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**Source: Lenovo, ZTE (?), LGE (?), NEC, Nokia (?), Ericsson (?), Vivo (?), CATT (?)**

**Title: KI#1 Evaluation and Conclusions**

**Document for: Approval**

**Agenda Item: 9.14**

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*Abstract: This paper proposes solution evaluation and conclusions for KI#1.*

# 1. Introduction/Discussion

The Key Issue #1 description captures multiple scenarios, however, only scenarios 1b, 1c and 2d are agreed to be studied. The following excerpt from the KI#1 description highlights the agreed scenarios:

***1)*** ***No mobility scenario:***

*Scenario 1a): network slice is overloaded in NG-RAN.*

***Scenario 1b)****: network slice or network slice instance is overloaded or undergoing planned maintenance in CN (e.g., network slice termination).*

***Scenario 1c)****: network performance of the network slice cannot meet the SLA.*

***2) Inter RA Mobility scenario:***

*Scenario 2a): network slice is not supported in the target RAN node.*

*Scenario 2b): network slice in target RAN node is overloaded.*

*Scenario 2c): network slice is not supported in the target CN.*

***Scenario 2d)****: network slice or network slice instance is overloaded in the target CN.*

*This key issue is to study whether and how to provide service continuity for PDU sessions in network slices in the above scenarios* ***1b), 1c) and 2d)****.*

The grey text above highlights the scenarios which were NOT agreed to be studied.

# 2. Text Proposal

It is proposed to capture the following changes vs. TR 23.700-41 V0.4.0.

\* \* \* \* First change \* \* \* \*

## 7.X Solution evaluation for KI#1 (Support of Network Slice Service continuity)

Solutions 1, 2, 3, 4, 5, 15, 32, 40, 41, 42 and 43 are documented to address all or some of the scenarios 1b), 1c) and 2d) from the KI#1 description.

The Table 7.X-1 shows the evaluation of the solutions.

**Table 7.X-1: Evaluation of solutions for Key Issue 1**

|  |  |
| --- | --- |
| Solution #1  Additional S-NSSAI associated with the PDU session | The main principle is that a PDU session can be associated with multiple S-NSSAIs in the network (i.e. NG-RAN, AMF, SMF, UPF). During PDU session establishment or HO procedure, the AMF notifies the new S-NSSAI to SMF. The SMF provides the new S-NSSAI to the NG-RAN. The network does not notify the change of S-NSSAI in the UE while NG-RAN, AMF, SMF and UPF update the S-NSSAI of the PDU Session.  The solution applies to certain deployments where the old S-NSSAI and the new S-NSSAI are associated with the same NSI (e.g. the new S-NSSAI uses shared resource of the NSI, whereas the old S-NSSAI uses dedicated resource of the NSI). One benefit is that the network can apply the procedure of PDU Session transfer to the new S-NSSAI for legacy UEs, as there are no UE impacts.  This solution requires that the new S-NSSAI is part of the Allowed NSSAI. |
| Solution #2  Slice Re-mapping Capabilities for Network Slice Service Continuity | The main principle is that the AMF derive a new/alternative S-NSSAI for a congested S-NSSAI optionally requesting the AM PCF (which specifically supports slice re-mapping), where the new/alternative S-NSSAI has to support the same DNN, DNAI and selected within Allowed NSSAI. Then, the AMF requests the current SMF to change the PDU Session to the new S-NSSAI. The SMF triggers the PDU session transfer to the new S-NSSAI without UPF relocation (i.e., Option 1, re-use the existing PDU session) and with UPF relocation (i.e., Option 2, new PDU session established similar to SSC mode 3) based on the SSC mode of the PDU session and sends to the UE a PDU Session Modification Request including the corresponding cause value and the new S-NSSAI.  The solution also proposes to update the URSP rules of the UE by means of UE Policy PCR trigger of slice re-mapping event. Further, in the solution, AM PCF-based new S-NSSAI selection requires that the AM PCF has knowledge about the S-NSSAIs configuration.  It is not specified when the AMF triggers the slice remapping procedure.  Besides, the UE may not use updated URSP immediately. It is unclear how the service continuity is supported in this case. |
| Solution #3  Support of Network Slice Service continuity using a SSC mode 3 type of Service continuity | The main principle is that the AMF determines the need to exchange old/original S-NSSAI 1 with a new/alternative S-NSSAI 2 (and in case of mobility to T-RAN, the T-RAN temporarily accepts the PDU Session of S‑NSSAI 1 and indicates in the Path Switch Request to the AMF an alternative S-NSSAI 2). The AMF triggers UCU procedure to the UE to include both S‑NSSAI 1 and S‑NSSAI 2 in the Allowed NSSAI, and afterwards the AMF notifies the SMF about the end of usage of S‑NSSAI 1 and to use the new S‑NSSAI 2.  The solution proposes to notify the UE of slice re-mapping by enhancing the Allowed NSSAI format and using the NAS MM signalling, and in addition, the solution proposes to also use SM signalling from the SMF (SSC mode 3 like procedure) to update the UE about the S‑NSSAI change/remapping. The question is whether a single NAS signalling is not enough to reconfigure the UE about the S-NSSAI change, i.e. either using NAS MM or NAS SM signalling may be sufficient. As the network slice configuration is performed in the NAS MM-sublayer, it would aligned with the existing network slice configuration to use the NAS MM signalling from the AMF to the UE.  Additionally, it is not clear whether the impacts to the NG-RAN (notification about slice re-mapping) are required, since there is no NG-RAN specific behaviour to support slice re-mapping. The AMF itself can determine the alternative S-NSSAI 2 as in other solutions (e.g. solution #1, 32, 42, etc.)  How to do slice remapping for N2 based handover is FFS. |
| Solution #4  PDU Session on compatible network slice | [Non-mobility use case] During new PDU Session Establishment, if there are further RSDs for the matching URSP rule, the UE includes in the NAS message to the AMF an alternative S-NSSAI (which is stored in the UE's context in the AMF). If the original S-NSSAI is congested, the AMF may use the alternative S-NSSAI to select an SMF and continue with the PDU Session establishment on the alternative S-NSSAI.  The solution covers the use case of a new PDU Session establishment. The following analysis is provided:  - If the alternative S-NSSAI (sent from the UE to the AMF) is part of the Rejected NSSAI or not available in the current TA, the AMF cannot use such UE-indicated alternative S-NSSAI. Therefore, the AMF itself is required to have the ability to determine an appropriate alternative S-NSSAI. As result, the indication of the alternative S-NSSAI from the UE to the AMF applies to limited scenarios and it is not necessarily needed.  - It is proposed that for a new PDU Session establishment on the old/current S-NSSAI, the AMF determines to apply the new/alternative S-NSSAI and select an SMF accordingly. It is not clear what is the UE behaviour when the UE receives the PDU Session Establishment Accept message with an S-NSSAI different from the requested S-NSSAI. Also, the UE may have applied cell selection using NSAG feature for the old S-NSSAI, however, the new S-NSSAI may be served preferably on another cell/frequency layer. Therefore, it may be more efficient if the AMF rejects the new PDU Session establishment request with an indication to the UE to use the new/alternative S-NSSAI replacing the old S-NSSAI; and then the UE would apply the new S-NSSAI for the PDU Session establishment appropriately.  This solution is not applicable when the matching URSP rule, which triggers the PDU Session establishment, is associated with a single S-NSSAI in the URSP rule. |
| Solution #5  PDU session handover to a target CN with an alternative S-NSSAI support | [Mobility use case, scenario 2d] This solution is similar to solution #4 with the addition that the T-AMF may select a different SMF based on the alternative S-NSSAI, if the PDU Session switches to an alternative S-NSSAI. The old SMF triggers PDU Session modification procedure.  It is unclear how (e.g. in step 7) the T-AMF selects a new SMF and in parallel the old SMF triggers PDU Session modification procedure, i.e. it seems there is concurrent SM signalling for the same PDU Session. Also, during the Registration procedure with the T-AMF, it is not clear whether and how the UE includes the alternative S-NSSAI in the Requested NSSAI.  This solution is not applicable when the matching URSP rule, which triggers the PDU Session establishment, is associated with a single S-NSSAI in the URSP rule. |
| Solution #15  Service continuity in case of Network Slice instance overload | It is assumed that multiple NSIs are deployed for the same S-NSSAI. The current NSI selection is done without being able to consider load balancing after the UE registration/PDU Session Establishment. The solution describes how the NSI can be changed. When the existing PDU session is decided as to be migrated to another Network Slice instance, the SMF performs PDU Session re-establishment by using the mechanism of SSC mode#2 or SSC mode#3. Then the PDU session establishment request arrives at the AMF, the AMF removes from the UE context the old NSI ID and the AMF can select another NSI.  This solution assume that the network is configured to use Early Binding because if network uses Late Binding, the network can select non-overloaded NSI. Then it is questionable why the NSI selected during the Early Binding process becomes overloaded. It seems that the NSI selection during the Early Binding is done without considering load balancing because if load balancing is considered all load of NSIs for the same S-NSSAI should be evenly distributed. Then what is needed is specifying that such load balancing needs to be considered rather than introducing new procedure.  This solution is not applicable for SSC mode#1. The service continuity is ensured at application layer. |
| Solution #32  Solution for Network Control for UE Slice Use | Three options are described in this solution:  - Option 1: the UE-initiated procedure, i.e. when the UE establishes a new PDU Session the UE is configured to use the new S-NSSAI. The new S-NSSAI is provided to the UE by the AMF during enhanced UCU procedure indicating that PDU session transfer is requested from an old S-NSSAI (i.e. to be removed) to the new S-NSSAI.  - Option 2: AMF-initiated procedure towards SMF, i.e. the AMF notifies the SMF to initiate SSC mode 3 like procedure so that the UE triggers PDU Session Establishment by using target slice. This option is similar to solutions # 2, 3, 4, 5.  - Option 3: PCF-initiated procedure, i.e. the PCF notifies the SMF that an alternative S-NSSAI is to be used. As in Option 2, the SMF uses enhanced NAS SM procedure to notify the UE to initiate a new PDU session towards the alternative S-NSSAI.  For the UE-initiated option, it is not clear how to apply the procedure for existing PDU Sessions. If Option 1 and Option 2 are combines, then the result would be similar to Solution #3. Please refer to the evaluation of solution #3.  Option 3 is similar to and solution #40. Therefore similar evaluation would apply as to solution #2 and solution #40.  The impact of overriding of the SSC mode is FFS. |
| Solution #40  S-NSSAI change decided by PCF | The main principle is that the PCF determines (e.g. triggered by a SMF or NWDAF) whether the S-NSSAI associated to an ongoing PDU session needs to be changed and which is the alternative/replacement S-NSSAI. Then, the PCF provides the suggested new S-NSSAI to the SMF, and the SMF initiates the modification of the PDU session and notifies the AMF.  The solution addresses scenarios 1b) and 1c).  The PCF for a Session may only serve the original S-NSSAI. It is not clear how the PCF can determine the new S-NSSAI in the roaming case and how the PCF can decide the mapped new S-NSSAI. |
| Solution #41  Network Slice change without service interruption | The main principle is that the AMF determines the new/alternative S-NSSAI to be used to replace the congested S-NSSAI and:  - (option 1) if the current SMF (PSA) supports the new S-NSSAI and the capability to change S-NSSAI, then AMF requests SMF to change to the new S-NSSAI. The SMF initiates SM procedure towards the UE to notify the UE that the S-NSSAI has been changed. This case is similar to solution #2, but solution #41 informs the UE about the S-NSSAI change.  - (option 2) if the current SMF (PSA) does not support the new S-NSSAI and/or the capability to change S-NSSAI, the AMF invokes procedure to initiate PDU Session transfer using any SSC mode as described by other solutions (e.g. solutions 3, 4).  The solution addresses scenarios 1b, 1c, 2d.  In option 1, similar as Solution #2, it is not clear what is the behaviour of the UE after receiving the PDU Session Modification request from the SMF indicating change of the S-NSSAI. |
| Solution #42  Network controlled change to an alternative S-NSSAI | The main principle is that the AMF (or together with the NSSF or OAM system) determines an alternative S-NSSAI (e.g. S-NSSAI-2) which is available in the current TA and can be used by the UE (e.g. S-NSSAI is not part of the Rejected NSSAI, or NSSAA has failed, etc.). If the NSSF is used to determine the alternative S-NSSAI, the AMF may include a new indication to the NSSF that an alternative S-NSSAI to S-NSSAI-1 is required (this is similar to solution #43). Two options are proposed:   * (Option 1) If the S-NSSAI-2 is part of the UE's subscribed S-NSSAIs, it is assumed that the S‑NSSAI-2 is part of further RSD the same URSP rule which is used for established PDU Session. The AMF triggers SM procedure towards the SMF to indicate that the PDU Session on S-NSSAI-1 should be released and alternative S-NSSAI may be used. The SMF releases the PDU Session with an indication to the UE to establish the PDU Session on an alternative S-NSSAI. * (Option 2) If the S-NSSAI-2 is not part of the UE's Subscribed S-NSSAIs, the AMF triggers UE network slice reconfiguration procedure (e.g. UCU procedure) in order to send a new Configured NSSAI with a corresponding Mapping of the Configured NSSAI information containing the mapping of S-NSSAI-2 to S-NSSAI-1 (and Mapping of the Allowed NSSAI). The AMF may wait with the UE reconfiguration when the PDU Session(s) on the old S-NSSAI are inactive.   In Option 1, it is not assured that the URSP rule includes an RSD with S-NSSAI-2 and also, the Option 1 works only when the RSD with S-NSSAI-2 in the URSP rule is configured to match the traffic to be moved in S-NSSAI-1. Therefore, it may be more deterministic if the option 2 is always performed, i.e. the UE should be updated to include in the Allowed NSSAI the S-NSSAI-2 and the mapping of S-NSSAI-2 to S-NSSAI-1. There can be another alternative that S-NSSNI-2 is part of Configured S-NSSAI then legacy behaviour can be used.  In Option 2, in addition to the MM reconfiguration in the UE, in case of existing PDU Session(s) on the old S-NSSAI-1, the AMF may indicate to the SMF that an explicit PDU Session release is required and the SMF releases the current PDU Session with re-establishment indication. This results in more deterministic behaviour that the UE riggers a new PDU Session establishment to the old S-NSSAI with a mapped new S-NSSAI value, i.e. not relying on the UE implicit trigger of PDU Session re-establishment after receiving the new Allowed NSSAI.  Option 2 describes that the S-NSSAI-2 is provided to the UE in the Mapping Of Configured/Allowed NSSAI" information when the S-NSSAI-2 is not within the Subscribed S-NSSAI to UE. However, if the S-NSSAI-2 is part of the Subscribed S-NSSAIs, the Mapping of the Allowed NSSAI information can be also provided to the UE, similar to solutions #3 and #32.  The S-NSSAI-2 may not be part of the Subscribed S-NSSAIs in the scenarios where the UE has a single Subscribed S-NSSAI, namely S-NSSAI-1. |
| Solution #43  Allowed NSSAI Determination in Initial Registration to Support Network Slice Service Continuity | The AMF queries the NSSF to obtain alternative/new S-NSSAI for each S-NSSAI of the Allowed NSSAI. The Allowed NSSAI, which is sent to the UE, contains two parts: (1) S-NSSAIs of network slices which UE can access and (2) alternative S-NSSAIs to support slice continuity. The USRP provided to UE contains only the part (1).  It may be inefficient to always query the NSSF about the alternative S-NSSAI for each S-NSSAI from the Allowed NSSAI, since the cases to use the alternative S-NSSAI are rather rare, and therefore, it is considered more efficient to query the alternative S-NSSAI from the NSSF on demand.  This solution does not describe how the UE uses this secondary S-NSSAI in the allowed NSSAI, i.e. whether the existing " Mapping Of Allowed NSSAI" information is used. |

Regarding the Network Function, which determines the new S-NSSAI to replace the old S-NSSAI, the solutions can be categorized into 2 groups:

- The AMF determines the new S-NSSAI (e.g. solutions #1, 2, 3, 4, 5, 32, 42, 43, etc.). The AMF may optionally use the NSSF services to determine the new S-NSSAI (e.g. solutions 42, 43). The AMF may optionally use the PCF services to determine the new S-NSSAI (e.g. solution #2, 41). The AMF may be triggered by the RAN (solution #3) or by the NWDAF.- The PCF determines the new S-NSSAI (e.g. 40). As documented in the#40 in Table 7.X-1, it is unclear how the PCF knows whether the new S-NSSAI is supported in the current TA and the RAN node.

Regarding the impacts to the UE, the solutions can be categorized into the following groups:

- Solutions without impact to the UE:

- For scenarios where the same S-NSSAI is deployed on multiple NSIs and NSI change is performed (e.g. solution #15): the NSI change is performed seamlessly to the UE, although there is signalling to the UE, but it uses legacy signalling.

- For scenarios where the old and new S-NSSAIs are deployed on the same NSI (e.g. solution #1): the principle is that the change of the old S-NSSAI to new S-NSSAI is handled within the 5GC and NG-RAN and transparent to the UE.

- Solutions with impact to the UE (e.g. solutions #2, 3, 4, 5, 32, 41, 42, etc.): the UE is informed either by using NAS MM signalling from AMF and/or by using NAS SM signalling from the SMF that the old S-NSSAI is to be replaced by a new S-NSSAI. It is beneficial if only a single configuration is performed to the UE. Usually, the NAS SM signalling is meant to influence a single PDU. It appears beneficial to use both:

- NAS MM signalling to include the new S-NSSAI in the Allowed NSSAI, the new S-NSSAI replaces the old S-NSSAI.

- NAS SM signalling is used to release the PDU Session with an indication to use an new/alternative S-NSSAI (e.g. as per NAS MM configuration).

In solutions #3, #4, #5 and #32, it is described that the AMF may provide back off timer for the old S-NSSAI and/or includes the old S-NSSAI in the Rejected NSSAI to prevent the UE requesting the old S-NSSAI due to URSP rule re-evaluation. However, if the old S-NSSAI is included in the Rejected NSSAI or back-off timer is configured, and the URSP rules have only the old S-NSSAI in the RSDs, the UE will not be able to establish a new PDU Session for the matching URSP rule, as the RSDs will be determined as invalid. Such solution is only applicable if the URSP rule(s) or local configuration contains multiple RSDs including the old S-NSSAI and the new S-NSSAI.

NOTE: Given the limitation of this solution (i.e. include the old S-NSSAI in the Rejected NSSAI or using of BOT), it would be beneficial if the old S-NSSAI is excluded from the Allowed NSSAI but included as replaced (or mapped) S-NSSAI value in the Mapping OF Allowed NSSAI (or a new IE), i.e. similar to the mapped S-NSSAI value sent in the existing mapping of Allowed NSSAI.

\* \* \* \* Next change \* \* \* \*

## 8.X Conclusions for Key Issue #1

The following principles are concluded for the normative work.

1) The AMF determines the new S-NSSAI to be used to exchange the old S-NSSAI. The AMF may interrogate for a new S-NSSAI with the URSP rules in the PCF or with the NSSF to determine the new S-NSSAI.

Editor's Note: It is FFS whether to allow the new S-NSSAI to be outside of the UE's Subscribed S-NSSAI.

Editor's Note: It is FFS whether the trigger event in the AMF is to be specified or it is left to AMF local configuration, trigger from OAM or other conditions.

2) In case of a same S-NSSAI associated with multiple NSIs and the change of the NSI is required, when an existing PDU session is decided as to be migrated to another NSI, the SMF performs PDU Session re-establishment by using the mechanism of SSC mode#2 or SSC mode#3. When the PDU session establishment request from the UE arrives at the AMF, the AMF removes from the UE context the old NSI ID and the AMF can select another NSI, as described in solution #15.

Editor's Note: Further details are FFS.

3) In cases where the old S-NSSAI and the new S-NSSAI are associated with the same NSI, the PDU session is associated with multiple S-NSSAIs in the network (i.e. NG-RAN, AMF, SMF, UPF). During PDU session establishment or HO procedure, the AMF notifies the new S-NSSAI to SMF and the SMF provides the new S-NSSAI to the NG-RAN without UE impact, as described in solution #1.

Editor's Note: Further details are FFS.

4) In cases where the old S-NSSAI is replaced be a new S-NSSAI deployed on a different NSIs, the following principles apply:

a) The AMF performs UE MM configuration update (e.g. UCU procedure) to include the new S-NSSAI in the Allowed NSSAI and/or in the Configured NSSAI, if not included yet. If the new S-NSSAI is not part of the Subscribed S-NSSAIs, the AMF provides the new S-NSSAI associated with a replaced/mapped value to the old S-NSSAI in both roaming or non-roaming case.

Editor's Note: It is FFS whether the existing Mapping Of Allowed NSSAI can be re-used, or a new IE (e.g. Replaced NSSAI) has to be specified.

Editor's Note: If there are existing PDU Sessions on the old S-NSSAI, it is FFS whether the AMF includes in the Allowed NSSAI the new S-NSSAI and temporarily the old S‑NSSAI to ensure that first the PDU Session transfer to the new S-NSSAI is performed before releasing the PDU Session on the old S-NSSAI, which is applicable only if the PDU Session is of SSC mode 3.

b) For a new PDU Session establishment request from the UE on the old S-NSSAI:

Editor's Note: It is FFS whether (1) the AMF rejects the UE's request for PDU Session establishment with an indication to use an alternative S-NSSAI; or (2) the AMF proceeds with the PDU Session establishment to the SMF, the AMF indicates the alternative S-NSSAI to the SMF and the SMF proceeds with the PDU Session establishment on the alternative S-NSSAI.

c) For an existing PDU Session transfer from the old S-NSSAI to a new S-NSSAI:

- The AMF notifies the current SMF, e.g. by triggering Nsmf\_PDUSession\_UpdateSMContext service operation, due to transferring to the new S-NSSAI.

- The SMF sends to the UE either PDU Session Modification Command (if the PDU Session is of SSC mode 3) or PDU Session Release Command (if the PDU Session is of SSC mode 1 or 2) and indicates to the UE that the PDU Session can be re-established on another S-NSSAI.

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Editor's Note: It is FFS whether the SMF sends to the UE (1) the new S-NSSAI or (2) only an indication that the PDU Session can be re-established on another S-NSSAI.

- the UE triggers a new PDU Session Establishment procedure to establish a PDU Session as follows:

- If the new S-SNSAI-2 is part of alternative RSD of the same URSP rule, the PDU Session establishment request include only the new S-NSSAI; otherwise

- The PDU Session establishment request includes the new S‑NSSAI together with the old S‑NSSAI (similar as to use the mapped S-NSSAI value of the VPLMN when applying the RSD matched to the HPLMN S-NSSAI).

Editor's Note: It is FFS whether to allow UE to modify the URSP rule by itself.

\* \* \* \* End of changes \* \* \* \*