PCRF is an important Entity in LTE Network

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1. PCRF in LTE Network

A important component in LTE network is the policy and charging control (PCC) function that brings together and enhances capabilities from earlier 3GPP releases to deliver dynamic control of policy and charging on a per subscriber and per IP flow basis.

The Policy Control and Charging Rules Function is responsible for policy control decision-making, as well as for controlling the flow-based charging functionalities in the Policy Control Enforcement Function (PCEF), which resides in the P-GW. The PCRF provides the QoS authorization (QoS class identifier [QCI] and bit rates) that decides how a certain data flow will be treated in the PCEF and ensures that this is in accordance with the user's subscription profile.

PCRF provides service management and control of the 4G service. It dynamically manages and controls data sessions, enables new business models. Apart from this, PCRF LTE also has the functionality to make it easy for other devices out of the 3GPP network- like WiFi or fixed broadband devices- to access the 4G LTE network.

In other words, PCRF LTE is the policy manager of the new 4G LTE technology. All the quality of service (QoS) rules and regulations are distributed to the packet data network gateway by the PCRF LTE, making it a very valuable aspect of any organization's policy and security management system.

The policy server or PCRF is a key component in the NDN. It provides the critical link between the service and transport layers and is the central decision point – the brain – of LTE networks. The PCRF provides the granular control of service quality, which is critical for managing resources, enabling seamless roaming, establishing new business models, and monetizing services.

A fundamental LTE concept is the ability to recognize and differentiate traffic flows. The degree and granularity with which that flow can be dynamically influenced largely determines the extent to which an operator can shape bandwidth, implement QoS, manage resource allocation, and create new applications. That's where policy comes into play. The PCRF is the key network element that enables that fine-grained control, which is essential to successfully managing and monetizing LTE networks. As such, it is a strategic component and consideration in LTE network design.

The diagram shown below represents the PCRF reference architecture in LTE/IMS network

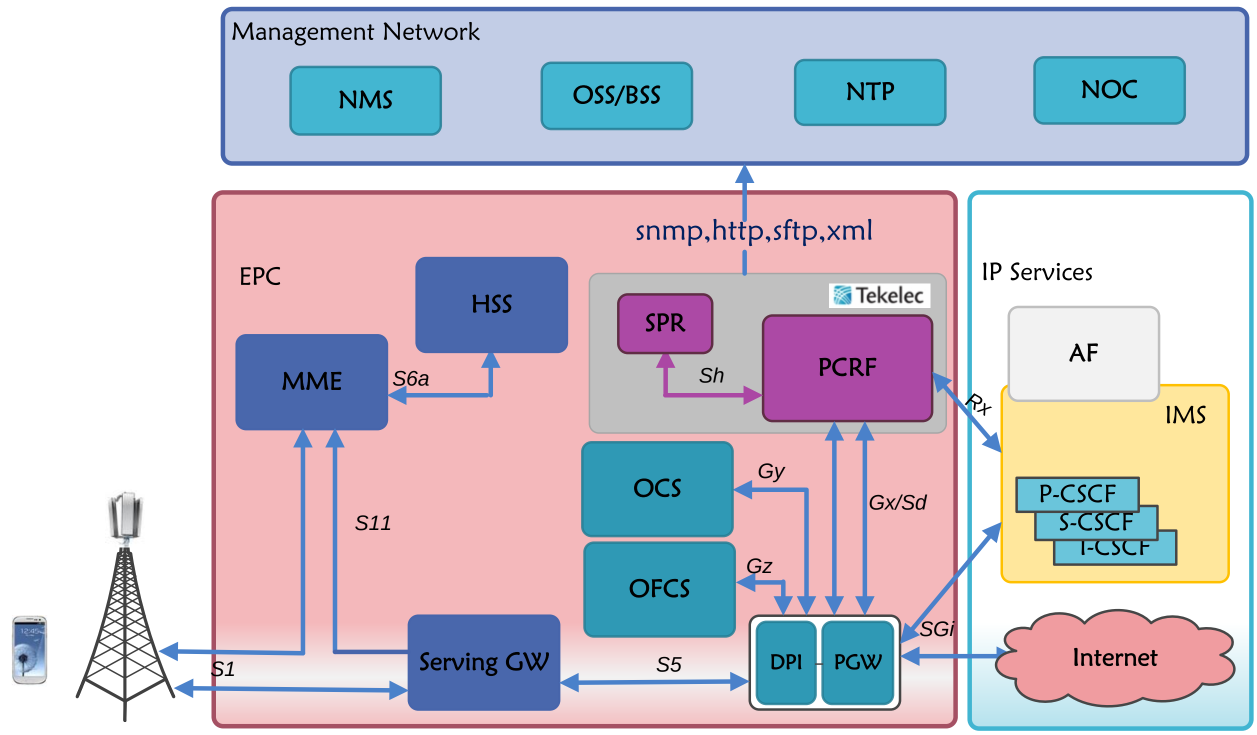


Figure 1: LTE PCRF reference network architecture

PCRF solution shall provide the following key capabilities as listed below:

1. **Network Control:** The PCRF provides network control regarding the service data flow detection, gating, QoS and flow based charging (except credit management) towards the PCEF (e.g., SAE-GW, PDN GW). The PCRF receives session and media related information from the AF and informs AF of traffic plane events.

2. **QoS Based on Subscription Information:** The PCRF may use the subscription information as basis for the policy and charging control decisions. The subscription specific information for each service may contain e.g. max QoS class and max bit rate.

3. **PCC Rule:** The PCRF shall inform the PCEF through the use of PCC rules on the treatment of each service data flow that is under PCC control, in accordance with the PCRF policy decisions.

4. **Gating Control:** The PCRF makes the gating decisions which are then enforced by the PCEF. The PCRF could, for example, make gating decisions based on session events (start/stop of service) reported by the P-CSCF via the Rx reference point.

5. **Support for emergency services:** Policy management solution fully supports emergency service calls with and without subscription information. The PCRF “upgrades” the user voice flow with appropriate priority when an IMS emergency call is placed. In the absence of the subscription information, it uses the assigned IP address to identify the user’s IP-CAN session and install appropriate rules.

6. **Access point name (APN)-specific policy control:** With Policy Server, operators can set up APNs to segregate traffic, apply specific controls to optimize that traffic or experience, and create service-specific charging for each. For example, an operator can set up an Internet protocol multimedia subsystem (IMS) APN dedicated to VoLTE and video and another APN for the Internet. Different controls and pricing can be applied to each. The IMS APN can be set up with a dedicated bearer that provides the more stringent QoS controls required for real-time applications, while the Internet APN delivers “best effort” and is charged based on bandwidth consumption. As another example, the operator can create a content-filtering APN to which user’s subscriber to restrict the services accessible their children can access.
7. **Application-driven QoS:** Policy Server enables operators to dynamically boost QoS to improve a subscriber’s application experience and create two-sided business models. For instance, a customer watching a Netflix video receives a prompt asking if she would like to have better resolution. The Netflix application server (AS) gets this request and sends it to the PCRF over a Diameter interface. The PCRF applies a real time upgrade to that user’s particular video stream. The operator generates additional revenue by adding value to the OTT provider with which it has a volume or wholesale agreement.
8. **Enhancement for location-based services (LBSs):** LTE identifiers such as location and network control and location change triggers provide the increased level of granularity required to support the complex delivery of LBSs in LTE networks.

2. Policy Principle

PCRF will send the PCC rules based on subscriber profile and plan. There are two types of services.

- LTE HSI
- VoLTE

2.1. PCC rules

The purpose of the PCC rule is to:

- Detect a packet belonging to a service data flow.
- The service data flow filters within the PCC rule are used for the selection of downlink IP CAN bearers.
- The service data flow filters within the PCC rule are used to enforce that uplink IP flows are transported in the correct IP CAN bearer.
- Identify the service data flow contributes to.
- Provide applicable charging parameters for a service data flow.
- Provide policy control for a service data flow.
- The PCEF shall select a PCC rule for each received packet by evaluating received packets against service data flow filters of PCC rules in the order of the precedence of the PCC rules. When a

packet matches a service data flow filter, the packet matching process for that packet is completed, and the PCC rule for that filter shall be applied.

There are two different ways of applying/implementing PCC rules:

- **Dynamic PCC rules**: Dynamically provisioned by the PCRF to the SAE-GW via the Gx interface. Dynamic PCC rules can be activated, modified and deactivated at any time.
- **Predefined PCC rules**: These rules are preconfigured in the SAE-GW. Predefined PCC rules can be activated or deactivated by the PCRF at any time. Predefined PCC rules within the SAE-GW may be grouped allowing the PCRF to activate a set of PCC rules over the Gx reference point.

2.2. Parameters in PCC rule:

A PCC rule consists of:

- A rule name;
- Service identifier;
- Service data flow filter(s);
- Precedence;
- Gate status;
- QoS parameters;
- Rating group;
- Other charging parameters;
- Monitoring key;
- Application service provider identity.

The rule name shall be used to reference a PCC rule in the communication between the PCEF and the PCRF.
The service identifier shall be used to identify the service or the service component the service data flow relates to.
The service flow filter(s) shall be used to select the traffic for which the rule applies.
The gate status indicates whether the service data flow, detected by the service data flow filter(s), may pass (gate is open) or shall be discarded (gate is closed) in uplink and/or in downlink direction.
The QoS information includes the QoS class identifier (authorized QoS class for the service data flow), the Allocation and Retention Priority (ARP) and authorized bitrates for uplink and downlink.
The 3GPP standards provide mechanisms to drop or downgrade lower-priority bearers in situations where the network become congested. Each bearer has an associated allocation and retention priority (ARP). The network looks at the ARP when determining if new dedicated bearers can be established through the radio base station.

- ***GBR Bearer:*** For GBR Bearer’s MBR UL, MBR DL and GBR UL, GBR DL AVP’s are present along with the QCI value. QCI Value informs the type bearer that needs to be created. GBR bearers are used for real-time services, such as conversational voice and video. A GBR bearer has a minimum amount of bandwidth that is reserved by the network

- ***Non GBR Bearer:*** For Non GBR Bearer APN AMBR UL and APN AMBR DL AVP's are present. Non-GBR bearers, however, do not have specific network bandwidth allocation. Non-GBR bearers are for best-effort services, such as file downloads, email, and Internet browsing. These bearers will experience packet loss when a network is congested.

The QCI specifies the treatment of IP packets received on a specific bearer.
QCI values impact several node-specific parameters, such as link layer configuration, scheduling weights, and queue management.

The 3GPP has defined a series of standardized QCI types, which are summarized in the below Table
Based on QCI values different services can be treated differently. Like some services will require a dedicated bearers while some may work via a non-dedicated bearers. Also the priority to these services has been defined.

QCI	Resource Type	Priority	Packet Delay Budget	Packet Error Loss Rate	Services
1	GBR	2	100 ms	10^{-2}	Conversational voice
2		4	150 ms	10^{-3}	Conversational video (Live streaming)
3		3	50 ms	10^{-3}	Real Time Gaming
4		5	300 ms	10^{-6}	Non-Conversation Video (Buffered Streaming)
5	Non-GBR	1	100 ms	10^{-6}	IMS Signalling
6		6	300 ms	10^{-6}	Video (buffered streaming) TCP-based (e.g. www, email, chat, FTP P2P file sharing, progressive video, etc.)
7		7	100 ms	10^{-3}	Voice, Video (Live streaming)
8		8	300 ms	10^{-6}	Video (buffered streaming) TCP-based (e.g., www, email, chat, FTP P2P file sharing, progressive video, etc.)
9		9	300 ms	10^{-6}	Video (buffered streaming) TCP-based (e.g., www, email, chat, FTP P2P file sharing, progressive video ,etc.)

Table 1: Quality of Class Indicator

The charging parameters define whether online and offline charging interfaces are used, what is to be metered in online/offline charging, at what level the PCEF shall report the usage related to the rule, etc.
For different PCC rules with overlapping service data flow filter, the precedence of the rule determines which of these rules is applicable. PCC rule also includes Application Function record information for enabling charging correlation between the application and bearer layer if the AF has provided this information via the Rx interface. For IMS this includes the IMS Charging Identifier (ICID) and flow identifiers.

2.3. LTE HSI

For LTE HSI service, any one of the PCC rule (Dynamic or Predefined) will be installed according to the requirement.

PCRF uses the subscriber profile in the SPR and install the rule based on subscriber profile.

Input for policy decision:-

The following important parameters will be considered by PCRF. There may be other parameters in the SPR which will be used by PCRF. But these parameters will be decided based on use case.

Parameters in SPR	IMSI	MSISDN	NAI	PASS	TIER	Expiry Date	Expiry Date
Example	404333333333333	9771717123	rjilpcrf@tekelec.com	1mbps (Prepaid Plan name)	GOLD (Subscriber category)	2013-07-30T00:00:04	2013-07-30T00:00:04

Table 2: SPR Parameters

Output given by PCRF:-

Any one of the PCC rule (Dynamic or Predefined) will be installed according to the customer requirement.

Rule Type/ Parameters	Rule Name	QCI	MBR	GBR	Charging Enable/Disable /NA	Rating Group
Dynamic	*RULE_LTE_HH_BP*	6	2048000	(Non GBR Bearer)	Enabled	111
Predefined	*RULE_LTE_HH_BP*	Pre-Configured in SAE-GW	Pre-Configured in SAE-GW	Pre-Configured in SAE-GW	Pre-Configured in SAE-GW	Pre-Configured in SAE-GW

Table 3: PCC Rule Name

The below call flow explains about interaction of PCRF with SAE-GW using dynamic PCC rule in LTE.

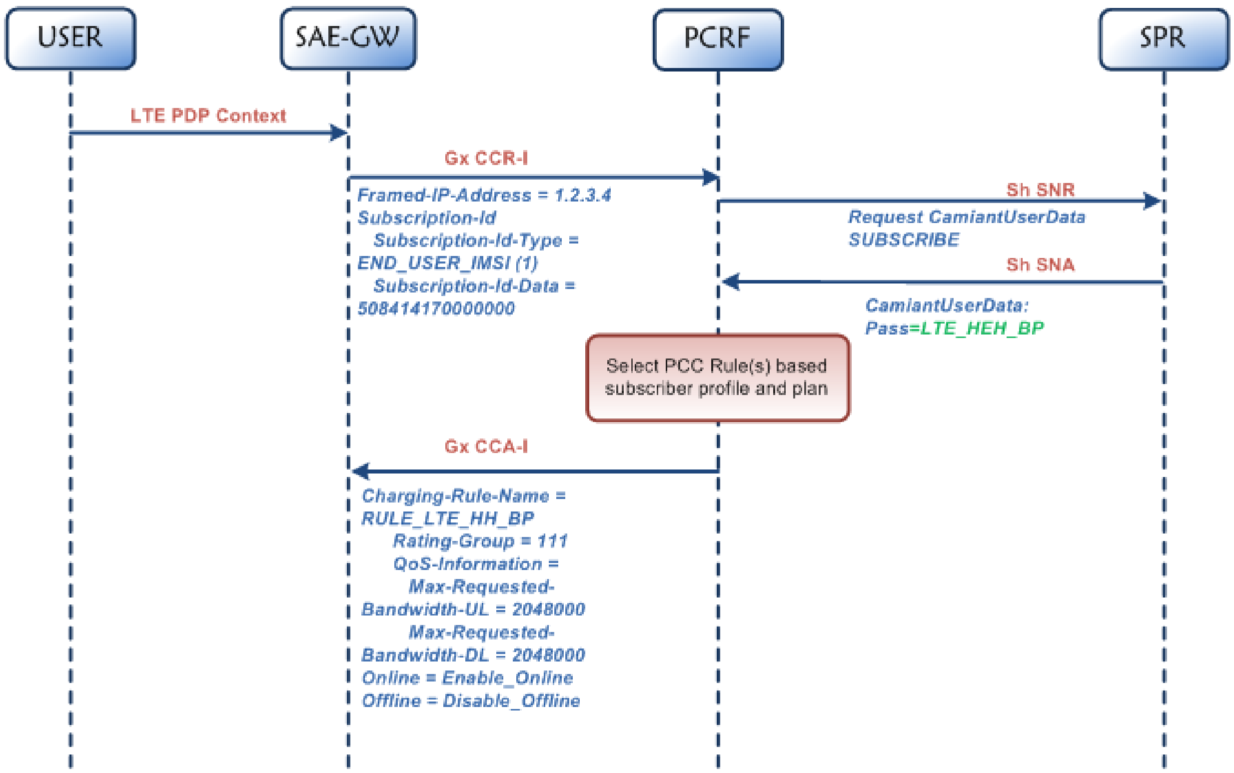


Figure 2: LTE Call Flow – Dynamic Rule

The below call flow explains about interaction of PCRF with SAE-GW using predefined PCC rule in LTE.

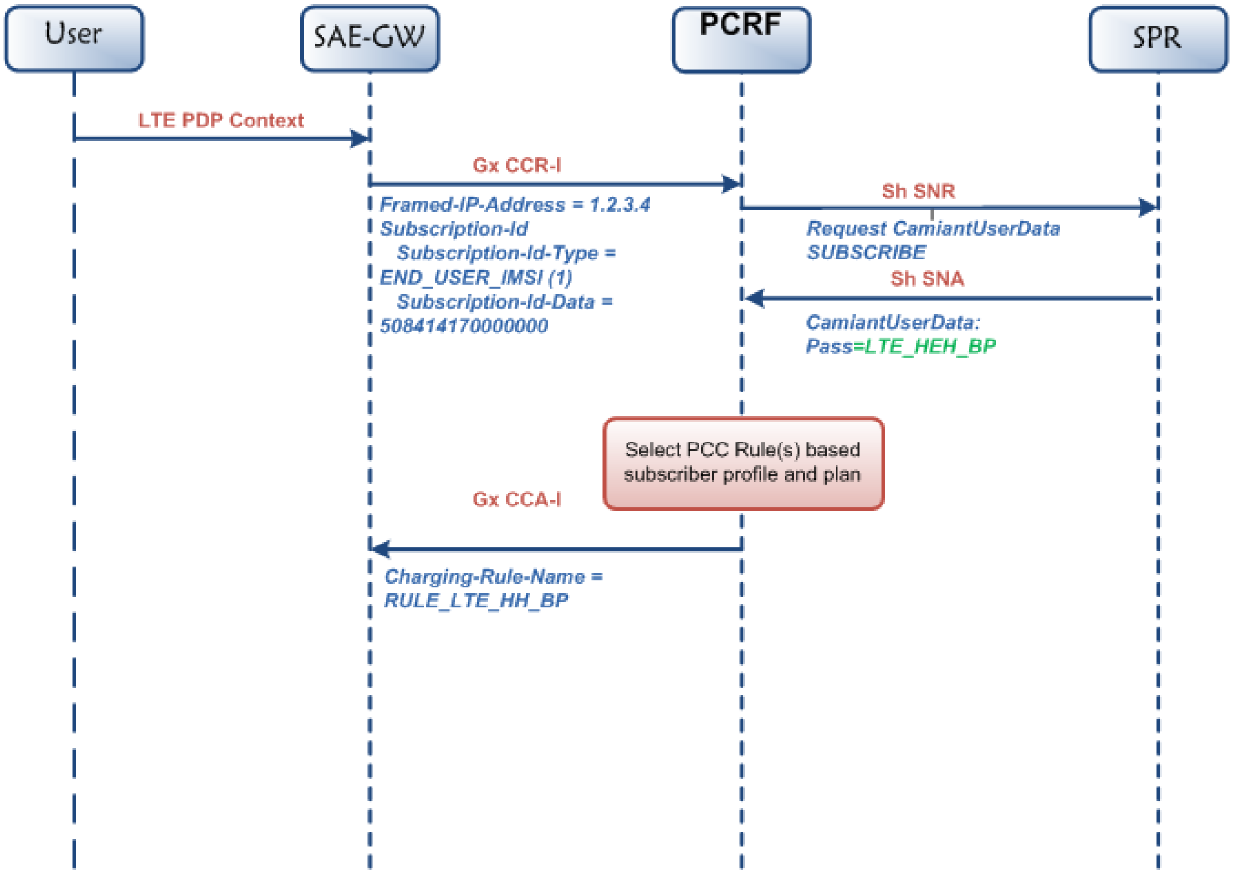


Figure 3: LTE Call Flow – Predefined Rule

2.4. VoLTE

For VoLTE service, Dynamic rule will be installed based on any one of the following.

- Codec – Based
- AF-Application-id
- Requested Bandwidth AVP from P-CSCF
- Operator Defined Policy

Rule Type/ Parameters	QCI	MBR	GBR	Flow Status	Flow Description
Dynamic	Pre-Configured in PCRF	Pre-Configured in PCRF/Received from P-CSCF	Pre-Configured in PCRF/Received from P-CSCF	Received from P-CSCF	Received from P-CSCF

Table 4: PCC Rule for VoLTE

PCRF will install the rule without any charging details for the IMS call to the SAE-GW. IMS node will interact with charging server for the IMS call. SAE-GW will use the default configuration regarding IMS call for charging server interaction.The below call flow explains about interaction of PCRF, SAE-GW and OCS based on dynamic rule sent by PCRF in CCA message for the IMS call.

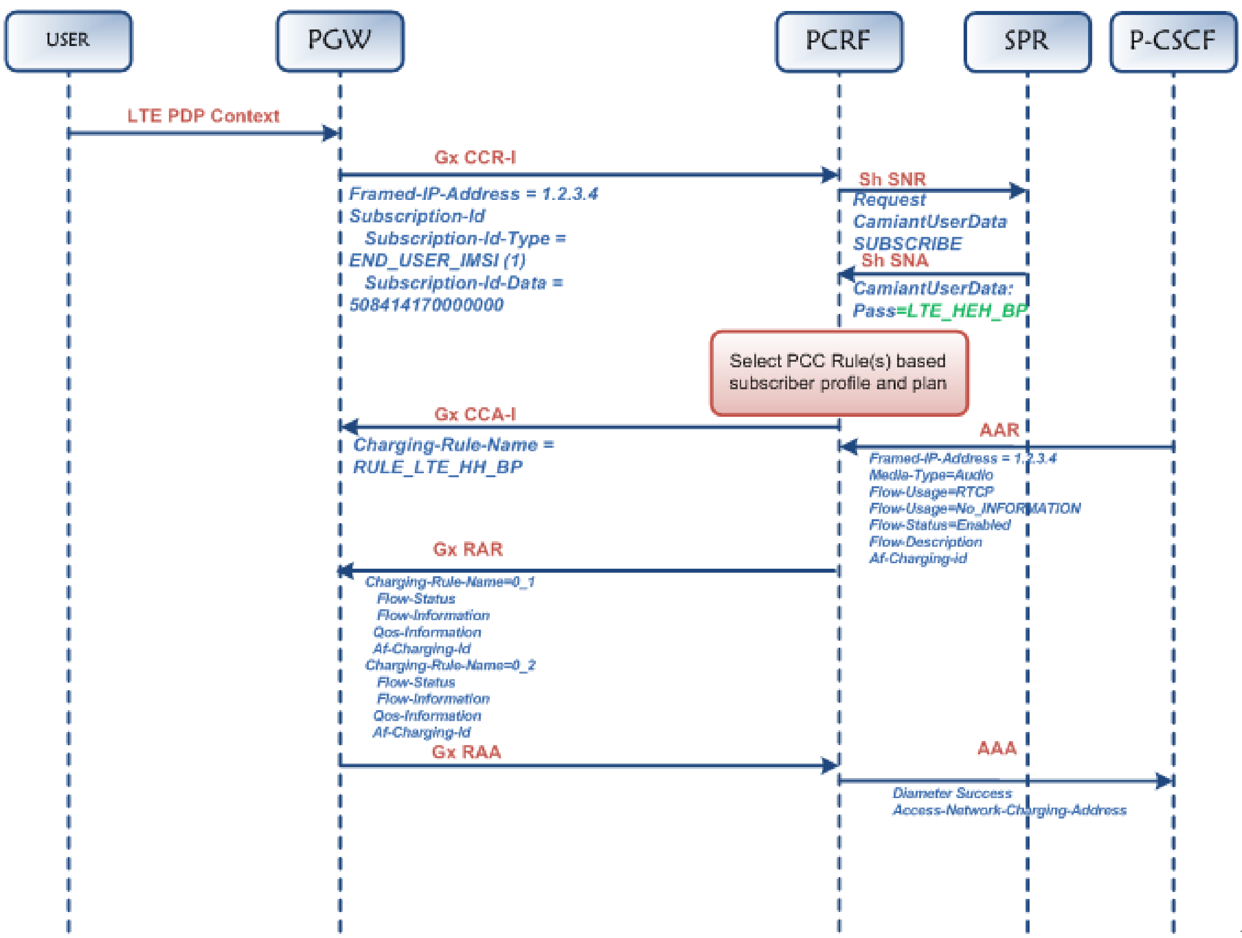


Figure 4: VoLTE Call Flow

3. PCRF Call Model

The following call model needs to be considered in calculating the TPS in each interface. This is Standard Call Model.

- UE Attach
- UE Detach
- Internet Access using DPI in the network
- Internet Access using L4L7 Optimizer in the network
- Bandwidth Boost
- VoLTE – Outgoing Call
- VoLTE – Incoming Call

Call Model 1: UE Attach

Please find the below call flow for UE attach using SAE-GW and corresponding TPS calculation.

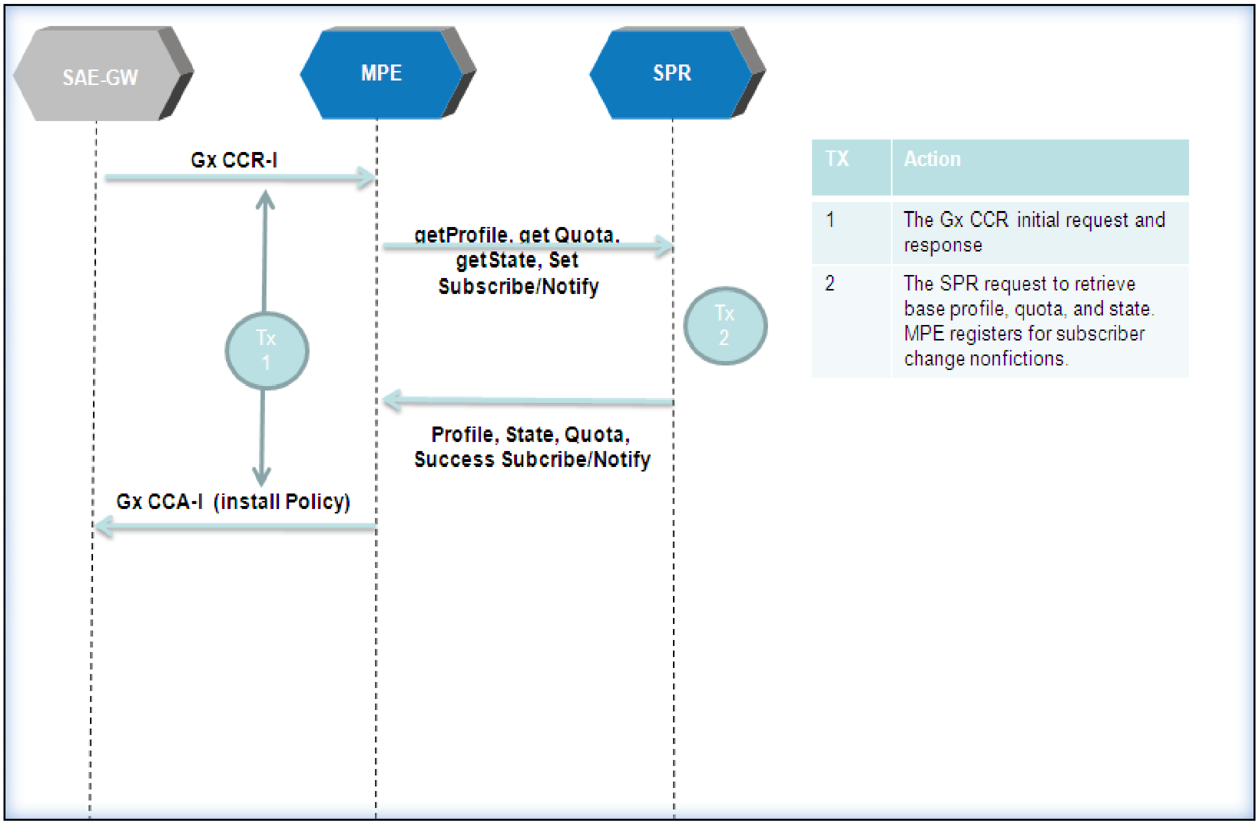


Figure 5: UE attach

Call Model 2: UE Detach

Please find the below call flow for UE detach using SAE-GW and corresponding TPS calculation.

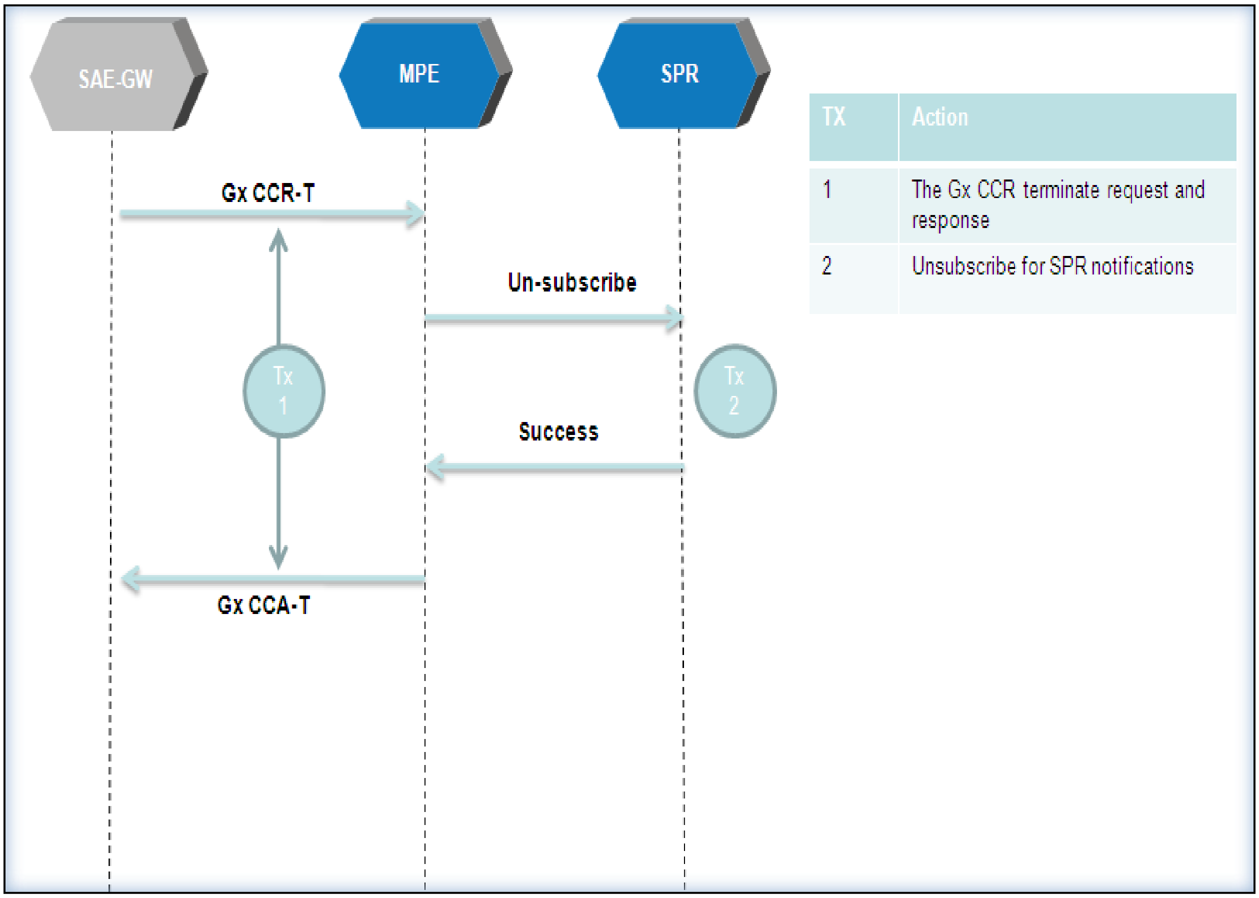
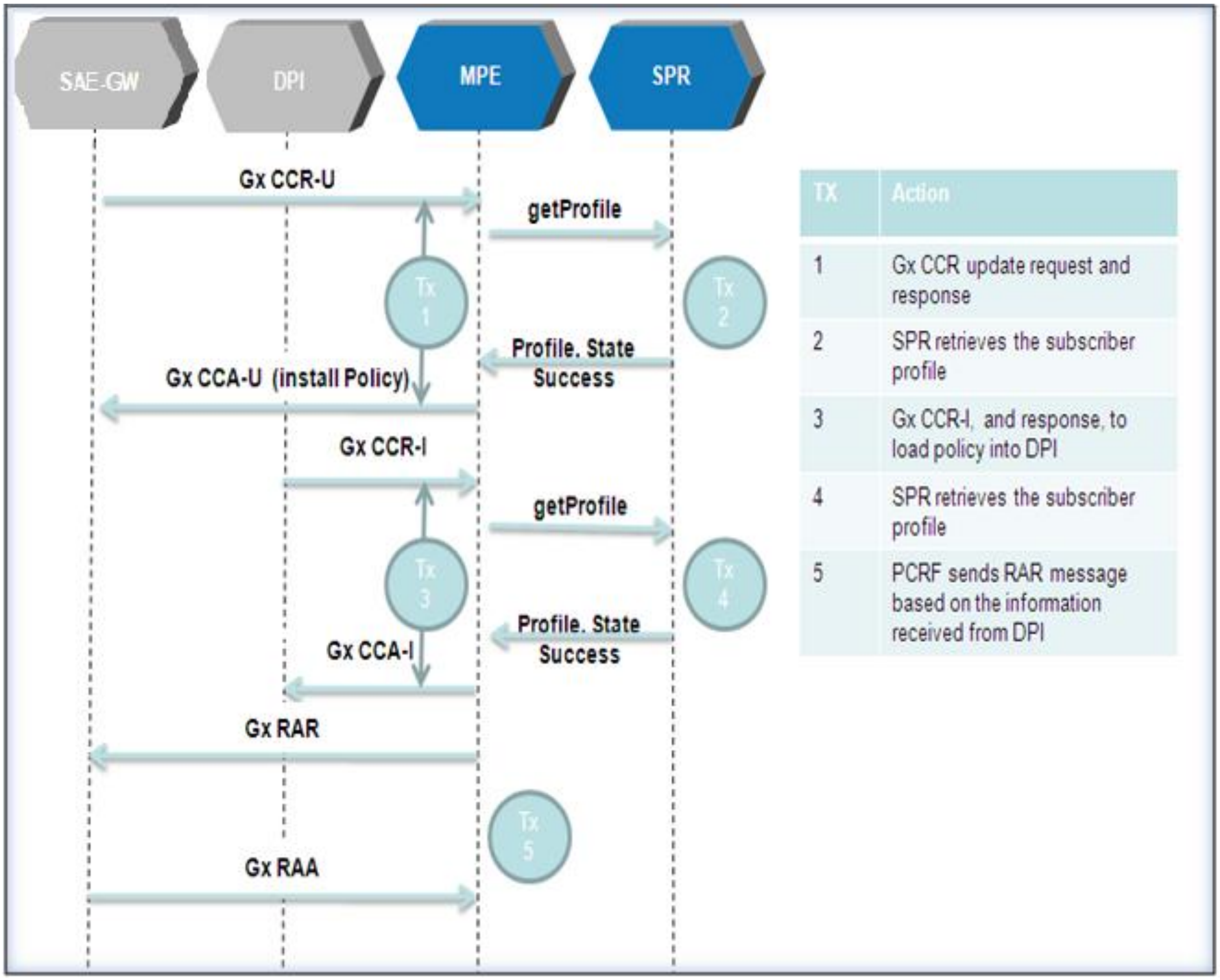


Figure 6: UE detach

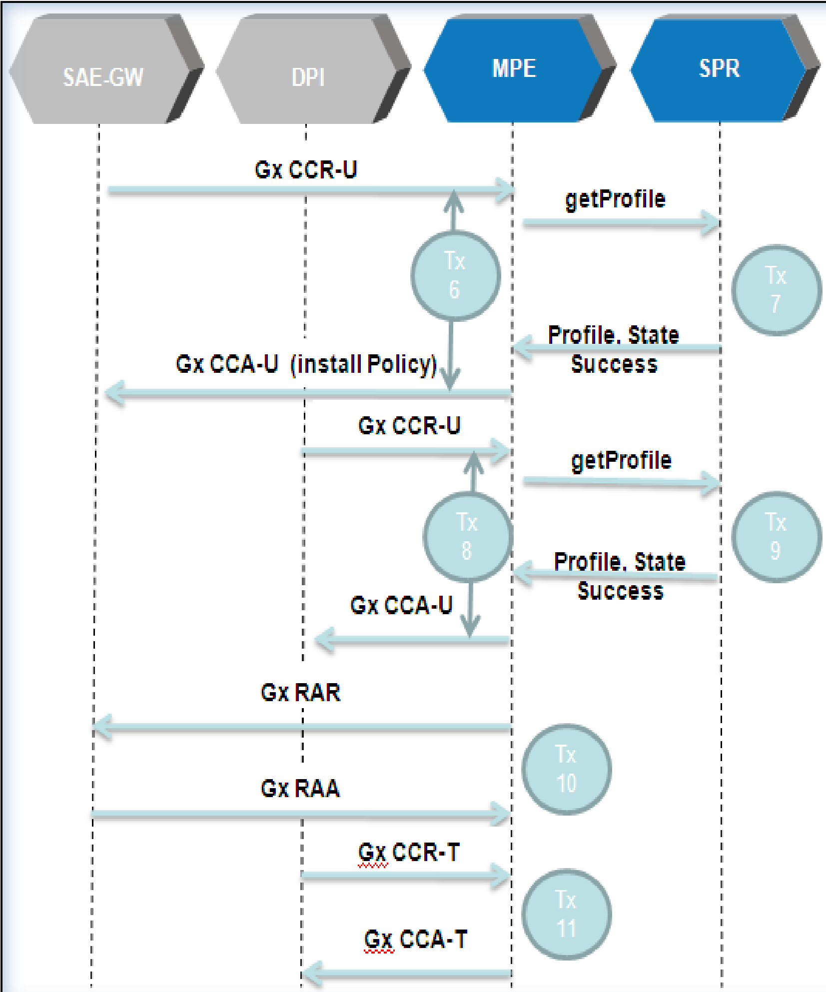
Call Model 3: Internet Access using DPI in the network

Please find the below call flow for UE accessing the internet and DPI in the network and corresponding TPS calculation. Assume, UE is already attached in the network.



TX	Action
1	Gx CCR update request and response
2	SPR retrieves the subscriber profile
3	Gx CCR-I, and response, to load policy into DPI
4	SPR retrieves the subscriber profile
5	PCRF sends RAR message based on the information received from DPI

Figure 7a: UE accessing internet and DPI

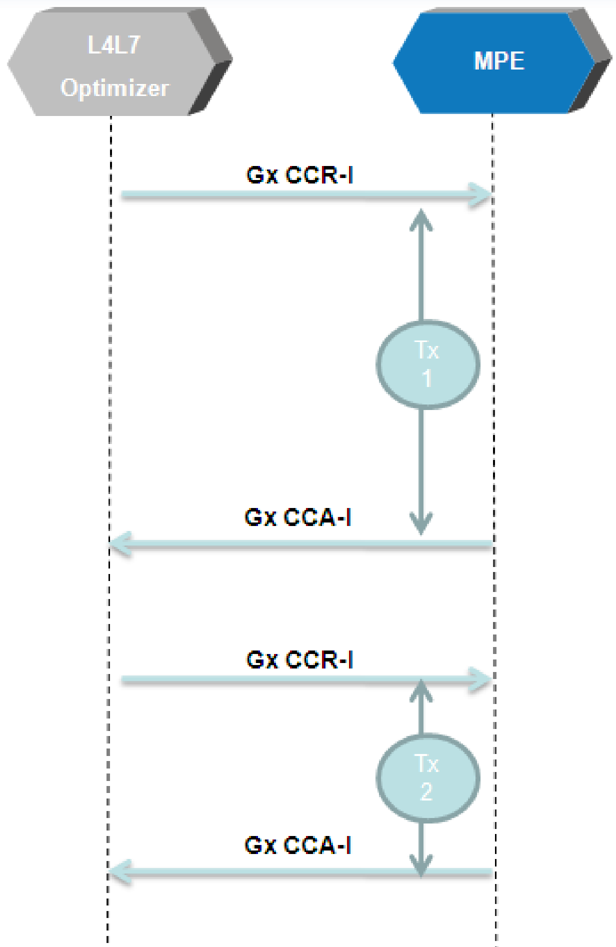


TX	Action
6	PGW sends CCR update request if any event occurs and receives the CCA
7	SPR retrieves the subscriber profile
8	Gx CCR-U, and response, to load policy into DPI
9	SPR retrieves the subscriber profile
10	PCRF sends RAR message based on the information received from DPI
11	DPI sends CCR-T and receives CCA-T

Figure 7b: UE accessing internet and DPI

Call Model 4: Internet Access using L4L7 Optimizer in the network

Please find the below call flow for UE accessing the internet and L4L7 Optimizer in the network. Assume, UE is already attached in the network.



TX	Action
1	L4L7 Optimizer sends CCR-I and receives CCA-I with proper policy rule
2	L4L7 Optimizer sends CCR-T and receives CCA-T

Figure 8: UE accessing internet and L4L7 Optimizer

Call Model 5: Bandwidth Boost

Please find the below call flow for Bandwidth boost and corresponding TPS calculation. Assume, UE is already attached in the network.

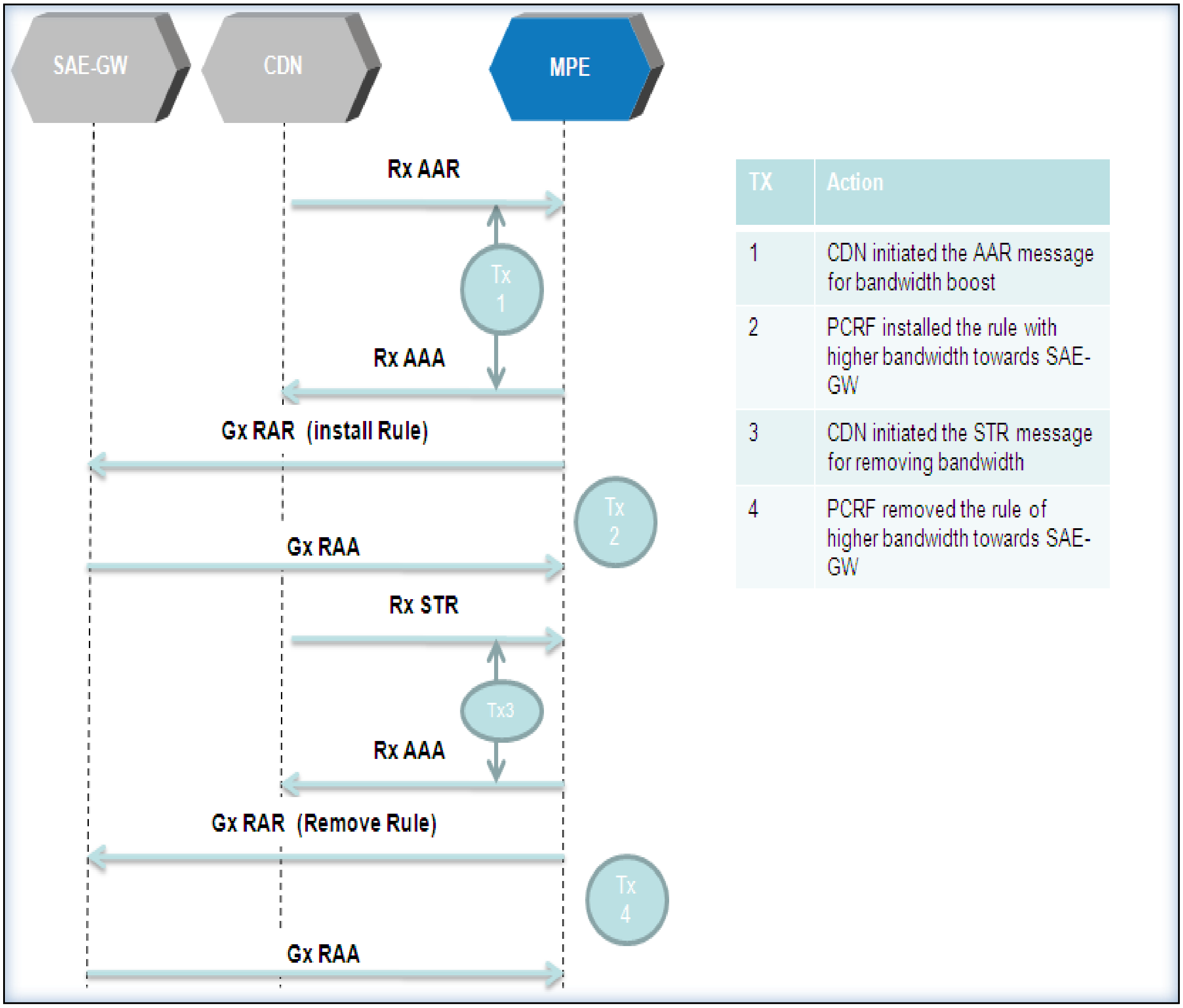


Figure 9: Bandwidth Boost

Call Model 6: VoLTE – Outgoing Call

Please find the below call flow for VoLTE (Outgoing Call) and corresponding TPS calculation. Assume UE is already attached in the network.

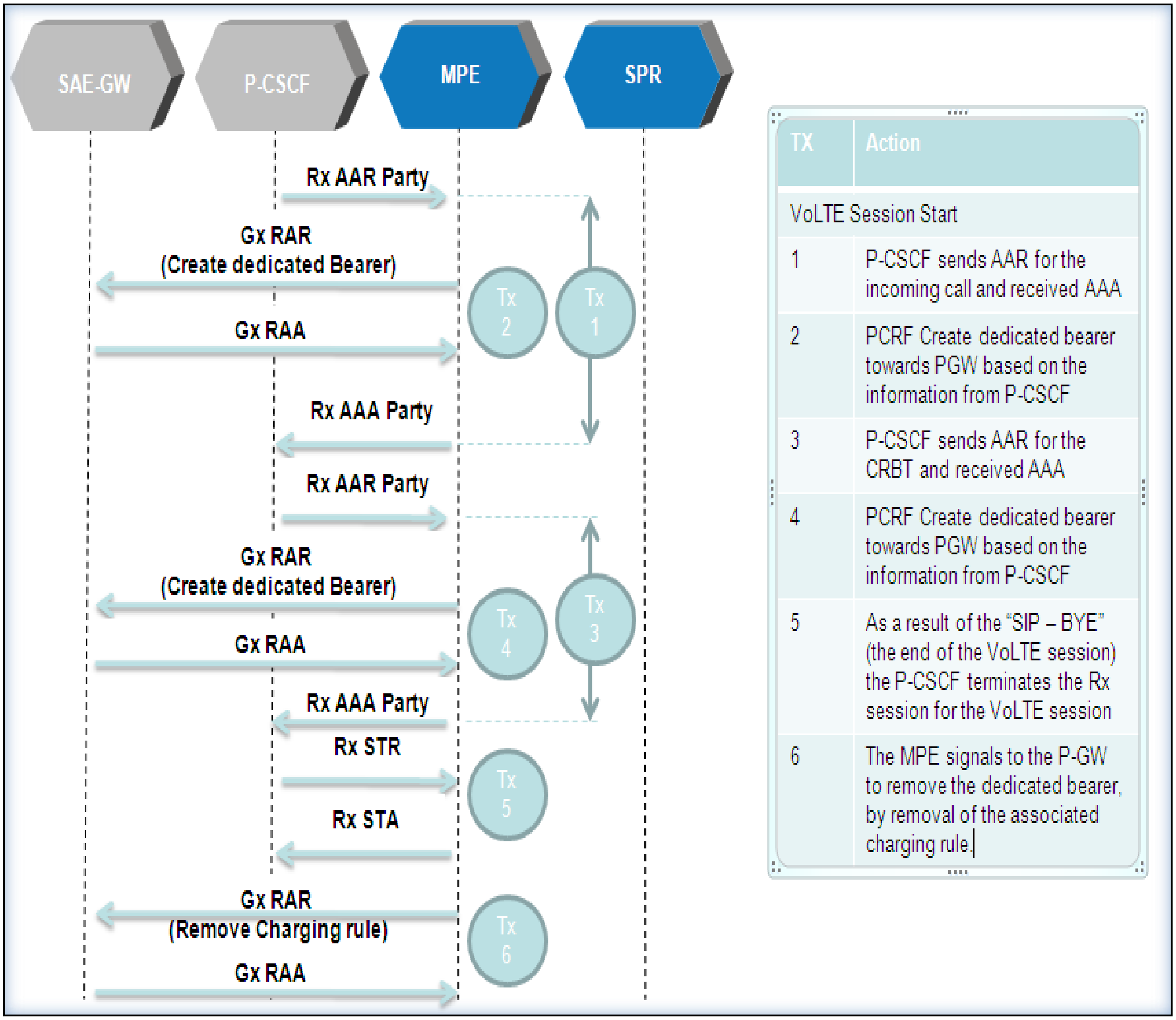


Figure 10: VoLTE – Outgoing Call

Call Model 7: VoLTE – Incoming Call

Please find the below call flow for VoLTE (Incoming Call) and corresponding TPS calculation. Assume UE is already attached in the network.

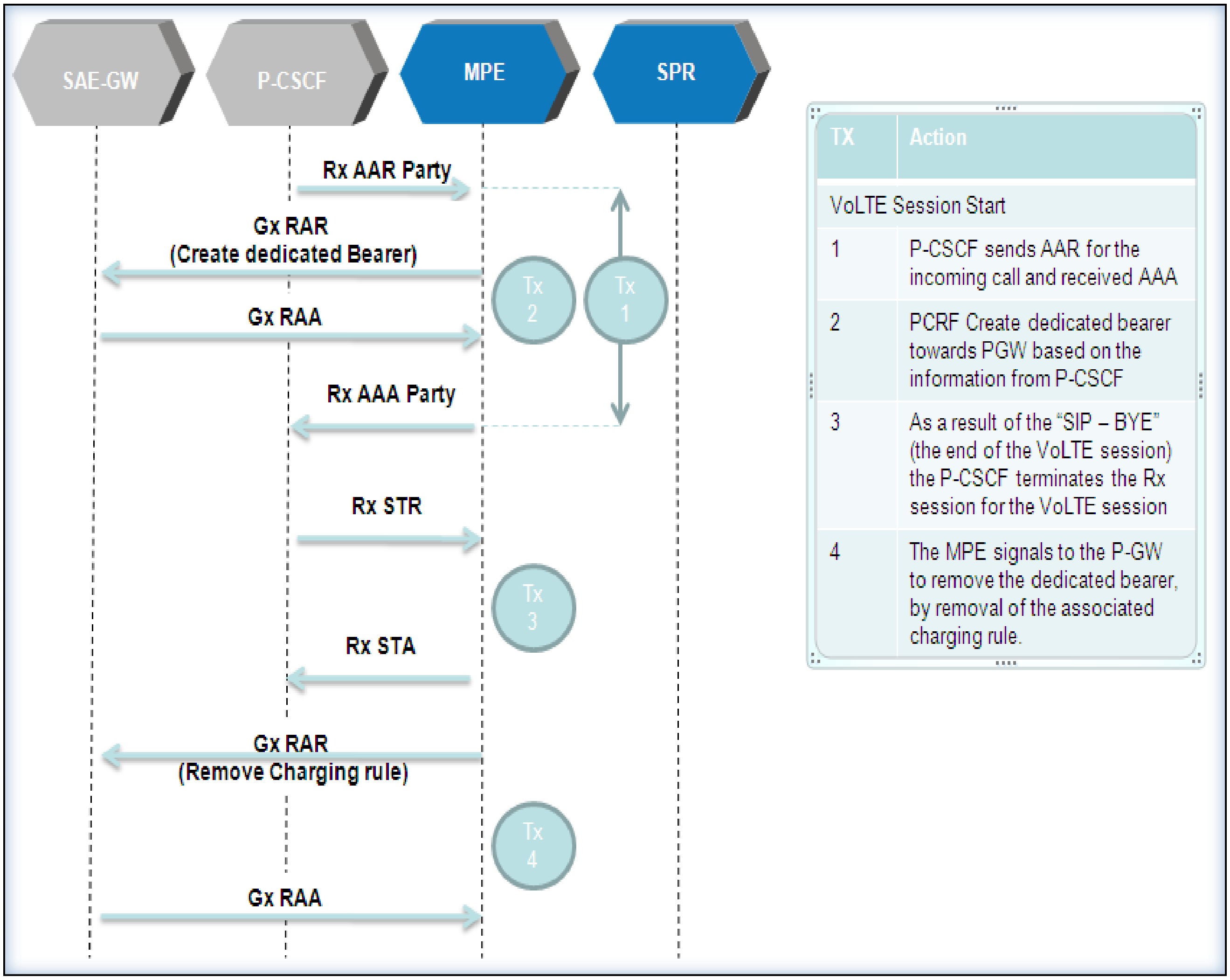


Figure 11: VoLTE – Incoming Call