DPDK
DATA PLANE DEVELOPMENT KIT

PDU Sessions
DRB and N3 GTP-U Tunnels

UE
gNB
UPF

PDU Session

N3 GTP-U Tunnel

DRB
DRB
DRB

QoS Flow 1
QoS Flow 2
QoS Flow 3
QoS Flow 4

Picture Source : linkedin

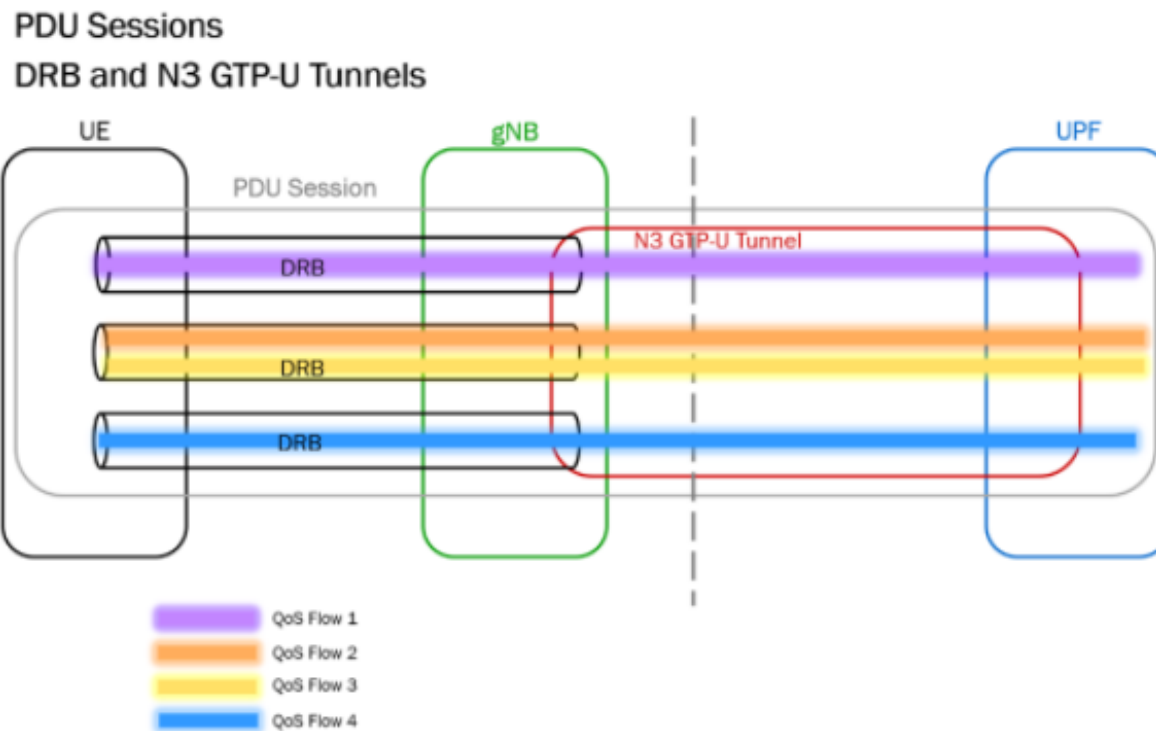## QoS Flow to DRB and GTP-U Tunnel Mapping

4G LTE :
➢ A one-to-one relationship for an EPS bearer between the DRB (UE to eNB), the S1-U GTP-U tunnel (eNB to S-GW) and the S5-U tunnel (S-GW to P-GW).
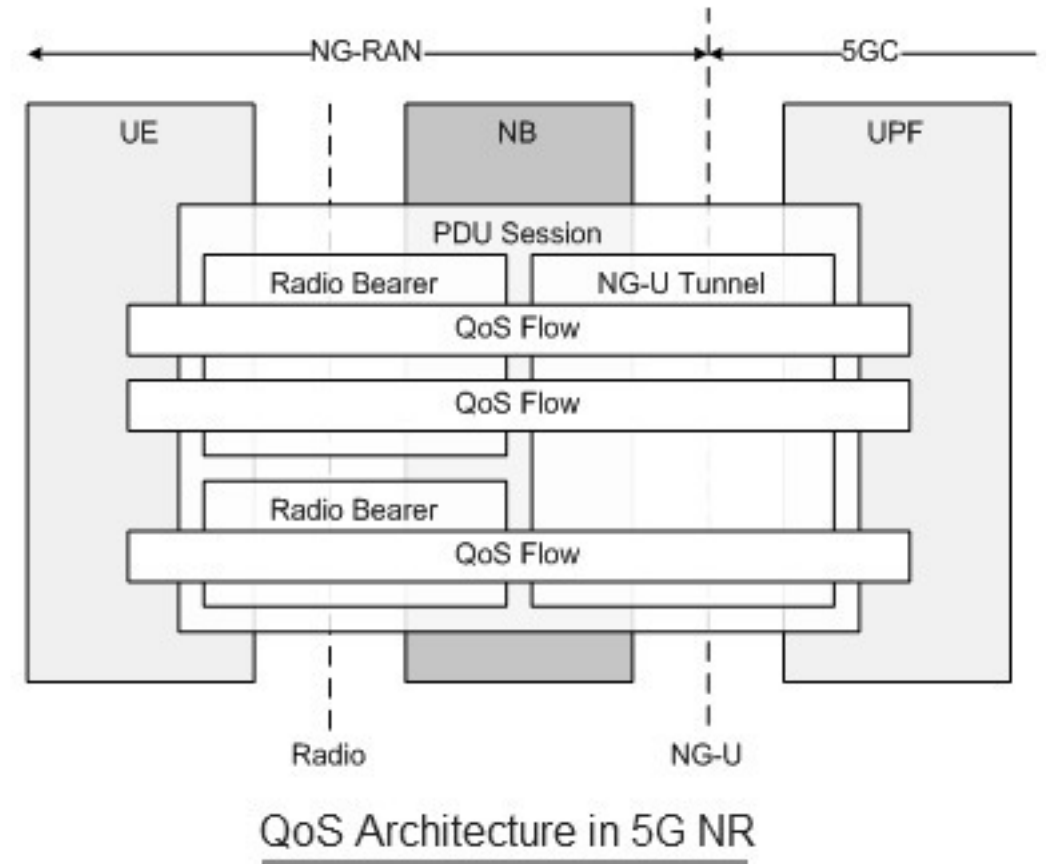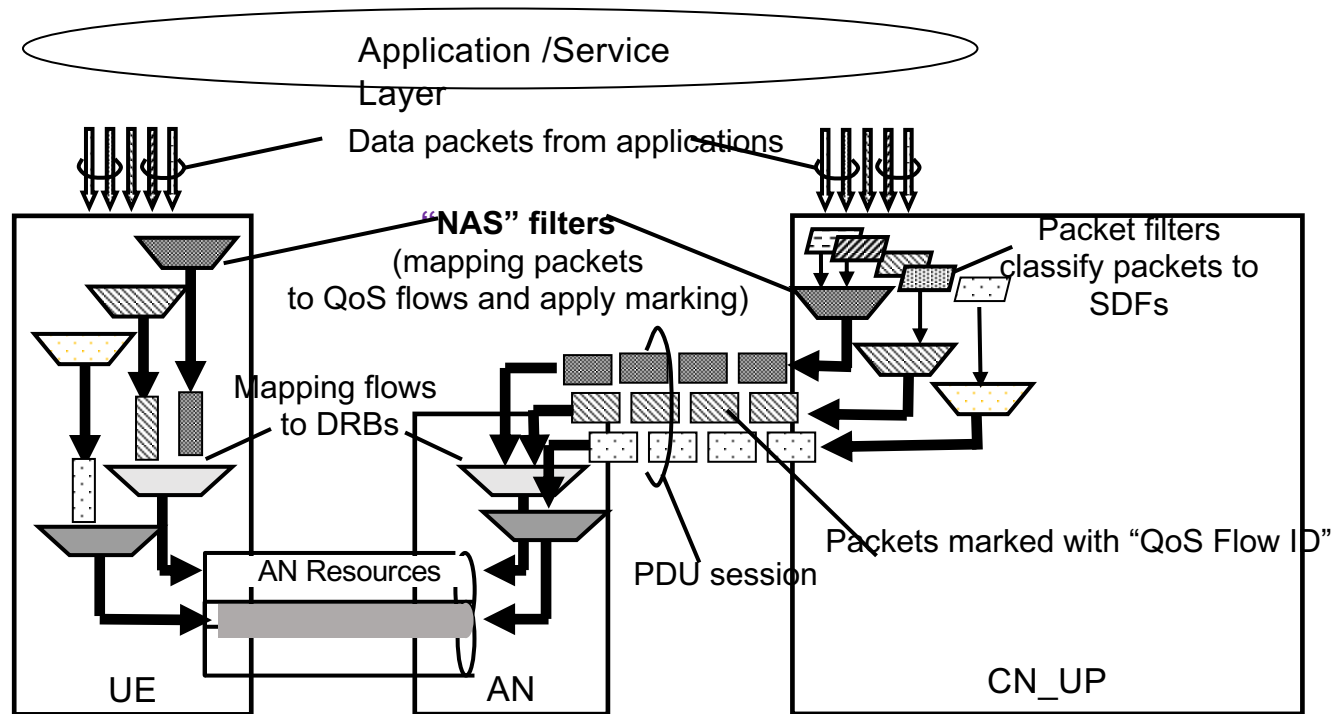
5GC :
➢ Only a single user plane network function – the UPF – for transport of data between the gNB and the core.
➢ one-to-many relationship between the GTP-U tunnel on N3 and the DRBs on the air interface.
➢ Each QoS flow on N3 is mapped to a single GTP-U tunnel.
➢ gNB may map individual QoS flows to one more DRBs. Thus, PDU session may contain multiple QoS flows and several DRBs but only a single N3 GTP-U tunnel.

Note : A DRB may transport one or more QoS flows.

5G QoS Model (DRB-Flows-Tunnel)

Application /Service Layer

Data packets from applications

"NAS" filters (mapping packets to QoS flows and apply marking)

Packet filters classify packets to SDFs

Mapping flows to DRBs

Packets marked with "QoS Flow ID"

PDU session

AN Resources

UE   AN   CN_UP

QoS Architecture in 5G NR

Source : 3GPP forum

5G vs 4G QoS & Mapping procedure

QoS Parameter	5G	4G
QoS Identifier	5QI / QFI field in the GTP-U extended header	Quality class indicator. Usually the quality is differentiated at the tunnel level – specific tunnel for a service
IP flow : UE -> UPF	QoS flow	EPS Bearer
Flow identifier	QFI	Bearer ID
Reflective QoS	RQI	-

Aspects of classifying the 5G GTP-U packet stream for QoS purpose and level of classification

➢ Tunnel EndPoint ID along with QFI / 5QI parameters
➢ Mapping based on IP subnet, Source IP address, L4 port numbers, DSCP
➢ Identifying the service from the higher order classification (web, video, email and etc)
➢ DPI may not be always possible as the packets are mostly encrypted which leads to service aware planning from the deployment is required

Flow based QoS @UPF-DL, @gNB/NA & @UE
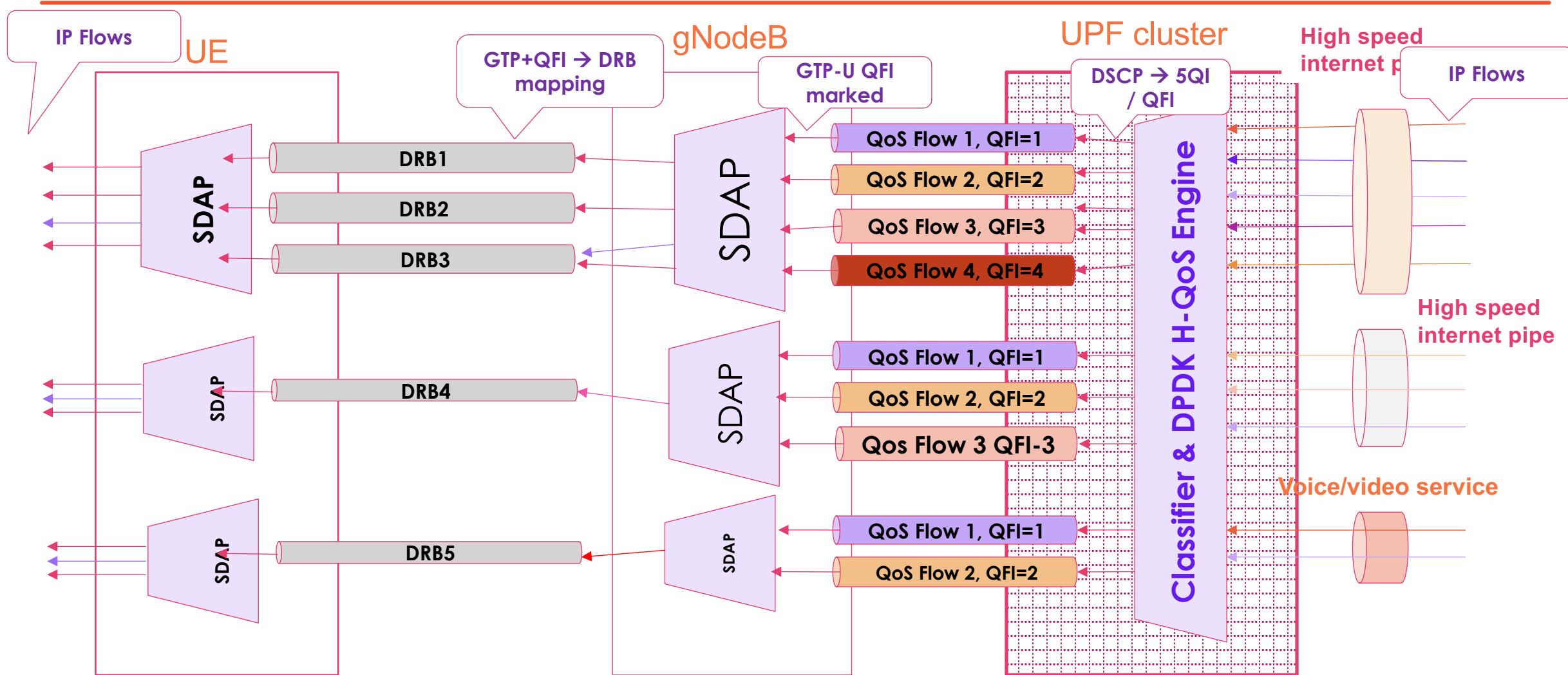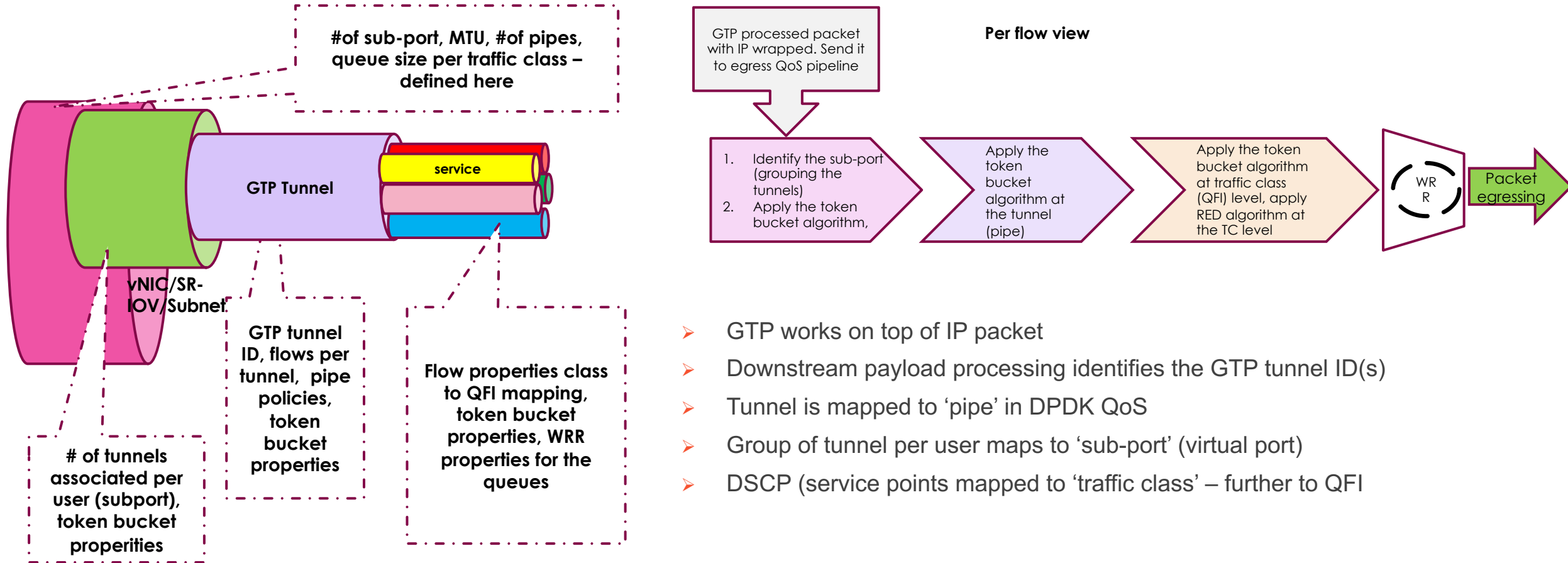
5G UPF QoS plugin –Goals

➢ DPDK H-QoS Engine integration to the VPP

➢ Enhancing the VPP configuration infra to support 5G QoS

➢ Flow classifier support (from the management plane via yang model)

➢ Attaching the traffic to appropriate UPF instance in a cluster (VLAN with SR-IOV, tunnel to instance)

➢ Metering support throughout the hierarchy

➢ Upstream QoS mapping verification – possible action

➢ Contribution to the VPP community

DPDK QoS pipeline
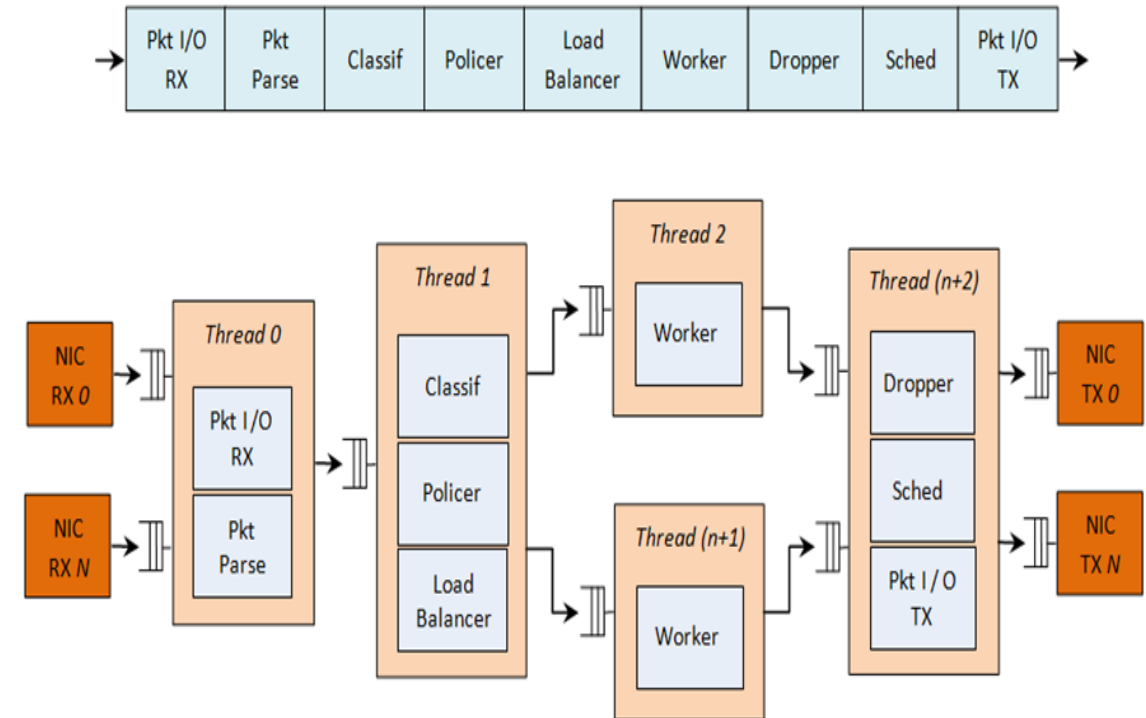
Port/vNIC/ SR-IOV -> UPF – instance / slice , GTP tunnel group per user -> Sub-port , GTP Tunnel (s) ->pipe, Flow -> Queue (WRR/SP)
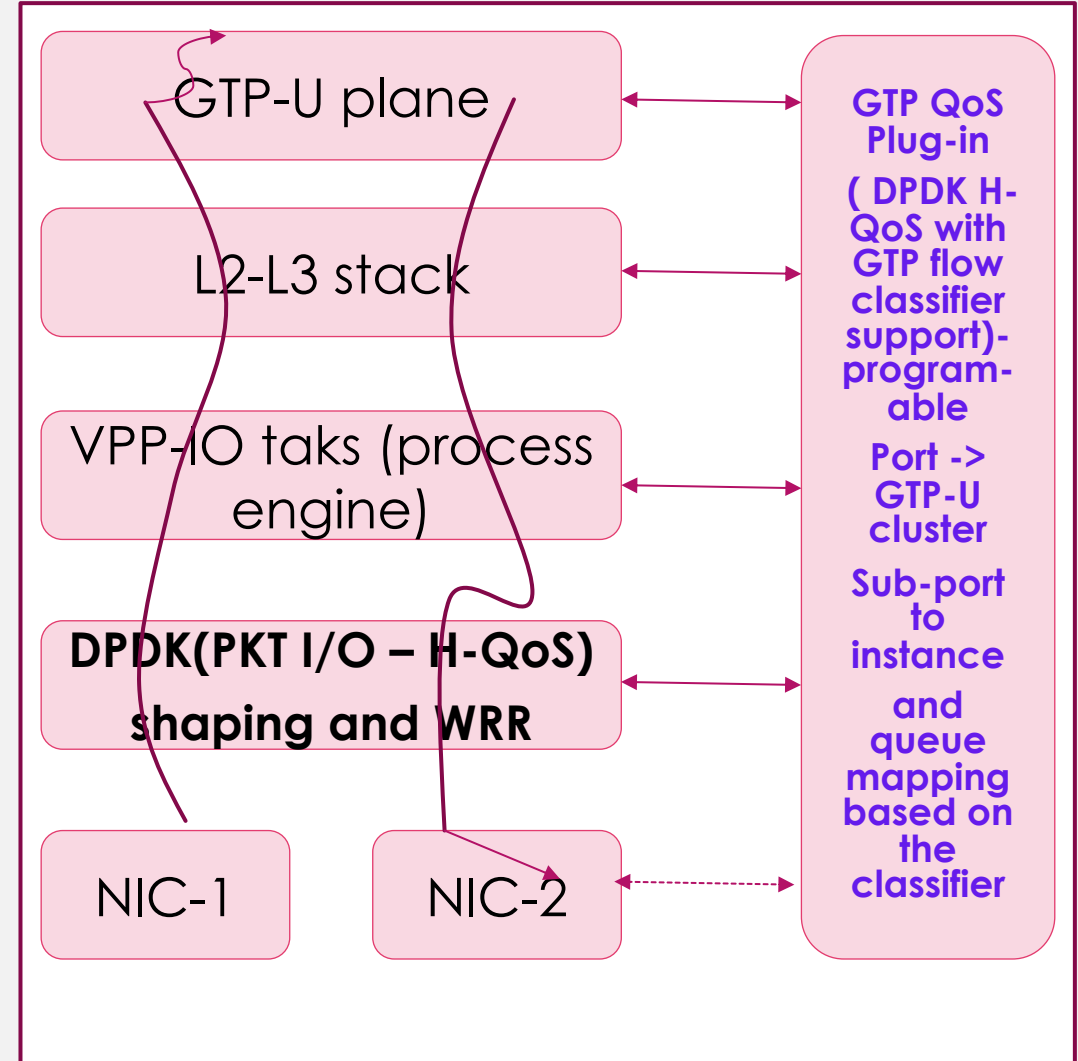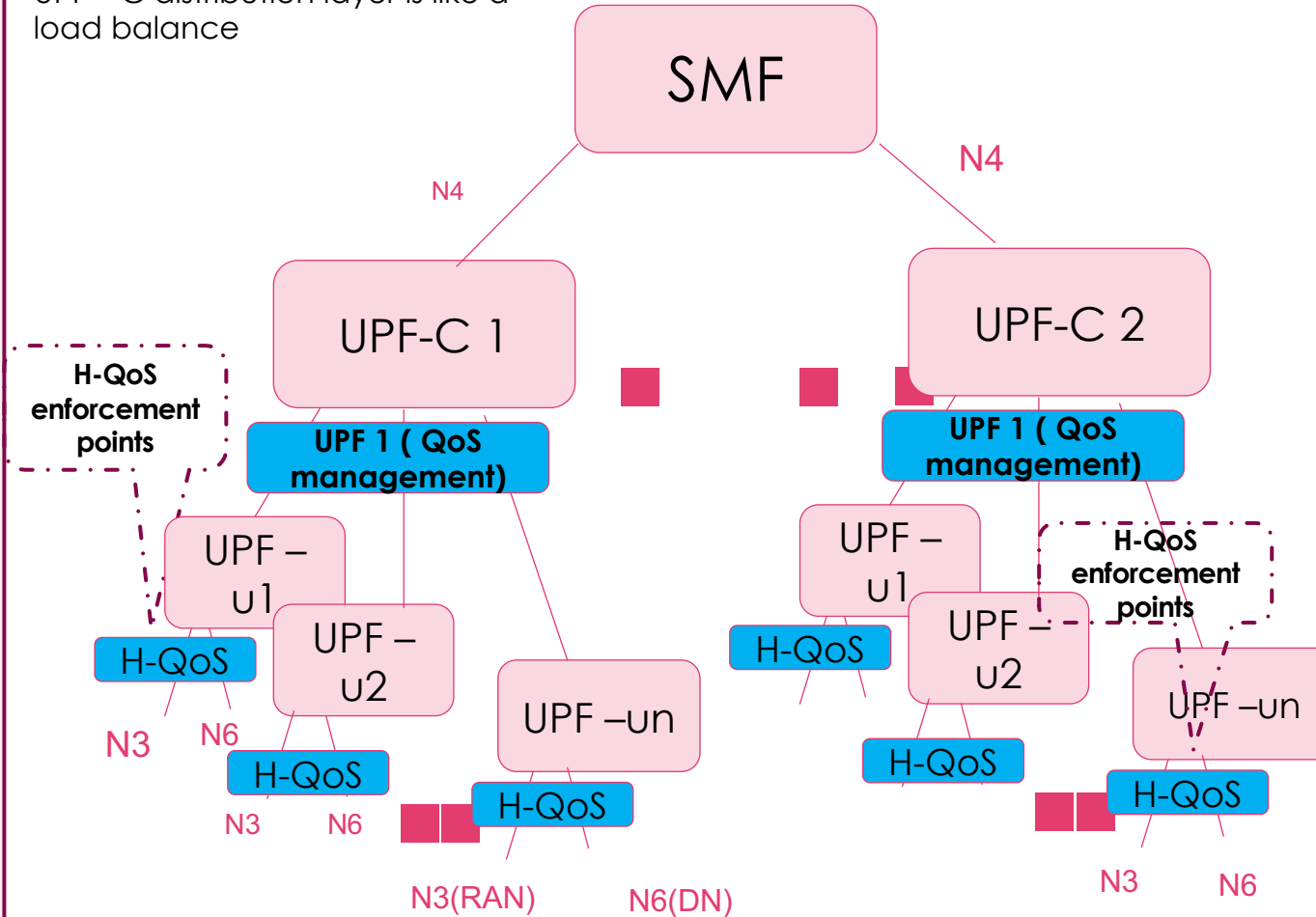
QoS in Downstream

#of sub-port, MTU, #of pipes, queue size per traffic class – defined here

GTP processed packet with IP wrapped. Send it to egress QoS pipeline

Per flow view

GTP Tunnel

service

vNIC/SR-IOV/Subnet

# of tunnels associated per user (subport), token bucket properities

GTP tunnel ID, flows per tunnel, pipe policies, token bucket properties

Flow properties class to QFI mapping, token bucket properties, WRR properties for the queues

1. Identify the sub-port (grouping the tunnels)
2. Apply the token bucket algorithm,

Apply the token bucket algorithm at the tunnel (pipe)

Apply the token bucket algorithm at traffic class (QFI) level, apply RED algorithm at the TC level

WRR

Packet egressing

➢ GTP works on top of IP packet

➢ Downstream payload processing identifies the GTP tunnel ID(s)

➢ Tunnel is mapped to 'pipe' in DPDK QoS

➢ Group of tunnel per user maps to 'sub-port' (virtual port)

➢ DSCP (service points mapped to 'traffic class' – further to QFI

```
set dpdk interface hqos subport <interface> subport <subport_id> [rate <n>] [bktsize <n>] [tc0 <n>] [tc1 <n>] [tc2 <n>] [tc3 <n>] [period <n>]
set dpdk interface hqos pipe <interface> subport <subport_id> pipe <pipe_id> profile <profile_id>
set dpdk interface hqos placement <interface> thread <n>
set dpdk interface hqos pktfield <interface> id subport|pipe|tc offset <n> mask <hex-mask>
set dpdk interface hqos tctbl <interface> entry <map_val> tc <tc_id> queue <queue_id>
```
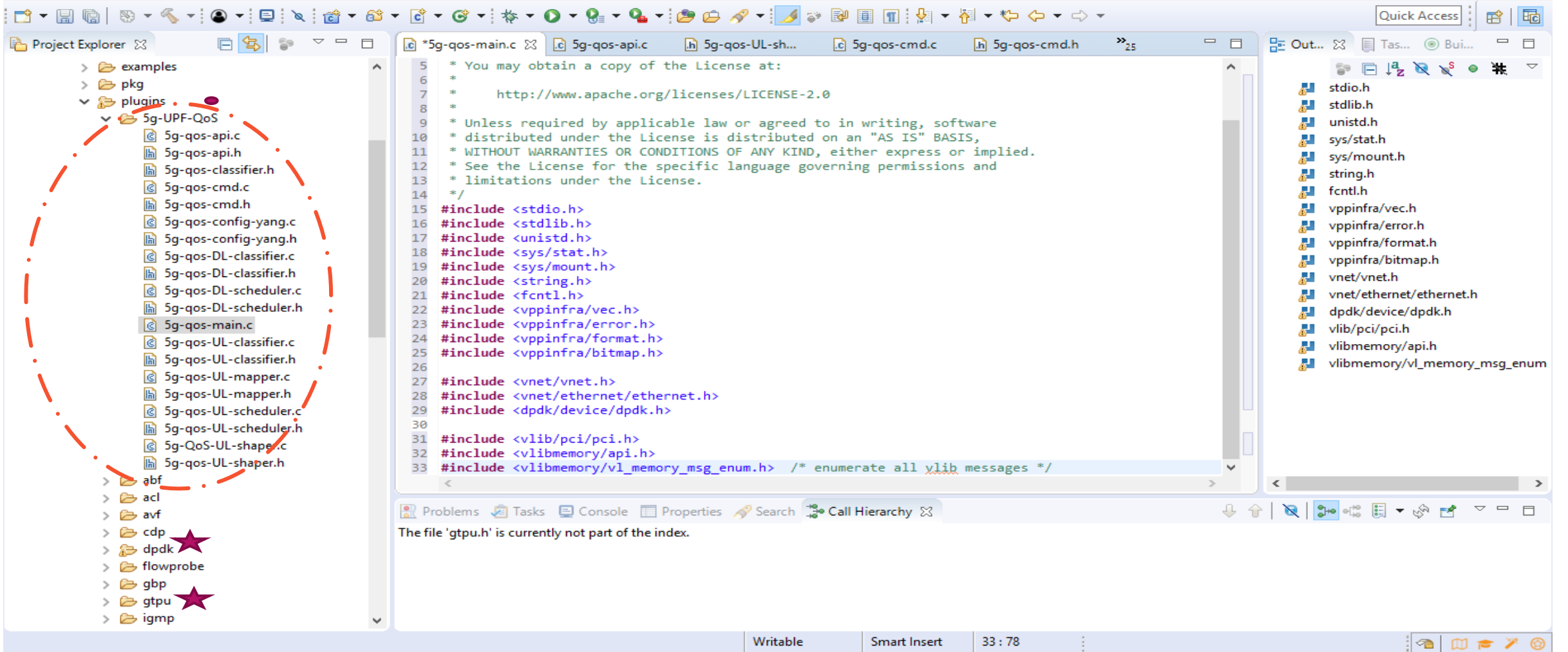
UPF architecture and QoS

5g-qos-dpdk-vpp : Code organization

Future Work / Proposal – QoS plugin Enhancement

➢ Possibility of Openflow enhancement to support the 5G flow classification to adapt in the SDN environment

➢ Pre-classification based L2 at SR-IOV / smartNIC to direct the traffic to the appropriate UPF instance + NSH header usage

➢ Adapting to Openstack ML2 path

➢ Docker based support

➢ Yang modeling for the GTP-U QoS
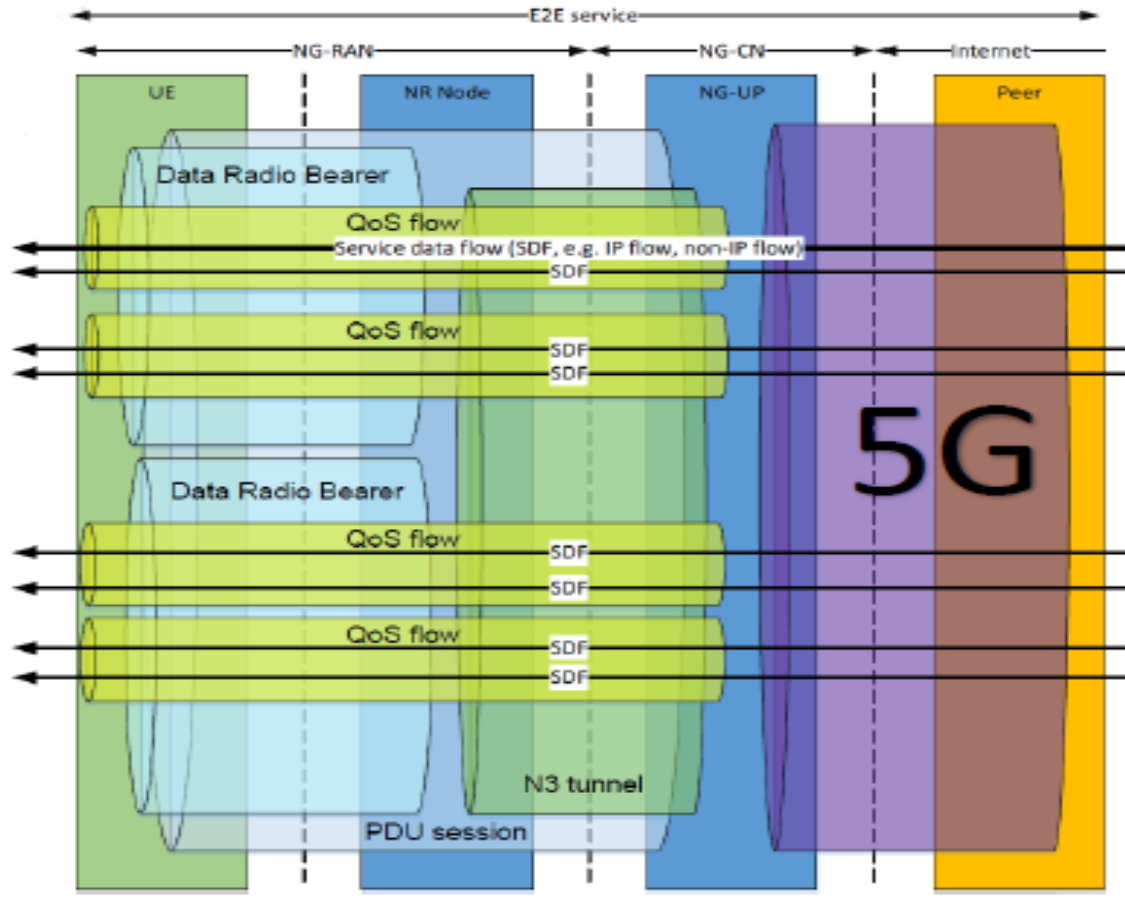
Thank You!

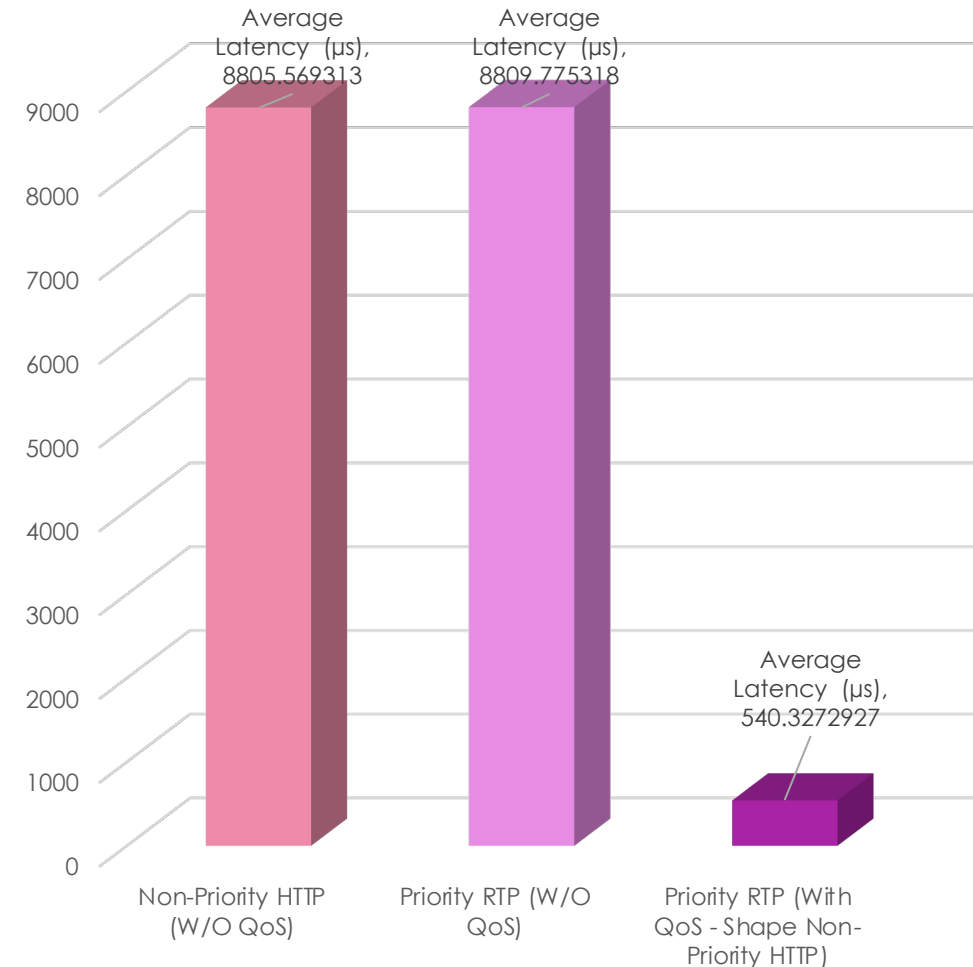# Backup slides

5G End to End QoS flow view

QoS flow
- ➢ the lowest level granularity within the 5G system
- ➢ the place policy and charging are enforced.
- ➢ One or more Service Data Flows (SDFs) can be transported in the same QoS flow, if they share the same policy
- ➢ All traffic within the same QoS flow receives the same treatment.

Picture Source : linkedin

Past work with OVS adaptation with DPDK H-QoS

- Open-flow based QoS mechanism which helps the controller to manage and enforce the QoS at network level

- Reduce packet loss, latency and jitter

- Ensure deterministic performance of real time applications

- QoS Differentiated service chaining path creation to accelerate certain services while queuing some of the non-critical TCP based service

- QoS with Openstack (with ML2 initial prototyping done)

Key use case: For the telco cloud traffic engineering and as well on the branch office QOS characterization

Bar chart — Average Latency (µs):
- Non-Priority HTTP (W/O QoS): 8805.569313
- Priority RTP (W/O QoS): 8809.775318
- Priority RTP (With QoS - Shape Non-Priority HTTP): 540.3272927

QoS requirements (@UE , @ AN & @UPF)

5QI Value	Resource Type	Default Priority Level	Packet Delay Budget	Packet Error Rate	Default Maximum Data Burst Volume	Default Averaging Window	Example Services
81	Delay Critical GBR	11	5 ms	10^{-5}	160 B	2000 ms	Remote control
82		12	10 ms	10^{-5}	320 B	2000 ms	Intelligent transport systems
83		13	20 ms	10^{-5}	640 B	2000 ms	Intelligent Transport Systems
84		19	10 ms	10^{-4}	255 B	2000 ms	Discrete Automation
85		22	10 ms	10^{-4}	1358 B NOTE 3	2000 ms	Discrete Automation

5QI Value	Re-rouce Type	Default Priority Level	Packet Delay Budget	Packet Error Rate	Default Avg Window	Example Services
1	GBR	20	100 ms	10^{-2}	2000 ms	Conversational Voice
2		40	15 0 ms	10^{-3}	2000 ms	Conversational Video (Live Streaming)
3		30	50 ms	10^{-3}	2000 ms	Real Time Gaming, V2X messages Electricity distribution – medium voltage, Process automation - monitoring
4		50	300 ms	10^{-6}	2000 ms	Non-Conversational Video (Buffered Streaming)
65		7	75 ms	10^{-2}	2000 ms	Mission Critical user plane Push To Talk voice (e.g., MCPTT)
66		20	100 ms	10^{-2}	2000 ms	Non-Mission-Critical user plane Push To Talk voice
67		15	100 ms	10^{-3}	2000 ms	Mission Critical Video user plane
75		25	50 ms	10^{-2}	2000 ms	V2X messages

The following characteristics apply for processing of Downlink traffic:

- UPF maps User Plane traffic to QoS flows based on the SDF templates
- UPF performs Session-AMBR (Aggregate MBR) enforcement and also performs PDU counting for support of charging.
- Applying Reflective QoS (based on QAI ON) – DSCP/ QFI markings

Reflective QoS : *For traffic that is subject to reflective QoS, the UL packet gets the same QoS marking as the reflected DL packet.*

Note : How to use QFI to be understood well while mapping to DSCP and as well as doing the shaping / scheduling function (this is the function to be done in UPF for downstream and for upstream enforcement check to be done!) ?

UL QoS requirements (@UE , @ AN & @UPF)

Following processing of uplink traffic:

➤ UE performs the classification and marking of UL User plane traffic, i.e. the association of uplink traffic to QoS flows, based on QoS rules.

➤ QFI filed is populated by RAN / AN

➤ (R)AN performs transport level packet marking in the uplink, transport level packet marking may be based on the 5QI and ARP (bearer allocation and retention priority) of the associated QoS Flow.

➤ **UPF verifies whether QFIs in the UL PDUs are aligned with the QoS Rules provided to the UE or implicitly derived by the UE (e.g. in case of reflective QoS)**

➤ **UPF performs Session AMBR(agg. Max bit rate) enforcement and counting of packets for charging.**

➤ **For UL Classifier PDU sessions, UL and DL Session AMBR shall be enforced in the UPF that supports the UL Classifier functionality.**

➤ **For multi-homed PDU sessions, UL and DL Session-AMBR is enforced separately per UPF that terminates the N6 interface (i.e. without requiring interaction between the UPFs)**

➤ (R)AN shall enforce Max BitRate (UE-AMBR) limit in UL and DL per UE for non-GBR QoS flows
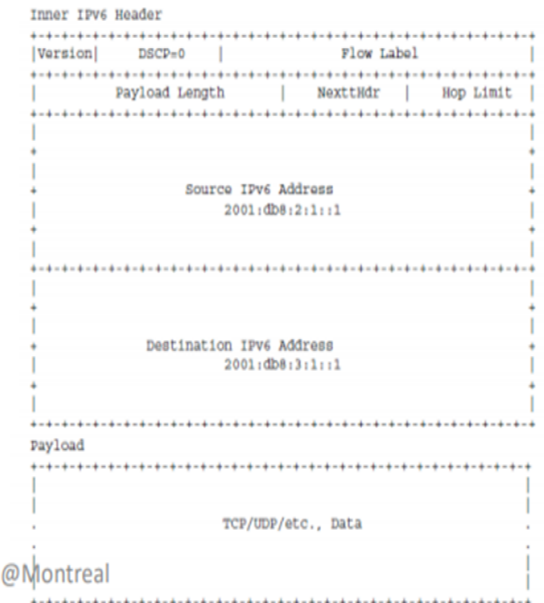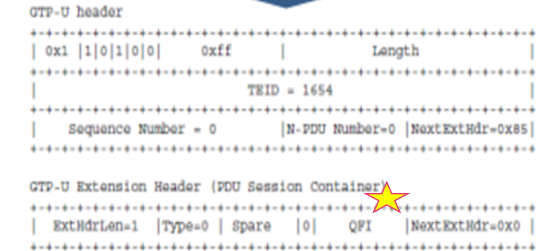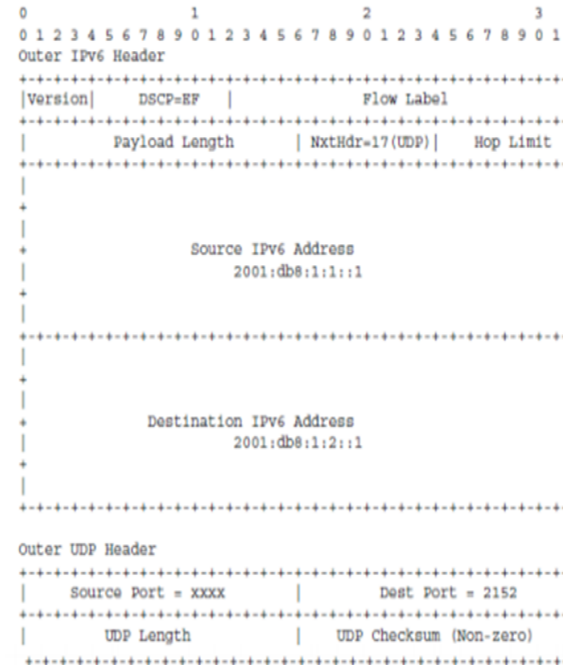
Note : Highlighted items for UPF specific

Ref : 3GPP recommendations

Parameters to be dealt in the QoS Plugin

QoS profile and parameters

➢ For each QoS flow: 5QI (5G QoS Identifier), ARP

➢ For GBR QoS flow only: GFBR (Guaranteed Flow Bit Rate), MFBR (Maximum Flow Bit Rate), AMBR & maximum packet loss rate for both uplink and downlink.

➢ For Non-GBR QoS only: Reflective QoS Attribute (RQA)

➢ Resource Type (GBR, delay critical GBR or non-GBR)

➢ Priority level

➢ Packet Delay Budget

➢ Packet Error Rate

➢ Averaging Window

➢ Maximum Data Burst Volume

GTP-U Packet Format Illustration