

LTE QoS

- SDF and EPS Bearer QoS -

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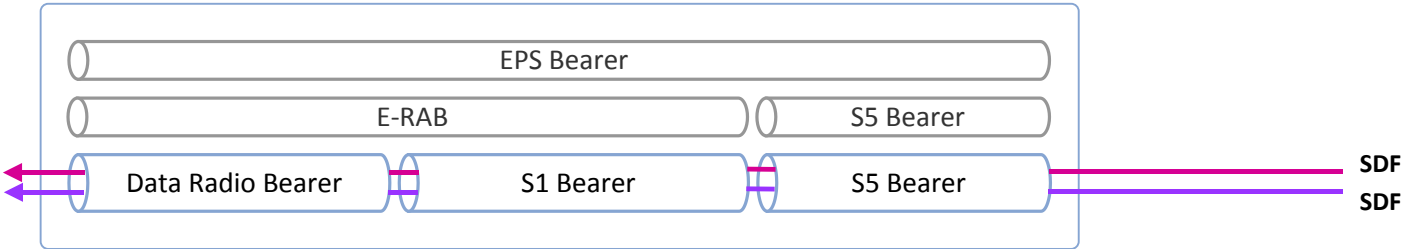
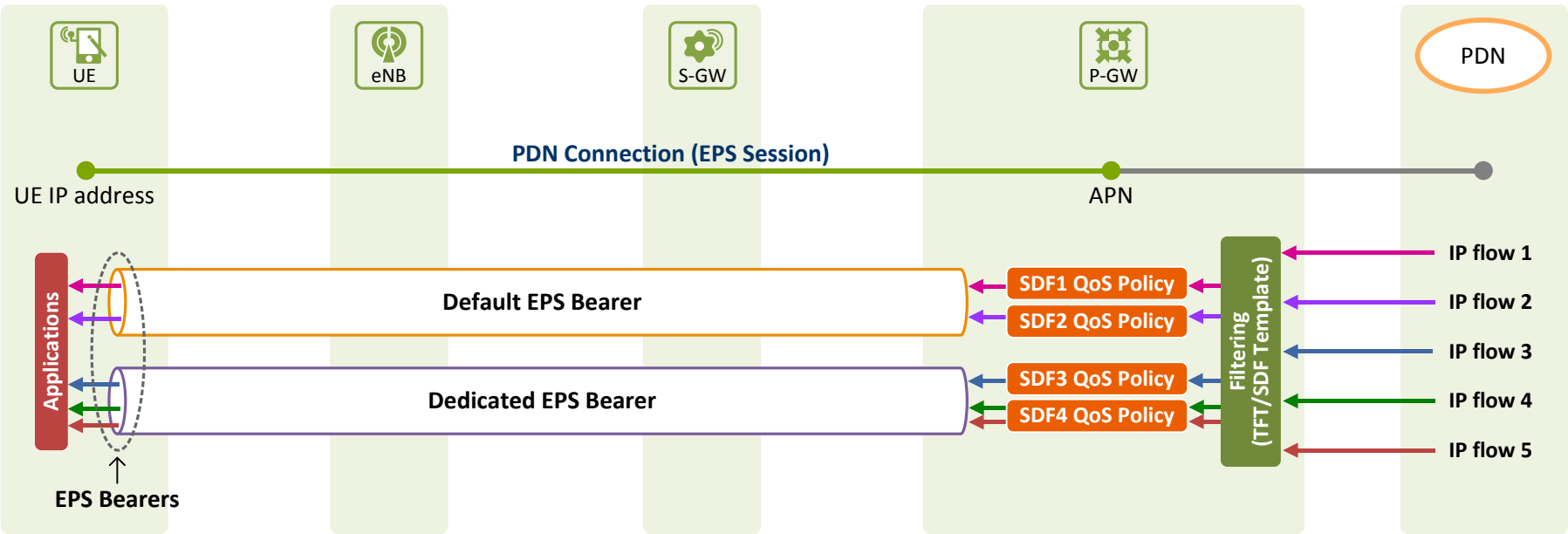
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SDF vs. EPS Bearer (1/2)



EPS Bearer: Concatenation of **DRB**, **S1 Bearer** and **S5 Bearer**

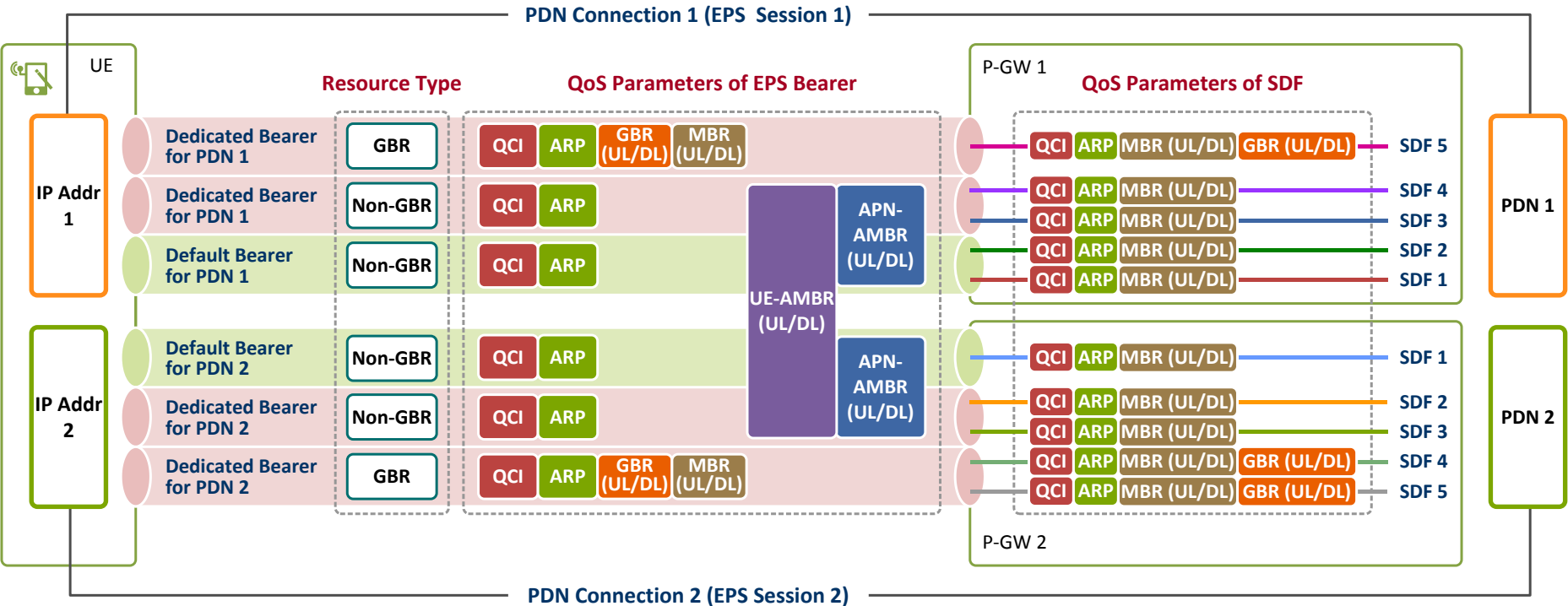
SDF vs. EPS Bearer (2/2)

Terms Relating to SDFs and EPS Bearers

Terms	Description
PDN Connection	<ul style="list-style-type: none"> • IP connection between UE and PDN (An LTE network identifies a PDN by its APN and assigns a PDN address (IP address) to UE)
EPS Session	<ul style="list-style-type: none"> • Used to refer to a PDN Connection • Must have at least one EPS bearer. Remains activated as long as UE stays connected to PDN network
EPS Bearer	<ul style="list-style-type: none"> • A Logical transport channel (transmission path) set between UE and P-GW to deliver user traffic (IP packets) with specific QoS • Each EPS Bearer is activated with QoS parameters that indicate the characteristics of the transport channel. • All EPS Bearers belonging to one PDN connection share the same UE IP address.
Default Bearer	<ul style="list-style-type: none"> • The first EPS bearer activated when an EPS session (PDN connection) is created. Stays activated until the EPS session is terminated • Always set as Non-GBR type ¹
Dedicated Bearer	<ul style="list-style-type: none"> • Additional EPS bearer activated on demand after an EPS session (PDN connection) is created • May be activated on demand • Can be either GBR ² or Non-GBR type ¹
Service Data Flow (SDF)	<ul style="list-style-type: none"> • An IP flow or an aggregation of IP flows of user traffic classified by the service type. Classified by using SDF templates • Different QoS is applied to each SDF. Each SDF is subject to different QoS rules determined by PCRF (See PCC technical document for more information). • Each SDF is delivered through an EPS bearer that can satisfy its QoS. • A SDF that matches the packet filters of a TFT (UL TFT in UE, DL TFT in P-GW) is mapped to an EPS bearer. • Multiple SDFs with the same QCI are mapped and delivered to one EPS bearer.

[1](#), [2](#): refer to the next page

QoS Parameter: SDF vs. EPS Bearer (1/2)



QoS Parameters (1)

SDF QoS Parameter	QCI, ARP, GBR, MBR
GBR SDF	QCI, ARP, GBR(UL/DL), MBR(UL/DL)
Non-GBR SDF	QCI, ARP, MBR(UL/DL)
EPS Bearer QoS Parameter	QCI, ARP, GBR, MBR, APN-AMBR, UE-AMBR
GBR Bearer	QCI, ARP, GBR(UL/DL), MBR(UL/DL)
Non-GBR Bearer	QCI, ARP, APN-AMBR(UL/DL), UE-AMBR(UL/DL)

GBR vs. Non-GBR

GBR SDF/Bearer	If dedicated network resources related to a GBR value are permanently allocated at SDF/Bearer establishment/modification.
Non-GBR SDF/Bearer	Otherwise

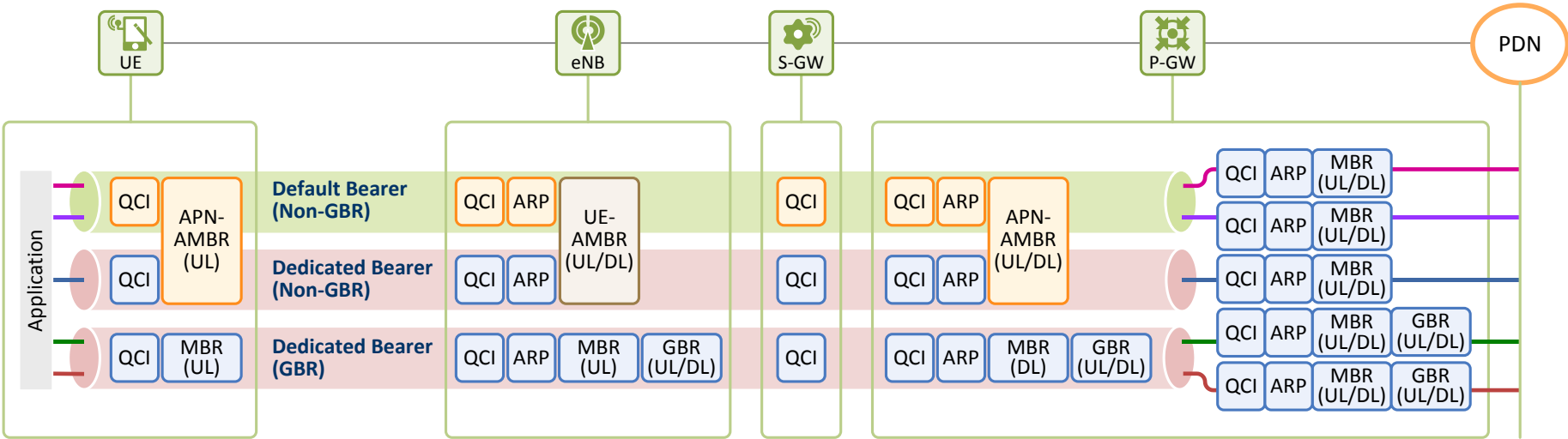
QoS Parameter: SDF vs. EPS Bearer (2/2)

QoS Parameters (2)

QoS Parameter	Description
QCI	<ul style="list-style-type: none"> Applied to a GBR/Non-GBR SDF/Bearer Value: Scalar (1 ~ 9) Standardized QoS characteristics values are defined as QCI = 1 ~ 9 (See 3GPP TS 23.203[3] Table 6.1.7) QoS characteristics represented by QCI value: (i) Resource Type (GBR or Non-GBR), (ii) Priority (1 ~ 9), (iii) Packet Delay Budget (50ms ~ 300ms), (iv) Packet Error Loss Rate ($10^{-2} \sim 10^{-6}$) Used as a reference to node specific parameters that control packet forwarding treatment <ul style="list-style-type: none"> Packet forwarding treatment: e.g. Scheduling weights, admission threshold, queue management thresholds, link layer protocol configuration, etc. Pre-configured in operators' network node (e.g. eNB)
ARP	<ul style="list-style-type: none"> Applied to a GBR/Non-GBR SDF/Bearer ARP Parameters: (i) Priority Level (1 ~ 15 , 1: the highest level), (ii) Pre-emption Capability (yes or no) and (iii) Pre-emption Vulnerability (yes or no) <ul style="list-style-type: none"> Priority Level: defines the relative importance of a resource request, with 1 being the highest. Pre-emption Capability: defines whether a SDF/Bearer can get resources already assigned to another SDF/Bearer with a lower priority level. Pre-emption Vulnerability: defines whether a SDF/Bearer can lose the resources assigned to it to admit a SDF/Bearer with a higher priority level. Used for controlling call admission. Once successfully established, ARP has no impact on packet forwarding treatment ³.
GBR (UL/DL)	<ul style="list-style-type: none"> Applied to a GBR SDF/Bearer Indicates a minimum bandwidth (bit rate) to be guaranteed for the SDF/Bearer
MBR (UL/DL)	<ul style="list-style-type: none"> Applied to a GBR/Non-GBR SDF and GBR Bearer Indicates a maximum bandwidth (bit rate) allowed for the SDF/Bearer Any traffic in excess of the specified MBR may get discarded through rate policing
APN-AMBR (UL/DL)	<ul style="list-style-type: none"> Applied only to the aggregated bandwidth of Non-GBR Bearers. Defined per APN. Indicates a maximum bandwidth (bit rate) allowed for all the non-GBR bearers associated with a PDN connected to a UE
UE-AMBR (UL/DL)	<ul style="list-style-type: none"> Applied only to the aggregated bandwidth of non-GBR bearers Defined for UE. Indicates a maximum bandwidth (bit rate) allowed for all the non-GBR bearers associated with a UE Subscription information provide by an HSS (UE-AMBR_{HSS}) Still, can be modified by an MME with the APN-AMBR of all PDNs within a UE to the extent permitted (within a range of values provided by the HSS, UE-AMBR_{HSS}) (UE-AMBR = \sum APN-AMBR(s) for all PDNs)

³: Packet forwarding treatment is solely determined by the other QoS parameters: (i) QCI, GBR and MBR (for SDF) and (ii) QCI, GBR, MBR and AMBR (for EPS Bearer)

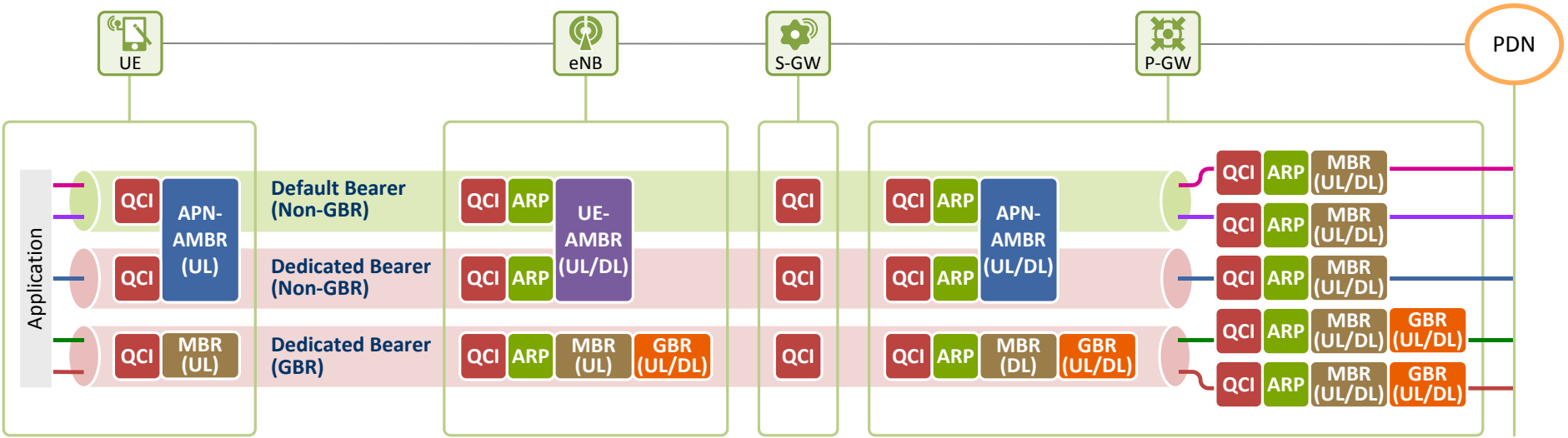
QoS Provisioning



QoS Provisioning

SDF QoS Parameter		EPS Bearer QoS Parameter	
SDF QoS parameters (QCI, ARP, MBR, GBR) are provisioned by PCRF	Default Bearer	Provisioned to HSS as a Subscribed Profile (Subscribed QCI, ARP, APN-AMBR and UE-AMBR)	
		Can be modified by PCC rule authorization of PCRF when a EPS session is created	
	Dedicated Bearer	Provisioned by PCRF	
		MME can replace the UE-AMBR with the aggregated APN-AMBR of all active APNs (to the extent not exceeding the subscribed value provided by the HSS)	

QoS Enforcement



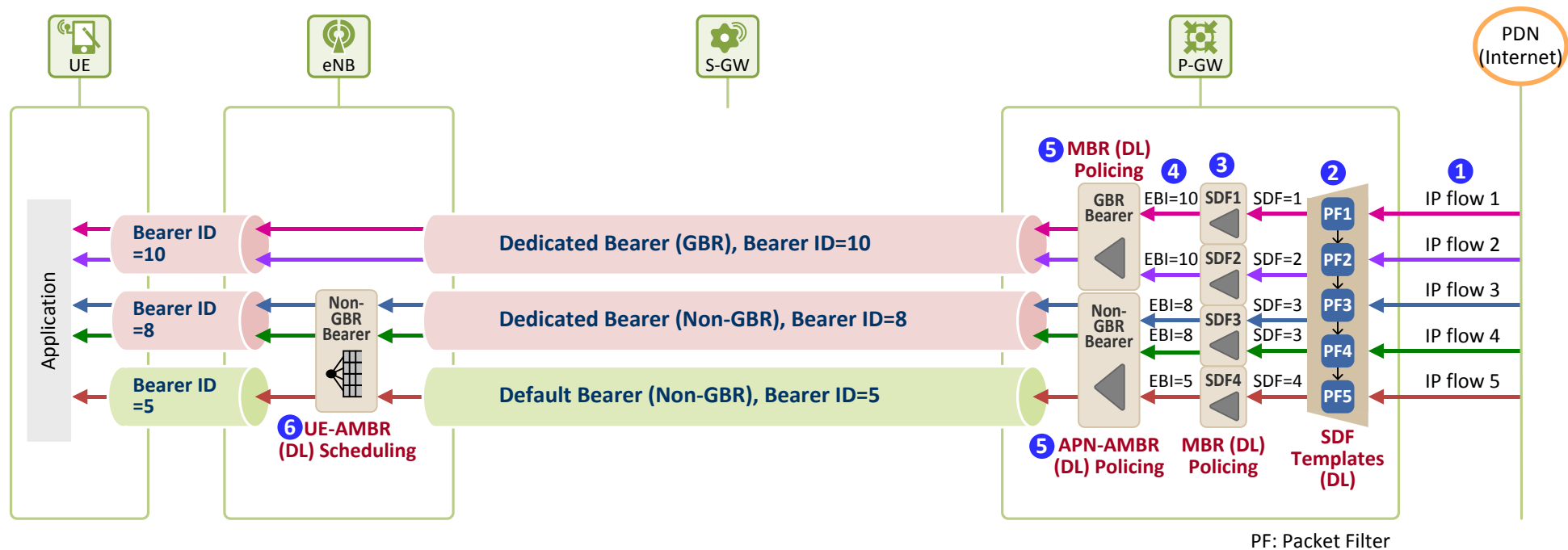
QoS Enforcement for SDF

QoS Parameter	Enforcement
QCI	Applied to all SDFs by P-GW
ARP	Applied to all SDFs by P-GW
MBR	Applied to all SDFs by P-GW
GBR	Applied to only GBR SDFs by P-GW

QoS Enforcement for EPS Bearer

QoS Parameter	Enforcement
QCI	Applied to all Bearers by all entities (UE, eNB, S-GW, P-GW)
ARP	Applied to all Bearers by all entities except UE (eNB, S-GW, P-GW)
MBR	Applied to only GBR Bearers at all entities <ul style="list-style-type: none">- UL: Applied to only non-GBR bearers by UE and eNB- DL: Applied to only non-GBR bearers by S-GW and P-GW
GBR	Applied to only GBR Bearers at all entities except UE (eNB, S-GW, P-GW)
APN-AMBR	Applied to only Non-GBR Bearers <ul style="list-style-type: none">- UL: Applied to only Non-GBR Bearers by UE and P-GW- DL: Applied to only Non-GBR Bearers by P-GW
UE-AMBR	Applied to only Non-GBR Bearers by eNB

Example of QoS Operation: Downlink (1/2)



DL TFTs (SDF Templates) in P-GW

	Filter Rule	SDF	Bearer ID	
SDF Template1 (TFT1)	(*, UE IP, RTP, *, UDP)	SDF 1	Bearer 10	Packet Filter1
SDF Template2 (TFT1)	(*, UE IP, Video, *, UDP)	SDF 2	Bearer 10	Packet Filter2
SDF Template3 (TFT2)	(*, UE IP, SIP, *, UDP)	SDF 3	Bearer 8	Packet Filter3
	(*, UE IP, Game, *, *)	SDF 3	Bearer 8	Packet Filter4
SDF Template4 (TFT3)	(*, UE IP, *, *, *)	SDF 4	Bearer 5	Packet Filter5

Packet Filter:
- Configured by network operator
- Referred to 5-tuple (Src IP, Dst IP, Src Port, Dst Port, Protocol ID)

Example of QoS Operation: Downlink (2/2)

1 [P-GW] Downlink IP Flows Arrival

- IP Flows arrived at a P-GW from the Internet .

2 [P-GW] IP Packet Filtering (SDF Templates)

- The received IP Flows are filtered through IP Packet Filters (**SDF templates**) into different **SDFs**
- Filter Rules: 5-tuple (Source IP, Destination IP, Source Port, Destination Port, Protocol ID)

3 [P-GW] SDF QoS Enforcement: MBR Rate Policing

- MBR (DL) rate policing** against each **SDF**: Excess packets are discarded.

4 [P-GW] SDF – EPS Bearer Mapping: IP Packet Filtering (TFT)

- SDFs are filtered through IP packet filters (**TFTs**) and mapped into **EPS Bearers**.

5 [P-GW] EPS Bearer QoS Enforcement: MBR/APN-AMBR Rate Policing

- EPS Bearer QoS is applied to each Bearer.
- MBR (DL) rate policing** against each **GBR Bearer** (EBI=10): Excess packets are discarded.
- APN-AMBR (DL) rate policing against Non-GBR Bearers** (EBI=5, EBI=8): Excess packets are discarded.
 - The sum of MBR (EBI=5) and MBR (EBI=8) is limited by APN-AMBR (DL).

6 [eNB] SDF QoS Enforcement: UE-AMBR Rate Policing

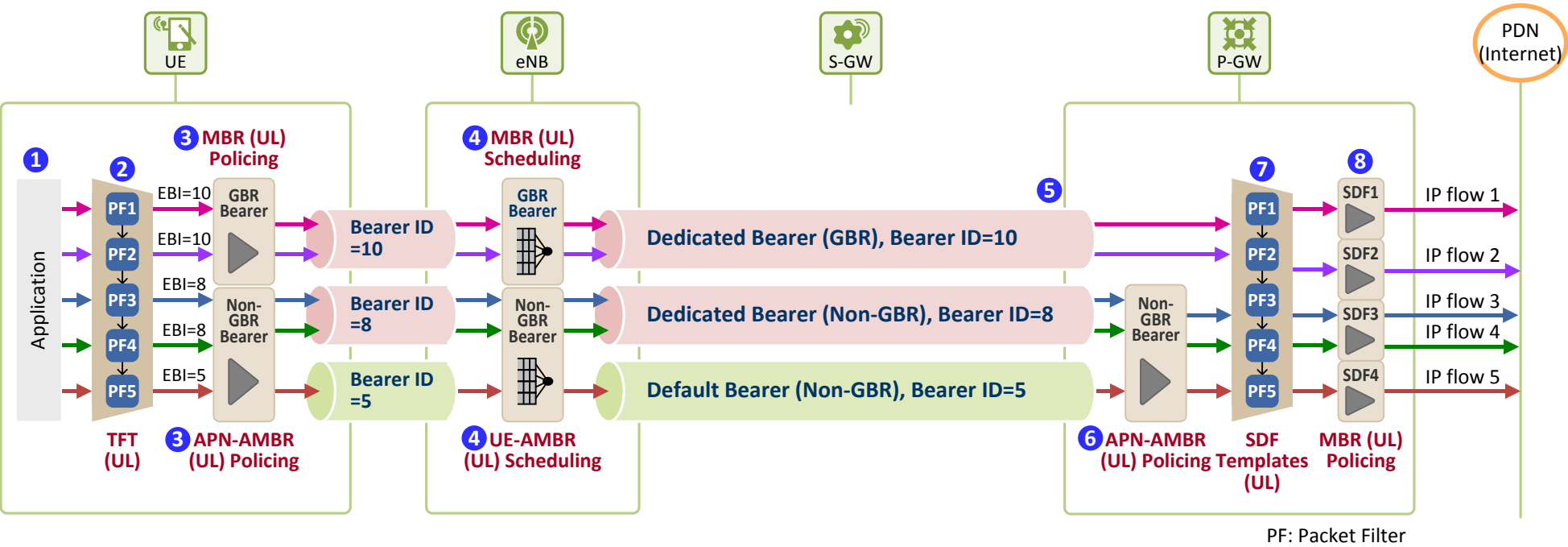
- UE-AMBR (DL) rate policing** per **Non-GBR Bearer** (EBI=5, EBI=8)

1	IP Flow	Application
	IP Flow 1	Voice
	IP Flow 2	Video Streaming
	IP Flow 3	IMS Signaling
	IP Flow 4	Gaming
	IP Flow 5	Internet Access (Best-Effort)

2	IP Flow		SDF
	IP Flow 1	→ PF (SDF Template)	SDF 1 (GBR)
	IP Flow 2		SDF 2 (GBR)
	IP Flow 3		SDF 3 (Non-GBR)
	IP Flow 4		SDF 3 (Non-GBR)
	IP Flow 5		SDF 4 (Non-GBR)

4	SDF		EPS Bearer
	SDF 1(GBR)	→ PF (TFT)	Bearer 10 (GBR Dedicated Bearer)
	SDF 2 (GBR)		Bearer 10 (GBR Dedicated Bearer)
	SDF 3 (Non-GBR)		Bearer 8 (Non-GBR Dedicated Bearer)
	SDF 4 (Non-GBR)		Bearer 5 (Non-GBR Default Bearer)

Example of QoS Operation: Uplink (1/2)



UL TFTs in UE

	Filter Rule	Bearer ID	
TFT1	(UE IP, *, RTP, *, UDP)	Bearer 10	Packet Filter1
	(UE IP, *, Video, *, UDP)	Bearer 10	Packet Filter2
TFT2	(UE IP, *, SIP, *, UDP)	Bearer 8	Packet Filter3
	(UE IP, *, Game, *, *)	Bearer 8	Packet Filter4
TFT3	(UE IP, *, *, *, *)	Bearer 5	Packet Filter5

Packet Filter: (Src IP, Dst IP, Src Port, Dst Port, Protocol ID)

UL TFTs (SDF Templates) in P-GW

	Filter Rule	SDF	Bearer ID	
SDF Template1 (TFT1)	(UE IP, *, RTP, *, UDP)	SDF 1	Bearer 10	Packet Filter1
SDF Template2 (TFT1)	(UE IP, *, Video, *, UDP)	SDF 2	Bearer 10	Packet Filter2
SDF Template3 (TFT2)	(UE IP, *, SIP, *, UDP)	SDF 3	Bearer 8	Packet Filter3
	(UE IP, *, Game, *, *)	SDF 3	Bearer 8	Packet Filter4
SDF Template4 (TFT3)	(UE IP, *, *, *, *)	SDF 4	Bearer 5	Packet Filter5

Packet Filter: (Src IP, Dst IP, Src Port, Dst Port, Protocol ID)

Example of QoS Operation: Uplink (2/2)

1 [UE] Uplink IP Flows Arrival

- IP Flows from user applications arrive at a UE (the same applications as in Downlink case).

2 [UE] IP Packet Filtering (TFT)

- The received IP Flows are filtered through IP Packet Filters (**TFT**) into **EPS Bearers** appropriately.
- Filter Rules: 5-tuple (Source IP address, Destination IP address, Source Port, Destination Port, Protocol ID)

3 [UE] EPS Bearer QoS Enforcement: MBR/APN-AMBR Rate Policing

- EPS Bearer QoS is applied to each Bearer.
- MBR (UL) rate policing** against each **GBR Bearer** (EBI=10)
- APN-AMBR (UL) rate policing** against **Non-GBR Bearers** (EBI=5, EBI=8)
 - The aggregated MBR (EBI=5, EBI=8) is limited by APN-AMBR (UL).

4 [eNB] EPS Bearer QoS Enforcement: MBR/UE-AMBR Rate Policing

- MBR (UL) rate policing** against each **GBR Bearer** (EBI=10)
- UE-AMBR (UL) rate policing** against **Non-GBR Bearers** (EBI=5, EBI=8)
 - The aggregated MBR (EBI=5, EBI=8) is limited by UE-AMBR (UL).

5 [P-GW] Bearer Traffic Arrival

- IP Flows transported through EPS Bearers arrive at a P-GW.

6 [P-GW] EPS Bearer QoS Enforcement: APN-AMBR Rate Policing

- APN-AMBR (UL) rate policing** against **Non-GBR Bearers** (EBI=5, EBI=8): Excess packets are discarded.
 - The aggregated MBR (EBI=5, EBI=8) is limited by APN-AMBR (UL).

7 [P-GW] IP Packet Filtering (SDF Templates)

- IP Flows are filtered through IP Packet Filters (**SDF templates**) into different **SDFs**.

8 [P-GW] SDF QoS Enforcement: MBR Rate Policing

- MBR (UL) rate policing** against each **SDF**: Excess packets are discarded.

2

IP Flow		EPS Bearer
IP Flow 1	→ PF (TFT)	Bearer 10 (GBR Dedicated Bearer)
IP Flow 2		Bearer 10 (GBR Dedicated Bearer)
IP Flow 3		Bearer 8 (Non-GBR Dedicated Bearer)
IP Flow 4		Bearer 8 (Non-GBR Dedicated Bearer)
IP Flow 5		Bearer 5 (Non-GBR Default Bearer)

5

EPS Bearer	IP Flow
Bearer 10	IP Flow 1
	IP Flow 2
Bearer 8	IP Flow 3
	IP Flow 4
Bearer 5	IP Flow 5

7

IP Flow		SDF
IP Flow 1	→ PF (SDF Template)	SDF 1 (GBR)
IP Flow 2		SDF 2 (GBR)
IP Flow 3		SDF 3 (Non-GBR)
IP Flow 4		SDF 3 (Non-GBR)
IP Flow 5		SDF 4 (Non-GBR)

References and Abbreviations

- [1] Netmanias Technical Document, “LTE Identification III: EPS Bearer Identifier”, August 2013, <http://www.netmanias.com/bbs/view.php?id=techdocs&no=60>
- [2] 3GPP TS 23.203, “Policy and charging control architecture”.
- [3] NMC Consulting Group Confidential Internal Report, “E2E LTE Network Design”, August 2010.

Abbreviations

AMBR	: Aggregate Maximum Bit Rate	PCC	: Policy and Charging Control
APN	: Access Point Name	PCRF	: Policy and Charging Rules Function
ARP	: Allocation and Retention Priority	PDN	: Packet Data Network
DL	: Downlink	PF	: Packet Filter
DRB	: Data Radio Bearer	P-GW	: PDN GW
EBI	: EPS Bearer Identity	QCI	: QoS Class Identifier
eNB	: Evolved Node B	QoS	: Quality of Service
EPS	: Evolved Packet System	SDF	: Service Data Flow
E-UTRAN	: Evolved Universal Terrestrial Radio Access Network	S-GW	: Serving GW
GBR	: Guaranteed Bit Rate	SRB	: Signaling Radio Bearer
HSS	: Home Subscriber Server	TFT	: Traffic Flow Template
LTE	: Long Term Evolution	UE	: User Equipment
MBR	: Maximum Bit Rate	UL	: Uplink
MME	: Mobility Management Entity		

Netmanias LTE Technical Documents

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4		LTE Identification III: EPS Session/Bearer Identifier	
5	Security	LTE Security I: LTE Security Concept and LTE Authentication	
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Netmanias Research and Consulting Scope

		99	00	01	02	03	04	05	06	07	08	09	10	11	12	13
Services	eMBMS/Mobile IPTV															
	CDN/Mobile CDN															
	Transparent Caching															
	BSS/OSS															
	Cable TPS															
	Voice/Video Quality															
	IMS															
	Policy Control/PCRF															
	IPTV/TPS															
Mobile Network	LTE															
	Mobile WiMAX															
	Carrier WiFi															
	LTE Backaul															
Wireline Network	Data Center Migration															
	Carrier Ethernet															
	FTTH															
	Data Center															
	Metro Ethernet															
	MPLS															
	IP Routing															

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