

Agenda item: 10.3.4.2
Source: Convida Wireless
Title: SDAP Header Format
Document for: Discussion & Decision

1 Introduction

As captured in 38.300 [1] and summarized in the LS R2-1706130 [2], RAN2's understanding of packet mapping and packet filters is the following:

- NAS level packet filters in the UE and in the 5GC associate UL and DL packets with QoS Flows.
- AS-level mapping in the UE and in the NG-RAN associate UL and DL QoS Flows with DRBs.
- NG-RAN and 5GC ensure quality of service (e.g. reliability and target delay) by mapping packets to appropriate QoS Flows and DRBs. Hence there is a 2-step mapping of IP-flows to QoS flows (NAS) and from QoS flows to DRBs (Access Stratum).
- In the downlink, the NG-RAN maps QoS Flows to DRBs based on NG-U marking (QoS Flow ID) and the associated QoS profiles.

As also captured in 38.300 and summarized in the LS R2-1706130, for reflective QoS, RAN2's understanding is that it is controlled at two levels (NAS and AS, corresponding to the 2-steps described above), and for reflective mapping at AS, RAN2 agreed the following:

- Reflective mapping: for each DRB, the UE monitors the QoS flow ID(s) of the downlink packets and applies the same mapping in the uplink; that is, for a DRB, the UE maps the uplink packets belonging to the QoS flows(s) corresponding to the QoS flow ID(s) and PDU Session observed in the downlink packets for that DRB. To enable this reflective mapping, the NG-RAN marks downlink packets over Uu with QoS flow ID.

This contribution discusses the header format of the Service Data Adaptation Protocol (SDAP) which is being designed by RAN2 to provide mapping between a QoS flow and a data radio bearer and Marking QoS flow ID (QFI) in both DL and UL packets.

2 Discussion

According to 23.501 [3], for UE supporting NAS reflective QoS function, and if NAS reflective QoS function is enabled by the 5GC for some traffic flows, the UE shall create a derived QoS rule for the uplink traffic based on the received downlink traffic. The UE shall use the derived QoS rules to determine mapping between uplink traffic and QoS flow. The derived QoS rule includes packet filter, QoS flow identifier (QFI) and rule precedence value.

The NAS reflective QoS may be controlled via User Plane or via Control Plane.

NAS Reflective QoS Control via User Plane:

When the User Plane reflective QoS is enabled by the 5GC, the UPF shall include the NAS Reflective QoS Indication (NAS RQI) in the encapsulation header on N3 reference point together with the QFI. From the UE perspective, the network controls the NAS reflective QoS via User Plane on per-packet basis by using the NAS RQI in the encapsulation header on N3 reference point together with the QFI. Consequently, the DL packets over Uu must be marked in band with NAS RQI for the purpose of NAS reflective QoS controlled via User Plane. Upon reception of a DL packet that is subject to Reflective QoS i.e. marked in band with NAS RQI, the UE creates a UE derived QoS rule.

Observation 1: *DL packets over Uu are marked in band with NAS RQI for the purpose of NAS reflective QoS controlled via User Plane.*

Observation 2: *Upon reception of a DL packet that is marked with NAS RQI for the purpose of NAS reflective QoS controlled via User Plane, the UE creates a UE derived QoS rule used to determine mapping between uplink traffic and QoS flow.*

NAS Reflective QoS Control via Control Plane:

In this case, the reflective QoS is controlled via Control Plane on per-QoS flow basis. When the 5GC determines to control reflective QoS via Control Plane, the SMF shall include the Reflective QoS Attribute (RQA) in the QoS flow parameters which are sent to the UE via N1 interface i.e. the interface between the AMF and the UE. When the UE receives a DL packet on a QoS Flow for which the RQA was previously set to NAS RQI over N1 interface, the UE creates a UE derived QoS rule. Consequently, for NAS reflective QoS controlled via Control Plane, DL packets are not marked in band with NAS RQI.

Observation 3: *DL packets over Uu are not marked in band with NAS RQI for the purpose of NAS reflective QoS controlled via Control Plane.*

Observation 4: *When the UE receives a DL packet on a QoS Flow for which the RQA was previously set to NAS RQI over N1 interface, the UE creates a UE derived QoS rule used to determine mapping between uplink traffic and QoS flow.*

Whether the reflective QoS is controlled via Control plane or via User Plane, the derived QoS rules created by the UE must include QFI so the UE needs to know the QFI of the received DL packet. If for e.g. the received DL packet is marked in band with QoS flow ID, the UE may know the QFI from the received DL packet, otherwise, the UE is assumed to know the QFI through out band signalling.

As also already agreed by RAN2, to enable AS reflective QoS mapping, the NG-RAN marks downlink packets over Uu with QFI. It is still FFS whether the QFI is always present.

Observation 5: *DL packet over Uu are marked with QFI for the purpose of NAS reflective QoS or AS Reflective QoS.*

When AS reflective QoS is enabled, if QFI is not assumed always present, then similar to NAS RQI, an AS RQI must be present to indicate whether the UE should create or update a QoS flow to DRB mapping.

From the discussion above, the SDAP DL PDU header may include three header fields NAS RQI, AS RQI and QFI.

Assuming 1 bit NAS RQI header field and 1 bit AS RQI header field, and one octet SDAP header, this leaves 6 bits for the QFI i.e. 64 possible values. SA2 has decided that the QFI is unique within a PDU session and therefore QFI may not be unique within the UE context, QFI values can be re-used across sessions. The QoS flow is the finest granularity of QoS differentiation in the PDU session, 64 possible values within a session seems reasonable. The scenarios where the AS RQI field is not present when AS reflective QoS is activated are likely to be rare cases considering RAN2 decision to support the mapping of multiple QoS flows onto the same DRBs. So an alternative option, is not to support AS RQI field. In that case, the QFI field length will 7 bits for 128 possible values.

Observation 6: *QFI is required to be unique only within a session.*

During RAN2#97bis, RAN2 agreed that the SDAP header is byte-aligned. It should also be noted that an SDAP header that is more than one byte long should be avoided as this will be a significant overhead and high cost to pay for the intended functionality. While RAN2 is still waiting for SA2 response on their view on the size of QFI, it should be noted that the QFI transmitted over the Uu interface may not necessarily be of the same size as the one transmitted over the N3 interface between 5GC and NG-RAN.

From the above discussion, in DL, SDAP header should be 1 byte long and may consist of two header fields i.e. NAS RQI and QFI, or three header fields i.e. NAS RQI, AS RQI and QFI. We therefore proposed the following:

Proposal 1: *The DL SDAP header size is 1 byte.*

Proposal 2: *The DL SDAP header includes a 1-bit NAS-RQI indication that indicates whether the UE shall create (or update) a UE derived QoS rule.*

Proposal 3: RAN2 to select one of the following two options:

Proposal 3-a): The SDAP header includes 1-bit AS-RQI indication that indicates whether the UE shall create (or update) a QoS Flow to DRB mapping and a 6-bit Flow ID.

Proposal 3-b): The SDAP header includes a 7-bit Flow ID.

NAS reflective QoS (whether controlled by Control Plane or User Plane) is not supported in UL and therefore, UL packets over Uu are not marked in band with RQI.

Observation 7: UL Packet over Uu are not marked in band with RQI for the purpose of NAS reflective QoS.

Observation 8: SDAP PDU header in the UL does not include RQI.

As per RAN2 previous agreement now reflected in 38.300 [1], in the uplink, the UE marks uplink packets over Uu with the QFI for the purposes of marking forwarded packets to the CN. So in the UL, the SDAP header should at least include the QFI. Since the SDAP PDU header must be byte-aligned and the QFI size should be the same for both UL and DL, the SDAP PDU header in the uplink needs to have a one-bit reserve field to make the header byte aligned.

Proposal 4: Similar to DL, the UL SDAP header size is 1 byte.

Proposal 5: RAN2 to select one of the following options:

Proposal 5-a): The UL SDAP PDU header has two spare bits if Proposal 3-a is agreed.

Proposal 5-b): The UL SDAP PDU header has one spare bit if Proposal 3-b is agreed.

Proposal 6: RAN2 to select one of the following options:

Proposal 6-a): The UL SDAP header includes a 6-bit Flow ID if Proposal 3-a is agreed.

Proposal 6-b): The UL SDAP header includes a 7-bit Flow ID if Proposal 3-b is agreed.

Another issue to be addressed is the location of the SDAP header in the SDAP PDU. Two options may be considered

1. The SDAP header is located at the front of the SDAP PDU.
2. The SDAP header is located at the end of the SDAP PDU.

In LTE, one of the PDCP functions is header compression and decompression using ROHC. During the NR SI, RAN2 discussed NR PDCP functions and still envisions NR PDCP to perform header and decompression using ROHC as captured in the TR 38.804.

SDAP header located at the front of the SDAP PDU:

Transmitter Side:

Assuming a DRB mapped to a PDCP entity is configured for header compression, on the transmitter side, the PDCP entity before compression needs to remove the SDAP header or skip SDAP header, perform header compression and then re-append the SDAP header in front of the compressed IP header. This means additional processing if SDAP header is located in front of the SDAP PDU. For NR targeted data rates, such processing overhead may be significant. With an UL target user experienced data rate of 500Mbps and peak data rate of 10Gbps, the number of IP packets per second assuming IP packet size of 1500B, is somewhere between 41 thousand IP packets per second and 834 thousand IP packet per second and at least that many unnecessary potential SDAP header removal and reattachments per second in the UE.

Receiver Side:

On the receiver side, header decompression must be performed for DRBs configured with header compression. With DL target user experienced data rate of 1Gbps and peak data rate of 20 Gbps, the number of IP packets per second is somewhere in the range of 80 thousand IP packets per second and 1.6 million IP packets per second and therefore that many potential header SDAP header displacements per second in the UE.

RAN2 has agreed to a mode in which SDAP header is not present and is configured per DRB if configured. For DRBs for which SDAP header is not configured, ROHC related processing overhead is avoided.

Observation 9: *If SDAP header is located in front of SDAP PDU, additional processing overhead for header compression and decompression in the UE may be significant for targeted NR data rates.*

Observation 10: *For DRBs configured with no SDAP header, header compression and decompression additional processing is avoided.*

SDAP header located at the end of the SDAP PDU:

When SDAP header is located at the end of SDAP PDU, PDCP header compression and decompression can be performed with less additional processing.

However, the saving in additional header compression may not be significant if transparent SDAP mode is used most of the time for data packet transmission and occasionally, data packets are transferred over DRBs configured with SDAP header in support of reflective QoS. In fact, the use of reflective QoS should be expected to be temporary for the packet flows involved, with the packet marking over time just long enough to allow the UE to reliably create the intended derived QoS rule for UL flow mapping. From that perspective, the protocol design should not unnecessarily be complex as a result of a potential overhead whose impact might not be significant. Furthermore, the placement of SDAP header at the end of SDAP PDU assumed SDAP header length is fixed, and this is an assumption that is yet to be confirmed.

Observation 11: *Transparent mode SDAP i.e. a mode in which SDAP header is not present is expected to be used most of the time.*

Proposal 7: *The SDAP header is located at the front of the SDAP PDU, for both DL and UL directions.*

3 Conclusion

In this contribution, we discuss the SDAP header format and propose the following:

Proposal 1: *The DL SDAP header size is 1 byte.*

Proposal 2: *The DL SDAP header includes a 1-bit NAS-RQI indication that indicates whether the UE shall create (or update) a UE derived QoS rule.*

Proposal 3: *RAN2 to select one of the following two options:*

Option a): The SDAP header includes 1-bit AS-RQI indication that indicates whether the UE shall create (or update) a QoS Flow to DRB mapping and a 6-bit Flow ID.

Option b) The SDAP header includes a 7-bit Flow ID.

Proposal 4: *Similar to DL, the UL SDAP header size is 1 byte.*

Proposal 5: *RAN2 to select one of the following options:*

Proposal 5-a): The UL SDAP PDU header has two spare bits if Proposal 3-a is agreed.

Proposal 5-b): The UL SDAP PDU header has one spare bit if Proposal 3-b is agreed.

Proposal 6: *RAN2 to select one of the following options:*

Proposal 6-a): The UL SDAP header includes a 6-bit Flow ID if Proposal 3-a is agreed.

Proposal 6-b): The UL SDAP header includes a 7-bit Flow ID if Proposal 3-b is agreed.

Proposal 7: *The SDAP header is located at the front of the SDAP PDU, for both DL and UL directions.*

4 Appendix

Examples of DL and UL SDAP headers if Proposal 3a is agreed are illustrated in Figure 1 and Figure 2 respectively.

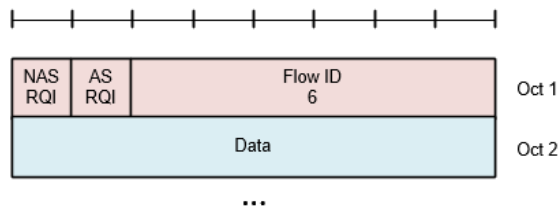


Figure 1: DL SDAP Header with 1 bit NAS RQI, 1bit AS RQI and 6-bit Flow ID

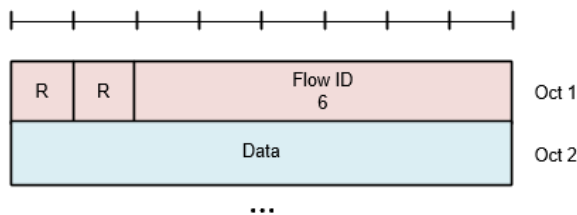


Figure 2: UL SDAP Header with two spare bits and 6-bit Flow ID

Examples of DL and UL SDAP headers if Proposal 3b is agreed are illustrated in Figure 3 and Figure 4 respectively.

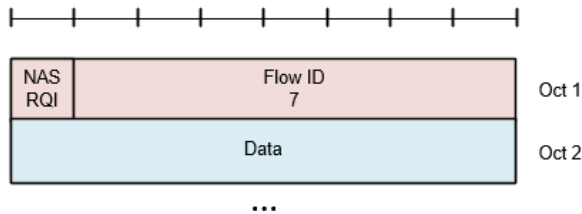


Figure 3: DL SDAP Header with 1 bit NAS RQI and 7-bit Flow ID

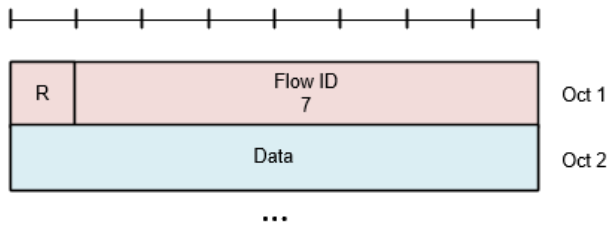


Figure 4: UL SDAP Header with one spare bit and 7-bit Flow ID

5 References

[1] 3GPP TS 38.300, NR; NR and NG-RAN Overall Description, Stage 2, V0.4.1
[2] R2-1706130, LS on NAS Reflective QoS from RAN2 to SA2
[3] 3GPP TS 23.501, System Architecture for the 5G System, Stage 2, V1.0.0