

LTE Charging I: Offline

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This document provides details of charging procedure and information, specifically in case when charging method, one of the PCC (Policy and Charging) rules, is set offline.

First we will look into charging rules to be forwarded when Policy and Charging Rule Function (PCRF) sends PCC rules to P-GW. Then, we will describe the procedure performed by P-GW to forward Charging Data Record (CDR) to Offline Charging System (OFCS) once users finish using services. Finally we will provide a summarized list of CDR parameters.

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Abbreviations

APN	Access Point Name
ARP	Allocation and Retention Priority
BSS	Business Support System
CCA	Credit-Control-Answer
CDR	Charging Data Record
DL	Downlink
ECGI	E-UTRAN Cell Global Identifier
eNB	Evolved Node B
EPC	Evolved Packet Core
ePDG	Evolved Packet Data Gateway
EPS	Evolved Packet System
E-UTRAN	Evolved Universal Terrestrial Radio Access Network
GPRS	General Packet Radio Service
GTP	GPRS Tunnelling Protocol
GTP'	GPRS protocol, used for CDR transport
HSS	Home Subscriber Server
IMS	IP Multimedia Subsystem
IMSI	International Mobile Subscriber Identity
IP-CAN	IP Connectivity Access Network
LTE	Long Term Evolution
MCC	Mobile Country Code
MME	Mobility Management Entity
MMS	Multimedia Messaging Service
MNC	Mobile Network Code
OFCS	Offline Charging System
PCC	Policy and Charging Control
PCEF	Policy and Charging Enforcement Function
PCRF	Policy and Charging Rule Function
PDN	Packet Data Network
P-GW	Packet Data Network Gateway
PLMN	Public Land Mobile Network
QCI	QoS Class Identifier
SDF	Service Data Flow
S-GW	Serving Gateway
SPR	Subscriber Profile Repository
TAI	Tracking Area Identifier
UE	User Equipment
UL	Uplink
UTC	Coordinated Universal Time

I. Introduction

In the previous PCC document [1], our main focus in discussing PCC rules was on QoS rules. Now, this document puts more focus on charging rules, specifically offline charging rules.

In LTE networks, services are charged at a bearer (e.g. EPC), subsystem (e.g. IMS) or service level (e.g. MMS), either by online or offline [2].

In **online charging**, when a user requests network resources, the network runs an account query and decides whether to grant permission or not before it actually let the user use the requested network resources. In this case, the network resource usage by the user is measured in real time, and thus charging information has a real time effect on service provision. This method is used for prepaid plans.

On the other hand, in **offline charging**, a user is charged for the network resources that he already used. That is, the network reports the resource usage by the particular user by forwarding his CDR (Charging Data Record) to its billing domain. Information on the user's usage is collected on a regular basis, or at the end of each session. Hence charging information does not have a real time effect on service provision.

In general, online charging is used in prepaid plans while offline charging is used in postpaid plans. For example, most mobile users in Korea are postpaid plan holders¹, and thus subject to offline charging policies. Holders with this type of plan use services (e.g. Internet or voice service) first, and their operators charge them later for their usage monthly. Globally, there are more prepaid plan holders than postpaid plan holders. Prepaid plan holders pay in advance and thus their quotas are secured. Once their quotas are exceeded, active service sessions are terminated.

This document will discuss a charging procedure used when applying offline charging policies at a bearer level to a postpaid plan holder using the Internet service.

This document is organized as follows: Chapter II provides an overview of charging-related interfaces and how offline charging works and Chapter III explains the offline charging procedure. Chapter IV summarizes CDR parameters, offline charging parameters.

II. Overview of Offline Charging

Below we will define charging-related interfaces in the LTE reference model presented in our LTE architecture document [3]. Figure 1 illustrates the LTE charging architecture and relevant interfaces.

¹ As of December 2014, the percentages of postpaid plan holders in SK Telecom, KT and LG U+ are 98%, 99% and 98%, respectively (<http://www.itstat.go.kr>).

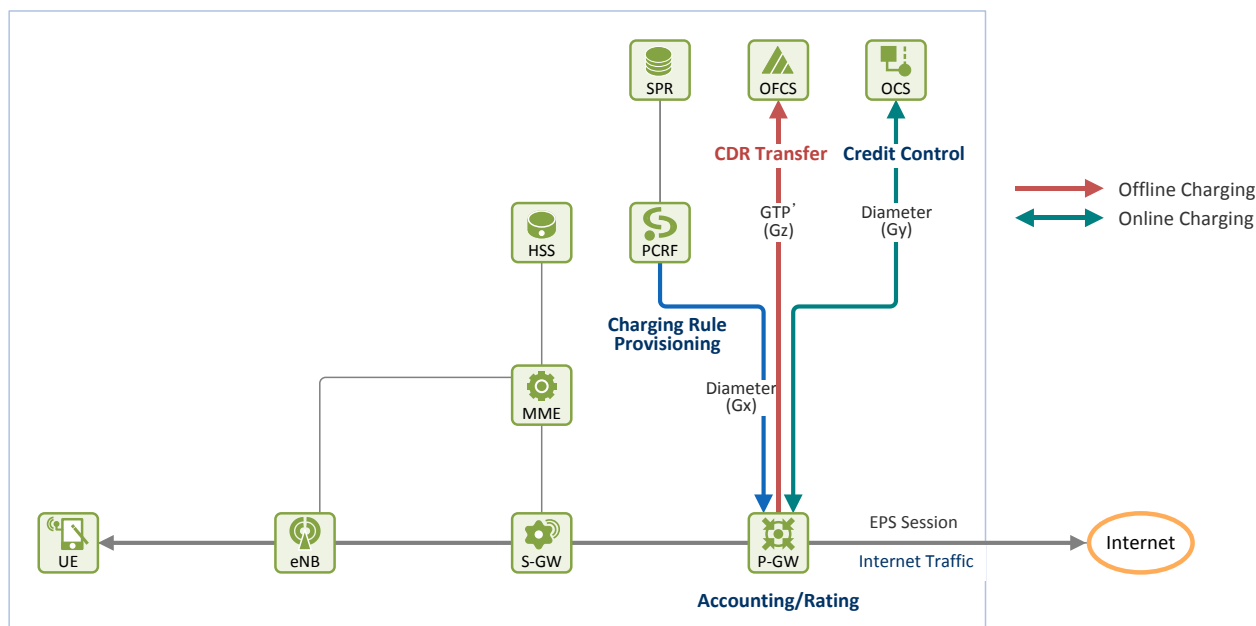


Figure 1. 3GPP LTE Charging Architecture and Relevant Interfaces

- **Policy and Charging Rule Function (PCRF):** When determining PCC rules for a user's SDF, it selects a charging rule to be applied to the SDF (Service Data Flow), and forwards it to Policy and Charging Enforcement Function (PCEF, i.e. P-GW) through Gx interface.
- **P-GW:** It enforces the charging rule forwarded by PCRF to the user's SDF. In offline charging, it generates CDR(s) according to the charging rule and forwards to Offline Charging System (OFCS) through Gz interface. In online charging however it requests and obtains a quota first, and then measures and reports the user's usage by performing credit control with Online Charging System (OCS) through Gy interface.
- **Offline Charging System (OFCS):** Upon receiving the CDRs from P-GW² through Gz interface, it post-processes them as necessary and then forwards to the billing domain³.
- **Online Charging System (OCS):** It allocates a quota to the user by performing credit control with P-GW through Gy interface (e.g. matters like for how long the session will last, how much data the user can deliver, etc. are determined).

This document is about offline charging, and hence Figure 1 shows how PCRF, P-GW and OFCS work for the task. Before we discuss offline charging procedures in details in Chapter III, we will briefly go over how this offline charging system works.

Figure 2 provides an overview of how offline charging works, particularly how a charging rule is delivered [1] and how a CDR is transferred [4].

² In the example presented here, OFCS receives CDRs from P-GW only. However, it may receive them from other nodes (e.g. S-GW, ePDG, etc.) as well.

³ Figure 1 shows EPS domain only. Billing domain is an operator's Business Support System (BSS) domain, and hence is not included in Figure 1.

III. Offline Charging Procedure

Figure 3 is an illustration of offline charging procedure in LTE networks. As the previous documents [1][5] already discussed initial attach in LTE networks [1] and PCC procedure [5], this document will be focusing on charging information processing.

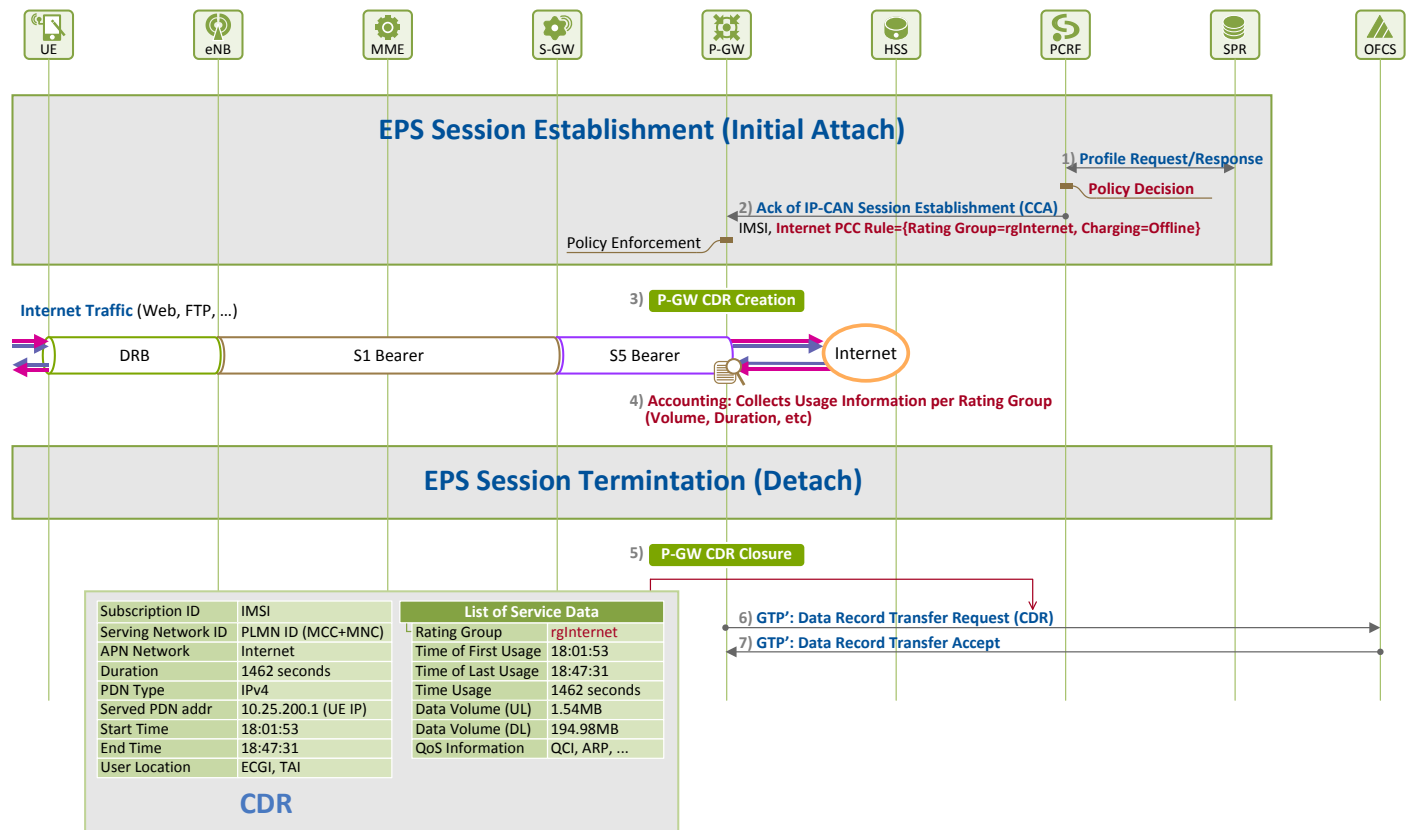


Figure 3. Offline Charging Procedure

1) [PCRF ← SPR] Obtaining User Profile

During a user's initial attach, PCRF requests and obtains the user's subscription profile from SPR, in order to determine a PCC rule.

2) [P-GW ← PCRF] Requesting Session Establishment

PCRF determines a charging rule for the Internet session based on the user subscription profile. It forwards a PCC rule ("Internet") that contains the Internet charging rule (e.g. Rating Group: rgInternet, Charging type: Offline) to P-GW via a **CCA (Credit-Control-Answer)** message.

3) [P-GW] CDR Creation

P-GW creates a default bearer in compliance with the PCC rule, and enforces the charging rule to the bearer. Then, it gets ready to generate charging information by creating a CDR to collect charging information.

4) [P-GW] Generating Charging Information

Once the user starts using the Internet, P-GW records his network resources usage (e.g. volume and duration of packet delivery), and detailed usage information, thereby generating charging information.

5) [P-GW] CDR Closure

P-GW closes the CDR once the EPS session is terminated as a result of user detach⁴.

6) [P-GW → OFCS] CDR Transfer

P-GW delivers the CDR to OFCS by sending a **Data Record Transfer Request (CDR)** message through GTP' protocol. Usage information per rating group, including packet delivery time (i.e. time of first/last usage), number of bytes delivered (i.e. data volume (UL/DL)), etc. is reported.

7) [P-GW ← OFCS] Acknowledging Receipt of CDR

OFCS acknowledges receipt of the CDR by sending P-GW a **Data Record Transfer Accept** message.

OFCS collects CDRs, post-processes as necessary and forwards them to the operator's billing domain. The billing domain then analyzes the received CDRs to obtain statistics needed to determine how much to charge. It then uses the findings to charge the user, or for inter-operator accounting.

IV. Parameters for Charging Data Record (CDR)

Figures 2 and 3 summarize key parameters of a CDR that P-GW forwards to OFCS. In addition to these parameters, a CDR has other various charging parameters as well. Table 1 lists CDR parameters used at bearer level (including generic CDR parameters) [6]. Please note key parameters are shown in blue.

Table 1. CDR Parameters (3GPP TS 32.298)

Parameter Name	Description	Format/Sample
Subscription Identifier	Identifies the charged party.	IMSI
Serving Network Identity	Contains the PLMN ID of the P-GW used during the location request.	MCC+MNC
APN Network/Operator Identifier	Contains the logical name of the access point that is actually connected to an external PDN.	APN
APN Selection Mode	Indicates how MME selected the APN to be used.	
Cause for Record Closing	Indicates a reason for the release of the CDR.	normal release/ abnormal release ...
Charging ID	A charging identifier. Used to identify EPS bearers among all records produced in S-GW and P-GW. Can be used with P-GW address. Generated by P-GW at EPS bearer activation.	
Duration	Indicates the duration of a record (PGW-CDR) at P-GW	e.g.) 3600 sec.
Dynamic Address Flag	Indicates an IP address has been dynamically allocated for the PDN connection.	Static/Dynamic
Event Time Stamps	Contains the event time stamps relevant for each of the individual record types.	DD-HH:MM:SS
IMSI Unauthenticated Flag	Indicates the "Served IMSI" is not authenticated. This flag is used when an emergency bearer is established with an IMSI.	
MS Time Zone	Contains the 'Time Zone' IE provided by MME. It is transferred to S-GW/P-GW during activation/modification of the EPS bearer.	
P-GW Address Used	The serving P-GW IP address for the control plane.	P-GW IP address
P-GW PLMN Identifier	The P-GW PMLN ID (MCC+MNC)	MCC+MNC

⁴ Or at every period specified by charging rule (e.g. every one minute)

Parameter Name	Description	Format/Sample
PDN Connection ID	Used to identify different records belonging to same PDN connection. It includes the charging ID of the first EPS bearer activated within the PDN connection. Together with P-GW address, it uniquely identifies the PDN connection.	
PDN Type	Defines the PDN type.	IPv4, IPv6, IPv4v6
QoS Requested/QoS Negotiated	QoS Requested: QoS requested by UE when EPS bearer is activated QoS Negotiated: applied QoS approved by PCRF	QCI, ARP
RAT Type	Defines the type of RAT used by UE	EUTRAN (6)
Record Opening Time	Indicates the time when EPS bearer is activated at S-GW/P-GW	See TS 32.250
Record Sequence Number	Contains a sequence number used to link the partial records generated in S-GW/P-GW for a particular MM context or EPS bearer.	
Record Type	Record type: e.g. SGW-CDR, PGW-CDR ...	PGW-CDR
S-GW Address Used	The serving S-GW IP address for the control plane.	S-GW IP address
Served IMSI	Indicates the IMSI value of the user.	
Served PDN Address	The IP address assigned to the PDN connection.	UE IP address
Serving Node Address	IP addresses of service nodes (e.g. MME, S-GW)	
Serving Node PLMN Identifier	PLMN IDs (MCC+MNC) of service nodes (e.g. MME, S-GW)	
Serving Node Type	Serving node type(s) in control plane of S-GW or P-GW.	
Start Time	The time when the EPS session starts at S-GW/P-GW. Available in the CDR for the first bearer in an EPS session.	
Stop Time	The time when the EPS session is terminated at S-GW/P-GW. Available in the CDR for the last bearer in an EPS session	
User Location Information	Contains the user location information described in TS 29.274. It is provided by MME and transferred to S-GW/P-GW during activation/modification of EPS bearer.	TAI, ECGI
List of Service Data	Includes one or more service data containers.	
Charging Rule Base Name	Reference to group of PCC rules predefined at the PCEF.	
Data Volume Downlink	Amount of data (in bytes) transmitted in downlink direction.	Bytes
Data Volume Uplink	Amount of data (in bytes) transmitted in uplink direction.	Bytes
Local Sequence Number	Service data container sequence number. It is increased by 1 for each service data container generated within the lifetime of EPS bearer.	
QoS Information	Negotiated QoS applied for EPS bearer.	
Rating Group	ID of Rating group	
Report Time	Time when service data container is closed.	
Service Condition Change	Reason for closing the service data container, e.g. tariff time change, EPS bearer modification (e.g. QoS change, S-GW change, user location change), service usage thresholds, etc.)	
Service Identifier	ID for a service. It is used only when reporting is per combination of the Rating Group and service ID.	
Service Specific Info	Holds service specific data for a pre-defined PCC rule that is used for enhanced packet filtering.	
Serving Node Address	The serving S-GW IP address for the control plane	S-GW IP address
Time of First Usage	Time when the first IP packet is transmitted	UTC Time

Parameter Name	Description	Format/Sample
Time of Last Usage	Time when the last IP packet is transmitted	UTC Time
Time Usage	Time used	Seconds
User Location Information	Information on the location (e.g. cell, tracking area) where UE is located while service data is collected.	TAI, ECGI

V. Closing

We have so far discussed the offline charging procedure during which a user's network resource usages and service usages are reported and collected at specified times (periodically or upon termination of a session). We have also covered charging parameters included in a CDR to be forwarded by P-GW to OFCS. Next time, we will look into online charging [7].

References

- [1] Netmanias Technical Document, "LTE Policy and Charging Control (PCC)", August 2014, <http://www.netmanias.com/en/?m=view&id=techdocs&no=6562>
- [2] 3GPP TS 32.240, "Telecommunication management; Charging management; Charging architecture and principles"
- [3] Netmanias Technical Document, "LTE Network Architecture: Basic", July 2013, <http://www.netmanias.com/en/?m=view&id=techdocs&no=5904>
- [4] 3GPP TS 32.295, "Telecommunication management; Charging management; Charging Data Record (CDR) transfer"
- [5] Netmanias Technical Document, "EMM Procedure 1. Initial Attach - Part 2. Call Flow of Initial Attach", January 2014, <http://www.netmanias.com/en/?m=view&id=techdocs&no=6102>
- [6] 3GPP TS 32.298, "Telecommunication management; Charging management; Charging Data Record (CDR) parameter description"
- [7] Netmanias Technical Document, "LTE Charging: Online", TBD
- [8] NMC Consulting Group Confidential Internal Report, "E2E LTE Network Design", August 2010

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