**3GPP TSG-WG SA2 Meeting #140 E e-meeting *S2-200xxxx***

**Elbonia, August 19 – September 02, 2020 (revision of S2-200xxxx)**

**Source: Huawei, HiSilicon**

**Title: Solution #1 for KI#4**

**Document for: Approval**

**Agenda Item: 8.4**

**Work Item / Release: eNS\_Ph2 / Rel-17**

*Abstract: This contribution proposes updates of Solution #1 to cover KI#4 by introducing interactions with AF for event notification and quota status reporting in TR 23.700-40.*

# 1. Discussion

This contribution proposes the solution #1 extension for KI#4 by introducing interactions with AF for event notification.

* Solution #1: ‘PCF measurement based Network Slice SLA control for Maximum Number of UEs parameter’ supports Key Issue #1, "Support of network slice related quota on the maximum number of UEs" and **Key Issue #4, "Support for network slice quota event notification in a network slice"**.

# 2. Text Proposal

It is proposed to capture the following changes to TR 23.700-40.

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

## 6.0 Mapping Solutions to Key Issues

Table 6.0-1: Mapping of Solutions to Key Issues

|  |  |  |
| --- | --- | --- |
| Solution#'s | Solution Titles | Key Issue#'s |
| 1 | PCF measurement based Network Slice SLA control for Maximum Number of UEs parameter | 1 & 4 |
| 2 | Max number of UEs per Network Slice control at registration | 1 |
| 3 | AMF/NSSF based counting of UEs in a Network Slice | 1 |
| 4 | NWDAF enhancements for supporting of network slice quota on the maximum number of UEs | 1 |
| 5 | NWDAF enhancements for supporting of network slice quota on the maximum number of PDU Sessions | 2 |
| 6 | PCF-based counting of PDU Sessions in a Network Slice | 2 |
| 7 | Support of Network Slice SLA for Maximum Number of PDU sessions parameter | 2 |
| 8 | AMF and O&M based solution | 1, 2 & 4 |
| 9 | Monitoring multiple quotas of number of UEs/PDU Sessions per S-NSSAI at NWDAF | 1, 2 & 4 |
| 10 | Max number of PDU Sessions per Network Slice control via NSQ function | 2 |
| 11 | Handling maximum number of sessions using NF status | 2 |
| 12 | NSQ assisted dynamic adjustment of data rate per slice via NAS signaling | 5 |
| 13 | Limitation of data rate per network slice in UL and DL per UE | 3 |
| 14 | **UE-Slice-AMBR adjustment to meet the limitation of data rate per Network Slice** | 5 |
| 15 | **Using Back-off timer** | 1 |
| 16 | **Slice data rate enforcement and dynamic adjustment** | 5 |
| 17 | Support of radio spectrum attribute by CN assisted RAN control | 7 |
| 18 | **Proactive Slice Quota Management in AMF** | 1, 2, 4, 5 |
| 19 | **Support of network slice quota control and enforcement** | 1, 2 & 5 |
| 20 | Reusing existing QoS model to ensure that to limit the Maximum throughput UL/DL in a Network slice is not exceeded | 3 & 5 |
| 21 | **Limitation of data rate per network slice in UL and DL per UE without RAN involvement** | 3 |
| 22 | **Solution on limitation of data rate per Network Slice in UL and DL per UE** | 3 |
| 23 | **Network slice quota event notification** | 4 |
| 24 | **NSQ assisted dynamic adjustment of data rate per slice via user plane adjustment** | 5 |
| 25 | **Enforcement of MBR UL/DL per S-NSSAI** | 5 |
| 26 | **Network controlled enforcement of simultaneous usage of network slices based on user preference** | 6 |
| 27 | **Network slices simultaneous usage incompatibility support** | 6 |
| 28 | Constraints on simultaneous use of the network slice | 6 |
| 29 | **Providing Operating Band Information in the Configured NSSAI** | 7 |
| 30 | Preferred frequency bands in Configured NSSAI | 7 |
| 31 | Steering the UE to a network slice in a different frequency band | 7 |

\* \* \* \* Second change \* \* \* \*

## 6.1 Solution #1: PCF measurement based Network Slice SLA control for Maximum Number of UEs parameter

### 6.1.1 Introduction

This is a solution to Key Issue #1, "Support of network slice related quota on the maximum number of UEs" and Key Issue #4, "Support for network slice quota event notification in a network slice". This solution assumes the following:

- It is assumed that Unified Data Repository (UDR) obtains information about network slice related global quota on the slice SLA attributes, e.g., maximum number of UEs from OAM to perform the enforcement of SLA of the number of UEs in a control plane procedure, and supports the functionalities of storage and retrieval of slice SLA data.

- It is assumed that 5GC may have multiple enforcement points (e.g., PCF instances of a Network Slice) to perform the SLA enforcement of network slice related quota on the maximum number of UEs.

- It is assumed that multiple enforcement points (i.e., PCF instances) of a network Slice are controlled by a central enforcement point (i.e., a master PCF) of the network slice. The central enforcement point (i.e., a master PCF for the S-NSSAI) obtains the global quota of the slice SLA attributes, maximum number of allowed UEs from UDR.

- It is assumed the central enforcement point (i.e., the master PCF of a given S-NSSAI) supports the functionalities of controlling distribution of the network slice related quota on maximum number of UEs parameter. The functionalities include the (re)-distribution of the received global quota of each slice SLA attribute from UDR to the associated multiple enforcement points (i.e., slave PCF instances of the associated S-NSSAI). The central enforcement point (i.e., the master PCF) can be found by its multiple distributed enforcement points (i.e., slave PCFs ) based on configuration or the assistance of the UDR.

- It is assumed that the support of Network Slice related quota on the maximum number of UEs applies to the associated Network Slice even when supported by multiple Network Slice instances.

- It is assumed that the AF interacts with central enforcement point (i.e., the primary PCF of a given S-NSSAI) for event notification of Network Slice related quota on number of registered UEs for a given S-NSSAI.

### 6.1.2 High-level Description

A global slice SLA information is the global quota of the maximum number of UEs for a given S-NSSAI. A local slice SLA information is the local quota of the maximum number of UEs for a given S-NSSAI, which is stored at the enforcement points, e.g. PCF instances. The local quota of a slice SLA attribute is based on the global quota of a slice SLA attribute.

The proposed solution highlights controlling distribution of network slice related quota at the control plane performed by 5GC NFs: PCF and /UDR. It considers a master PCF of a given S-NSSAI /UDM for controlling distribution of the network slice related local quota to its slave PCF instances. The slave PCF instances apply/enforce the associated network slice related local quotas in registration procedure.

The mechanisms of distributed management of a network slice attribute related quota by a central enforcement point (i.e. a master PCF of a given S-NSSAI) provides a precise control of slice SLA for maximum number of UEs.

### 6.1.3 Procedures

#### 6.1.3.1 General

The following figure represents a high-level principles and workflow procedure of the solution.



Figure 6.1.3-1: A high-level workflow of the solution

1. UDR in 5GC obtains from OAM global slice SLA information including a global quota on the maximum number of allowed UEs per S-NSSAI and stores the global slice SLA information. A master PCF of a given S-NSSAI obtains the global quota on the maximum number of allowed UEs from UDR to be used to perform the distribution of local quota of slice SLA control on the number of UEs. The UDR store the S-NSSAI and its associated master PCF.

2. A Master PCF provides the local slice SLA information including local quotas of the maximum number of allowed UEs per S-NSSAI to its slave PCF instances (which is for AM policy control) of the related Network Slice (enforcement points). A master PCF may keep a shared quota of the maximum number of allowed UEs per S-NSSAI (e.g., to handle the delegation requests from its slave PCFs). The sum of the local quotas to the associated slave PCF instances of S-NSSAI shall be less or equal to the network slice related global quota of the maximum number of UEs per S-NSSAI.

NOTE: This local quota distribution of a S-NSSAI can be performed before a UE registration request for the S-NSSAI arrives (e.g., pre-configuration) or it can be triggered by a master PCF after the registration request(s) for the S-NSSAI by a slave PCF. It is also possible that a slave PCF has no local quota granted by a master PCF, e.g., based on the operator's policy.

3. When a UE registers for the network slice, the AMF instance of the network slice interacts with the proper PCF instance (enforcement point) for the quota enforcement by re-using existing Registration procedure, i.e. as part of the AM Policy handling. The allowed S-NSSAI(s) of UE are provided to the PCF when the AMF interacts with the PCF.

4. Quota enforcement:

4a. For the S-NSSAI which needs quota control, each PCF instance (enforcement point) associated to the S-NSSAI maintains the local quota sent by its master PCF for the associated number of allowed registered UEs. Each PCF instance generates a policy counter to track the local quota (i.e. per S-NSSAI the allowed number of registered UEs, received from master PCF) and the local quota status (i.e., per S-NSSAI the actual number of registered UEs). Upon receiving UE registration request, the PCF instance decides, based on the local quota status and local quota of the S-NSSAI, the acceptance or rejection of the UE registration request for that S-NSSAI.

4b. In addition to step 4a, the PCF instance may send a delegation request of quota enforcement for the indicated S-NSSAI to its master PCF, e.g., when the local quota of the S-NSSAI is consumed by the PCF instance or the slave PCF has no local quota granted per operator's policy. Based on the global/shared quota status of the S-NSSAI the master PCF (e.g. interaction with UDR) decides the acceptance or rejection of the delegation request for the UE registration on the indicated S-NSSAI and sends a response to the delegation request with the decision to the PCF.

 The detail procedure of quota enforcement in registration procedure is described in clause 6.1.3.2.

5. Upon PCF decision from step 4, PCF sends the response of the registration request for S-NSSAI(s) to the serving AMF. If all requested S-NSSAI included in the UE registration request violates or exceeds the related quotas of the requested S-NSSAIs the decision for the registration request can be decided based on, e.g., operator policy in PCF, The PCF sends an indication, e.g. rejection message, to the serving AMF. The Registration Reject message is sent to the UE by a serving AMF along with the back-off timer and a suitable cause value. If the registration request of one or more S-NSSAI is accepted, the AMF send the Registration Accept message to the UE, which includes the Allowed S-NSSAI(s), and Rejected S-NSSAI(s) and associated back-off timer if needed.

6. It is possible at any time the UE initiates the registration procedure to update the allowed S-NSSAI(s), e.g. adding/removing one S-NSSAI to the Allowed NSSAI. In that case the AMF compares the updated Allowed NSSAI with the stored Allowed NSSAI and notifies the status to the PCF. The PCF decides the update the policy counter(s) of associated S-NSSAI(s).

7. Independently of registration with quota enforcement procedure in step 1-6, local slice SLA quota re-distribution can be triggered by (slave) PCF instances or the master PCF of the network slice at any time. The detail procedure of controlling (re)-distribution of local quota is described in clause 6.1.3.4.

7a. PCF instances (enforcement points) may request their local quotas update for the indicated S-NSSAI (e.g., when the local quotas are (about to) consumed) to the master PCF. The master PCF based on the received requests may re-calculate and provide the updated local quota of the maximum number of UEs associated with the indicated S-NSSAI to one or more PCF instances. The master PCF supports mechanisms for the (re)-distribution of local quota(s) to one or more PCF instances of associated S-NSSAI based on the global quota status of registered number of UEs of the indicated S-NSSAI.

7b. Independently of step 7a, one or more PCF instances (enforcement points) shall report/notify the local quota statuses per S-NSSAI to the master PCF (e.g., periodically or event based). Based on the reported local quotas the master PCF can track the global status of number of registered UEs of indicated S-NSSAI and provides to one or more PCF instances an updated local quota (i.e., quota re-distribution) if required. It enables 5GS to know about the current number of UEs accessing the network slice, i.e. specific S-NSSAI.

8. Independently of registration with quota enforcement and controlling local quota (re)-distribution, a de-registration for a S-NSSAI can be triggered by a UE (or network) any time.

8a. A UE triggers a de-registration request to the serving AMF. The AMF triggers the update of policy counter to the associated PCF during AM policy association termination procedure.

8b. Upon receiving a deregistration request from the AMF, the slave PCF of the S-NSSAI increases the remaining local quota of the S-NSSAI by one. If the slave PCF has no local quota been granted per operator's policy, the slave PCF may interact with the master PCF for the quota update.

8c. The response of the deregistration of the S-NSSAI is sent to the UE by the serving AMF.

The detail procedure of deregistration of a S-NSSAI is described in clause 6.1.3.3.

In the roaming case, the UDM in the VPLMN shall receive the local quota for the allowed maximum number of UEs per Subscribed S-NSSAI per SLA agreement and store it in VPLMN UDR as local policy data. The V-PCF in VPLMN can perform the corresponding network slice enforcement for the related S-NSSAI in the serving network based on the received local quota from the UDR and UE PLMN ID.

#### 6.1.3.2 General Registration with Quota Enforcement



Figure 6.1.3.2-1: General registration procedure with quota update

1. Registration procedure (steps 1-15) according to clause 4.2.2.2.2 in TS 23.502 [6].

2. The AMF performs an AM Policy Association Establishment/Modification. The allowed S-NSSAI(s) and its associated operation (i.e. increment or decrement of the associated policy counter) is also provided to the PCF.

3. For each indicated allowed S-NSSAI, per the received allowed S-NSSAI(s) and its associated operation the PCF verifies the status of the associated local quota based on its policy counter of a slice parameter, the number of registered UEs. A policy counter per S-NSSAI indicates the local quota and its status, which comprises information of remaining number of allowed UEs and consumed number of UEs. If the number of UEs for the specific S-NSSAI is still within a valid bound, there is no negative affect for the registration request of that S-NSSAI.

4a. Upon identification of no quota left or the slave PCF has no local quota granted, the PCF instance shall decide for the delegation of quota enforcement to the master PCF. The delegation of quota enforcement message includes the S-NSSAI and its associated operation.

4b. The master PCF upon receiving the delegation message, verifies the status of the shared quota of the requested S-NSSAI and decides the acceptance or rejection based on the status of a shared quota of each requested S-NSSAI. The master PCF has its own policy counter per S-NSSAI to manages the status of a shared quota in the same way as the slave PCF per S-NSSAI4c. Based on step 4b, the master PCF sends a message to its requested PCF instance. The response message includes an indication to accept the registration or rejection of the indicated S-NSSAI.

5. Based on step 3 or 4b, the local quota status is updated (e.g., increase the associated policy counter value for the indicated S-NSSAI by one).

6. The PCF instance sends the response of quota enforcement (i.e., acceptance or rejection) of S-NSSSAI(s), based on step 3 or step 4c, to the AMF instance.

 If more than one allowed S-NSSAI is provided to PCF, it is possible that part of S-NSSAIs is authorized and others are rejected per the action taken in step 3 or 4c.

**Alt A**: UE registration request includes at least one S-NSSAI, which does not violate or exceed the local quota without delegation of quota enforcement, or the shared/global quota with delegation of quota enforcement.

7. Registration procedure (steps 17-22) according to clause 4.2.2.2.2 in TS 23.502 [6].

 If one S-NSSAI is rejected, it is included in the rejected NSSAI and associated with cause value and back-off timer.

 If the transaction is not completed successfully, e.g. the registration accept message is not received by the UE, the incorrect count at the PCF is corrected when the AMF deregister the UE due to the periodic registration timer expires.

**Alt B:** All the S-NSSAIs in theUE registration request violates or exceeds the local quota without delegation of quota enforcement, or the shared/global quota with delegation of quota enforcement.

8. The Network cleans the related state, e.g. the AMF changes the UE registration state as deregistered.

9. The AMF sends a registration reject message to the UE, which includes the Rejected NSSAI, associated cause value and back-off timer.

In the following when the UE initiates the registration procedure to update the registered S-NSSAI, e.g. adding one S-NSSAI to the Allowed NSSAI, the AMF compares the updated Allowed NSSAI with the stored Allowed NSSAI.

If one S-NSSAI is added into the Allowed NSSAI, the AMF checks with the PCF on whether this Allowed NSSAI is permitted per the status of quota information. If one S-NSSAI is removed from the Allowed NSSAI, the AMF notifies this status to the PCF.

#### 6.1.3.3 Deregistration with Slice SLA Quota Update



Figure 6.1.3.3-1: Deregistration procedure with Slice SLA quota update.

UE is deregistered, which slice Quota management is required.

1. UE or network initiates a deregistration procedure according to (steps 1-5) in clause 4.2.2.3.2 or (step 1-4) in clause 4.2.2.3.3 in TS 23.502 [6], accordingly.

2. During the AM policy association termination procedure as defined in clause 4.16.3.2 in TS 23.502 [6], for each S-NSSAI the PCF instance of the deregistered UE decreases the policy counter value of a given S-NSSAI by one.

 Optionally, If the PCF instance of the UE does not have local quota granted, e.g., as per operator's policy, the PCF instance delegates the request of policy counter update for the deregistration of the S-NSSAI to the master PCF. The master PCF decreases the policy counter value of the indicated S-NSSAI and sends the response to the slave PCF.

NOTE: If the PCF instance has local quota granted before, during the de-registration procedure, the involvement of the master PCF is not required. The local quota reporting and re-distribution mechanism described in clause 6.1.3.4 can be used to recover the previously delegated requests to the master PCF of the indicated S-NSSAI.

3. UE or network initiates deregistration procedure according to (steps 6a-8) in clause 4.2.2.3.2 or (steps 5a-7) in clause 4.2.2.3.3 in TS 23.502 [6], accordingly.

#### 6.1.3.4 Controlling (re)-distribution of local quota of Slice SLA attributes



Figure 6.1.3.4-1: Controlling (re)-distribution of local quotas of slice SLA attributes

The procedures of local quota distribution and re-distribution between a master PCF and its slave PCFs of a specific S-NSSAI are described in Figure 6.1.3.4-1.

1. Local quota distribution.

 Based on the received global quota of maximum number of allowed UEs from UDR, a master PCF may proactively distributes the local quotas of maximum number of allowed registered UEs to the associated PCFs of the specific S-NSSAI. For example, a local quota is given to the slave PCF to reduce signalling.

NOTE: How much local quota shall be distributed on each PCF instance of S-NSSAI can be determined based on Operator policy (e.g., equal local quota distribution, with respect to the estimated load of PCFs, etc.)

2. For the specific S-NSSAI, Local quota re-distribution - Local quota status reporting.

2a. The master PCF subscribes the status of local quotas to its PCF instances, which may include time interval or an event trigger, e.g. when the remaining quota is less than 5% of the local quota or above a threshold.

2b. Each PCF instance triggers the report of the status of the local quota to the master PCF based on, e.g., events (as described in 2a) or periodically.

2c. Optionally, the master PCF requests the status of local quotas to the specific PCF instances.

2d. Upon receiving the request, the requested PCF instances send the statuses of local quota report to the master PCF.

3. For the specific S-NSSAI, Local quota re-distribution - triggering.

3a. The master PCF may trigger the update of quota re-distribution to the other slave PCF instances without the requests of quota update from these PCFs. The trigger is initiated based on the status of global quota or based on the local quota updates from other PCF instances of the same S-NSSAI, as described in 2a.

3b. One or more PCF instance send request(s) for local quota(s) update to the master PCF.

3c. Upon receiving of one or more local quota update requests from slave PCFs, the master PCF provides re-distribution of local quotas to one or more PCF instances.

#### 6.1.3.Y Interactions with AF for event notification and report of Network Slice attributes related quota

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Figure 6.1.3.Y-1 The interaction of a primary PCF and AF for the Network Slice attribute of maximum number of UEs.

1a. The AF subscribes for an event notification of registered number of UEs parameter of S-NSSAI via NEF to the 5GS. The subscription request includes the information of Network Slice and event notification information, e.g., threshold for quota notification.

1b. Upon receiving the subscription request from AF, the NEF checks whether the AF is authorised for the requested subscription. If this check successes, the NEF query the UDR or others to find the primary PCF.

The NEF initiate a subscription request to the primary PCF.

2. The primary PCF checks the event subscriptions (e.g., threshold for quota notification related to the registered number of UEs) and triggers the notification to the AF when the event occurs.

3a,3b. The primary PCF notifies the event to the AF directly or via NEF based on the event notification information.

4a. Independently, the AF may request the status of registered number of UEs of the S-NSSAI to the 5GS via NEF.

4b. Upon receiving the status request from AF, the NEF checks that the AF is authorised for the request. If this check successes, the NEF find the primary PCF and invokes a status request service to the primary PCF.

5. The primary PCF performs the request based on the status of the registered number of UEs of the indicated S-NSSAI.

6a,6b. The primary PCF reports the request to AF via NEF.

Based on the event notification from step 3a,3b or the status report from step 6a,6b about the registered number of UEs quota of the S-NSSAI, the slice SLA re-negotiation can be triggered.

### 6.1.4 Impacts on services, entities and interfaces

UDR: obtaining, storing and allowing retrieval of global slice SLA information including a global quota on the maximum number of registered UEs.

PCF: A master PCF of a given S-NSSAI for distributing/providing the network slice related shared/local quota on the maximum number of UEs; and its slave PCF to apply/enforce the network slice related local quota on the number of UEs

AMF: handling of quota enforcement decision on the number of UEs

UE: handling of back-off timer and a (new) cause value as a rejection response

Editor's note: Impacts on existing services and interfaces are FFS.

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