribe to initiate the subscription for the NG-RAN timing synchronization status updates from the AMF. As part of this subscription, the TSCTSF may specify TA(s) and/or NG-RAN node(s) in the subscription for the timing synchronization status reporting. Based on local configuration and/or TA or NG-RAN node information as received from the TSCTSF, the AMF may subscribe to some or all NG-RAN nodes in the TA(s) for the timing synchronizations status reporting.

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Background (2/2)

#---excerpt from clause 4.15.9.5 of TS 23.502 (continue)---

3. (When the procedure is triggered by the AF request for PTP instance activation, modification and if the UPF/NW-TT is involved in providing time information to DS-TT):

   Upon the reception of the clock quality acceptance criteria in the AF request in step 0, the TSCTSF needs to be subscribed to UPF/NW-TT timing synchronization status updates at the UPF/NW-TT that may provision time information via PTP to the target UE. UPF/NW-TT timing synchronization status updates provisioning may be configured via OAM or via UMIC.

4. The RAN node is pre-configured for the thresholds for each timing synchronization status attribute as described in clause 5.27.1.12 of TS 23.501 [2]. When the network timing synchronization status exceeds or meets again any of the pre-configured thresholds, the NG-RAN node detects a change on its timing synchronization status (e.g., degradation, failure, improvement).

5-6. If the NG-RAN node detects a change on its timing synchronization status as described in clause 5.27.1.12 of TS 23.501 [2] and the timing synchronization status reporting is configured via the AMF in step 1, the NG-RAN node notifies the AMF providing a NG-RAN timing synchronization status update. The update can contain the information elements listed in Table 5.27.1.12-1 of TS 23.501 [2], and the scope of the timing synchronization status (as described in clause 5.27.1.12 of TS 23.501 [2]). The AMF forwards the update to the subscribed TSCTSF.

7. …

8. …

#---end of the excerpt---

- TSCTSF uses an Namf_Communication_NonUeN2InfoSubscribe to send N2 message to an NG-RAN node(s), previously an Namf_Communication_NonUeN2MessageTransfer had been used for this purpose before it was removed by S2-2309819.

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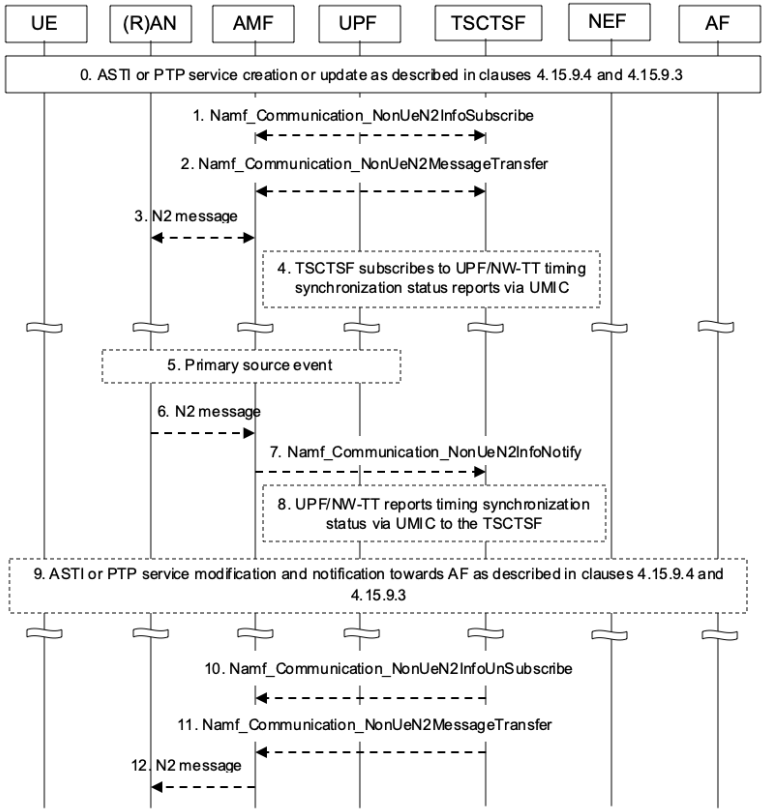
Alternatives triggering NG-RAN to report TSS attributes (1/2)



Alternative#1 for triggering NG-RAN to start reporting the TSS attributes; it exploits an Namf_Communication_NonUeN2MessageTransfer.

- In this solution, when doing activation, the Namf_Communication_NonUeN2MessageTransfer Request message would include an N2 Container encapsulating the NGAP message "TIMING SYNCHRONISATION STATUS REQUEST":
  - AMF will TRANSPARENTLY forward the message to the concerning NG-RANs based on the TAI List or NG-RAN node identifiers;
  - AMF will transparently forward the response message from NG-RANs, either accept or failure result, via the Namf_Communication_NonUeN2MessageTransfer response message, e.g. upon the first acceptance result and a Namf_Communication_NonUeN2InfoNotify request if there are a large list of NG-RANs involved and some of NG-RANs may respond a little late (since it is not possible for the AMF to wait for outcome from all NG-RANs).
  - The similar for deactivation.

The proposed solution that requires changes in the current specifications.

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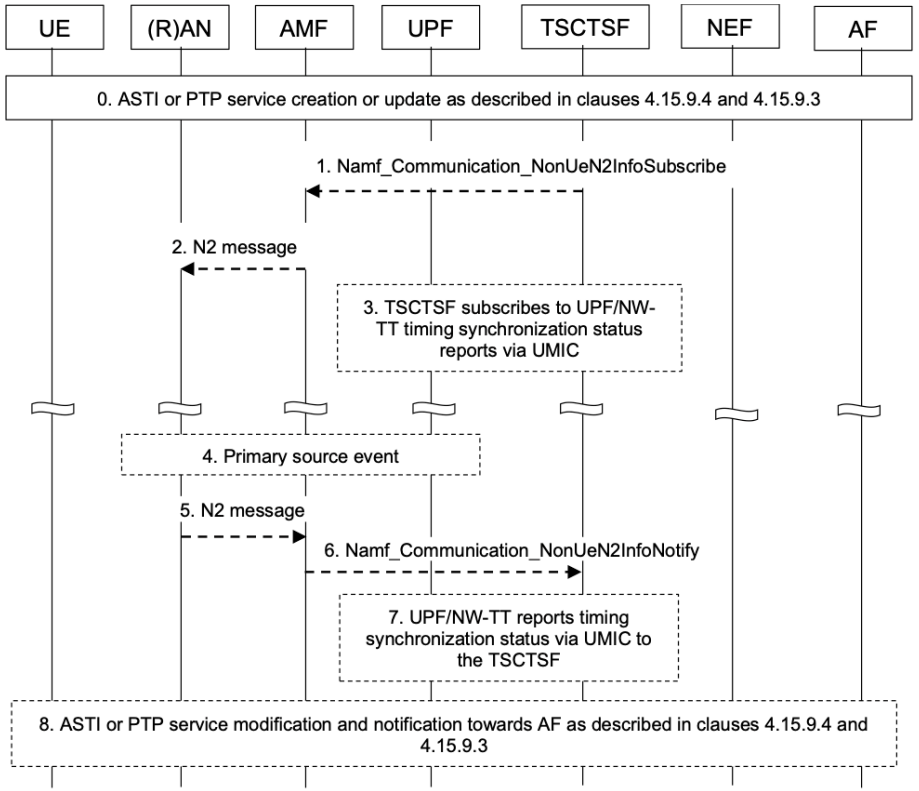
Alternatives triggering NG-RAN to report TSS attributes (2/2)



Alternative#2 for triggering NG-RAN to start reporting the TSS attributes; it exploits an Namf_Communication_NonUeN2InfoSubscribe.

- In this solution, upon receiving Namf_Communication_NonUeN2InfoSubscribe request from the TSCTSF with a subscription for Time synchronisation Status:
  - AMF shall trigger to send the NGAP "TIMING SYNCHRONISATION STATUS REQUEST" message with START to all concerning NG-RANs
  - AMF needs to keep the state if the NG-RAN(s) has been activated for Time synchronisation Status report, so that, the AMF can avoid sending the same message again if there is another TSCTSF request the same.
  - AMF shall consider the Time synchronization status report deactivated by the TSCTSF if the AMF receives the Namf_Communication_NonUeN2InfoUnSubscribe request to delete the subscription.
  - However, the AMF shall deactivate towards the NG-RAN only when no TSCTSF requests Time synchronisation Status Report.

The current solution in the specifications.

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Corresponding Requirements in RAN3 (1/3)

- According to baseline RAN3 CR (R3-238135), RAN3 has introduced the following Class 1 NGAP Elementary Procedure and related NGAP Messages to activate timing synchronization status report

Table 8.1-1: Class 1 procedures

Elementary Procedure	Initiating Message	Successful Outcome Response message	Unsuccessful Outcome Response message
AMF Configuration Update	AMF CONFIGURATION UPDATE	AMF CONFIGURATION UPDATE ACKNOWLEDGE	AMF CONFIGURATION UPDATE FAILURE
RAN Configuration Update	RAN CONFIGURATION UPDATE	RAN CONFIGURATION UPDATE ACKNOWLEDGE	RAN CONFIGURATION UPDATE FAILURE
<<<<<<<<<<<<<<<<<<<<< Unmodified Text Omitted >>>>>>>>>>>>>>>>>>>>>			
Distribution Release	DISTRIBUTION RELEASE REQUEST	DISTRIBUTION RELEASE RESPONSE	
Multicast Session Activation	MULTICAST SESSION ACTIVATION REQUEST	MULTICAST SESSION ACTIVATION RESPONSE	MULTICAST SESSION ACTIVATION FAILURE
Multicast Session Deactivation	MULTICAST SESSION DEACTIVATION REQUEST	MULTICAST SESSION DEACTIVATION RESPONSE	
Multicast Session Update	MULTICAST SESSION UPDATE REQUEST	MULTICAST SESSION UPDATE RESPONSE	MULTICAST SESSION UPDATE FAILURE
Timing Synchronisation Status	TIMING SYNCHRONISATION STATUS REQUEST	TIMING SYNCHRONISATION STATUS RESPONSE	TIMING SYNCHRONISATION STATUS FAILURE

- TIMING SYNCHRONIZATION STATUS REQUEST:
  - This message is sent by the AMF to request the NG-RAN node to start or stop reporting of RAN timing synchronization status information.
  - Direction: AMF to NG-RAN node

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.3.1.1		YES	reject
RAN TSS Request Type	M		ENUMERATED (start, stop, …)		YES	reject

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Corresponding Requirements in RAN3 (2/3)

9.2.yy.4 TIMING SYNCHRONIZATION STATUS REPORT:

- This message is sent by the NG-RAN node to report previously requested RAN timing synchronisation status information.
- Direction: NG-RAN node to AMF

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.3.1.1		YES	ignore
RAN Timing Synchronisation Status Information	M		9.3.1.x3		YES	ignore
RAN TSS Scope	M		9.3.1.x6		YES	ignore

9.3.1.x3 RAN Timing Synchronization status Information

- This IE indicates the RAN timing synchronisation status information provided towards the AMF as defined in TS 23.501 [9]

IE/Group Name	Presence	Range	IE type and reference	Semantics description
Synchronisation State	O		ENUMERATED (locked, holdover, freeRun, …)	
Traceable to UTC	O		ENUMERATED (true, false, …)	
Traceable to GNSS	O		ENUMERATED (true, false, …)	
Clock Frequency Stability	O		BIT STRING (SIZE (16))	Indicates the offsetScaledLogVariance as specified in TS 23.501 [9].
Clock Accuracy	O		9.3.1.x5	
Parent Time Source	O		ENUMERATED (syncE, pTP, gNSS, atomicClock, terrestrialRadio, serialTimeCode, nTP, handSet, other, …)	

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Corresponding Requirements in RAN3 (3/3)

9.3.1.x6 RAN TSS Scope

- This IE indicates the scope of the RAN timing synchronisation status as defined in TS 23.501 [9].

IE/Group Name	Presence	Range	IE type and reference	Semantics description
CHOICE *RAN TSS scope*	M			
>RAN node level				
>>Global gNB ID	M		9.3.1.6	
>cell list level				
>>RAN TSS Cell List		*1*		
>>>RAN TSS Cell Item		*1..<maxnoofCellsTSS>*		
>>>>NR CGI	M		9.3.1.7	

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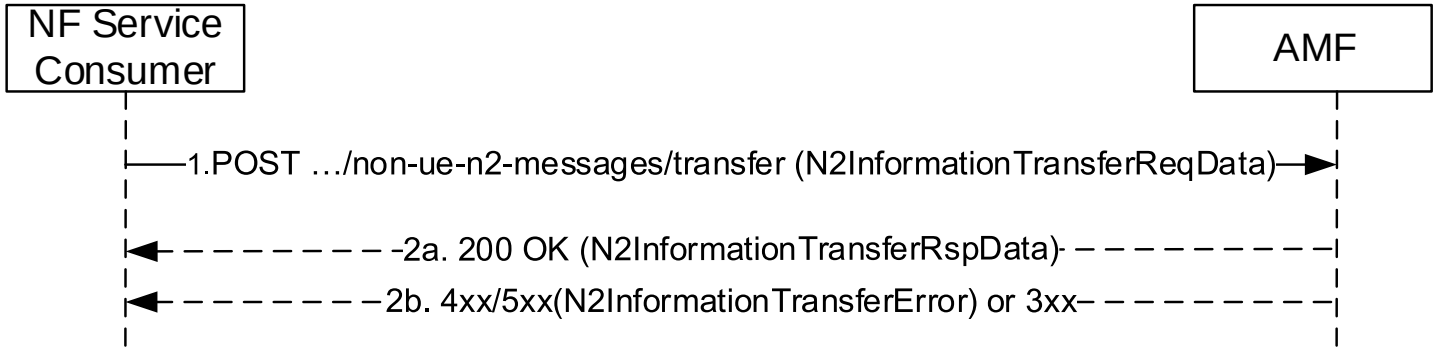
Consideration for AMF implementation (1/3)

- Namf_Communication_NonUeN2MessageTransfer service operation is used by a NF Service Consumer to transfer N2 information to the 5G-AN through the AMF in the following procedures:
  - Obtaining non-UE associated network assistance data (See clause 4.13.5.6 in 3GPP TS 23.502 [3]); Warning Request Transfer procedures (See clause 9A in 3GPP TS 23.041 [20]);
  - Configuration Transfer procedure (see clause 5.26 of 3GPP TS 23.501 [2])
  - RIM Information Transfer procedures (see clause 8.16 of 3GPP TS 38.413 [12]).
  - Broadcast of Assistance Data by an LMF (see clause 6.14.1 of 3GPP TS 23.273 [42]).
  - Management of network timing synchronization status monitoring procedures (see clause 4.15.9.5.1 of TS 23.502 [3]) ** This was added in CT4# August meeting, Nokia's CT4 is attempting to remove it.*
- Hence, TSCTSF shall use Namf_Communication_NonUeN2MessageTransfer service operation to request the AMF to transport the NGAP TIMING SYNCHRONISATION STATUS REQUEST message which is included in an N2 container. The AMF sends the corresponding N2 message, i.e. the Timing Synchronisation Status Request message, based on the N2 Container, to all applicable NG-RAN node(s). Upon receiving the responses from the NG-RAN node(s), the AMF includes a list of N2 Containers together with the NG-RAN Ids where each N2 Container encapsulates the NGAP message Timing Synchronisation Status Response or the Timing Synchronisation Status Failure received from that NG-RAN, in the Namf_Communication_NonUeN2MessageTransfer response or Namf_Communication_N2InfoNotify request to the TSCTSF.



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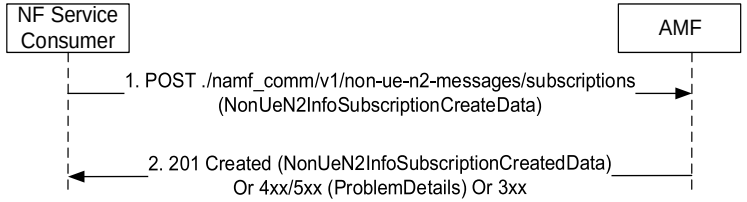
Consideration for AMF implementation (2/3)

- Namf_Communication_NonUeN2InfoSubscribe service operation can used by a NF Service Consumer (e.g. CBCF, PWS-IWF, TSCTSF) to subscribe to the AMF to get notifications about non-UE-specific-N2 information of a specific type (e.g. PWS Indications, TSS).
- An NF Service Consumer (e.g. CBCF, PWS-IWF, TSCTSF) may subscribe to notifications of specific N2 information type (e,g PWS Indications, TSS) that are not associated with any UE. In this case, the NF Service Consumer shall subscribe by using the HTTP POST method with the URI of the "Non-UE-N2-Messages Subscriptions Collection" resource (see clause 6.1.3.9.3.1 and Figure 5.2.2.4.2.1-1 of TS XXXXX)



- *Note that there is no Update of Namf_Communication_NonUeN2InfoSubscribe request. Hence, if the TSCTSF wants, for example, to MODIFY the range of concerning NG-RAN nodes, it needs to create a new subscription*

- Basically, the existing AMF implementation for Namf_Communication_NonUeN2InfoSubscribe is quite simple, the AMF simply forwards the received NGAP IE or NGAP message applicable to a specific type (as requested in the subscription request) to the consumer NF who has made the subscription

NonUeN2MessageTransfer	Request/Response	Peer AMF, LMF, CBCF, PWS-IWF, TSCTSF
NonUeN2InfoSubscribe	Subscribe/Notify	CBCF, PWS-IWF, TSCTSF
NonUeN2InfoUnSubscribe		CBCF, PWS-IWF, TSCTSF
NonUeN2InfoNotify		LMF, CBCF, PWS-IWF, TSCTSF

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Consideration for AMF implementation (3/3)

- Other aspects: N2InformationTransferReqDataTransfer and NonUeN2InfoSubscriptionCreateData

Table 6.1.6.2.9-1: Definition of type N2InformationTransferReqDataTransfer

Attribute name	Data type	P	Cardinality	Description
taiList	array(Tai)	C	1..N	This IE shall be included if the N2 information needs to be sent to the 5G-AN nodes that serve the list of tracking areas provided.
ratSelector	RatSelector	C	0..1	This IE shall be included to indicate if the N2 information shall be transferred to ng-eNBs or gNBs exclusively.
globalRanNodeList	array(GlobalRanNodeId)	C	1..N	This IE shall be included if the N2 information needs to be sent to the list of RAN nodes provided.
n2Information	N2InfoContainer	M	1	This IE includes the information to be sent on the N2 interface to the identified 5G-AN nodes and additional information required for the processing of the message by the AMF.
supportedFeatures	SupportedFeatures	C	0..1	This IE shall be present if at least one optional feature defined in clause 6.1.8 is supported.

Table 6.1.6.2.10-1: Definition of type NonUeN2InfoSubscriptionCreateData

Attribute name	Data type	P	Cardinality	Description
globalRanNodeList	array(GlobalRanNodeId))	C	1..N	This IE shall be included if the subscription is for N2 information from RAN node(s) for which the N2 information notification is subscribed (i.e N3IWF identifier or gNB identifier or Ng-eNB identifier). (NOTE)
anTypeList	array(AccessType)	C	1..N	This IE shall be included, if the globalRanNodeId IE is not included and if the N2 information from a specific access network needs to be subscribed. When included this IE shall contain the access type of the access network from which Non UE specific N2 information is to be notified. (NOTE)
n2InformationClass	N2InformationClass	M	1	This IE represents the class of N2 information that the NF Service Consumer requires to be notified.
n2NotifyCallbackUri	Uri	M	1	This IE represents the callback URI on which the N2 information shall be notified.
nfId	NfInstanceId	C	0..1	This IE shall be present if the subscription is for "NRPPa" N2 information class and/or "LPP" N1 information class. When present, this IE shall carry the value to be used for NGAP "Routing ID" IE, which identifies the Network Function (e.g. LMF) instance handling the NRPPa and/or LPP data. This IE may also be present if the subscription is for "PWS" N2 information class. When present, this IE shall carry the instance identity of the network function (e.g. CBCF or PWS-IWF) creating the subscription. This IE should be included when more than one CBCF/PWS-IWF instances are deployed in the network. The AMF may use this IE to identify whether the same CBCF/PWS-IWF instance has subscribed for N2 PWS information to receive the PWS Response data from the RAN. This IE shall be present if the subscription is for "TSS" N2 information class. When present, this IE shall identify the TSCTSF NF instance subscribing the TSS data.
supportedFeatures	SupportedFeatures	C	0..1	This IE shall be present if at least one optional feature defined in clause 6.1.8 is supported.
notifCorrelationId	string	O	0..1	When present, this IE shall contain the notification correlation ID of the subscription.
NOTE: Absence of both IEs means the subscription is for N2 information from all connected Access Network node(s) via any access type.				

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Comparison and Conclusion (1/2)

- **Alternative#2** imposes extra complexity to AMF, e.g.:
  - generating non-MM NGAP messages on its own, i.e., generating a TIMING SYNCHRONISATION STATUS REQUEST for a start based on the Namf_Communication_NonUeN2InfoSubscribe Request, and a TIMING SYNCHRONISATION STATUS REQUEST for stop based on the Namf_Communication_NonUeN2InfoUnSubscribe Request;
  - keeping track of the timing synchronisation status of each NG-RAN, i.e. the AMF needs to store which TSCTSFs have requested to start "timing synchronization status reporting" and which TSCTSFs have requested to stop "timing synchronisation status reporting" in a NG-RAN node;
  - At the moment, the TIMING SYNCHRONISATION STATUS REQUEST message is very simple, it has only one enumeration type IE (start/stop), and thus **Alternative#2** works. However, what if new IEs to be added as part of time synchronization status report activation, e.g. to describe the conditions, e.g. different S-NSSAIs, different thresholds to trigger a report, to activate? Different TSCTSFs from different network slices corresponding to different time-sensitive communication domains likely have different parameters to be reported in the future. **Alternative#2 is NOT future-proof.**
- When comes to handling failure scenarios when, for example, one or more NG-RANs fail to activate timing synchronization status reporting, **this should be reported to the TSCTSF**, e.g. to retry the same after some time. For **Alternative#2**, AMFs would need:
  - to generate an N2 container encapsulating TIMING SYNCHRONISATION STATUS FAILURE or Response message in the Namf_Communication_NonUeN2InfoNotify request message towards the TSCTSF, while be noted that the TIMING SYNCHRONISATION STATUS Request message was not included by the TSCTSF.
  - Or alternatively Namf_Communication_NonUeN2InfoNotify request message would need to be enhanced to carry an NGAP cause per NG-RAN Id (which is then needs to be included in the TIMING SYNCHRONISATION STATUS FAILURE or Response message)

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Comparison and Conclusion (2/2)

- **Alternative#1** matches the current design of the AMF communication service for Non-Ue-related N2 message transfer. However, comparing the existing services, e.g., for the support of the PWS and NRPP where these procedures are also not intended for an individual UE, NGAP has designed a mechanism using, for example, Message Identifier/Serial Number or Routing ID, to determine if the message is from a different sender or with a different content.
- To support the scenario where multiple TSCTSFs are deployed, TIMING SYNCHRONISATION STATUS REQUEST shall contain at least a TSCTSF NF ID (e.g. Routing ID) of the TSCTSF sending the request for START or STOP, so that the NG-RAN could store this information and determine if multiple TSCTSFs have requested activation of TIMING SYNCHRONISATION STATUS reporting; therefore, when doing deactivation, the NG-RAN shall keep the TIMING SYNCHRONISATION STATUS active as long as there is at least ONE TSCTSF left.
- Furthermore, to be future-proof, different TSCTSFs configured for different network slices may want to set/have different TSS attribute thresholds for the NG-RAN to trigger TSS reporting or a time condition where the NG-RAN performs TSS reporting only in a specific time.
- At the message level of the NGAP message "TIMING SYNCHRONISATION STATUS REPORT", the Routing ID shall be included to contain a TSCTSF NF ID as the intended receiver, so that the AMF will forward the report only to that specific TSCTSF, similarly as shown below:

9.2.8.1 WRITE-REPLACE WARNING REQUEST

This message is sent by the AMF to request the start or overwrite of the broadcast of a warning message.

Direction: AMF → NG-RAN node

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.3.1.1		YES	reject
Message Identifier	M		9.3.1.35		YES	reject
Serial Number	M		9.3.1.36		YES	reject
Warning Area List	O		9.3.1.37		YES	ignore

9.2.9.3 DOWNLINK NON UE ASSOCIATED NRPPA TRANSPORT

This message is sent by the AMF and is used for carrying NRPPa message over the NG interface.

Direction: AMF → NG-RAN node

IE/Group Name	Presence	Range	IE type and reference	Semantics description	Criticality	Assigned Criticality
Message Type	M		9.3.1.1		YES	ignore
Routing ID	M		9.3.3.13		YES	reject
NRPPa-PDU	M		9.3.3.14		YES	reject

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Concluding Remarks

- The Timing Synchronisation Status Reporting procedure and its related NGAP messages are not for Mobility Management. In principle, these messages should be made transparent to AMFs. AMFs offer the Namf_communication service to transport these messages between TSCTSF and NG-RAN, similarly as for SMF (for a PDU session), MB-SMF (for a Broadcast MBS session), CBCF (for Public Warning messages), LMF, etc. Since AMF is just offering the communication service, it should not be required to build non-MM related messages on its own instead of just building these NGAP messages based on an N2 container (encapsulating an NGAP IE or an NGAP message). **Alternative#1** matches the current design of the AMF communication service for transferring Non-Ue-related N2 messages. This alternative is also future-proof since the NGAP message can be evolved independently of the Namf_Communication service, which is the exact merit of the AMF communication service.
- One of the possible motivations for Alternative#2 to consider is that RAN3 has designed the Time Synchronization Status Elementary procedure as a NODE-level procedure between NG-RAN and AMF. However, functional-wise NG-RAN and TSCTSF are peer entities. Consequently, **Alternative#1** should ALSO be designed as a node-level procedure (between NG-RAN and TSCTSF) by adding a Routing ID encapsulating a TSCTSF NF ID.
- **Alternative#2** works only if the TIMING SYNCHRONISATION STATUS REQUEST contains ONLY one ACTION with two enumeration values, START and STOP, i.e. an AMF will be triggered to send a TIMING SYNCHRONISATION STATUS REQUEST with “start” when receiving a Namf_Communication_NonUeN2InfoSubscribe request, and a TIMING SYNCHRONISATION STATUS REQUEST with “stop” when receiving a Namf_Communication_NonUeN2InfoUnSubscribe request. The TSCTSF has no possibility to modify the subscription either. Even when e.g. the TSCTSF would like to extend the TSS reporting scope, covering more NG-RANs, it has to create a new subscription. In case of this alternative, it is also tricky to handle failure scenarios, for example, when one or more NG-RAN nodes fail to activate timing synchronization status reporting; it needs to be reported to the TSCTSF so that it could retry to make the request after some time.
- **Alternative#1 as further described in the next slide proposed to be the way forward.**

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Detailed description of Alternative#1

- **Alternative#1 for Rel-18 shall be as follows:**

1. The TSCTSF invokes Namf_Communication_NonUeN2InfoSubscribe service operation towards the AMF to receive notifications related to N2 information class defined for Time Synchronization Status (TSS) without including a list of NG-RAN IDs/TAs for which subscription applies;
2. The TSCTSF invokes Namf_Communication_NonUeN2MessageTransfer service operation containing an N2 Container encapsulating Timing Synchronization Status Request message to request the NG-RAN(s) to start reporting the Time Synchronization Status. The NGAP message Time Synchronization Status Request contains ***a Routing ID*** encoded with the TSCTSF NF ID. *The NG-RAN needs to know when there are multiple TSCTSF instances that have requested the TSS reporting so that the NG-RAN could keep reporting until the last TSCTSF instance requests to stop the reporting*.
3. Upon receiving the responses from the NG-RAN node(s), the AMF includes a list of N2 Containers together with the corresponding NG-RAN IDs where each N2 Container encapsulates the NGAP message Timing Synchronisation Status Response or the Timing Synchronisation Status Failure received from that NG-RAN, in the Namf_Communication_NonUeN2MessageTransfer response or Namf_Communication_N2InfoNotify request messages to the TSCTSF. *The AMF adds the corresponding NG-RAN ID to enable the TSCTSF to know which NG-RAN has failed to initiate the TSS reporting (when receiving a* Timing Synchronization Status Failure). The Timing Synchronization Status Response may indicate a protocol error.
4. The NG-RAN includes the ***Routing ID*** in the Time Synchronization Status Report message. Upon receiving the NGAP message Time Synchronization Status Report message, the AMF forwards the Time Synchronization Status Report message as an N2 Container in the Namf_Communication_N2InfoNotify Request message to that specific TSCTSF.

- **Restoration considerations are done by CT4 and thus not included here.**

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Thank you

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