Interaction between an Online Charging System and a Policy Server

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Abstract— **According to the 3GPP standard architecture up to Release 9, a Charging System is not supposed to interact directly with a Policy Server. The Charging System is responsible for rating and charging, while the Policy Server is responsible for determining the right policy depending on the kind of traffic. In reality, it appears that the decision about the right policy might be influenced by some real-time subscriber information, which might also be relevant for charging, and therefore stored in the Charging System. In this context, a direct interface between the Charging System and the Policy Server might be required. The goal of this paper is to study what such an interface would look like, based on an actual implementation. The main achievement is to validate a scenario where the policy should change in real-time during a data session because a volume threshold has been crossed.**

Keywords- Rating; Policy; IMS; OCS; PCRF; PCC; QoS

I. INTRODUCTION

According to the 3GPP IP Multimedia Subsystem (IMS) standard architecture, rating and charging takes place for online charging in a so-called Online Charging System (OCS) [1]. The latter contains rating and charging rules depending on all traffic typology criteria. The decision regarding policy falls to the Policy and Control Resource Function (PCRF) [2]. The latter contains policy rules depending on all traffic typology criteria.

In the standard Policy and Charging Control (PCC) architecture [3], the core network, which knows the actual traffic properties, asks the PCRF which policy it should apply, and the OCS (in case of online charging) which charging scheme it should apply. The Policy and Charging Enforcement Function (PCEF) at core network level, included in a Packet Data Network (PDN) Gateway, which can be for example the Gateway GPRS Support Node (GGSN), is then responsible to apply the proper policy and the correct pricing structure to the actual traffic, according to the input from the PCRF and the OCS.

However, there are some scenarios where the decision on policy might be influenced by the OCS. In Section II, we shall describe such scenarios, and check whether some of them have been studied already in the literature. In Section III, we will describe an approach in which the OCS interacts with the PCRF. Finally, in Section IV, we will present an actual implementation.

Please note that we focus on online charging in this paper, not on offline charging, because we are interested in rating respectively policy decisions / changes in real-time while a data session is running.

II. PURPOSE OF THE INTERACTION BETWEEN THE PCRF AND THE OCS

Going into more details in the IMS standard architecture for online charging [1], the OCS relies on two databases:
- The database in the Rating Function (RF), which contains generic tariff information at service level;
- The database in the Account Balance Management Function (ABMF), which contains subscriber-specific information relevant for the rating.

Actually, searching the literature, an interface between the policy decision function and external databases is mentioned in [4], but it does not relate specifically to an OCS database. And the dynamic mid-session interaction is not studied in detail either. A direct interaction between the PCRF and the OCS has already been studied in [5], but it restricts to an interaction of the PCRF with the Rating or Tariff Function of the OCS. It means that the policy decision might indeed depend on tariff rules, but it still does not depend on subscriber-specific information such as his/her current consumption or life cycle state.

Moreover, reducing the subscriber tariff information to a single tariff class ID might be restrictive given newer tariff schemes, where multiple charging options might be applied individually on top of a default tariff. Such charging options are for example usage-based discounts, subscriber bonus, or individual buckets e.g., free minutes, that the subscriber can book in addition to his/her default tariff, or that he/she gets as a reward for high consumption or recharge.

Basically, one of the functions of the OCS is to perform account balance management towards external systems through the ABMF. For this purpose, the OCS might store subscriber's pieces of information applicable for rating like usage counters. Furthermore, it might store additional information like his/her life-cycle state e.g., validity dates, or the status of his/her valid tariff options.

According to [1], in order to support the online rating process, the Rating Function necessitates counters. The counters are maintained by the Rating Function through the Account Balance Management Function. Assuming that these counters are maintained at subscriber level, storing them together with other real-time subscriber information in the ABMF makes sense.

According to [3], in order to support the policy decision process, the PCRF may receive information about total allowed usage per user from the Subscription Profile Repository (SPR). Going further in this direction, some additional subscriber information might be relevant to the PCRF in order to determine the right policy: not only static data like an allowed usage threshold specific to a subscriber, but also subscriber dynamic data like the value of some counters at a certain point in time, his/her life-cycle state, or the status of his/her valid tariff options.

Such an approach supports scenarios like the following: as long as the subscriber consumption within one month does not exceed a certain limit, he/she is eligible for a better Quality of Service (QoS) than once the threshold has been exceeded. Alternatively, a scenario might occur in which a specific subscriber bought on top of his/her standard tariff an option for data traffic so that he/she is eligible for a better policy than "normal" subscribers.

Consequently, the SPR would have to store such information as well. However, this information is still mandatory in the OCS because it might influence ratings. For example, the high value of a usage counter respectively having subscribed to a certain tariff option might lead to a reduced or negligible price for data traffic. Or taking the example above again, once the subscriber consumption within one month exceeds a certain limit (not necessarily the same limit as for policy decision), the subscriber might enjoy cheaper rates for data traffic.

This shows that some subscriber data is meaningful both for the SPR and the ABMF. There could be here a kind of overlapping between the SPR and the ABMF as represented in Figure 1.
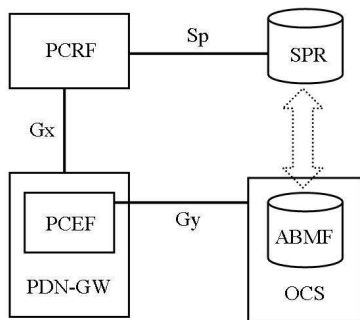

Figure 1. Potential overlapping between the SPR and the ABMF

Replicating the information both in the SPR and in the ABMF would be an option. But this would assume efficient synchronization mechanisms between the two databases, since the number of subscribers respectively their data traffic in today's telecommunication networks might be substantial. Furthermore, the involved pieces of information consist of real-time data. If the policy should change when the subscriber's consumption reaches a certain limit, the change would happen in real-time and without delay. In the same

way, if the rating should change when a certain limit is reached, the change should happen in real-time too.

Duplication of databases, which store a great deal of real-time data, could increase the complexity of the implementation. If the relevant subscriber information is already present in the OCS, why should not the PCRF retrieve it directly from the OCS? This is represented in Figure 2.
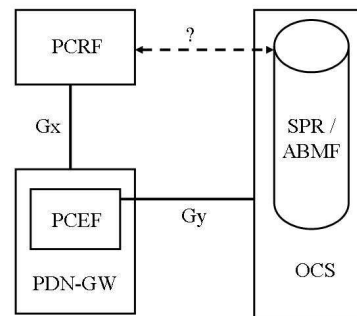

Figure 2. OCS acting as an SPR

III. PROPOSED APPROACH

The proposed approach consists of a framework where the PCRF and the OCS exchange in real-time subscriber information, which is necessary not only for charging, but also in order to determine the right policy. The goal is to support such scenarios where the policy might be changed based on the value of some subscriber data volume counters.

The latter are stored in the OCS as master copy in any case because they are relevant for charging, in order to support offers like the following: after a subscriber has consumed 1MB within one week, he/she gets 10 free SMS, or he/she is allowed free data traffic till the end of the week. Furthermore, these counters are relevant to the PCRF in order to support similar offers where, for example, the data speed is throttled once the subscriber has reached 10MB consumption within one month. In the context of the present contribution, we shall focus on volume counters. However, it could be another piece of subscriber data, which would be relevant for the policy server, for example, the life-cycle state of the subscriber. For example, if a prepaid data card is near expiry, the surfing speed may diminish.

In the context of the implementation described in the next section, these are the values of subscriber volume counters, which should be reported in real-time from the OCS to the PCRF. More precisely, the counter values will be reported when they exceed some predefined thresholds. The latter might be defined either for a certain subscriber marketing category, or for all the subscribers in the same tariff, or individually at subscriber level. Since these thresholds might be reached in the middle of a session, the OCS might have to notify the PCRF in the middle of a data session too.

Nevertheless, the PCRF should retrieve latest subscriber information like the tariff plan ID and the values of the

volume counters at the beginning of the session as well in order to determine correctly the initial policy. Alternatively, the PCRF could replicate this subscriber information, meaning again that some synchronization mechanisms would have to be implemented.

In general, the message flow when a data session is established would resemble Figure 3. In (1), the PCEF asks the PCRF about the policy that should apply to the session, which is about to start for this subscriber. For this purpose, the PCRF retrieves latest subscriber information from the OCS in (2) and (3). Consequently, the PCRF can notify the initial policy to the PCEF in (4). This would happen through the Gx interface in accordance with [2].
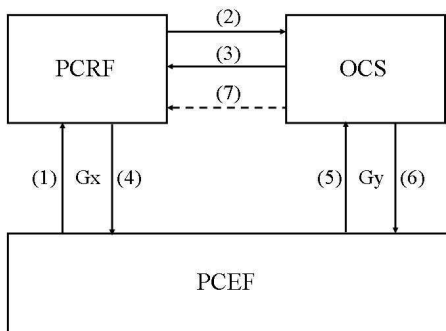

Figure 3. Message flow with PCRF/OCS interaction

Once the policy has been determined, the PCEF requests the OCS for a volume slice in (5). After checking the current subscriber consumption, the subscriber's default tariff respectively available options, and current balance, the OCS allocates a slice in (6). This would happen through the Gy interface in accordance with [2]. In order to allocate the proper slice, the OCS takes into account charging-relevant thresholds, but it should take into account policy-relevant thresholds as well: this will ensure a timely charging or policy change. Depending on the duration of the session, there might be several volume slices requested i.e., several messages like (5) and (6).

The arrow in (7) is represented in dotted line because it may or may not occur during a session: the OCS would notify the PCRF only if a policy-relevant threshold is exceeded during the on-going data session.

As stated above, the protocol for (1) & (4) respectively (5) & (6) is Gx respectively Gy. The protocol for (2) & (3) respectively (7) will be discussed in the next section. Since (2) & (3) respectively (7) are not fully covered by standard bodies yet to the best of our knowledge, the protocol which is the most convenient will be assessed.

An alternative approach, trying to stick to existing standards, would have been for the PCRF and the OCS to exchange information through the PCEF i.e., through the Gx and Gy protocols. But this would imply an extension of the existing protocols as well. In fact, since the present

implementation, various alternatives are being discussed in [6]. They focus on the exchange of information about volume or monetary counters. Additional pieces of information such as the subscriber's life cycle state or his/her optional tariff options may become relevant too.

IV.   IMPLEMENTATION

Regarding the protocol for (7) in Figure 3, since Gx and Gy rely on Diameter, and Gy on Diameter Credit Control Application [7], it was decided to use Diameter Credit Control Request (CCR) Event. The reader might have noted that in (5) & (6), the OCS acts as a Diameter Server towards its client i.e., the PCEF, while in (7) the OCS acts as a Diameter Client toward the Diameter Server, which is the PCRF in this case. As there might be several PCRF nodes, the OCS should support an N+K PCRF architecture in order to ensure a good scalability. The OCS should be able to send CCR Event messages to the PCRF nodes in round-robin way in order to ensure high-availability, meaning that the functionality can still be supported, even if one PCRF node is down.

Regarding (2) and (3), it is about the PCRF's retrieving subscriber profile data from the OCS database at the beginning of a session. Therefore, it is not really about Credit Control, nor Authentication / Accounting. Consequently, Diameter was not chosen, but SOAP/XML instead, because it is a simple protocol to let applications exchange information over HTTP in a platform-independent manner. For more information on SOAP/XML, the reader might refer to [8] and [9].

Within this framework, the following scenario can be supported: let us assume that a subscriber is entitled a downlink/uplink speed of 768/384 Kbps as long as he/she has not exceeded 10MB within a month. Once he/she reaches 10MB, he/she should be throttled to 128/64 Kbps. Let us assume that at the beginning of a session, the subscriber has a consumption of 9.9MB in the current month.

Consequently, when the session is established, the PCRF communicates a QoS corresponding to 768/384 Kbps to the PCEF. In addition, the OCS allocates a quota of only 0.1MB (10-9.9) in the initial Credit Control Answer (CCA) message. That way, when the threshold of 10MB is reached, the PCRF can be notified in real-time. This is represented in Figure 4.
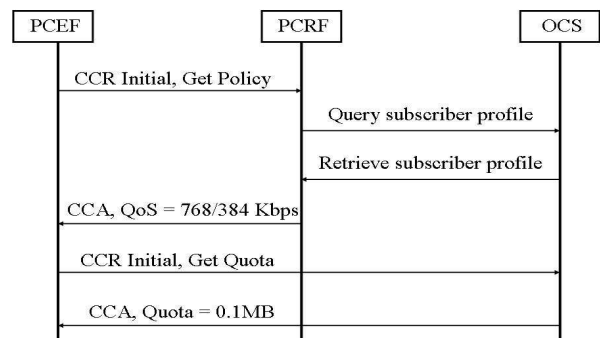

Figure 4. Initial slice granted by the OCS at session start

In case the PCRF has a local database duplicating the OCS database, and containing subscriber information that is not outdated, the query from the PCRF to the OCS may be skipped.

When the allocated quota of 0.1MB has been used up, the PCEF should request another volume quota. If the subscriber balance is sufficient, the OCS will allocate another quota so that the data session can carry on. The allocated quota might be bigger than 0.1MB this time, for example 0.5MB.

Simultaneously, the OCS will notify through a Diameter CCR Event message as suggested previously that the volume threshold of 10MB has been reached for this subscriber, so that the PCRF can calculate the new QoS and notify it to the PCEF. This is represented in Figure 5.
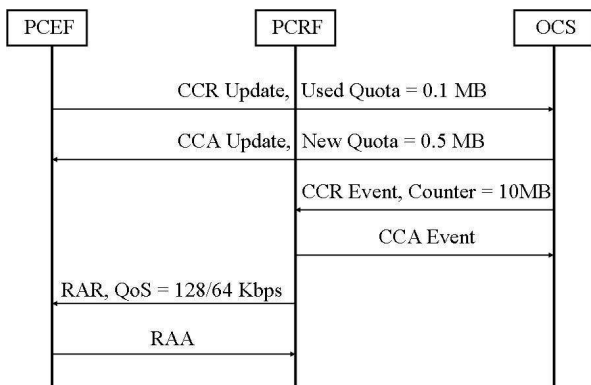
Figure 5. Mid-session notification from the OCS to the PCRF

In order to further notify the policy's change to the PCEF, the PCRF uses Diameter Re-Authentication Request / Answer messages (RAR/RAA) [10].

In case of multiple parallel sessions, the policy change should apply to all on-going sessions. For example, let us assume that one session – Session 1 – starts when the counter value is 9.9MB. Given the threshold of 10MB, the OCS should allocate initially a slice of 0.1MB. Before the latter is used up, another session – Session 2 – starts. The OCS also allocates 0.1MB as initial slice because the counter value is still 9.9MB in the OCS database. This is represented in Figure 6.
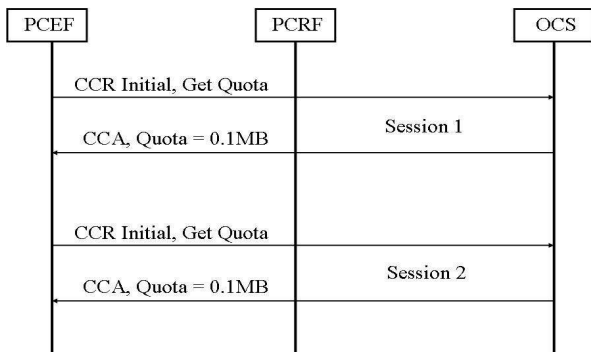
Figure 6. Initial slice for parallel sessions

As soon as the initial slice of 0.1MB of Session 1 or Session 2 is used up, the PCEF will request another slice. The OCS will grant a new slice, but it will update the volume counter value to 10MB, which should trigger the notification to the PCRF. This is represented in Figure 7, where the first session using up the 0.1MB quota is Session 1.
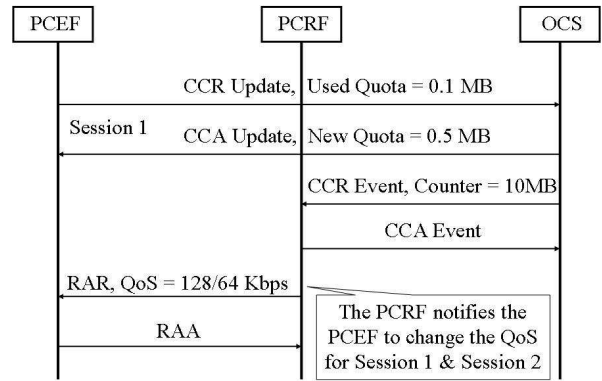
Figure 7. Mid-session QoS notification for parallel sessions

Consequently, the PCRF should notify the PCEF to change the QoS obviously for Session 1, but for Session 2 too, since the volume threshold is applicable to both Session 1 and Session 2, even if it was triggered by Session 1 only.

V. CONCLUSION

The 3GPP defines a valuable framework in order to grant different traffic policies applicable to different kinds of data traffic typologies. The policy server has the ability to retrieve subscriber information from a subscription repository in order to make individual policy decisions. However, the policy server could interact directly with an online charging system in order to support scenarios where the policy depends on subscriber real-time information, which is mandatory for rating and charging too. For this reason, we allowed ourselves to extend the 3GPP framework available at the time of the design, and implemented the described proposal.

In the IMS standard in Release 10, subscriber data is still present in different network elements depending on the application for which this data is required. When it comes to dynamic subscriber data required by different applications, dispatching might not always be suitable. Therefore, as in the approach presented in this paper, it will lead to the specification of new interfaces.

TERMINOLOGY

3GPP   3rd Generation Partnership Project
ABMF   Account and Balance Management Function
CCA   Credit Control Answer
CCR   Credit Control Request
GW   Gateway

GGSN   GPRS Gateway Support Node
GPRS   General Packet Radio Service
GW   Gateway
Gx   IMS reference point between PCEF & PCRF
Gy   IMS reference point between PCEF & OCS
IMS   IP Multimedia Subsystem
IP   Internet Protocol
Kbps   kilo bit per Second
MB   Mega Byte
OCF   Online Charging Function
OCS   Online Charging System
PCC   Policy and Charging Control
PCEF   Policy and Control Enforcement Function
PCRF   Policy and Control Resource Function
PDN   Packet Data Network
QoS   Quality of Service
RAA   Re-Authentication Answer
RAR   Re-Authentication Request
RF   Rating Function
SOAP   Simple Object Access Protocol
Sp   IMS reference point between PCRF & SPR
SPR   Subscription Profile Repository
XML   eXtended Markup Language

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