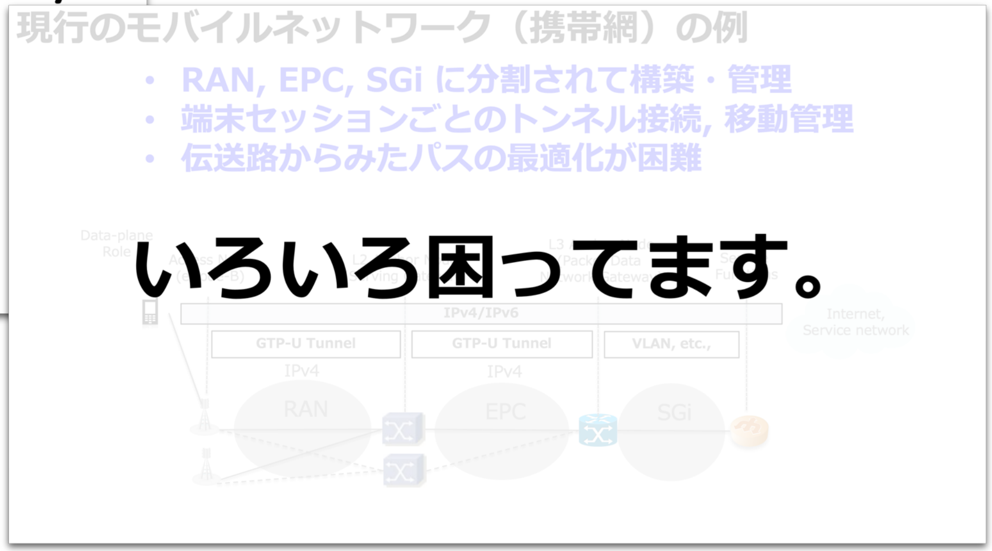
SRv6にまつわる標準化

2019/02/22

enog#55

松嶋 聡

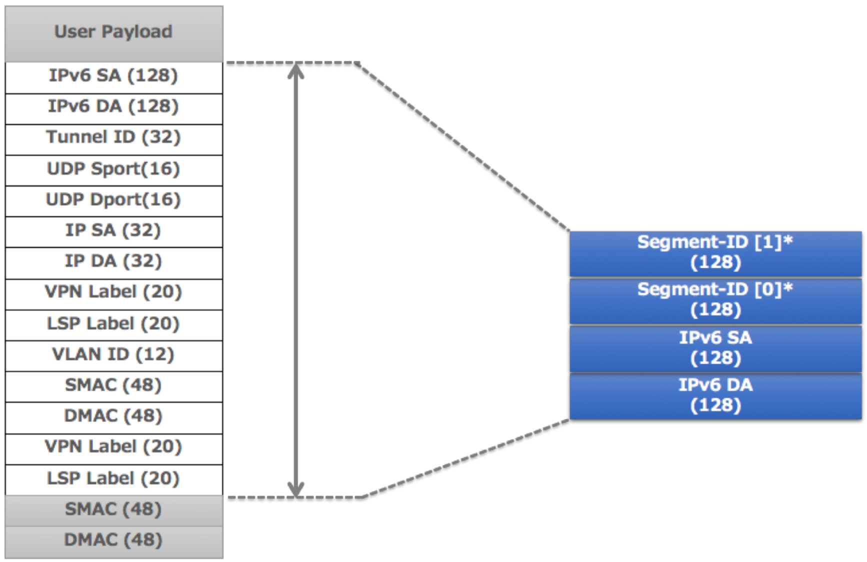
Updates After JANOG40…

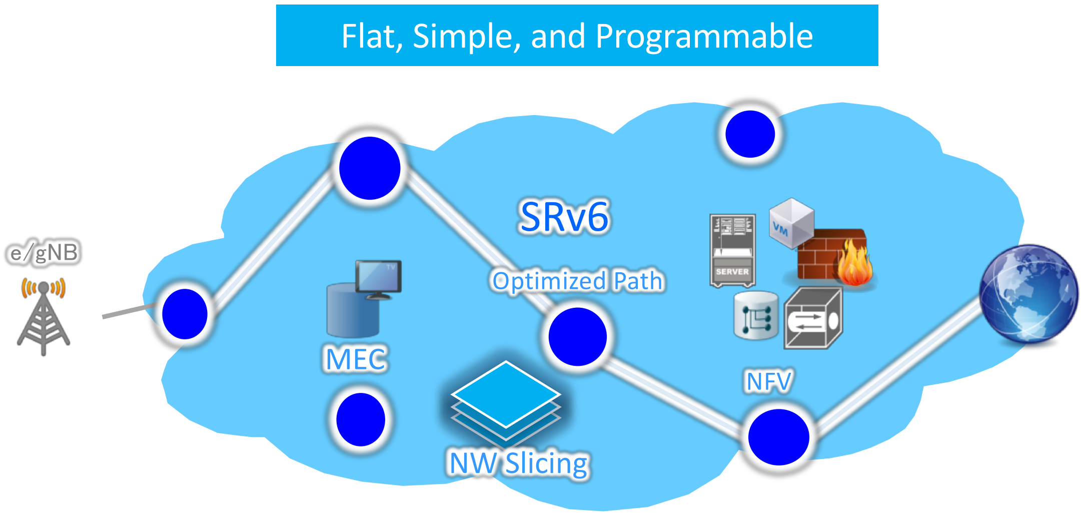


https://www.janog.gr.jp/meeting/janog40/application/files/8015/0122/1167/janog40-route-matsushima-01.pdf

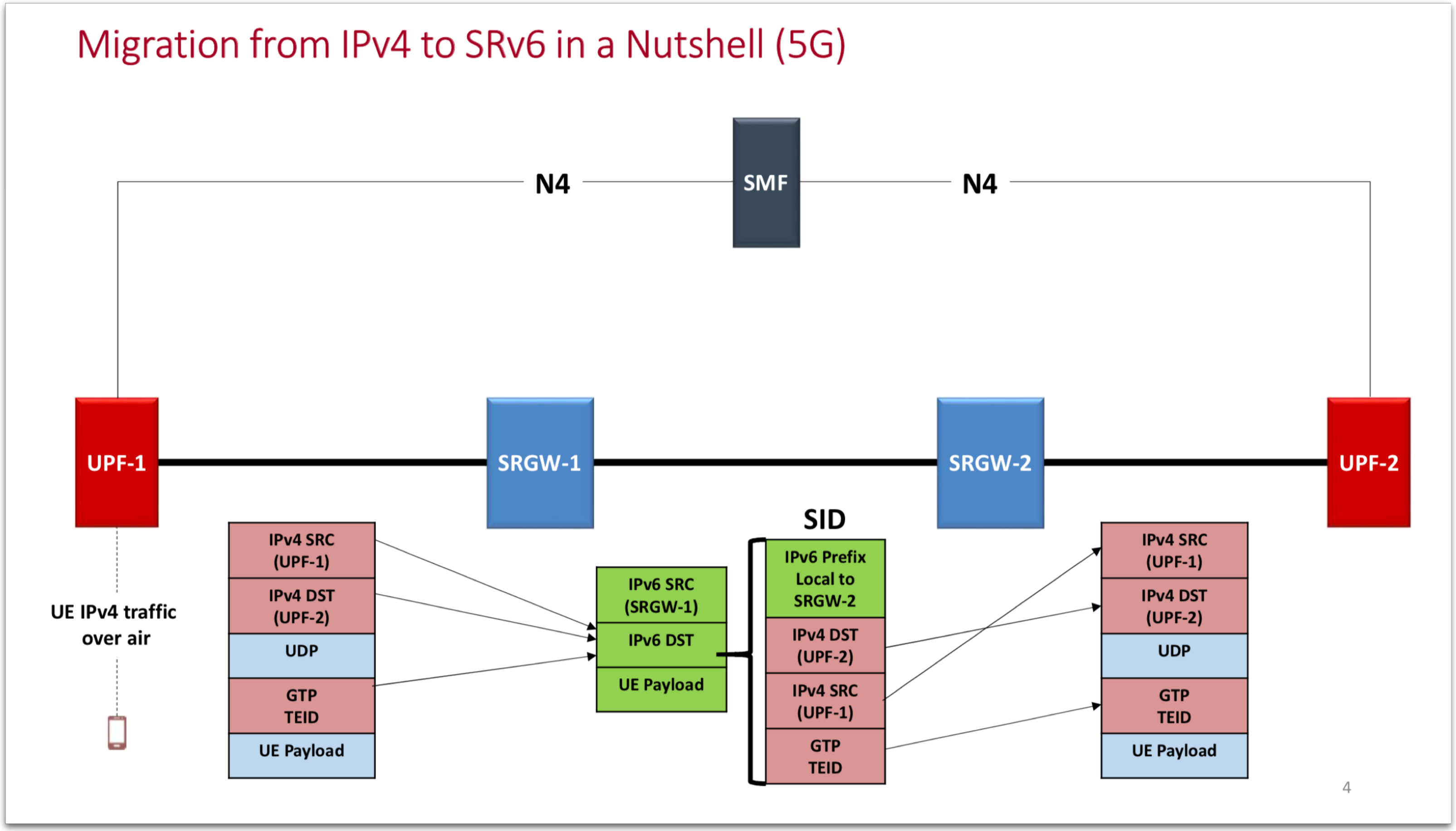
なぜSRv6なのか

- ~~Well fragmented to RAN, EPC and SGi.~~
- ~~Per-session tunnel creation and handling.~~
- ~~Non-optimal data-path.~~
- **IPv6 integrates networks of the mobile and others.**
- **A SID represents data-plane role and function.**





Stateless Interworking between GTP-U and SRv6 User Plane



Acknowledge: Arashmid Akhavain, Chenchen Liu, Pablo Camarillo

https://meetings.webex.com/collabs/url/3sEHGlYO2Ley1qiZUMsoA5JCz6x4bIrbMDH6JHRpCo400000

Latest Status in SDOs

User Plane Protocol Study in 3GPP has been started!

3GPP TSG CT4 Meeting #81 **C4-176400**
Reno, US; 27th Nov – 1st Dec 2017

(revision of C4-175222)

Source:	**SoftBank Corp.**
Title:	**New Study Item on User-plane Protocol**
Document for:	**Approval**
Agenda Item:	**5**

3GPP™ Work Item Description

For guidance, see 3GPP Working Procedures, article 39; and 3GPP TR 21.900.
Comprehensive instructions can be found at http://www.3gpp.org/Work-Items

Title: Study on User Plane Protocol in 5GC

Acronym: FS_UPPS

Unique identifier:

1 Impacts

Specification # 29.892

Satoru

保護された通信 https://portal.3gpp.org/desktopmodules/Specifications/Specificatio...

3GPP Portal

General | Versions | Responsibility | Related

Specification #: 29.892

Reference:	29.892
Title:	Study on User-plane Protocol in 5GC
Status:	Draft
Type:	Technical report (TR)
Initial planned Release:	Release 16
Internal:	☑
Common IMS Specification:	☐
Radio technology:	☐ 2G ☐ 3G ☐ LTE ☑ 5G

Remarks (0)

Creation date	Author	Remark
No Remarks Added		

History

Action date	Action	Author
2018-01-02 10:11 UTC	Specification has been created for release Rel-16	John M Meredith

Exit

Latest Status in IETF

DMM Working Group
Internet-Draft
Intended status: Standards Track
Expires: April 25, 2019

S. Matsushima
SoftBank
C. Filsfils
M. Kohno
P. Camarillo
Cisco Systems, Inc.
D. Voyer
Bell Canada
C. Perkins
Futurewei
October 22, 2018

Segment Routing IPv6 for Mobile User Plane
draft-ietf-dmm-srv6-mobile-uplane-03

Abstract

This document shows the applicability of SRv6 (Segment Routing IPv6) to the user-plane of mobile networks. The network programming nature of SRv6 accomplish mobile user-plane functions in a simple manner. The statelessness of SRv6 and its ability to control both service layer path and underlying transport can be beneficial to the mobile user-plane, providing flexibility and SLA control for various applications. This document describes the SRv6 mobile user plane behavior and defines the SID functions for that. It also provides a mechanism for end-to-end network slicing.


```
                                            +----+  SRv6            ________
                      SRv6              --| C1 |--[N3]            /        \
+--+    +-----+       [N3]             /  +----+  \  +-------+ [N6] /          \
|UE|----| gNB |--           SRv6  /      SRv6     --| UPF2  |------\    DN     /
+--+    +-----+  \          [N3]/         TE        +-------+       \________/
      SRv6 node   \  +----+ /                      SRv6 node
                    -| S1 |-
                     +----+
                   SRv6 node
                      CNF
```

Figure 3: Enhanced mode - Example topology

5.2.1. Packet flow - Uplink

The uplink packet flow is as follows:

```
UE_out  : (A,Z)
gNB_out : (gNB, S1)(U2::1, C1; SL=2)(A,Z)-> T.Encaps.Red<S1,C1,U2::1>
S1_out  : (gNB, C1)(U2::1, C1; SL=1 (A,Z)
C1_out  : (gNB, U2::1)(A,Z)              -> PSP
UPF2_out: (A,Z)                          -> End.DT4 or End.DT6
```

Latest Status in IETF

```
DMM Working Group                                              S. Homma
Internet-Draft                                                      NTT
Intended status: Informational                              T. Miyasaka
Expires: July 10, 2019                                    KDDI Research
                                                          S. Matsushima
                                                               SoftBank
                                                               D. Voyer
                                                            Bell Canada
                                                        January 6, 2019


     User Plane Protocol and Architectural Analysis on 3GPP 5G System
                   draft-ietf-dmm-5g-uplane-analysis-00

Abstract

   This document analyzes the mobile user plane protocol and the
   architecture specified in 3GPP 5G documents.  The analysis work is to
   clarify those specifications, extract protocol and architectural
   requirements and derive evaluation aspects for user plane protocols
   on IETF side.  This work is corresponding to the User Plane Protocol
   Study work on 3GPP side.

Status of This Memo

   This Internet-Draft is submitted in full conformance with the
   provisions of BCP 78 and BCP 79.
```

```
0                   1                   2                   3
0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
Outer IPv6 Header
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|Version|      DSCP=EF     |               Flow Label            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|          Payload Length        | NxtHdr=17(UDP)|    Hop Limit  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                                |
+                                                                +
|                                                                |
+                       Source IPv6 Address                      +
|                          2001:db8:1:1::1                       |
+                                                                +
|                                                                |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                                |
+                                                                +
|                                                                |
+                    Destination IPv6 Address                    +
|                          2001:db8:1:2::1                       |
+                                                                +
|                                                                |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+

Outer UDP Header
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     Source Port = xxxx         |         Dest Port = 2152      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|         UDP Length             |    UDP Checksum (Non-zero)    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 GTP-U header
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| 0x1 |1|0|1|0|0|     0xff      |            Length              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                           TEID = 1654                          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|    Sequence Number = 0         |N-PDU Number=0 |NextExtHdr=0x85|
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+

GTP-U Extension Header (PDU Session Container)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|  ExtHdrLen=2  |Type=0 | Spare |0|0|    QFI    |  PPI |  Spare  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                      Padding                |NextExtHdr=0x0  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+

Inner IPv6 Header
```

Latest Status in IETF

```
DMM Working Group                                              S. Homma
Internet-Draft                                                      NTT
Intended status: Informational                              T. Miyasaka
Expires: July 10, 2019                                    KDDI Research
                                                           S. Matsushima
                                                               SoftBank
                                                               D. Voyer
                                                            Bell Canada
                                                         January 6, 2019


     User Plane Protocol and Architectural Analysis on 3GPP 5G System
                   draft-ietf-dmm-5g-uplane-analysis-00

Abstract

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   Study work on 3GPP side.

Status of This Memo

   This Internet-Draft is submitted in full conformance with the
   provisions of BCP 78 and BCP 79.
```

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
Outer IPv6 Header
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|Version|    DSCP=EF    |              Flow Label               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|        Payload Length         | NxtHdr=17(UDP)|   Hop Limit   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
+                                                               +
|                                                               |
+                     Source IPv6 Address                       +
|                        2001:db8:1:1::1                        |
+                                                               +
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
+                                                               +
|                                                               |
+                  Destination IPv6 Address                     +
|                        2001:db8:1:2::1                        |
+                                                               +
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+

Outer UDP Header
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     Source Port = xxxx        |       Dest Port = 2152        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|          UDP Length           |     UDP Checksum (Non-zero)   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 GTP-U header
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| 0x1 |1|0|1|0|0|     0xff      |            Length             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                          TEID = 1654                          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|    Sequence Number = 0        |N-PDU Number=0 |NextExtHdr=0x85|
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+

GTP-U Extension Header (PDU Session Container)
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| ExtHdrLen=2   |Type=0 | Spare |0|0|    QFI    |  PPI  | Spare |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                  Padding                     |NextExtHdr=0x0 |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Latest Status in 3GPP

3GPP TR 29.892 V0.4.0 (2018-12)

Technical Report

セクション区切り (次のページから新しいセクション)

3rd Generation Partnership Project;
Technical Specification Group Core Network and Terminals;
Study on User Plane Protocol in 5GC.
(Release 16)

5G

3GPP A GLOBAL INITIATIVE

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6.1.1.3 Path/Tunnel Management functions....
6.1.1.4 Load Balancing....
6.1.1.5 Multicast....
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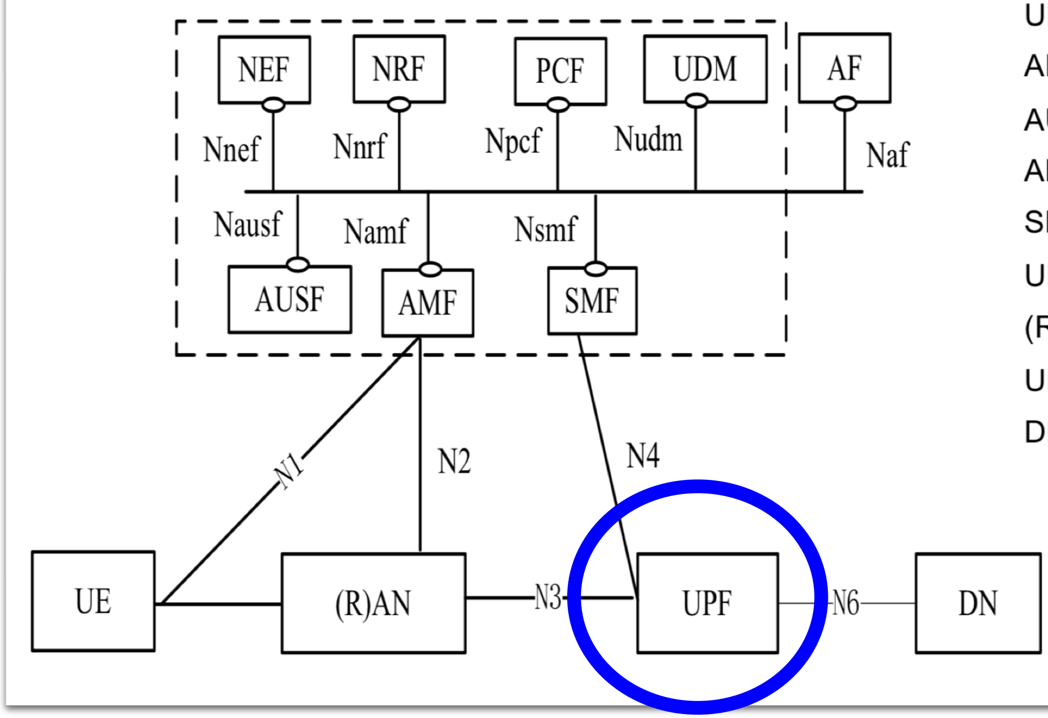
Packet Proce...

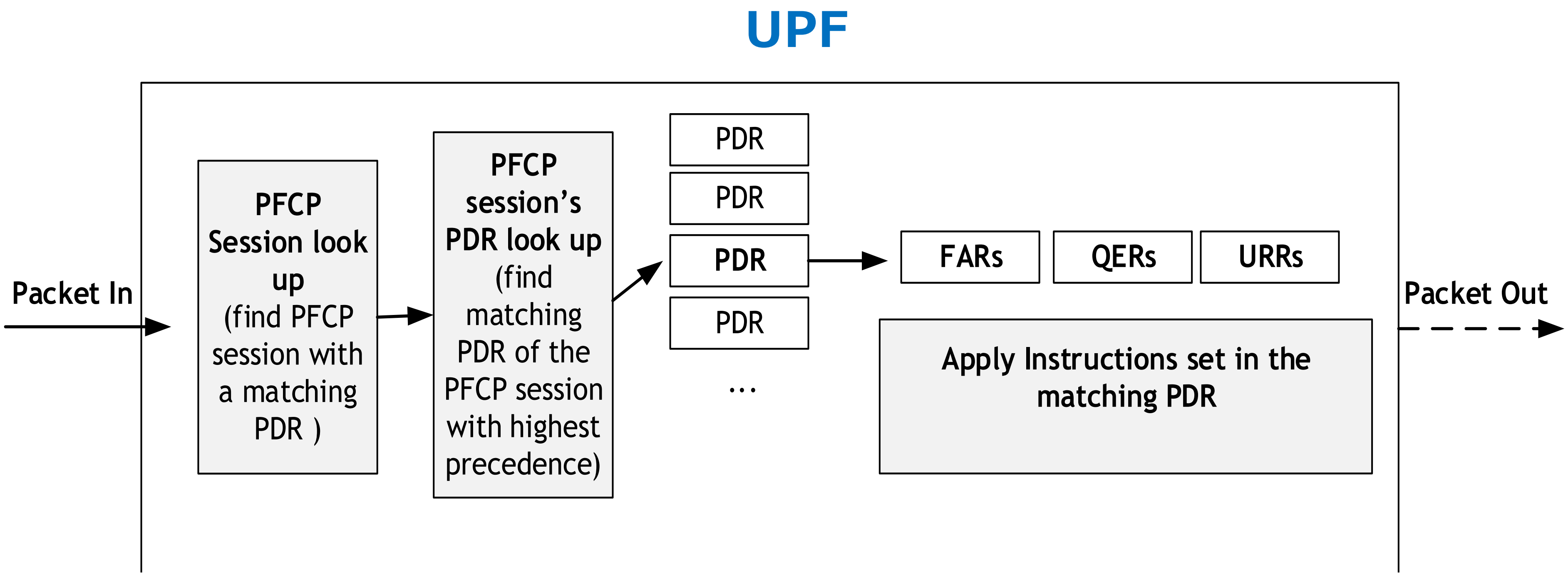
User Plane Model of 3GPP 5G

3GPP Rel-15 Architecture (5G Phase.1)



NEF	Network Exposure Function
NRF	Network Repository Function
PCF	Policy Control Function
UDM	Unified Data Management
AF	Application Function
AUSF	Authentication Server Function
AMF	Access &Mobility Management Function
SMF	Session Management Function
UE	User Equipment
(R)AN	(Radio) Access Network
UPF	User Plane Function
DN	Data Network

UPF Packet Forwarding Model in 3GPP

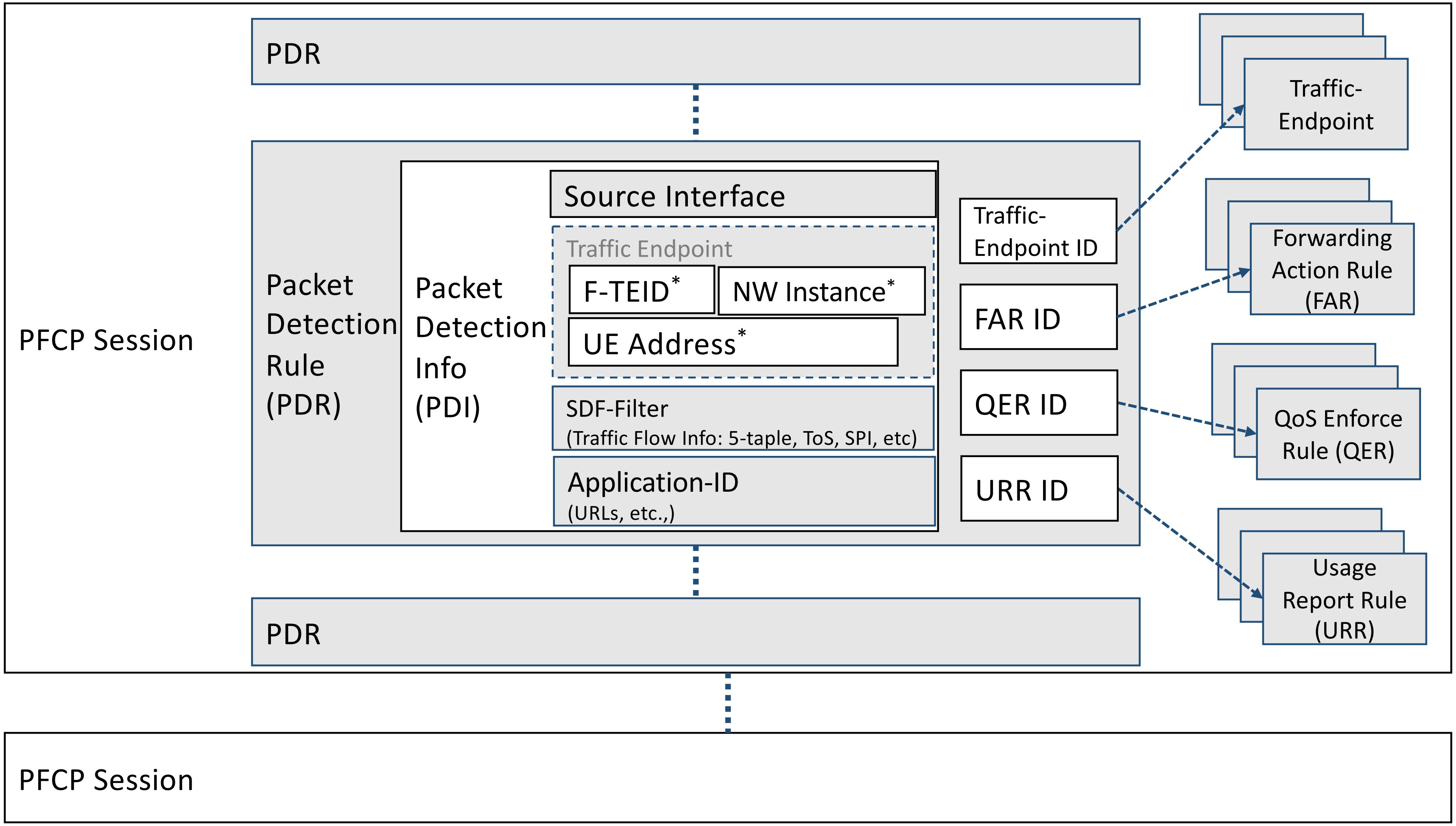


PFCP: Packet Flow Control Protocol PDR: Packet Detection Rule FAR: Forwarding Action Rule

QER: QoS Enforcement Rule URR: Usage Report Rule

Source: 3GPP TS29.244

PFCP Session Data Structure Overview



*: Not exist if Traffic-Endpoint ID is present.

User Plane Protocol Study Work in 3GPP

Takeaways from the protocol study

- In terms of subclause 6.2.2 ”Description of SRv6 solution in 5GC”
  - Follow Rel-16 5GC architecture
  - SRv6 as an encapsulation of User Plane.

- We are doing a Protocol Study work
  - i.e, not doing stage3 work.
  - Whole SRv6 concepts and possible advantages which could beyond Rel-16 stage2 architecture can be brought into other section.

- So we need principle for:
  - 5GC NFs (UPF, SMF, or if any) to be able to use SRv6.
  - 5GC interfaces (N4, N9, or if any) to be able to bring SRv6 related info.
  - Studying how it works and what’s missing specifically in 5GC.

8 Principles out for SRv6 User Plane in 5GC

No	Principle
1	No additional header other than IPv6, or IPv6 with SRH to encapsulate all type of PDU session packet and user plane messages required to N9 interface.
2	A SID of Locator:Function shall consist of a IPv6 prefix assigned to user plane IP resource of UPF, and the Argument shall encode the identifiers of tunnel and QoS. (i.e; TEID, QFI and RQI)
3	UPF shall lookup N4 session based on active SID as the destination address in the IPv6 header of receiving user plane packet.
4	SMF shall allocate a SID which enables UPF to be able to lookup the corresponding N4 session for each uplink and/or downlink.
5	N4 interface shall enable SMF to configure incoming and outgoing SID for a N4 session in each N9 UPF.
6	N4 interface shall enable UPF to notify SRv6 User Plane capability to SMF.
7	UPF shall be allowed to encapsulate T-PDU without SRH.
8	UPF shall be allowed to add SIDs mapping to corresponding Network Instance into a SRH to encapsulate T-PDU.

Principle (1)

No additional header other than IPv6, or IPv6 and SRH to encapsulate all type of PDU session packet and user plane messages required to N9 interface.

- Reason
  - As 128-bits IPv6 address and the capability to accumulate it in SRH, all information user plane needs could only use IPv6 header, or IPv6 with SRH.
  - It enables IP layer only user plane (i.e, w/o UDP/GTP-U)
  - We study how the SRv6 encapsulation can follow this principle.

Principle (2)

A SID of Locator:Function shall consist of a IPv6 prefix assigned to user plane IP resource of UPF, and the Argument shall encode the identifiers of tunnel and QoS. (i.e; TEID, QFI and RQI)

- Reason
  - SRv6 takes SID in the format of "Locator:Funcition:Argument" in IPv6 address as described in subclause 6.2.1.3
  - To follow 5GC architecture, the Locator:Function part can turn out to be IPv6 prefix of user plane IP resource.
  - The argument encodes the user plane IDs that derives principle (3).

Principle (3)

UPF shall lookup N4 session based on active SID as the destination address in the IPv6 header of receiving user plane packet.

- Reason
  - To follow stage2 CUPS architecture.
  - As principle (2), all UPF needs to lookup N4 session have to exist in SID
  - N4 session lookup shall be based on last active SID. Hence the SID exists as the destination address in the IPv6 header.

Principle (4)

SMF shall allocate a SID which enables UPF to be able to lookup the corresponding N4 session for each uplink and/or downlink.

- Reason
  - To follow 5GC architecture, all forwarding configurations need to be came from SMF.

Principle (5)

N4 interface shall enable SMF to configure incoming and outgoing SID for a N4 session in each N9 UPF.

- Reason
  - Same reason with principle (4)
  - To follow 5GC architecture, all forwarding configurations need to be came from SMF.

Principle (6)

N4 interface shall enable UPF to notify SRv6 User Plane capability to SMF.

- Reason
  - To follow stage2 5GC and CUPS architecture that IP resources information on a UPF shall come from the UPF to the SMF.

Principle (7)

UPF shall be allowed to encapsulate T-PDU without SRH.

- Reason
  - To clarify minimum encapsulation, i.e, only IPv6 header.
  - Without this principle, Traditional mode is still have another encapsulation option which T-PDU can be encapsulated with a SRH with just one SID. Because the traditional mode is fundamentally defined as hop-by-hop model over N9.
  - This principle requires some solution to be defined that it does not require SRH to encapsulate T-PDU. The traditional mode should be the consequence.

Principle (8)

UPF shall be allowed to add SIDs mapping to corresponding Network Instance into a SRH to encapsulate T-PDU.

- Reason
  - The SID could represent functions which are going to be standardized in IETF, or very operator specific service functions that are fully out of scope of 3GPP.
  - Traffic engineering paths, VNFs on NFV, etc., can be represented as SID but it fully depends on local information as described in subclause of 5.2.1.2.

3GPP N4 Interface Protocol

(PFCP: Packet Forwarding Control Protocol)

User Plane IP Resource IE

Octets	Bits 8	7	6	5	4	3	2	1
1 to 2	Type = 116 (decimal)							
3 to 4	Length = n							
5	Spare	ASSO SI	ASSO NI	TEIDRI			V6	V4
6	TEID Range							
m to (m+3)	IPv4 address							
p to (p+15)	IPv6 address							
k to l	Network Instance							
r	Spare				Source Interface			
s to (n+4)	These octet(s) is/are present only if explicitly specified							

Figure 8.2.82-1: User Plane IP Resource Information

Source:
3GPP TS29.244

Source Interface IE

	Bits							
Octets	8	7	6	5	4	3	2	1
1 to 2	Type = 20 (decimal)							
3 to 4	Length = n							
5	Spare				Interface value			
6 to (n+4)	These octet(s) is/are present only if explicitly specified							

Figure 8.2.2-1: Source Interface

The Interface value shall be encoded as a 4 bits binary integer as specified in in Table 8.2.2-1.

Table 8.2.2-1: Interface value

Interface value	Values (Decimal)
Access	0
Core	1
SGi-LAN/N6-LAN	2
CP-function	3
Spare	4 to 15
NOTE 1: The "Access" and "Core" values denote an uplink and downlink traffic direction respectively. NOTE 2: For indirect data forwarding, the Source Interface in the PDR and the Destination Interface in the FAR shall both be set to "Access", in the forwarding SGW(s). The Interface value does not infer any traffic direction, in PDRs and FARs set up for indirect data forwarding, i.e. with both the Source and Destination Interfaces set to Access.	

Source:
3GPP TS29.244

PFCP Session Definition in TS29.244 V15.2.0

A PFCP session consists of multiple PDRs, FARs, URRs and BARs.

Table 7.5.2.1-1: Information Elements in an PFCP Session Establishment Request

Information elements	P	Condition / Comment	Appl. Sxa	Appl. Sxb	Appl. Sxc	Appl. N4	IE Type
Node ID	M	This IE shall contain the unique identifier of the sending Node.	X	X	X	X	Node ID
CP F-SEID	M	This IE shall contain the unique identifier allocated by the CP function identifying the session.	X	X	X	X	F-SEID
Create PDR	M	This IE shall be present for at least one PDR to be associated to the PFCP session. Several IEs with the same IE type may be present to represent multiple PDRs. See Table 7.5.2.2-1.	X	X	X	X	Create PDR
Create FAR	M	This IE shall be present for at least one FAR to be associated to the PFCP session. Several IEs with the same IE type may be present to represent multiple FARs. See Table 7.5.2.3-1.	X	X	X	X	Create FAR
Create URR	C	This IE shall be present if a measurement action shall be applied to packets matching one or more PDR(s) of this PFCP session. Several IEs within the same IE type may be present to represent multiple URRs. See Table 7.5.2.4-1.	X	X	X	X	Create URR
Create QER	C	This IE shall be present if a QoS enforcement action shall be applied to packets matching one or more PDR(s) of this PFCP session. Several IEs within the same IE type may be present to represent multiple QERs. See Table 7.5.2.5-1.	-	X	X	X	Create QER
Create BAR	O	When present, this IE shall contain the buffering instructions to be applied by the UP function to any FAR of this PFCP session set with the Apply Action requesting the packets to be buffered and with a BAR ID IE referring to this BAR. See table 7.5.2.6-1.	X	-	-	X	Create BAR
Create Traffic Endpoint	C	This IE may be present if the UP function has indicated support of PDI optimization. Several IEs within the same IE type may be present to represent multiple Traffic Endpoints. See Table 7.5.2.7-1.	X	X	X	X	Create Traffic Endpoint
PDN Type	C	This IE shall be present if the PFCP session is setup for an individual PDN connection or PDU session (see subclause 5.2.1). When present, this IE shall indicate whether this is an IP or non-IP PDN connection/PDU session or, for 5GC, an Ethernet PDU session.	X	X	-	X	PDN Type
SGW-C FQ-CSID	C	This IE shall be included according to the requirements in clause 23 of 3GPP TS 23.007 [24].	X	X	-		FQ-CSID
MME FQ-CSID	C	This IE shall be included when received on the S11 interface or on S5/S8 interface according to the requirements in clause 23 of 3GPP TS 23.007 [24].	X	X	-	-	FQ-CSID
PGW-C FQ-CSID	C	This IE shall be included according to the requirements in clause 23 of 3GPP TS 23.007 [24].	X	X	-	-	FQ-CSID
ePDG FQ-CSID	C	This IE shall be included according to the requirements in clause 23 of 3GPP TS 23.007 [24].	-	X	-	-	FQ-CSID
TWAN FQ-CSID	C	This IE shall be included according to the requirements in clause 23 of 3GPP TS 23.007 [24].	-	X	-	-	FQ-CSID
User Plane Inactivity Timer	O	This IE may be present to request the UP function to send a User Plane Inactivity Report when no user plane packets are received for this PFCP session for a duration exceeding the User Plane Inactivity Timer. When present, it shall contain the duration of the inactivity period after which a User Plane Inactivity Report shall be generated.	-	X	X	X	User Plane Inactivity Timer
User ID	O	This IE may be present, based on operator policy. It shall	X	X	X	X	User ID

Source:
3GPP TS29.244

PDR Definition

Table 7.5.2.2-1: Create PDR IE within PFCP Session Establishment Request

Octet 1 and 2		Create PDR IE Type = 1(decimal)					
Octets 3 and 4		Length = n					
Information elements	**P**	**Condition / Comment**	**Appl.**				**IE Type**
			Sxa	**Sxb**	**Sxc**	**N4**	
PDR ID	M	This IE shall uniquely identify the PDR among all the PDRs configured for that PFCP session.	X	X	X	X	PDR ID
Precedence	M	This IE shall indicate the PDR's precedence to be applied by the UP function among all PDRs of the PFCP session, when looking for a PDR matching an incoming packet.	-	X	X	X	Precedence
PDI	M	This IE shall contain the PDI against which incoming packets will be matched. See Table 7.5.2.2-2.	X	X	X	X	PDI
Outer Header Removal	C	This IE shall be present if the UP function is required to remove one or more outer header(s) from the packets matching this PDR.	X	X	-	X	Outer Header Removal
FAR ID	C	This IE shall be present if the Activate Predefined Rules IE is not included or if it is included but it does not result in activating a predefined FAR. When present this IE shall contain the FAR ID to be associated to the PDR.	X	X	X	X	FAR ID
URR ID	C	This IE shall be present if a measurement action shall be applied to packets matching this PDR. When present, this IE shall contain the URR IDs to be associated to the PDR. Several IEs within the same IE type may be present to represent a list of URRs to be associated to the PDR.	X	X	X	X	URR ID
QER ID	C	This IE shall be present if a QoS enforcement action shall be applied to packets matching this PDR. When present, this IE shall contain the QER IDs to be associated to the PDR. Several IEs within the same IE type may be present to represent a list of QERs to be associated to the PDR.	-	X	X	X	QER ID
Activate Predefined Rules	C	This IE shall be present if Predefined Rule(s) shall be activated for this PDR. When present this IE shall contain one Predefined Rules name. Several IEs with the same IE type may be present to represent multiple "Activate Predefined Rules" names.	-	X	X	X	Activate Predefined Rules

Source:
3GPP TS29.244

PDI Definition (Included in PDR)

Table 7.5.2.2-2: PDI IE within PFCP Session Establishment Request

Octet 1 and 2		PDI IE Type = 2 (decimal)					
Octets 3 and 4		Length = n					
Information elements	**P**	**Condition / Comment**	**Appl. Sx a**	**Sx b**	**Sx c**	**N4**	**IE Type**
Source Interface	M	This IE shall identify the source interface of the incoming packet.	X	X	X	X	Source Interface
Local F-TEID	O	This IE shall not be present if Traffic Endpoint ID is present. If present, this IE shall identify the local F-TEID to match for an incoming packet. The CP function shall set the CHOOSE (CH) bit to 1 if the UP function supports the allocation of F-TEID and the CP function requests the UP function to assign a local F-TEID to the PDR.	X	X	-	X	F-TEID
Network Instance	O	This IE shall not be present if Traffic Endpoint ID is present. If present, this IE shall identify the Network instance to match for the incoming packet. See NOTE 1, NOTE2.	X	X	X	X	Network Instance
UE IP address	O	This IE shall not be present if Traffic Endpoint ID is present. If present, this IE shall identify the source or destination IP address to match for the incoming packet.	-	X	X	X	UE IP address
Traffic Endpoint ID	C	This IE may be present if the UP function has indicated the support of PDI optimization. If present, this IE shall uniquely identify the Traffic Endpoint for that PFCP session.	X	X	X	X	Traffic Endpoint ID
SDF Filter	O	If present, this IE shall identify the SDF filter to match for the incoming packet. Several IEs with the same IE type may be present to provision a list of SDF Filters. The full set of applicable SDF filters, if any, shall be provided during the creation or the modification of the PDI. See NOTE 3.	-	X	X	X	SDF Filter
Application ID	O	If present, this IE shall identify the Application ID to match for the incoming packet.	-	X	X	X	Application ID
Ethernet PDU Session Information	O	This IE may be present to identify all the (DL) Ethernet packets matching an Ethernet PDU session (see subclause 5.13.1).	-	-	-	X	Ethernet PDU Session Information
Ethernet Packet Filter	O	If present, this IE shall identify the Ethernet PDU to match for the incoming packet. Several IEs with the same IE type may be present to represent a list of Ethernet Packet Filters. The full set of applicable Ethernet Packet filters, if any, shall be provided during the creation or the modification of the PDI.	-	-	-	X	Ethernet Packet Filter
QFI	O	If present, this IE shall identify the QoS Flow Identifier to match for the incoming packet. Several IEs with the same IE type may be present to provision a list of QFIs. When present, the full set of applicable QFIs shall be provided during the creation or the modification of the PDI.	-	-	-	X	QFI

NOTE 1: The Network Instance parameter is needed e.g. in the following cases:
- PGW/TDF UP function supports multiple PDNs with overlapping IP addresses;
- SGW UP function is connected to PGWs in different IP domains (S5/S8);
- PGW UP function is connected to SGWs in different IP domains (S5/S8);
- SGW UP function is connected to eNodeBs in different IP domains;
- UPF is connected to 5G-ANs in different IP domains.

NOTE 2: When a Local F-TEID is provisioned in the PDI, the Network Instance shall relate to the IP address of the F-TEID. Otherwise, the Network Instance shall relate to the UE IP address.

NOTE 3: SDF Filter IE(s) shall not be present if Ethernet Packet Filter IE(s) is present.

Source: 3GPP TS29.244

Traffic Endpoint Definition (Pointed by PDI)

Table 7.5.2.7-1: Create Traffic Endpoint IE within PFCP Session Establishment Request

Octet 1 and 2	Create Traffic Endpoint IE Type = 127(decimal)						
Octets 3 and 4	Length = n						
Information elements	**P**	**Condition / Comment**	**Appl.**				**IE Type**
			Sxa	**Sxb**	**Sxc**	**N4**	
Traffic Endpoint ID	M	This IE shall uniquely identify the Traffic Endpoint for that Sx session.	X	X	X	X	Traffic Endpoint ID
Local F-TEID	O	If present, this IE shall identify the local F-TEID to match for an incoming packet. The CP function shall set the CHOOSE (CH) bit to 1 if the UP function supports the allocation of F-TEID and the CP function requests the UP function to assign a local F-TEID to the Traffic Endpoint.	X	X	-	X	F-TEID
Network Instance	O	If present, this IE shall identify the Network instance to match for the incoming packet. See NOTE 1, NOTE2.	X	X	X	X	Network Instance
UE IP address	O	If present, this IE shall identify the source or destination IP address to match for the incoming packet.	-	X	X	X	UE IP address
Ethernet PDU Session Information	O	This IE may be present to identify all the (DL) Ethernet packets matching an Ethernet PDU session (see subclause 5.13.1).	-	-	-	X	Ethernet PDU Session Information

NOTE 1: The Network Instance parameter is needed e.g. in the following cases:
- PGW/TDF UP function supports multiple PDNs with overlapping IP addresses;
- SGW UP function is connected to PGWs in different IP domains (S5/S8);
- PGW UP function is connected to SGWs in different IP domains (S5/S8);
- SGW UP function is connected to eNodeBs in different IP domains;
- UPF is connected to 5G-ANs in different IP domains.

NOTE 2: When a Local F-TEID is provisioned in the Traffic Endpoint, the Network Instance shall relate to the IP address of the F-TEID. Otherwise, the Network Instance shall relate to the UE IP address.

Source:
3GPP TS29.244

F-TEID IE (Included in PDI/Traffic Endpoint IE)

	Bits							
Octets	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**
1 to 2	Type = 21 (decimal)							
3 to 4	Length = n							
5	Spare				CHID	CH	V6	V4
6 to 9	TEID							
m to (m+3)	IPv4 address							
p to (p+15)	IPv6 address							
q	CHOOSE ID							
k to (n+4)	These octet(s) is/are present only if explicitly specified							

Figure 8.2.3-1: F-TEID

The following flags are coded within Octet 5:

- Bit 1 – V4: If this bit is set to "1" and the CH bit is not set, then the IPv4 address field shall be present, otherwise the IPv4 address field shall not be present.
- Bit 2 – V6: If this bit is set to "1" and the CH bit is not set, then the IPv6 address field shall be present, otherwise the IPv6 address field shall not be present.
- Bit 3 – CH (CHOOSE): If this bit is set to "1", then the TEID, IPv4 address and IPv6 address fields shall not be present and the UP function shall assign an F-TEID with an IP4 or an IPv6 address if the V4 or V6 bit is set respectively. This bit shall only be set by the CP function.
- Bit 4 – CHID (CHOOSE ID): If this bit is set to "1", then the UP function shall assign the same F-TEID to the PDRs requested to be created in a PFCP Session Establishment Request or PFCP Session Modification Request with the same CHOOSE ID value. This bit may only be set to "1" if the CH bit it set to "1". This bit shall only be set by the CP function.
- Bit 5 to 8: Spare, for future use and set to 0.

At least one of the V4 and V6 flags shall be set to "1", and both may be set to "1" for both scenarios:

- when the CP function is allocating F-TEID, i.e. both IPv4 address field and IPv6 address field may be present;
- or when the UP function is requested to allocate the F-TEID, i.e. when CHOOSE bit is set to "1", and the IPv4 address and IPv6 address fields are not present.

Octet 6 to 9 (TEID) shall be present and shall contain a GTP-U TEID, if the CH bit in octet 5 is not set. When the TEID is present, if both IPv4 and IPv6 addresses are present in the F-TEID IE, then the TEID value shall be shared by both addresses.

Octets "m to (m+3)" and/or "p to (p+15)" (IPv4 address / IPv6 address fields), if present, it shall contain the respective IP address values.

Octet q shall be present and shall contain a binary integer value if the CHID bit in octet 5 is set to "1".

Source:
3GPP TS29.244

FAR Definition (Pointed by PDR)

Table 7.5.2.3-1: Create FAR IE within PFCP Session Establishment Request

Octet 1 and 2		Create FAR IE Type = 3 (decimal)					
Octets 3 and 4		Length = n					
Information elements	**P**	**Condition / Comment**	**Appl.**				**IE Type**
			Sx a	**Sx b**	**Sx c**	**N4**	
FAR ID	M	This IE shall uniquely identify the FAR among all the FARs configured for that PFCP session.	X	X	X	X	FAR ID
Apply Action	M	This IE shall indicate the action to apply to the packets, See subclauses 5.2.1 and 5.2.3.	X	X	X	X	Apply Action
Forwarding Parameters	C	This IE shall be present when the Apply-Action requests the packets to be forwarded. It may be present otherwise. When present, this IE shall contain the forwarding instructions to be applied by the UP function when the Apply-Action requests the packets to be forwarded. See table 7.5.2.3-2.	X	X	X	X	Forwarding Parameters
Duplicating Parameters	C	This IE shall be present when the Apply-Action requests the packets to be duplicated. It may be present otherwise. When present, this IE shall contain the forwarding instructions to be applied by the UP function for the traffic to be duplicated, when the Apply-Action requests the packets to be duplicated. Several IEs with the same IE type may be present to represent to duplicate the packets to different destinations. See NOTE 1. See table 7.5.2.3-3.	X	X	-	X	Duplicating Parameters
BAR ID	O	When present, this IE shall contain the BAR ID of the BAR defining the buffering instructions to be applied by the UP function when the Apply Action requests the packets to be buffered. See table 7.5.2.6-1.	X	-	-	X	BAR ID
NOTE 1: The same user plane packets may be required, according to operator's policy and configuration, to be duplicated to different SX3LIFs.							
Editor's Note: Regarding duplication of parameters for interception is FFS on N4, needs confirmation from SA3.							

Source:
3GPP TS29.244

Forwarding Parameter Definition (Included in FAR)

Table 7.5.2.3-2: Forwarding Parameters IE in FAR

Octet 1 and 2		Forwarding Parameters IE Type = 4 (decimal)					
Octets 3 and 4		Length = n					
Information elements	**P**	**Condition / Comment**	**Appl.**				**IE Type**
			Sx a	**Sx b**	**Sx c**	**N4**	
Destination Interface	M	This IE shall identify the destination interface of the outgoing packet.	X	X	X	X	Destination Interface
Network Instance	O	When present, this IE shall identify the Network instance towards which to send the outgoing packet. See NOTE 1.	X	X	X	X	Network Instance
Redirect Information	C	This IE shall be present if the UP function is required to enforce traffic redirection towards a redirect destination provided by the CP function.	-	X	X	X	Redirect Information
Outer Header Creation	C	This IE shall be present if the UP function is required to add one or more outer header(s) to the outgoing packet. If present, it shall contain the F-TEID of the remote GTP-U peer when adding a GTP-U/UDP/IP header, or the Destination IP address and Port Number when adding a UDP/IP header.	X	X	-	X	Outer Header Creation
Transport Level Marking	C	This IE shall be present if the UP function is required to mark the IP header with the DSCP marking as defined by IETF RFC 2474 [22]. When present, it shall contain the value of the DSCP in the TOS/Traffic Class field set based on the QCI, and optionally the ARP priority level, of the associated EPS bearer, as described in sub-clause 4.7.3 of 3GPP TS 23.214 [2].	X	X	-	X	Transport Level Marking
Forwarding Policy	C	This IE shall be present if a specific forwarding policy is required to be applied to the packets. It shall be present if the Destination Interface IE is set to SGi-LAN. It may be present if the Destination Interface is set to Core. When present, it shall contain an Identifier of the Forwarding Policy locally configured in the UP function.	-	X	X	X	Forwarding Policy
Header Enrichment	O	This IE may be present if the UP function indicated support of Header Enrichment of UL traffic. When present, it shall contain information for header enrichment.	-	X	X	X	Header Enrichment
Linked Traffic Endpoint ID	C	This IE may be present, if it is available and the UP function indicated support of the PDI optimisation feature, (see subclause 8.2.25). When present, it shall identify the Traffic Endpoint ID allocated for this PFCP session to receive the traffic in the reverse direction (see subclause 5.2.3.1).	X	X	-	X	Traffic Endpoint ID
Proxying	C	This IE shall be present if proxying is to be performed by the UP function. When present, this IE shall contain the information that the UPF shall perfom ARP proxying as specified in IETF RFC 1027 [32] and / or IPv6 Neighbour Solicitation Proxying as specified in IETF RFC 4861 [33] functionality for the Ethernet PDUs.	-	-	-	X	Proxying

NOTE 1: The Network Instance parameter is needed e.g. in the following cases:
- PGW/TDF UP function supports multiple PDNs with overlapping IP addresses;
- SGW UP function is connected to PGWs in different IP domains (S5/S8);
- PGW UP function is connected to SGWs in different IP domains (S5/S8);
- SGW UP function is connected to eNodeBs in different IP domains;
- UPF is connected to 5G-ANs in different IP domains.

Editor's Note: PCC dependencies are FFS on N4.

Source: 3GPP TS29.244

Outer Header Creation IE (Included in FAR)

	Bits							
Octets	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**
1 to 2	Type = 84 (decimal)							
3 to 4	Length = n							
5 to 6	Outer Header Creation Description							
m to (m+3)	TEID							
p to (p+3)	IPv4 Address							
q to (q+15)	IPv6 Address							
r to (r+1)	Port Number							
t to (t+2)	C-TAG							
u to (u+2)	S-TAG							
s to (n+4)	These octet(s) is/are present only if explicitly specified							

Figure 8.2.56-1: Outer Header Creation

Table 8.2.56-1: Outer Header Creation Description

Octet / Bit	Outer Header to be created in the outgoing packet
5/1	GTP-U/UDP/IPv4 (NOTE 1), (NOTE 3)
5/2	GTP-U/UDP/IPv6 (NOTE 1), (NOTE 3)
5/3	UDP/IPv4 (NOTE 2, NOTE 5)
5/4	UDP/IPv6 (NOTE 2, NOTE 5)
5/5	IPv4 (NOTE 5)
5/6	IPv6 (NOTE 5)
5/7	C-TAG (see NOTE 4)
5/8	S-TAG (see NOTE 4)

NOTE 1: The SGW-U/I-UPF shall also create GTP-U extension header(s) if any has been stored for this packet, during a previous outer header removal (see subclause 8.2.64).

NOTE 2: This value may apply to UL packets sent by a PGW-U for non-IP PDN connections with SGi tunnelling based on UDP/IP encapsulation (see subclause 4.3.17.8.3.3.2 of 3GPP TS 23.401 [14]).

NOTE 3: The SGW-U/I-UPF shall set the GTP-U message type to the value stored during the previous outer header removal.

NOTE 4: This value may apply to UL packets sent by a UPF for Ethernet PDU sessions over N6 (see subclause 5.8.2.11.6 of 3GPP TS 23.501 [28]).

NOTE 5: This value may apply e.g. to UL packets sent by a UPF (PDU Session Anchor) over N6, when explicit N6 traffic routing information is provided to the SMF (see subclause 5.6.7 of 3GPP TS 23.501 [28]).

Source:
3GPP TS29.244

Overhead Analysis
(incl. Underlay Protocols)

Total Header Size Comparison

	Deployment Scenario	Total Overhead (Bytes)
1	SRv6 Mobile User Plane over Ethernet (No SRH) (Traditional Mode)	58
2	SRv6 Mobile User Plane over Ethernet (No SRH) (Traditional Mode + VLAN just for dot1p CoS)	62
3	SRv6 Mobile User Plane over VLAN over Ethernet (2x SIDs) (Enhanced Mode, TE + 1x Service)	98
4	SRv6 Mobile User Plane over VLAN over Ethernet (2x SIDs) (Enhanced Mode, TE + 1x Service + VLAN just for dot1p CoS)	102
5	GTP-U over IPv4 over Ethernet	66
6	GTP-U over IPv4 over MPLS L3VPN over Ethernet	74
7	GTP-U over IPv4 over MPLS L3VPN over TE-LSP over Ethernet	78
8	GTP-U over IPv4 over VLAN over Ethernet	70
9	GTP-U over IPv4 over QinQ over Ethernet	74
10	GTP-U over IPv4 over PBB L2VPN	90
11	GTP-U over IPv4 over VLAN over PBB L2VPN	94
12	GTP-U over IPv4 over QinQ over PBB L2VPN	98
13	GTP-U over IPv4 over Ethernet over MPLS L2VPN over Ethernet	74
14	GTP-U over IPv4 over Ethernet over MPLS L2VPN over TE-LSP over Ethernet	78
15	GTP-U over IPv4 over VLAN over MPLS L2VPN over Ethernet	78
16	GTP-U over IPv4 over QinQ over MPLS L2VPN over TE-LSP over Ethernet	86
17	GTP-U over IPv4 over PBB over MPLS L2VPN over Ethernet	98
18	GTP-U over IPv4 over VLAN over PBB over MPLS L2VPN over Ethernet	102
19	GTP-U over IPv4 over QinQ over PBB over MPLS L2VPN over Ethernet	106
20	GTP-U over IPv4 over PBB over MPLS L2VPN over TE-LSP over Ethernet	102
21	GTP-U over IPv4 over VLAN over PBB over MPLS L2VPN over TE-LSP over Ethernet	106
22	GTP-U over IPv4 over QinQ over PBB over MPLS L2VPN over TE-LSP over Ethernet	110
23	GTP-U over IPv4 over MPLS L3VPN over VLAN over Ethernet	78
24	GTP-U over IPv4 over MPLS L3VPN over QinQ over Ethernet	82
25	GTP-U over IPv4 over MPLS L3VPN over PBB L2VPN	98
26	GTP-U over IPv4 over MPLS L3VPN over VLAN over PBB L2VPN	102
27	GTP-U over IPv4 over MPLS L3VPN over QinQ over PBB L2VPN	106

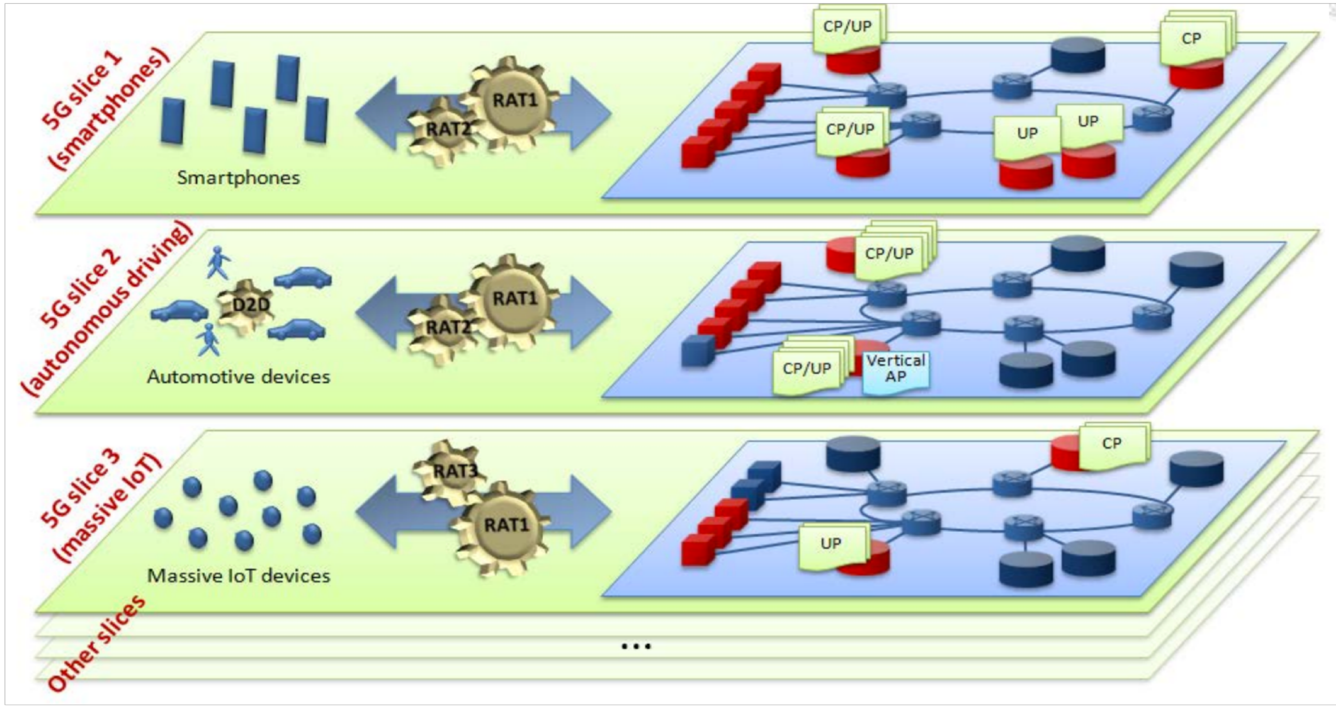
https://docs.google.com/spreadsheets/d/1Fx8ilE_bQPkhFBoSd-qRS5ok2IO1i0VZbmwzZJNVh0g/edit?usp=sharing

Thank you

Backup Slides

Generic Expectations for 5G Networks

U-Plane must be simplified because to meet Complicated Optimizations



eMBB

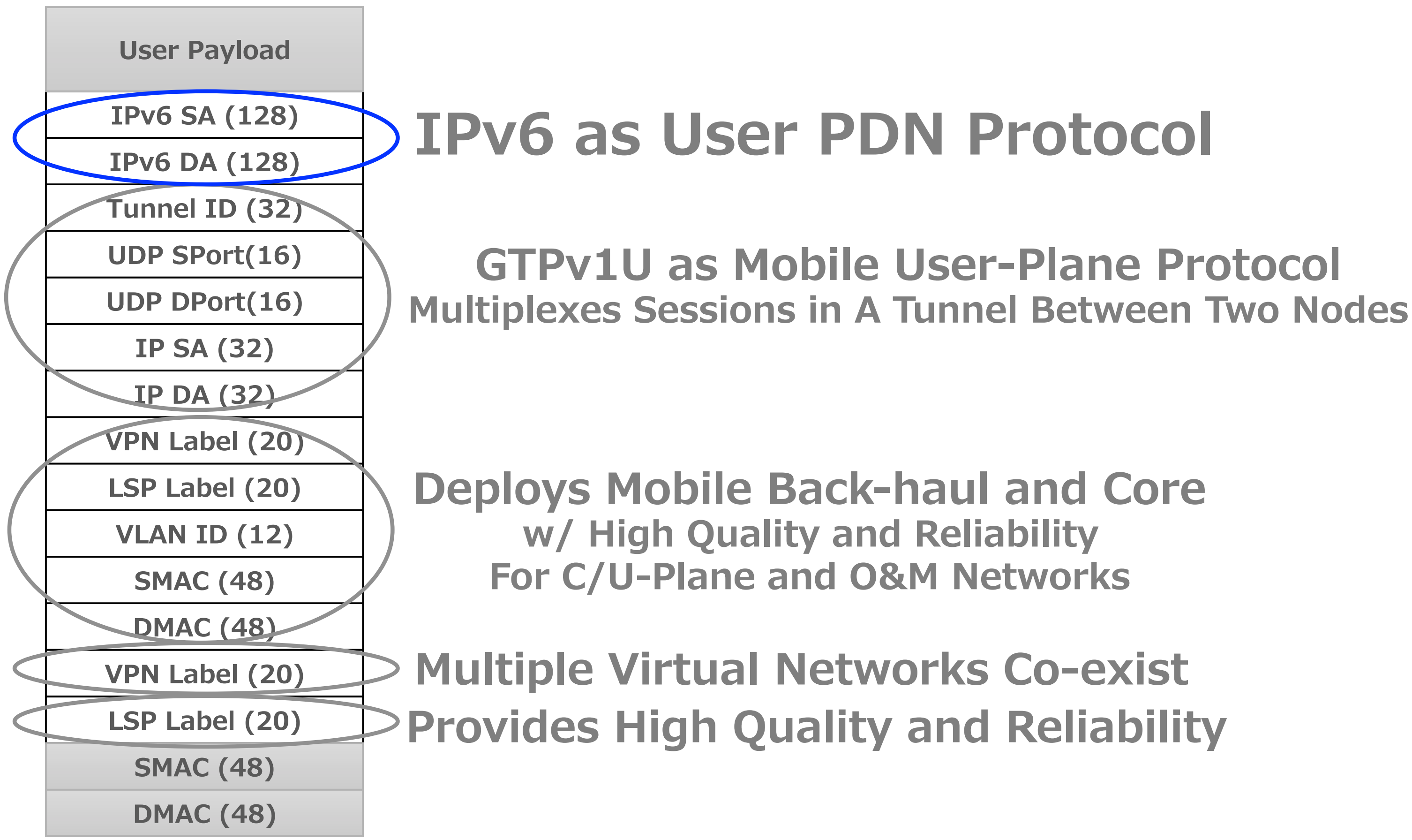
uRLLC

mMTC

Source: [NGMN white-paper]

But Today's U-plane Transports Are Well Complicated Already, Why?

Stacking Multiple Small ID Space Networks to Fulfill Requirements of Reliability, VPNs, etc.,



So Please Beware..

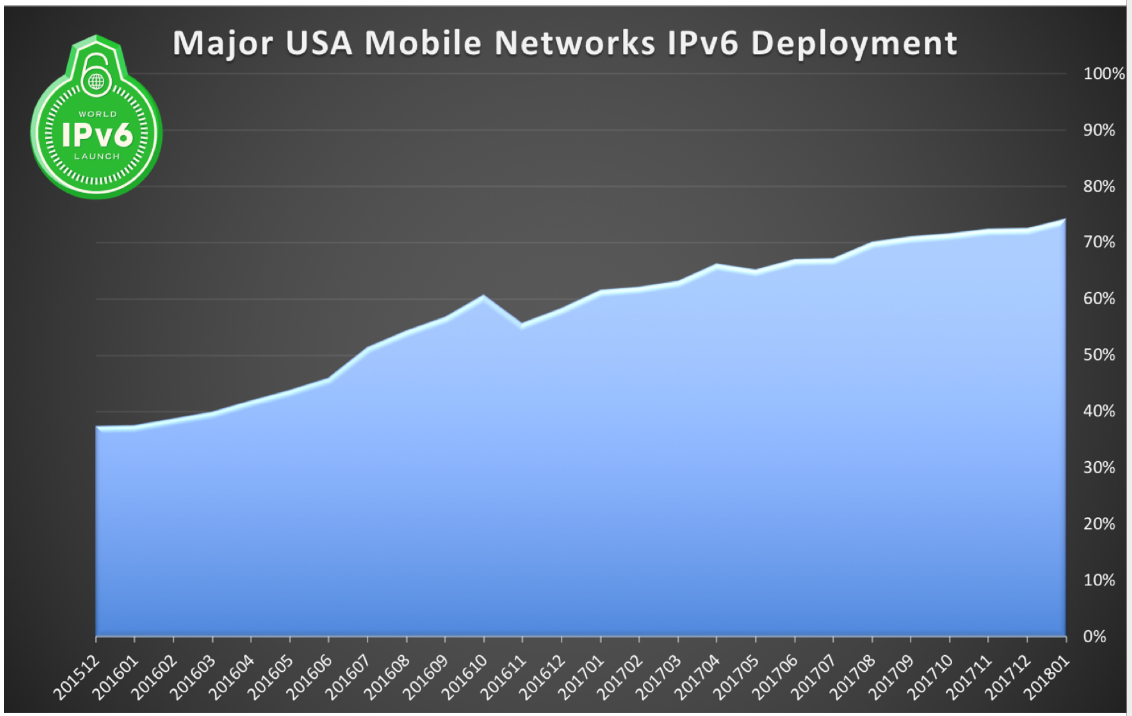
Integrating Mobile UPlane and Transport is A Key

- For Mobile Experts:
  - The wire you see is **NOT** actual wire.
  - There are many layers stacked underneath the wire.

- For IP/Transport Experts:
  - Your end customers are **NOT** accommodated onto your VXLAN/LSP/Pseudo-Wire tunnels.
  - They are accommodated onto far more tunnels (GTP-U!) on top of the VXLAN/LSP/Pseudo-Wire tunnels.

So SRv6 Requires IPv6 Customers, Where Are They?

In fact, IPv6 is widely deployed in Mobile already!



Network operator measurements, 9th January 2019

To understand our IPv6 Deployment metric, please read the notes below. Results are ranked by overall traffic volume. Click on Participating Network name to view a longitudinal deployment graph for that network.

Show 10 entries Search:

Rank	Participating Network	ASN(s)	IPv6 deployment
1	Comcast	7015, 7016, 7725, 7922, 11025, 13367, 13385, 20214, 21508, 22258, 22909, 33287, 33489, 33490, 33491, 33650, 33651, 33652, 33653, 33654, 33655, 33656, 33657, 33659, 33660, 33661, 33662, 33664, 33665, 33666, 33667, 33668, 36732, 36733	69.26%
2	KDDI	2516	50.99%
3	RELIANCE JIO INFOCOMM LTD	55836, 64049	89.18%
4	SoftBank	17676	40.78%
5	Charter Communications	7843, 10796, 11351, 11426, 11427, 12271, 20001, 20115, 33363	45.30%
6	ATT	6389, 7018, 7132	61.98%
7	Deutsche Telekom AG	3320	65.26%
8	Verizon Wireless	6167, 22394	87.95%
9	Liberty Global	5089, 6830, 20825, 29562	21.76%
10	Chunghwa Telecom (HiNet)	3462, 9680, 17419	21.38%

Showing 1 to 10 of 315 entries

First Previous 1 2 3 4 5 Next Last

A Blog Entry: Reducing the complexity of 5G networks using SRv6

blog.apnic.net/2018/03/07/reducing-complexity

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Reducing the complexity of 5G networks using Segment Routing IPv6

By Satoru Matsushima on 7 Mar 2018

Category: Tech matters

Tags: 5G, Guest Post, IETF, IPv6, Mobile, network topology

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Blog home

5G, the fifth and latest generation of cellular network standards, is attracting plenty of attention within the Internet realm, in particular, the increased bandwidth, greater connectivity, stability and lower latency the technology will provide mobile applications.

With an expected release date of September 2018, the first release of 5G still has a lot of areas to be studied, including how 5G mobile technology interacts with IP networking. Our work has been looking at how to simplify the data path of mobility management.

https://blog.apnic.net/2018/03/07/reducing-complexity-5g-networks-using-segment-routing-ipv6/

EoF