Quality of Experience Based Policy Control Framework for RTP Based Video and Non-Voice Media Sessions

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Abstract

PCRF is defined as an entity used for policy and QoS control for a converged network by 3GPP.

Though there are elaborate procedures defined for policy and QoS control for session establishment, modification and deletion, however, there are no procedure defined which can help in improving the Quality of Experience (QoE) for an established session. The current paper focuses on tracking actual QoS which is being experienced by the user (termed as QoE in this paper) and defines procedures for Policy control entities in a 3GPP defined setup for RTP based Video and non-Voice Media session.

Keywords: *INTERNET, VoIP, MOBILE, QUALITY OF SERVICE*

1. Introduction

1.1. Background

3GPP in release-10 [1] [2] and release-11 have defined and extended the LTE network for carrying different type of access. The architecture is towards convergence and IP Network is used to achieve such convergence.

Whenever a person wants to setup or modify a media session using a 3GPP LTE network, the session is negotiated as defined by 3GPP [2] [4]. The QoS and policy control work is done by PCRF [3]. After the session is in progress, it is assumed that the QoS negotiated during the setup will hold well, till a new service or policy is required. However, there may be a chance that user’s ongoing session experience is not what it has requested in the session setup. Hence, the” QoE” is not equal to” QoS” requested in the session setup.

Currently, 3GPP PCC architecture [3] does not define any mechanism, using which the PCRF can apply policies based on the user’s ongoing session QoE.

The QoE measurements are specified as end-to-end. It can translate into systems engineering measures based on the architecture at the network, transport or application layer. Reliable delivery of packets is not always true for IP based networks. The End-to-end packet losses in such networks can vary significantly. Also, there are different kinds of access technologies available (e.g. WLAN, 3GPP, etc). They differ in terms of performances and behavior. Hence, there might be a requirement for end-to-end QoE measurement mechanisms.

The policy control framework can play an important role here in improving the QoE. Figure 1 shows a converged network defined by 3GPP. PCRF, GW/GGSN, TDF and AF are shown here.

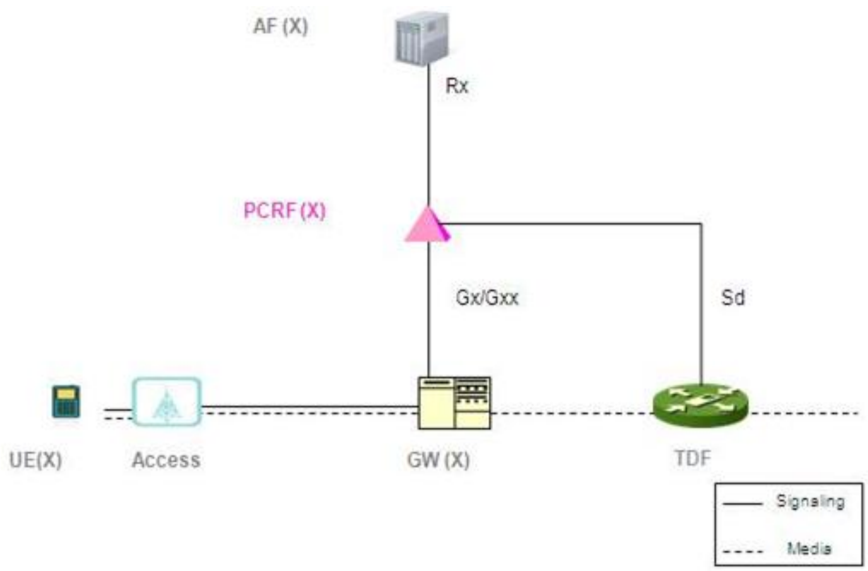

Figure 1. 3GPP Converged Network with PCRF (3GPP Release-11 Architecture)

The 3GPP has promoted local breakout [3] case, where a user is in a visited network and uses GW(X) and TDF of the visited network. In such a case, the PCRF in the home network (H-PCRF) is not aware of the gateway and TDF through which the bearer contents are passing through.

The PCRF in the visited network (V-PCRF) takes care of handling of the gateways and the TDF here. Since, the policy decisions are always intended to be taken at the H-PCRF (as the home network has the user's subscription data); hence, the H-PCRF is connected to V-PCRF on S9 interface.

There may be a need where, the QoE improvement is required even in local breakout case. Figure 2 shows a 3GPP defined local breakout architecture:

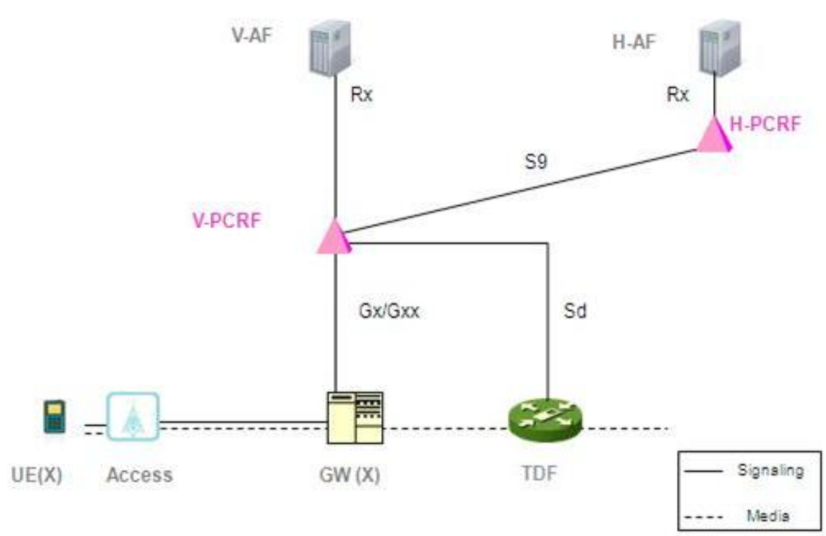

Figure 2. A 3GPP Converged Network with PCRF for Local Breakout (3GPP Release-11 Architecture)

1.2 Requirements Identified

The PCRF is unaware of QoE of the ongoing session. In such a case, the rules applied during the session setups may not be appropriate for the ongoing sessions where the experienced network conditions are low. As part of solution, the following enhancements are needed into the Policy Control Framework:

(A) Sd interface is enhanced to identify the ongoing session details for IP Services
(B) S9 interface is enhanced to provide the QoE Event Triggers to the home network
(C) Procedures defined on PCRF for QoE derivation
(D) Rx interface enhanced to provide inputs for further QoS exchange
(E) PCRF can apply the charging-rules with lower rates for networks with constrained QoE.

2. Solution Overview

2.1. Interfaces Used

PCRF Interaction with GW:

The PCRF can interact with the GW on Gx/Gxx [5] interface. This interface is diameter based.

PCRF Interaction with AF:

The PCRF can interact with the AF on Rx [6] interface. This interface is diameter based.

PCRF Interaction with TDF:

The PCRF can interact with the TDF on Sd [3] interface.

V-PCRF Interaction with H-PCRF:

The V-PCRF can interact with the H-PCRF on S9 [3] interface.

2.2 Procedures

After a session is established, the PCRF in conjunction of TDF will keep monitoring quality of service in progress. This will be done by monitoring the RTCP packets or RTCP-XR packets. The key action points will be as follows:

(a) PCRF will provision a request to TDF, to report RTCP/RTCP-XR packets after a given point of Time for an established session.
(b) The TDF will detect the RTCP/RTCP-XR packets flowing for the given Media session.
(c) TDF will send the report to PCRF, at the specified times.
(d) PCRF will execute policy and evaluate the reports send by the TDF. If the QoS transferred on the network is not what was provisioned in the setup, the PCRF will intimate the same to the AF. Optionally, if PCRF have information about the capability available at the UE, it may recommend the AF for required codec(s) for constrained networks.
(e) PCRF can apply the charging-rules with lower rates for networks with constrained QoE.
(f) The AF (e.g. if working as a AS) may request the UE to update the session. (optional)

3. Solution Details

3.1. Call Flows – Non-Roaming

For non-roaming cases, the Sd interface and Rx interface will be enhanced to monitor QoE activities.

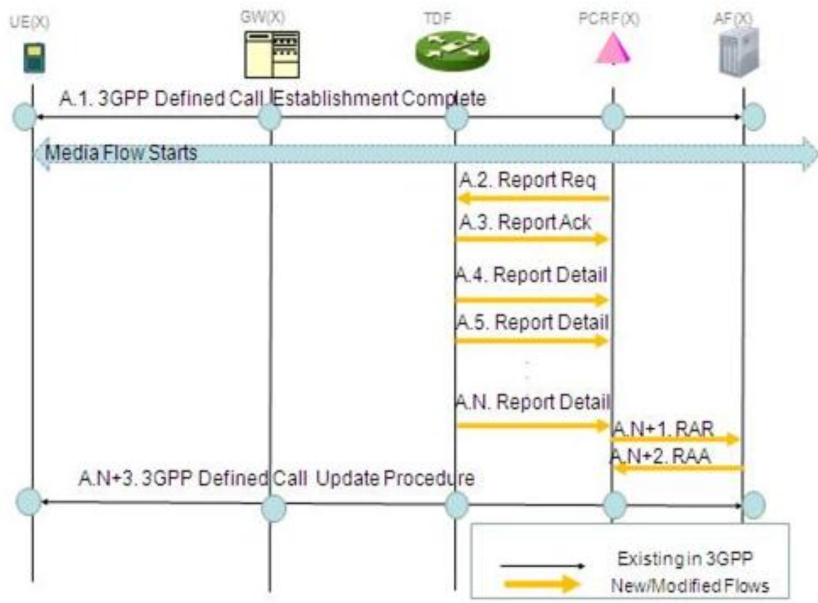

Figure 3. PCRF Based QoE Monitoring Procedure-Non Roaming

[A.1]. Session is established for UE(X) based on 3GPP defined procedures in [1], [2]. The media flow starts.

[A.2]. PCRF instructs the TDF to detect RTCP flows and report Session statistics parameters after every K th time interval, from the current time.

[A.3]. PCRF receives Report Ack, mentioning it has started monitoring the request sends in A.2.

[A.4] – [A.N]. TDF starts sending the report to the PCRF. PCRF calculates the user QoE based on certain algorithm (e.g. one proposed in section 2.5).

[A.N+1]. PCRF detects that the user experience has faced degradation and is not what was installed during the session establishment. It sends an RAR message with a new "specific action" field mentioning "Lower-QoE-Detected".

[A.N+2]. AF sends the RAA message to PCRF.

[A.N+3] IPCAN Session modification procedure where PCRF can apply the charging-rules with lower rates for networks with constrained QoE.

3.2. Call Flows – Local Breakout

In the local breakout case, the Sd interface, Rx interface and S9 interface will be enhanced for QoE monitoring.

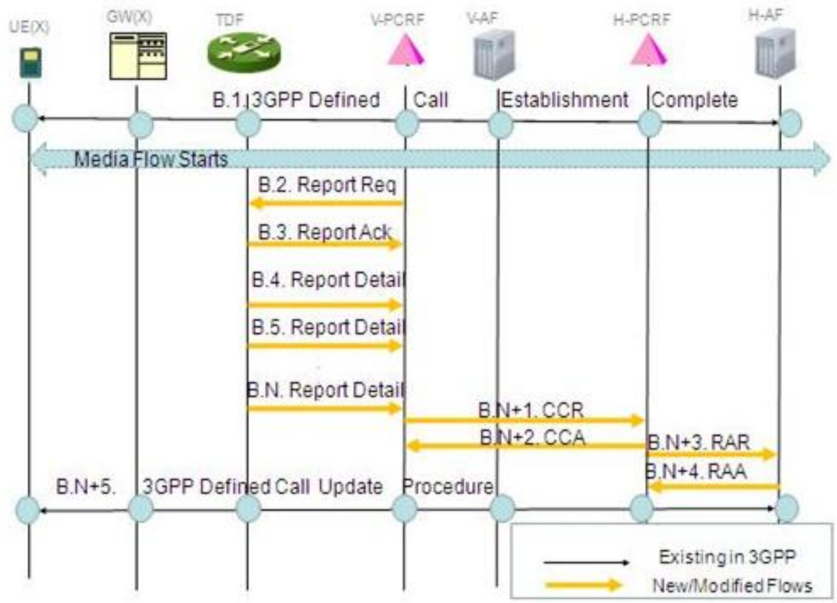

Figure 4. PCRF Based QoE Monitoring Procedure- Local Breakout

[B.1]. Session is established for UE(X) based on 3GPP defined procedures in [1], [2]. The media flow starts. The H-PCRF will send information to V-PCRF on the S9 interface if QoE monitoring is required and its details.

[B.2]. V-PCRF instructs the TDF to detect RTCP flows and report Session statistics parameters after every K th time interval, from the current time.

[B.3]. V-PCRF receives Report Ack, mentioning it has started monitoring the request sends in B.2.

[B.4] – [B.N]. TDF starts sending the report to the V-PCRF. V-PCRF calculates the user QoE based on certain algorithm (e.g. one proposed in section 2.5).

[B.N+1]. V-PCRF detects that the user experience has faced degradation and is not what was installed during the session establishment. It sends an S9 CCR message with a new “Event-Trigger “mentioning “QoS-Degrade-Experienced” to H-PCRF.

[B.N+2]. H-PCRF sends the CCA message to V-PCRF.

[B.N+3]. H-PCRF sends an RAR message with a new “specific action” field mentioning “Lower-QoE-Detected” to H-AF.

[B.N+4]. H-AF sends the RAA message to H-PCRF.

[B.N+5] IPCAN Session modification procedure where PCRF can apply the charging-rules with lower rates for networks with constrained QoE.

3.3. Proposed Message Details

(1) The PCRF will send request to TDF to monitor specific protocol packet like RTCP. Further it will calculate the Avg traffic statistics for a given time using the fields from the RTCP/RTCP-XP to send. The message looks like:

Report-Request
-Protocol: RTCP/RTCP-XP
-Time: T1
--Fields: Avg-SenderReport

---Avg-Packet-Count
---Avg-Packet-Lost
---Inter-Arrival-Jitter
---Avg-Additional-Delay
--Fields: Avg-Receiver-Report
---Avg-Packet-Lost
---Avg-Packet-Lost
---Inter-Arrival-Jitter
---Avg-Additional-Delay

(2) The PCRF will inform the AF to with a new specific-action AVP value "Lower-QoE-Detected". Optionally, if PCRF is aware of the codec list which is available with the endpoints (like a list received during earlier AARs), it may recommend such a codec.
RAR
-Specific-Action= "Lower-QoE-Detected"
-Recommended-Codec= <codec-list>

(3) For local breakout case, the V-PCRF will inform H-PCRF with an event trigger with "QoS-Degrade" and the report details.

3.4. Algorithm for QoE Calculation

Based on the codec used in a given video and non-voice session, the PCRF will calculate the default bandwidth required. Consider an example, where a session which involves AACLC codec. The session setup has been done with packet size of 20 ms, sampling rate of 320Kbps, with network and Layer 2 (Ethernet) overheads of 40 octets and 38 octets respectively. This will need the bandwidth of 351200 bit/sec. The calculation for this example is shown in the Table 1:

Table 1. Default QoS Required for AAC-LC Codec

Packet Size	(in ms)	20
Frame generated per sec	(Frames/sec)	50
Sampling rate	(bit/sec)	320000
Data in each Frame	(bit)	6400
Data in each Frame	(octet)	800
Latency and Packet Overheads (IP/RTP)	(octet)	40
L2 Overhead (Ethernet)	(octet)	38
Total BW needed	***(bit/sec)***	***351200***

For a given period, the user satisfaction can be also calculated by the PCRF. This can be done by the use of E-Model, defined by ITU-T [7] [8] [9]. The E-Model is an analytic computation technique which can be used to model the data quality used for network planning purposes. One of the corollaries of the E-Model is the calculation of the R-factor. This can be used to measure of data quality.

Specifically, the R-Factor defined by ITU-T [7] is mentioned as under:

$$R = 93.2 - Id - Ie \quad (1)$$

Where,

Id = the impairment associated with the mouth-to-ear delay
Ie = the equipment impairment factor (associated with loss probability)

The RTT (Return Transfer Delay) is calculated as equation (2)

$$RTT = CurrentT\ imestamp - LastSRTimestamp \quad (2)$$

Furthermore the loss probability is calculated as equation (3)

$$LossP\ robability = PacketLost – TotalPacket \quad (3)$$

For a user using the AAC-LC codec on a given network, the average real time statistics result to the one shown in table 2.

Table 2. User Satisfaction for the AAC-LC Codec

Reported Time	**(in sec)**	**20**	**40**	**60**	**80**
Number of Packets lost	(count)	13	17	10	2
Total Packets sent	(count)	200	220	200	230
Jitter	(in ms)	19	19	19	19
RTT (Return Transfer Delay)	(Current Timestamp - Last SR Timestamp)	5.746	5.9	5.8	5.6
Loss Probability	Packet Lost/Total Packet	6.5	7.727273	5	0.869565
R-Factor	**As per G.107**	**61.954**	**60.57273**	**63.4**	**67.73043**
Effective Bandwidth	**(in bit/sec)**	**74800**	**81200**	**76000**	**91200**

Based on results obtained in Table 2, the MOS (Mean Opinion Score) [7] is calculated.

The MOS values are plotted in Figure 5. Quality ratings are decided on a five-point scale: Excellent (five), Good (four), Fair (three), Poor (two), and Worst (one). It falls somewhere between one and five. Higher MOS reflects better end-to-end QoE.

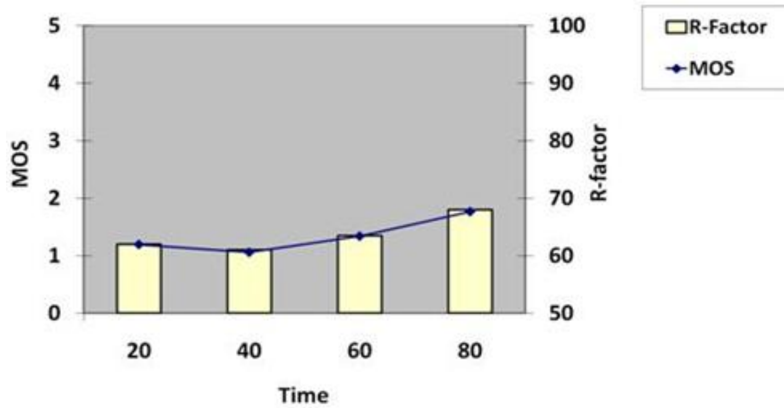

Figure 5. MOS and R-Factor Correlation for AAC-LC Codec

The average MOS for the user comes to less than 1.3 for the experienced data. This relates to poor quality of experience received by the user [7]. Table 2 also contains details of the effective bandwidth possible for the given session in the network conditions. Figure 6 contains the difference in pattern obtained for expected bandwidth (Table 1) and the actual bandwidth (Table 2) obtained for the traffic.

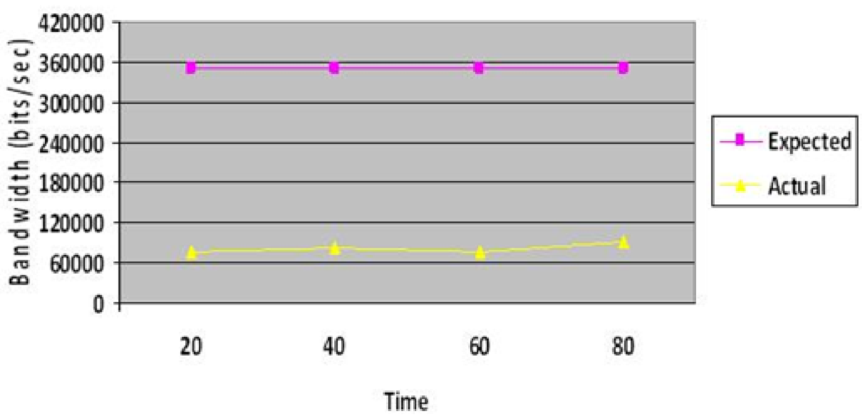

Figure 6. Expected v/s Actual Bandwidth Experienced Plot

The PCRF will keep on getting the event notifications as defined in section 3.1. Over a period of time, the PCRF will infer that the network is a constrained one based on the difference shown in Figure 6.

PCRF can apply the new charging-rules for the networks with constrained QoE.

For the same traffic, the PCRF can evaluate which are the other codec which the UE supports and can perform well in the given network conditions. For example, the PCRF may infer that HE-AAC codec can work well in the actual network conditions.

Table 3 contains the details of the HE-AAC codec:

Table 3. Default QoS Required for HE-AAC Codec

Packet Size	**(in ms)**	**20**
Frame generated per sec	(Frames/sec)	50
Sampling rate	(bit/sec)	36000
Data in each Frame	(bit)	720
Data in each Frame	(octet)	90
Latency and Packet Overheads (IP/RTP)	(octet)	40
L2 Overhead (Ethernet)	(octet)	38
Total BW needed	**(bit/sec)**	**67200**

4. Benefits of the Solution

The paper presents a solution where, the operator can use the QoE matrices into the policy decisions. Based upon the user's experience, the PCRF can apply the rules which are appropriate under the network conditions. The end user is benefitted as the rules will be based on its real time experience. The operator can use the policy control framework including TDF and GW to monitor the real time user experience. The network can play an important role here in deriving the QoE statistics and hence provide better rules for end-to-end system.

5. Conclusion

There is industry wide need to measure the end user QoE and take it into as a factor for the policy decisions. As the trend continues and the operators are moving towards the whole IP Network, hence, there are great chances that the QoS negotiated are not the same what a user is experiencing. The operator can also use the reports, into a better network planning. The end user will be benefitted by getting the appropriate charging rules under the present network conditions

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