**3GPP TSG-WG SA2 Meeting #154-AH-e *S2-220xxxx***

**Elbonia, 16 - 20 Jan 2023 (revision of S2-220xxxx)**

**Source: Huawei, HiSilicon**

**Title: KI#4, evaluations and conclusions**

**Document for: Approval**

**Agenda Item: 9.2.1**

**Work Item / Release: FS\_GMEC / Rel-18**

*Abstract: Discuss the solutions for KI#4-Multiple SMFs for VN group communication, and capture the evaluations and conclusions.*

# 1. Introduction/Discussion

There are 6 solutions (sol#3, sol#4, sol#5, sol#16, sol#19, and sol#20) for this KI. The main aspects include the following aspects:

- Support of SMF redundancy for reliability of the 5G VN group communication

- Rel-16 compatibility issue

- Architectural enhancements a) How to manage session management when multiple SMFs are involved to serve a 5G VN group b) How to manage communication among the UE group members when they are served by different UPFs and different SMFs including the case of UE(s) mobility

The evaluation of solutions for key issue #4 separates into two aspects and uses the principles as below table:

| Objectives | Principles | Impacts | Solution |
| --- | --- | --- | --- |
| Serving SMF selection | All the SMF serving the same 5G VN group belongs to a single SMF set | NRF configuration with association between DNN/S-NSSAI and single SMF Set | sol#3 |
| All the SMF serving the same 5G VN group can belong to different SMF sets | NRF configuration with association between DNN/S-NSSAI and multiple SMF Sets | sol16 |
| All the SMF serving the same 5G VN group can belong to different SMF sets | NRF or GSMF: supports SMF discovery using serving VN ID.  SMF: Update/Register serving VN ID to NRF or GSMF. | sol#4, sol#5, sol#19, sol#20, |
| Introduce the Single-SMF indicator as part of the group data in group subscription data so the SMF can be informed that whether this 5G VN group needs multiple SMFs | AF/NEF/UDM/UDR: support Single-SMF indicator when defining the 5G VN group.  SMF: handle the Single-SMF indicator in the received 5G VN group data. | sol#19 |
| Connection of PSA UPFs | N19 tunnels between UPFs controlled by SMFs in a single SMF set are set up.  N6-based forwarding is applied between UPFs controlled by SMFs in different SMF sets.  Local switching at I-UPF as instructed by A-SMF is applied. | SMF: Implementation dependent signaling can be used between SMF(s) that are part of a SMF set e.g. based on an implementation choice SMF(s) within the set can select one SMF to control the N19 configuration.  UPF: Support of VPN solution towards N6, e.g. to act as Provider Edge router in IP/E VPN solution based on IETF RFCs.  AF/NEF/UDM/SMF: Support of "usage of PSA UPF" event. | sol#3, sol#16 |
| N19 tunnels between UPFs controlled by SMFs in either the same SMF set or different SMF sets are set up. | SMF: two SMFs interact with each other to establish/update N19 tunnels and routing rules directly or indirectly via GSMF/relay-SMF. | sol#4, sol#5 sol#19, sol#20 |

## 1.1 Support of SMF redundancy for reliability of the 5G VN group communication

To support SMF redundancy for reliability of the 5G VN group communication, the SMFs serving a 5G VN group can belong to the same SMF Set (e.g. solution #3) or different SMF Sets (e.g. solution #4, #5, #16, #19, #20). In the latter case, the SMFs serving a 5G VN group can benefit from multiple-vendor SMF deployment to support a 5G VN group. Moreover, the latter case enables the network operator to flexibly scale up/down a 5G VN group, e.g., the coverage, capacity.

To support a 5G VN group over a wide area (e.g. nationwide), the network operator can deploy

- One or more SMF sets in each region within the service area of the 5G VN group for solution #4, #5, #19, and #20.

- A central SMF set with distributed I-SMF in each region within the service area of the 5G VN group for solution #3.

**Observation 1:** Multiple SMF Sets based deployment supports multiple-vendor SMF redundancy for reliability of the 5G VN group communication. To achieve this, 5G VN group is extended with one or more SMF Sets via associating one or more SMF Sets with the DNN, S-NSSAI of the 5G VN group via NRF

**Proposal 1:** Multiple SMF Sets for a 5G VN group is supported by association between one or more SMF Sets and the DNN, S-NSSAI of the 5G VN group in NRF.

## 1.2 Rel-16 compatibility issue

Rel-16/17 5G VN group is served by only one SMF instance and Rel-18 5G VN group may be supported by one or more SMF Sets. In order to enable correct SMF selection for either the Rel-16/17 5G VN group or Rel-18 5G VN group, associations between the only SMF instance or more SMFs and the DNN, S-NSSAI of the 5G VN group can be registered or discovered via NRF.

The SMFs that serve a 5G VN group should be available in the service area of the 5G VN group, and the NRF stores the association between such SMFs and the DNN, S-NSSAI of the 5G VN group. The service area for a Rel-16/17 5G VN group is considered equal to service are of the common SMF instance of the Rel-16/17 5G VN group. The service area of a Rel-18 5G VN group may change by AF via Parameter Provisioning service as concluded by KI#1, this may trigger the SMF to update its association with the Rel-18 5G VN group in NRF.

**Observation 2:** Rel-16 compatibility issue can be addressed by Proper NRF configuration e.g. associations between the only SMF instance and the DNN, S-NSSAI of the Rel-16/17 5G VN group or associations between the one or more SMFs and the DNN, S-NSSAI of the Rel-18 5G VN group. The SMFs that serve a 5G VN group should be available in the service area of the 5G VN group. The update of the service area of a 5G VN group may trigger the SMF to update its association with the 5G VN group in NRF.

**Proposal 2:** The SMFs that serve a 5G VN group should be available in the service area of the 5G VN group. The update of the service area of a 5G VN group may trigger the SMF to update its association with the 5G VN group in NRF.

## 1.3 Architectural enhancements

To support traffic forwarding between the UPFs controlled by different SMFs serving a 5G VN group, either the N6-based forwarding or N19-based forwarding is used:

- If N6-based forwarding is used, how to transmit traffic over N6 depends on configuration and is out of 5GC control but could remain under operator control when the operator administers N6 connectivity. For example, solution #16 proposes to use Native N6 or N6 Overlay (IP/E-VPN) and it ensures the correct connectivity between UPFs via proper configuration between all UPFs supporting the DNN/S-NSSAI of a 5G VN group. However, if the network operator deploys many UPFs for the DNN/S-NSSAI of a 5G VN group, each time a new UPF is deployed or a UPF is released, the network operator needs to re-configure the connectivity between UPFs. This could be alleviated by "usage of PSA UPF" event notifications from SMF to an AF responsible of the management of the N6 connectivity for a VN group

- If N19-based forwarding is used, the 5GC is in charge of the N19 tunnel establishment and routing rules over the N19 tunnel. The 5GC can dynamically control the N19 connectivity for a newly joined UPF or released UPFs for a 5G VN group, as well as the routing rules over the N19 connectivity. For example, solution #4, #5 and #20 propose to enable SMF discovery and selection, exchange of N19 tunnel and UE address between SMFs, as well as the UPF N19 connectivity topology management.

Since Rel-16, two-step forwarding approach (i.e. 5G VN internal interface) is specified to support local switching, N19-based forwarding, and N6-based forwarding. In Rel-18, the same local switching, N19-based forwarding, N6-based forwarding can also be used for a 5G VN group. In particular, N19-based forwarding can be an option for the MNO to connect e.g. different bank branches, or different electric campuses, or different enterprise sites. This option enables the MNO to quickly apply the 5G LAN-type service to the verticals and control the forwarding between sites/branches/campuses on demand. Since 5GC controls N19-based forwarding automatically to achieve group communication routing between UPFs for a specific group, this provides flexibility to scale in/scale out a 5G LAN-type service.

### 1.3.1 For UPFs served by a single SMF Set

For UPFs served by a single SMF Set, N19-based forwarding, 5G VN group communication (i.e. N6-based forwarding and local switch) as per Rel-17 can be used with the following clarifications on session management:

- The SMF set or SMF instances in SMF set need to support functionality for 5G VN group communications across SMFs. As an example, The SMF(s) can share contextual information associated with the 5G VN group (DNN + S-NSSAI). The contextual information may e.g. relate to the N19 configuration, to the list of PDU Sessions established by 5G VN group members, etc.

- No standard impacts are expected for this purpose except a NOTE such as: Implementation dependent mechanism can be used between SMF(s) that are part of a SMF set e.g. based on an implementation choice SMF(s) within the set can select one SMF to control the N19 configuration.

**Proposal 3:** 5G VN group communication for UPFs served by a single SMF Set can be supported per Rel-17 mechanism and Implementation dependent mechanism.

### 1.3.2 For UPFs served by different SMF Sets

There are two ways to enable the 5G VN group communication for UPFs served by different SMF Sets, the connectivity between those UPFs is either static configured (sol#3 and #16) or dynamically controlled (so#4, #5, #19 and #20):

- in case of static connectivity, correct N6 connectivity between UPFs supporting the DNN/S-NSSAI of a 5G VN group needs to be guaranteed via configuration. N6 connectivity between all related UPFs are pre-configured, so the transmission QoS, security, forwarding of the N6 interface between UPFs are not controlled by 3GPP but may be controlled by the 3GPP operator when it administers N6 connectivity. If the network operator deploys many UPFs for the DNN/S-NSSAI of a 5G VN group, each time a new UPF is deployed or a UPF is released, the network operator needs to re-configure the connectivity between UPFs. If notifications from SMF to an AF responsible of the management of the N6 connectivity is used, then it includes additional impacts.

In order to alleviate the configuration work, only one UPF for each SMF Set will be configured with the static connectivity to enable 5G VN group communication across SMF Sets. Within each SMF Set, the traffic that does not match with local switching or N19-based forwarding will be routed to the selected UPF for this SMF Set, this selected UPF will then forward the traffic to the selected UPF within other SMF Sets. For IP-type traffic, the selected UPF can route the traffic using different IP address range/prefix corresponding different IP domains; for ethernet-type traffic, the selected UPF can route the traffic based on the learned MAC address over the static connectivity, e.g. ARP messages. The implementation of the static connectivity between these UPFs is up to network implementation and deployment.

**Proposal 4:** Static connectivity can be configured via OA&M between PSA UPFs controlled by different SMF sets, only one UPF within each SMF Set is configured with the static connectivity and how to implement the static connectivity is up to network implementation and deployment.

- **in case of dynamic control of the connectivity,**

a) new “usage of PSA UPF” event is introduced to allow AF to subscribe for insertion/ removal of a PSA UPF to serve the DNN and S-NSSAI associated with the 5G VN group. Based on the N6 addressing information of the PSA UPF that has been added or removed in SMF notifications, the AF may update the N6 forwarding capabilities.

This method assumes the transmission QoS, security, forwarding of the N6 interface between UPFs are controlled by AF, but not controlled by the 3GPP operator. This method also exposes sensitive network information to the AF. It has a lot of systematic impacts on NEF, UDM, SMF and UPF etc.

b) N9 between I-UPF and PSA UPF is used per Rel-16/17 mechanism, but N16a communication between A-SMF and I-SMF is enhanced to enable A-SMF to instruct the local PSA UPF via I-SMF to support N19-based forward or local switching.

This method doesn't support dynamic control of connectivity between UPFs under different Anchor SMF sets, the data synchronization across different regions/data centres will become big in real deployment for a single SMF set serving a 5G VN group spread over a huge country. And this needs the network to deploy ETSUN first, and are still lack of the information flows to support N16a enhancements.

c) new SMF-SMF interface is introduced to manage the 5GVNSM session, over which the information of N19 tunnel between UPFs controlled by different SMF Sets and the UE addresses anchored at each UPF can be exchanged between SMF Sets to control the N19-based forwarding.

This method assumes the network deployment determines the UPF topology e.g. full mesh or star, and the N19 tunnels for UPFs in use and forwarding rules for active UEs are always ready to be used following the interactions between SMF-SMF interfaces. If the UPF cannot match a packet with local switching nor N19-based forwarding, then this packet can be discarded or routed to N6 by default PDR and FAR. This assumption aligns with the Rel-16.

d) New NF: GSMF is specified to store the SMFs and UPFs that serve a 5G VN group, at the same time, it receives from a SMF instance the information of N19 tunnel for each UPF controlled by the SMF and the UE addresses anchored at each UPF controlled by the SMF, so the GSMF can

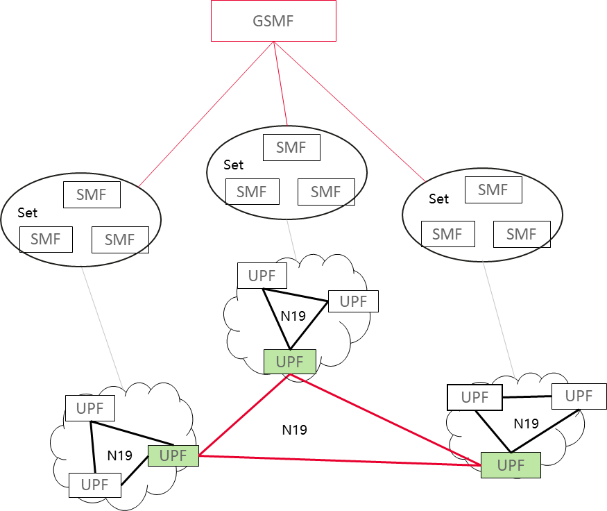
- Proactive approach - inform the changes on N19 tunnel information and UE addresses for a UPF of one SMF to all the other SMFs that serve the 5G VN group.

This method has the same assumption as c) and can benefit from a more efficient manner to manage the exchange messages between SMFs.

- Reactive approach - inform the information of N19 tunnel for an indicated target UE address to the SMF that queries or subscribes about that address.

This method assumes that the N19 tunnel and related forwarding rule can be installed based on on-demand packet. The SMF installs a default PDR containing a match-all Packet Filter and a Precedence set to the lowest precedence value and an associated URR to report the unknown destination address. If a UPF cannot match a packet with local switching nor N19-based forwarding, then the UPF matches the packet with the default PDR, and the URR indicates this UPF to report the unknown destination address of the packet to SMF. If the SMF knows that the unknown destination address is managed by itself or managed by other SMFs by querying and subscribing to GSMF about the N19 tunnel information for the unknown destination address, the SMF updates the local switching and N19-based forwarding at the UPF, otherwise the SMF applies N6-based forwarding for that destination address or discards such packet. Compared to Proactive approach, this can save a lot of N4 signaling.

Similar with the static connectivity, in order the reduce the signaling overload, only one UPF within each A-SMF Set is selected to connect with other UPFs served by different SMF Sets. The traffic that does not match with local switching or N19-based forwarding will be routed to that selected UPF, then the selected UPF forwards the traffic to the corresponding UPFs within other SMF Sets.



**Observation 3:** Support of dynamic control of the connectivity between UPFs under different (A-)SMF Sets enables 5GC controlled VN group communication in an automatic manner. There is almost same level of impacts to support dynamic management of N6-based forwarding (a) and N19-based forwarding (c, d). While support of N19-based forwarding allows MNO to flexibility to scale in or scale out the 5G LAN-type service. The introduction of a GSMF can benefit from a more efficient manner to manage the exchange messages between SMF Sets.

**Observation 4:** Method b) has dependency on ETSUN deployment and is not applicable for case where multiple A-SMF sets exist.

For dynamic control of the connectivity between UPFs controlled by different SMF Sets, a SoH was performed in CC#1 of last SA2#153e meeting, there is no clear way forward achieved. Still there is no consensus reached after offline discussion during SA2#153e and SA2#154 meeting. At the end of SA2#153e meeting, the companies have different views on how to handle this open issue, some prefer to keep the ENs to not lose the progress, some prefer to defer those open issues to normative phase, some prefer to delete the ENs, some insist to explicitly state that this open issue is not pursued in R18.

**Observation 5:** There is no consensus for how to support dynamic control of the connectivity between UPFs controlled by different SMF Sets, and now different views on how to move forward with this open issue defer the whole conclusion progress for KI#4.

**Proposal 5:** To move forward for dynamic control of the connectivity between UPFs controlled by different SMF Sets, the following can be a compromise

- N16a between A-SMF Set and I-SMF Set is improved to enable A-SMF Set to control 5G VN group communication for I-UPF/local PSA under I-SMF Set, the N9 is used to route traffic between I-UPF controlled by I-SMF and A-UPF controlled by A-SMF per existing mechanism.

- The GSMF is used for dynamic management of N19-based connectivity between the A-UPFs, each of them is served by different A-SMF Sets.

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

## 7.4 Key Issue #4: Multiple SMFs for VN group communication

There are 6 solutions (sol#3, sol#4, sol#5, sol#16, sol#19, and sol#20) for this KI. The main aspects include support of SMF redundancy for reliability of the 5G VN group communication and which architectural enhancements, if any, are needed to enable the support of multiple SMFs to serve a 5G VN group. The evaluation of key issue #4 is summarized as below table:

Table 7.X-1: Evaluation of KI#4 related solutions

| Objectives | Principles | Impacts | Solution |
| --- | --- | --- | --- |
| Serving SMF selection | All the SMF serving the same 5G VN group belongs to a single SMF set | NRF configuration with association between DNN/S-NSSAI and single SMF Set | sol#3 |
| All the SMF serving the same 5G VN group can belong to different SMF sets | NRF configuration with association between DNN/S-NSSAI and multiple SMF Sets | sol16 |
| All the SMF serving the same 5G VN group can belong to different SMF sets | NRF or GSMF: supports SMF discovery using serving VN ID.  SMF: Update/Register serving VN ID to NRF or GSMF. | sol#4, sol#5, sol#19, sol#20, |
| Introduce the Single-SMF indicator as part of the group data in group subscription data so the SMF can be informed that whether this 5G VN group needs multiple SMFs | AF/NEF/UDM/UDR: support Single-SMF indicator when defining the 5G VN group.  SMF: handle the Single-SMF indicator in the received 5G VN group data. | sol#19 |
| Connection of PSA UPFs | N19 tunnels between UPFs controlled by SMFs in a single SMF set are set up.  N6-based forwarding is applied between UPFs controlled by SMFs in different SMF sets.  Local switching at I-UPF as instructed by A-SMF is applied. | SMF: Implementation dependent signaling can be used between SMF(s) that are part of a SMF set e.g. based on an implementation choice SMF(s) within the set can select one SMF to control the N19 configuration.  UPF: Support of VPN solution towards N6, e.g. to act as Provider Edge router in IP/E VPN solution based on IETF RFCs.  AF/NEF/UDM/SMF: Support of "usage of PSA UPF" event. | sol#3, sol#16 |
| N19 tunnels between UPFs controlled by SMFs in either the same SMF set or different SMF sets are set up. | SMF: two SMFs interact with each other to establish/update N19 tunnels and routing rules directly or indirectly via GSMF/relay-SMF. | sol#4, sol#5 sol#19, sol#20 |

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

## 8.4 Key Issue #4: Multiple SMFs for VN group communication

The following are way forward principles for normative work.

- The multiple SMFs serving a same 5G VN group can belong to a single SMF Set or different SMF Sets, this is to support SMF redundancy for reliability of the 5G VN group communication

- The associations between one or more SMF Sets and the DNN, S-NSSAI of the associated 5G VN group is registered and discovered in NRF per existing mechanisms (SMF registers the DNN+S-NSSAI it supports).

- The SMFs that registered to associate with the DNN, S-NSSAI of the associated 5G VN group should be available in the service area of the 5G VN group. The update of the service area of a 5G VN group may trigger the SMF to update its association with the 5G VN group in NRF.

- For UPFs served by a single SMF Set, N19-based forwarding, N6-based forwarding and local switch as per Rel-17 can be used with the following clarifications:

- The SMF set or SMF instances in SMF set need to support functionality for 5G VN group communications across SMFs. As an example, The SMF(s) can share contextual information associated with the 5G VN group (DNN + S-NSSAI). The contextual information may e.g. relate to the N19 configuration, to the list of PDU Sessions established by 5G VN group members, etc.

- No standard impacts are expected for this purpose except a NOTE such as:

NOTE 1: Implementation dependent mechanism can be used between SMF(s) that are part of a SMF set e.g. based on an implementation choice SMF(s) within the set can select one SMF to control the N19 configuration.

- For UPFs controlled by different SMF Sets,

- static connectivity (configured via OA&M) between PSA UPFs controlled by different SMF sets can be GTP-U tunnel or based on IETF protocols, the type of tunnel to implement the 5G VN connectivity between these UPFs is up to network implementation and deployment. In this case, no specification work beyond potential limited N4 impacts will be done to specify how an SMF set and its UPF are configured with the static tunnels to use to reach an UPF controlled by another SMF set.

NOTE 2: The above assumes that only one UPF within each SMF Set is configured with the static connectivity. The traffic that does not match with local switching or N19-based forwarding will be routed to that configured UPF, then the configured UPF forwards the traffic to the corresponding configured UPF within other SMF Sets using the static connectivity (for IP-type traffic, the traffic routing is based on different IP address ranges/prefixes corresponding different IP domains; for ethernet-type traffic, the traffic routing is based on the learned MAC address over the static connectivity, e.g. using ARP messages, ethernet packets received over the connectivity etc.; for packets with destination MAC that has not been learnt, the traffic is forwarded to every connectivity).

- support dynamic control of the connectivity between UPFs controlled by different SMF Sets

In the case that ETSUN is deployed within the network, 5G VN group communication can be supported by local PSA UPFs served by I-SMFs as instructed by A-SMFs over N16a. If I-UPF and local PSA UPF are inserted for a PDU Session targeting to a 5G VN group, N9 between I-UPF of I-SMF and A-UPF of A-SMF is used to route traffic between I-UPF controlled by I-SMF and A-UPF controlled by A-SMF.

NOTE 3: The above is only applicable for a single A-SMF Set connected with one or more I-SMF Sets. It doesn’t support control of the connectivity between A-UPFs controlled by different A-SMF Sets.

In order to enable dynamic control of the connectivity between A-UPFs controlled by different A-SMF Sets, a new GSMF NF is introduced, the GSMF is responsible for dynamic management of N19-based forwarding between A-UPFs controlled by different A-SMF Sets:

NOTE 4: The above assumes that only one UPF within each A-SMF Set is selected to connect with other UPFs served by different SMF Sets. The traffic that does not match with local switching or N19-based forwarding will be routed to that selected UPF, then the selected UPF forwards the traffic to the corresponding UPFs within other SMF Sets. The GSMF functions as a SMF (Set) that manages N19-based forwarding between the UPFs, where each of them is served by different A-SMF Set.

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