



Ultra IoT C-SGN Administration Guide, StarOS Release 21.28

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About this Guide



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This preface describes the *Ultra IoT C-SGN Solution Guide*, how it is organized and its document conventions.

This guide describes the Cellular IoT EPS optimizations on Control Plane and Bearer Plane Nodes. The supported features on Control Plane and Bearer Plane Nodes are explained in two parts. See *Part I: CIoT EPS Optimizations on Control Plane Node* and *Part II: CIoT EPS Optimizations on Bearer Plane Nodes*.

- [Conventions Used, on page xiii](#)
- [Supported Documents and Resources, on page xiv](#)
- [Contacting Customer Support, on page xv](#)

Conventions Used

The following tables describe the conventions used throughout this documentation.

Notice Type	Description
Information Note	Provides information about important features or instructions.
Caution	Alerts you of potential damage to a program, device, or system.
Warning	Alerts you of potential personal injury or fatality. May also alert you of potential electrical hazards.

Typeface Conventions	Description
Text represented as a <code>screen display</code>	This typeface represents displays that appear on your terminal screen, for example: <code>Login:</code>
Text represented as commands	This typeface represents commands that you enter, for example: show ip access-list This document always gives the full form of a command in lowercase letters. Commands are not case sensitive.
Text represented as a command <i>variable</i>	This typeface represents a variable that is part of a command, for example: show card <i>slot_number</i> <i>slot_number</i> is a variable representing the applicable chassis slot number.
Text represented as menu or sub-menu names	This typeface represents menus and sub-menus that you access within a software application, for example: Click the File menu, then click New

Supported Documents and Resources

Related Common Documentation

The following common documents are available:

- *AAA Interface Administration and Reference*
- *Command Line Interface Reference*
- *GTPP Interface Administration and Reference*
- *Installation Guide* (platform dependant)
- *Release Change Reference*
- *SNMP MIB Reference*
- *Statistics and Counters Reference*
- *System Administration Guide* (platform dependant)
- *Thresholding Configuration Guide*

Related Product Documentation

The following product documents are also available and work in conjunction with the Ultra IoT C-SGN documentation:

- *MME Administration Guide*
- *P-GW Administration Guide*

- *SAEGW Administration Guide*
- *S-GW Administration Guide*

Obtaining Documentation

The most current Cisco documentation is available on the following website:

<http://www.cisco.com/cisco/web/psa/default.html>

Contacting Customer Support

Use the information in this section to contact customer support.

Refer to the support area of <http://www.cisco.com> for up-to-date product documentation or to submit a service request. A valid username and password are required to access this site. Please contact your Cisco sales or service representative for additional information.



CHAPTER 1

Ultra IoT C-SGN Overview

The Ultra IoT C-SGN (CIoT Serving Gateway Node) is a combined node EPC implementation option that minimizes the number of physical entities by collocating EPS entities in the control plane and user plane paths. C-SGN combines the MME, P-GW and S-GW functions to provide a highly optimized CIoT solution.

The Ultra IoT C-SGN runs on virtualized environments to support Cellular IoT (CIoT) traffic. The CIoT EPS Optimizations in this release provide improved support of small data transfer.

The topics in this chapter include:

- [Overview of IoT, on page 1](#)
- [CIoT EPS Optimizations, on page 5](#)

Overview of IoT

The Internet of Things (IoT) is a computing concept where everyday objects have internet connectivity and they can collect and exchange data. The IoT network comprises of a wide variety of physical devices, vehicles, buildings, and any other devices or objects used in our daily lives. IoT is expected to bring a revolution of tremendous growth opportunities by bringing millions of new set of devices, applications and new set of enablement of protocols/technologies into the network.

The IoT devices use MTC (Machine Type Communication). The key objective is to provide solutions to support high efficient handling of tracking devices using small data transmissions for ultra-low complexity, power constrained, and low data-rate IoT devices, called CIoT devices. The main requirements for IoT devices is EPS optimization for small data transfer.

NarrowBand IoT (NB-IoT) is a narrowband radio technology that is optimized for IoT in 3GPP Release 13. Optimizations on the core network are applicable to both NB-IoT RAT and EUTRAN RAT (for eMTC / LTE-M devices).

CIoT Overview

Cellular Internet of Things (CIoT) technology is an important branch of IoT. The CIoT devices use small data transmissions for ultra-low complexity as they also use low data-rates and have power constraints. While the number of CIoT devices in the network might increase exponentially, the data size per device remains small.

The following enhancements are required to support CIoT devices:

- Minimize system signaling load over the radio interface

- Provide adequate security to the EPS system
- Improve battery life of the devices
- Support delivery of IP data
- Support delivery of non-IP data
- Support of SMS
- Extended coverage
- Low cost

The EPS optimized for CIoT supports different traffic patterns as compared to normal UEs and supports only a sub-set and necessary functionalities as compared with the existing EPS core network, in a single logical entity known as the CIoT Serving Gateway Node (C-SGN). The C-SGN is a new node specified for optimizations that consolidates functions from control plane node (MME) and user plane nodes (S-GW, P-GW, and SAE-GW).

The C-SGN is a combined node EPC implementation option that minimizes the number of physical entities by collocating EPS entities in the control plane and user plane paths in CIoT deployments.

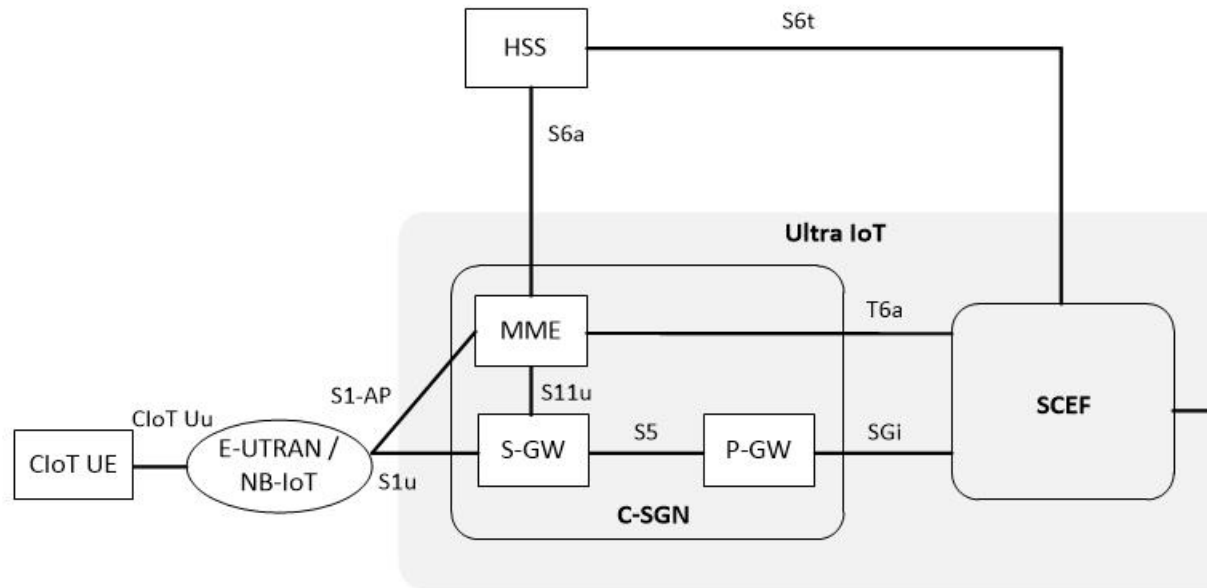
Cisco Service Capability Exposure Function (SCEF) is a key entity within the 3GPP architecture and enables the 3GPP network to securely expose its services and capabilities to third party service provider applications. SCEF leverages the 3-tier Cisco Policy Suite (CPS) architecture. The C-SGN interacts with the SCEF via the Diameter T6a interface to support non-IP data delivery (NIDD).



Important Cisco SCEF runs on the CPS platform and is available for trial purposes only. Contact your Cisco account representative for more information.

The following figure illustrates the architecture of Ultra IoT C-SGN.

Figure 1: Ultra IoT C-SGN Architecture



Supported Interfaces

C-SGN supports the following interfaces required for CIoT:

- **S11-U:** The S11-U interface is introduced as a part of the Control Plane CIoT EPS optimization for small data transmission between the MME and S-GW. It is based on the existing GTP-U architecture. It is a GTPv1 user plane interface and carries small data sent and received over NAS between the MME and S-GW.
- **SGi:** The SGi interface is introduced between the P-GW and packet data network (PDN). The PDN can be an operator's external public or private packet data network or an intra-operator packet data network.
- **T6a:** The Diameter T6a interface connects the SCEF to the serving MME and supports the following functionality:
 - Non IP PDN connection establishment
 - MO Non IP data
 - MT Non IP data
 - Monitoring Event configuration at MME
 - Monitoring Event configuration by MME to SCEF

Platform Requirements

The Ultra IoT C-SGN runs on VPC-DI, VPC-SI and UGP platforms. For additional information, refer to the *VPC-DI System Administration Guide* and/or contact your Cisco account representative.

Licensing Requirements

The CIoT EPS Optimization features on the Control Plane and Bearer Plane nodes require specific license(s). Contact your Cisco account representative for more information on how to obtain a license.

Standards Compliance

The Ultra IoT C-SGN solution complies with the following standards:

- 3GPP TS 23.007 V12.8.0: Technical Specification Group Core Network and Terminals Restoration procedures.
- 3GPP TS 23.041 V10.6.0: Technical realization of Cell Broadcast Service (CBS)
- 3GPP TS 23.216 V12.2.0: 3rd Generation Partnership Project Technical Specification Group Services and System Aspects Single Radio Voice Call Continuity (SRVCC) Stage 2
- 3GPP TS 23.272 V12.5.0: 3rd Generation Partnership Project Technical Specification Group Services and System Aspects Circuit Switched (CS) fallback in Evolved Packet System (EPS) Stage 2
- 3GPP TS 23.401 V12.8.0: General Packet Radio Service (GPRS) enhancements for Evolved Universal Terrestrial Radio Access Network (E-UTRAN) access
- 3GPP TS 23.682 V13.8.0: Architecture enhancements to facilitate communications with packet data networks and applications
- 3GPP TS 23.842 V11.0.0: 3rd Generation Partnership Project Technical Specification Group Services and System Aspects Study on Network Provided Location Information to the IMS
- 3GPP TS 24.008 V13.6.0 (2016-06): Mobile radio interface Layer 3 specification; Core network protocols; Stage 3
- 3GPP TS 24.008 V13.9.0 (2017-03): Mobile radio interface Layer 3 specification; Core network protocols; Stage 3
- 3GPP TS 24.080, V12.8.0: Mobile radio interface layer 3 supplementary services specification Formats and coding
- 3GPP TS 24.301 V12.8.0: 3rd Generation Partnership Project Technical Specification Group Core Network and Terminals Non-Access-Stratum (NAS) protocol for Evolved Packet System (EPS) Stage 3
- 3GPP TS 29.118 V10.9.0: 3rd Generation Partnership Project Technical Specification Group Core Network and Terminals Mobility Management Entity (MME) - Visitor Location Register (VLR) SGs interface specification
- 3GPP TS 29.128 V13.3.0: Mobility Management Entity (MME) and Serving GPRS Support Node (SGSN) interfaces for interworking with packet data networks and applications
- 3GPP TS 29.168 V12.8.0: Cell Broadcast Centre Interfaces with the Evolved Packet Core
- 3GPP TS 29.171 V10.4.0: 3rd Generation Partnership Project Technical Specification Group Core Network and Terminals Location Services (LCS) LCS Application Protocol (LCS-AP) between the Mobile Management Entity (MME) and Evolved Serving Mobile Location Centre (E-SMLC) SLs interface
- 3GPP TS 29.172 V12.5.0 : 3rd Generation Partnership Project Technical Specification Group Core Network and Terminals Location Services (LCS) Evolved Packet Core (EPC) LCS Protocol (ELP)

between the Gateway Mobile Location Centre (GMLC) and the Mobile Management Entity (MME) S1-M interface

- 3GPP TS 29.272 V12.7.0: 3rd Generation Partnership Project Technical Specification Group Core Network and Terminals 3GPP Evolved Packet System (EPS) Mobility Management Entity (MME) and Serving GPRS Support Node (SGSN) related interfaces based on Diameter protocol
- 3GPP TS 29.274 V12.8.0: 3rd Generation Partnership Project Technical Specification Group Core Network and Terminals 3GPP Evolved Packet System (EPS) Evolved General Packet Radio Service (GPRS) Tunneling Protocol for Control plane (GTPv2-C) Stage 3
- 3GPP TS 29.277 V12.0.0: 3rd Generation Partnership Project Technical Specification Group Core Network and Terminals Optimised Handover Procedures and Protocol between EUTRAN access and non-3GPP accesses (S102) Stage 3
- 3GPP TS 29.280 V10.4.0 (2012-06): 3rd Generation Partnership Project Technical Specification Group Core Network and Terminals 3GPP Evolved Packet System (EPS) 3GPP Sv interface (MME to MSC, and SGSN to MSC) for SRVCC
- 3GPP TS 29.305 V12.4.0: 3rd Generation Partnership Project Technical Specification Group Core Network and Terminals InterWorking Function (IWF) between MAP based and Diameter based interfaces
- 3GPP TS 32.422 V12.4.0: 3rd Generation Partnership Project Technical Specification Group Services and System Aspects Telecommunication management Subscriber and equipment trace Trace control and configuration management
- 3GPP TS 32.423 V12.1.0: 3rd Generation Partnership Project Technical Specification Group Services and System Aspects Telecommunication management Subscriber and equipment trace: Trace data definition and management
- 3GPP TS 36.304 V13.5.0 (2017-03): Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) procedures in idle mode
- 3GPP TS 36.413 V11.6.0: 3rd Generation Partnership Project Technical Specification Group Radio Access Network Evolved Universal Terrestrial Radio Access Network (E-UTRAN) S1 Application Protocol (S1AP)
- 3GPP TS 36.304 V13.5.0 (2017-03): Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) procedures in idle mode

CIoT EPS Optimizations

Cellular IoT EPS Optimizations provide improved support of small data transfer. In order to send data to an application, CIoT supports two methods of optimizations in the evolved packet system (EPS):

- Control Plane CIoT EPS Optimization – This is a method for transferring encapsulated user data in Control Plane signaling messages in the form of a Non-access Stratum Protocol Data Unit (NAS-PDU).
- User Plane CIoT EPS Optimization – This is a method based on User Plane transport of user data. Data is transferred over the conventional user plane through the network, that is, the eNB forwards the data to the S-GW or receives it.

Support for NB-IOT Access Type

In order to support Low Power Wider Area (LPWA) access, 3GPP has defined Narrowband access technology that operates over the 128 KHz spectrum. C-SGN supports the NB-IoT Access types. This new technology provides improved indoor coverage, support of massive number of low throughput devices, low delay sensitivity,

ultra-low device cost, low device power consumption and optimized network architecture. NB-IoT is optimized for machine type traffic.

In addition to the NB-IoT Access type, 3GPP has also defined a set of low complexity devices that use Wideband LTE access. The C-IoT optimization features are applicable to Low Complexity Wideband LTE devices and NB-IoT devices.

The optimizations can be used:

- Separately if the UE or the network supports one of them
- In parallel if the UE and the network supports both

If the UE supports both optimizations, the PDN connections that only use the Control Plane C-IoT EPS Optimization (for example, the MME that has Control Plane Only Indicator in ESM request) will only be handled by the Control Plane C-IoT EPS optimization. All other PDN connections are handled using Control Plane or User Plane C-IoT EPS optimizations.

The Control Plane C-IoT optimization can be used to support PDN connections to an SCEF while regular S1-U data transfer is used independently to support PDN connections to P-GW. All the S-Gi PDN connections of a UE will use S11-U or S1-U at any point in time. Support for the S-Gi based delivery of Non-IP data can also be used by any UE. That is, it is independent of support for the User Plane C-IoT EPS Optimization and the Control Plane C-IoT EPS Optimization.

CloT EPS Optimizations on Control Plane Node

The C-IoT EPS optimization on the control plane node transports user data or SMS messages via MME by encapsulating the user data in NAS PDUs. Since no data plane setup is required when sending data to MME via NAS messaging, using CP C-IoT optimization results in reducing the total number of control plane messages when handling a short data transaction.

The optimizations supported in this release include:

- UE Attach without PDN connection

The MME provides enhanced support to allow "Attach without PDN connectivity" for IoT devices. The UE can be registered with the EPS network without activating a PDN connection and the device can now exchange SMS data using Control Plane optimization.

- Support for small data transfer

MME supports small data transmission over NAS, S11-U and S-Gi interfaces as part of the C-IoT EPS optimization.

- Data over NAS - This mechanism is designed for efficient small data transfer in 3GPP systems by using signaling plane for small data transfer. Data transferred over NAS can be IP or non-IP. Small data transfer is further optimized using non-IP Data delivery (NIDD). Uplink data is transferred from the eNodeB to MME and data may be transferred via the S-GW/P-GW (S-Gi) or to the SCEF. Downlink data is also transmitted over the same paths in the reverse direction.
- IP and non-IP Data Delivery over S-Gi - Small data delivery via S-Gi is supported for both IP and non-IP PDN. The S-GW/P-GW nodes are used for data transfer. Uplink data is transferred from the eNodeB to MME and data is transferred to the S-GW and P-GW. Downlink data is also transmitted over the same paths in the reverse direction.
- Non-IP Data Delivery over SCEF - The SCEF is a new node for machine type data communication and supports delivery of non-IP data over Control Plane. Non-IP small data transfer over SCEF

works for the existing EPC architecture with the addition of T6a interface that terminates between the MME and SCEF.

- eDRX Support

The Extended Discontinuous Reception (eDRX) feature allows IoT devices to remain inactive for longer periods. This feature allows the device to connect to a network on a need basis – the device can remain inactive or in sleep mode for minutes, hours or even days, thus increasing the battery life of the device.

- Power Saving Mode in UE

Power Saving Mode (PSM) was introduced in 3GPP Release 12, to improve device battery life of IoT devices. The most significant benefit of this feature is the UE has more control in terms of power management required for its application. The timers of all the devices can be managed using PSM, and the wake-up periods can be adjusted to be offset as much as possible. The PSM mode is similar to power-off but the UE remains registered on the network. The UE activates PSM by including two timer values in the Attach or Tracking Area Update (TAU). The first timer is the T3324, which defines the time the UE stays active after idle mode following the Attach or TAU procedure. The second timer is an extended T3412 which defines the extended time for an UE to send periodic TAU.

- Paging Optimizations for coverage

MME supports new S1AP information elements (IEs) to and from eNodeB (eNB) required for paging optimizations in existing S1AP messages.

- Paging for Enhanced Coverage on MME - For the EPC and E-UTRAN to optimize usage of network resources, the eNB sends paging assistance IEs as part of the UE Context Release procedure and the MME sends back this information during Paging procedure to eNB. "Information on Recommended Cells and eNBs for Paging" and "Cell Identifier and Coverage Enhancement Level" IEs are included by eNB in the UE Context Release Complete message to MME. MME stores these IEs received from eNB and uses it for subsequent Paging by including "Assistance Data for Paging" IE in Paging requests to eNB.
- UE Radio Capability for Paging IE Support - The existing S1AP procedure is used to enable the eNB to provide UE capability related information to MME. This message will also include Paging specific UE capability information within the "UE Radio Capability for Paging IE". MME stores "UE Radio Capability for Paging IE" received from eNB and sends in Paging request message to eNB. If the UE Radio Capability for Paging IE is included in the Paging request message, the eNB uses it to apply specific Paging schemes.

Refer to the respective feature chapters described in *Part I: CIoT EPS Optimizations on Control Plane Node* for detailed information.

CIoT EPS Optimizations on Bearer Plane Nodes

The CIoT EPS optimizations on the bearer plane nodes is based on User Plane transport of user data. Data is transferred over the conventional user plane through the network, that is, the eNodeB forwards the data to the S-GW or receives it.

The optimizations supported in this release include:

- Data over S11-U Support

This feature provides control plane CIoT optimization support by establishing S11-U PDN connection with the S11-U interface between the MME and S-GW.

- eDRX and PSM Support

The Extended Discontinuous Reception (eDRX) feature allows IoT devices to remain inactive for longer periods. This feature allows the device to connect to a network on a need basis - the device can remain inactive or in sleep mode for minutes, hours or even days, thus increasing the battery life of the device. Extended DRX cycles provide UEs longer inactive periods between reading, paging or controlling channels.

Power Saving Mode (PSM) was introduced in 3GPP Release 12, to improve device battery life of IoT devices. The most significant benefit of this feature is the UE has more control in terms of power management required for its application. There are a wide range of IoT applications where flexibility of the UE to manage its power is very important also implementation of PSM can prevent network congestion. The timers of all the devices can be managed using PSM, and the wake-up periods can be adjusted to be offset as much as possible. The PSM mode is similar to power-off but the UE remains registered on the network.

- HLCOM UE Support

High latency communication (HLCOM) includes invoking extended buffering of MT data at the S-GW when the UE is in power saving mode and not reachable. The handling is specified in the Network Triggered Service Request procedures and buffered data are delivered to the UE on establishing user plane for data delivery. Extended buffering of downlink data in the S-GW is controlled by the MME/S4-SGSN or the Gn/Gp-SGSN.

- Non-IP PDN Support

A non-IP PDN connection is supported to allow specific protocols to be used by the CIoT UE towards the non-IP protocols destination node, for example, the application server(s) or a non-IP gateway. The C-SGN/P-GW acts as a transparent passthrough via a direct forwarding interface between itself and the application server/non-IP gateway. The CIoT UE interacts with the specific non-IP destination node directly using appropriate protocols.

Refer to the respective feature chapters described in *Part II: CIoT EPS Optimizations for Bearer Plane Nodes* for detailed information.



PART I

CloT EPS Optimizations on Control Plane Node

- [eDRX Support on the MME, on page 11](#)
- [NB-IoT and Low Power Session Counters, on page 33](#)
- [NB-IoT RAT and Attach Without PDN Connectivity Support, on page 35](#)
- [Non-IP Data Over SCEF, on page 51](#)
- [Paging Enhancements on MME , on page 77](#)
- [Power Saving Mode \(PSM\) in UEs , on page 81](#)
- [Small Data over NAS, S11-U and SGi Interfaces, on page 91](#)



CHAPTER 2

eDRX Support on the MME

This feature describes the Extended Discontinuous Reception (eDRX) support on the MME in the following sections:

- [Feature Summary and Revision History, on page 11](#)
- [Feature Description, on page 12](#)
- [How eDRX Works, on page 13](#)
- [Configuring eDRX on the MME, on page 16](#)
- [Configuring NB-IoT in UE Context, on page 22](#)
- [Monitoring and Troubleshooting eDRX, on page 22](#)

Feature Summary and Revision History

Summary Data

Applicable Products or Functional Area	<ul style="list-style-type: none">• C-SGN• MME
Applicable Platforms	<ul style="list-style-type: none">• ASR 5500• UGP• VPC-DI• VPC-SI
Feature Default	Disabled - Configuration Required Enabled - Configuration Required (eDRX GPS time support in 21.4)
Related Changes in This Release	Not applicable

Related Documentation	<ul style="list-style-type: none"> • <i>Command Line Interface Reference</i> • <i>Statistics and Counters Reference</i> • <i>MME Administration Guide</i> • <i>Ultra IoT C-SGN Administration Guide</i>
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Revision History

Revision Details	Release
MME is enhanced to detach the UE on deletion of the last PDN associated with the NB-IoT.	21.27
Support is added for Delete Subscriber Data Request (DSR) flag bits 28 and 30 Paging Time Window (PTW) subscription withdrawal with eDRX.	21.26
Paging eDRX H-SFN changed to 10 bits counter.	21.11.3
The eDRX feature is enhanced to support H-SFN Start time configuration in GPS format and H-SFN Reference time in GPS and UTC format. The edrx command in the MME Service Configuration mode is enhanced in this release. Refer to the <i>Configuring Hyper SFN Synchronization</i> section for more information. The feature default for this enhancement is "Enabled - Configuration Required".	21.4
The feature is tested and qualified on the ASR 5500 platform.	21.3
The enhancements in the N5.1 release include: <ul style="list-style-type: none"> • MME supports configuration of the T3415 paging timeout value. MME uses the T3415 timer for eDRX UEs. • The edrx CLI command is enhanced to support DL Buffering Suggested Packet Count in DDN ACK when unable to page UE. • Support of the DL-Buffering-Suggested-Packet-Count AVP 	N5.1 (21.1.V0)
First introduced.	21.0

Feature Description

The Extended Discontinuous Reception (eDRX) feature allows IoT devices to remain inactive for longer periods. This feature allows the device to connect to a network on a need basis – the device can remain inactive or in sleep mode for minutes, hours, or even days, thus increasing the battery life of the device.

Extended DRX cycles provide UEs longer inactive periods between reading, paging, or controlling channels.



Important The Extended DRX feature is license controlled. Contact your Cisco Account or Support representative for information on how to obtain a license.



Important With release 21.11.3 Paging eDRX H-SFN changed to 10 bits counter to allow values between 0 to 1023 as per 3GPP TS 36.331 V13.13.0.

The primary advantage is that without eDRX support, the MME will page the UE unconditionally. When eDRX is enabled, the MME pages the UE only at valid paging occasions and the MME sends the eDRX paging parameters to eNodeB during paging.

DSR flag and PTW Subscription Withdrawal on eDRX

The MME is enhanced to support Delete Subscriber Data Request (DSR) flags bits 28 and 30, and Paging Time Window (PTW) subscription withdrawal with eDRX. This feature supports on the eDRX related Radio Access Technology (RAT) AVP in the DSDR message. This feature is beneficial to the Session Manager (SessMgr) running the MME application stack.

Enforcing Detach on Last PDN Deactivation

MME is enhanced to detach the UE on deletion of the last PDN associated with the NB-IoT access type. The enhancement supports a deviation from the 3GPP standards in this respect.

This scenario is applicable only when Attach without PDN Connectivity is enabled for the user.

How eDRX Works

In order to use the eDRX feature, the UE requests the eDRX parameters during ATTACH and TAU procedures. Based on the configuration, the MME may accept or reject the UE’s request to enable the eDRX feature. If the MME accepts the eDRX request, different values of the eDRX parameters are provided based on operator policies, apart from the parameters requested by the UE.

The operator can configure the eDRX parameters Paging Time Window (PTW) and eDRX cycle length duration in the Call Control Profile Configuration mode. The UE requested values of PTW and eDRX cycle is received in the Attach or TAU request. The H-SFN start time and H-SFN reference time for leap second adjustment can also be configured. MME calculates the paging occasion for the UE using the values of H-SFN start time, H-SFN reference time, PTW, and eDRX cycle length. The UE is paged only at the paging occasion until the PTW expires. The MME rejects all other paging requirements which occur in between the paging occasion.

The downlink buffer duration in DDN ACK can be configured when the MME cannot page the UE. This is an optional configuration. For Downlink Data Notifications (DDN), if the UE is not in a paging occasion, the MME does not page the UE. The MME sends a Downlink Data Notification Reject message to the S-GW along with the DL buffering duration and DL suggested packet count IEs as per the operator configuration. The packet count in DDN ACK can be configured to configure the packet count value. The MME starts a timer to page at the next paging occasion. If downlink buffer duration is not configured, the MME rejects the DDN without these IEs. If the packet count value is not configured locally, the subscription provided value is used. The subscription value can be "0" in which case the packet count IE will not be sent for that subscriber even if it is configured locally.

If the UE is not in a paging occasion, the MME rejects the paging request for dedicated bearer creation request and sends bearer reject to the S-GW with the cause "UE is temporarily not reachable due to power saving". The MME starts a timer to page at the next paging occasion. If the UE is not in a paging occasion during MME-initiated detach where the MME needs to page the UE to send a detach request, the MME does not page the UE and performs an implicit detach.

The following new flags are introduced as part of this feature. These flags are supported in GTPCv2 Indication IE:

- Pending Network Initiated PDN Connection Signaling Indication (PNSI): The source MME supports sending of PNSI flag in GTPCv2 Indication IE of Context response.
- UE Available for Signaling Indication (UASI): The MME supports sending of the UASI flag in GTPCv2 Indication IE of Create Session Request and Modify Bearer Request to indicate to the P-GW that the UE is available for end-to-end signaling.
- Delay Tolerant Connection Indication (DTCI): The MME supports receiving the DTCI flag in Create Session Response from the S-GW. The MME supports receiving of the DTCI flag in Context Response and Forward Relocation Request from peer MME or S4-SGSN.

The MME rejects CBR/UBR when PPF is False. The cause "UE is temporarily not reachable due to power saving" is sent in the response by the MME if the corresponding PDN was marked "Delay tolerant" by P-GW.

DSR flag and PTW Subscription Withdrawal on eDRX

If MME receives the eDRX-Related-RAT AVP (1705) with the DSR flag set for eDRX withdrawal, the MME compares the RAT type of the subscriber session with the received RAT type in eDRX-Related-RAT AVP. If it matches, then the MME resets the eDRX information to the values negotiated in the Attach Request.

Table 1: Procedure

Step	Message Type	Description
1	Create Session Request	The MME includes Origination Time Stamp and Maximum Wait time on S11 interface. When present, the Origination Time Stamp contain the Universal Time Code (UTC) time when the originating entity initiated the request, and the Maximum Wait Time will contain the duration (number of milliseconds since the Origination Time Stamp) during which the originator of the request waits for a response. If S-GW receives IEs from the MME, then the S-GW includes these IEs on the S5 or S8 interface.
2	Credit Control Request-Initial Request	The IEs received in P-GW sends messages to PCRF through Gx interface. This gets included only in the initial request of CCR.
3	Authentication Authorization Request	The IEs received in P-GW sends messages AAA through s6b interface.

eDRX Parameters

A Hyper-SFN (H-SFN) frame structure is defined for regular idle mode DRX. Each H-SFN value corresponds to a legacy SFN cycle comprised of 1024 radio frames (10.24 seconds). For WB-E-UTRAN, the extended idle mode DRX value range consists of values starting from 5.12seconds (for example, 5.12, 10.24, 20.48 seconds and so on) up to a maximum of 2621.44 seconds (almost 44 minutes). For NB-IoT, the extended idle mode DRX value range starts from 20.48seconds (for example, 20.48, 40.96, 81.92 seconds and so on) up to

a maximum of 10485.76 seconds (almost 3 hours). When eDRX is enabled for a UE, the UE is reachable for paging in specific Paging Hyperframes (PH), which is a specific set of H-SFN values. The PH computation is a formula that is function of the eDRX cycle, and a UE specific identifier. This value can be computed at all UEs and MMEs without need for signalling. The MME includes the extended idle mode DRX cycle length in paging message to assist the eNodeB in paging the UE.

The MME also assigns a Paging Time Window length, and provides this value to the UE during attach/TAU procedures together with the extended idle mode DRX cycle length. The UE first paging occasion is within the Paging Hyperframe. The UE is assumed reachable for paging for an additional Paging Time Window length after first paging occasion. After the Paging Time Window length, the MME considers the UE unreachable for paging until the next Paging Hyperframe.

Loose Hyper SFN Synchronization

In order for the UE to be paged at the same time, the H-SFN of all eNodeBs and MMEs must be loosely synchronized. Each eNodeB and MME synchronizes the H-SFN counter so that the start of H-SFN=0 coincides with a pre-configured time. It is assumed that eNodeBs and MMEs are able to use the same H-SFN value with accuracy in the order of legacy DRX cycle lengths, for example 1 to 2 seconds. Synchronization is not required at SFN level and signaling between network nodes is not required to achieve loose H-SFN synchronization.

Paging and Paging Retransmission Strategy

When the MME receives trigger for paging and the UE is reachable for paging, the MME sends the paging request. If the UE is not reachable for paging, then the MME pages the UE just before the next paging occasion. The MME determines the Paging Time Window length based on paging retransmission strategy, and uses it to execute the retransmission scheme.

The MME uses the T3413 timer for non-eDRX UEs to re-transmit paging. For eDRX UEs the MME uses the T3415 timer and on expiry of T3415 timer, the network aborts the paging procedure.

If a session recovery occurs then the eDRX timer re-starts only for the remaining time of the total time configured before session recovery. This is to ensure that the UE and MME are in sync with respect to the paging occasion.

Limitations and Restrictions

The following are the limitations for eDRX Support for the MME feature:

- eDRX feature is compatible only with IoT devices. It is not available for all Mobile Stations (MS). For example, only those MSs and their respective Base Service Stations (BSS) that have the extended coverage parameters are supported by the SGSN.
- 'eDRX withdrawal through HSS' feature to withdraw HSS provided eDRX parameters through Delete Subscriber Data Request (DSR) flag bits 28 (Paging Time Window Subscription Withdrawal) and 30 (eDRX-Cycle-Length Withdrawal) <3GPP rel 15 TS 29.272> is currently supported for NB-IoT subscribers.
- The **show mme-service session** CLI command is enhanced to print the current EDRX parameters PTW and EDRX-Cycle-Length values for only NB-IoT subscribers.
- As part of HSFN synchronization, if eNodeBs and MMEs use different epochs, (for example, due to the use of different time references), the GPS time should be set as the baseline. This is currently not supported.

- If the network starts timer T3415, the network shall set timer T3415 to a value smaller than the value of timer T3-RESPONSE. This is currently not supported.

Standards Compliance

The eDRX feature complies with the following standards:

- 3GPP TS 23.682 version 13.4.0, Architecture enhancements to facilitate communications with packet data networks and applications (Release 13)
- 3GPP TS 24.302 version 13.5.0, Non-Access-Stratum (NAS) protocol for Evolved Packet System (EPS); Stage 3 (Release 13)
- 3GPP TS 23.401 version 13.5.0, General Packet Radio Service (GPRS) enhancements for Evolved Universal Terrestrial Radio Access Network (E-UTRAN) access.
- 3GPP TS 29.274 version 13.5.0, 3GPP Evolved Packet System (EPS); Evolved General Packet Radio Service (GPRS) Tunneling Protocol for Control plane (GTPv2-C); Stage 3
- 3GPP TS 36.304 version 13.3.0, Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) procedures in idle mode
- 3GPP TS 36.300 version 13.2.0, Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Overall description; Stage 2
- 3GPP TS 36.413 version 13.1.0, Evolved Universal Terrestrial Radio Access Network (E-UTRAN); S1 Application Protocol (S1AP)
- 3GPP TS 24.008 version 13.5.0, Mobile radio interface Layer 3 specification; Core network protocols; Stage 3

Configuring eDRX on the MME

Enabling eDRX on MME

Use the following configuration to enable the eDRX feature on the MME in the Call Control Profile Configuration mode. The configuration provides options to configure:

- Accept eDRX parameters: Paging Time Window (PTW) and eDRX cycle length value, from the UE
- PTW and eDRX cycle length value
- Downlink buffer duration in DDN ACK when unable to page UE
- "DL Buffering Suggested Packet Count" in DDN ACK when unable to page UE

```
configure
  call-control-profile profile_name
    edrx { ptw ptw_value edrx-cycle cycle_length_value | ue-requested } [
  dl-buf-duration [ packet-count packet_count_value ] ]
    remove { edrx | nb-iot edrx }
  end
```


Notes:

- The **remove** keyword disables the eDRX configuration on the MME.
- The **edrx** keyword configures extended discontinuous reception parameters.
- The **ue-requested** keyword specifies the accepted UE requested values of the of the Paging Time Window (PTW) and the eDRX cycle length received from the UE in the Attach Request/TAU Request message be accepted.
- The **ptw** *ptw_value* keyword configures the PTW value.
 In releases prior to 21.2: *ptw_value* is an integer ranging from 0 to 20.
 In 21.2 and later releases: *ptw_value* is an integer ranging from 0 to 15. The values 0 to 15 are mapped to 2.56, 5.12, 7.68, 10.24, 12.80, 15.36, 17.92, 20.48, 23.04, 25.60, 28.16, 30.72, 33.28, 35.84, 38.40 and 40.96 seconds.
- The **edrx-cycle** keyword configures the eDRX cycle length. The *cycle_length_value* is an integer value in seconds from 5.12 to 2621.44. It is a multiple of 2 starting from 5.12 up to 2621.44 seconds (for example: 5.12, 10.24, 20.48, and so on).
- The **dl-buf-duration** keyword sends Downlink Buffer Duration data in the DDN ACK message when MME is unable to page the UE.
- The **packet-count** keyword sends "DL Buffering Suggested Packet Count" in DDN ACK when the UE cannot be paged. The *packet_count_value* is an integer from 0 to 65535. If the *packet_count_value* is not configured locally, the subscription provided value for the *packet_count_value* is used. The subscription value can be 0 in which case the packet count IE will not be sent for that subscriber even if it is configured locally.
- This command is disabled by default.

Verifying eDRX on the MME

Execute the following command to verify the configured values.

show call-control-profile full name *profile_name*

```
Extended DRX:
  Paging Time Window           : 10 Seconds
  eDRX Cycle Length           : 512 Seconds
  Downlink Buffer Duration in DDN Ack : Enabled
  DL Buffering Suggested Packet count in DDN Ack : 10
```

Configuring Hyper SFN Synchronization

This section describes the Hyper-SFN Synchronization start time and reference time configuration.

Configuring Hyper-SFN Synchronization Start Time

Use the following configuration to configure the Hyper-SFN Synchronization start time in GPS or UTC format.

```
configure
  context context_name
    mme-service service_name
```

```
edrx hsfn-start start_time [ gps | utc ]
no edrx hsfn-start
end
```

Notes:

- The **no** option disables the H-SFN synchronization time configuration.
- *start_time*: Specifies the time at which H-SFN=0 starts, entered in GPS or UTC time format. The UTC time format is **YYYY:MM:DD:hh:mm:ss**.
- **gps | utc**:
 - **gps**: Specifies the time at which H-SFN=0 starts in GPS format. GPS time starts from 1980:01:06:00:00:00.
For example: **edrx hsfn-start 2000:03:01:12:34:56 gps**
 - **utc**: Specifies the time at which H-SFN=0 starts in UTC format. UTC time starts from 1972:06:30:00:00:00.
For example: **edrx hsfn-start 2000:03:01:12:34:56 utc**
- The **gps** and **utc** keywords are optional. If not explicitly provided, then H-SFN=0 starts in UTC format.
- After the HSFN-start configuration, the HSFN-reference can be configured to adjust the leap seconds.

Configuring Hyper-SFN Synchronization Reference Time

Use the following configuration to configure the Hyper-SFN Synchronization reference time for leap second adjustment.

```
configure
context context_name
mme-service service_name
edrx hsfn-reference ref_time adjust leap_seconds
no edrx hsfn-reference
end
```

Notes:

- *ref_time*: Specifies the reference time in UTC format as **YYYY:MM:DD:hh:mm:ss**.
- **adjust leap_seconds**: Specifies the number of leap seconds that need to be adjusted. *leap_seconds* must be an integer from 0 to 100.
 - A maximum of 2 H-SFN reference time configuration is allowed. The first configuration will be the latest leap-second adjustment UTC time and the second configuration will be the next or declared leap-second adjustment UTC time.

For example:

Consider the following H-SFN reference time configuration:

```
edrx hsfn-reference 2017:01:01:00:00:00 adjust 5
```

When the next leap second adjustment is announced with new time **2018:01:01:00:00:00**, MME can be configured any time before 2018:01:01 with the following configuration.

```
edrx hsfn-reference 2018:01:01:00:00:00 adjust 6
```

When another leap second adjustment is announced with another new time **2018:06:30:00:00:00**, MME can be configured any time before 2018:06:30 with the following configuration, and deletes the oldest time reference (2017:01:01) configuration.

```
no edrx hsfm-reference 2017:01:01:00:00:00
edrx hsfm-reference 2018:06:30:00:00:00 adjust 7
```

- For HSFN-Start in GPS format, the number of leap seconds must be provided from 1980:1:06. For example: at 2017:01:01:00:00:00, the number of leap seconds from 1980:1:06 are 18.
- For HSFN-Start in UTC format, the number of leap seconds must be provided from the HSFN-Start time. For example: at 2000:03:01:12:34:5, the number of leap seconds from 2000:03:01:12 are 5.
- The **no** option disables the H-SFN reference time configuration.
- The **edrx hsfm-reference** command is disabled by default.

Understanding Lead Seconds Adjustments

A second (leap second) is added to our clocks to synchronize them with the Earth's slowing rotation.

The International Earth Rotation and Reference Systems Service (IERS) is responsible for monitoring the Earth's rotation and deciding when to insert a leap second.

Leap seconds are added from time to time to ensure that our clocks reflect the Earth's rotation speed as accurately as possible. The speed at which our planet rotates around its axis fluctuates daily and it slows down slightly when measured over a long period (although for shorter periods it may speed up).

By adding an extra second to the time count allows clocks to stop for that second to give Earth the opportunity to catch up.

How it Works

The Coordinated Universal Time (UTC) is the world's time standard, and each time zone is defined by some hours or minutes ahead or behind UTC.

At its core, UTC follows International Atomic Time (TAI). This time scale combines the output of some 200 highly precise atomic clocks that are maintained in laboratories around the world.

UTC was already 10 seconds behind TAI before the first leap second was added in 1972. Since then, the Earth has slowed down an extra 27 seconds, and a total of 27 leap seconds have been added. This means that UTC is currently 37 seconds behind TAI. For more information see, the *Past Leap Seconds* table.

Table 2: Past Leap seconds

UTC Date	UTC Time	Difference TAI vs. UTC
30/06/1972	23:59:60	11 secs
31/12/1972	23:59:60	12 secs
31/12/1973	23:59:60	13 secs
31/12/1974	23:59:60	14 secs
31/12/1975	23:59:60	15 secs

UTC Date	UTC Time	Difference TAI vs. UTC
31/12/1976	23:59:60	16 secs
31/12/1977	23:59:60	17 secs
31/12/1978	23:59:60	18 secs
31/12/1979	23:59:60	19 secs
30/06/1981	23:59:60	20 secs
30/06/1982	23:59:60	21 secs
30/06/1983	23:59:60	22 secs
30/06/1985	23:59:60	23 secs
31/12/1987	23:59:60	24 secs
31/12/1989	23:59:60	25 secs
31/12/1990	23:59:60	26 secs
30/06/1992	23:59:60	27 secs
30/06/1993	23:59:60	28 secs
30/06/1994	23:59:60	29 secs
31/12/1995	23:59:60	30 secs
30/06/1997	23:59:60	31 secs
31/12/1998	23:59:60	32 secs
31/12/2005	23:59:60	33 secs
31/12/2008	23:59:60	34 secs
30/06/2012	23:59:60	35 secs
30/06/2015	23:59:60	36 secs
31/12/2016	23:59:60	37 secs
<i>*Further leap seconds not yet announced.</i>		

Calculating Leap Seconds

Use the *Past Leap Seconds* table to count the number of leap seconds that are added in between the start time and the reference time chosen.

Example 1: For HSFN-Start in GPS format, provide the number of leap seconds from 1980:01:06:00:00:00. For example, if start time is configured at 1980:01:06:00:00:00 and reference time is configured at 2017:01:01:00:00:00, then the number of leap seconds that is added in between these start and reference times are 18. Hence, leap seconds adjustment becomes 18.

Example 2: For HSFN-Start in UTC format, provide the number of leap seconds from the HSFN-Start time. For example, if start time is configured at 2000:03:01:12:34:05 and reference time is configured at

2017:01:01:00:00:00, then the number of leap seconds that is added in between these start and reference times are 5. Hence, leap seconds adjustment becomes 5.

Verifying H-SFN Synchronization

Use the following command to verify the H-SFN configuration:

```
show mme-service full service_name
```

```
Extended DRX:
H-SFN Start           : 2016:03:01:12:34:56 GPS | UTC
H-SFN UTC Reference   : 1982:209.165.200.224
Adjusted time         : 1
```

Configuring the T3415 eDRX Timer

This section describes how to configure the T3415 eDRX timer. This timer is used to configure the eDRX paging timeout. The **t3415-timeout** keyword is added as part of the **emm** command in the MME Service Configuration mode. The **emm** command is used to configure evolved mobility management timer parameters such as timeout durations for timers and retransmission counts and for Non-Access Stratum (NAS) message retransmission in MME service.

configure

```
mme-service service_name
  emm { implicit-detach-timeout detach_dur | mobile-reachable-timeout
mob_reach_dur | t3346-timeout t3346_dur | t3412-extended-timeout t3412_ext_dur
| t3412-timeout t3412_dur | t3413-timeout t3413_dur | t3415-timeout t3415_dur
| t3422-timeout t3422_dur | t3423-timeout t3423_dur | t3450-timeout t3450_dur
| t3460-timeout t3460_dur | t3470-timeout t3470_dur }
  default emm { implicit-detach-timeout | mobile-reachable-timeout |
t3346-timeout | t3412-extended-timeout | t3412-timeout | t3413-timeout |
t3415-timeout | t3422-timeout | t3423-timeout | t3450-timeout |
t3460-timeout | t3470-timeout }
```

Notes:

- The keyword **t3415-timeout t3415_dur** is used to configure the T3415 paging timeout value. The *t3415_dur* is an integer value in the range 1 up to 20 seconds. The default value is 6 seconds.

Verifying the T3415 eDRX Timer

Execute the **show mme-service full service_name** command to verify the configured value of the T3415 timer.

For example: The **T3415 Timeout** parameter displays the configured value of T3415 timer as 3 seconds.

```
show mme-service full service_name
```

```
T3415 Timeout : 3s
```

Configuring the T3415 eDRX Timer in LTE Paging Profile Configuration Mode

This section describes how to configure the T3415 eDRX timer in the LTE Paging Profile Configuration mode. This timer is used to configure the eDRX paging timeout. The **t3415-timeout** keyword is added as part of the **paging-stage** command under the LTE Paging Profile Configuration mode. The **paging-stage**

command enables the operator to configure different stages of paging in the order of desired execution with parameters that control the pace, volume, and behavior of a given paging stage.

```
configure
  lte-policy policy_name
    paging-profile profile_name
      [ no ] paging-stage level match-criteria { ue-contact-time seconds |
        all } action { last-n-enb-last-tai max-n-enb value | all-enb-last-tai |
        all-enb-all-tai } t3413-timeout seconds max-paging-attempts attempts [
        t3415-timeout t3415_dur ]
    end
```

Notes:

- The **t3415-timeout** *t3415_dur* keyword is used to configure the T3415 paging timeout value. The *t3415_dur* is an integer ranging from 1 to 20 seconds.
- The **no** keyword disables the configuration.
- There are no re-tries in a paging stage.
- This command is disabled by default.

Configuring NB-IoT in UE Context

Use the following configuration to detach the UE on the deletion of the last PDN for NB-IoT access type even if the UE did an attach with Attach Without PDN Connectivity enabled:

```
configure
  call-control-profile profile_name
    [ remove ] nb-iot ignore-attach-without-pdn
  end
```

NOTES:

- **nb-iot ignore-attach-without-pdn**: Allows detach of Attach-Without-PDN UE after last PDN disconnect.
- **remove**: Disables the existing configuration.

Monitoring and Troubleshooting eDRX

eDRX Show Command(s) and /or Outputs

This section provides information regarding the show commands and their outputs for the eDRX feature.

show mme-service statistics

The following fields are added to the output of this command.

- EDRX Subscribers - Displays information about the eDRX subscribers.
- Attached Cells - Displays the number of attached subscribers for which eDRX is enabled.

- DDN Rejects - Displays the number of DDNs rejected when eDRX subscribers cannot be paged (UE is out of the paging window).

show egtpc statistics verbose

The following fields are added to the output of this command.

- UE not reachable due to PSM
- Create Bearer Denied
- Create Bearer Denied TX
- Update Bearer Denied
- Update Bearer Denied TX

The Create Bearer Request (CBR) and Update Bearer Request (UBR) are rejected when the UE is in Power Saving Mode. The MME sends the cause "EGTP_CAUSE_UE_TEMP_NOT_REACHABLE_DUE_TO_POWER_SAVING" in the reject message if that PDN is marked "Delay Tolerant" by PGW (DTCI flag enabled in PDN Connection Indication IE of Create Session Response). Otherwise the MME sends the cause "EGTP_CAUSE_UNABLE_TO_PAGE_UE" to S-GW in CBR/UBR Reject.

show lte-policy paging-profile name *profile_name*

The following fields are added to the output of this command.

- Paging Stage
- Paging Action
- Match Criteria
- T3413-Timeout
- Max Paging Attempts
- T3415-Timeout

Troubleshooting

The following troubleshooting steps can be used to verify the eDRX configuration:

- If eDRX is not enabled, verify if the eDRX parameters are configured in the call control profile and the eDRX H-SFN start time is configured for the MME service.
- If paging failures occur, verify the eDRX parameters.

Show Commands and Outputs

This section provides information about the show commands and outputs to displays the current Paging eDRX information of a subscriber.

show mme-service session full all | grep Paging

Table 3: show mme-service session full all | grep Paging Command Output Descriptions

Field	Description
SessMgr Instance	The Session Manager instance managing this session.
Paging eDRX	The following are the paging eDRX parameters: <ul style="list-style-type: none"> • eDRX cycle length • PTW
MSID	The UE identity (MS Identity) of a connected subscriber to an MME service, and whether the subscriber is unauthenticated (such as during emergency attach).
Callid	The call identity in 8 digit hex number of connected calls to an MME service.
MME Service	The name of the serving MME service of which information is displayed.
MME HSS Service	The name of the serving MME-HSS service which is used for AAA for this subscriber with HSS on S6a interface.
EGTP S11 Service	The name of the serving eGTP service which is used for connectivity between MME and S-GW on S11 interface.
MME S1 Address	The IP address of MME used for connecting with eNodeB on S1-MME interface.
EGTP S11 Address	The IP address assigned to eGTP service which is used for connectivity between MME and S-GW on S11 interface.
ME Identity	The mobile equipment identity of connected UE.
GUTI	The Globally Unique Temporary Identifier (GUTI) used for this subscriber session. GUTI is constructed with following identifiers: <ul style="list-style-type: none"> • PLMN (MMC and MNC) • MME Group ID (MMEGI) • MME Code (MMEC) • MME TMSI (M-TMSI)
MSISDN	The Mobile Station International ISDN Number (MSISDN) of connected EPS subscriber to an MME service.

Field	Description
EMM State	The status of EPS Mobility Management (EMM) session of connected subscriber. Possible status are: <ul style="list-style-type: none"> • Registered • Connected
ECM State	The status of EPS Connection Management (ECM) session of connected subscriber. Possible status are: <ul style="list-style-type: none"> • Registered • Connected • Idle
Attach type	Indicates the type of UE attachment of active subscriber to MME service, for example: Emergency or Initial EPS.
Active SGW S11 Addr	The IP address of S-GW connected to MME on S11 interface.
SGW Control TEID	Displays the TEID of the S-GW currently serving the UE.
UE Offloading	Displays the UE offload state for load rebalancing. Possible values are None, Marked, In-Progress and Done.
UE Reachability Timer	The configured value of the mobile reachability timer set for tracking UE in EMM session.
Remaining Time	The remaining time in seconds out of the configured value of the mobile reachability timer in the EMM session.
Paging Proceed Flag (PPF)	The current state of the Paging Proceed Flag indicating whether or not the UE is sending periodic TAUs within the span of the mobile reachability timer. If the UE fails to send a TAU within the timer value, this flag is set to "Paging Disabled" indicating that the MME is no longer paging the UE.
ISR Status	Displays if the session is using Idle mode Signaling Reduction (ISR). Possible configurations are Activated or Not activated.
Low Access Priority Indication	Displays whether this session has LAPI indicator in any of attach/extended service/TAU/bearer resource allocation/bearer resource modification/PDN connectivity requests.
Initial UE establishment cause	Displays the establishment cause as set in the Initial UE message: Delay Tolerant Access / High Priority Access / Emergency / MT-Access / Unknown
Peer SGSN	Displays the IP address of the SGSN which has a context for this UE in support of Idle mode Signaling Reduction (ISR). A Peer SGSN address is only shown when ISR is activated for this session.

show mme-service session full all | grep Paging

Field	Description
UE Capability Information	This group shows the UE Capability information for connected UE received by an MME service.
Radio Capability	The radio capability information received by an MME service for connected UE in UE capability exchange message.
Radio Capability for Paging	The radio capability information received by an MME service for paging the UE. This field displays the value in hexadecimal format if the UE receives "UE Radio Capability for Paging" IE in S1 "UE-CAPABILITY-INFO-INDICATION" message from eNB. Otherwise, this field displays N/A.
Supported Codec List	The Supported Codec List information received by an MME service for connected UE in UE capability exchange message.
Mobile Station Classmark 2	The Mobile Station Classmark 2 information received by an MME service for connected UE in UE capability exchange message.
Mobile Station Classmark 3	The Mobile Station Classmark 3 information received by an MME service for connected UE in UE capability exchange message.
Security Mode Information	This group shows the status of NAS integrity check and NAS ciphering along with applicable algorithm as security mode information. It contains following information: <ul style="list-style-type: none"> • NAS Integrity Check • NAS Integrity Check Algorithm • NAS Ciphering • NAS Ciphering Algorithm
Active ENodeB information	This group shows the information of active eNodeB serving to this session.
Global ENodeB ID	The global identifier of active eNodeB serving to this session.
S1AP End Point	The IP address used by eNodeB on S1AP interface to connect with MME service.
Crypto-map Name	The name of the crypto map supporting this ENodeB association.
MME UE S1AP ID	Indicates the session identifier between MME and UE on S1AP interface serving to this session.
ENodeB UE S1AP ID	Indicates the session identifier between eNodeB and UE on S1AP interface serving to this session.
MME UE S1AP ID (stack):	Indicates up to three MME UE S1AP session identifiers present in this S1AP stack.

Field	Description
ENodeB UE S1AP ID (stack):	Indicates up to three eNodeB UE S1AP session identifiers present in this S1AP stack.
Total S1AP ID (stack)	Indicates the total count of S1AP session identifiers present in the stack.
Idle Mode Information Data	This group shows the information for the sessions in ECM idle mode.
Last TAI	Tracking Area Identity of the last Tracking Area visited by UE.
Last ECGI	E-UTRAN Cell Global Identifier of the last Cell visited by UE.
Last Connected ENodeB	Displays information about the ENodeB to which the session was last connected. <ul style="list-style-type: none"> • Global ENodeB ID: Global ENodeB Identifier of the ENodeB to which the UE last connected. • S1AP End Point: End Point IP Address of the ENodeB to which the UE last connected.
UE Subscription Data	This group shows the subscribed aggregate maximum bit rate applicable for connected UE in this session.
UE-UL-AMBR	The subscribed aggregate maximum bit rate in bits per second in upload traffic for connected UE in this session.
UE-DL-AMBR	The subscribed aggregate maximum bit rate in bits per second in download traffic for connected UE in this session.
Enforced UE-UL-AMBR at eNodeB	The enforced aggregate maximum bit rate in bits per second in upload traffic for connected UE at eNodeB in this session.
Enforced UE-DL-AMBR at eNodeB	The enforced aggregate maximum bit rate in bits per second in download traffic for connected UE at eNodeB in this session.
PDN Information	This group shows the information of PDNs connected for this session.
APN Name	The APN name which is serving for this PDN in this session.
UE Requested APN	Displays the UE requested APN with non-standard characters in hexadecimal format and standard characters in normal string format.
APN Restriction	The total number of APN restriction applied to this PDN.
PDN Type	The type of PDN (IPv4 and/or IPv6) which is serving in this session for PDN.
PGW Address	The IP address of the P-GW which is serving this session for connected PDN.

show mme-service session full all | grep Paging

Field	Description
PGW control TEID	The control tunnel end identifier at P-GW on S5/S8 interface for control messaging serving to this session.
UE IPv4 Address	The IP address allocated to UE while connected to PDN in this session.
APN-UL-AMBR	The applicable aggregate maximum bit rate in bits per second in upload traffic for APN serving this PDN.
APN-DL-AMBR	The applicable aggregate maximum bit rate in bits per second in download traffic for APN serving this PDN.
Bearer Suspension State	The current suspension state of the bearer.
CSG Cell Change Notification	Displays CSG Information Reporting as specified by the PGW. If enabled, the MME sends notification when the UE enters or leaves a closed CSG cell.
CSG Subscribed Hybrid Cell Change Notification	Displays CSG Information Reporting as specified by the PGW. If enabled, the MME sends notification when the UE enters or leaves a hybrid cell as a subscribed member of the CSG in question.
CSG Unsubscribed Hybrid Cell Change Notification	Displays CSG Information Reporting as specified by the PGW. If enabled, the MME sends notification when the UE enters or leaves a hybrid cell with unsubscribed (non-member) status of the CSG in question
Marked for Deletion	Displays whether the PDN has marked for deletion flag set.
APN Restoration Priority	Displays the priority for reactivating impacted PDNs following a P-GW Restart Notification (PRN) where 1 is highest priority, 16 is lowest.
Low Access Priority Indication	Displays whether this PDN has LAPI indicator set as received in PDN connectivity requests.
Bearer Id	The identifier used for bearer between eNodeB and S-GW while connected to PDN in this session.
QCI	The quality class identifier applicable for this MME session.
AMBR	The applicable aggregate maximum bit rate in bits per second in download/upload direction for APN serving this PDN.
S1U ENodeB TEID	Indicates the tunnel end identifier at eNodeB on S1-U interface serving to this session.
S1U SGW TEID	Indicates the tunnel end identifier at S-GW on S1-U interface serving to this session.
S5S8 PGW TEID	Indicates the tunnel end identifier at P-GW on S5/S8 interface serving to this session.

Field	Description
S1U ENodeB IPv4 Addr	Indicates the IPv4 address used at eNodeB while connecting to S-GW on S1-U interface serving to this session.
S1U ENodeB IPv6 Addr	Indicates the IPv6 address used at eNodeB while connecting to S-GW on S1-U interface serving to this session.
S1U SGW IPv4 Addr	Indicates the IPv4 address used at S-GW while connecting to eNodeB on S1-U interface serving to this session.
S1U SGW IPv6 Addr	Indicates the IPv6 address used at S-GW while connecting to eNodeB on S1-U interface serving to this session.
S5S8 PGW Addr	Indicates the IP address used at P-GW while connecting to S-GW on S5/S8 interface serving to this session.
ESM State	The EPS session Management status serving to this session.
Bearer Type	The type of bearer used for this session. Possible values are: <ul style="list-style-type: none"> • Default • Dedicated
ARP	The Allocation Retention Priority value assigned to the bearer. The HSS assigns the value for default bearers and the P-GW assigns it for dedicated bearers.
PCI	Specifies the ARP Pre-emption Capability Indicator, either Enabled or Disabled.
PVI	Specifies the ARP Pre-emption Vulnerability Indicator, either Enabled or Disabled.
PGW-C+SMF Selected	Specifies that Combined PGW-C/SMF selection indicator, either Yes or No.
Marked for Deletion	Displays whether the bearer has marked for deletion flag set.
Total PDNs	The total number of PDNs connected through this session for a subscriber.
Total Bearers	The total number of bearers created for UE to use in this session.
Max APN Restrictions	The maximum number of APN restrictions applied to this PDN.
Tracking Area Information	This group displays the tracking area information available for this session.
TAI of last TAU	The tracking area identifier used in last Tracking Area Update (TAU) message received for TAU procedure in this session.
Current Tracking Area List	The tracking area list used for TAU procedure in this session.

show mme-service session full all | grep Paging

Field	Description
CSG Information	This group displays Closed Subscriber Group information relating to this session.
CSG ID at Last Connection	Displays the CSG ID for this session. This is a unique identifier within the scope of PLMN which identifies a Closed Subscriber Group (CSG) in the PLMN.
CSG Cell Type	Displays the Closed Subscriber Group cell access mode (type) for this session, either Closed or Hybrid.
CSG Membership Status	Displays if the session is a member of the cell's CSG. Possible values are Member or Non-Member.
Operator Policy Association	The operator policy associated with this PDN.
CSFB Information	This group displays the Circuit-Switched Fall Back configuration associated with the session.
SGS Assoc State	The state of the SGs association with the VLR for the UE as determined by the MME. Possible states are: <ul style="list-style-type: none"> • SGs-NUL: Specifies that there is no SGs association with the VLR for the UE. In this state, no fields in this group will display information. • LA_UPDATE_REQUESTED: Specifies that the MME has requested an update location from the VLR before sending a response to the UE • SGs-ASSOCIATED: Specifies that the MME has stored an SGs association for the UE.
SGS Service	The name of the configured SGs service associated with the session.
VLR	The name of the VLR, as configured in the SGs service, associated with the session.
LAI	The Location Area Identifier to which the UE is mapped.
Pool Area	The name of the configured Location Area Code (LAC) pool area associated with the SGs service and the session.
P-TMSI	The Packet-Temporary Mobile Subscriber Identifier allocated by the MSC for the UE.

Field	Description
Flags	<p>The current active variables associated with the UE. Possible states are:</p> <ul style="list-style-type: none"> • SMS-Only: Specifies that the UE is combined attached for SMS services only. • MME Reset Indicator: Specifies that the MME has restarted after a failure. • VLR Reliable Indicator: Specifies that the MME has received a reset indication from the VLR. • VLR Offload: Specifies that the UE is set to offload state. • Non-EPS Alert: Specifies that the VLR is requesting from the MME an indication when any signaling activity from the UE is detected.
CIoT Optimisation Information	Displays the CIoT optimization information.
NB-IoT RAT	Displays if the RAT type NB-IoT is either enabled or disabled.
Attach Without PDN Support	Displays if attach without PDN support is either enabled or disabled.
UE capable of operating in CE-mode-B	Displays "TRUE" or "FALSE" to indicate if UE is operating in CE Mode-B.
Access Profile Association	Displays the configured access-profile name.
DECOR Information:	
UE Usage type	Displays the configured UE usage types.
DCN Id	Displays the configured DCN identifier.
UE DC-NR Information:	
DC-NR capable UE	Indicates whether the UE is DCNR capable.
DC-NR operation allowed	Indicates whether the DCNR operation is allowed by MME for the DCNR capable UE.
UE N1-Mode Information	
N1-mode capable UE	Indicates whether the UE N1 mode information is allowed by MME for the N1-mode capable UE.

Bulk Statistics

The following bulk statistics are added in the MME Schema in support of the eDRX feature.

- attached-edrx-subscriber - The current number of attached subscribers in eDRX mode.

- `ddn-rejects-edrx` - The total number of DDN rejects due to eDRX ever since the chassis was up.

Diameter Attributes

Diameter Attribute Value Pairs (AVPs) carry specific authentication, accounting, authorization, routing and security information as well as configuration details for the request and reply. The following Diameter attributes are added in support of this feature:

DL-Buffering-Suggested-Packet-Count

This AVP indicates the DL buffering suggested packet count.

Vendor ID 10415

VSA Type 1674

AVP Type Integer32

AVP Flag V-bit is set to true, M-bit is set to false.



CHAPTER 3

NB-IoT and Low Power Session Counters

This chapter describes the following topics:

- [Feature Summary and Revision History, on page 33](#)
- [Feature Description, on page 34](#)
- [Monitoring and Troubleshooting, on page 34](#)

Feature Summary and Revision History

Summary Data

Applicable Product(s) or Functional Area	C-SGN, MME
Applicable Platform(s)	<ul style="list-style-type: none"> • ASR 5500 • VPC-DI • VPC-SI
Feature Default	Enabled - Always-on
Related Changes in This Release	Not applicable
Related Documentation	<ul style="list-style-type: none"> • <i>MME Administration Guide</i> • <i>Statistics and Counters Reference</i> • <i>Ultra IoT C-SGN Administration Guide</i>

Revision History

Revision Details	Release
First introduced.	21.6

Feature Description

On MME and C-SGN, new counters are added to count the number of low power subscribers when RAT type is E-UTRAN or NB-IoT. The counters will increment by 1 for each subscriber if eDRX or PSM or both are received in Attach or TAU Request.

The **show mme-service statistics** command and MME schema are enhanced to support the new counters and and new bulk statistics respectively.

Monitoring and Troubleshooting

This section provides information on the bulk statistics and show commands available to support NB-IoT and Low Power Session RAT type.

Show Commands and/or Outputs

This section provides information regarding show commands and/or their outputs.

show mme-service statistics

The following new fields are added to the output of this command to display the number of low power subscribers attached when RAT type is NBIOT and E-UTRAN.

- Low power Subscribers:
 - NB-IoT Attached Calls — The current total number of attached low power subscribers which are operating in NB-IoT.
 - EUTRAN Attached Calls — The current total number of attached low power subscribers which are operating in E-UTRAN.

Bulk Statistics

The following bulk statistics are added in the MME schema to display the number of low power subscribers attached when RAT type is NB-IOT and E-UTRAN.

Bulk Statistics	Description
attached-lp-nbiot-subscriber	The current total number of attached low power subscribers which are operating in NB-IoT.
attached-lp-eutran-subscriber	The current total number of attached low power subscribers which are operating in E-UTRAN.



CHAPTER 4

NB-IoT RAT and Attach Without PDN Connectivity Support

This feature chapter describes the MME support for the CIoT optimizations attach without PDN connectivity and NB-IoT RAT type.

- [Feature Summary and Revision History, on page 35](#)
- [Feature Description, on page 36](#)
- [How it Works, on page 36](#)
- [Configuring NB-IoT RAT and Attach Without PDN Connectivity, on page 38](#)
- [Monitoring and Troubleshooting, on page 43](#)

Feature Summary and Revision History

Summary Data

Applicable Product(s) or Functional Area	<ul style="list-style-type: none">• C-SGN• MME
Applicable Platform(s)	<ul style="list-style-type: none">• UGP• VPC-DI• VPC-SI
Feature Default	Disabled
Related Changes in This Release	Not applicable
Related Documentation	<ul style="list-style-type: none">• <i>Command Line Interface Reference</i>• <i>Statistics and Counters Reference</i>

Revision History

Revision Details	Release
The feature is tested and qualified on the ASR 5500 platform.	21.3
First introduced.	N5.1 (21.1.V0)

Feature Description

The 3GPP has specified a new radio interface, the Narrow band Internet of Things (NB-IoT) to address the requirements of the IoT devices. NB-IoT is a new RAT type. This new technology provides improved indoor coverage, support of massive number of low throughput devices, low delay sensitivity, ultra-low device cost, low device power consumption and optimized network architecture. In order to support this RAT type the MME now allows the operator to enable Extended Discontinuous Reception (eDRX) feature for NB-IoT subscribers. The operator can also enable or disable NB-IoT RAT per TAI database or per TAI object. If the HSS does not support this new RAT-Type AVP Value E-UTRAN-NB-IOT, the MME can now override the RAT-Type AVP value to E-UTRAN in messages sent to the HSS.



Important This feature is license controlled. Contact your Cisco account representative for information on how to obtain a license.

The EPS Attach procedure includes a PDN connectivity procedure. An UE registered in the EPS network has a PDN connection and an allocated IP address. The IoT devices in most cases support only SMS. For such devices a PDN connectivity procedure is an overhead as it requires signaling over the radio interface while establishing or re-establishing the connection, this in turn leads to additional battery consumption and hence incurs additional cost. The MME provides enhanced support to allow "Attach without PDN connectivity" for IoT devices. The UE can be registered with the EPS network without activating a PDN connection and using Control Plane optimization the device can now exchange SMS data.

Relationships to Other Features

The MME supports other CIoT optimization functions in order to provide support for IoT devices in the EPS network, some of the related features are:

- MME Support For CIoT Devices
- IP and non-IP data over NAS
- IP and non-IP data over the NAS and S11-U interface
- Support for non-IP data over SCEF

How it Works

The MME supports various CIoT optimization functions; this feature chapter describes MME enhancements for NB-IoT RAT support and Attach without PDN connectivity for CIoT devices.

MME Enhancements for NB-IoT RAT Support

As per 3GPP TS 23.401, cells of NB-IoT RAT and WB-EUTRAN are configured with different TA codes. The MME supports local configuration to indicate whether a given TA or group of TAs belong to NB-IoT RAT type or not. During call setup or updating procedures the MME passes the RAT Type to other nodes such as SGW/PGW or peer MME. The MME also passes the RAT type information to HSS over the S6a interface.

The MME has been enhanced with the following functionalities and commands to support the new NB-IoT RAT type:

- A new command **nb-iot edrx** has been introduced under the call control profile configuration mode to enable the Extended Discontinuous Reception (eDRX) feature for NB-IoT subscribers. When the eDRX feature is enabled the MME, it pages the NB-IoT subscribers only at valid paging occasions. This results in reduced signaling in the IoT devices.
- A new command **access-type** is introduced under the LTE TAI management database configuration and LTE TAI management object configuration modes enable or disable NB-IoT RAT per TAI database or per TAI object.
- The MME verifies if the current TA belong to NB-IoT RAT or not and provides this information to the SGW in GTPv2 messages that include RAT type.
- The MME sends the current RAT type information to the peer MME or S4-SGSN in Context Request or Response messages and Forward Relocation Requests.
- Emergency bearer services are not applicable to NB-IoT RAT type. Therefore the MME does not support emergency bearer services during Attach and TAU with UEs having NB-IoT RAT type.
- The MME can also be a target MME in which case it rejects Inter-MME TAU if it identifies a change in the RAT type (either to or from NB-IoT RAT to another RAT type). This in turn forces the UE to re-attach. If the RAT type is not send by the peer, the target MME does not consider the RAT type as NB-IoT.
- As a target MME, it rejects Inter-MME TAU if the UE is moving from SGSN to MME. The MME can identify the peer as SGSN by the DNS response or from “Fall back to GTPv1” cause code.
- The MME rejects Intra-MME TAU if it detects change in RAT Type either to or from NB-IoT RAT to another RAT type.
- As a source MME, it rejects the SGSN Context Request from the SGSN when it is registered as NB-IoT RAT.
- As a source MME, it rejects Context Request from peer MME or S4-SGSN when it identifies a change in RAT either to or from NB-IoT RAT to another RAT type.
- The MME ignores the “voice domain preference” and UE settings if present in Attach Request while accessing from NB-IoT RAT.
- The MME rejects in-bound handover for NB-IoT subscribers.

Attach without PDN Connectivity

- The MME supports configuration to enable Attach without PDN connectivity CIoT optimization on per access-type. The new **ciot-optimisation** command under the call control profile configuration mode is used to enable or disable this functionality. Attach without PDN connectivity can be enabled or disabled only at the IMSI level.

- When this feature is enabled for a subscriber, the following apply:
 - The MME processes the attach Request with a dummy ESM container without establishing a PDN connection with SGW or PGW and without setting up Radio access bearer connection with an eNodeB.
 - The MME retains the subscriber in a registered state after the last PDN de-activation.
 - The MME handles EMM-registered to EMM-idle state transition successfully.
 - The MME handles periodic TAU and Intra-MME TAU successfully.
 - The MME does not reject Context Response without any PDN connections.
 - The MME sends a Context Response without any PDN connection information if the subscriber is attached without a PDN.
- The MME retains the subscriber in EMM-Registered state if the first PDN connectivity procedure fails for any reason and “Attach without PDN connectivity” CIoT optimization is applied.

Standards Compliance

This feature complies with the following standards:

- 3GPP TS 24.301, Non-Access-Stratum (NAS) protocol for Evolved Packet System (EPS); Stage 3.
- 3GPP TS 23.401, version 13.5.0, General Packet Radio Service (GPRS) enhancements for Evolved Universal Terrestrial Radio Access Network (E-UTRAN) access.

Configuring NB-IoT RAT and Attach Without PDN Connectivity

This section describes the configuration procedures for NB-IoT RAT and Attach Without PDN Connectivity.

Configuring CIoT Optimization for an UE

The **ciot-optimisation** CLI command is introduced in the Call Control Profile Configuration mode to enable CIoT optimization for an UE.

```

configure
  call-control-profile profile_name
    ciot-optimisation [ cp-optimisation access-type { all | nb-iot |
wb-eutran } | eps-attach-wo-pdn access-type { all | nb-iot | wb-eutran }
  ]
  remove ciot-optimisation cp-optimisation
  remove ciot-optimisation eps-attach-wo-pdn access-type { all | nb-iot
| wb-eutran }
  exit
    
```

Notes:

- The **ciot-optimisation** keyword enables CIoT optimization for an UE.
- The **cp-optimisation** keyword is used to enable Control Plane optimization for an UE.

- This command is disabled by default.
- The **remove** keyword deletes the existing configuration.
- The **eps-attach-wo-pdn** keyword is used to enable EPS attach without PDN support for an UE.
- The call-control-profile can be associated with the operator-policy, it is possible to either enable or disable CloT optimization on a per subscriber (IMSI) basis.

Configure EPS Attach without PDN support for an UE

Use the following command to configure EPS Attach without PDN support for an UE.

```
configure
  call-control-profile profile_name
    [ remove ] ciot-optimisation eps-attach-wo-pdn access-type { all |
nb-iot | wb-eutran }
  exit
```

Notes:

- The **eps-attach-wo-pdn** keyword is used to enable EPS Attach without PDN support for an UE.
- The **access-type** keyword specifies the access type extension on which EPS Attach without PDN support should be enabled. EPS Attach without PDN can be enabled on both NB-IoT and WB-EUTRAN RATs or on either of them. Enabling one RAT type does not disable the other RAT type.
- The **remove** keyword deletes the existing configuration.
- The **all** keyword enables EPS Attach without PDN for all access types.
- The **nb-iot** keyword enables EPS Attach without PDN for NB-IoT access type. This keyword is provided to the operator for the ease of configuring. Both NB-IoT and WB-EUTRAN will be considered as two independent access types for all functions.
- The **wb-eutran** keyword enables EPS Attach without PDN for WB-EUTRAN access type.
- This command is disabled by default.

Verifying the EPS Attach without PDN support for UE Configuration

Execute the show command **show call-control-profile *profile-name*** to verify the configured values. For example:

```
show call-control-profile full name profile_name
```

```
Attach without PDN Support for WB-EUTRAN      : Disabled/Enabled
Attach without PDN Support for NB-IoT         : Enabled/Disabled
```

Configure TAC Access Type as NB-IoT

The **access-type** CLI command is provided to enable or disable NB-IoT RAT per TAI database or per TAI object. The default RAT is WB-EUTRAN. As per 3GPP standards, the same TAC cannot belong to both EUTRAN and NB-IoT RATs. The new command access-type is added in the LTE TAI Management Database Configuration mode and LTE TAI Management Database Configuration mode.

LTE TAI Management Database Configuration Mode

```

configure
  lte-policy
    tai-mgmt-db db_name
      [ no ] access-type nb-iot
    exit
    
```

Notes:

- The LTE TAI Management Database Configuration Mode is used to create and manage the LTE Tracking Area Identifier (TAI) management database on the system.
- The **no** keyword removes the configured access type for the TAI database.
- The **nb-iot** keyword configures the access type as NB-IoT for a TAI database.
- This command is disabled by default.

LTE TAI Management Object Configuration Mode

```

configure
  lte-policy
    tai-mgmt-db db_name
      tai-mgmt-obj obj_name
      [ no ] access-type nb-iot
    exit
    
```

Notes:

- The LTE TAI Management Object Configuration Mode is used to create and manage the LTE Tracking Area Identifiers for the TAI database.
- The **no** keyword removes the configured access type for the TAI object.
- The **nb-iot** keyword configures the access type as NB-IoT for a TAI object.
- This command is disabled by default.

Configure eDRX for NB-IoT subscribers

The **nb-iot** CLI command is added in the Call Control Profile Configuration mode to enable the Extended Discontinuous Reception (eDRX) feature for NB-IoT subscribers. When the eDRX feature is enabled on the MME, it pages the NB-IoT subscribers only at valid paging occasions. The MME sends the NB-IoT eDRX paging parameters to the eNodeB during paging. The operator can either configure the option to accept the UE requested values or configure the values using this command.

This command is used for:

- Accept eDRX parameters: Paging Time Window (PTW) and eDRX cycle length value, from the UE
- Configure PTW and eDRX cycle length value
- Configure downlink buffer duration in DDN ACK when unable to page UE
- Configure "DL Buffering Suggested Packet Count" in DDN ACK when unable to page UE


```

configure
  call-control-profile profile_name
    nb-iot edrx { ptw ptw_value edrx-cycle cycle_length_value | ue-requested
} [ dl-buf-duration [ packet-count packet_count_value ] ]
  remove nb-iot edrx
end
    
```

- This command is not enabled by default.
- The **remove** keyword deletes the existing eDRX configuration for NB-IoT subscribers.
- The **nb-iot** keyword enables eDRX configuration for NB-IoT subscribers.
- The **edrx** keyword configures extended discontinuous reception parameters.
- The **ue-requested** keyword specifies the UE requested values of the Paging Time Window (PTW) and the eDRX cycle length received from the UE in the Attach Request or TAU Request message be accepted.
- The **ptw** keyword is used to configure the PTW value. *ptw_value* is an integer value in seconds. The allowed values are 2.56, 5.12, 7.68, 10.24, 12.80, 15.36, 17.92, 20.48, 23.04, 25.60, 28.16, 30.72, 33.28, 35.84, 38.40 and 40.96 seconds.
- The **edrx-cycle** keyword is used to configure the eDRX cycle length. The *cycle_length_value* is an integer value in seconds. The allowed values are 5.12, 7.68, 10.24, 12.80, 15.36, 17.92, 20.48, 40.96, 81.92, 163.84, 327.68, 655.36, 1310.72, 2621.44, 5242.88 and 10485.76 seconds.
- The optional **dl-buf-duration** keyword is used to send downlink buffer duration in DDN ACK when unable to page UE.
- The optional **packet-count** keyword is used to send "DL Buffering Suggested Packet Count" in DDN ACK when unable to page UE. The *packet_count_value* is an integer value from 0 up to 65535. If the *packet_count_value* is not configured locally, the subscription provided value for the *packet_count_value* is used. The subscription value can be 0 in which case the packet count IE will not be sent for that subscriber even if it is configured locally.
- A similar CLI is implemented for WB-EUTRAN subscribers. Both WB-UTRAN eDRX and NB-IoT eDRX parameters can be configured on the system for WB-UTRAN and NB-IoT subscribers.

See the *eDRX Support on the MME* feature chapter in the *MME Administration Guide* for more information.

Verifying the eDRX Configuration for NB-IoT Subscribers

Execute the **show call-control-profile** *profile-name* command to verify the configured values. For example:

```
show call-control-profile profile-name
```

NB-IoT Extended DRX:

```

      Paging Time Window                : UE Requested/xx
Seconds
      eDRX Cycle Length                  : UE Requested/xx
Seconds
      Downlink Buffer Duration in DDN Ack : Enabled/Disabled

      DL Buffering Suggested Packet count in DDN Ack : X
    
```

Configure IE Override in MME Message to HSS

A new CLI command is introduced under the call control profile configuration mode to override the RAT type AVP value with the configured value for messages sent from MME to HSS. This CLI ensures backward compatibility as the HSS does not support the new NB-IoT RAT type.

```
configure
  call-control-profile profile_name
    [ remove ] ie-override s6a rat-type wb-eutran
  exit
```

Notes:

- This CLI is disabled by default.
- The **remove** keyword deletes the existing configuration.
- The **ie-override** keyword allows the operator to configure IE override in messages sent from MME to HSS.
- The **s6a** keyword is used to specify the interface as s6a. This is the interface used by the MME to communicate with the Home Subscriber Server (HSS).
- The **rat-type** keyword is used to configure the supported RAT type AVP IE.
- The **wb-eutran** keyword specifies the WB-EUTRAN AVP Value.

Verifying the IE Override Configuration

Execute the **show call-control-profile *profile-name*** command to verify the configured values. For example:

```
show call-control-profile full name profile_name
```

```
IE Override:
  S6A Interface           : Enabled
  Supported RAT Type AVP : WB-EUTRAN
```

Sample Configuration

```
configure
  call-control-profile cp1
    ciot-optimisation eps-attach-wo-pdn access-type all
  exit
  call-control-profile cp2
    ie-override s6a rat-type wb-eutran
  exit
  call-control-profile cp3
    nb-iot edrx ptw 512 edrx-cycle 2048 dl-buf- duration
packet-count 50
  exit
  lte-policy
    tai-mgmt-db taidb1
    tai-mgmt-obj obj3
    access-type nb-iot
```

`exit`

Monitoring and Troubleshooting

This section provides information regarding show commands and bulk statistics for this feature.

Show Command(s) and/or Outputs

show subscriber all

The following new field is added to the show output to display the new NB-IoT RAT type:

- (N) - NB-IoT

show lte-policy tai-mgmt-db name *db_name*

The following new fields are added to the show output to display the configured access type:

- Access-Type NB-IoT

The show output displays whether all the TACs configured belong to either WB-EUTRAN or NB-IoT RAT. It is also possible that some of the configured TACs belong to WB-EUTRAN and the rest belong to NB-IoT RAT.

show lte-policy tai-mgmt-db name *db_name* tai-mgmt-obj *obj_name*

The following new fields are added to the show output to display the configured access type:

- Access-Type NB-IoT

The show output displays whether all the TACs configured belong to either WB-EUTRAN or NB-IoT RAT.

show mme-service session full all

The following new fields are added to the show output to display the Clot optimization information:

- Clot Optimisation Information
- NB-IoT RAT: Disabled/Enabled
- Attach Without PDN Support: Enabled/Disabled

show mme-service statistics verbose

The following new fields are added to the show output to display the statistics for NB-IoT subscribers, Attach without PDN subscribers, NB-IoT statistics and Attach without PDN statistics:

- NB-IoT Subscribers: Displays information about NB-IoT subscribers
- Attached Calls: Displays the number of attached calls for NB-IoT subscribers.
- Connected Calls: Displays the number of connected calls for NB-IoT subscribers.

- Idle Calls: Displays the number of idle calls for NB-IoT subscribers.
- Attach Without PDN Subscribers: Displays information about the Attach without PDN subscribers.
- Attached Calls: Displays the number of attached calls for Attach without PDN subscribers.
- Connected Calls: Displays the number of connected calls for Attach without PDN subscribers.
- Idle Calls: Displays the number of idle calls for Attach without PDN subscribers.
- NB-IoT Statistics: Displays the NB-IoT statistics.
- Handover Denied
- Path Sw Failure
- HO Prep Failure
- Inter MME Denied (TAU Reject)
- Src Peer Node Gn SGSN
- Src Peer Node S3 SGSN
- NB-IoT RAT as Src
- NB-IoT RAT as Tgt
- Intra MME Denied (TAU Reject)
- NB-IoT RAT as Src
- NB-IoT RAT as Tgt
- Inter MME Denied (Context Failure)
- Tgt Peer Node Gn SGSN
- Tgt Peer Node S3 SGSN
- NB-IoT RAT as Src
- NB-IoT RAT at Tgt
- Inter MME Denied (Forward Relocation Reject)
- NB-IoT RAT as Tgt
- Attach Without PDN Statistics: Displays the Attach without PDN statistics
- Attach Procedure
- Attach Request Rcvd
- Attach Accept Sent
- Attach Complete Rcvd
- Attach Reject Sent
- Config Err NB-IoT
- Config Err WB-Eutran

- Intra MME TAU Procedure
- TAU Request Rcvd
- TAU Accept Sent
- TAU Complete Rcvd
- Inter MME TAU Procedure
- TAU Request Rcvd
- TAU Accept Sent
- TAU Complete Rcvd
- TAU Reject Sent
- Config Err NB-IoT
- Config Err WB-Eutran
- PDN Procedure
- PDN Conn Req after wopdn
- PDN Conn Succ wopdn
- Last PDN Del wo Detach
- Inter MME Denied (Context Failure)
- No WOPDN sup by S3 SGSN
- No WOPDN sup by Peer MME
- No WOPDN sup by MME

show mme-service statistics emm-only

The following new fields are added to the show output to display the NB-IoT statistics:

- NB-IoT Statistics
- Handover Denied
- Path Sw Failure
- HO Prep Failure
- Inter MME Denied (TAU Reject)
- Src Peer Node Gn SGSN
- Src Peer Node S3 SGSN
- NB-IoT RAT as Src
- NB-IoT RAT as Tgt
- Intra MME Denied (TAU Reject)

- NB-IoT RAT as Src
- NB-IoT RAT as Tgt
- Inter MME Denied (Context Failure)
- Tgt Peer Node Gn SGSN
- Tgt Peer Node S3 SGSN
- NB-IoT RAT as Src
- NB-IoT RAT at Tgt
- Inter MME Denied (Forward Relocation Reject)
- NB-IoT RAT as Tgt

Bulk Statistics

The new following statistics are included in the MME Schema in support of this feature:

Counter	Description
idle-nbiot-subscriber	The current total number of nb-iot subscribers in idle state. This is a Gauge. Increments for any nb-iot subscriber moving to ECM-IDLE state. An UE is in ECM-IDLE state when no NAS signaling connection between UE and network exists.
connected-nbiot-subscriber	The current total number of nb-iot subscribers in connected state. This is a Gauge. Increments for any nb-iot subscriber in ECM-CONNECTED state. The UE and the MME shall enter the ECM-CONNECTED state when the signaling connection is established between the UE and the MME.
nbiot-path-sw-fail	The total number of Path Switch Request failure b/c subscriber is attached with NB-IoT RAT.
nbiot-ho-prep-fail	The total number of HO Preparation Failure b/c subscriber is attached with NB-IoT RAT.
nbiot-irat-tau-rej-gn	The total number of Inbound NB-IoT RAT TAU reject for Source Gn-SGSN.
nbiot-irat-tau-rej-s3	The total number of Inbound NB-IoT RAT TAU reject for Source S3-SGSN.

Counter	Description
nbiot-irat-tau-rej-nb-to-wb	The total number of Inbound WB-EUTRAN RAT TAU reject for Source NB-IoT RAT.
nbiot-irat-tau-rej-wb-to-nb	The total number of Inbound NB-IoT RAT TAU reject for Source WB-EUTRAN RAT.
nbiot-tau-rej-nb-to-wb	The total number of Intra MME WB-EUTRAN RAT TAU reject for Source NB-IoT RAT.
nbiot-tau-rej-wb-to-nb	The total number of Intra MME NB-IoT RAT TAU reject for Source WB-EUTRAN RAT.
nbiot-irat-denied-gn	The total number of Outbound NB-IoT RAT Context failure for Target Gn-SGSN.
nbiot-irat-denied-s3	The total number of Outbound NB-IoT RAT Context failure for Target S3-SGSN.
nbiot-irat-denied-nb-to-wb	The total number of Outbound WB-EUTRAN RAT Context failure for Target NB-IoT RAT.
nbiot-irat-denied-wb-to-nb	The total number of Outbound NB-IoT RAT Context failure for Target WB-EUTRAN RAT.
nbiot-irat-frwd-rloc-rej-wb-to-nb	The total number of Inbound NB-IoT RAT Forward Relocation Request reject for Source WB-EUTRAN RAT.
idle-wopdn-subscriber	<p>The current total number of without PDN subscribers in idle state.</p> <p>This is a Gauge.</p> <p>Increments for any wopdn subscriber moving to ECM-IDLE state. A UE is in ECM-IDLE state when no NAS signaling connection between UE and network exists.</p>
connected-wopdn-subscriber	<p>The current total number of without PDN subscribers in connected state.</p> <p>This is a Gauge.</p> <p>Increments for any wopdn subscriber in ECM-CONNECTED state. The UE and the MME shall enter the ECM-CONNECTED state when the signaling connection is established between the UE and the MME.</p>
wopdn-attach-req	<p>The total number of Attach Request without PDN.</p> <p>Increments for Attach Request received with Dummy ESM Container</p>

Counter	Description
wopdn-attach-acc	The total number of Attach Accept without PDN. Increments for Attach Accept sent with Dummy ESM container
wopdn-attach-comp	The total number of Attach Complete without PDN. Increments for Attach Complete sent with Dummy ESM container.
wopdn-attach-rej-config-err-nbiot	The total number of Attach Reject for NB-IoT config error. Increments for Attach Request with Dummy ESM container received on NB-IoT when wopdn support is not enabled
wopdn-attach-rej-config-err-eps	The total number of Attach Reject for WB-EUTRAN config error. Increments for Attach Request with Dummy ESM container received on WB-EUTRAN when wopdn support is not enabled
wopdn-intra-tau-req	The total number of Intra MME TAU Request when UE is attached without PDN.
wopdn-intra-tau-acc	The total number of Intra MME TAU Accept when UE is attached without PDN.
wopdn-intra-tau-comp	The total number of Intra MME TAU Complete when UE is attached without PDN.
wopdn-inter-tau-req	The total number of Inter MME TAU Request without PDN.
wopdn-inter-tau-acc	The total number of Inter MME TAU Accept without PDN.
wopdn-inter-tau-comp	The total number of Inter MME TAU Complete without PDN.
wopdn-inter-tau-rej-config-err-nbiot	The total number of Inter MME TAU Reject for NB-IoT config error.
wopdn-inter-tau-rej-config-err-eps	The total number of Inter MME TAU Reject for WB-EUTRAN config error.
wopdn-pdn-conn-req	The total number of Additional PDN Connectivity Request for subscriber attached without PDN.
wopdn-pdn-conn-succ	The total number of Successful Additional PDN Connectivity procedure for subscriber attached without PDN.

Counter	Description
wopdn-last-pdn-del-allowed	The total number of PDN Disconnect for last PDN deletion allowed.
wopdn-irat-denied-no-wopdn-supp-s10	The total number of S10 Outbound Context failure due to Peer's limitation for WO-PDN support.



CHAPTER 5

Non-IP Data Over SCEF

This chapter describes the transfer of Non-IP data over SCEF using Cellular Internet of Things (CIoT) technology. This feature is discussed in the following sections:

- [Feature Summary and Revision History, on page 51](#)
- [Feature Description, on page 52](#)
- [How It Works, on page 54](#)
- [Configuring Non-IP Data over SCEF, on page 65](#)
- [Monitoring and Troubleshooting, on page 70](#)

Feature Summary and Revision History

Summary Data

Applicable Product(s) or Functional Area	MME
Applicable Platform(s)	<ul style="list-style-type: none">• UGP• ASR 5500• VPC-DI• VPC-SI
Feature Default	Disabled - Configuration Required
Related Changes in This Release	Not applicable
Related Documentation	<ul style="list-style-type: none">• <i>Command Line Interface Reference</i>• <i>Statistics and Counters Reference</i>• <i>Ultra IoT C-SGN Administration Guide</i>

Revision History

Revision Details	Release
This release supports, Connection Release when UE in Idle Mode.	21.20.26
This release supports: <ul style="list-style-type: none"> • Connection Management by SCEF Procedure to release a T6a connection between MME and SCEF. • PDN disconnect and detach procedure towards the UE when it receives a MO Data Answer message with Permanent Failure from SCEF. 	21.19
The feature is tested and qualified on the ASR 5500 platform. This release supports temporary buffering of single MT Data Request received from SCEF while UE is in idle mode.	21.3
First introduced.	N5.1 (21.1.V0)

Feature Description

The Service Capability Exposure Function (SCEF) is the key entity within the 3GPP architecture for service capability exposure that provides a means to securely expose the services and capabilities provided by 3GPP network interfaces. SCEF resides either on the edge of an IoT domain or completely within the IoT domain, interfacing with an external API Management Platform at the edge.



Important This feature is license controlled. Contact your Cisco account representative for information on how to obtain a license.

CIoT brings in newer set of applications and requirements to be supported at various network elements. One such requirement is the support of Non-IP data over SCEF. Non-IP Data Delivery (NIDD) is one of the prime features of SCEF that helps transfer data between the SCEF and the Application Server (AS) using APIs. The support of Non-IP Data Delivery is part of the CIoT EPS optimizations.

Non-IP data over SCEF requires “Data over NAS” support and the implementation of T6a - Diameter interface at MME. A PDN Type "Non-IP" is used for NIDD over SCEF.

The Diameter T6a interface interacts between the MME and SCEF to support:

- Non IP PDN connection establishment
- MO Non IP data
- MT Non IP data
- Monitoring Event configuration at MME
- Monitoring Event configuration by MME to SCEF



Important Cisco SCEF runs on the CPS platform and is available for trial purposes only. Contact your Cisco account representative for more information.

Non-IP Data Delivery over SCEF supports the following functionalities:

- Non-IP Data Delivery
- Connection Management
- Idle to Active transition and vice-versa with ClOT Optimization for subscribers having SCEF PDN
- Recovery of subscribers with Control Plane ClOT optimizations on Session Manager restart
- Control Plane ClOT Optimizations

SCEF Initiated T6a Connection Release Enhancement: MME allows Service Capability Exposure Function (SCEF) to initiate T6a connections release procedure in compliance with the 3GPP specifications 23.682 Release 15 of Section 5.13.5.3 and 29.128 Release 15 of Section 5.8.

Buffering Non-IP Data from SCEF

MME supports temporary buffering of single MT Data Request received from SCEF while UE is in idle mode. The request is buffered till UE is paged and an MT Data Answer is sent upon paging success/failure.

The following functionality for temporary buffering is applicable on a UE basis.

- MT Data Request is buffered while UE is being paged till the corresponding MT Data Answer is sent.
- A single MT Data Request will be buffered per SCEF PDN.
- The subsequent MT Data Request for the PDN will not be buffered and immediately rejected with experimental result code `DIAMETER_ERROR_UNABLE_TO_COMPLY` (5012).
- Sends buffered non-IP payload to UE and MT Data Answer with success result code (2001) to SCEF, upon paging success.
- Sends MT Data Answer with experimental result code `DIAMETER_ERROR_USER_TEMPORARILY_UNREACHABLE` (5653) upon paging failure. MME also sends MT Data Answer with this result code due to expiry of SCEF wait time prior to paging completion.
- Sends Connection Management Request (CMR) with Connection-Action AVP set to Connection Update and CMR-Flags AVP set to 1, once UE comes to connected mode. MT Data Answer was previously sent with experimental result code `DIAMETER_ERROR_USER_TEMPORARILY_UNREACHABLE` (5653), so that SCEF can send buffered data to MME once UE is reachable.
- MT Data Request is not buffered if UE cannot be paged due to PSM/eDRX.
MT Data Answer with cause code `DIAMETER_ERROR_USER_TEMPORARILY_UNREACHABLE` (5653) will be sent followed by CMR when UE comes to connected mode.
- Statistics are supported for MT Data Request buffered, MT Data Answer sent for buffered requests and MT Data Answer dropped for buffered requests.

The Buffering Non-IP Data from SCEF feature is enabled by default.

Connection Release when UE in Idle Mode : In this StarOS 21.20.26 release, MME supports the Connection Release (CMR - Connection Management Request) received from SCEF when UE in the Idle mode.

Without PDN support, if Connection Release is requested from SCEF for the last PDN in the UE Idle mode, MME initiates:

- Paging when ppf flag was TRUE
- Detach with Re-Attach required towards UE after successful completion of paging.

Packet Data Network Disconnect or Detach Procedure

Before the implementation of Packet Data Network (PDN) Disconnect or Detach procedure in a network, MME followed the below process after receiving the permanent failure code:

1. The User Equipment (UE) connects to the network with Non-IP Data Delivery (NIDD) option and establishes T6a connection.
2. UE tries Mobile Originated (MO) NIDD whenever a Session DB on the SCEF gets cleared.
3. UE sends Non-Access Stratum (NAS) “MO REQUEST” with the data and receives NAS_SERVICE_ACCEPT.
4. The MME sends Diameter “MO-Data-Request” over T6A and receives “DIAMETER_ERROR_INVALID_EPS_BEARER (5651)” or “DIAMETER_ERROR_USER_UNKNOWN”.

However, there was data loss. This data loss was because of the lack of PDN Disconnect or Detach procedure initiation from MME towards the UE. UE may assume that it is T6a connected and retry MO NIDD indefinitely.

In StarOS 21.19 and later releases, the MME supports PDN Disconnect or Detach procedure towards the UE when it receives a MO Data Answer message with Permanent Failure Result-Code/Experimental-Result from SCEF. If the permanent failure is different from DIAMETER_ERROR_INVALID_EPS_BEARER and from DIAMETER_ERROR_USER_UNKNOWN, then MME also initiates the "Connection Management by MME/SGSN" procedure to release the T6a connection between the MME and the SCEF.

How It Works

Several IoT applications are implemented where Non-IP data is transferred between Applications/Service Capability Servers and CIoT devices.

The Non-IP data delivery to SCS/AS is accomplished by one of two mechanisms:

- Delivery using SCEF
- Delivery using a Point-to-Point (PtP) SGI tunnel.

This section only covers Non-IP data delivery over SCEF.

Interaction between MME and SCEF

The UE indicates in the ESM connection request (for example: in the Attach or PDN Connectivity Request) that a Non-IP PDN type is used. The subscription information has a default APN for PDN Type Non-IP, which the MME uses for the first received Non-IP connectivity request unless the UE has included an APN in the

request. The MME then initiates a T6a connection towards the SCEF corresponding to the SCEF ID indicator for that APN.

At each PDN connectivity request, the MME decides which delivery mechanism (SCEF based delivery or SGI based delivery) is used for delivering the Non-IP data between RAN and AS. An indication associated with the used APN determines if SCEF based delivery or SGI based delivery shall be used.

When the MME decides to use SCEF based delivery mechanism for Non-IP data, a PDN connection is established towards the selected SCEF. Such a PDN Connection is also known as an "SCEF Connection".

Connection Management

The Application Server (AS) and UE information are registered with the SCEF using two different call flows:

- AS registration with SCEF
- UE registration with SCEF

AS Registration

The AS registration is also called as the Non-IP Data Delivery configuration procedure. The call-flow procedure is as given below:

1. AS registers itself for a particular UE.
2. SCEF performs authentication and authorization. SCEF may downgrade the load information, if the specified load exceeds the local limits maintained in the SCEF's configuration.
3. SCEF sends a Non-IP Data Delivery Information Request to HSS.
4. HSS sends a Non-IP Data Delivery Information Answer. The answer includes the UE's 3GPP identifier, since the request may have used an external-id. The answer may also include load-control information, although such is not defined in the current NIA specification.

UE Registration

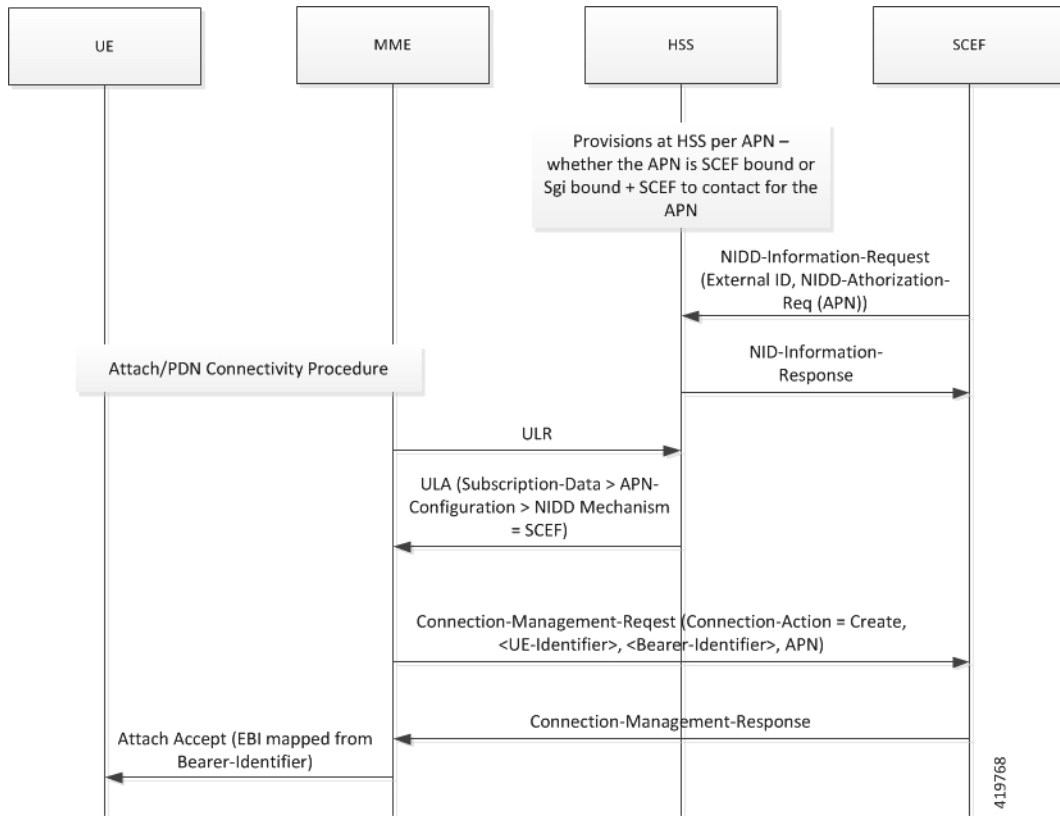
The UE registration is called the T6a Connection establishment procedure. The call-flow procedure is as given below:

1. The UE attaches, indicating a desired connection for non-IP data. This registers the UE with the MME.
2. MME sends a Connection Management Request to SCEF.
3. If an AS has not already registered with the SCEF for that UE, SCEF may either reject the Connection Management Request, or SCEF may initiate the Non-IP Data Delivery Configuration Procedure for an AS.
4. SCEF sends a Connection Management Answer.

The following call-flow is used between MME and SCEF/Inter-working SCEF (IWK-SCEF), and is invoked by the MME to:

- Establish a T6a connection between MME and SCEF
- Release a T6a connection between the MME and the SCEF

Figure 2: SCEF PDN Connection Creation



This procedure is mapped to the commands: Connection-Management-Request and Connection-Management-Answer (CMR/CMA) in the Diameter application along with IEs, described below:



Note Not all IEs included are supported by MME.

Connection Management Request

Information Element Name	Mapping to Diameter AVP	Category	Description
User Identity	User-Identifier	M	This information element contains the identity of the UE. This is a grouped AVP which contains the IMSI.
EPS Bearer Identity	Bearer-Identifier	M	This information element contains the identity of the EPS bearer, identifying the T6a connection to the applicable request.

Information Element Name	Mapping to Diameter AVP	Category	Description
T6a Connection Action	Connection-Action	M	This information element contains T6a connection management action indicating a T6a connection establishment, a T6a connection release or a T6a connection update.
APN	Service-Selection	C	This information element contain the APN that the user wants to connect with. This information element is applicable if the request is for a T6a connection establishment.
Serving PLMN Rate Control	Serving-PLMN-Rate-Control	O	This information element contains the Serving PLMN rate control set by the MME.
CMR Flags	CMR-Flags	O	This information element contains a Bit mask.
Maximum UE Availability Time	Maximum-UE-Availability-Time	O	<p>This information element may be included, if available, if the Connection-Action AVP indicates a T6a connection update and the UE-Reachable-Indicator is set in the CMR-Flags AVP.</p> <p>When present, it indicates the timestamp (in UTC) until which a UE using a power saving mechanism (such as extended idle mode DRX) is expected to be reachable for MT Non-IP Data Delivery.</p> <p>This information may be used by the SCEF to prioritize the retransmission of MT Non-IP Data to UEs using a power saving mechanism.</p>
Extended PCO	Extended-PCO	C	This information element is present, if the MME receives Extended PCO information from the UE.
3GPP Charging Characteristics	3GPP-Charging-Characteristics	C	<p>This information element contains PDN Connection Charging Characteristics data for an APN Configuration with SCEF-based NIDD mechanism.</p> <p>It will be present, if the request is for a T6a connection establishment or for a T6a connection update.</p>

Information Element Name	Mapping to Diameter AVP	Category	Description
RAT-Type	RAT-Type	C	This Information element contains the used RAT Type. It will be present, if the request is for a T6a connection establishment.
Supported Features	Supported-Features	O	This information element contains the list of features supported by the origin host.
Terminal Information	Terminal-Information	C	This information element contains the identity of the UE
Visited PLMN ID	Visited-PLMN-Id	C	This information element shall contain the identity (MCC and MNC) of serving PLMN. It will be present if the request is for a T6a connection establishment or for a T6a connection update.

Connection Management Answer

Information Element Name	Mapping to Diameter AVP	Category	Description
Result	Result-Code / Experimental-Result	M	This information element provides the result of the request. Result-Code AVP shall be used for errors defined in the Diameter Base Protocol. Experimental-Result AVP is used for T6a/b errors. This is a grouped AVP, which contains the 3GPP Vendor ID in the Vendor-Id AVP, and the error code in the Experimental-Result-Code AVP.
NIDD Charging Identifier	PDN-Connection-Charging-Id	C	This Information element is defined in 3GPP TS 32.253 [23] and will be present if the answer is for a T6a connection establishment.
Extended PCO	Extended-PCO	C	This Information Element shall be present, if the SCEF needs to send Extended PCO information to the UE.
Supported Features	Supported-Features	O	This information element contains the list of features supported by the origin host.

Connection Release

MME allows Service Capability Exposure Function (SCEF) to initiate T6a connections release procedure in compliance with the 3GPP specifications 23.682 Release 15, Section 5.13.5.3 and 29.128 Release 15, Section 5.8.

Using one of the following procedures, the MME releases the T6a connection towards the SCEF(s) corresponding to the SCEF ID indicator for an APN:

- User Equipment (UE)-initiated Detach procedure for E-UTRAN
- MME-initiated Detach procedure
- HSS-initiated Detach procedure
- UE or MME requested PDN disconnection procedure.

In one of the following scenarios, the SCEF releases the T6a connection towards the MME corresponding to PDN connections:

- When an NIDD Authorization Update request from the HSS indicates that the user is no longer authorized for NIDD.
- Failure of SCEF or failure of SCS/AS connection
- Based on a request from the SCS/AS
- Based on removal of the APN associated with the T6a connection from the SCEF

SCEF Initiated T6a Connection Release Procedure

SCEF invokes Connection Management by SCEF procedure to release a T6a connection between MME and SCEF. This procedure is mapped to the commands Connection-Management-Request/Answer (CMR/CMA) in the Diameter application along with IEs.

The following table describes Connection Request management IE from SCEF.

Table 4: Connection Management SCEF Request

Information Element Name	Mapping to Diameter AVP	Category	Description
User Identity	User-Identifier	M	This information element contains the identity of the UE. This is a grouped AVP which contains the IMSI.
EPS Bearer Identity	Bearer-Identifier	M	This information element contains the identity of the EPS bearer, identifying the T6a connection to the applicable request.

Information Element Name	Mapping to Diameter AVP	Category	Description
T6a/b Connection Action	Connection Action	M	This information element contains T6a connection management action indicating a T6a connection establishment, a T6a connection release, or a T6a connection update.
Extended PCO	Extended- PCO	C	This information element contains Extended-Protocol Configuration Options (PCO), indicating that the SCEF needs to send updated extended PCO information (for example, APN Rate Control information) to the UE.
Supported Features	Supported-Features	O	Lists the features supported by the origin host.

SCEF sets the Connection-Action to CONNECTION_RELEASE (1) for a T6a Connection Release.

The following table describes SCEF Answer management from MME.

Table 5: Connection Management SCEF Answer

Information Element Name	Mapping to Diameter AVP	Category	Description
Result	Result-Code/Experimental-Result	M	This information element provides the result of the request. Result-Code AVP is used for errors defined in the Diameter Base Protocol. Experimental-Result AVP is used for T6a/b errors. This is a grouped AVP, which contains the 3GPP Vendor ID in the Vendor-Id AVP, and the error code in the Experimental-Result-Code AVP.

Information Element Name	Mapping to Diameter AVP	Category	Description
Supported Features	Supported-Features	O	This information element contains the list of features supported by the origin host.

After MME receives the Connection Management Request with Connection-Action set to 1 in t6a interface, MME does the following.

Table 6: T6a Connection Release Procedure by SCEF

Step	Description
1	Checks if the User Identity exists in the MME. If the User Identity does not exist, sets the Experimental-Result to DIAMETER_ERROR_USER_UNKNOWN in the Connection Management SCEF Answer.
2	Checks whether the T6a connection action indicates a T6a connection update or T6a connection release. If the T6a connection action is not update or release, then sets the Experimental-Result to DIAMETER_ERROR_OPERATION_NOT_ALLOWED in the Connection Management SCEF Answer.
3	Checks whether a T6a connection context exists for a user and the received EPS Bearer Identity. If T6a connection context does not exist, then sets the Experimental-Result to DIAMETER_ERROR_INVALID_EPS_BEARER in the Connection Management SCEF Answer.
4	If the T6a connection action indicates T6a connection release, delete the T6a connection context at the MME. If successful, sets the Result code to DIAMETER_SUCCESS in the Connection Management SCEF Answer.
5	The MME performs the MME initiated Detach procedure.

Initiating Packet Data Network Disconnect or Detach Procedure

MME triggers the PDN disconnect or detach procedure based on the following conditions:

- MME checks whether to trigger PDN Disconnect procedure or Detach procedure based on the PDN Count.
- If the last PDN and Attach without PDN connectivity is supported by UE, then MME triggers the PDN Disconnect procedure.
- If UE has more than one PDN, and UE sends MO Data Request procedure towards SCEF-specific PDN, and if MME receives MO Data answer with any permanent failure cause, MME triggers PDN disconnect procedure towards UE. MME initiates Connection release procedure towards SCEF except when the error is other than “DIAMETER_ERROR_USER_UNKNOWN” and “DIAMETER_ERROR_INVALID_EPS_BEARER”
- If UE has only one PDN and Attach without PDN is not supported, then MME triggers Detach procedure. If permanent failure is different than Diameter_Error_User_Unknown and Invalid EPS Bearer ID, MME initiates a Connection Management procedure to release the T6a connection.

- If UE has one PDN or more than one PDN and UE sends MO Data Request procedure towards SCEF-specific PDN, and if MME receives MO Data answer with failure cause as User-Unknown, MME triggers Detach procedure.

The following table provides an easy reference point when MME initiates Detach/PDN disconnect towards UE and release of T6a connection towards SCEF in certain error cases.

Table 7: Detach/PDN disconnect Errors

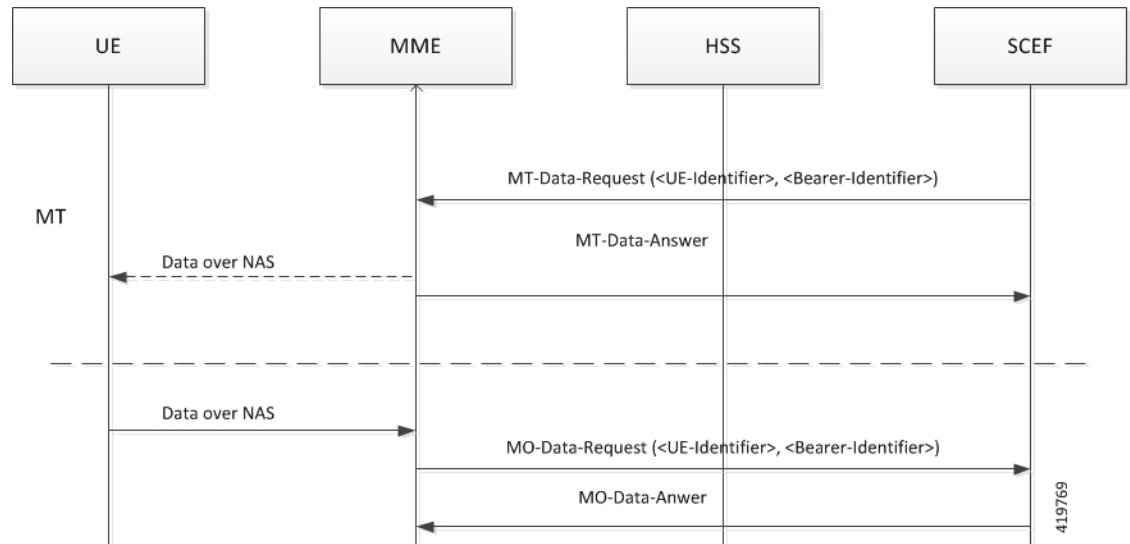
DIAMETER_ERROR/No of PDNs	1 PDN & Attach without PDN Support by UE	>1 PDN	1 PDN & Attach without PDN not Support by UE
USER_UNKNOWN	Detach towards UE and no T6a Connection release towards SCEF	Detach towards UE and no T6a Connection release towards SCEF	Detach towards UE and no T6a Connection release towards SCEF
INVALID_EPS_BEARER	PDN Disconnect towards UE and no T6a Connection release towards SCEF	PDN Disconnect towards UE and no T6a Connection release towards SCEF	Detach towards UE and no T6a Connection release towards SCEF
OPERATION_NOT_ALLOWED	PDN Disconnect towards UE and T6a Connection release towards SCEF	PDN Disconnect towards UE and T6a Connection release towards SCEF	Detach towards UE and T6a Connection release towards SCEF
NIDD_CONFIGURATION_NOT_AVAILABLE	PDN Disconnect towards UE and T6a Connection release towards SCEF	PDN Disconnect towards UE and T6a Connection release towards SCEF	Detach towards UE and T6a Connection release towards SCEF
SCEF_REFERENCE_ID_UNKNOWN	PDN Disconnect towards UE and T6a Connection release towards SCEF	PDN Disconnect towards UE and T6a Connection release towards SCEF	Detach towards UE and T6a Connection release towards SCEF

Non-IP Data Delivery

Non-IP data delivery over the SCEF have the following data delivery modes:

- Mobile Originated (MO) Data Delivery
- Mobile Terminated (MT) Data Delivery

Figure 3: SCEF PDN MO and MT Data Delivery



MO Data Procedure

The Mobile Originated procedure is used between the MME and the SCEF/IWK-SCEF that is invoked by the MME to forward mobile originated Non-IP data of a UE from the MME to the SCEF.

This procedure is mapped to the commands MO-Data-Request and MO-Data-Answer (ODR/ODA) in the Diameter application with IEs described below:

Information Element Name	Mapping to Diameter AVP	Category	Description
User Identity	User-Identifier	M	This information element contains the identity of the UE. This is a grouped AVP which also contains the IMSI.
EPS Bearer Identity	Bearer-Identifier	M	This information element contains the identity of the EPS-bearer identifying the T6a connection for the Non-IP data delivery.
Non-IP Data	Non-IP-Data	C	This information element contains the Non-IP data to be delivered to the SCEF. This Information Element will present when the request conveys Non-IP data.
Supported Features	Supported-Features	O	If present, this information element shall contain the list of features supported by the origin host.

Information Element Name	Mapping to Diameter AVP	Category	Description
MO Exception Data Counter	RRC-Cause-Counter	C	The MME includes this Information Element when the MME needs to send a non-zero counter value for the MO Exception Data Counter. The timestamp in the counter is set with the time at which the counter value increased from 0 to 1.

MO Data Answer

Information Element Name	Mapping to Diameter AVP	Category	Description
Result	Result-Code / Experimental-Result	M	This information element contains the result of the request. The Result-Code AVP is used to indicate success or errors as defined in the Diameter Base Protocol. The Experimental-Result AVP is used for T6a/b errors. This is a grouped AVP, which contains the 3GPP Vendor ID in the Vendor-Id AVP, and the error code in the Experimental-Result-Code AVP.
Requested Retransmission Time	Requested Retransmission Time	O	This information element may be present if the Experimental-Result-Code is set to DIAMETER_ERROR_USER_TEMPORARILY_UNREACHABLE and the Maximum Retransmission Time information element is present in the MT Data Request. It may be included if the UE is using a power saving mechanism (such as extended idle mode DRX) and the UE is currently not reachable. When present, this indicate the retransmission time (in UTC) at which the SCEF is requested to retransmit the MT Non-IP Data. The Requested Retransmission Time shall not exceed the Maximum Retransmission Time received from the SCEF.
Supported Features	Supported-Features	O	If present, this information element shall contain the list of features supported by the origin host.

Limitations

The Non-IP Data Delivery over SCEF feature has the following limitations:

- In release 21.1.V0 (N5.1): MME does not support buffering of data.

In 21.3 and later releases: MME supports temporary buffering of single MT Data Request received from SCEF while UE is in idle mode. Buffering of multiple MT Data Request messages per SCEF PDN for a UE is not supported.

- Non-IP data in-sequence delivery cannot be guaranteed and data PDUs may be lost requiring higher protocol layers to ensure guaranteed delivery when needed.
- Currently, only Connection Establishment, Connection Release, MO data transfer, MT data transfer with connected mode is supported.

In StarOS 21.20.26 release, paging on MT data request and paging on Connection Release from SCEF for the UE in IDLE mode, is supported.

- For Control Plane IoT Optimized UEs, both Inter-MME and Intra-MME handovers are not supported.
- T6a interface messages are not supported in mon sub (monitor subscriber).

Supported Standards

The Non-IP Data Delivery over SCEF feature complies with the following standards:

- 3GPP TS 24.301 Non-Access-Stratum (NAS) protocol for Evolved Packet System (EPS); Stage 3.
- 3GPP TS 23.401 General Packet Radio Service (GPRS) enhancements for Evolved Universal Terrestrial Radio Access Network (E-UTRAN) access.
- 3GPP TS 23.682 Architecture enhancements to facilitate communications with packet data networks and applications.
- 3GPP TS 29.128 Mobility Management Entity (MME) and Serving GPRS Support Node (SGSN) interfaces for interworking with packet data networks and applications.
- 3GPP TS 29.274 3GPP Evolved Packet System (EPS); Evolved General Packet Radio Service (GPRS) Tunnelling Protocol for Control plane (GTPv2-C); Stage 3.
- 3GPP TS 29.272 Evolved Packet System (EPS); Mobility Management Entity (MME) and Serving GPRS Support Node (SGSN) related interfaces based on Diameter protocol.

Configuring Non-IP Data over SCEF

This section documents the configuration procedures for the transfer of Non-IP data over SCEF.

This feature is configured in the following stages:

- Configuring SCEF-service
- Association of SCEF-service to MME-service
- Association of SCEF-service to Call-Control-Profile
- Configuring PDN Type Identifier in APN Profile

Configuring SCEF-service

The following CLI command configures SCEF-service:

```
configure
  context context_name
    scef-service service_name
      [ no ] diameter endpoint endpoint_name
      [ default ] diameter dictionary standard
    end
```

Notes:

- The prefix **no** disables the configuration.
- The prefix **default** assigns or restores the default value for the selected parameters.
- The **scef-service** command is used to create and configure an SCEF Peer Service to communicate with SCEF peers.
- The *service_name* variable identifies the scef-service. The service name is a string with range 1 to 63 characters.
- The **diameter** command configures the Diameter interface (T6a-interface).
- The **dictionary standard** command configures the standard dictionary to be used for T6a interface.
- The **endpoint** *endpoint_name* command configures the diameter endpoint.



Note It is recommended to not remove a diameter endpoint when there are active calls on the system. Adhere to the 'Method of Procedure' to remove an endpoint, otherwise the system behavior would be undefined.

Verifying the Configuration

The SCEF-service configuration can be verified using the show commands provided in this section.

To verify all configured SCEF services, use the following command:

show scef-service all

On executing the above command the following new fields are displayed for SCEF service configuration:

- Service Name
- Context
- Status
- Diameter endpoint
- Diameter dictionary

To verify a specified SCEF service, use the following command:

show scf-service name *service_name*

On executing the above command the following output is displayed for SCEF service configuration:

```
Service name           : scf1
Context                : hss
Status                 : STARTED
Diameter endpoint      : t6a-endpoint
Diameter dictionary    : Standard
```

Association of SCEF-service to MME-service

The following CLI configuration associates the SCEF-service to an MME-service:

```
configure
  context context_name
    mme-service service_name
      [ no ] scf-service service_name
    end
```

Notes:

- The **no** command prefix disables/disassociates the scf-service configuration.
- The **scf-service** command associates SCEF with its MME peer.
- The *service_name* identifies the name of the SCEF service that will be used by the MME service. It is a string of range from 1 to 63.

Verifying the Configuration

The association of an SCEF-service to an MME-service can be verified using the show commands provided in this section.

To verify all associated SCEF services, use the following command:

show mme-service all

On executing the above command the following new field(s) are displayed:

- SCEF Service

To verify a specific MME-service, use the following command:

show mme-service name *service_name*

On executing the above command, the following output is displayed:

```
SCEF Service           : scf1
```

Association of SCEF-service to Call-Control-Profile

The following CLI configuration associates SCEF-service to the Call-Control-Profile.

```
configure
  call-control-profile profile_name
```

```
[ remove ] scef-service service_name
end
```

Notes:

- The **no** command prefix disables/disassociates the scef-service configuration.
- The **scef-service** command associates SCEF with the call-control-profile.
- The *service_name* identifies the name of the SCEF service. It is a string of range from 1 to 63.

Verifying the Configuration

The association of an SCEF-service to the Call Control Profile can be verified using the show commands provided in this section.

To verify all associated SCEF services, use the following command:

show call-control-profile full all

On executing the above command the following new field(s) are displayed:

- SCEF Service

To verify a specific MME-service, use the following command:

show call-control-profile name profile_name

On executing the above command, the following output is displayed:

```
SCEF Service : scef1
```

To verify configured values for specified Call Control Profile with CP CIoT Optimization, use the following command:

show call-control-profile full name profile_name

When CP CIoT Optimization is enabled, the output displayed on executing the above command is as follows:

```
CIoT Optimisation:
CP-Optimisation  : Enabled
Access-Type      : WB-EUTRAN
```



Note In the above output, the field **Access-Type** can have other results such as: NB-IoT, or both WB-EUTRAN and NB-IoT, based on the configuration.

When CP CIoT Optimization is disabled, the output displayed on executing the above command is as follows:

```
CIoT Optimisation
CP-Optimisation      : Disabled
Access-Type          : N/A
```

Configuring PDN Type Identifier in APN Profile

The following CLI configures/overrides PDN Type indicator in APN profile.

```

configure
  apn-profile profile_name
    pdn-type { ip | non-ip { sgi | t6a [ scef-id scef_id [ scef-realm
realm_name ] ] } }
    remove pdn-type
  end

```

Notes:

- The **remove** command prefix removes the pdn-type configuration.
- The **pdn-type** command identifies the Cellular IoT PDN type.
- The **ip** keyword identifies the Cellular IoT PDN type as IP PDN.
- The **non-ip** keyword identifies the Cellular IoT PDN type as Non-IP PDN.
- The **t6a** keyword identifies the Cellular IoT Non-IP PDN delivery path type as T6a
- The **scef-id** *scef-id-string* is an optional keyword, which specifies the SCEF identifier at the T6a interface. The SCEF identifier is a string of length 1 up to 63 characters.
- The **scef-realm** *realm-name* is an optional keyword, which specifies the SCEF Diameter realm. The *realm_name* is string of length 1 up to 127 characters.

Verifying the Configuration

The PDN Type Identifier for a specified APN Profile can be verified using the following show command(s):

show apn-profile full name *profile_name*

On executing the above command, the following new fields are displayed:

- PDN Type
- NON-IP Delivery Mechanism Type
- SCEF-Id (for T6a interface)
- SCEF-Realm (for T6a interface)

When PDN Type is configured, the output displayed on executing the above command is as follows:

```

PDN Type                : NON-IP
NON-IP Delivery Mechanism Type : SGi/T6A
SCEF-Id                 : scef1
SCEF-Realm              : xyz.com

```

When PDN Type is not configured, the output displayed on executing the above command is as follows:

```

PDN Type                : Not Configured

```

Configuring SCEF Wait Time in APN Profile

Use the following configuration in the APN Profile Configuration mode to configure the SCEF wait time value in APN Profile.

```

configure
  apn-profile profile_name

```

```
[ remove ] ciot scef wait-time wait_time
end
```

Notes:

- **ciot**: Configures the parameters related to Cellular IoT features.
- **scef**: Configures the SCEF specific parameters.
- **wait-time wait_time**: Specifies the wait time in seconds, before which MME is expected to send MT Data Answer (TDA) to SCEF in response to the MT Data Request (TDR) message. *wait_time* is an integer ranging from 1 to 100.
- The SCEF wait time configuration at MME overrides the value of SCEF wait time received in MT Data Request. MME will respond with MT Data Answer within the configured SCEF wait time value irrespective of the presence or absence of SCEF Wait Time AVP in MT Data Request sent by SCEF.
- This command is disabled by default.

Verifying the Configuration

The SCEF wait time in APN Profile can be verified using the following show command.

show apn-profile full name *profile_name*

The following fields display the configured SCEF wait time for a specified APN profile on executing the above command:

```
CIoT:
  SCEF:
    Wait-Time : 10 secs
```

Monitoring and Troubleshooting

This section provides information on how to monitor and troubleshoot using show commands and bulk statistics available to support of this feature.

Show Commands and/or Outputs

This section provides information regarding show commands and/or their outputs in support of this feature.

show mme-service db record imsi *mobile_station_identifier*

```
DB RECORD
=====
  Sessmgr Instance : 1
  Imsmgr Instance : 2
.
.
APN Config Data
-----
.
.
PDN-GW Name           : test
PDN-GW Realm          : test.com
Non-IP-PDN-Type-Indicator : FALSE
```

```

Non-IP-Data-Delivery-Mechanism : N/A
SCEF-ID                        : N/A
SCEF-Realm                     : N/A
    
```

show mme-service session all

The above show command displays the MME Session information. For this feature, a new field is added as displayed in the following output:

- PDN information
 - PDN Type: IPv4/IPv6/IPv4v6/Non-IP
 - PDN Data Delivery Interface: S1-U/S11-U/T6a
 - PDN Non-IP Data Delivery Charging Identifier



Note This information is applicable when CloT Optimization is enabled.

show mme-service session counters imsi *mobile_station_identifier*

On executing the above command the following output is displayed for this feature:

```

Username: n/a                               Callid: 00004e22
MSID:           123456789012346
...
...
...
ESM Events:
  PDN Connections:
    Attempted:      0   Success:      0
    Failures:       0
  NON-IP PDN Connections With SCEF:
    Attempted:      0   Success:      0
    Failures:       0
...
...
...
  PDN Disconnections With SCEF:
    Attempted:      0   Success:      0
    Failures:       0
...
...
Control Plane User Data Statistics:
  Cumulative Data Over T6A (SCEF) Statistics:
    Rx Packets:     0   Rx Bytes:     0
    Tx Packets:     0   Tx Bytes:     0
    Rx Drop Packets: 0   Rx Drop Bytes: 0
    Tx Drop Packets: 0   Tx Drop Bytes: 0
  Per PDN Statistics:
    APN Name: starent.com
    Data Over T6A (SCEF) Statistics:
      Rx Packets:   0   Rx Bytes:   0
      Tx Packets:   0   Tx Bytes:   0
      Rx Drop Packets: 0   Rx Drop Bytes: 0
      Tx Drop Packets: 0   Tx Drop Bytes: 0
    
```

show mme-service statistics

The ESM procedure statistics counters are added for the following:

- Non-IP PDN Connections over SCEF (T6a)
- Non-IP PDN Disconnects over SCEF (T6a)

The statistics added are as follows:

```
ESM Statistics:
.
.
PDN Connections With PDN Type Override to ipv6:
  Attempted:      0   Success:      0
  Failures:       0
NON-IP PDN Connections With SCEF:
  Attempted:      0   Success:      0
  Failures:       0
NON-IP PDN Connections With SGI:
  Attempted:      0   Success:      0
  Failures:       0
PDN Disconnects With SCEF:
  Attempted:      0   Success:      0
  Failures:       0
```

For PDN statistics, the following is displayed:

```
.
.
PDN Statistics:
  All PDNs:      0   Connected PDNs:  0
  Idle PDNs:     0
NON-IP PDN Statistics:
...
...
Data Over T6A (SCEF) Statistics:
  Rx Packets:    0   Rx Bytes:         0
  Tx Packets:    4   Tx Bytes:         0
  Rx Drop Packets: 0   Rx Drop Bytes:    0
  Tx Drop Packets: 0   Tx Drop Bytes:    0
```

show scf-service statistics all

On executing the above command, the following output is displayed. The below fields are newly added to show the SCEF service statistics:

```
SCEF statistics for Service: scf1
Session Stats:
  Total Current Sessions: 0
  Sessions Failovers:    0   Total Starts:      2
  Total Session Updates: 4   Total Terminated: 2
Message Stats:
  Total Messages Rcvd:   5   Total Messages Sent: 5
  OD Request:            0   OD Answer:         0
  ODR Retries:           0   ODA Timeouts:     0
  ODA Dropped:           0
  TD Request:            1   TD Answer:         1
  TDR Retries:           0   TDA Timeouts:     0
  TDA Dropped:           0
  TD Request Buffered :  0   TD Answer Buffered: 0
  TDA Dropped Buffered:  0
  CI Request:            0   CI Answer:         0
```



```

CIR Retries:          0   CIA Timeouts:          0
CIA Dropped:         0
RI Request:          0   RI Answer:          0
RIR Retries:         0   RIA Timeouts:       0
RIA Dropped:         0
CM-E Request:        2   CM-E Answer:        2
CMR-E Retries:       0   CMA-E Timeouts:     0
CMA-E Dropped:       0
CM-R Request:        2   CM-R Answer:        2
CMR-R Retries:       0   CMA-R Timeouts:     0
CMA-R Dropped:       0
CM-U Request:        0   CM-U Answer:        0
CMR-U Retries:       0   CMA-U Timeouts:     0
CMA-U Dropped:       0

Message Error Stats:
Unable To Comply:    0   User Unknown:       0
Other Errors:       0   RAT Not Allowed:    0

Bad Answer Stats:
Auth-Applicaiotn-Id: 0   Session-Id:         0
Origin-Host:         0   Origin Realm:       0
Parse-Message-Errors: 0   Parse-Misc-Errors:  0
Miscellaneous:       0
    
```

show scsf-service statistics summary

On executing the above command, the following statistics are displayed for SCEF service:

```

Session Stats:
Total Current Sessions:      0
Sessions Failovers:          0   Total Starts:          2
Total Session Updates:      4   Total Terminated:
    
```

show subscribers all

The above show command displays the subscriber information. For this feature, a new Network Type is added as displayed in the following output:

```

Network (I) - IP (M) - Mobile-IP (L) - L2TP
Type: (P) - Proxy-Mobile-IP (i) - IP-in-IP (G) - GRE
(V) - IPv6-in-IPv4 (S) - IPSEC (C) - GTP
(A) - R4 (IP-GRE) (T) - IPv6 (u) - Unknown
(W) - PMIPv6 (IPv4) (Y) - PMIPv6 (IPv4+IPv6) (R) - IPv4+IPv6
(v) - PMIPv6 (IPv6) (/) - GTPv1 (For SAMOG) (+) - GTPv2 (For SAMOG)
(N) - NON-IP
    
```

Bulk Statistics

Counters	Description
The following bulk statistics are included in the MME Schema to track T6a data:	
t6a-data-pkts-rx	Proprietary counter provides the total number of NON-IP packets received over T6A Interface
t6a-data-pkts-tx	Proprietary counter provides the total number of NON-IP packets transmitted over T6A Interface

Counters	Description
t6a-data-bytes-rx	Proprietary counter provides the total number of NON-IP data in bytes received over T6A Interface
t6a-data-bytes-tx	Proprietary counter provides the total number of NON-IP data in bytes transmitted over T6A Interface
t6a-data-pkts-rx-drop	Proprietary counter provides the total number of NON-IP packets received over T6A Interface, but dropped by MME
t6a-data-pkts-tx-drop	Proprietary counter provides the total number of NON-IP packets transmitted over T6A Interface, but transmission failed
t6a-data-bytes-rx-drop	Proprietary counter provides the total number of NON-IP data in bytes received over T6A Interface, but dropped by MME
t6a-data-bytes-tx-drop	Proprietary counter provides the total number of NON-IP data in bytes transmitted over T6A Interface, but transmission failed
The following bulk statistics are included in the SCEF Schema to track the SCEF service data:	
vpnname	The name of the VPN associated with the interface.
vpnid	The identification number of the context configured on the system that is currently facilitating the LCS service. This is an internal reference number. The identification number is generated during system startup
servname	The name of the LCS service for which these statistics are being displayed.
servid	The identification number of the LCS service for which these statistics are being displayed. This is an internal reference number. The identification number is generated during system startup
tot-active-sess	The current total number of active sessions per SCEF service.
tot-sess-failover	The total number of session failovers.
tot-sess-starts	The total number of session starts.
tot-sess-updates	The total number of session updates.
tot-sess-term	The total number of session terminations.
tot-msg-rcvd	The total number of messages received per SCEF service.
tot-msg-sent	The total number of messages sent by MME per SCEF service.
mo-data-req	The total number of MO data request sent by the MME.
mo-data-answer	The total number of MO data answers received by MME.
mo-data-retries	The total number of MO data request retries.
mo-data-timeout	The total number of MO data request timeout happened because of SCEF not responding.

Counters	Description
mo-data-dropped	The total number of MO data requests dropped at MME.
mt-data-req	The total number of MT data requests received.
mt-data-answer	The total number of MT data answer sent by MME to SCEF.
mt-data-retries	The total number of MT data retries received at MME.
mt-data-timeout	The total number of MT data time outs happened.
mt-data-dropped	The total number of MT data requests dropped at MME.
mt-data-req-buffered	The total number of MT Data Requests buffered temporarily.
mt-data-answer-buffered	The total number of MT Data Answers sent for buffered requests.
mt-data-buffered-dropped	The total number of buffered MT Data Answers dropped at MME.
config-info-req	The total number of Configuration Information Requests received at MME.
config-info-answer	The total number of Configuration Information Answer sent by MME.
config-info-retries	The total number of duplicate Configuration Information Requests received at MME.
config-info-timeout	The total number of Configuration Information Request timeout happened.
config-info-dropped	The total number of Configuration Information Requests dropped.
report-info-req	The total number of Report Information Requests sent by MME to SCEF.
report-info-answer	The total number of Report Information Answer recieved by MME.
report-info-retries	The total number of Report Information Requests retries sent by MME.
report-info-timeout	The total number of Report Information Requests timed out.
report-info-dropped	The total number of Report Information Requests dropped.
conn-mgmt-est-req	The total number of Connection-Management-Requests sent by MME for the connection action establishment.
conn-mgmt-est-answer	The total number of Connection-Management-Answers received for the connection action establishment.
conn-mgmt-est-retries	The total number of Connection-Management-Request retry happened for the connection action establishment.
conn-mgmt-est-answer-timeout	The total number of Connection-Management-Answer timeouts for the connection action establishment.
conn-mgmt-est-answer-dropped	The total number of Connection-Management-Answers dropped for the connection action establishment.

Counters	Description
conn-mgmt-rel-req	The total number of Connection-Management-Requests sent by MME for the connection action release.
conn-mgmt-rel-answer	The total number of Connection-Management-Answers received for the connection action release.
conn-mgmt-rel-retries	The total number of Connection-Management-Request retry happened for the connection action release.
conn-mgmt-rel-answer-timeout	The total number of Connection-Management-Answer timeouts for the connection action release.
conn-mgmt-rel-answer-dropped	The total number of Connection-Management-Answers dropped for the connection action release.
conn-mgmt-update-req	The total number of Connection-Management-Requests sent by MME for the connection action update.
conn-mgmt-update-answer	The total number of Connection-Management-Answers received for the connection action update.
conn-mgmt-update-retries	The total number of Connection-Management-Request retry happened for the connection action update.
conn-mgmt-update-answer-timeout	The total number of Connection-Management-Answer timeouts for the connection action release.
conn-mgmt-update-answer-dropped	The total number of Connection-Management-Answers dropped for the connection action release.
msg-error-other	The total number of other result error codes received from SCEF .
msg-error-unable-to-comply	The total number of result code diameter-unable-to-comply received from SCEF.
msg-error-user-unknown	The total number of result code user-unknown received from SCEF.
msg-error-rat-not-allowed	The total number of result code rat-not-allowed received from SCEF.
bad-answer-auth-app-id	The total number of bad answers received because of error in auth-app-id.
bad-answer-session-id	The total number of bad answers received because of invalid session id.
bad-answer-origin-host	The total number of bad answers received because of invalid origin host.
bad-answer-origin-realm	The total number of bad answers received because of invalid origin realm.
bad-answer-parse-msg-err	The total number of bad answers received because of message parse error.
bad-answer-parse-misc-err	The total number of bad answers received because of miscellaneous msg parse error.
bad-answer-answer-misc	The total number of bad answers received because of miscellaneous errors.



CHAPTER 6

Paging Enhancements on MME

This chapter describes the optimizations introduced in release 13 version of 3GPP specification to page for the availability of UE by eNB. The paging enhancements are introduced to support IoT requirements.

- [Feature Summary and Revision History, on page 77](#)
- [Feature Description, on page 78](#)
- [How it Works, on page 78](#)
- [Monitoring and Troubleshooting the Paging Enhancements, on page 79](#)

Feature Summary and Revision History

Summary Data

Applicable Product(s) or Functional Area	<ul style="list-style-type: none">• C-SGN• MME
Applicable Platform(s)	<ul style="list-style-type: none">• UGP• VPC-DI• VPC-SI
Feature Default	Disabled
Related Changes in This Release	Not applicable
Related Documentation	<ul style="list-style-type: none">• <i>Command Line Interface Reference</i>• <i>Statistics and Counters Reference</i>

Revision History

Revision Details	Release
The feature is tested and qualified on the ASR 5500 platform.	21.3

Revision Details	Release
First introduced.	N5.1 (21.1.V0)

Feature Description

MME supports encoding or decoding of these additional Information Elements (IEs) in S1AP layer as part of paging optimizations introduced in Release 13 version of 3GPP TS 36.413 standard.

The IEs supported for S1AP Paging are:

- **UE Radio Capability for Paging:** This IE contains paging specific UE Radio Capability information. This IE is sent in UE-CAPABILITY-INFO-INDICATION message over S1AP.
- **Information on Recommended Cells and eNodeBs (eNBs) for Paging:** This IE provides information on recommended cells and eNBs for paging. This IE is included in UE-CONTEXT-RELEASE-COMPLETE message.
- **Cell Identifier and Coverage Enhancement Level:** This IE provides information for paging CE capable UEs. This IE is included in UE-CONTEXT-RELEASE-COMPLETE message.
- **Assistance Data for Paging:** This IE provides assistance information for paging optimization. This IE is sent in PAGING request message to page a UE in one or several tracking areas.
- **Extended UE Identity Index Value:** This IE is used by the eNB to calculate the paging resources to be used for the UE. This IE is included in the PAGING request message.

The eNodeB sends paging assistance IEs as part of UE Context Release procedure. MME stores these decoded IEs and sends back this information during paging procedure to eNB in order for the EPC and the E-UTRAN to optimize usage of network resources.

The MME supports UE Radio Capability for Paging Information as per TS 23.401 standard. This is required for Cat-0/Cat-M1/NB-IoT devices to provide extended coverage.

The MME supports Extended UE Identity Index Value as per TS 36.413 standard. This new IE is always sent by the MME to eNB in the PAGING message. Since this is an optional IE, it is up to eNB whether to process or discard it.



Important This feature is license controlled. Contact your Cisco account representative for information on how to obtain a license.

How it Works

MME initiates paging procedure to page a UE by sending PAGING message to the eNB. MME includes "UE Radio Capability for Paging" and "Assistance Data for Paging" IEs if available for the UE. If the "UE Radio Capability for Paging" IE is included in the PAGING message, the eNB uses it to apply specific paging schemes. If the "Assistance Data for Recommended Cells" and "Assistance Data for CE Capable UEs" IEs are included in the Assistance Data for Paging IE, it is used along with the Paging Attempt Information IE if

present. If the "Next Paging Area Scope" information is included in the Paging Attempt Information IE, it is used for paging the UE.

The eNB controlling a UE-associated logical S1 connection initiates the procedure by sending a UE-CAPABILITY-INFO-INDICATION message to the MME. This message includes UE Radio Capability for Paging IE containing paging specific UE capability information. This information replaces any previously stored information in the MME for the UE. This information is transparent to MME, which stores the received information as is and sends back the same to eNB in S1-Paging message.

Upon successful operation of MME initiated UE-CONTEXT-RELEASE, the eNB, if supported, reports the following information "Information on Recommended Cells and eNBs for Paging" IE & "Cell Identifier and Coverage Enhancement Level" IE in UE-CONTEXT-RELEASE-COMplete message. The MME stores this information and sends back the same in subsequent Paging message initiated from MME. This information replaces any previously stored information in the MME for the UE. This information is transparent to MME, which stores the received information as is and sends back the same to eNB.

During Attach without PDN / Attach with CP Optimization enabled / TAU Attach with Attach without PDN enabled cases, MME sends the Connection Establishment Indication message without UE Radio Capability IE to eNB if it does not have the information after Attach Accept/TAU Accept. If eNB receives this message without UE Radio Capability IE, it fetches the data and sends it in the UE-CAPABILITY-INFO-INDICATION message.

Limitations

The following are the list of limitations with respect to the configuration of this feature:

- MME does not store the "UE Radio Capability for Paging" IE with a length exceeding 1024 bytes. This IE information is stored only when the maximum length of the IE is within 1024 bytes.
- MME recovers the stored "UE Radio Capability for Paging" information as part of session recovery, but does not recover the following information "Information on Recommended Cells and eNBs for Paging" and "Cell Identifier and Coverage Enhancement Level".

Monitoring and Troubleshooting the Paging Enhancements

This feature does not have any functional impact in the field if MME fails to decode the new S1AP IE(s);

- It continues to process the "UE-CONTEXT-RELEASE-COMplete" and release the resources if any exists for the S1 connection.
- It continues to send the S1-Paging as it is sending currently without the optional parameters.

If the feature is not working as expected, the following information needs to be collected to help debug the issue further:

- Output of **show mme-service session full imsi** <imsi> command will help to identify if MME is able to decode and store the "UE Radio Capability for Paging" IE as part of UE context.
- Output of **monitor subscriber ...** or **monitor protocol** command along with S1-AP protocol enabled for the affected subscriber where the dissected protocol information is available for all S1AP messages with the new IE(s).



Important MME does not store the received UE Radio Capability for Paging information if it exceeds the maximum allowed limit and it prints the following log, "2016-Aug-18+05:40:14.307 [mme-app 147072 debug] [2/0/14972 <sessmgr:1> access_s1.c:1461] [software internal user syslog] Error processing NAS msg. Length of UE Radio Capability for Paging IE is more than expected."

Paging Enhancements Show Command(s) and/or Outputs

This section provides information regarding show commands and/or their outputs in support of this feature.

The show commands in this section are available in support of the Paging Enhancement feature.

mme Schema

A new bulk statistic "s1ap-transdata-connestind" is added in this schema to count the total number of times MME has sent Connection Establishment Indication message over S1AP interface to eNodeB.

show mme-service session full imsi

A new field "Radio Capability for Paging" has been added to the output of this show command. This field displays the value in hexadecimal format if the UE received "UE Radio Capability for Paging" IE in S1 "UE-CAPABILITY-INFO-INDICATION" message from eNB. Otherwise, this field displays N/A.

show mme-service statistics

A new field "Connection Est Ind" is added to this command under Transmitted S1AP Statistics to display the total number of times MME has sent Connection Establishment Indication message over S1AP interface to eNodeB.

monitor protocol

This command is used for monitoring and troubleshooting a particular UE. When S1-AP protocol is enabled for the UE, this command displays the dissected protocol information for the associated IE(s).



CHAPTER 7

Power Saving Mode (PSM) in UEs

This feature describes the Power Saving Mode (PSM) support on the MME in the following sections:

- [Feature Summary and Revision History, on page 81](#)
- [Feature Description, on page 82](#)
- [How It Works, on page 84](#)
- [Configuring UE Power Saving Mode, on page 85](#)
- [Monitoring and Troubleshooting, on page 86](#)

Feature Summary and Revision History

Summary Data

Applicable Product(s) or Functional Area	<ul style="list-style-type: none">• C-SGN• MME
Applicable Platform(s)	<ul style="list-style-type: none">• UGP• VPC-DI• VPC-SI
Feature Default	Disabled
Related Changes in This Release	Not applicable
Related Documentation	<ul style="list-style-type: none">• <i>Command Line Interface Reference</i>• <i>Statistics and Counters Reference</i>

Revision History

Revision Details	Release
The feature is tested and qualified on the ASR 5500 platform.	21.3

Revision Details	Release
<ul style="list-style-type: none"> • If the packet-count value is not configured locally, the subscription value for packet-count is used. The subscription value can be “0”, in this case the packet count IE will not be sent for that subscriber even if it is configured locally. If the T3324 active and T3412 extended timers are locally configured these values are always used. If the UE does not request T3412 extended timer, then the value available in subscription data is used for Extended Periodic timer. If the values are not available in the subscription data then the values configured under the MME service are used. • If a session recovery occurs then the T3324 Active Timer restarts only for the remaining time of the total time configured before session recovery. Once the remaining time of the active timer elapses the UE moves to the power saving mode. • The DL-Buffering-Suggested-Packet-Count AVP is supported. 	<p>N5.1 (21.1.V0)</p>
<p>First introduced.</p>	<p>21.0</p>

Feature Description

Internet of Things (IoT) is a computing concept where everyday objects have internet connectivity and they can collect and exchange data. IoT is a network which can comprise of a wide variety of physical devices, vehicles, buildings, and any other device/object used in our daily lives. They are embedded with sensors, software and network connectivity which help them communicate with other devices in the network and can be controlled remotely thus increasing efficiency, accuracy and economic benefit. Any device/object which has to be a part of the IoT network must have:

- Long battery life
- Low device cost
- Low deployment cost
- Full network coverage
- Support to connect to large number of devices



Important This feature is license controlled. Please consult your Cisco Account Representative for information about the specific license.

Power Saving Mode (PSM) was introduced in 3GPP Release 12, to improve device battery life of IoT devices. The most significant benefit of this feature is the UE has more control in terms of power management required for its application. There are a wide range of IoT applications where flexibility of the UE to manage its power is very important and also implementation of PSM can prevent network congestion. The timers of all the devices can be managed using PSM, and the wake-up periods can be adjusted to be offset as much as possible. This way all of the devices will not wake at the same time and attempt to access the network. The PSM mode is similar to power-off but the UE remains registered on the network.

The UE activates PSM by including two timer values in the Attach or Tracking Area Update (TAU). The first timer is the T3324, which defines the time the UE stays active after idle mode following the Attach or TAU procedure. The second timer is an extended T3412 which defines the extended time for an UE to send periodic TAU.

Power Saving Mode Timers

T3324 Active Timer

The UE requests for a T3324 Active Timer value during Attach and TAU procedures. The MME allocates the T3324 value to the UE. The T3324 active timer determines the duration during which the device remains reachable for mobile terminated transaction on transition from connected to idle mode. The device starts the active timer when it moves from connected to idle mode and when the active timer expires, the device moves to Power Saving Mode. The MME takes the UE requested value and MME local configuration into account for determining the Active Timer value. The MME includes the T3324 value IE in the ATTACH ACCEPT/TAU ACCEPT message only if the T3324 value IE was included in the ATTACH REQUEST/TAU REQUEST message. A UE using PSM is available for mobile terminating services only for the period of an Active Time after a mobile originated event like data transfer or signaling for example after a periodic TAU/RAU procedure.

The MME allows a value of '0' for the T3324 timer. In this case the UE enters the Power Saving Mode immediately.

The Mobile reachability timer is set equal to the T3324 timer (Active Time). The MME allows a value of '0' for the T3324 timer. In this case the UE enters the Power Saving Mode immediately.

If a session recovery occurs then the active timer re-starts only for the remaining time of the total time configured before session recovery. Once the remaining time of the active timer elapses the UE moves to the power saving mode.

T3412 Extended Timer

The T3412 timer is also referred to as the periodic Tracking Area Update (TAU) timer. Periodic tracking area updating is used to periodically notify the availability of the UE to the network. The procedure is controlled in the UE by the periodic tracking area update timer (timer T3412). The value of timer T3412 is sent by the network to the UE in the ATTACH ACCEPT message and can be sent in the TRACKING AREA UPDATE ACCEPT message. The UE shall apply this value in all tracking areas of the list of tracking areas assigned to the UE, until a new value is received. A longer periodic TAU timer is possible using T3412 extended timer. When the UE includes the T3324 value IE and the UE indicates support for extended periodic timer value in the MS network feature support IE, it may also include the T3412 extended value IE. Apart from the value requested by the UE, the MME verifies the local configuration into account while selecting a value for the T3412 extended timer. When the MME includes the T3412 extended value IE in the ATTACH ACCEPT message or TRACKING AREA UPDATE ACCEPT message, the MME uses timer T3412 extended value IE as the value of timer T3412. The Implicit Detach Timer (IDT) is set to 4 minutes greater than the T3412 extended timer.

Other Feature Enhancements

The MME allows a value of "0" for timer T3324 (Which implies the UE enters Power Saving Mode immediately).

MME may also include Downlink buffer duration and "Downlink suggested packet count" in DDN ACK if it is configured.

The following new flags are introduced as part of this feature; these flags are supported in GTPCv2 Indication IE:

- Pending Network Initiated PDN Connection Signaling Indication (PNSI): The source MME supports sending of PNSI flag in GTPCv2 Indication IE of Context response.
- UE Available for Signaling Indication (UASI): The MME supports sending of the UASI flag in GTPCv2 Indication IE of Create Session Request and Modify Bearer Request to indicate to the PGW that the UE is available for end to end signaling.
- Delay Tolerant Connection Indication (DTCI): The MME supports receiving the DTCI flag in Create Session Response from the SGW. The MME supports receiving of the DTCI flag in Context Response and Forward Relocation Request from peer MME or S4-SGSN.
- Availability after DDN Failure: If there is an Availability after DDN Failure monitoring event configured for the UE in the MME/SGSN, the MME/SGSN does not invoke extended buffering. Instead, the MME/SGSN sets the Notify-on-available-after-DDN-failure flag to remember to send an Availability after DDN Failure notification when the UE becomes available. If there is a UE Reachability monitoring event configured for the UE in the MME/SGSN, the MME/SGSN does not invoke extended buffering.

The MME rejects CBR/UBR when PPF is False. The cause "UE is temporarily not reachable due to power saving" is sent in the response by the MME if the corresponding PDN was marked "Delay tolerant" by PGW.

How It Works

A subscriber is PSM enabled only when:

- The Power Saving Mode timers T3324 active and T3412 extended timers are configured.
- The MME supports Power Saving Mode for that subscriber.

A CLI based configuration is provided to configure the T3324 active and T3412 extended timers. The CLI provides an option to either accept UE requested values or MME configured values for these timers. When the PSM CLI configuration is enabled, the MME accepts the use of PSM and a UE requested value of T3324 is received in Attach/TAU request. If the CLI is configured to accept UE requested values of timers and if T3412 extended timer is not received from the UE along with T3324 in Attach/TAU request, then MME uses the same value of T3412 timer available in HSS subscription and if not, then MME service configuration. The values of T3324 and T3412 timers are determined based on the configuration. If the MME has allocated an Active Time (T3324) to the UE, then the MME starts the Active timer with the value of T3324 whenever the UE enters IDLE mode. If this timer expires, then MME clears the PPF (Paging Proceed Flag) and sets the IDT timer as "4" minutes greater than T3412 extended. When the PPF is clear, the MME does not page the UE on receiving a Downlink Data Notification message and sends a Downlink Data Notification Ack message with cause "Unable to page UE" to the Serving GW with DL buffering duration and DL suggested packet count IEs as per the operator configuration. The CLI option **dl-buf-duration** [**packet-count** *packet_value*] is used to optionally configure either to send or not send the downlink buffer duration in DDN Ack, the DDN Ack Optional IE "Downlink Suggested Packet Count" can also be configured. If this option is not configured and not sent in subscription, MME does not send IE in DDN reject. If the **packet-count** value is not configured locally, the subscription value for **packet-count** is used. The subscription value can be "0", in this case the packet count IE will not be sent for that subscriber even if it is configured locally. If the T3324 active and T3412 extended timers are locally configured these values are always used. If the **psm** command is configured to use the UE requested values for Active and Extended Periodic timers the UE requested values are accepted, but in case if the UE does not request T3412 extended timer, then the value available in subscription data are used for Extended Periodic timer. If the values are not available in the subscription data then the values configured under the MME service are used .

The MME rejects network initiated PDN connections during power saving mode. The MME sends the cause "UE is temporarily not reachable due to power saving" if the corresponding PDN was marked Delay Tolerant (DTCI flag set) by PGW. The source MME sets the PNSI flag in Context Response if there are any pending network initiated PDN connections (for example, Create Bearer Request/Update Bearer Request). The MME sets the UASI flag in the Create Session Request or Modify Bearer Request message when UE is available for end-to-end signaling. The UE is in PSM until a mobile originated event (for example periodic RAU/TAU, mobile originated data or detach) requires the UE to begin any procedure towards the MME.

Limitations

UE Power Saving Mode is not supported in the CS domain on the network side. A UE that uses mobile terminated IMS or CS services other than SMS should not use PSM as neither IMS nor the CS domain provide support for mobile terminated CS voice or IMS services to UEs that are in PSM.

As per latest version of 3GPP TS 24.008, the maximum value of T3412 extended timer can be "320*31" hours that is "35712000" seconds. Due to MME constraints on timer implementation the T3412 extended timer is restricted to 1050 hours that is "3780000" seconds. However, the nearest usable value of this timer as 3GPP TS 24.008 GPRS Timer 3 is 960 hours (320 * 3) that is 3456000 seconds.

Standards Compliance

The Power Saving Mode feature complies with the following standards:

- 3GPP TS 24.301 Release 13.5.0
- 3GPP TS 23.401 Release 13.5.0
- 3GPP TS 29.274 Release 13.5.0
- 3GPP TS 24.008 Release 13.5.0
- 3GPP TS 36.413 Release 13.5.0

Configuring UE Power Saving Mode

Use the following configuration in the Call Control Profile Configuration mode to configure the UE Power Saving Mode parameters.

```

configure
  call-control-profile profile_name
    [ remove ] psm { ue-requested [ dl-buf-duration [ packet-count
packet_value ] ] | t3324-timeout t3324_value t3412-extended-timeout t3412_ext_value
    [ dl-buf-duration [ packet-count packet_value ] ] }
  exit
  
```

Notes:

- The operator can use the **ue-requested** keyword when UE requested values for Active and Extended Periodic timers are to be accepted.

- The **dl-buf-duration** keyword is used to send the Downlink Buffer Duration in DDN ACK when unable to page UE. If this keyword is not configured, buffer duration will not be sent in DDN-ACK. By default, the buffer duration is not sent in DDN ACK.
- The **packet-count** keyword is used to send "DL Buffering Suggested Packet Count" in DDN ACK when unable to page UE. The packet count value is an integer ranging from 0 to 65535.
- The **t3324-timeout** keyword is used to configure the T3324 active timer value. The T3324 active timer is an integer ranging from 0 to 11160 seconds.
- The **t3412-timeout** keyword is used to configure the T3412 Extended timer value. The T3412 extended timer is an integer ranging from 0 to 35712000 seconds.
- The **remove** keyword is used to disable the UE power saving mode.
- This command is disabled by default.

Monitoring and Troubleshooting

This section provides information on how to monitor the UE Power Saving Mode feature and to determine that it is working correctly.

Show Command(s) and/or Outputs

This section provides information regarding show commands and/or their outputs updated in support of the UE Power Saving Mode feature.

The show commands in this section are available in support of this feature.

show call-control-profile full name

The PSM parameters are added to this command:

- UE Power Saving Mode - This section displays all the PSM related parameters.
- T3324 Timeout - Displays the T3324 timer value in seconds.
- T3412 Extended Timeout - Displays the T3412 extended timer value in seconds.
- Downlink Buffer Duration in DDN ACK - Displays if Downlink Buffer Duration in DDN ACK is either enabled or disabled.
- DL Buffering Suggested Packet Count in DDN ACK - Displays the DL buffering suggested packet count in DDN ACK.

show mme-service session all

The following new parameters are added to this command:

- UE Reachability Timer (PSM UE)
- T3412 Extended Timer
- UE Active Timer

- Remaining Time



Note These timers are calculated based on the **psm** command configuration in the Call Control Profile Configuration mode.

show mme-service statistics

The following new parameters are added to this command:

- PSM Subscribers: Displays information related to PSM subscribers.
- Attached Calls: Displays the number of attached subscribers for whom PSM is enabled.
- DDN Rejects: Displays the number of DDN rejects that have occurred for PSM enabled subscribers. A Downlink Data Notification (DDN) is rejected when an UE is in power saving mode.

show egtpc statistics verbose

The following new parameters are added to this command:

- UE not reachable due to PSM
- Create Bearer Denied
- Create Bearer Denied TX
- Update Bearer Denied
- Update Bearer Denied TX

The Create Bearer Request and Update Bearer Request are rejected when the UE is in Power Saving Mode. The MME sends the cause "EGTP_CAUSE_UE_TEMP_NOT_REACHABLE_DUE_TO_POWER_SAVING" in the reject message if that PDN is marked "Delay Tolerant" by P-GW (DTCI flag enabled in PDN Connection Indication IE of Create Session Response). Otherwise the MME sends the cause "EGTP_CAUSE_UNABLE_TO_PAGE_UE" to S-GW in CBR/UBR Reject.

UE Power Saving Mode Bulk Statistics

The following statistics are added in the MME Schema in support of the UE Power Saving Mode feature:

- attached-psm-subscriber - The current number of attached subscribers in PSM mode.
- ddn-rejects-psm - The total number of DDN rejects due to PSM ever since the chassis was up.

Diameter Attributes

Diameter Attribute Value Pairs (AVPs) carry specific authentication, accounting, authorization, routing and security information as well as configuration details for the request and reply.

The following Diameter attributes are added in support of this feature:

DL-Buffering-Suggested-Packet-Count

This AVP indicates the DL buffering suggested packet count.

Vendor ID 10415

VSA Type 1674

AVP Type Integer32

AVP Flag V-bit is set to true, M-bit is set to false.

Troubleshooting

The troubleshooting steps for operator configured and UE requested timers are described in this section.

Operator Configured Timers

The operator can configure the T3324 active and T3412 extended timer using the **psm** CLI command. The procedure below is a step-by-step procedure for troubleshooting.

1. The **psm** command in the Call Control Profile Configuration mode is used to configure the active and extended timers:

```
psm t3324-timeout 5 t3412-extended-timeout 1000
```



Note If the value of T3324 is set as 5 seconds, it will try to set the nearby value that is 4 seconds and if the value of T3412 extended timer is set as 1000 seconds, it will set as 960 seconds. See the *3GPP TS 24.008* for more information.

2. A subscriber with T3324 and T3412 extended timers sends the Attach Request.
3. The Attach request is completed and followed by the S1 release. The UE moves to an IDLE state.
4. On execution of the **show mme-service session** command, the following parameters are displayed:


```
UE Active Timer : 4 secs          Remaining Time : 2 secs
T3412 Extended Timer : 960 secs
```
5. The Paging Proceed Flag (PPF) changes to “FALSE” after the configured T3324 timer expires and the UE enters power saving mode.
6. Downlink Data Notification (DDN) is sent and it gets rejected as the UE is in power saving mode.
7. On execution of the **show mme-service statistics** command, the following parameters are displayed:


```
PSM Subscribers:
Attached Calls: 1          DDN Rejects: 1
```
8. The UE continues to be in power saving mode until the IDT timer expires or the UE initiates any other procedure.

UE Requested Timers

The user can enable the usage of UE requested values for Active and Extended Periodic timers by using the **ue-requested** keyword in the **psm** command. The procedure below is a step-by-step procedure for troubleshooting.

1. The **psm ue-requested** command in the Call Control Profile Configuration mode is used to configure the usage of UE requested active and extended timers.
2. A subscriber with T3324 and T3412 extended timers sends the Attach Request.
3. The Attach Request is completed and followed by the S1 release. The UE moves to an IDLE state.
4. The Paging Proceed Flag (PPF) changes to “False” after the T3324 expires (UE requested value) and the UE enters power saving mode.
5. The Create Bearer Request (CBR) is rejected when the PPF is “False”. The cause “UE is temporarily not reachable due to power saving” is sent in the response by the MME if the corresponding PDN was marked “Delay tolerant” by P-GW.
6. On execution of the **show egtpc statistics verbose** command, the following parameters are displayed:

```
Create Bearer Denied:
Create Bearer Denied TX:
UE not reachable due to PSM: 1
```




CHAPTER 8

Small Data over NAS, S11-U and SGI Interfaces

The MME support for small data transmission over NAS, S11-U and SGI interfaces is described in this chapter.

- [Feature Summary and Revision History, on page 91](#)
- [Feature Description, on page 92](#)
- [How it Works, on page 96](#)
- [Configuring Data over NAS, S11-U and SGI Interfaces, on page 106](#)
- [Monitoring and Troubleshooting Data over NAS, S11-U and SGI Interfaces, on page 111](#)

Feature Summary and Revision History

Summary Data

Applicable Product(s)	<ul style="list-style-type: none"> • C-SGN • MME
Applicable Platform(s)	<ul style="list-style-type: none"> • UGP • VPC-DI • VPC-SI
Default Setting	Disabled
Related Changes in This Release	Not applicable
Related Documentation	<ul style="list-style-type: none"> • <i>Command Line Interface Reference</i> • <i>Statistics and Counters Reference</i>

Revision History

Revision Details	Release
The feature is tested and qualified on the ASR 5500 platform.	21.3

Revision Details	Release
First introduced.	N5.1 (21.1.V0)

Feature Description

MME support for small data transmission over NAS, S11-U and SGi interfaces is a part of the CIoT EPS optimization. This feature describes the following aspects of small data transfer:

- IP data over NAS and S11-U interfaces
- Non-IP data over NAS and SGi interfaces

For information related to non-IP data over SCEF, see the *Non-IP Data Over SCEF* chapter in this guide.



Important This feature is license controlled. Contact your Cisco account representative for information on how to obtain a license.

As part of Release 13, the Narrowband Internet of Things (NB-IoT) is a new 3GPP defined radio interface. NB-IoT is optimized for machine type traffic. The NB-IoT RAT type is designed to reduce device costs and to minimize battery consumption. It is also adapted to work in difficult radio conditions, which is a frequent operational area for some machine type communication devices. Although NB-IoT is an independent radio interface, it is tightly connected with LTE and also shows up in its integration in the current LTE specifications.

The Non-Access Stratum (NAS) is a set of protocols in the Evolved Packet System. The NAS is used to convey non-radio signaling between the User Equipment (UE) and the Mobility Management Entity (MME) for an LTE/E-UTRAN access.

The NAS protocols perform:

- Mobility management - maintaining connectivity and active sessions with user equipment as the user moves
- Call control management
- Session management - establishing, maintaining and terminating communication links
- Identity management

The Access Stratum (AS) is the functional layer below NAS, working between the UE and radio network. It is responsible for transporting data over wireless connection and managing radio resources.

The S11-U interface is used for small data transmissions between the MME and S-GW. It is based on the existing GTP-U architecture. It is a GTPv1 user plane interface and carries small data sent and received over NAS between the MME and S-GW.

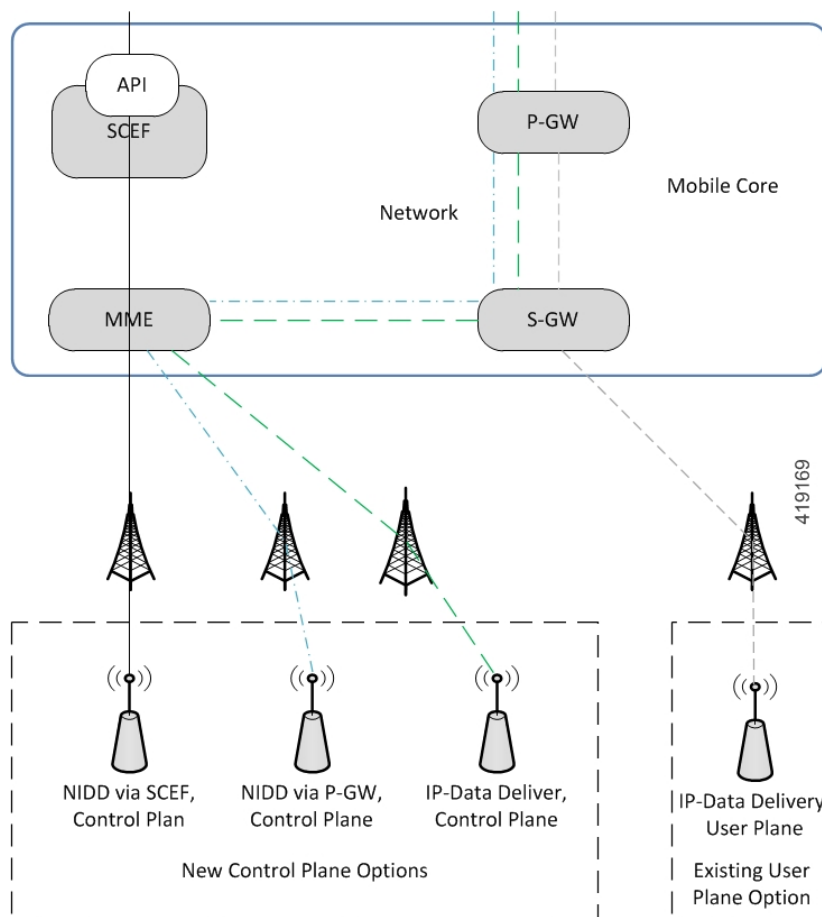
The SGi interface is an existing interface between the P-GW and packet data network (PDN). The PDN can be an operator’s external public or private packet data network or an intra-operator packet data network.

Data over NAS

Data over NAS is a mechanism designed for efficient small data transfer in 3GPP systems by using the existing signaling plane for small data transfer. Data over NAS utilizes the Signaling Radio Bearers (SRB) to carry data from UE to eNodeB. To facilitate small data transfer over NAS, the same data plane is used. This in turn results in reduced signaling and conserves the battery life of the UE. The user data is transported via the MME by encapsulating user data in NAS PDUs. This results in a reduced total number of control plane messages to send a short data transaction. Both IP and non-IP data can be sent over NAS. Small data transfer is even further optimized using Non-IP Data delivery (NIDD). Uplink data is transferred from the eNodeB to MME and data can also be transferred via the S-GW/P-GW (SGi) or to the SCEF and downlink data is also transmitted over the same paths in the reverse direction.

The following diagram illustrates the new control plane options for small data delivery.

Figure 4: Control Plane Architecture for Small Data Delivery



Data Delivery via SGi Interface

Small data delivery via SGi is supported for both IP and non-IP PDNs. The S-GW or P-GW are existing nodes used for data transfer. The uplink data is transferred from the eNodeB to MME and further to the S-GW and then to the P-GW. Downlink data is also transmitted over the same paths in the reverse direction.

- IP data delivery via SGi interface

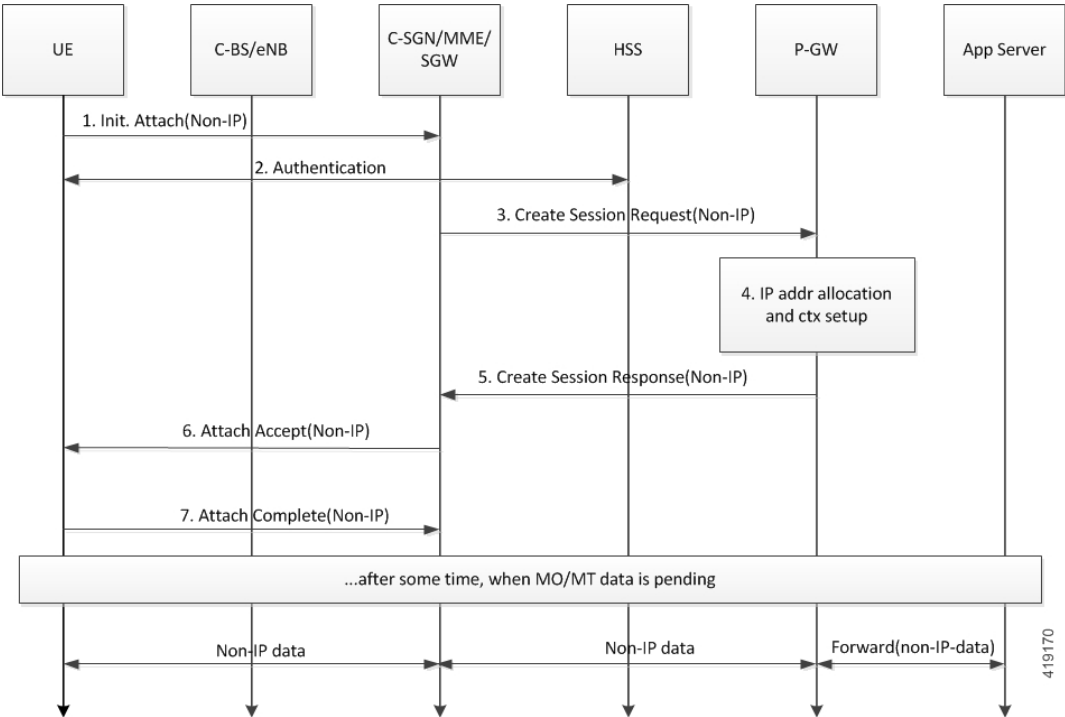
The IP packets are encapsulated in a transparent container in the EPS session management messages that are sent to the MME. The MME extracts the data from the container and forwards it to the S-GW, which in turn forwards it to the P-GW. The IP packets are then forwarded to the AS/Internet via the SGi interface. Data flows in the reverse direction in a similar manner.

• Non-IP data delivery via SGi interface

Non-IP data delivery is supported via the SGi interface using different point-to-point tunneling techniques. Point-to-point tunneling by UDP or IP encapsulation can be used. Support for the SGi based delivery of non-IP data can be used by any UE.

The following call flow illustrates non-IP data delivery over the SGi interface.

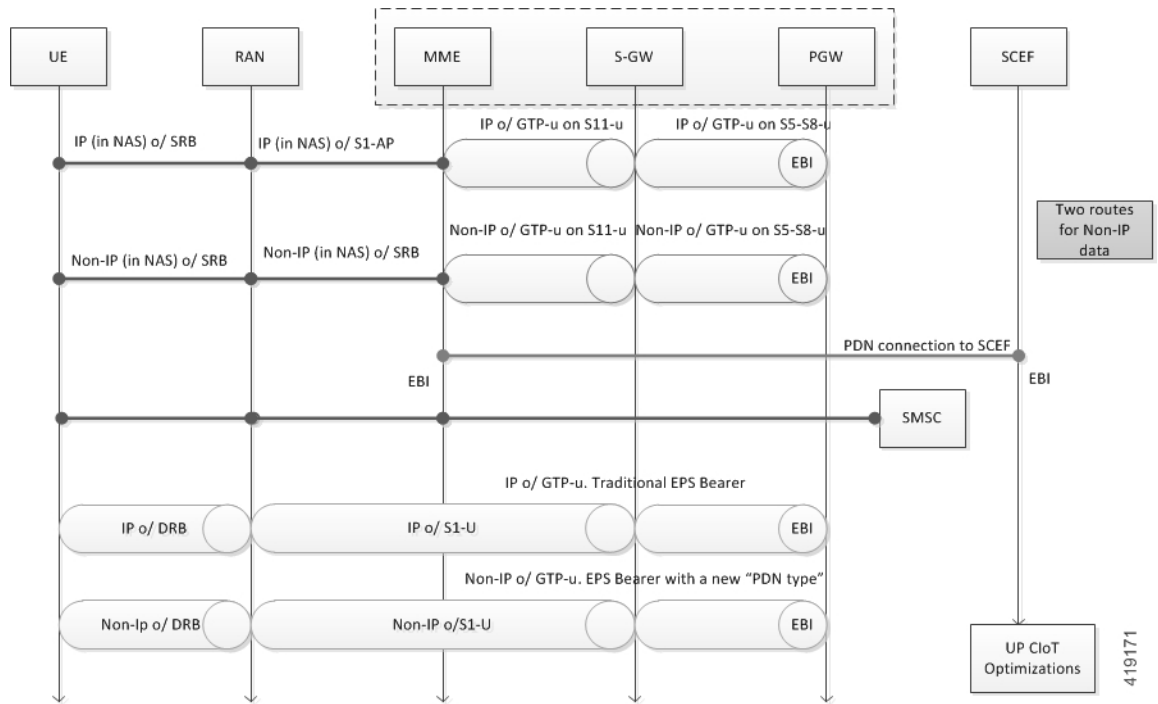
Figure 5: Non-IP Data Delivery over the SGi Interface



Architecture

The following diagram illustrates the various data paths possible with and without CIoT EPS optimization for IP and non-IP data.

Figure 6: Data Paths - CloT Optimization for IP and Non-IP Data



- **S1 interface:** Exists between the eNodeB (RAN) and MME. It carries the signaling for data radio bearer (DRB) setup and NAS PDU (includes UE signaling and small data over NAS).
- **NAS:** The Non-Access Stratum (NAS) is a set of protocols between the UE and MME. It carries the UE signaling data for mobility management and session management. NAS allows small data to be transmitted using the Signaling Radio Bearer (SRB) over the S1AP protocol.
- **S1-U interface:** Exists between the E-UTRAN and S-GW for per bearer user plane tunneling and inter-eNodeB path switching during handover.
- **S5-C interface:** Exists between the S-GW and P-GW to control signaling. It is a GTPv2 control interface for tunnel management, creation/modification/deletion of per bearer user plane tunneling on the S5-U interface.
- **S5-U interface:** Exists between the S-GW and P-GW for user plane tunneling between S-GW and P-GW. It is a GTPv1 user plane interface for carrying IP and non-IP data within GTP-U.
- **S11-C interface:** Exists between the MME and S-GW to control signaling. It is a GTPv2 control interface for creation or modification or deletion of per bearer user plane tunneling on the S1-U and S11-U interfaces.
- **S11-U interface:** Exists between the MME and S-GW. It is a GTPv1 user plane interface and allows small data transmission over NAS between MME and S-GW.
- **SGi interface:** Exists between the P-GW and packet data network (PDN). The PDN can be an operator's external public or private packet data network or an intra-operator packet data network.
- **T6a interface:** Exists between the SCEF and MME. It enables transfer of non-IP data between MME and SCEF.

IP data over S1-U is the traditional IP data path from the UE to eNodeB over DRB and the eNodeB to S-GW over S1-U. IP data over S11-U makes use of CP CIoT optimization. The data path from the UE to eNodeB is over SRB, eNodeB to MME is over S1AP/NAS, and MME to S-GW is over the S11-U interface.

Non-IP data over S1-U interface is the traditional data path from the UE to eNodeB over DRB and the eNodeB to S-GW over S1-U. Non-IP data over S11-U makes use of CP CIoT optimization. The data path from the UE to eNodeB is over SRB, eNodeB to MME is over S1AP/NAS, and MME to S-GW is over the S11-U interface.

Non-IP data over T6a makes use of CP CIoT optimization. The data path from UE to the eNodeB is over SRB, eNodeB to MME is over NAS/S1AP, and MME to SCEF is over the T6a interface.

Relationships to Other Features

The MME supports other CIoT optimization functions in order to provide support for IoT devices in the EPS network. The related features are:

- MME support for CIoT devices
- CIoT Optimizations for NB-IoT RAT and Attach Without PDN Connectivity Support
- Non-IP data over SCEF
- SMS over MME without SGs or CS attach

Refer to the other feature chapters in this guide for more information.

How it Works

The following sections describe the Control Plane CIoT optimization, small data over NAS, data over S11-U interface, IP data over NAS and S11-U interface, and Non-IP data over NAS and SGi interface.

Control Plane CIoT Optimization

The MME supports Control Plane CIoT optimization. The significant changes on the MME to support CP CIoT optimization are:

- The **ciot-optimisation** CLI command added in the Call Control Profile configuration mode enables or disables CP CIoT optimization for an UE. This command is used to specify the access type extension on which control plane optimization must be enabled. Control plane optimization can be enabled on both NB-IoT and WB-EUTRAN RATs or on either of them.
- The MME supports NAS IEs for CIoT optimization, additional octet in UE network capability (now 6 octets), additional octet in EPS Network Feature Support IE, additional Update Type and additional Update Result are included in the NAS IE. The activate default EPS bearer context request is marked as applicable only to control plane.
- The MME supports both attach with and without PDN.
- Intra-MME TAU with CP CIoT optimization is supported.
- A new PDN connection is supported as a part of CP CIoT optimization.
- Idle to Active transition and vice versa is allowed as a part of CP CIoT optimization.

- When CIoT optimization is enabled, it is assumed that all the S-GWs in the network support CIoT optimizations.
- No dedicated bearers are set up when CP CIoT optimization is enabled.
- No radio bearers are set up at the eNodeB for UEs using CP CIoT optimization.
- There is no change in the paging functions supported by the MME after the implementation of CIoT optimization.
- There is no change in the P-GW selection process and it is based on the APN as in the case of earlier releases. In case of non-IP PDNs, all the P-GWs serving the non-IP APN must be capable to route non-IP data and P-GWs are configured to route non-IP data.
- After a session manager re-start, the MME supports recovery of CP CIoT subscribers.

Small data over NAS

Small data over NAS supports the following features:

- Partial ciphering for NAS messages
- NAS messages required for CP CIoT optimization with related NAS IE's are:
 - Control Plane Service Request
 - ESM Data Transport message
 - Service Accept
- Extended PCO (ePCO) IE in NAS
- Signaling Active Flag in TAU messages
- Release Assistance Indication received from UE is honored.
- New statistics are added to display the following information:
 - NAS messages received and sent.
 - Number of packets sent or received over NAS.
 - Number of data packets sent or received over NAS per UE, per PDN and per MME service.

New bulk statistics are added corresponding to the new counters listed above.

- MME data buffering is not supported.

Data over S11-U Interface

Data over S11-U interface supports the following features:

- A new S11-U interface is introduced. The S11-U interface is a reference point between MME and Serving GW for user plane. It uses the existing GTPU protocol. It is a GTPv1 user plane interface and carries small data sent and received over NAS between MME and S-GW. The S11-U interface is introduced as a part of Control Plane CIoT EPS optimization.
- S11-C IEs are supported in the GTPCv2 control messages for corresponding S11-U information.

- Allocation and de-allocation of MME-S11U FTEID for S11-U data tunnel termination at MME is supported.
- The MME supports path management for the S11-U interface.
- Sending and receiving GTPU path failure and error indication on S11-U interface is supported.
 - On detecting Path Failure, all sessions on that path are disconnected.
 - On receiving Error Indication, session corresponding to that TEID is disconnected.
- Specific DSCP value can be configured for packets sent over the S11-U interface.
- S11-U GTPU sessions are recovered after a session manager restart.
- New statistics are introduced to display information on data packets sent or received over the S11-U per UE, per PDN and per MME service.
- New statistics are introduced to display information data packet sent/received over S11-U per GTPU service.

IP data over NAS and S11-U Interface

IP data over NAS and S11-U interface supports the following features:

- The S11-U interface is a reference point between the MME and S-GW for user plane. It uses the existing GTP-U protocol. It is a GTPv1 user plane interface and carries small data sent and received over NAS between the MME and S-GW. The S11-U interface is added as a part of Control Plane CIoT EPS optimization.
- S11-C IEs are supported in the GTPCv2 control messages for corresponding S11-U information.
- New statistics are introduced to display information on data packets sent or received over the S11-U per UE, per PDN and per MME service. Corresponding bulk statistics are added for IP data over NAS.

Non-IP data over NAS and SGi Interface

Non-IP data over NAS and SGi interface supports the following features:

- The S11-U interface is a reference point between the MME and S-GW for user plane. It uses the existing GTP-U protocol. It is a GTPv1 user plane interface and carries small data sent and received over NAS between the MME and S-GW. The S11-U interface is introduced as a part of Control Plane CIoT EPS optimization.
- S11-C IEs are supported in the GTPCv2 control messages for corresponding S11-U information.
- The CLI command added in the APN Profile Configuration mode configures the PDN type as either IP or non-IP. It is used to override the HSS provided APN subscription PDN type. This configuration is applicable during attach and additional PDN connectivity not during handovers. This command is also used to configure the non-IP data delivery mechanism (SGi/SCEF).
- Additional Context Identifier in the APN configuration is supported within the HSS subscription. It is used to select the default non-IP APN, when the UE has subscription for IP and non-IP APNs.
- Non-IP data delivery mechanism is supported. The SCEF ID and SCEF Realm can be specified using the **pdn-type** command in the APN Profile Configuration mode.

- Bearer Type IE in S1 Initial Context Setup / ERAB Setup / Handover Request message is supported. This bearer type is non-IP delivery mechanism (SGi) as non-IP for Non-IP PDNs using S1-U path. It is applicable for Non-IP PDN without CP CIoT optimization while using SGi interface and S1U path.
- The “Non-IP” PDN type is supported for GTPCv2 control messages towards S-GW/MME.
- Extended PCO (ePCO) in GTPCv2 control messages towards S-GW is supported.
- Inter and Intra RAT MME handovers for non-IP PDNs are supported without CP CIoT optimization (that is, while using S1-U interface for data path.)
- Inter MME or SGSN handover with CP CIoT optimization is not supported (that is, either for IP or non-IP).
- Non-IP PDNs which cannot not be transferred to the peer node are locally de-activated during handover (due to peer MME/SGSN limitation). New handover statistics for PDNs deactivated and handovers rejected due to peer not supporting non-IP PDN are displayed.
- New statistics are introduced to display information on Non-IP data packets sent/received over the S11-U interface per UE, per PDN and per MME service.
- New bulk statistics corresponding to the statistics are added for Non-IP data over NAS.

Limitations

The known limitations with this feature are listed below:

- The MME does not support buffering of data.
- The MME does not support User Plane CIoT optimization.
- The maximum size of NAS PDU supported is 2KB.
- Switching data path from control plane CIoT optimization to S1-U while the UE is in ECM-connected state is not supported.
- Enforcement of Serving PLMN rate limit is not done at the MME.
- Inter-MME/SGSN handovers are not supported when control plane CIoT optimization is implemented (for both IP and non-IP).
- Intra-MME handovers are not supported when control plane CIoT optimization is implemented (for both IP and non-IP).
- Inter-MME/SGSN idle mode mobility is not supported when control plane CIoT optimization is implemented (for both IP and Non-IP).
- APN remap is not supported for non-IP PDN type.
- Idle mode handover to peer SGSN is not supported for Non-IP SGi PDNs.
- IPv6 is not supported for the S11-U interface.
- Execution of the **associate** or **no associate** command in the GTPU service under the MME EGTP service restarts the MME service.
- Removal or addition of the GTPU service that is already associated with the MME EGTP service restarts the MME service.

Call Flows

Attach with PDN using CP CIoT Optimization (SGi Path)

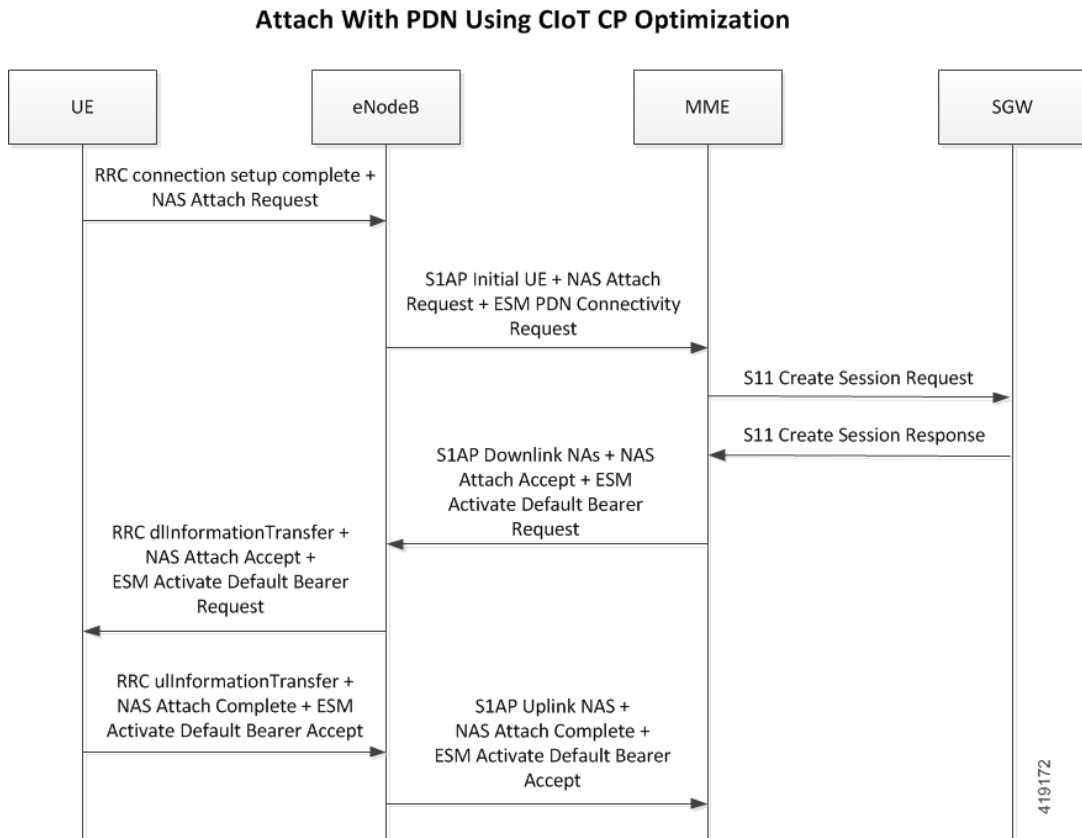
The following call flow diagram displays the Attach with PDN procedure with CP CIoT optimization.

This call flow does not display the following:

- HSS interaction for authentication and S6a Location update
- UE authentication
- Security setup

However, these procedures are applicable and performed by the MME for this call flow.

Figure 7: Attach with PDN using CIoT Optimization



Attach with CP CIoT optimization performs bearer setup on the UE and network (SGi/SCEF) without reserving radio resources in the RAN. Data Radio Bearer (DRB) is not setup on the eNodeB for the UE. Signaling Radio Bearer (SRB) is used for all communication over the air interface between UE and the eNodeB. The MME does not send the S1 Initial Context Setup request to the eNodeB. The eNodeB does not send RRC re-configuration to the UE as there is no Initial Context Setup at the eNodeB. The MME sends a NAS Attach Accept to the UE in S1 Downlink NAS Transport message instead of S1 Initial Context Setup request. The UE sends NAS Attach Complete in the S1 Uplink NAS Transport message. The MME establishes the S11-U

tunnel during S11 Create Session request/response signalling. S11 Modify Bearer request sent is not sent to the S-GW after Attach Complete is received from UE.

Step 1: The UE sends the RRC connection set up complete message and the NAS attach request to the eNodeB.

Step 2: The eNodeB sends the S1AP Initial UE Message, NAS attach request message and ESM PDN connectivity request to the MME.

Step 3: The MME sends the S11 create session request to the S-GW.

Step 4: The S-GW responds to the MME with the S11 create session response.

Step 5: The MME sends the S1AP downlink NAS message, NAS attach accept and ESM activate default bearer request to the eNodeB.

Step 6: The eNodeB in turn sends the RRC downlink information transfer message, NAS attach accept and ESM activate default bearer request to the UE.

Step 7: The UE sends the RRC uplink information transfer message, NAS attach complete and an ESM activate default bearer accept message to the eNodeB.

Step 8: The eNodeB sends the S1AP uplink NAS message, NAS attach complete and ESM activate default bearer accept message to the MME.

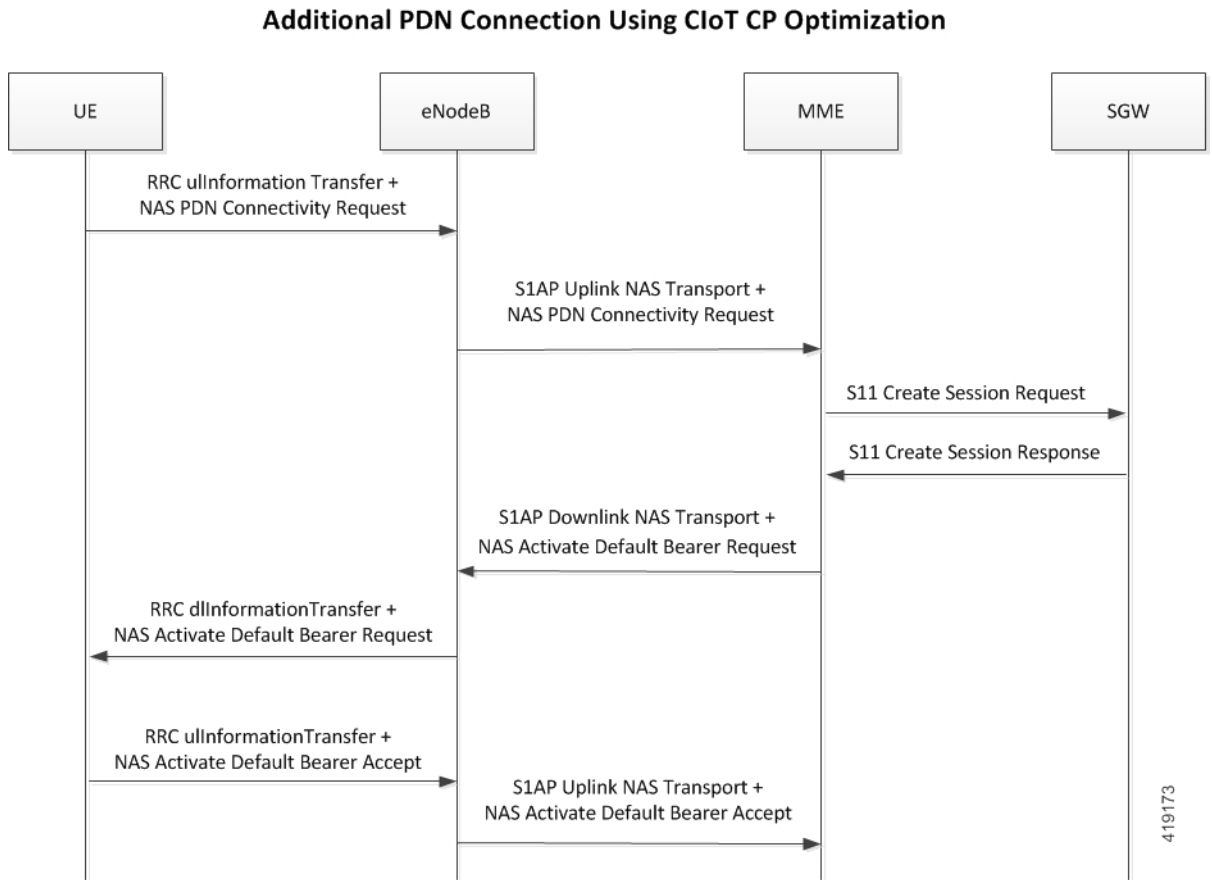
Additional PDN Connection with CP CloT Optimization

The following call flow diagram displays the additional PDN connection procedure with CP CloT optimization.

This call flow does not display the HSS interaction for S6a notify request.

However, these procedures are applicable and performed by the MME for this call flow.

Figure 8: Additional PDN Connection using CloT CP Optimization



Additional PDN connection with CP CloT optimization performs bearer setup on the UE and network (SGi/SCEF) without reserving radio resources in the RAN. Data Radio Bearer (DRB) is not setup on the eNodeB for the UE. Signaling Radio Bearer (SRB) is used for all communication over the air interface between UE and eNodeB. The MME does not send S1 ERAB Setup request to eNodeB. The eNodeB does not send RRC reconfiguration to the UE as there is no S1 ERAB Setup at the eNodeB. The MME sends a NAS Activate default EPS bearer context request to UE in S1 Downlink NAS Transport message instead of S1 ERAB Setup request. The UE sends NAS Activate Default Bearer Accept in the S1 Uplink NAS Transport message. The MME establishes the S11-U tunnel during S11 Create Session request/response signaling. S11 Modify Bearer request is not sent to the S-GW after Activate Default Bearer Accept is received from UE.

Step 1: The UE sends the RRC uplink information transfer message and the NAS PDN connectivity request to the eNodeB.

Step 2: The eNodeB sends the S1AP uplink NAS transport Message and the NAS PDN connectivity request to the MME.

Step 3: The MME sends the S11 create session request to the S-GW.

Step 4: The S-GW responds to the MME with the S11 create session response.

Step 5: The MME sends the S1AP downlink NAS transport message and the NAS activate default bearer request to the eNodeB.

Step 6: The eNodeB in turn sends the RRC downlink information transfer message and the NAS activate default bearer request accept to the UE.

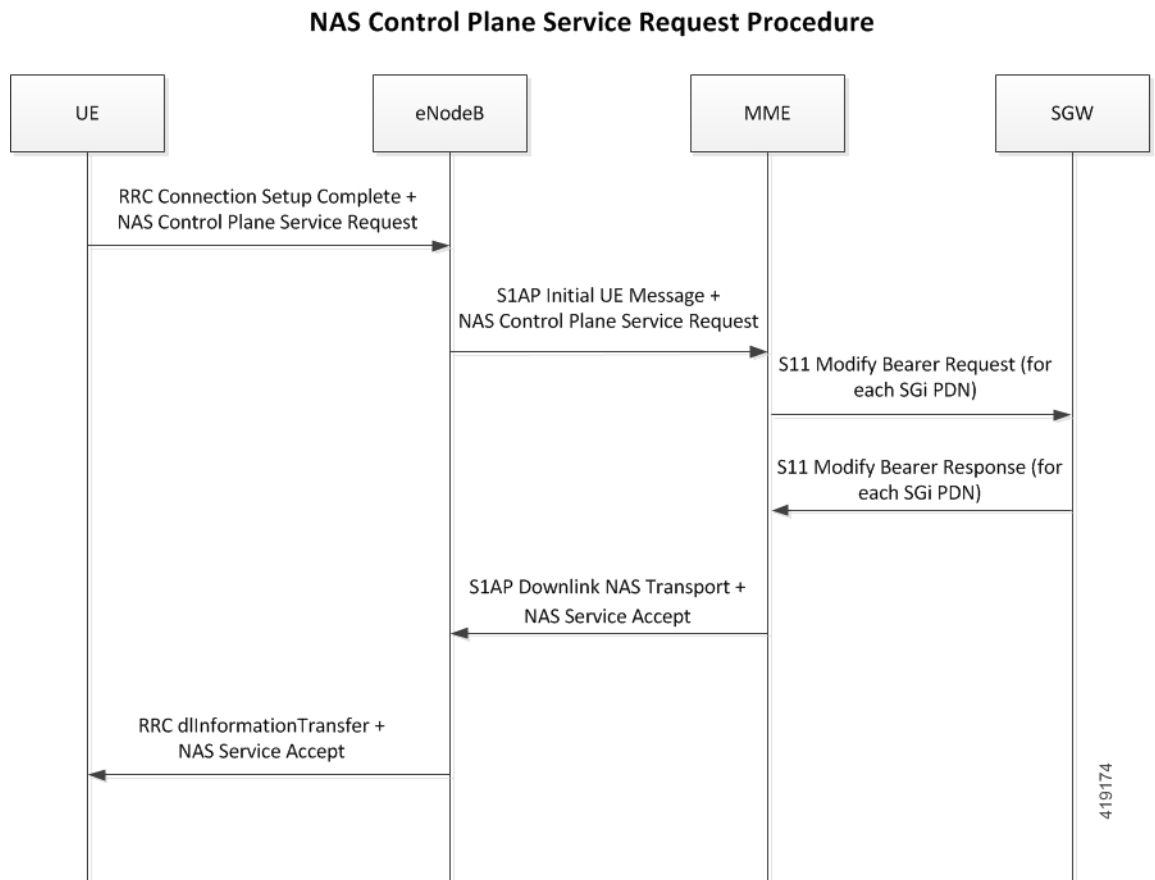
Step 7: The UE sends the RRC uplink information transfer message and the NAS activate default bearer accept message to the eNodeB.

Step 8: The eNodeB sends the S1AP uplink NAS message and the NAS activate default bearer accept message to the MME.

Idle to Active Transition with Control Plane Service Request

The following call flow diagram displays an Idle to Active mode state transition for a CIoT UE.

Figure 9: NAS Control Plane Service Request Procedure



A CIoT UE transitioning from idle to active mode does not reserve any radio resources in the RAN. Data Radio Bearer (DRB) is not setup on the eNodeB for the UE. Signaling Radio Bearer (SRB) is used for all communication over the air interface between UE and the eNodeB. The MME does not send S1 Initial Context Setup request to the eNodeB. The eNodeB does not send RRC re-configuration to the UE as there is no Initial Context Setup at the eNodeB. The MME sends a NAS Service Accept to UE in S1 Downlink NAS Transport message and it brings up S11U tunnel for each SGi PDN through S11 Modify Bearer request/response signaling with the S-GW.

Step 1: The UE sends the RRC connection set up complete message and NAS control plane service request to the eNodeB.

Step 2: The eNodeB sends the S1AP initial UE message and NAS control plane service request to the MME.

Step 3: The MME sends the S11 modify bearer request to the S-GW for each SGi PDN.

Step 4: The S-GW responds to the MME with the S11 modify bearer response for each SGi PDN.

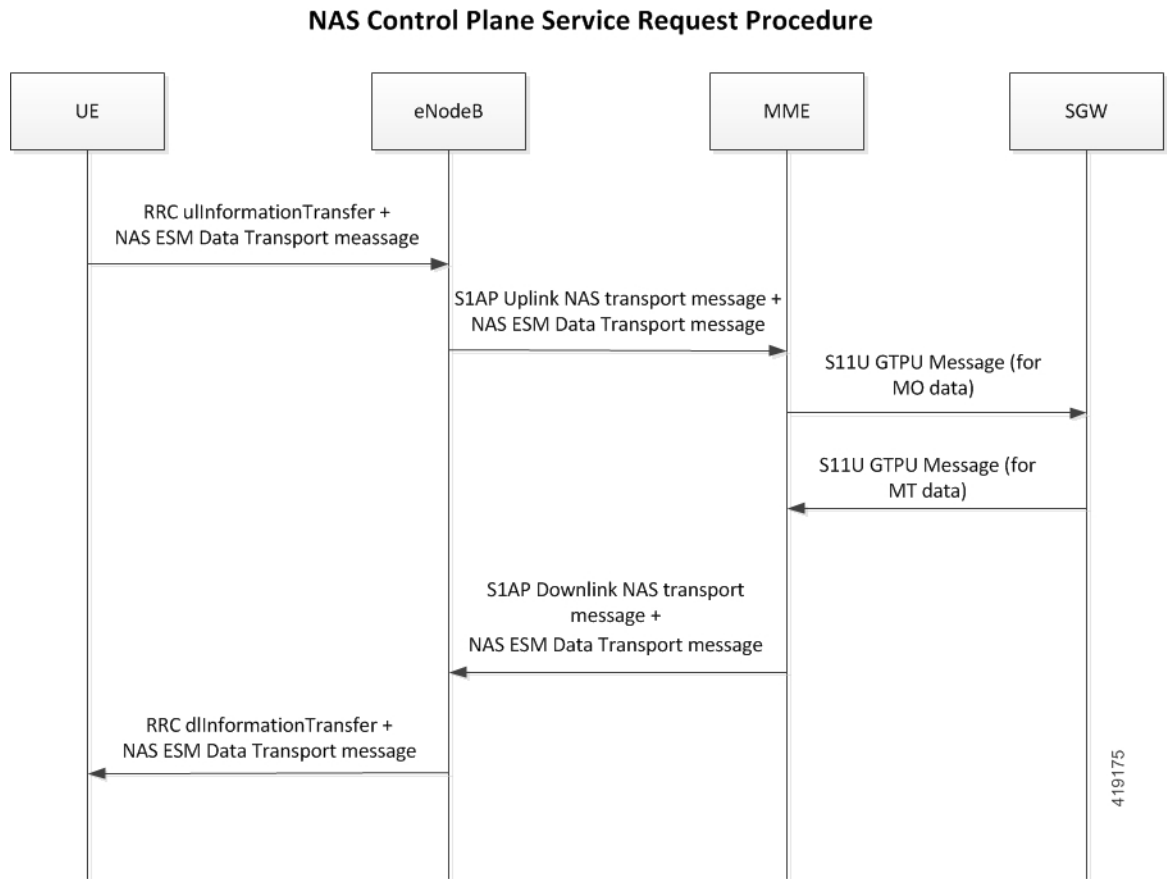
Step 5: The MME sends the S1AP downlink NAS transport message and NAS service accept message to the eNodeB.

Step 6: The eNodeB in turn sends the RRC downlink information transfer message and the NAS service accept message to the UE.

MO and MT Data Exchange with CP CloT Optimization

The following call flow diagram displays MO and MT data exchange with CloT UE in active state (connected mode).

Figure 10: NAS Control Plane Service Request Procedure



MO and MT data exchange utilizes the SRB to carry data over NAS. The MME receives the ESM payload in NAS message from the UE and sends it to the S-GW over GTP-U using S11-U tunnel. The MME receives the GTP-U payload from S-GW over S11-U tunnel and sends it to the UE in a NAS message.

MO data can be sent by the UE to MME in the following NAS messages:

- NAS Control Plane Service Request

- NAS ESM Data Transport Message

MT data can be sent by the MME to the UE in the "NAS ESM Data Transport Message" message.

Step 1: The UE sends the RRC uplink information transfer message and the NAS ESM data transport message to the eNodeB.

Step 2: The eNodeB sends the uplink NAS transport message and the NAS ESM data transport message to the MME.

Step 3: The MME sends the S11-U GTP-U message to the S-GW for MO data.

Step 4: The S-GW responds to the MME with the S11-U GTP-U message for MT data.

Step 5: The MME sends the S1AP downlink NAS transport message and the NAS ESM data transport message to the eNodeB.

Step 6: The eNodeB in turn sends the RRC downlink information transfer message and the NAS ESM data transport message to the UE.

Standards Compliance

The Small Data over NAS, S11-U and SGi Interfaces feature complies with the following standards:

- **3GPP TS 36.413 v13.4.0 (2016-09)**, 3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access Network (E-UTRAN); S1 Application Protocol (S1AP) (Release 13)
- **3GPP TS 23.401 v13.8.0 (2016-09)**, 3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; General Packet Radio Service (GPRS) enhancements for Evolved Universal Terrestrial Radio Access Network (E-UTRAN) access (Release 13)
- **3GPP TS 24.301 v13.7.0 (2016-09)**, 3rd Generation Partnership Project; Technical Specification Group Core Network and Terminals; Non-Access-Stratum (NAS) protocol for Evolved Packet System (EPS); Stage 3 (Release 13)
- **3GPP TS 29.272 v13.7.0 (2016-09)**, 3rd Generation Partnership Project; Technical Specification Group Core Network and Terminals; Evolved Packet System (EPS); Mobility Management Entity (MME) and Serving GPRS Support Node (SGSN) related interfaces based on Diameter protocol (Release 13)
- **3GPP TS 29.274 v13.7.0 (2016-09)**, 3rd Generation Partnership Project; Technical Specification Group Core Network and Terminals; 3GPP Evolved Packet System (EPS); Evolved General Packet Radio Service (GPRS) Tunneling Protocol for Control plane (GTPv2-C); Stage 3 (Release 13)
- **3GPP TS 23.682 v13.7.0 (2016-09)**, 3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; Architecture enhancements to facilitate communications with packet data networks and applications (Release 13)

Configuring Data over NAS, S11-U and SGi Interfaces

Configuring Control Plane CIoT Optimization

The **ciot-optimisation** CLI command has been introduced under the Call Control Profile to enable CIoT optimization for an UE.

```

configure
  call-control-profile profile_name
    ciot-optimisation [ cp-optimisation access-type { all | nb-iot | wb-eutran } | eps-attach-wo-pdn access-type { all | nb-iot | wb-eutran } ]
  remove ciot-optimisation cp-optimisation
  remove ciot-optimisation eps-attach-wo-pdn access-type { all | nb-iot | wb-eutran }
  exit

```

Notes:

- The **ciot-optimisation** command enables CIoT optimization for an UE.
- The **cp-optimisation** keyword enables Control Plane optimization for an UE.
- The **remove** keyword deletes the existing configuration.
- The **access-type** keyword specifies the access type extension on which control plane optimization must be enabled. Control plane optimization can be enabled on both NB-IoT and WB-EUTRAN RATs or on either of them. Enabling one RAT type overrides the existing configuration.
- The **all** keyword enables control plane optimization for all access types. Both NB-IoT and WB-EUTRAN are considered as two independent access types for all functions.
- The **nb-iot** keyword enables control plane optimization for NB-IoT access type.
- The **wb-eutran** keyword enables control plane optimization for WB-EUTRAN access type.
- The **eps-attach-wo-pdn** keyword enables EPS attach without PDN support for an UE.
- The call-control-profile can be associated with the operator-policy and the CIoT optimization can be enabled or disabled on a per subscriber (IMSI) basis.
- This command is disabled by default.

Verifying the Configuration

Execute the **show call-control-profile full name** *profile-name* command to verify the configured values. For example:

```

show call-control-profile full name profile_name
  CIoT Optimisation:
    CIoT Optimisation: Enabled/Disabled
    Access-Type: all/nb-iot/wb-eutran/N/A

```

Configuring PDN Type in the APN Profile

The **pdn-type** CLI command added in the APN Profile Configuration mode specifies the PDN type indicator in the APN profile.

```

configure
  apn-profile profile_name
    pdn-type { ip | non-ip { sgi | t6a [ scef-id scef_id [ scef-realm
realm_name ] ] } }
    remove pdn-type
  exit
  
```

Notes:

- Use this command to specify the Cellular IoT PDN type. The user has an option to override the HSS provided APN subscription PDN type. This command is applicable only during Attach and additional PDN connectivity, and not during Handover scenarios.
- The **remove** keyword deletes the existing configuration.
- The **ip** keyword configures the Cellular IoT PDN type as IP PDN.
- The **non-ip** keyword configures the Cellular IoT PDN type as non-IP PDN.
- The **sgi** keyword configures the Cellular IoT Non-IP PDN delivery path type as SGI.
- The **t6a** keyword configures the Cellular IoT Non-IP PDN delivery path type as T6a.
- The **scef-id** *scef_id* keyword optionally specifies the SCEF ID. The *scef_id* is an alphanumeric string of 1 to 63 characters.
- The **scef-realm** *realm_name* keyword optionally specifies the SCEF diameter realm name. The *realm_name* is an alphanumeric string of 1 to 127 characters.
- This command is disabled by default.

Verifying the Configuration

Execute the **show apn-profile** *profile_name* command to verify the configured values. For example:

```

show apn-profile full name profile_name
PDN Type : NON-IP/IP/Not configured
NON-IP Delivery Mechanism Type : SGi/T6a
SCEF-Id : SCEF_Identifier
SCEF-Realm : SCEF_diameter_realm_name
  
```

Configuring Serving PLMN Rate Control

The **serving-plmn-rate-control** CLI command added in the Call Control Profile Configuration mode configures the serving PLMN rate control for control plane CIoT optimization. The serving PLMN rate control limits the rate at which UE or P-GW / SCEF sends data over the control plane when CP optimization is enabled.

```

configure
  call-control-profile profile_name
    serving-plmn-rate-control ul-rate ul_rate_value dl-rate dl_rate_value
  
```

```
remove serving-plmn-rate-control
exit
```

Notes:

- The **remove** keyword deletes the existing configuration.
- The **ul-rate** *ul_rate_value* keyword configures the maximum number of data NAS PDUs that the UE can send in uplink path per deci-hour (6 minutes). The uplink rate is an integer from 10 up to 65535. A value of 65535 in this case implies no limit on the number of PDUs that the UE can send in the uplink path per deci-hour.
- The **dl-rate** *dl_rate_value* keyword configures the maximum number of data NAS PDUs that the P-GW / SCEF can send in the downlink path to the UE per deci-hour (6 minutes). The downlink rate is an integer from 10 up to 65535. A value of 65535 in this case implies no limit on the number of PDUs that the P-GW / SCEF can send in the downlink path per deci-hour.
- This command is disabled by default.

Verifying the Configuration

Execute the **show call-control-profile full name** *profile_name* command to verify the configured values. For example:

```
show call-control-profile full name profile_name
Serving PLMN Rate Control : Enabled/Disabled
  UL Rate                  : x pdus per deci hour.
  DL Rate                  : x pdus per deci hour.
```

Configuring DSCP Value in the GTPU Packets from MME on the S11-U Interface

The **ip** CLI command added in the APN Profile Configuration mode defines the IP parameters for the APN profile. This command is used to configure:

- SGSN/S-GW action in response to detected IP source violations
- DSCP marking for downlink and uplink configuration per traffic class
- QoS class diffserv code

The **s11u-mme** keyword is added in this command which is used to configure the S11-U interface parameters.

```
configure
  apn-profile profile_name
    ip { qos-dscp { { { downlink | uplink } { background forwarding |
conversational forwarding | interactive traffic-handling-priority priority
forwarding | streaming forwarding } + } | s11u-mme value } | source-violation
  { deactivate [ all-pdp | exclude-from accounting | linked-pdp |
tolerance-limit } | discard [ exclude-from-accounting ] | ignore }
    default ip { qos-dscp [ downlink | uplink | s11u-mme ] |
source-violation }
    no ip qos-dscp { downlink | uplink } { background | conversational
| interactive | streaming } +
```



Important All parameters that are not specifically configured will be included in the configuration with default values.

Notes:

- The **default** keyword resets the configuration to the default values.
- The **no** keyword disables the specified IP QoS-DSCP mapping.
- The **qos-dscp** keyword configures the Differentiated Services Code Point (DCSP) marking to be used for sending packets of a particular 3GPP QoS class.
- The **s11u-mme** keyword configures the S11-U interface parameters. The DSCP values can be specified using this keyword. The DSCP value for S11-U interface can be separately specified for each APN. This keyword is not enabled by default. The default value is “**be**”.

The DSCP values configured for the S11-U interface are:

- af11 - Designates use of Assured Forwarding 11 PHB
- af12 - Designates use of Assured Forwarding 12 PHB
- af13 - Designates use of Assured Forwarding 13 PHB
- af21 - Designates use of Assured Forwarding 21 PHB
- af22 - Designates use of Assured Forwarding 22 PHB
- af23 - Designates use of Assured Forwarding 23 PHB
- af31 - Designates use of Assured Forwarding 31 PHB
- af32 - Designates use of Assured Forwarding 32 PHB
- af33 - Designates use of Assured Forwarding 33 PHB
- af41 - Designates use of Assured Forwarding 41 PHB
- af42 - Designates use of Assured Forwarding 42 PHB
- af43 - Designates use of Assured Forwarding 43 PHB
- be - Designates use of Best Effort forwarding PHB
- cs0 - Designates use of Class Selector 0 PHB
- cs1 - Designates use of Class Selector 1 PHB
- cs2 - Designates use of Class Selector 2 PHB
- cs3 - Designates use of Class Selector 3 PHB
- cs4 - Designates use of Class Selector 4 PHB
- cs5 - Designates use of Class Selector 5 PHB
- cs6 - Designates use of Class Selector 6 PHB
- cs7 - Designates use of Class Selector 7 PHB

- ef - Designates use of Expedited Forwarding PHB

Sample Configuration



Important If you modify the **interface-type** command, the parent service (service within which the eGTP/GTP-U service is configured) will automatically restart. Service restart results in dropping of active calls associated with the parent service.

```

configure
  call-control-profile profile_name
    ciot-optimisation cp-optimisation access-type all
    ciot-optimisation eps-attach-wo-pdn access-type all
  exit
  operator-policy name policy_name
    associate call-control-profile profile_name
    apn network-identifier apn_net_id_1 apn-profile apn_profile_name_1

    apn network-identifier apn_net_id_1 apn-profile apn_profile_name_1

  exit
  apn-profile profile_name_1
    pdn-type non-ip t6a
  exit
  apn-profile profile_name_2
    pdn-type non-ip sgi
  exit
  lte-policy
    subscriber-map map_name
      precedence number match-criteria all operator-policy-name
policy_name
    exit
  exit
  context ingress
    mme-service service_name
      bind s1-mme ipv4-address ipv4_address
      s1-mme sctp port port_number
      mme-id group-id id mme-code code
      plmn-id mcc mcc_value mnc mnc_value
      associate egtp-service egtp_svc_name context context_name
      associate hss-peer-service svc_name context context_name
      associate subscriber-map map_name
    exit
  egtp-service service_name
    interface-type interface-mme
    gtpc bind ipv4-address ipv4_address
    associate gtpu-service name
  exit
  gtpu-service service_name
  
```

```

        bind ipv4-address ipv4_address
    exit
exit
end

```

The configuration can be verified by issuing the following show commands:

- **show configuration**
- **show mme-service all**
- **show call-control-profile full all**
- **show apn-profile full all**

Monitoring and Troubleshooting Data over NAS, S11-U and SGi Interfaces

This section provides information on show commands, disconnect reasons, diameter attributes and bulk statistics for this feature.

Show Command(s) and/or Outputs

show call-control-profile full name *profile_name*

The following new fields are added to the output of this command to display the configured CP ClOT optimization parameters:

- ClOT Optimisation
- CP-Optimisation
- Access-Type
- Serving PLMN Rate Control
- UL Rate
- DL Rate

show apn-profile full name *profile_name*

The following new fields are added to the output of this command to display the configured PDN type:

- PDN Type
- Non-IP Delivery Mechanism Type
- SCEF-Id
- SCEF-Realm

show subscriber all

The following new field is added to the output of this command to display the new network type:

- (N) – Non-IP

show mme-service session full all

The following new fields are displayed in the output of this command if CP CIoT optimization is enabled:

- CIoT Optimisation Information
 - NB-IoT RAT
 - Attach Without PDN Support
 - CP-CIoT Optimization
- PDN Type
- PDN Data Delivery Interfacea
- Non-IP Data Delivery Mechanism Identifier
- S11U MME TEID: Displays the S11U MME Tunnel Identifier.
- S11U SGW TEID: Displays the S11U SGW Tunnel Identifier
- S11U MME IPv4 Addr: Displays the S11U MME IPv4 transport address
- S11U MME IPv6 Addr: Displays the S11U MME IPv6 transport address
- S11U SGW IPv4 Addr: Displays the S11U SGW IPv4 transport address
- S11U SGW IPv6 Addr: Displays the S11U SGW IPv6 transport address

show mme-service db record imsi *imsi_number*

The following new fields are added to the output of this command:

- Non-IP-PDN-Type-Indicator
- Non-IP-Data-Delivery-Mechanism
- SCEF-ID
- SCEF-Realm

show mme-service statistics

The following new ECM statistics are added to display the UE-initiated CP service request events and network-initiated CP service request events. These parameters are displayed only if CP CIoT optimization is enabled.

- UE Initiated CP Service Request Events
 - Attempted
 - Success

- Failures
- NW Initiated CP Service Request Events
 - Attempted
 - Success
 - Failures
- New EMM message statistics are added to display the number of NAS service accept messages sent, partially ciphered NAS messages received and NAS control plane service request messages received:
 - Service Accept
 - Partially Ciphered messages
 - CP Service Request
- New ESM procedure statistics are added to display the number of Non-IP PDN Connections over SCEF (t6a), Non-IP PDN Connections over SGI (s1u or s11u) and PDN Disconnections over SCEF (t6a) attempted, successful and failed:
 - NON-IP PDN Connections With SCEF
 - Attempted
 - Success
 - Failures
 - NON-IP PDN Connections With SGI
 - Attempted
 - Success
 - Failures
 - NON-IP PDN Connections With SCEF
 - Attempted
 - Success
 - Failures
- New statistics are added to display the Non-IP PDN statistics - the number of non-IP PDN Connections over SCEF (T6a), number of Non-IP PDN Connections over SGI (S1U or S11-U) and all non-IP PDN connections (the total sum of non-IP PDN connections over SCEF and SGI):
 - NON-IP PDN Statistics
 - All PDNs
 - SCEF PDNs
 - SGI PDNs

- New statistics have been added to display the number of attached calls, connected calls and idle calls for NB-IoT subscribers, Attach without PDN subscribers and CP-CIoT enabled subscribers:
 - NB-IoT Subscribers
 - Attached Calls
 - Connected Calls
 - Idle Calls
 - Attach Without PDN Subscribers
 - Attached Calls
 - Connected Calls
 - Idle Calls
 - CP-CIoT Enabled Subscribers
 - Attached Calls
 - Connected Calls
 - Idle Calls

- New statistics have been added to the show output and are grouped according to:
 - Data over NAS statistics
 - IP data over S11-U statistics
 - Non-IP data over S11-U statistics
 - Data over T6a statistics

Received packets (Rx packets), Received bytes (Rx Bytes), Transmitted packets (Tx Packets), Transmitted Bytes (Tx Bytes), Received packets dropped (Rx Drop Packets), Received Bytes dropped (Rx Drop Bytes), Transmitted packets dropped (Tx Drop Packets) and Transmitted bytes dropped (Tx Drop Bytes) are displayed for each of the above listed group of statistics.

- Data Over NAS Statistics
 - Rx Packets
 - Rx Bytes
 - Tx Packets
 - Tx Bytes
 - Rx Drop Packets
 - Rx Drop Bytes
 - Tx Drop Packets
 - Tx Drop Bytes

- IP Data Over S11U Statistics
 - Rx Packets
 - Rx Bytes
 - Tx Packets
 - Tx Bytes
 - Rx Drop Packets
 - Rx Drop Bytes
 - Tx Drop Packets
 - Tx Drop Bytes

- NON-IP Data Over S11U Statistics
 - Rx Packets
 - Rx Bytes
 - Tx Packets
 - Tx Bytes
 - Rx Drop Packets
 - Rx Drop Bytes
 - Tx Drop Packets
 - Tx Drop Bytes

- Data Over T6A (SCEF) Statistics
 - Rx Packets
 - Rx Bytes
 - Tx Packets
 - Tx Bytes
 - Rx Drop Packets
 - Rx Drop Bytes
 - Tx Drop Packets
 - Tx Drop Bytes

show mme-service statistics verbose

New statistics are added to display number of Idle mode Outbound Relocation using TAU/RAU Denied, Idle mode Outbound Relocation using TAU/RAU with PDN deactivation at MME, Connected mode Outbound Relocation Denied and Connected mode Outbound Relocation with PDN deactivation at MME.

- NON-IP Statistics
 - Outbound Relocation for TAU/RAU - Denied (Context Failure)
 - No SGI Non-IP sup by peer MME
 - No SCEF Non-IP sup by peer MME
- Outbound Relocation for TAU/RAU - PDN Deactivation
 - No SGI Non-IP sup by peer S3 SGSN o No SCEF Non-IP sup by peer S3 SGSN
 - No SGI Non-IP sup by peer Gn SGSN
 - No SCEF Non-IP sup by peer Gn SGSN
 - No SGI Non-IP sup by peer MME
 - No SCEF Non-IP sup by peer MME
- Outbound Handover Denied (HO Prep Failure)
 - No SGI Non-IP sup by peer Node
 - No SCEF Non-IP sup by peer Node
- Outbound Relocation using S1HO/SRNS/PSHO - PDN Deactivation
 - No SGI Non-IP sup by peer S3 SGSN
 - No SCEF Non-IP sup by peer S3 SGSN
 - No SGI Non-IP sup by peer Gn SGSN
 - No SCEF Non-IP sup by peer Gn SGSN
 - No SGI Non-IP sup by peer MME
 - No SCEF Non-IP sup by peer MME

show mme-service session counters imsi *imsi_number*

The following new fields are added to the output of this command. These statistics are displayed only when CP CIoT optimization is enabled.

- ECM events:
 - UE Initiated CP Service Request Event
 - Attempted
 - Success
 - Failures
 - NW Initiated CP Service Request Events
 - Attempted
 - Success

- Failures
- ESM events:
 - NON-IP PDN Connections to SCEF
 - Attempted
 - Success
 - Failures
 - NON-IP PDN Connections to SGI:
 - Attempted
 - Success
 - Failures
 - PDN Disconnections to SCEF:
 - Attempted
 - Success
 - Failures
 - Control Plane User Data Statistics:
 - Cumulative Data Over NAS Statistics:
 - Rx Packets
 - Rx Bytes
 - Tx Packets
 - Tx Bytes
 - Rx Drop Packets
 - Rx Drop Bytes
 - Tx Drop Packets
 - Tx Drop Bytes
 - Cumulative IP Data Over S11U Statistics:
 - Rx Packets
 - Rx Bytes
 - Tx Packets
 - Tx Bytes
 - Rx Drop Packets

- Rx Drop Bytes
- Tx Drop Packets
- Tx Drop Bytes
- Cumulative Non- IP Data Over S11U Statistics:
 - Rx Packets
 - Rx Bytes
 - Tx Packets
 - Tx Bytes
 - Rx Drop Packets
 - Rx Drop Bytes
 - Tx Drop Packets
 - Tx Drop Bytes
- Cumulative Data Over T6A (SCEF) Statistics:
 - Rx Packets
 - Rx Bytes
 - Tx Packets
 - Tx Bytes
 - Rx Drop Packets
 - Rx Drop Bytes
 - Tx Drop Packets
 - Tx Drop Bytes
- Per PDN Statistics
- APN Name
- Data Over NAS Statistics
 - Rx Packets
 - Rx Bytes
 - Tx Packets
 - Tx Bytes
 - Rx Drop Packets
 - Rx Drop Bytes
 - Tx Drop Packets

- Tx Drop Bytes
- IP Data Over S11U Statistics:
 - Rx Packets
 - Rx Bytes
 - Tx Packets
 - Tx Bytes
 - Rx Drop Packets
 - Rx Drop Bytes
 - Tx Drop Packets
 - Tx Drop Bytes
- Non-IP Data Over S11U Statistics:
 - Rx Packets
 - Rx Bytes
 - Tx Packets
 - Tx Bytes
 - Rx Drop Packets
 - Rx Drop Bytes
 - Tx Drop Packets
 - Tx Drop Bytes
- Data Over T6A (SCEF) Statistics:
 - Rx Packets
 - Rx Bytes
 - Tx Packets
 - Tx Bytes
 - Rx Drop Packets
 - Rx Drop Bytes
 - Tx Drop Packets
 - Tx Drop Bytes
- Partially Ciphared messages

show session disconnect-reasons verbose

The following new statistics are added to the output of this command:

- mme-gtpu-path-failure-s11u
- mme-gtpu-err-ind-s11u

Bulk Statistics

The following bulk statistics are added in the MME Schema in support of the Small Data over NAS, S11-U and SGI Interfaces feature.

Table 8: MME Schema

Counter	Description
NAS bulk statistics	
nas-data-pkts-rx	Total number of user data packets received over NAS.
nas-data-pkts-tx	Total number of user data packets transmitted over NAS.
nas-data-bytes-rx	Total number of user data in bytes received over NAS.
nas-data-bytes-tx	Total number of user data in bytes transmitted over NAS.
nas-data-pkts-rx-drop	Total number of user data in bytes received over NAS, but dropped by MME.
nas-data-pkts-tx-drop	Total number of user data in bytes transmitted over NAS, but transmission failed.
S11-U IP data bulk statistics	
s11u-ip-data-pkts-rx	Total number of IP packets received over S11U Interface.
s11u-ip-data-pkts-tx	Total number of IP packets transmitted over S11U Interface.
s11u-ip-data-bytes-rx	Total number of IP data in bytes received over S11U Interface.
s11u-ip-data-bytes-tx	Total number of IP data in bytes transmitted over S11U Interface.
s11u-ip-data-pkts-rx-drop	Total number of IP packets received over S11U Interface, but dropped by MME.
s11u-ip-data-pkts-tx-drop	Total number of IP packets transmitted over S11U Interface, but transmission failed.

Counter	Description
s11u-ip-data-bytes-rx-drop	Total number of IP data in bytes received over S11U Interface, but dropped by MME.
s11u-ip-data-bytes-tx-drop	Total number of IP data in bytes transmitted over S11U Interface, but transmission failed.
S11-U Non-IP data bulk statistics	
s11u-nonip-data-pkts-rx	Total number of NON-IP packets received over S11U Interface.
s11u-nonip-data-pkts-tx	Total number of NON-IP packets transmitted over S11U Interface.
s11u-nonip-data-bytes-rx	Total number of NON-IP data in bytes received over S11U Interface.
s11u-nonip-data-bytes-tx	Total number of NON-IP data in bytes transmitted over S11U Interface.
s11u-nonip-data-pkts-rx-drop	Total number of NON-IP packets received over S11U Interface, but dropped by MME.
s11u-nonip-data-pkts-tx-drop	Total number of NON-IP packets transmitted over S11U Interface, but transmission failed.
s11u-nonip-data-bytes-rx-drop	Total number of NON-IP data in bytes received over S11U Interface, but dropped by MME.
s11u-nonip-data-bytes-tx-drop	Total number of NON-IP data in bytes transmitted over S11U Interface, but transmission failed.
EMM message bulk statistics	
emm-msgrx-cp-service-req	Total number of EMM control messages received - Control Plane service requests.
emm-msgtx-service-accept	Total number of EMM Service Accept messages sent.
emm-msgrx-partially-ciphered	Total number of EMM control messages received - partially ciphered messages.
ESM message bulk statistics	
esm-msgtx-esm-data-transport	Total number of ESM control messages sent - ESM Data Transport.
esm-msgrx-esm-data-transport	Total number of ESM control messages received - ESM Data Transport.
CP CIoT subscribers bulk statistics	
attached-cp-ciot-subscriber	Total number of attached UEs with CP Optimization Enabled.

Counter	Description
connected-cp-ciot-subscriber	Total number of CP Optimization Enabled subscribers in connected state.
idle-cp-ciot-subscriber	Total number of CP Optimization Enabled subscribers in idle state.
Non-IP PDN bulk statistics	
nonip-pdn-all	Total number of Non-IP PDN connections.
nonip-pdn-scef	Total number of Non-IP PDN connections with SCEF.
nonip-pdn-sgi	Total number of Non-IP PDN connections with SGI.
ECM procedure bulk statistics	
ecmevent-ue-cp-srvcreq-attempt	Total number of EPS Connection Management events - UE-initiated service requests - attempted.
ecmevent-ue-cp-srvcreq-success	Total number of EPS Connection Management events - UE-initiated service requests - successes.
ecmevent-ue-cp-srvcreq-failure	Total number of EPS Connection Management events - UE-initiated service requests - failures.
ecmevent-nw-cp-srvcreq-attempt	Total number of EPS Connection Management events - Network-initiated service requests - attempted.
ecmevent-nw-cp-srvcreq-success	Total number of EPS Connection Management events - Network-initiated service requests - successful.
ecmevent-nw-cp-srvcreq-failure	Total number of EPS Connection Management events - Network-initiated service requests - failures.
Non-IP PDN connect procedure bulk statistics	
esmevent-nonip-pdncon-scef-attempt	Total number of EPS Session Management events - PDN connections of PDN type Non-IP with SCEF - attempted.
esmevent-nonip-pdncon-scef-success	Total number of EPS Session Management events - PDN connections of PDN type Non-IP with SCEF - successes.
esmevent-nonip-pdncon-scef-failure	Total number of EPS Session Management events - PDN connections of PDN type Non-IP with SCEF - failures.
esmevent-nonip-pdncon-sgi-attempt	Total number of EPS Session Management events - PDN connections of PDN type Non-IP with SGI - attempted.

Counter	Description
esmevent-nonip-pdncon-sgi-success	Total number of EPS Session Management events - PDN connections of PDN type Non-IP with SGI - successes.
esmevent-nonip-pdncon-sgi-failure	Total number of EPS Session Management events - PDN connections of PDN type Non-IP with SGI - failures.
Idle mode handover of non-IP PDN bulk statistics	
outbound-tau-rau-denied-no-sgnipdn-sup	Total number of Outbound Context failure due to Peer's limitation for SGI Non-IP PDN support.
outbound-tau-rau-denied-no-scnipdn-sup	Total number of Outbound Context failure due to Peer's limitation for SCEF Non-IP PDN support.
outbound-tau-rau-pdn-deact-no-sgnipdn-sup-s3	Total number of PDN deactivations during Outbound TAU/RAU due to Peer S3 SGSN limitation for SGI Non-IP PDN support.
outbound-tau-rau-pdn-deact-no-sgnipdn-sup-gn	Total number of PDN deactivations during Outbound TAU/RAU due to Peer GN SGSN limitation for SGI Non-IP PDN support.
outbound-tau-rau-pdn-deact-no-sgnipdn-sup-mme	Total number of PDN deactivations during Outbound TAU/RAU due to Peer MME limitation for SGI Non-IP PDN support.
outbound-tau-rau-pdn-deact-no-scnipdn-sup-s3	Total number of PDN deactivations during Outbound TAU/RAU due to Peer S3 SGSN limitation for SCEF Non-IP PDN support.
outbound-tau-rau-pdn-deact-no-scnipdn-sup-gn	Total number of PDN deactivations during Outbound TAU/RAU due to Peer GN SGSN limitation for SCEF Non-IP PDN support.
outbound-tau-rau-pdn-deact-no-scnipdn-sup-mme	Total number of PDN deactivations during Outbound TAU/RAU due to Peer MME limitation for SCEF Non-IP PDN support.
Connected mode handover of non-IP PDN bulk statistics	
outbound-ho-denied-no-sgnipdn-sup	Total number of Outbound S1Ho/SRNS/PSHO failure due to Peer's limitation for SCEF Non-IP PDN support.
outbound-ho-pdn-deact-no-sgnipdn-sup-s3	Total number of PDN deactivations during Outbound S1HO/SRNS/PSHO due to Peer S3 SGSN limitation for SGI Non-IP PDN support.
outbound-ho-pdn-deact-no-sgnipdn-sup-gn	Total number of PDN deactivations during Outbound S1HO/SRNS/PSHO due to Peer GN SGSN limitation for SGI Non-IP PDN support.

Counter	Description
outbound-ho-pdn-deact-no-sgnipdn-sup-mme	Total number of PDN deactivations during Outbound S1HO/SRNS/PSHO due to Peer MME limitation for SGI Non-IP PDN support.
outbound-ho-pdn-deact-no-scnipdn-sup-s3	Total number of PDN deactivations during Outbound S1HO/SRNS/PSHO due to Peer S3 SGSN limitation for SCEF Non-IP PDN support.
outbound-ho-pdn-deact-no-scnipdn-sup-gn	Total number of PDN deactivations during Outbound S1HO/SRNS/PSHO due to Peer GN SGSN limitation for SCEF Non-IP PDN support.
outbound-ho-pdn-deact-no-scnipdn-sup-mme	Total number of PDN deactivations during Outbound S1HO/SRNS/PSHO due to Peer MME limitation for SCEF Non-IP PDN support.
outbound-ho-denied-no-sgnipdn-sup	Total number of outbound S1HO/SRNS/PSHO failure due to Peer's limitation for SGI Non-IP PDN support.
outbound-ho-denied-no-scnipdn-sup	Total number of Outbound S1Ho/SRNS/PSHO failure due to Peer's limitation for SCEF Non-IP PDN support.
outbound-ho-pdn-deact-no-sgnipdn-sup-s3	Total number of PDN deactivations during Outbound S1HO/SRNS/PSHO due to Peer S3 SGSN limitation for SGI Non-IP PDN support.
outbound-ho-pdn-deact-no-sgnipdn-sup-gn	Total number of PDN deactivations during Outbound S1HO/SRNS/PSHO due to Peer GN SGSN limitation for SGI Non-IP PDN support.
outbound-ho-pdn-deact-no-sgnipdn-sup-mme	Total number of PDN deactivations during Outbound S1HO/SRNS/PSHO due to Peer MME limitation for SGI Non-IP PDN support.
outbound-ho-pdn-deact-no-scnipdn-sup-s3	Total number of PDN deactivations during Outbound S1HO/SRNS/PSHO due to Peer S3 SGSN limitation for SCEF Non-IP PDN support.
outbound-ho-pdn-deact-no-scnipdn-sup-gn	Total number of PDN deactivations during Outbound S1HO/SRNS/PSHO due to Peer GN SGSN limitation for SCEF Non-IP PDN support.
outbound-ho-pdn-deact-no-scnipdn-sup-mme	Total number of PDN deactivations during Outbound S1HO/SRNS/PSHO due to Peer MME limitation for SCEF Non-IP PDN support.

Disconnect Reasons

The following disconnect reasons are added in support of the Small Data over NAS, S11-U and SGi Interfaces feature.

- **mme-gtpu-path-failure-s11u:** This disconnect reason is pegged when the session gets disconnected due to path failure on S11-U path between MME and S-GW.
- **mme-gtpu-err-ind-s11u:** This disconnect reason is pegged when the session gets disconnected due to GTP-U Error Indication received on S11-U interface on MME.

Diameter Attributes

Diameter Attribute Value Pairs (AVPs) carry specific authentication, accounting, authorization, routing and security information as well as configuration details for the request and reply.

The following Diameter attributes are added in support of the Small Data over NAS, S11-U and SGi Interfaces feature.

Non-IP-PDN-Type-Indicator

This AVP indicates whether the APN has a Non-IP PDN type.

Vendor ID 10415

VSA Type 1681

AVP Type ENUM

AVP Flag V

Non-IP-Data-Delivery-Mechanism

This AVP indicates the mechanism to be used for Non-IP data delivery for a given APN.

Vendor ID 10415

VSA Type 1682

AVP Type UINT32

AVP Flag V

Additional-Context-Identifier

This AVP indicates the identity of another default APN to be used when the subscription profile of the user contains APNs with both IP-based and non-IP PDN types.

Vendor ID 10415

VSA Type 1683

AVP Type UINT32

AVP Flag V

Troubleshooting

The troubleshooting scenarios described in this section help in resolving minor issues related to incorrect configurations.

If the Control Plane CIoT optimization is not functioning as configured, use the following troubleshooting steps to resolve the issue:

1. Verify the **ciot-optimisation** command configuration.
2. Execute the **show call-control-profile full name** *profile_name* and **show mme-service session full all** commands to verify if the call-control profile criteria matches that of the UE.
3. Use the **monitor subscriber** CLI command to ensure that the UE supports and has requested for Control Plane optimization in NAS Attach or TAU messages.
4. Verify if the GTP-U service is configured correctly and is associated with the S11-U interface. See the sample configuration documented in this chapter.
5. Ensure that the current S-GW selected for the UE supports the S11-U interface.

If the PDN setup fails for PDN type non-IP, use the following troubleshooting steps to resolve the issue:

1. Execute the **show mme-service db record imsi** *imsi_number* command to verify if the non-IP PDN is present in the subscription provided by the HSS.
2. If the HSS provided subscription is missing or incorrect, add a non-IP PDN type by executing the **pdn-type** CLI command in the APN Profile Configuration mode.
3. Ensure that the P-GW serving the APN supports non-IP.
4. Ensure that the current S-GW selected for the UE supports non-IP.

If the PDN setup fails for PDN type non-IP, use the following troubleshooting steps to resolve the issue:

1. 1. Execute the **show mme-service db record imsi** *imsi_number* command to verify if the non-IP PDN is present in the subscription provided by the HSS.
2. Execute the **show call-control-profile full name** *profile_name* and **show mme-service session full all** commands to verify if the call-control profile criteria matches that of the UE.
3. Use the **monitor subscriber** CLI command to ensure that the UE supports and has requested for Control Plane optimization in NAS Attach or TAU messages.



PART II

CloT EPS Optimizations on Bearer Plane Nodes

- [APN Rate Control for CIoT Devices, on page 129](#)
- [eDRX and PSM Support on Gateways, on page 139](#)
- [HLCOM Support, on page 143](#)
- [NB-IoT RAT Type Support for P-GW, S-GW, and SAEGW, on page 161](#)
- [Non-IP PDN Support, on page 173](#)
- [S11U Interface Support on S-GW for CIoT Devices, on page 193](#)



CHAPTER 9

APN Rate Control for CIoT Devices

This chapter contains the following topics:

- [Feature Summary and Revision History, on page 129](#)
- [Feature Description, on page 130](#)
- [How it Works, on page 130](#)
- [Configuring the APN Rate Control for CIoT Devices Feature, on page 136](#)
- [Monitoring and Troubleshooting the APN Rate Control for CIoT Devices Feature, on page 136](#)
- [Accounting Support, on page 138](#)

Feature Summary and Revision History

Summary Data

Applicable Product(s) or Functional Area	<ul style="list-style-type: none">• C-SGN• P-GW
Applicable Platform(s)	<ul style="list-style-type: none">• UGP• VPC-DI• VPC-SI
Feature Default	Disabled - License Required
Related Changes in This Release	Not applicable
Related Documentation	<ul style="list-style-type: none">• <i>Command Line Interface Reference</i>• <i>P-GW Administration Guide</i>• <i>Statistics and Counters Reference</i>• <i>Ultra IoT C-SGN Administration Guide</i>

Revision History

Revision Details	Release
First introduced.	21.15

Feature Description

In usual scenarios, CIoT-enabled UE send data packets infrequently. However, in unusual scenarios, UE can send data packets frequently during a short period resulting in network congestion and affecting services. APN Rate Control is one of the 3GPP standards-compliant mechanisms for rate limiting when UEs send data packets.

APN Rate Control allows Home Public Land Mobile Network (HPLMN) operators to control the amount of user data sent in Downlink (DL) and Uplink (UL). This is done with help of policing the user data on a maximum number of user data packets per time-unit, and/or maximum number of user data octets per time-unit, for both DL and UL.

How it Works

APN Rate Control policing for DL is done in the P-GW or the SCEF, and the APN Rate Control policing for UL is done in the UE. The P-GW or SCEF can also do APN Rate Control UL policing. For more information on:

- APN Rate Control UL in the UE, see 3GPP TS 24.301.
- APN Rate Control in the SCEF, see 3GPP TS 29.128.



Note The existing AMBR mechanisms are not suitable for APN Rate Control for CIoT Devices considering radio efficiency and UE battery-life. For example, an AMBR greater than 100 Kbps translates to a potentially large daily data volume.

The P-GW or Service Capability Exposure Function (SCEF) sends an APN Uplink Rate Control command to the UE using the PCO information element (IE). The APN Uplink Rate Control applies to data PDUs sent on that APN by either Data Radio Bearers (S1-U) or Signaling Radio Bearers (NAS Data PDUs). The UE complies with this uplink rate control instruction. The UE considers the rate control instruction as valid until it receives a new one from either P-GW or from SCEF. The P-GW or SCEF enforces the Uplink Rate Control by discarding or delaying packets that exceed the rate as indicated to the UE.

APN Rate Control Indications

APN Rate Control Indication Status is sent as part of Protocol Configuration Options (PCO)/Extended Protocol Configuration Options (ePCO). If P-GW/MME supports the ePCO as part of its capability exchange, the P-GW/S-GW sends the APN Rate Control parameters as part of ePCO. If ePCO is not supported by these entities, the P-GW/S-GW sends the APN Rate Control parameters as part of PCO.

As part of PCO/ePCO, the APN Rate Control parameters are sent as “additional parameters list”. A specific “container identifier” identifies the type of the parameter that is carried in a container. The “container identifier” related to the APN Rate Control are:

- Mobile Station (MS) to network direction:
 - 0016H (APN rate control support indicator)
 - 0019H (Additional APN rate control for exception data support indicator)
- Network to MS direction:
 - 0016H (APN rate control parameters)
 - 0019H (Additional APN rate control for exception data parameters)

When the “container identifier” indicates APN Rate Control support indicator, the “container identifier contents” field is empty and the “length of container identifier contents” indicates a length equal to zero. If the “container identifier contents” field is not empty, it is ignored. This information indicates that the MS supports APN Rate Control functionality.

When the “container identifier” indicates APN Rate Control parameters, the “container identifier contents” field contains parameters for APN Rate Control functionality.

When the “container identifier” indicates Additional APN Rate Control for exception data support indicator, the “container identifier contents” field is empty and the “length of container identifier contents” indicates a length equal to zero. If the “container identifier contents” field is not empty, it is ignored. This information indicates that the MS supports additional APN Rate Control for exception data functionality.

When the “container identifier” indicates Additional APN Rate Control for exception data parameters, the “container identifier contents” field contains parameters for additional APN Rate Control for exception data functionality.

APN Rate Control Status

APN Rate Control Status is the new IE, added as part of Create Session Request (CSReq), Delete Bearer Request (DBReq), and Delete Session Response (DSRes), which holds information of APN Rate Control Value. This IE is encoded as part of CSReq on the UR reattach to denote the P-GW about the remaining limits available for the subscriber on the current timeout period.

P-GW includes this IE when the DBReq is sent only for the default bearer, so that it can be used when the UE is attaching again. In addition, the P-GW includes this IE when the DSRes is sent to MME through S-GW.

	Bits								
Octets	8	7	6	5	4	3	2	1	
1	Type = 204 (decimal)								
2 to 3	Length = n								
4	Spare				Instance				
5 to 8	Number of Uplink packets allowed								
9 to 12	Number of additional exception reports								
13 to 16	Number of Downlink packets allowed								

17 to 24	APN Rate Control Status validity Time	
25 to (n+4)	These octet(s) is/are present only if explicitly specified	

Octets 17 to 24 are coded as time in seconds relative to 00:00:00 on 1 January 1900 (calculated as continuous time without leap seconds and traceable to a common time reference) where the binary encoding of the integer part is in the 32 most significant bits, and binary encoding of the fraction part in the 32 least significant bits. The fraction part is expressed with a granularity of $1/2^{32}$ second.

The APN Rate Control Status information is sent by P-GW to MME through S-GW to store the APN Rate control parameters in Mobility Management (MM) context. This helps in restoring the rate control for the same subscriber when it is reestablished again after some time. The parameters are treated as the remaining messages on the remaining time period of the time-unit.

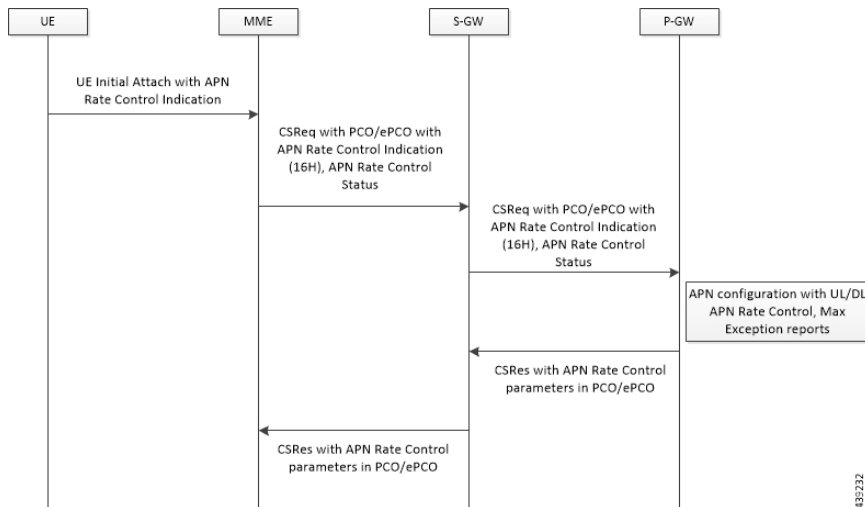
On reestablishment of the same subscriber (on first PDN for the same APN), the MME provides the information back to P-GW in PCO/ePCO. While processing, P-GW considers the values received from MME instead of its local configuration until the first timeout is complete.

Call Flows

This section describes the features' key call flows.

APN Rate Control Handling at P-GW on CSReq

On establishment or re-establishment of the subscriber for the APN, the MME sends the Indication Flags of APN Rate limit, Addition Exception indication, and APN Rate Control status in the CSReq.



Steps	Description
1	UE Initial Attach with APN Rate Control Indication is sent from UE to MME.
2	On receiving CSReq, the P-GW considers the APN Rate Control Status while encoding the APN Rate Control parameters in PCO, and while enforcing the APN Rate Control.
3	P-GW has two options to enforce the APN Rate Control:

Steps	Description
	<ol style="list-style-type: none"> 1. On subsequent establishment of the first PDN connection for the given APN, the P-GW/SCEF receives the previously stored APN Rate Control Status, and if the first APN Rate Control validity period has not expired, it applies the received APN Rate Control Status and provides the related parameters to the UE in the PCO (instead of the configured APN Rate Control parameters). 2. If the initially applied parameters differ from the configured APN Rate Control parameters, the P-GW/SCEF uses the configured APN Rate Control parameters after the first APN Rate Control validity period expires, and sends an update to the UE with the configured APN Rate Control parameters.
4	<p>P-GW sends CSRes to S-GW.</p> <p>P-GW prepares and encodes the APN Rate Control parameter into PCO/ePCO and sends back to S-GW in CSRes message with APN Rate Control parameters and Additional APN rate control parameters for exception data.</p>
5	S-GW forwards the information (received from P-GW in Step 4) to MME.

APN Rate Control Parameter encodes information about Uplink time-unit and the Uplink rate supported.

8	7	6	5	4	3	2	1	
Spare				AER		Uplink time-unit		Octet 1
Maximum uplink rate								Octet 2 to Octet 4

Additional APN Rate control parameter for exception data encodes information about Uplink time-unit and the Uplink rate that is supported for the additional exception data.

8	7	6	5	4	3	2	1	
Spare					Uplink time-unit			Octet 1
Additional uplink rate for exception data								Octet 2 to Octet 3

Where Uplink Time-unit can take the value of any one as shown in the following format.

Uplink time-unit (Octet 1)	
Bit	
3 2 1	
0 0 0	Unrestricted
0 0 1	Minute
0 1 0	Hour
0 1 1	Day

1 0 0	Week
-------	------

Maximum uplink rate (Octet 2 to Octet 4) is a binary coded representation of the maximum number of messages the UE is restricted to and sent per time-unit. If the uplink time-unit is set to "unrestricted", the maximum uplink data volume the UE can send is not restricted.

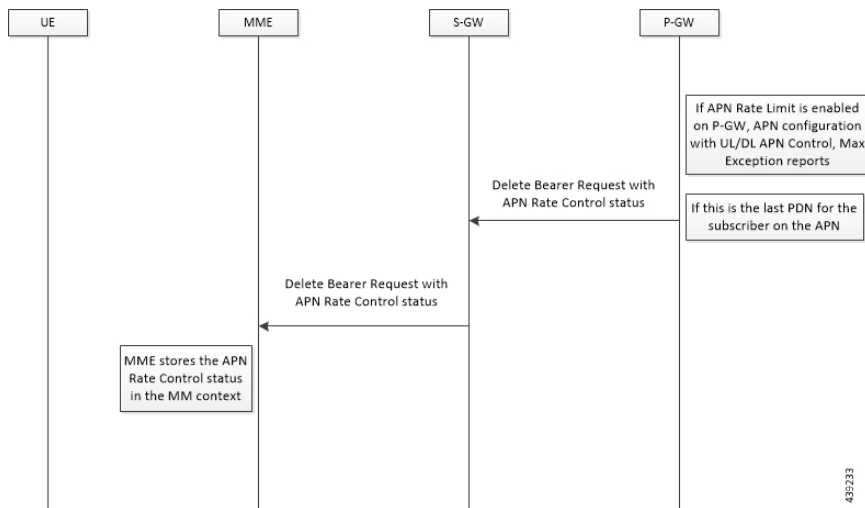
P-GW informs MME about UL APN Rate Control information in APN Rate Control Parameter, which is later stored by MME in MM context.

P-GW side APN Rate Control is based on "Maximum Allowed Rate" per direction. If P-GW provided the "number of additional allowed exception report packets per time unit" to the UE, then the "maximum allowed rate" is equal to the "number of packets per time unit" plus the "number of additional allowed exception report packets per time unit". Otherwise, the "maximum allowed rate" is equal to the "number of packets per time unit".

The P-GW enforces the uplink rate by discarding or delaying packets that exceed the "maximum allowed rate". The P-GW enforces the downlink rate by discarding or delaying packets that exceed the downlink part of the "maximum allowed rate".

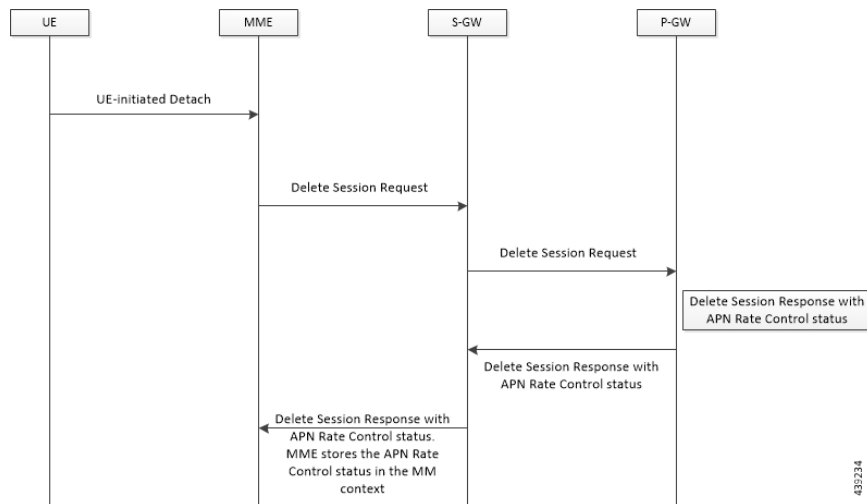
APN Rate Control Handling at P-GW on DBReq

On bearer deletion, if P-GW detects the current bearer is going to be the last bearer in the PDN for that specified APN, then it includes the APN Rate control status to MME through S-GW with the current quota of the rate limiting values (remaining messages on the remaining time-unit).



APN Rate Control Parameters on DSRes

On receiving the DSReq, P-GW clears the subscribers and sends the APN Rate Control status in CSRes with the remaining quota of the time and the messages for the subscriber to MME to update its MM context.



Licensing

The APN Rate Control for CIoT Devices is a license-controlled feature. Contact your Cisco Account representative for more information.

Standards Compliance

The APN Rate Control for CIoT Devices feature complies with the following standards:

- 3GPP TS 29.274 v15.8.0 - 3GPP Evolved Packet System (EPS); Evolved General Packet Radio Service (GPRS) Tunnelling Protocol for Control plane (GTPv2-C); Stage 3
- 3GPP TS 23.401 v15.7.0 - General Packet Radio Service (GPRS) enhancements for Evolved Universal Terrestrial Radio Access Network (E-UTRAN) access

Limitations and Considerations

The APN Rate Control for CIoT Devices feature has the following limitations and restrictions:

- This feature takes highest priority and checks if the rate limit is done before checking for any other feature.
- Both uplink and downlink rate limit take same time-unit (unlimited, minute, hour, day, or week) value. It never accepts different values.
- Applicable for P-GW and Collapsed calls.
- Applicable only for CIoT subscribers; check on RAT Type is done to identify the CIoT subscribers.
- Applicable only for the CIoT IP PDNs. This feature is not applicable for Non-IP PDNs.
- This feature is implemented on I-CUPS on ASR 5500 in slow path if the amount of traffic for IoT is low. Only data packets of the APN Rate-controlled CIoT subscribers go in slow path. Remaining CIoT subscribers still proceed on the existing implementation.

- In case of reattach, P-GW sends the CSRes with APN Rate Control parameters which are remaining for the subscriber to UE to perform Uplink Rate control operation. On time-unit expiry, P-GW renews its quota, but it never shares the updated quota values to UE. UE gets the P-GW configured APN Rate Control values only at initial attach.
- If Virtual-APN concept is applied on the subscriber, the Gi-APN Rate Control parameters are considered.

Configuring the APN Rate Control for CloT Devices Feature

Use the following configurations to enable the feature.

```
configure
  context context_name
    apn apn_name
      iot-rate-control time-unit { unrestricted | mins | hours | days | week }
      downlink packet-count dl_packet_count uplink packet-count ul_packet_count
      aer aer_value
    end
```

NOTES:

- **time-unit { unrestricted | mins | hours | days | week }**: Specifies the mode of time-unit.
- **downlink**: Applies the APN Rate Control in the downlink direction.
- **packet-count dl_packet_count**: Specifies the allowed number of downlink packets. The *dl_packet_count* must be an integer ranging from 0 through 16777215. Integer 0 disables rate control on the downlink direction.
- **uplink**: Applies the APN Rate Control in the uplink direction.
- **packet-count ul_packet_count**: Specifies the allowed number of uplink packets. The *ul_packet_count* must be an integer ranging from 0 through 16777215. Integer 0 disables rate control on the uplink direction.
- **aer aer_value**: Specifies the number of Additional Exception Reports (AER) in the uplink direction. The *aer_value* must be an integer ranging from 1 through 65535.
- If previously configured, use the **no iot-rate-control** CLI command to disable the feature.

Monitoring and Troubleshooting the APN Rate Control for CloT Devices Feature

This section describes the CLI commands available to monitor and/or troubleshoot the feature.

Show Command Support

The following show CLI commands are available in support of the feature.

show apn statistics

The output of this CLI command has been enhanced to display the following feature-specific parameters.

- CloT APN Rate Control:
 - Dropped UL packets: Displays the total number of APN Rate Control uplink packets that are dropped.
 - Dropped DL packets: Displays the total number of APN Rate Control downlink packets that are dropped.
 - Dropped UL bytes: Displays the total number of APN Rate Control uplink bytes that are dropped.
 - Dropped DL bytes: Displays the total number of APN Rate Control downlink bytes that are dropped.

show session subsystem facility sessmgr all debug-info

The output of this CLI command has been enhanced to display the following feature-specific parameters.

- CloT APN Rate Control
 - Dropped UL packets: Displays the total number of APN Rate Control uplink packets that are dropped.
 - Dropped DL packets: Displays the total number of APN Rate Control downlink packets that are dropped.
 - Dropped UL bytes: Displays the total number of APN Rate Control uplink bytes that are dropped.
 - Dropped DL bytes: Displays the total number of APN Rate Control downlink bytes that are dropped.

show subscriber full all

The output of this CLI command has been enhanced to display the following feature-specific parameters.

- CloT APN Rate Control:
 - Allowed UL limit: Displays the number of packets allowed for uplink direction.
 - Allowed DL limit: Displays the number of packets allowed for downlink direction.
 - Remaining UL limit: Displays the number of packets remaining for uplink direction.
 - Remaining DL limit: Displays the number of packets remaining for downlink direction.
 - Allowed Time unit: Displays the time-unit configured in either unrestricted, minutes, hours, days, or week mode.
 - Status Validity Time: Displays the validity time in YYYY-MM-DD HH:MM:SS format.

Bulk Statistics

This section provides information on the bulk statistics for the APN Rate Control for CloT Devices feature.

APN Schema

The following bulk statistics are available in the APN schema in support of the APN Rate Control for ClOT Devices feature.

Bulk Statistics	Description
apn-rate-control-ul-pkt-drop	Indicates the total number of APN Rate Control uplink packets that are dropped.
apn-rate-control-dl-pkt-drop	Indicates the total number of APN Rate Control downlink packets that are dropped.
apn-rate-control-ul-bytes-drop	Indicates the total number of APN Rate Control uplink bytes that are dropped.
apn-rate-control-dl-bytes-drop	Indicates the total number of APN Rate Control downlink bytes that are dropped.

Accounting Support

The following table provides details of the GTPP dictionary available in support of the APN Rate Control for ClOT Devices feature.

CDR Dictionaries/Fields	
Type of dictionary change (New/Modified):	Modified
Dictionary name:	P-GW custom24 GTPP dictionary
Based on (3GPP specification):	3GPP TS 32.299
Applicable record type(s):	G-CDR
Applicable product:	P-GW

The following CDR fields are introduced in the P-GW custom24 GTPP dictionary:

1. Field name: datapacketsFBCDownlink
 - Description: Downlink Packets count
 - Format: Integer
 - CLI command to configure the field: **gtp fbc-downlink-pkt-cnt**
 - Default value for field: 0

2. Field name: datapacketsFBCUplink
 - Description: Uplink Packets count
 - Format: Integer
 - CLI command to configure the field: **gtp fbc-uplink-pkt-cnt**
 - Default value for field: 0



CHAPTER 10

eDRX and PSM Support on Gateways

This chapter describes the support of Extended Discontinuous Reception (eDRX) and Power Saving Mode (PSM) on gateways.

- [Feature Summary and Revision History, on page 139](#)
- [Feature Description, on page 140](#)
- [How It Works, on page 140](#)
- [Configuring eDRX and PSM Support on Gateways, on page 141](#)
- [Monitoring and Troubleshooting, on page 142](#)

Feature Summary and Revision History

Summary Data

Applicable Product(s) or Functional Area	<ul style="list-style-type: none">• C-SGN• P-GW• S-GW• SAEGW
Applicable Platform(s)	<ul style="list-style-type: none">• UGP• VPC-DI• VPC-SI
Feature Default	Disabled - License Required
Related Changes in This Release	Not Applicable
Related Documentation	<i>Statistics and Counters Reference</i>

Revision History

Revision Details	Release
The feature is tested and qualified on the ASR 5500 platform.	21.3
First introduced.	N5.1 (21.1.V0)

Feature Description

The Extended Discontinuous Reception (eDRX) feature allows IoT devices to remain inactive for longer periods. This feature allows the device to connect to a network on a need basis – the device can remain inactive or in sleep mode for minutes, hours or even days, thus increasing the battery life of the device. Extended DRX cycles provide UEs longer inactive periods between reading, paging or controlling channels.

Power Saving Mode (PSM) was introduced in 3GPP Release 12, to improve device battery life of IOT devices. The most significant benefit of this feature is the UE has more control in terms of power management required for its application. There are a wide range of IoT applications where flexibility of the UE to manage its power is very important and also implementation of PSM can prevent network congestion. The timers of all the devices can be managed using PSM, and the wake-up periods can be adjusted to be offset as much as possible. This way, all of the devices will not wake at the same time and attempt to access the network. The PSM mode is similar to power-off but the UE remains registered on the network.

As part of this eDRX and PSM Support on Gateways feature, when UE is in PSM and any Update Bearer Request (UBReq) or Create Bearer Request (CBReq) is rejected with Cause Code “UE is temporarily not reachable due to power saving”, control packets are buffered for delay tolerant PDN’s.

How It Works

A CLI-based configuration is introduced under APN Configuration Mode for P-GW to determine if a PDN connection is Delay Tolerant. If the PDN is Delay Tolerant, the P-GW sends Delay Tolerant Connection Indication (DTCI) flag (set to 1) in Create Session Response.

A new GTP cause code (UE is temporarily not reachable due to power saving) in Create Bearer Response/Update Bearer Response (CBResp/UBResp) messages is introduced to indicate the corresponding network initiated control plane procedure is rejected when the UE is in PSM/eDRX mode.

The ongoing network initiated procedure are buffered until further indication that the UE is available again for end-to-end signaling. In the time interval when MME indicates the UE is in PSM/eDRX mode, the P-GW buffers all the control packets that requires UBReq/CBReq. The buffering at session manager (SM) is done using the existing framework. Any subsequent request is rejected. When P-GW receives MBReq with ‘UE Available for Signaling Indication’ (UASI) flag (set as 1), the P-GW reattempts the pending network initiated procedure. When P-GW is Delay Tolerant, it includes DTCI flag in MBResp on S-GW Relocation, and when UE moves from S4-SGSN/MME.

For S-GW, the UASI flag is set to 1 by the MME during a TAU/RAU or a Service Request procedure for E-UTRAN, when the PDN connection is delay tolerant, and when there is pending network initiated PDN connection signaling. The S-GW includes the UASI Information Element (IE) on S5/S8 when it receives from the MME.

The S-GW receives the UASI flag in Create Session Request (CSReq) when the UE is available for signaling and the S-GW relocation is initiated at the same time. The S-GW forwards the UASI flag in MBReq to P-GW to reattempt pending network initiated procedure.

Limitations

Following are the known limitations of this feature:

- SR/ICSR of buffered packets is not supported.
- Maximum of four control signal transactions can be buffered at gateway, beyond which any network requested transactions are rejected.
- S-GW and MME restoration does not consider Delay Tolerant Connection Indication (DTCI) capability while retaining the session.

License Requirements

The eDRX and PSM Support on Gateways feature is license dependent. Contact your Cisco account representative for detailed information on specific licensing requirements.

Configuring eDRX and PSM Support on Gateways

This section explains the configuration procedures required to enable the feature.

Configuring APN for P-GW to Support Delay Tolerant PDN

Use the following configuration under APN Configuration Mode for P-GW to support Delay Tolerant PDN connections and to configure maximum number of P-GW initiated control signaling messages to be buffered.

```

configure
  context context_name
    apn apn_name
      delay-tolerant-pdn max-control-signal-buffer <1-4>
    end

```

Notes:

- **delay-tolerant-pdn**: Configures Delay Tolerant behavior for PDN connection to support UE in Power Saving Mode.
- **max-control-signal-buffer** <1-4>: Configures maximum number of P-GW initiated control signaling messages to be buffered (range 1 to 4) when UE is in Power Saving Mode.
- If previously configured, use the **no delay-tolerant-pdn** CLI command to remove and restore the configuration to its default value.
- By default, the command is disabled and eDRX support is not applicable.
- This CLI command takes effect during new call set-up or during handoff procedure to S5/S8 interface.

Monitoring and Troubleshooting

Show Commands and/or Outputs

This section provides information regarding show commands and/or their outputs in support of the eDRX and PSM Support on Gateways feature.

show subscribers pgw-only full all

The output of this command is modified to display if the UE is in Power saving Mode. Sample output below:

```
UE in Power Saving Mode: No | Yes
```

show apn name

The output of this command is modified to display the APN configuration. Sample output below:

```
delay tolerant pdn: yes
max-control-signal-buffer: 4
```

show pgw-service statistics all

The output of these command are modified to display the number of UE that are in Power Saving Mode per P-GW Service. Sample output below:

```
Power Saving Mode (PSM) Statistics:
  No of UEs in PSM mode: 0
```

These new fields are also introduced in the output of following show command:

- **show pgw-service statistics name**

eDRX and PSM Support on Gateways Bulk Statistics

The following statistic is introduced in support of the feature:

P-GW Schema

- **ue-in-psm** - This statistic indicates the total number of UEs currently in Power Saving Mode.



CHAPTER 11

HLCOM Support

- [Feature Summary and Revision History, on page 143](#)
- [Feature Description, on page 144](#)
- [How It Works, on page 145](#)
- [Standards Compliance, on page 155](#)
- [Limitations and Restrictions, on page 155](#)
- [Configuring CIoT Feature Support Indication , on page 155](#)
- [Monitoring and Troubleshooting, on page 156](#)

Feature Summary and Revision History

Summary Data

Applicable Product(s) or Functional Area	<ul style="list-style-type: none">• C-SGN• P-GW• S-GW• SAEGW
Applicable Platform(s)	<ul style="list-style-type: none">• UGP• VPC-DI• VPC-SI
Feature Default	Disabled - License Required
Related Changes in This Release	Not Applicable
Related Documentation	<ul style="list-style-type: none">• <i>Statistics and Counters Reference</i>

Revision History

Revision Details	Release
The feature is tested and qualified on the ASR 5500 platform. With this release, HLCOM support is added for SAEGW.	21.3
First introduced (HLCOM Support on P-GW and S-GW).	N5.1 (21.1.V0)

Feature Description



Important This feature is license controlled. Contact your Cisco account representative for information on how to obtain a license.

When the User Equipment (UE) is unreachable due to 'Power Saving Mode' or 'Extended Idle Mode DRX', there might be high latency for initial response before the exchange of packets, which is the time taken by the UE to establish a connection and initiate data transfer. Owing to high latency, there is a need to buffer data for a longer duration.

High Latency Communication (HLCOM) feature introduces buffering of MT data at the S-GW (part of SAEGW), when the UE is in a power saving state and not reachable.

The HLCOM buffering time duration or the packet count is based on the first successful DDN Ack carrying those parameters. No new DDNs are initiated once the call is received and HLCOM parameters start buffering the packets. Other features such as "Priority Paging" do not override the HLCOM UE. Packets buffered are not recovered and neither the state of the HLCOM. Buffered packets are lost on recovery. HLCOM duration and packet count to be buffered is not recovered. Hence, any packet post recovery triggers DDN.

HLCOM buffers, configurations, and timers are independent of existing IDLE mode of buffering. This means that the buffer allocated for HLCOM is more than the IDLE mode memory for buffering data.

The 2-4 KB buffering legacy paging limit is not applicable for HLCOM. In case of HLCOM devices, upto 4KB data can be buffered per UE in the dedicated 96MB memory. Those devices for which 4k memory is utilized and more is needed, memory can be extended upto 10k, provided memory available in the extended memory of size 10MB.

Extended buffering is applied in case buffer duration and suggested packet count IE in successful DDN Ack is received.



Important This feature supports only HLCOM buffering for P-GW, S-GW, and SAEGW calls.



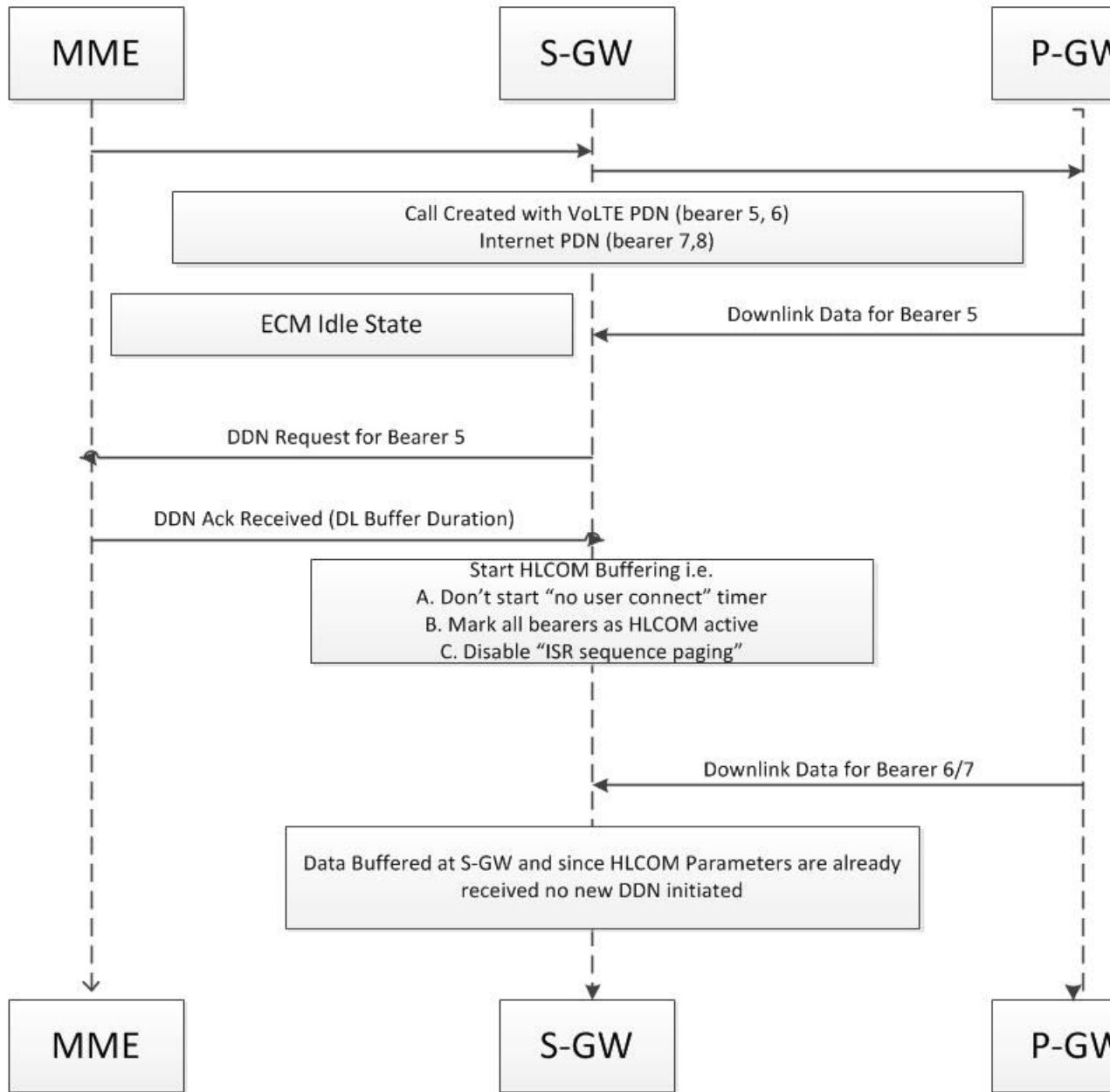
Important Buffering is done per UE. So irrespective of the number of bearers or PDNs for a session, all the buffering limits such as the suggested packet count IE sent in DDNAck and 4KB and 10 KB limits are all valid for the UE as a whole. HLCOM IE's buffer duration and suggested packet count in DDNAck are honored only for cause EGTP_CAUSE_REQ_ACCEPTED and EGTP_CAUSE_UNABLE_TO_PAGE_UE. For other causes, these IE's are ignored.

How It Works

The DDN Ack carries packet count or duration. The buffered data is delivered to the UE on establishing user plane for data delivery, when the UE contacts the MME or SGSN by signaling. This signaling happens in the Tracking Area Update and the Routing Area Update procedures, which triggers MBR towards the S-GW. Extended buffering of the downlink data in the S-GW is controlled by the MME/S4-SGSN or in the Gn/Gp-SGSN. The Gn/Gp-SGSN similarly buffers downlink data until the UE is expected to come back from its power saving state. If there is S-GW change or a Gn/Gp-SGSN change, the buffered packets are forwarded and are not lost. The number of packets to buffer is decided by the S-GW or Gn/Gp-SGSN, but the MME/S4-SGSN may optionally provide a suggestion for the number of downlink packet to be buffered.

Following are the various Call Flow Scenarios to explain how HLCOM works:

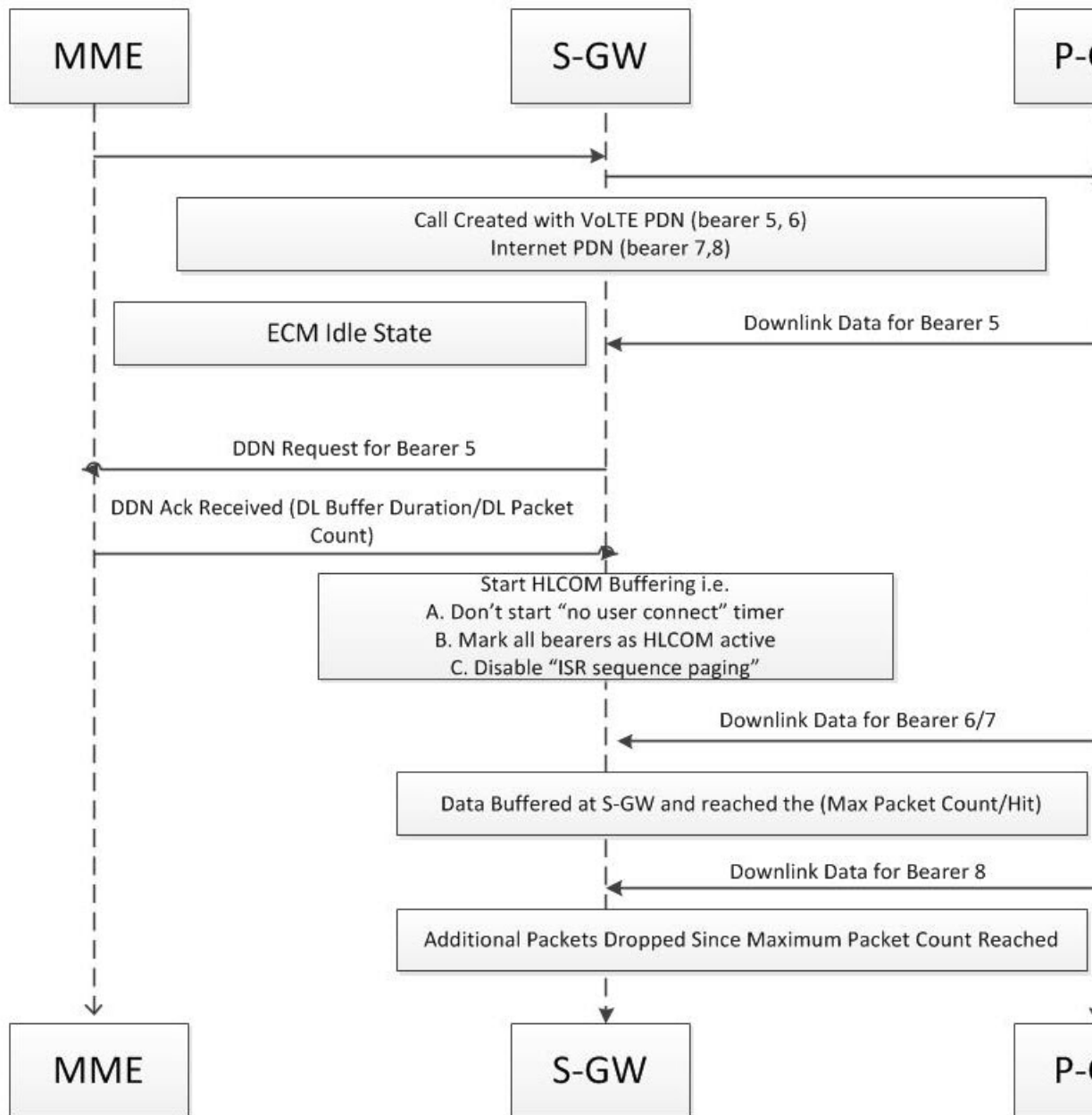
Basic Call Setup Scenario (HLCOM)



1. Call is setup with Volte and Internet PDN with bearers 5, 6, 7, and 8.
2. UE is moved to idle mode and SIU interface for the UE is released.
3. Downlink Data is received for the bearer 5 and DDN Initiated for the same.

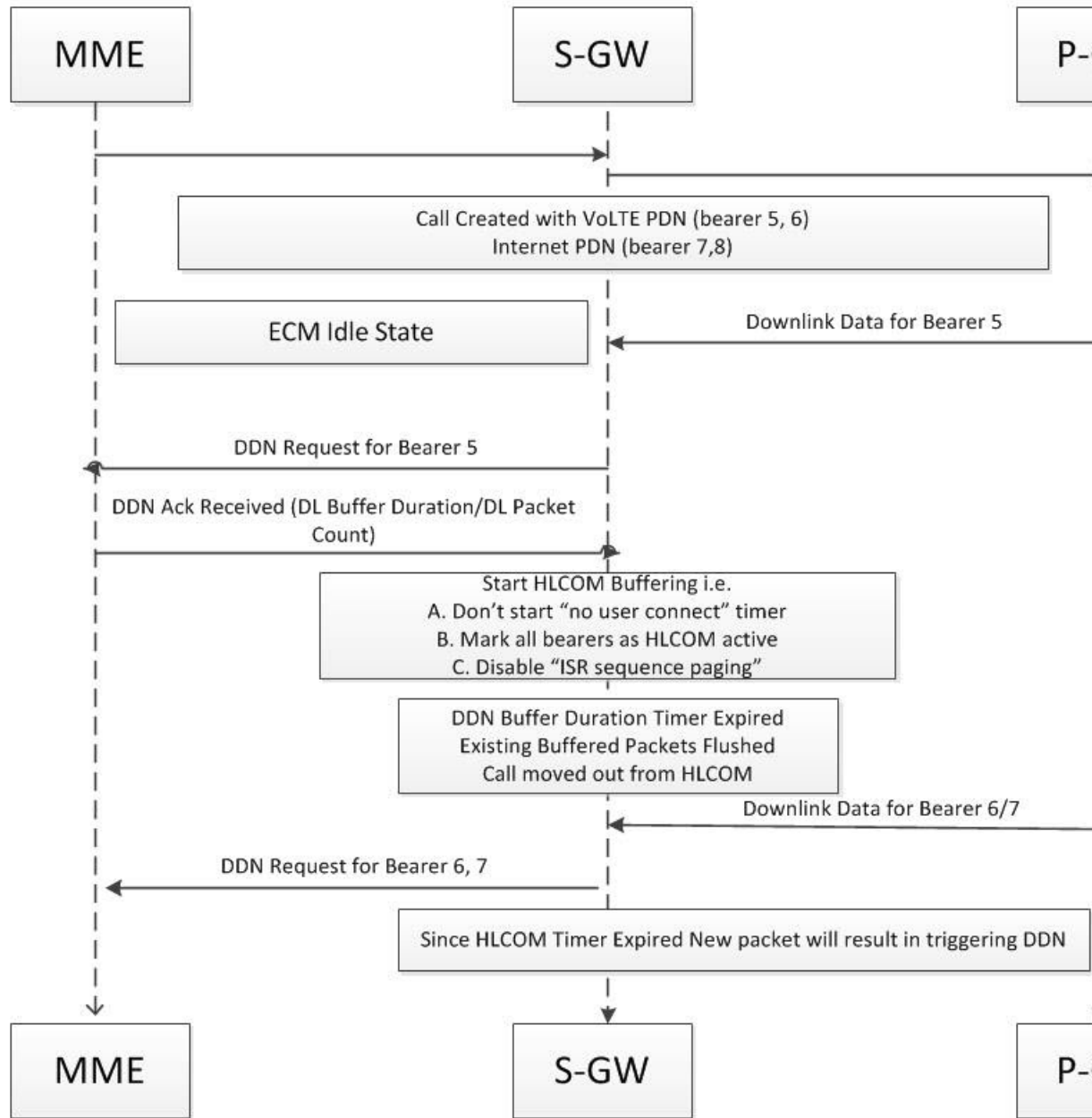
4. DDN-Ack carries "DL Buffering Duration" and HLCOM Duration timer is started.
5. Data is received for bearers 6, 7, and no DDN is initiated. As a result, packets are queued in S-GW.

Packet Dropped when DL Maximum Packet Count is Reached



1. Call is setup with VoLTE and Internet PDN with bearers 5, 6, 7, and 8.
2. UE is moved to idle mode and S1U interface is released to the UE.
3. Downlink data is received for the bearer 5 and DDN is initiated for the same.
4. DDN-Ack carries DL buffering duration and DL packet count. The HLCOM duration timer is started.
5. Data is received for the bearers 6 and 7, and no DDN is initiated. Packets are queued in S-GW. With this the maximum packet count is reached.
6. No further packets are queued as the limit is reached.

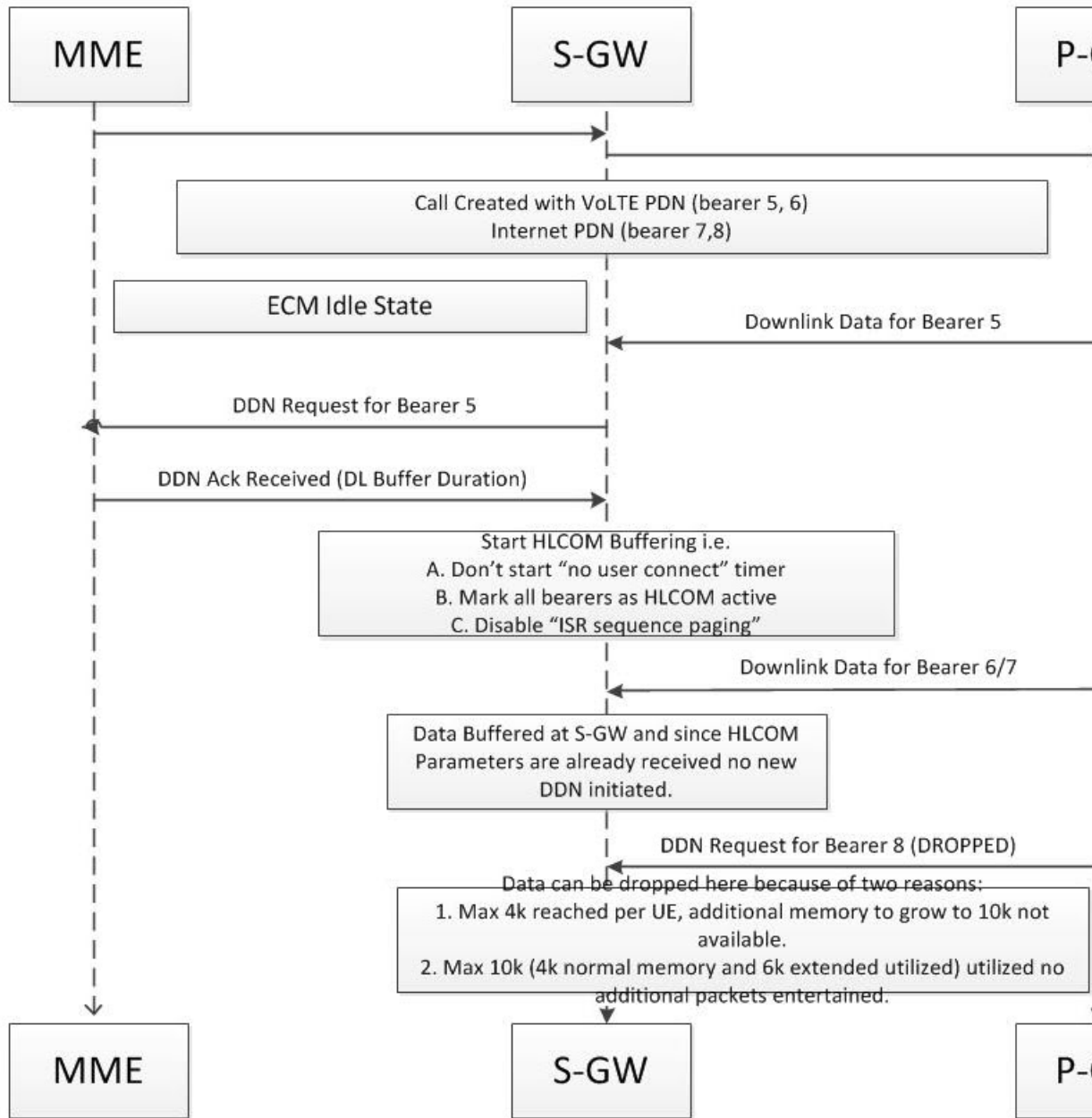
Packet Handled on DL Buffer Duration Expired



1. Call is setup with VoLTE and internet PDN with bearers 5, 6, 7, and 8.
2. UE is moved to idle mode and S1U interface is released for the UE.
3. Downlink data is received for the bearer 5 and DDN is initiated for the same.

4. DDN Ack carries the DL buffering duration and the DL packet count. The HLCOM duration timer is started.
5. DL buffer duration timer is expired and existing buffered packets are flushed.
6. Data is received for bearers 6 and 7, and DDN is initiated. Packets are queued in S-GW.

Packet Dropped on Max Packet Buffer is Reached



1. Call is setup with VoLTE and Internet PDN with bearers 5, 6, 7, and 8.
2. UE is moved to idle mode and S1U interface is released.
3. Downlink data is received for bearer 5 and DDN is initiated for the same.

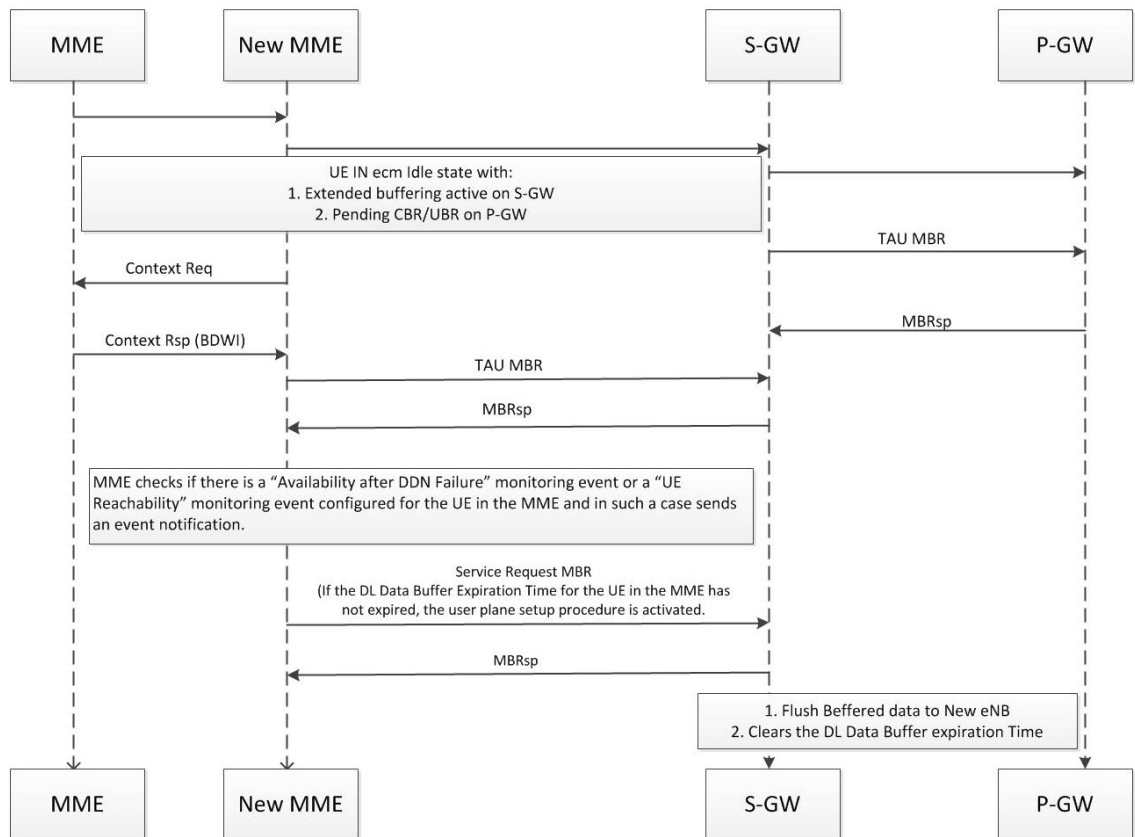
4. DDN-Ack carries the DL buffering duration and DL packet count. HLCOM duration timer is started.
5. Data is received for bearer 6 and 7, and no DDN is initiated. Packets are queued in S-GW.
6. Downlink data is received for bearer 8 and data is buffered since DL packet count is not reached and packets are dropped. That is, when the 4k buffer is exhausted, it expands to additional 6k for the UE (Total 10k).
 - a. If 6k buffer is available in the extended buffer, buffering expands to 10k.
 - b. If 6k buffer is not available in extended buffer, packets beyond 4k are dropped.

Handoff Procedure Support

The following sections describe the handoff procedure support for this feature.

Tracking Area Update without S-GW Change

In below mentioned call scenarios, S-GW and P-GW are part of SAEGW and the session would be a co-located session.

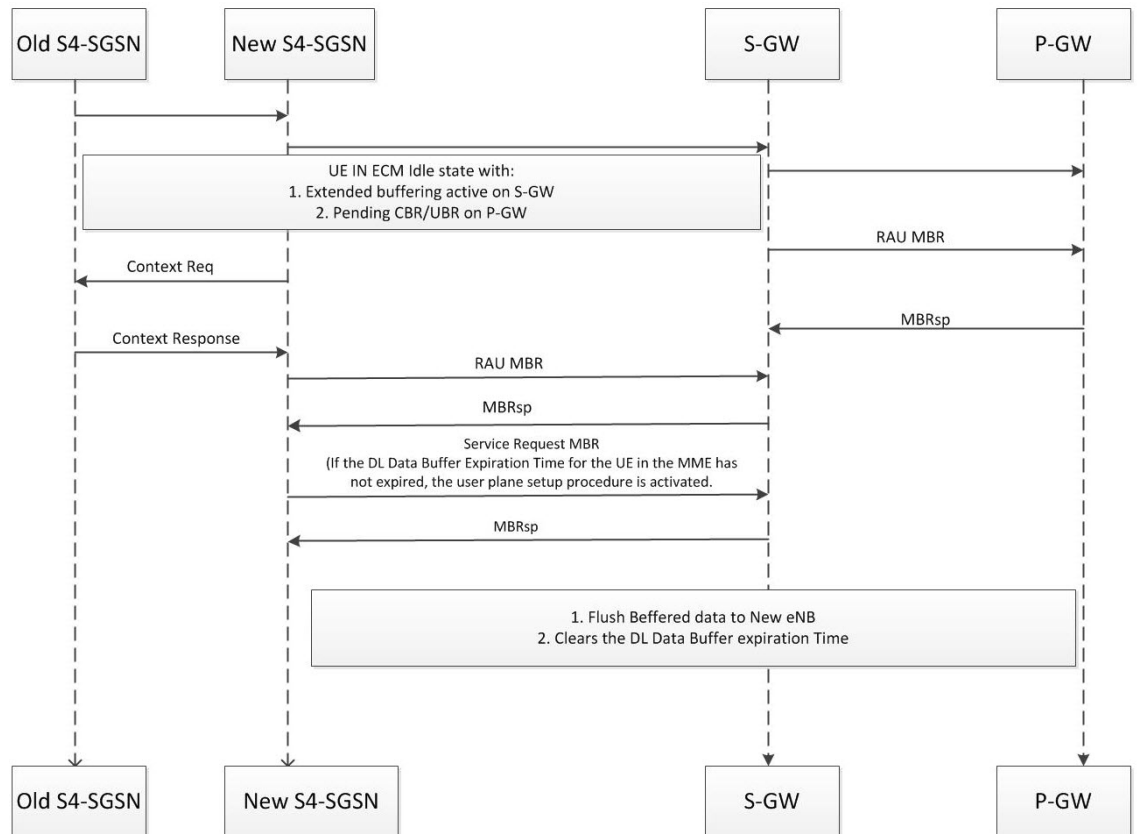


- MME changes to the new MME and sends a Modify Bearer Request (new MME address and TEID, ISR Activated, RAT type) message per PDN connection to the Serving GW.

- This is the TAU MBR. Another MBR is received at S-GW, which establishes the S1 connection, carrying the eNodeB's FTEID.
- Once this MBR is received at S-GW, the buffered data at S-GW is sent through. This TEID is received as S1 eNodeB F-TEID in the Modify Bearer Request.

Routing Area Update Without S-GW Change

In the following mentioned call scenarios, S-GW and P-GW are part of SAEGW and the session would be a co-located session.

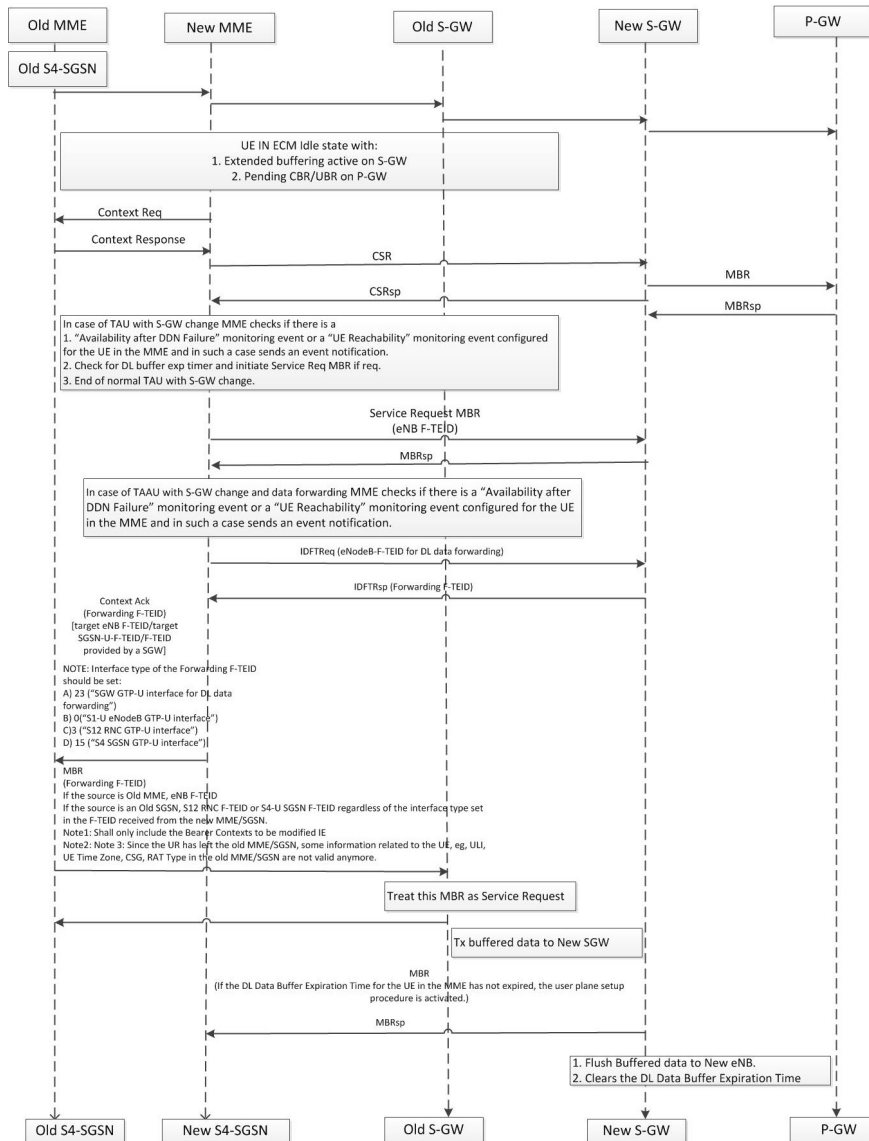


- If the SGSN has changed, the new SGSN sends a Modify Bearer Request (new SGSN address and TEID) message per PDN connection to the S-GW.
- This is the RAU MBR. Another MBR is received at S-GW, which establishes the S1 connection, carrying the RNC FTEID. Once this MBR is received at S-GW, the buffered data at S-GW is sent through. This TEID is received as S12 RNC F-TEID in Modify Bearer Request.

Tracking Area Update with S-GW Change and Data Forwarding

In below mentioned call scenario, S-GW (old or new) and P-GW can be part of SAEGW.

Tracking Area Update with S-GW Change and Data Forwarding



- If the Modify Bearer Request message is sent from the old MME/old S4SGSN as part of Tracking Area Update procedure with S-GW change and data forwarding, the old MME shall only include the Bearer Contexts to be modified IE.
- During a TAU with S-GW change procedure and data forwarding, the old MME/old S4SGSN will provide the old S-GW with the Forwarding F-TEID received in the Context Acknowledge message and encode it as either an eNB F-TEID (for an old MME), or an S12 RNC F-TEID or S4-U SGSN F-TEID (for an old SGSN), regardless the interface type set in the F-TEID received from the new MME/SGSN. This is to make the downlink data forwarding appear as a regular downlink data transmission for the old S-GW, i.e. like a Service Request procedure.
- The Target S-GW will receive Create Indirect Data Forwarding Tunnel, with either eNodeB F-TEID for DL data forwarding (for a new MME) or RNC F-TEID for DL data forwarding or SGSN F-TEID for DL data forwarding (for a new SGSN).

- If Delete IDFT Request is not received at S-GW, S-GW will clean up the IDFT tunnel after the IDFT guard timer expiry of 100 seconds.
- Please note that S-GW rejects any IDFT message received for an ECM Idle UE.

Standards Compliance

The Non-IP PDN feature complies with the following standards:

- 3GPP TS 23.060 - General Packet Radio Service (GPRS); Service description; Stage 2.
- 3GPP TS 23.401 - General Packet Radio Service (GPRS) enhancements for Evolved Universal Terrestrial Radio Access Network (E-UTRAN) access.
- 3GPP TS 23.682 - Architecture enhancements to facilitate communications with packet data networks and applications.

Limitations and Restrictions

Following are the limitations of this feature:

- A maximum of 4k of buffer memory is available which can be extended up to 10k, provided the additional 10 MB memory is still available.
- Other features such as "Priority Paging" do not override the HLCOM UE.
- Packets buffered are not recovered and neither the state of the HLCOM. Buffered packets are lost on recovery.
- HLCOM duration and packet count to be buffered is not recovered. Hence, any packet post recovery triggers DDN.
- Inter Rat Handover's from GnGp SGSN to MME and vice-a-versa, are not supported with data forwarding.
- IDFT support for Inter S-GW relocation from MME to S4SGSN and Inter S4SGSN - Inter S-GW relocation is not supported.
- Since the UE leaves the old MME/SGSN, some information related to the UE, for example ULI, UE Time Zone, CSG, RAT type in the old MME/SGSN are not valid any more. However, for Inter S-GW handovers on old S-GW, the modify bearer request is just like any other service request. Hence, if any of ULI, UE Time Zone, CSG, and RAT Type is received in the MBR, the same will be forwarded to P-GW, as this MBR cannot be distinguished explicitly.

Configuring CloT Feature Support Indication

A new CLI command **cellular-iot** has been introduced under the eGTP Service Configuration Mode to enable CloT feature support indication.

configure

```

context context_name
  egtp-service egtp_service_name
    [no | default ] gtpc node-feature cellular-iot
  end

```

Notes:

- **cellular-iot:** enables the Cellular IoT Features support for EGTP Service.
- **no:** disables the Cellular IoT Features support for EGTP Service.
- **default:** By default, CLI is disabled.

Monitoring and Troubleshooting

This section provides information on how to monitor and troubleshoot using show commands and bulk statistics available to support of this feature.

Bulk Statistics

The following bulk stats have been added to the respective schemas as part of this project:

S-GW Schema

- **pagingstat-hlcom-success** - Indicates the total number of HLCOM sessions successfully created during paging. These stats increment when HLCOM Session is created during paging.

SAEGW Schema

- **sgw-pagingstat-hlcom-success** - Indicates the total number of HLCOM sessions successfully created for S-GW (part of SAEGW) during paging. These stats increment when S-GW (part of SAEGW) creates HLCOM session during paging.

Show Commands and/or Outputs

This section provides information regarding show commands and their outputs for the HLCOM feature. Statistics have been added at three levels:

- Instance Level
- Subscriber Level
- S-GW Service Level

Instance Level Statistics

The following command tracks the current memory usage at process level. It shows how much of the actual and extended buffer is in use.

show session subsystem full | grep HLCOM

This command has been modified to display the following output:

- HLCOM Statistics
 - 4 Total HLCOM Buffer Used in bytes
 - 496 Total HLCOM Cache Used in bytes
 - 0 Total HLCOM Extended Buffer Used in bytes
 - 0 Total HLCOM Extended Cache Used in bytes

- HLCOM Statistics
 - 0 Total HLCOM Buffer Used in bytes
 - 0 Total HLCOM Cache Used in bytes
 - 0 Total HLCOM Extended Buffer Used in bytes
 - 0 Total HLCOM Extended Cache Used in bytes

- HLCOM Statistics
 - 0 Total HLCOM Buffer Used in bytes
 - 0 Total HLCOM Cache Used in bytes
 - 0 Total HLCOM Extended Buffer Used in bytes
 - 0 Total HLCOM Extended Cache Used in bytes

- HLCOM Statistics
 - 0 Total HLCOM Buffer Used in bytes
 - 0 Total HLCOM Cache Used in bytes
 - 0 Total HLCOM Extended Buffer Used in bytes
 - 0 Total HLCOM Extended Cache Used in bytes

Subscriber Level Statistics

This command indicates the buffer and buffered packet count based on whether HLCOM flag is set or not. If the HLCOM flag is set, the buffered packet is utilizing HLCOM buffer. If the HLCOM buffer is not set, the buffered packet is using the existing idle buffer.

show subscribers saegw-only full all

This command has been modified to display the following output:

```
Username           : 9326737733
SAEGW Call mode   : Co-located
Subscriber Type    : Visitor
```

show subscribers saegw-only full all

```

Status           : Online/Active
State            : Idle
Bearer State     : N/A
Chrg Char Sel Mod : Peer Supplied
Restoration priority level : n/a
HLCOM Session    : Yes
IP Address       : 209.165.200.224
Bearer capable for restoration: No
UE P-CSCF Restoration Support : n/a
Idle mode buffering:
buffered pkts    : 2                               buffered bytes    : 1000
    
```

show subscribers saegw-only full all

This command has been modified to display the following output:

```

Username         : 9326737733
SAEGW Call mode  : Co-located
Subscriber Type   : Visitor
Status           : Online/Active
State            : Idle
Bearer State     : N/A
Chrg Char Sel Mod : Peer Supplied
Restoration priority level : n/a
HLCOM Session    : Yes
IP Address       : 209.165.200.224
Bearer capable for restoration: No
UE P-CSCF Restoration Support : n/a
Idle mode buffering:
buffered pkts    : 2                               buffered bytes    : 1000
    
```

SAEGW Service Level Statistics

At service level counters have been added for the following reasons:

- to identify current packets/bytes in buffer to give a picture on current usage at service level
- to calculate cumulative packets/bytes which give a picture on usage till that time
- different reasons of discard

The following command shows the current buffer usage at service level.

show saegw-service statistics all function sgw

This command has been modified to display the following output:

```

Subscribers Total:
Active:           1      Setup:           1
Released:        0
  Inactivity Timeout: 0
...
Paging Statistics:
Requests:        3      Success :           3
Rejects:         0      Failures:          0
HLCOM Success:   1
UE State Transitions:
  Idle-to-Active: 1      Active-to-Idle:    2

Data Statistics Related To HLCOM:
    
```

```

Total Packets Buffered:          5   Total Bytes Buffered:          25
Current Packets Buffered:       0   Current Bytes Buffered:       0
Total Packets Discarded:       5   Total Bytes Discarded:       25

Data Statistics Related To Paging:
Packets Buffered:              2   Bytes Buffered:              10
Packets Discarded:            2   Bytes Discarded:            10
Idle Mode ACL Statistics:
  Packets Discarded:          0   Bytes Discarded:           0

Data Discarded By Reason-Type:
Shared Buffer Full:
  Packets Discarded:          0   Bytes Discarded:           0
Dedicated Buffer Full:
  Packets Discarded:          0   Bytes Discarded:           0
SIU State Inactive:
  Packets Discarded:          0   Bytes Discarded:           0
Paging Throttled:
  Packets Discarded:          0   Bytes Discarded:           0
Paging Failure:
  Packets Discarded:          0   Bytes Discarded:           0
No User Connect Data Flushed:
  Packets Discarded:          2   Bytes Discarded:           10
MBR Guard Timer Expiry Flushed Data:
  Packets Discarded:          0   Bytes Discarded:           0
Buffered Data Flushed:
  Packets Discarded:          0   Bytes Discarded:           0
HLCOM Buffer Full:
  Packets Discarded:          0   Bytes Discarded:           0
HLCOM Timer Expiry Flushed Data:
  Packets Discarded:          5   Bytes Discarded:           25
HLCOM Suggested Packet Count Exceeded:
  Packets Discarded:          0   Bytes Discarded:           0
HLCOM Buffered Data Flushed:
  Packets Discarded:          0   Bytes Discarded:           0
HLCOM UE Limit Exceeded:
  Packets Discarded:          0   Bytes Discarded:           0

High Priority Paging Statistics:
  Initiated:                  0   Suppressed:                  0

Handover Paging Statistics:
  DDN Ack with Temporary-HO-Rejection (Cause #110): 0
  TAU/RAU MBR Triggered DDN: 0

Paging (DDN) Throttling Statistics:  Not available
    
```

S-GW Service Level Statistics

At service level counters have been added for the following reasons:

- to identify current packets/bytes in buffer to give a picture on current usage at service level
- to calculate cumulative packets/bytes which give a picture on usage till that time
- different reasons of discard

The following command shows the current buffer usage at service level.

show sgw-service statistics all

This command has been modified to display the following output:

```

Subscribers Total:
  Active:                1          Setup:                1
  Released:              0
  Inactivity Timeout:   0
.....
PDNs Total:
  Active:                1          Setup:                1
  Released:              0          Rejected:            0
  LIPA:                  0          Paused Charging:    0
.....
Data Statistics Related To HLCOM:
  Packets Buffered:      0          Bytes Buffered:      0
  Packets Discarded:    0          Bytes Discarded:    0
  Current Packets Buffered: 0          Current Bytes Buffered: 0
  Current Packets Discarded: 0          Current Bytes Discarded: 0
.....
Data Discarded By Reason-Type:
.....
  HLCOM Buffer Full:
.....
    Packets Discarded: 0          Bytes Discarded: 0
  HLCOM Timer Expiry Flushed Data:
    Packets Discarded: 0          Bytes Discarded: 0
  HLCOM Suggested Packet Count Exceeded:
    Packets Discarded: 0          Bytes Discarded: 0

```

Troubleshooting

HLCOM buffer is utilized post DDN Ack. Hence the buffered packet count existing should be interpreted as idle/HLCOM buffer based on the flag added at the subscriber level. That is, if HLCOM flag is set then buffered packets are in HLCOM buffer. If the HLCOM is not set then the buffered packets are in idle buffer. Additionally, packets are discarded based on the following classification:

- Max memory usage (Max HLCOM buffer). This includes data payload + EGTP header.
- UE level Utilization of 4k - 10k. This includes only Data Payload.

The following commands can be used to troubleshooting:

- show saegw-service statistics all function sgw
- show session subsystem full
- show sgw-service statistics all
- show subscriber saegw-only full



CHAPTER 12

NB-IoT RAT Type Support for P-GW, S-GW, and SAEGW

This feature chapter describes the support for Narrow band Internet of Things (NB-IoT) RAT Type for P-GW, S-GW, and SAEGW products.

- [Feature Summary and Revision History, on page 161](#)
- [Feature Description, on page 162](#)
- [License Requirements, on page 163](#)
- [Limitations, on page 164](#)
- [Monitoring and Troubleshooting, on page 164](#)
- [Bulk Statistics, on page 170](#)

Feature Summary and Revision History

Summary Data

Applicable Product(s) or Functional Area	<ul style="list-style-type: none">• C-SGN• P-GW• S-GW• SAEGW
Applicable Platform(s)	<ul style="list-style-type: none">• UGP• VPC-DI• VPC-SI
Feature Default	Disabled - License Required
Related Changes in This Release	Not Applicable
Related Documentation	<i>Statistics and Counters Reference</i>

Revision History

Revision Details	Release
The feature is tested and qualified on the ASR 5500 platform.	21.3
First introduced.	N5.1 (21.1.V0)

Feature Description

The NB-IoT is a new 3GPP-specified-radio interface that supports IoT devices. This release provides support for NB-IoT RAT type for S-GW, P-GW, and SAEGW products to enable the support for NB-IoT calls that are based on 3GPP release 13 standards.

While the RAT type AVP is already supported across all the interfaces, this release introduces support for the ‘NB-IoT RAT type’ value in those AVPs. It provides the exact value of those RAT types for various interfaces.

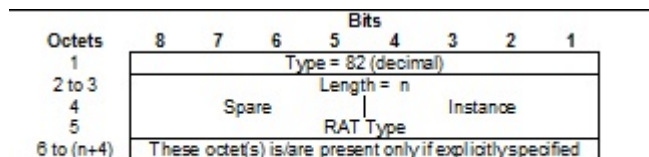
On RF billing records, NB-IoT RAT type is populated as 3GPP-RAT-Type: 0x08.



Note A legacy S-GW or P-GW may reject a Create Session Request message received with an unknown RAT Type because the RAT Type is a Mandatory IE in this message. The S-GW/P-GW selection procedures for UEs accessing the network via a NB-IoT access will ensure that the selected S-GW/P-GW supports the new NB-IoT RAT-Type.

RAT Type

As per 3GPP 29.274 (release 13.6.0) RAT Type is coded as depicted in the following figure.



419555

RAT Type Values

As part of this feature, the S-GW, P-GW, and SAEGW now support a new RAT type (EUTRAN-NB-IOT).

RAT Types	Values (Decimal)
<reserved>	0
UTRAN	1
GERAN	2
WLAN	3

RAT Types	Values (Decimal)
GAN	4
HSPA Evolution	5
EUTRAN (WB-E-UTRAN)	6
Virtual	7
EUTRAN-NB-IoT	8
<spare>	9-255

By adding a new ENUM support for RAT type (NB-IoT), calls can be decoded and calls allowed S-GW/P-GW (egtpc_decode_rat_ie). New RAT type: SESS_ACCESS_TECH_NB_IOT (8)



Note The RAT type string (EUTRAN) is also represented as (WB-E-UTRAN). However, the string EURTRAN is also supported to provide backward compatibility.

Currently various features act based on the RAT type. Following are the features that are related to the RAT type value of the call. These features are modified to support the new RAT type: EUTRAN-NB-IOT.

Virtual APN Selection Based on RAT Type

The virtual APN can be selected by configuring it directly under the base APN. This APN selection can be done based on RAT Type. Now a support is added to select the virtual APN if the RAT type is NB-IoT.

Configuration under APN:

```
virtual-apn preference <> apn <> rat-type nb-iot
```

Intra IoT-RAT Hand Over Support

As part of this feature, support for IoT device mobility within IoT-RAT area is supported.

Clearing Calls Based on RAT Type

An existing call based on RAT type can be cleared including RAT type as NB-IoT using the following command:

```
Clear subscriber access-type <>
```

License Requirements

This feature is license controlled. Contact your Cisco account representative for information on how to obtain a license.



Note

- All show commands where NB-IoT is only in display is not license controlled.
- If an exec command is extended - where rat type NB-IoT is newly added CLI keyword – it is not under a license.
- Only if a feature is specific to NB-IoT and requires a new config CLI change, it will be under a license.
- • Call acceptance and restriction at S-GW/P-GW is based on this license. Therefore, NB-IoT calls are allowed only when the license is enabled. (Currently there are no restrictions on the number of calls – the license is just used as a Boolean – allow or deny NB-IoT calls).

The call is rejected as: EGTPC_SET_SERVICE_NOT_SUPPORTED_CAUSE

Limitations

This feature has the following limitations:

- GBR bearer is not created for NB-IoT RAT type.
- Inter-RAT mobility to and from NB-IoT is not supported.
- Emergency Bearer services are not available when the UE is using NB-IoT RAT type.
- Under ACS, only GERAN, UTRAN, and WLAN access types are supported.
- If the call is NB-IoT, then the ICSR checkpointing to a lower version of ICSR peer is not performed.

Monitoring and Troubleshooting

This section provides information regarding show commands and bulk statistics for this feature.

Show Commands and/or Outputs

This section lists all the show commands available to monitor this feature.

show subscribers activity all

The following new field is added to the show output to display the new NB-IoT RAT type:

NB-IoT

The show output displays the RAT type of the call as NB-IoT.

show subscribers all

The following new field is added to the show output to display the new NB-IoT RAT type:

(N) - NB-IoT

'N' is used to represent the Access Technology in the call description. The show output displays the RAT type of the call as NB-IoT.

show subscribers callid <call_id>

The following new field is added to the show output to display the new NB-IoT RAT type:

(N) - NB-IoT

'N' is used to represent the Access Technology in the call description. The show output displays the RAT type of the call as NB-IoT.

show subscribers full all

The following new field is added to the show output to display the new NB-IoT RAT type:

NB-IoT

The show output displays the RAT type of the call as NB-IoT.

show subscribers pgw-only all

The following new field is added to the show output to display the new NB-IoT RAT type:

(N) - NB-IoT

'N' is used to represent the Access Technology in the call description. The show output displays the RAT type of the call as NB-IoT.

show subscribers pgw-only full

The following new field is added to the show output to display the new NB-IoT RAT type:

NB-IoT

The show output displays the RAT type of the call as NB-IoT.

show subscribers pgw-only full all

The following new field is added to the show output to display the new NB-IoT RAT type:

NB-IoT

The show output displays the RAT type of the call as NB-IoT.

show subscribers saegw-only full

The following new field is added to the show output to display the new NB-IoT RAT type:

NB-IoT

The show output displays the RAT type of the call as NB-IoT.

show subscribers saegw-only full all

The following new field is added to the show output to display the new NB-IoT RAT type:

NB-IoT

The show output displays the RAT type of the call as NB-IoT.

show subscribers saegw-only all

The following new field is added to the show output to display the new NB-IoT RAT type:

(N) - NB-IoT

'N' is used to represent the Access Technology in the call description. The show output displays the RAT type of the call as NB-IoT.

show subscribers sgw-only all

The following new field is added to the show output to display the new NB-IoT RAT type:

(N) - NB-IoT

'N' is used to represent the Access Technology in the call description. The show output displays the RAT type of the call as NB-IoT.

show subscribers sgw-only full

The following new field is added to the show output to display the new NB-IoT RAT type:

NB-IoT

The show output displays the RAT type of the call as NB-IoT.

show subscribers sgw-only full all

The following new field is added to the show output to display the new NB-IoT RAT type:

NB-IoT

The show output displays the RAT type of the call as NB-IoT.

show subscribers subscription full

The following new field is added to the show output to display the new NB-IoT RAT type:

NB-IoT

The show output displays the RAT type of the call as NB-IoT.

show apn statistics all

The following new field is added in the “Initiated Sessions per RAT Type” and “Active Sessions per RAT Type” sections.

NB-IoT

The show output displays the number of initiated sessions and active sessions with NB-IoT RAT type per APN.

show apn <apn_name>

The following new field is added in the “Initiated Sessions per RAT Type” and “Active Sessions per RAT Type” sections.

NB-IoT

The show output displays the number of initiated sessions and active sessions with NB-IoT RAT type per APN.

show pgw-service name

The following new field is added in the “Initiated PDNs By RAT-Type:” and “Current PDNs By RAT-Type:” sections.

NB-IoT

The show output displays the number of initiated PDNs and current PDNs with NB-IoT RAT type per P-GW service.

show pgw-service statistics all

The following new field is added in the “Initiated PDNs By RAT-Type:” and “Current PDNs By RAT-Type:” sections.

NB-IoT

The show output displays the number of initiated PDNs and current PDNs with NB-IoT RAT type per P-GW service.

show sgw-service name

The following new field is added in the “Current Subscribers By RAT-Type:” and “Current PDNs By RAT-Type:” sections.

NB-IoT

The show output displays the current subscribers and current PDNs with NB-IoT RAT type per S-GW service.

show sgw-service statistics all

The following new field is added in the “Current Subscribers By RAT-Type:” and “Current PDNs By RAT-Type:” sections.

NB-IoT

The show output displays the current subscribers and current PDNs with NB-IoT RAT type per S-GW service.

show saegw-service name

The following new field is added in the “Colocated PDNs”, “PGW-Anchor PDNs:”, and “SGW-Anchor PDNs:” sections.

NB-IoT

The show output displays the statistics for Colocated PDNs , PGW-Anchor PDNs, and SGW-Anchor PDNs with NB_IoT RAT type.

show saegw-service statistics all

The following new field is added in the “Colocated PDNs”, “PGW-Anchor PDNs:”, and “SGW-Anchor PDNs:” sections.

NB-IoT

The show output displays the statistics for Colocated PDNs , PGW-Anchor PDNs, and SGW-Anchor PDNs with NB_IoT RAT type.

show session subsystem

The following new field is added in the “User Data Statistics” section.

NB-IoT

The show output displays the data packets per RAT type and subscribers count per RAT type.

show session subsystem full

The following new field is added in the “User Data Statistics” section.

NB-IoT

The show output displays the data packets per RAT type and subscribers count per RAT type.

show session subsystem verbose

The following new field is added in the “User Data Statistics” section.

NB-IoT

The show output displays the data packets per RAT type and subscribers count per RAT type.

show session summary

The following new field is added in the “User Data Statistics” section.

NB-IoT

The show output displays the data packets per RAT type and subscribers count per RAT type.

RADIUS Attributes

RADIUS Attributes	
Type of change - new / modified	New
Attribute Name	RAT Type
AAA Attribute (if applicable)	
Description	RAT type
Vendor ID	
VSA Type	
Length - Data part	
Value	
Source	

RADIUS Attributes	
Applicable product/feature. Please indicate products/features individually, do not include generic statement such as “all.”	

Diameter Attributes

Diameter Attributes	
Type of change - new / modified	New
Attribute Name	RAT-Type
Description	Provides the RAT type of the call.
AVP Header	
Vendor ID	(10415) 3GPP
VSA Type	
AVP Type	(1032) RAT-Type
Group Value	NB-IoT (1005)
AVP Flag	
Source	
Applicable product/feature. Please indicate products/features individually, do not include generic statement such as “all.”	P-GW/S-GW/SAEGW

CDR Dictionaries/Fields

CDR Dictionaries/Fields	
Type of change - new / modified dictionary:	New
Dictionary name	RAT-Type
Customer name	Provides the RAT type of the call.
Standard(s), based on	
Applicable record type(s)	(10415) 3GPP
Link to Engineering document with details of fields	
For new/modified fields	New

CDR Dictionaries/Fields	
Field name	ratType
Description of new/modified field	New rat type field information added for NB-IoT.
Custom field?	N.A.
Standard(s) based? Which standard(s)	Standard
Applicable dictionaries	All
Category	New value added for specifying NB-IoT RAT Type
Format	String
Length	4
Exceptions for each applicable dictionary (if any)	N.A.
Corresponding CLI command to configure the field	No CLI is required to configure this.
Default value for field	NB-IoT

Bulk Statistics

This section lists all the bulk statistics that have been added, modified, or deprecated to support this feature.

APN Schema

This section displays the new bulk stats that have been added to indicate number of NB-IoT sessions for APNs.

- active-nb-iot-sessions%: The total number of active NB-IoT sessions per APN (with RAT Type NB-IoT).
- initiated-nb-iot-sessions%: The total number of initiated NB-IoT sessions.

P-GW Schema

This section displays the new bulk stats that have been added to indicate NB-IoT PDNs.

- sesstat-pdn-rat-nb-iot%: The total number of PDN Type statistics with RAT type=NB-IoT.
- sssstat-rat-init-nb-iot-gtp%: The total number of initiated NB-IoT PDNs (with RAT Type NB-IoT).

SAEGW Schema

This section displays the new bulk stat that have been added to indicate NB-IoT PDNs.

- pgw-sesstat-pdn-rat-nb-iot%: The total number of NB-IoT PDNs (PGW anchored/Collapsed PDN) with RAT Type NB-IoT.

S-GW Schema

This section displays the new bulk stats that have been added to indicate active UEs.

- `sessstat-totcur-ue-nb-iot%`: The total number of active UEs with RAT type=NB-IoT.
- `sessstat-totcur-pdn-nb-iot%`: The total number of active PDNs with RAT type=NB-IoT.



CHAPTER 13

Non-IP PDN Support

This chapter describes the support of Non-IP PDN on P-GW and S-GW.

- [Feature Summary and Revision History, on page 173](#)
- [Feature Description, on page 174](#)
- [How It Works, on page 174](#)
- [Configuring Non-IP PDN, on page 181](#)
- [Monitoring and Troubleshooting the Non-IP PDN, on page 183](#)

Feature Summary and Revision History

Summary Data

Applicable Product(s) or Functional Area	<ul style="list-style-type: none">• C-SGN• P-GW• S-GW
Applicable Platform(s)	<ul style="list-style-type: none">• UGP• VPC-DI• VPC-SI
Feature Default	Disabled - License Required
Related Changes in This Release	Not Applicable
Related Documentation	<ul style="list-style-type: none">• <i>Command Line Interface Reference</i>• <i>Statistics and Counters Reference</i>

Revision History

Revision Details	Release
Non IP UE P-GW support for SGi through RADIUS is tested on P-GW. This feature is tested and qualified on VPC-DI platform.	21.22
S-GW CDR support is added for Non-IP PDN subscribers.	21.13
The feature is tested and qualified on the ASR 5500 platform. A new PDP Type, Non-IP, is introduced along with the existing IPv4, IPv6, and IPv4v6 in S-GW CDR. Volume traffic fields are also updated for Non-IP PDN subscribers.	21.3
First introduced.	N5.1 (21.1.V0)

Feature Description

There are specific protocol optimizations already defined for low-power networking (For example, IPv6 over Low-power Wireless Personal Area Networks - 6LoWPAN). These protocol adaptations provided efficient ways of header compression and operation optimization to allow effective transmission of data with small frame size. Due to this, some of the Cellular Internet of Things (CIoT) devices may not use normal IP services. Therefore, it is useful to support a Non-IP PDN connection to allow such protocol to be used by the CIoT UE toward the Non-IP protocols destination node, like Application Server (AS) or a Non-IP gateway. The C-SGN/P-GW, in this case, can act as a transparent passthrough by a direct forwarding interface between itself and the AS or Non-IP gateway, and the CIoT UE can interact with the specific Non-IP destination node directly using appropriate protocols.

As part of this feature, along with Non-IP PDN, support is also added for extended Protocol Configuration Options (ePCO) IE at P-GW, and S-GW. Support is also added for Radius authentication and radius accounting for NoN-IP UE with 3GPP compliant Radius dictionary.

How It Works

Support for the SGi based delivery of Non-IP data can be used by any UE. The P-GW decides at PDN connection establishment, based on pre-configuration, which point-to-point (PtP) tunneling technique is used for the SGi based delivery between the P-GW and the AS.

SGi PtP tunneling based on UDP/IP

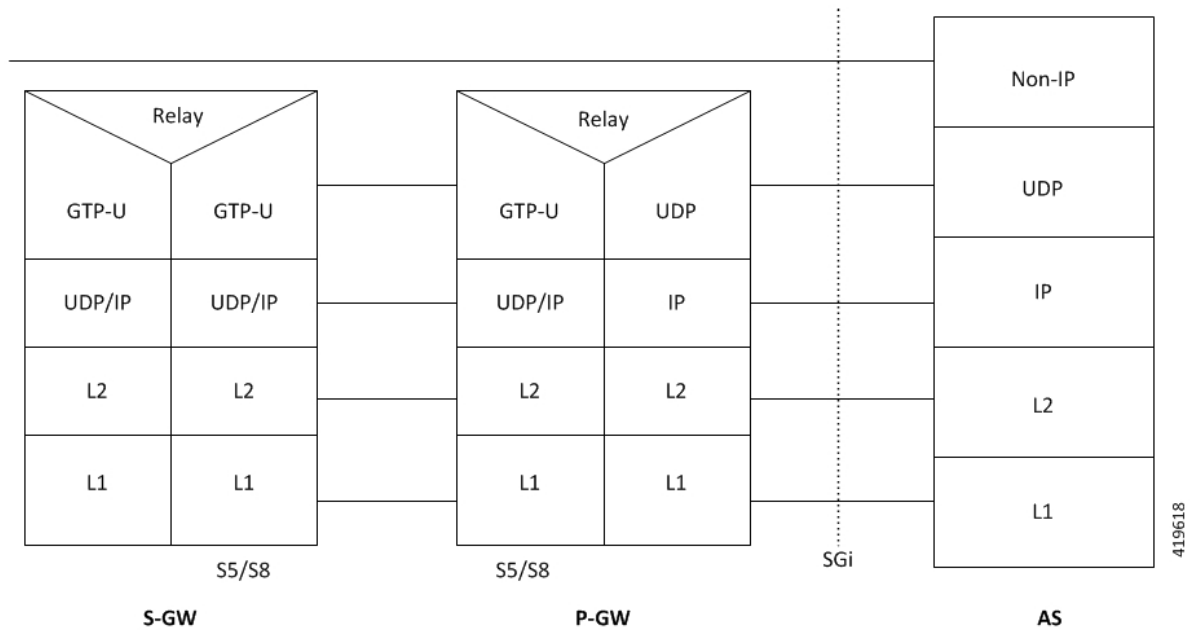
A PtP tunnel is used by the P-GW toward the AS. The tunnel parameters (that is, destination IP address and UDP port) for SGi PtP tunneling based on UDP/IP are pre-configured on the P-GW. The IP address allocation procedure for PDN connections is performed locally by the P-GW based on APN configuration. And, according

to 3GPP defined existing IP address allocation procedures, only single IP address is used (that is, both IPv4 and IPv6 addresses are not allocated).

The P-GW acts as a transparent forwarding node for the payload between the UE and the AS. For uplink Non-IP data, the P-GW forwards the received data to the AS over the SGi PtP tunnel using UDP/IP encapsulation. For downlink Non-IP data, the AS sends the data using UDP/IP encapsulation with the IP address of the UE and the 3GPP defined UDP port for "Non-IP" data. The P-GW decapsulates the received data (that is, removes the UDP/IP headers) and forwards the data to S-GW on the GTP-U tunnel, identified by the IP address of the UE, for delivery to the UE.

The P-GW performs the IP-related operations but the IP address or IP prefix is not provided to the UE. For IPv6, the P-GW assigns an Interface Identifier for the PDN connection. The allocated IP address or IPv6 prefix identifies the PDN connection of the UE.

The following image illustrates the protocol configuration for Non-IP data (user plane) using SGi PtP tunneling.



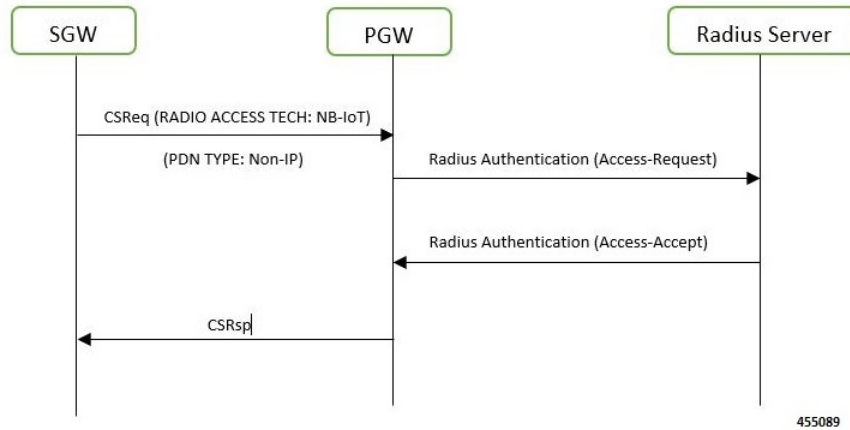
Important For Non-IP data, IP protocol-related functionalities are not applicable.

SGi based delivery of Non-IP data is used by any UE. The P-GW decides at PDN connection establishment, based on pre-configuration, where a point-to-point (PtP) tunneling technique is used for the SGi-based delivery between the P-GW and the AS. Radius authentication and radius accounting are supported for Non-IP UE with 3GPP compliant radius dictionary.

Radius Authentication and Accounting Support at P-GW

P-GW supports Radius authentication. Following call flow describes Radius authentication workflow.

Figure 11: Call Flow



Following call flow describes the radius accounting workflow at P-GW.

Figure 12: Call flow

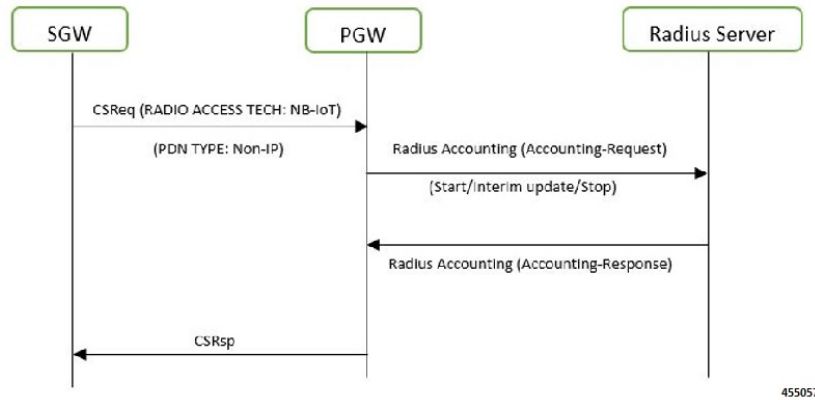


Table 9: Procedure

Step	Description
1	P-GW sends radius accounting start to radius server when it receives an NB-IOT/EUTRAN call with PDN type as Non-IP.
2	PGW continuously sends radius accounting interim-updates to radius server after configured timer expiration.
3	Finally, it sends a radius accounting stop to radius server when the subscriber is detached

Inter-RAT and Intra-RAT Handovers for Non-IP PDNs

The following table shows the current behavior of Inter-RAT and Intra-RAT Handovers for Non-IP PDNs.

Handover	Type	Non-IP PDNs
S-GW Relocation	Intra/Inter-RAT	Supported (Handover successful).
MME <-> S4-SGSN	Inter-RAT	Supported (Handover successful).
GnGp (4G -> 3G)	Inter-RAT	Not Supported (Handover Reject with cause 'Non-existent' followed by drop of existing 4G call).
LTE -> eHRPD	Inter-RAT	Not Supported (Handover Reject with status code 'Insufficient Resources'. Existing 4G call continues).
LTE -> Wi-Fi (S2a/S2b)	Inter-RAT	Not Supported (Handover Reject with cause 'pdn type not supported'. Existing 4G call continues).

ePCO IE Support

With this feature, ePCO IE for Non-IP PDN is supported at P-GW and S-GW.

ePCO IE Support at P-GW

Following is a gist of requirements supported for the ePCO IE at P-GW:

- Support is added for EPCOSI bit in Indication Flags IE in CSReq and MBReq at the P-GW.
- The P-GW includes PCO in ePCO IE based on EPCOSI bit received in CSReq message.
- Currently supported PCOs in ePCO IE is added.
- Support is added for Non-IP link MTU in both PCO as well as in ePCO. Depending on EPCOSI Indication Flag, the P-GW communicates Non-IP link MTU in PCO or ePCO. The Non-IP link MTU is sent for Non-IP PDNs when requested in CSReq message.
- When EPCOSI is received, requested options in ePCO IE are considered. When EPCOSI is not received, then ePCO IE is ignored at P-GW.

ePCO IE Support at S-GW

Following is a gist of requirements supported for the ePCO IE at S-GW:

- Support is added for EPCOSI bit in Indication Flags IE in CSReq and MBReq at the S-GW.
- The S-GW sets ePCO support for a PDN under following condition:
 1. During new call establishment:
 - a. When EPCOSI is received from MME in CSReq.
 - b. When ePCO IE is received in CSRsp from PGW.

2. During inter-SGW relocation:
 - a. When EPCOSI is received from MME in CSReq toward S-GW.
 3. During inter-MME intra-SGW relocation:
 - a. When EPCOSI is received from MME in MBReq toward S-GW.
- During inter-MME intra-SGW handover scenario, if S-GW detects any change in ePCO IE support on MME, the S-GW initiates MBReq toward P-GW to notify the change accordingly by setting or re-setting EPCOSI flag in Indication Flags IE.
 - The S-GW transparently forwards the received PCO/ePCO IE from the peer. As such, the S-GW does not put any restriction or checks, if ePCO is received for a PDN, for which ePCO is not supported and the other way around.
 - For any PDN supporting ePCO IE, if MBReq without EPCOSI is received, the S-GW assumes that the ePCO IE support for the PDN is discontinued at MME and S-GW triggers MBReq toward P-GW without sending EPCOSI flag, or without sending Indication Flag IE. Similarly, if ePCO IE support is indicated in MBReq for an existing PDN not supporting ePCO, the S-GW triggers MBReq toward P-GW with EPCOSI set.



Important

During initial PDN establishment messages, it is expected that MME sends the same EPCOSI support in CSReq and the followed MBReq (MBReq for S1 establish). If there is any change, it is considered as a misbehavior by MME and S-GW uses the final value received in MBReq. As such, signaling toward P-GW is triggered to indicate the change.

The ePCO IE supported at P-GW and S-GW has the following limitations:

- Lawful Intercept (LI) is not supported for ePCO IE.
- Currently supported PCO in MBR is not sent in MBRsp for PDN supporting ePCO IE.
- ePCO IE is not supported in DSReq/DSRsp messages. This is in parity with PCO IE.

Limitations

Following are the known limitations or restrictions of Non-IP PDN feature:

- Non-IP PDN connection is not supported on GGSN and SAEGW in this release.
- For Non-IP PDN at P-GW, following interfaces are not supported in this release:
 - S6b
 - LI Interface
 - Gx
 - Gy
 - Gz

- Rf



Important We recommend the operator to not configure these interfaces or CLI commands related to these interfaces for Non-IP PDN connections.

- P-GW does not support Local Policy for Non-IP PDN connections in this release.
- P-GW does not support other SGi PtP tunneling mechanisms (like PMIPv6/GRE, L2TP, GTP-C/U) to deliver Non-IP data to AS via SGi.
- P-GW does not support APN-AMBR rate limit for non-IP PDN connections.
- P-GW does not support shaping and policing for Non-IP data in this release.
- P-GW/S-GW does not support session trace for Non-IP PDNs in this release.
- P-GW/S-GW does not support RTT for Non-IP PDNs in this release.
- P-GW does not support NEMO for Non-IP PDNs in this release.
- P-GW does not support VRF for Non-IP PDNs in this release.
- P-GW does not support MPLS for Non-IP PDNs in this release.
- P-GW does not support IPsec for Non-IP PDNs in this release.
- For Non-IP PDNs, P-GW does not support VLAN tagging based on private pool configuration and next-hop address.
- P-GW does not support Framed Route for Non-IP PDNs in this release.
- ICSR upgrade/downgrade is not supported for Non-IP PDN sessions in this release.
- S-GW does not support Local IP Access (LIPA) for Non-IP PDN in this release.
- In-sequence delivery of Non-IP data cannot be guaranteed and data PDUs may be lost, requiring higher protocol layers to ensure guaranteed delivery when needed.
- P-GW supports reassembly of fragmented packets received on SGi UDP-IP tunnel, but currently does not send Internet Control Message Protocol (ICMP) “reassembly time exceeded” error message to the sender.
- Non-IP UE user-plane traffic is not supported on ICUPS.
- Following existing APN configuration are not supported for Non-IP PDNs:
 - accounting-mode gtp



Note The accounting-mode with RADIUS configuration is supported.

- active-charging
- apn-ambr
- authorize-with-hss

- backoff timer-value
- data-tunnel mtu
- ppp mtu
- dcca
- emergency-apn
- fw-and-nat
- gtpv
- ignore-alt-config
- ims-auth-service
- ip hide-service-address
- l3-to-l2-tunnel
- nai-construction
- pco-options
- reporting-action event-record
- ip pool <pool_name> <ip_address/subnet_mask> private nexthop-forwarding-address <ip_address> overlap vlanid <vlan_id>.

License Requirements

This feature is license controlled. Contact your Cisco account representative for information on how to obtain a license.

Standards Compliance

The Non-IP PDN feature complies with the following standards:

- 3GPP TS 23.060 - General Packet Radio Service (GPRS); Service description; Stage 2.
- 3GPP TS 23.401 - General Packet Radio Service (GPRS) enhancements for Evolved Universal Terrestrial Radio Access Network (E-UTRAN) access.
- 3GPP TS 24.008 - Mobile radio interface Layer 3 specification; Core network protocols; Stage 3.
- 3GPP TS 24.301 - Non-Access-Stratum (NAS) protocol for Evolved Packet System (EPS); Stage 3.
- 3GPP TS 29.274 - 3GPP Evolved Packet System (EPS); Evolved General Packet Radio Service (GPRS) Tunnelling Protocol for Control plane (GTPv2-C); Stage 3.

Configuring Non-IP PDN

Enabling Support for Non-IP PDP-Type for APN

Use the following commands under APN Configuration Mode for configuring APN to support Non-IP context types:

```
configure
context context_name
apn apn_name
    pdp-type non-ip
end
```

Notes:

- By default, the command is disabled.
- This CLI command takes effect during new subscriber call creation on S5/S8 interface to the APN.

Configuring UDP-IPv4 or UDP-IPv6 Tunneling Parameters

Use the following commands under APN Configuration Mode to configure UDP-IPv4 or UDP-IPv6 tunneling parameters between the P-GW and an external application server for the APN.

```
configure
context context_name
apn apn_name
    tunnel udpip peer-address peer_address peer-port peer_udp_port [ local-port
<local_udp_port> ]
end
```

Notes:

- **udpip** - Specifies the per subscriber UDP/IPv4 or UDP/IPv6 tunnel. Based on IPv4/IPv6 peer and local address, tunnel will be UDP/IPv4 or UDP/IPv6.
- **peer-address** *peer_address* - Specifies the Peer address for the tunnel. *peer_address* must be expressed in dotted decimal notation.
- **peer-port** *peer_udp_port* - Specifies the port number of the peer for the tunnel.
- **local-port** - Specifies the local UDP port number. Default value is 49152.
- If previously configured, use the `no tunnel udpip` CLI command to disable the UDP-IPv4/UDP-IPv6 tunneling for the APN.
- For local and peer UDP port number, it is recommended to use unregistered port number with IANA.
- This CLI command takes effect during new subscriber call creation on S5/S8 interface to the APN.

Enabling Support for Non-IP PDP Type for Radius Accounting and Authentication

Use the following commands for configuring radius accounting:

```
configure
  context context_name
    aaa group default
      radius dictionary 3gpp
    exit
  apn apn_name
    pdp-type non-ip
    tunnel udp peer-address peer_address peer-port peer_UDP_port local-port local_UDP_port
    no ims-auth-service service_name
    no active-charging rulebase
    authentication imsi-auth username-strip-apn
    accounting-mode radius
    mediation-device context-name ISP1 delay-GTP-respo
  end
```

Notes:

- By default, the command is disabled.
- This CLI command is applicable only for legacy PDN features.
- **radius dictionary 3gpp**: Configures 3GPP radius dictionary for radius accounting.

Verifying the Non-IP PDN Configuration

Use the **show apn name *apn_name*** command to verify the configuration that you have entered following the steps outlined earlier. The output appears similar to the following:

```
show apn name intershat

access point name (APN): intershat
authentication context: ingress
pdp type: non-ip
emergency: no
.
.
.
Tunnel peers
  udp peer-address 10.0.0.1 peer-port 65535 local-port 49152
.
.
.
```

The following show commands can also be used for verifying the Non-IP PDP-Type and UDP-IP tunnel configurations for the APN:

- **show configuration apn *apnname***
- **show configuration**
- **show configuration apn *apnname* verbose**

- **show configuration verbose**

Monitoring and Troubleshooting the Non-IP PDN

This section provides information regarding show commands and/or their outputs in support of the feature.

Non-IP PDN Show Command(s) and/or Outputs

This section provides information regarding show commands and/or their outputs in support of the feature.

show session progress

The following new field is added to the output of this command to show the number of Non-IP PDN sessions that are in CONNECTED state:

- **In-progress calls @ PDN-TYPE-Non-IP CONNECTED state**

show session subsystem

The following new field is added to the output of this command to show the number of Non-IP PDN sessions that are in CONNECTED state:

- **In-progress calls @ PDN-TYPE-Non-IP CONNECTED state**

show session summary

The following new fields are added to the show output to display the summary information of sessions active or dormant along with total sessions for each access-type:

- **pgw-gtp-non-ip** – Total number of Non-IP subscribers on GTP-PGW.
- **sgw-gtp-non-ip** – Total number of Non-IP subscribers on GTP-SGW.

These new fields are also introduced in the output of following show commands:

- **show subscribers**
- **show subscribers summary**

show subscribers aaa-configuration

The output of this show command displays the following new fields under Access Type and Network Type:

- **Access Type: sgw-pdn-type-non-ip | gtp-pdn-type-non-ip**
- **Network Type: Non-IP | UDP-IPv4 | UDP-IPv6**

Notes:

- **Access Type: sgw-pdn-type-non-ip** is displayed for S-GW sessions, when PDN-type is Non-IP.
- **Access Type: gtp-pdn-type-non-ip** is displayed for P-GW sessions, when PDN-type is Non-IP.

- **Network Type: (N) – Non-IP** is displayed for S-GW sessions with PDN-type Non-IP.
- **Network Type: (x) – UDP-IPv4** is displayed for P-GW sessions with PDN-type Non-IP and IP address allocated to the session is IPv4.
- **Network Type: (X) – UDP-IPv6** is displayed for P-GW sessions with PDN-type Non-IP and IP address allocated to the session is IPv6.

These new fields are also introduced in the output of following show commands:

- **show subscribers activity all**
- **show subscribers full all**

show subscribers pgw-only full all

The output of this show command displays the following new fields under Access Type and Network Type:

- **Access Type: gtp-pdn-type-non-ip**
- **Network Type: UDP-IPv4 | UDP-IPv6**

Notes:

- **Access Type: gtp-pdn-type-non-ip** is displayed for P-GW sessions, when PDN-type is Non-IP.
- **Network Type: (x) – UDP-IPv4** is displayed for P-GW sessions with PDN-type Non-IP and IP address allocated to the session is IPv4.
- **Network Type: (X) – UDP-IPv6** is displayed for P-GW sessions with PDN-type Non-IP and IP address allocated to the session is IPv6.

show subscribers sgw-only full all

The output of this show command displays the following new fields under Access Type and Network Type:

- **Access Type: sgw-pdn-type-non-ip**
- **Network Type: Non-IP**

Notes:

- **Access Type: sgw-pdn-type-non-ip** is displayed for S-GW sessions, when PDN-type is Non-IP.
- **Network Type: Network Type: (N) – Non-IP** is displayed for S-GW sessions with PDN-type Non-IP.

show pgw-service statistics all

The output of this show command displays the following new fields:

1. PDNs By PDN-Type:
 - **Non-IP PDNs:**
 - **Active:**
 - **Setup:**

- **Released:**
2. VAPNs Selected Based on Configured PDP-Type:
 - **Non-IP PDNs:**
 - **Setup:**
 - **Rejected:**
 3. Data Statistics Per Interface:
 - **Drop Due To Non-IP Port Violation:**
 - **Packets:**
 - **Bytes:**
 - **Drop Due To Non-IP Protocol Violation:**
 - **Packets:**
 - **Bytes:**
 - **Drop Due To Non-IP Invalid AS Source Address:**
 - **Packets:**
 - **Bytes:**
 4. Data Statistics Per Interface:
 - **Non-IP Reassembly Statistics:**
 - **Packets:**
 - **Bytes:**
 5. IP Address Allocation Statistics:
 - **Non-IP PDN:**
 - **Total IPv4 addrs allocated:**
 - **Local pool assignment:**
 - **Total IPv6 addrs allocated:**
 - **Local pool assignment:**
 6. SGi tunneling statistics:
 - **UDP-IPv4 Tunnels:**
 - **Active:**

- Setup:
- Released:
- UDP-IPv6 Tunnels:
 - Active:
 - Setup:
 - Released:

7. Data Statistics Per PDN-Type:

- Non-IP PDNs:
 - Uplink:
 - Total Pkts:
 - Total Bytes:
 - Downlink:
 - Total Pkts:
 - Total Bytes:

Where:

1. Number of Active, Setup and Release session counters for Non-IP PDN type.
2. Setup and Rejected counters for Virtual APN selection based on Non-IP PDP type.
3. Packets and bytes drop counters for invalid port, invalid protocol and invalid application server source address.
4. Packets and bytes reassembled counters for Non-IP downlink data on UDP-IPv4/UDP-IPv6 tunnel.
5. Counters for locally allocated IPv4/IPv6 address for Non-IP PDN type UEs.
6. SGI tunneling statistics for UDP-IPv4 and UDP-IPv6.
7. Data statistics (uplink/downlink) for Non-IP PDN types.

show sgw-service statistics all

The output of this show command displays the following new fields:

1. PDNs By PDN-Type:
 - Active:
 - Setup:
 - Released:
 - Rejected:

2. Data Statistics Per PDN-Type:

- **Non-IP PDNs:**
 - **Uplink:**
 - **Total Pkts:**
 - **Total Bytes:**
 - **Downlink:**
 - **Total Pkts:**
 - **Total Bytes:**

Where:

1. Number of Active, Setup, Release, and Rejected session counters for Non-IP PDN type.
2. Data statistics (Uplink and Downlink) for Non-IP PDN types.

show subscribers network-type

The output of the show subscribers network-type udp-ipv4 | udp-ipv6 | non-ip command displays the following new fields:

1. Access Type:
 - **(B) - pgw-gtp-non-ip**
 - **(J) - sgw-gtp-non-ip**
2. Network-Type:
 - **(N) - NON-IP**
 - **(x) - UDP-IPv4**
 - **(X) - UDP-IPv6**

Where:

1. Non-IP PDNs for GTP-PGW and S-GW based on Access Type.
2. Non-IP network type for S-GW and UDP-IPv4/UDP-IPv6 network type for P-GW.

show subscribers pgw-only summary

The following new field is added to the output of this command which displays the summary information for P-GW subscribers, based on defined parameters:

- **gtp-pdn-type-non-ip**

show subscribers sgw-only summary

The following new field is added to the output of this command which displays the summary information for S-GW subscribers, based on defined parameters:

- **gtp-pdn-type-non-ip**

show subscribers pgw-only

The following new field is added to the output of this command to display Non-IP PDN Access Type:

- **(B) - pgw-gtp-non-ip**

show subscribers sgw-only

The following new field is added to the output of this command to display Non-IP PDN Access Type:

- **(J) - sgw-gtp-non-ip**

show apn statistics

The output of this show command displays the following new fields:

1. Data Statistics:
 - **Non-IP port violations drop:**
 - **Non-IP protocol violation drop:**
 - **Non-IP invalid AS src addr drop:**
2. Data Statistics:
 - **Non-IP reassembled pkts:**
3. Total PDN-Type stats:
 - **PDN-Type Non-IP sessions:**
 - **Active:**
 - **Setup:**
 - **Released:**

Where:

1. Non-IP drop statistics for port violation, protocol violation, and application server source address violations for the APN.
2. Number of reassembled packets from fragmented downlink packets on SGi UDP-IP tunnel for Non-IP PDNs for the APN.
3. Number of Active, Setup and Release session counters for Non-IP PDN type.

show apn statistics name

Use the **show apn statistics name** *apn_name* command to verify the Non-IP UE APN statistics. The output appears similar to the following:

```
show apn name intershat

access point name (APN): intershat
authentication context: ingress
pdp type: non-ip
emergency: no
.
.
.
Tunnel peers
  udp peer-address 10.0.0.1 peer-port 65535 local-port 49152
.
.
.
```

Monitor Protocol

When using the monitor protocol command, enable the following options::

- 26 (GTPU)and 33 (L3 Tunnel)
- 12 (RADIUS Auth),13 (Acct),31(RADIUS COA) for RADIUS messages

Show Configuration Errors

The following APN configuration error is displayed when APN pdp-type is Non-IP and UDP-IP tunnel is not configured under APN:

```
#####
      Displaying APN-configuration errors
#####
Error   : UDP tunnel not configured in Non-IP APN <apn_name> in the context <context>
Total 1 error(s) in this section !
```

Non-IP PDN Bulk Statistics

The following statistics are introduced in support of the feature:

APN Schema

- invalid-dst-port-pkt-drop – This statistics indicates the total number of downlink packets dropped due to invalid destination port for a Non-IP APN PDN.
- pdn-non-ip-actsess – This statistics indicates the total number of active Non-IP sessions at APN.
- pdn-non-ip-setupsess – This statistics indicates the total number of Non-IP session setup at APN.
- pdn-non-ip-relsess – This statistics indicates the total number of Non-IP session release at APN.
- invalid-tun-proto-pkt-drop – This statistics indicates the total number of downlink packets dropped due to invalid SGi tunnel protocol for a Non-IP APN PDN.
- invalid-as-src-pkt-drop – This statistics indicates the total number of downlink packets dropped due to invalid application server source address for a Non-IP APN PDN.

P-GW Schema

- `sessstat-pdn-non-ip-active` – This statistic indicates the total number of active Non-IP PDNs at P-GW.
- `sessstat-pdn-non-ip-setup` – This statistic indicates the total number of Non-IP PDNs setup at P-GW.
- `sessstat-pdn-non-ip-rel` – This statistic indicates the total number of Non-IP PDNs released at P-GW.
- `sessstat-non-ip-ipv4addalloc` – This statistic indicates the total number of times IPv4 address is allocated for Non-IP P-GW PDNs.
- `sessstat-non-ip-ipv6addalloc` – This statistic indicates the total number of times IPv6 address is allocated for Non-IP P-GW PDNs.
- `sessstat-non-ip-addalloc-ipv4loacalpool` – This statistic indicates the total number of times IPv4 address is allocated from local pool for Non-IP P-GW PDNs.
- `sessstat-non-ip-addalloc-ipv6loacalpool` – This statistic indicates the total number of times IPv6 address is allocated from local pool for Non-IP P-GW PDNs.
- `udptunstat-ipv4sessact` – This statistic indicates the total number of active UDP-IPv4 SGi tunnel.
- `udptunstat-ipv4sesssetup` – This statistic indicates the total number of UDP-IPv4 SGi tunnel setup at P-GW.
- `udptunstat-ipv4sessrel` – This statistic indicates the total number of UDP-IPv4 SGi tunnel setup at P-GW.
- `udptunstat-ipv6sessact` – This statistic indicates the total number of active UDP-IPv6 SGi tunnel.
- `udptunstat-ipv6sesssetup` – This statistic indicates the total number of UDP-IPv6 SGi tunnel setup at P-GW.
- `udptunstat-ipv6sessrel` – This statistic indicates the total number of UDP-IPv6 SGi tunnel released at P-GW.
- `non-ip-pdn-to-user-pkt` – This statistics indicates the total number of downlink packets sent on Non-IP P-GW PDNs.
- `non-ip-pdn-to-user-byte` – This statistics indicates the total number of downlink bytes sent on Non-IP P-GW PDNs.
- `non-ip-pdn-from-user-pkt` – This statistics indicates the total number of uplink packets received for Non-IP S-GW PDNs.
- `non-ip-pdn-from-user-byte` – This statistic indicates the total number of uplink bytes with Non-IP S-GW PDNs.
- `sessstat-invalid-port-dnlkpktdrop` – This statistics indicates the total number of downlink packets dropped due to invalid destination port for a Non-IP P-GW PDN.
- `sessstat-invalid-port-dnlkbytedrop` – This statistics indicates the total number of downlink bytes dropped due to invalid destination port for a Non-IP P-GW PDN.
- `sessstat-invalid-tun-proto-dnlkpktdrop` – This statistics indicates the total number of downlink packets dropped due to invalid SGi tunnel protocol for a Non-IP P-GW PDN.
- `sessstat-invalid-tun-proto-dnlkbytedrop` – This statistics indicates the total number of downlink bytes dropped due to invalid SGi tunnel protocol for a Non-IP P-GW PDN.
- `sessstat-invalid-as-src-dnlkpktdrop` – This statistics indicates the total number of downlink packets dropped due to invalid application server source address for a Non-IP P-GW PDN.
- `sessstat-invalid-as-src-dnlkbytedrop` – This statistics indicates the total number of downlink bytes dropped due to invalid application server source address for a Non-IP P-GW PDN.

S-GW Schema

- `sessstat-totcur-pdn-non-ip` – This statistic indicates the total number of current Non-IP S-GW PDN.
- `sessstat-pdnsetuptype-non-ip` – This statistic indicates the total number of Non-IP PDNs setup at S-GW.
- `sessstat-pdnrel-non-ip` – This statistic indicates the total number of Non-IP PDNs released at S-GW.
- `sessstat-pdnrej-non-ip` – This statistic indicates the total number of Non-IP PDNs rejected by S-GW.

- non-ip-pdn-to-user-pkt – This statistic indicates the total number of downlink packets with Non-IP S-GW PDNs.
- non-ip-pdn-to-user-byte – This statistic indicates the total number of downlink bytes with Non-IP S-GW PDNs.
- non-ip-pdn-from-user-pkt – This statistic indicates the total number of uplink packets with Non-IP S-GW PDNs.
- non-ip-pdn-from-user-byte – This statistic indicates the total number of uplink bytes with Non-IP S-GW PDNs.



CHAPTER 14

S11U Interface Support on S-GW for Clot Devices

- [Feature Summary and Revision History, on page 193](#)
- [Feature Description, on page 194](#)
- [How It Works, on page 196](#)
- [Standards Compliance, on page 201](#)
- [Configuring S11U Interface Support on S-GW for Clot Devices, on page 201](#)
- [Monitoring and Troubleshooting, on page 204](#)

Feature Summary and Revision History

Summary Data

Applicable Product(s) or Functional Area	<ul style="list-style-type: none">• C-SGN• P-GW• SAEGW• S-GW
Applicable Platform(s)	<ul style="list-style-type: none">• UGP• VPC-DI• VPC-SI
Feature Default	Disabled - License Required
Related Changes in This Release	Not Applicable
Related Documentation	<ul style="list-style-type: none">• <i>Command Line Interface Reference</i>• <i>Statistics and Counters Reference</i>

Revision History

Revision Details	Release
The feature is tested and qualified on the ASR 5500 platform.	21.3
First introduced.	N5.1 (21.1.V0)

Feature Description

Cellular IoT EPS optimization provides improved support of small data transfers. The IoT devices mostly use Machine-Type-Communication (MTC), and they have a broad spectrum of capabilities with varied devices. The numbers of MTC devices are growing rapidly and using the existing LTE technology for transmitting data of these IoT devices would lead to a network overload. Though the user data transmitted is small, amount of signaling remains the same.

The Non-Access Stratum (NAS) is a set of protocols in the Evolved Packet System. The NAS is used to convey non-radio signaling between the User Equipment (UE) and the Mobility Management Entity (MME) for LTE/E-UTRAN access.

The Access Stratum (AS) is the functional layer below NAS, working between the UE and radio network. It is responsible for transporting data over wireless connection and managing radio resources.

A new interface named S11-U interface is introduced as a part of control plane ClIoT EPS optimization for small data transmission between the MME and S-GW. It is based on the existing GTP-U architecture. It is a GTPv1 user plane interface and carries small data sent and received over NAS between MME and S-GW.

The SGI interface exists between the PDN gateway and the packet data network. The PDN can be an operator's external public or private packet data network or an intra-operator packet data network.



Important This feature is license controlled. Contact your Cisco account representative for information on how to obtain a license.

The Cellular IoT EPS optimizations are categorized as follows:

1. User Plane ClIoT EPS Optimization - transports user data passing through the user plane
2. Control Plane ClIoT EPS Optimization - transports user data or SMS messages passing through MME. This is done by encapsulating them in NAS, reducing the total number of control plane messages when handling a short data transaction.

These optimizations can be used:

1. **Separately:** If the UE or the network supports one of them.
2. **In Parallel:** If the UE or the network supports both. If both the Control Plane and User Plane ClIoT EPS optimizations are supported for a UE, the PDN connections that use only control plane ClIoT optimizations are handled through the Control Plane ClIoT EPS optimizations. For example, the MME that has included the "control plane only indicator" in the ESM request will be handled by the control plane ClIoT EPS optimization.

All other PDN connections are handled using Control Plane or User Plane CloT EPS optimizations. In addition, the Control Plane CloT optimization can be used to support PDN connections to an SCEF.

The regular S1-U data transfer is used independently to support PDN connections to P-GW. All the SGi PDN connections of a UE either use S11-U or S1-U interface at any point in time. Support for SGi based delivery of Non-IP data is used by any UE, that is, it is independent of support for the User Plane CloT EPS Optimization and the Control Plane CloT EPS Optimization.

This feature provides control plane CloT optimization support by establishing S11-U PDN connection and other applicable procedures for the S11-U interface.

Old Behavior: S11u data support was not present for S-GW.

New Behavior: S11u data support is now present for S-GW.

Impact on Customer: Data can now be sent from S-GW to MME over the S11u tunnel.

Node Feature Support for CloT Feature

S-GW already supports Echo Request/Response functionality for S11 control interface. In this Echo Request/Response message functionality, Node Feature gives an indication for supporting CloT features. This flag is received by the MME in Echo Request/Response message exchange and is used during the selection of S-GW for CloT capability. A new CLI command cellular-iot has been added for enabling CloT feature functionality. Please see section, [Configuring S11U Interface Support on S-GW for CloT Devices, on page 201](#) for more information.

The following table specifies the features defined on GTPv2 interfaces and the interfaces on which the features apply.

Feature	Interface	Description
PRN	S11, S4	P-GW Restart Notification: If both the S-GW and the MME/S4-SGSN support this feature, then S-GW sends P-GW Restart Notification message to the MME/S4-SGSN, when the S-GW detects that the peer P-GW has restarted. S-GW might send P-GW Restart Notification message when the S-GW detects that the peer P-GW has failed and not restarted.
MABR	S11	Modify Access Bearers Request: If both S-GW and MME support this feature, then MME modifies the S1-U bearers of all the PDN connections of the UE by sending a Modify Access Bearers Request message.
NTSR	S11/S4	Network Triggered Service Restoration procedure: If both S-GW and MME/S4-SGSN support this feature, then S-GW sends a Downlink Data Notification message including the IMSI to the MME/S4-SGSN on the TEID 0 as part of a network triggered service restoration procedure.

Feature	Interface	Description
CIOT	S11	<p>Cellular Internet Of Things:</p> <p>This feature is supported over the S11 interface, from the S-GW to the MME.</p> <p>If the S-GW notifies the support of this feature, it indicates to the MME that the S-GW supports all the following CIoT features:</p> <ul style="list-style-type: none"> • EUTRAN-NB-IoT RAT type • Non-IP PDN type • S11-U tunneling • Serving PLMN Rate Control <ul style="list-style-type: none"> • MO Exception Data indication • Extended PCO

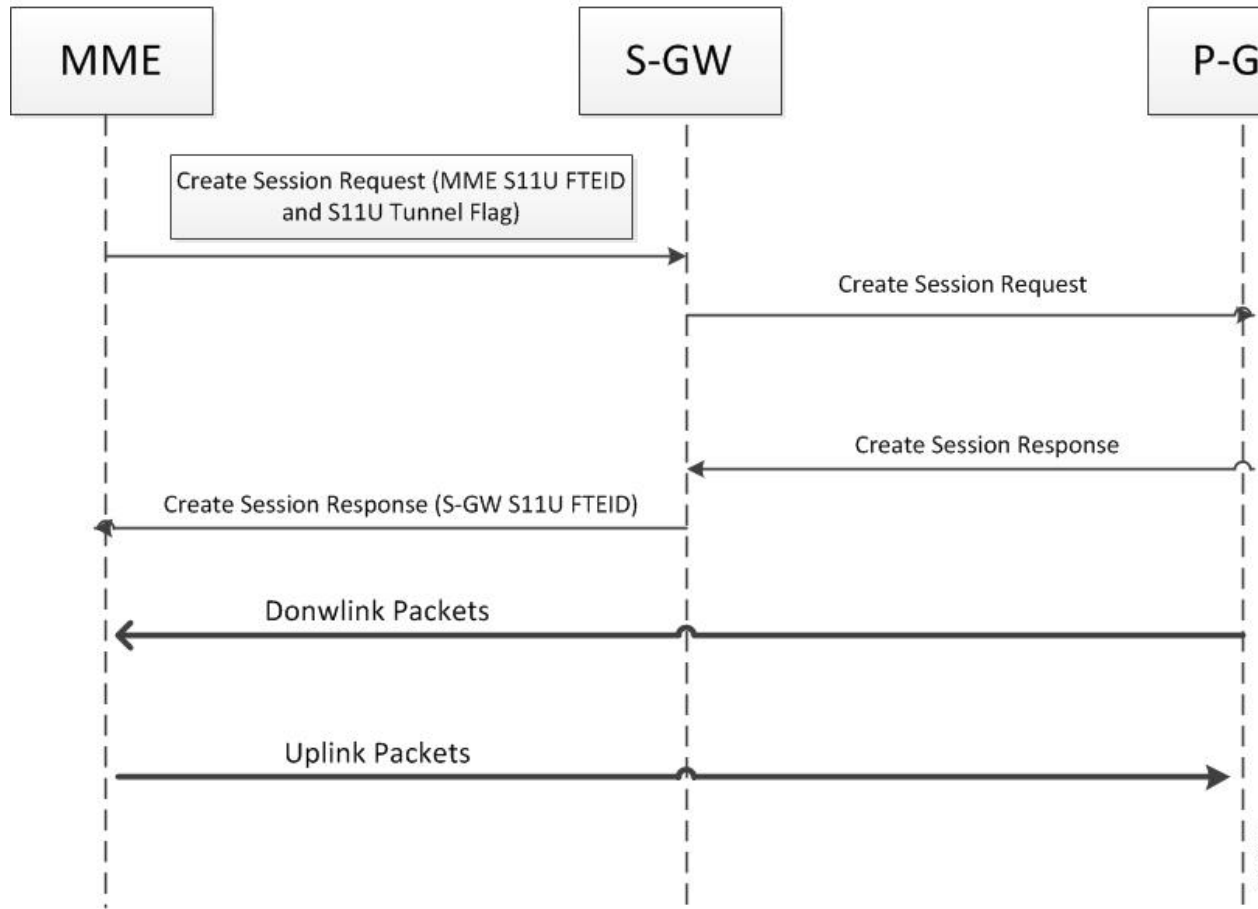
How It Works

The Attach Procedure

If the control plane CIoT EPS Optimization applies, then the MME indicates S11U tunneling of the NAS user data and sends its own S11U IP address and MME DL TEID for DL data forwarding to the S-GW.

The S-GW returns a Create Session Response, for Control Plane CIoT EPS optimization, with the S-GW address for S11U User Plane and S-GW TEID. They are used by the MME to forward the UL data toward the S-GW.

The following diagram explains the attach procedure:



Following summary table describes the S-GW behavior when Modify Bearer Request (Intra-MME, no change in MME control TEID) is received.

Table 10: Summary Table for S-GW Behavior when Modify Bearer Request is Received

UE State	Presence of S11tf	Presence of S11UFTEID	Presence of enb-FTEID	Behavior
Idle	0	0	0	UE remains in the Idle state and any other update is accepted in the MBR.
Idle	0	0	1	MBR is accepted and UE is moved to the connected state on S1U.
Idle	0	1	0	MBR is Rejected with Cause: EGTP_CAUSE_CONDITIONAL_IE_MISSING OFFENDING IE: (FTEID) UE remains in the Idle state.
Idle	0	1	1	MBR is Rejected with Cause: EGTP_CAUSE_MANDATORY_IE_INCORRECT OFFENDING IE: (FTEID) UE remains in the Idle state.
Idle	1	0	0	MBR is Rejected with Cause: CONDITIONAL_IE_MISSING (FTEID (87, 1)) UE remains in the Idle state.
Idle	1	0	1	MBR is Rejected with Cause: EGTP_CAUSE_MANDATORY_IE_INCORRECT: FTEID UE remains in the Idle state.
Idle	1	1	0	MBR is accepted and UE moves to the Connected State MBR is Rejected with Cause: EGTP_CAUSE_MANDATORY_IE_INCORRECT OFFENDING IE: (FTEID) UE remains in Idle state
Idle	1	1	1	MBR is rejected with Cause: EGTP_CAUSE_REQUEST_REJECTED
UE Active with s11u	0	0	0	MBR is rejected with Cause: EGTP_CAUSE_REQUEST_REJECTED
UE Active with s11u	0	0	1	MBR is rejected with Cause: EGTP_CAUSE_CONDITIONAL_IE_MISSING OFFENDING IE: (FTEID)
UE Active with s11u	0	1	0	MBR is rejected with Cause: EGTP_CAUSE_MANDATORY_IE_INCORRECT OFFENDING IE: (FTEID)

UE State	Presence of S11tf	Presence of S11UFTEID	Presence of enb-FTEID	Behavior
UE Active with s11u	0	1	1	MBR Rejected with Cause: CONDITIONAL_IE_MISSING (FTEID (87, 1))
UE Active with s11u	1	0	0	MBR Rejected with Cause: EGTP_CAUSE_MANDATORY_IE_INCORRECT FTEID
UE Active with s11u	1	0	1	MBR Rejected with Cause: EGTP_CAUSE_MANDATORY_IE_INCORRECT FTEID
UE Active with s11u	1	1	0	MBR is Accepted.
UE Active with s11u	1	1	1	MBR Rejected with Cause: EGTP_CAUSE_MANDATORY_IE_INCORRECT OFFENDING IE: (FTEID)



Important In the above table, MBR means Modify Bearer Request GTPv2 message.

- Establishing first PDN connection with S11TF flag indicating S11U PDN establishment, sets the characteristics of all PDNs for that UE as S11U based PDNs. Hence, all the subsequent PDN connection request are rejected if UE tries to setup S1U based PDN connections. This ensures that at a given point in time, UE has all PDNs either S1U or S11U based. But once UE moves into an idle mode, these UE characteristics are reset to allow the UE to come active with either S11u or S1u interface.
- The first Modify Bearer Request received with the S11TF flag indicating UE is using S11U interface, sets the characteristics of all PDNs for that UE as S11U based PDN. Hence, all the subsequent PDNs are rejected if the UE is trying to setup S1U based PDN. This is to ensure that at a given time on S-GW, UE has all PDNs, either S1U or S11U based.
- PDN connection request with S11TF and valid RAT type (NB-IoT & E-UTRAN) is rejected if the ClOT feature is not enabled at the S-GW. Any other RAT type with S11TF flag set is rejected.
- PDN connection request with S11TF set and CPOPCI flag sets this UE session as Control Plane only session. S-GW does not allow Interface change from S11u to S1u when CPOPCI flag is set.
- CPOPCI flag is only considered when S11TF flag is set in the Create Session Request. If S11TF flag is not set, CPOPCI flag is ignored on S-GW node.
- All existing DDN related features continue to work as is.
- If Indirect Tunnel Forwarding message is rejected for an UE in ECM Idle state, there is no special handling for S11U interface based data packet processing with respect to S1U interface and all existing data path features work as earlier.

- When UE is in ACTIVE STATE, Control Plane Optimization to User Plane Optimization interface change is not allowed.

Following table summarizes the Intra S-GW handover behavior:

Table 11: Summary Table for Handover Behavior

Current State	Intra / Inter MME	Source Interface	Target Interface	CPOPCI Flag	Agreed Behavior
Idle	Intra MME	S11U -> Idle	S11U	0	Connection is re-established with new FTEID.
Idle	Intra MME	S11U -> Idle	S11U	1	Connection is re-established with new FTEID.
Idle	Intra MME	S11U -> Idle	S1U	0	Connection is re-established with new FTEID.
Idle	Intra MME	S11U -> Idle	S1U	1	Connection will be rejected, as CP to UP is not allowed.
Connected	Intra MME	S11U	S1U	NA	Connection is rejected, as CP to UP is not allowed in connected mode.
Connected	Intra MME	S1U	S11U	NA	Connection is rejected, as UP to CP is not allowed in connected mode.
Connected	Intra MME	S11U	S11U	NA	Connection is accepted.
Idle	Inter MME	S11U -> Idle	Idle	NA	Connection is accepted.
Idle	Inter MME	S11U -> Idle	S11U	NA	Inter MME handover is accepted.
Idle	Inter MME	S11U -> Idle	S1U	0	Inter MME handover is accepted.
Idle	Inter MME	S11U -> Idle	S1U	1	Inter MME handover is accepted.
Connected	Inter MME	S11U	Idle	NA	Inter MME TAU is accepted.
Connected	Inter MME	S11U	S11U	NA	Inter MME handover is accepted.

Current State	Intra / Inter MME	Source Interface	Target Interface	CPOPCI Flag	Agreed Behavior
Connected	Inter MME	S11U	S1U	NA	UE is moved to Idle state internally as MBR is then handled as if received in UE Idle state. If CPOPCI=0, CP to UP is accepted. Else if CPOPCI=1, MBR is rejected.
Connected	Inter MME	S1U	S11U	NA	UE is moved to Idle state internally as MBR is then handled as if received in UE Idle state. UP to CP is then accepted.



Note

- NA - indicates that irrespective of CPOPCI flag 0 or 1, the behavior is same.
- In all above cases, RAT-Type does not change from E-UTRAN-to-E-UTRAN or NB-IoT-to-NB-IoT.
- In the above table, CP means Control Plane CloT Optimisization and UP means User Plane CloT optimization.

Standards Compliance

This feature is compliant with the following 3GPP technical standards:

- 3GPP TS 29.274 - 3GPP Evolved Packet System (EPS); Evolved General Packet Radio Service (GPRS) Tunnelling Protocol for Control plane (GTPv2-C); Stage 3.
- 3GPP TS 23.401 - General Packet Radio Service (GPRS) enhancements for Evolved Universal Terrestrial Radio Access Network (E-UTRAN) access.

Configuring S11U Interface Support on S-GW for CloT Devices

This section explains the configuration procedures required to enable the feature.

Configuring CloT Feature Support Indication

A new CLI command **cellular-iot** has been introduced under the eGTP Service Configuration Mode to enable CloT feature support indication.

```
configure
  context context_name
    egtp-service egtp_service_name
      [no | default ] gtpc node-feature cellular-iot
    end
```

Notes:

- **cellular-iot:** enables the Cellular IoT Features support for EGTP Service.
- **no:** disables the Cellular IoT Features support for EGTP Service.
- **default:** By default, CLI is disabled.

Verifying CloT Feature Support Indication Configuration

Execute the show commands **show configuration** and **show egtp-service** command to verify the configured values. For example:

show configuration

This command when executed shows the following field in the output:

```
egtp-service egtp_service
gtpc node-feature cellular-iot
```

show egtp-service

This command when executed shows the following output:

```
Service name: egtp_service
..
GTPC Node Feature
PGW Restart Notification           : Enabled
Network Triggered Service Restoration : Disabled
Cellular IoT                       : Enabled
```

Configuring GTPU Error Indication Related CLI Command

The interface S11u has been added to the command **gtpu-error-ind**, which configures the action to be taken upon receiving a GTP-U error indication on the S11u interface.

```
configure
  context context_name
    sgw-service sgw-service_name
      [ default ] gtpu-error-ind { { s11u | s12 | s1u } { local-purge
| page-ue [ custom1-behavior ] } | { s4u | s5u } { local-purge |
signal-peer } }
    end
```

Notes:

- **S11U:** Represents S11U interface.

Configuring Path Failure Related Behavior CLI Command for S11U

The interface S11u has been added to the command **path-failure**, which configures the action to take upon the occurrence of a path failure on the S11u interface.

```

configure
  context context_name
    sgw-service sgw_service_name
      [no] path-failure { s11 | s11u | s12 | s1u | s4 | s4u | s5 |
s5u } ( local-purge | signal-peer )
    end

```

Notes:

- **S11U:** Represents S11U interface.

Configuration for Adding S11U Interface Related Attribute in GTPP Attribute

The keywords **ciot-cp-optind** and **ciot-unipdu-cponly** have been added to the command **gtp attribute**, which enables the specification of some of the optional fields in the CDRs that the GSN (GGSN or SGSN) generates and/or how the information has to be presented.

```

configure
  context context_name
    [ no | default ] gtp attribute { ciot-cp-optind | ciot-unipdu-cponly
}
  end

```

Notes:

- **ciot-cp-optind:** Specifying this option includes optional field "CP ClOT EPS optimisation indicator" in the CDR.
- **ciot-unipdu-cponly:** Specifying this option includes optional field "UNI PDU CP Only Flag" in the CDR
- **no:** Disables the specified optional field so that the information will not be present in generated CDRs.
- **default:** Resets the default attribute values for this GTPP group configuration.

Configuration for Adding S11U Interface Related Attribute in GTPP Trigger

The keywords **ciot-userplane-change** has been added to the command **gtp trigger**, for enabling or disabling GTPP trigger conditions that cause either partial CDR record closure or opening of a new CDR record container.

```

configure
  context context_name
    [ no ] gtp trigger { ciot-userplane-change }
  end

```

Notes:

- **ciot-userplane-change:** Enables User Plane change trigger for CDR.
- **no:** Disables the specified trigger condition.
- **default:** Sets the specified trigger condition back to the default setting. All trigger conditions are enabled by default.

Monitoring and Troubleshooting

This section provides information on how to monitor and troubleshoot using show commands and bulk statistics available to support of this feature.

Show Commands and/or Outputs

This section provides information regarding show commands and their outputs for the HLCOM feature. Statistics have been added at three levels:

- Instance Level
- Subscriber Level
- S-GW Service Level

show configuration

The following fields are added to the show output of this command:

- gtpc node-feature cellular-iot
- gtp attribute ciot-cp-optind
- gtp attribute ciot-unipdu-cponly
- no gtp trigger ciot-userplane-change
- path-failure s11u signal-peer
- gtpu-error-ind s11u local-purge

show egtp-service

The following fields are added to the show output of this command:

- Cellular IoT: Enable

show egtp-service

The following fields are added to the show output of this command:

- S11U-Interface: signal-peer
- S11U-Interface: local-purge

show egtpc peers wf1

The following fields are added to the show output of this command:

- CIOT(C)
- (C) - CIOT

show subscribers sgw-only full all

The following fields are added to the show output of this command:

- mme u-teid: [0x20148c2c] 538217516
- mme u-addr: 172.9.9.12

show subscribers saegw-only full all

The following fields are added to the show output of this command:

- mme u-addr: 172.9.9.11
- mme u-teid: [0x2006b8e8]

show saegw-service statistics all function sgw

The following new statistics are added to the show output:

Path failure/Error indication Stats:

PDNs Released By Reason:

- S11 Error Ind: 1
- Path Failure S11-U: 1

DataStats

S11-U Total Data Statistics:

- Uplink/Downlink
 - Total Packets
 - Total Bytes
 - Dropped Packets
 - Dropped Bytes
- Packets/Bytes/Dropped Packets/Dropped Bytes:
 - QCI 1
 - QCI 2
 - QCI 3

- QCI 4
- QCI 5
- QCI 6
- QCI 7
- QCI 8
- QCI 9
- QCI 65
- QCI 66
- QCI 69
- QCI 70
- Non-Std QCI

show saegw-service statistics all function sgw verbose

The following new statistics are added to the show output:

Path failure/Error indication Stats:

PDNs Released By Reason:

- S11 Error Ind
- Path Failure S11-U

DataStats

S11-U Total Data Statistics

- Uplink/Downlink
 - Total Packets
 - Total Bytes
 - Dropped Packets
 - Dropped Bytes
- Packets/Bytes/Dropped Packets/Dropped Bytes:
 - QCI 1
 - QCI 2
 - QCI 3
 - QCI 4
 - QCI 5

- QCI 6
- QCI 7
- QCI 8
- QCI 9
- QCI 65
- QCI 66
- QCI 69
- QCI 70
- Non-Std QCI

Changes in S-GW CDR

The following attributes have been added to the S-GW CDR:

- Main Level Attributes
- Container Level Attributes

Table 12: Main Level Attributes Added in S-GW CDR

Attributes	Dictionary	Description
CP ClIoT EPS Optimization Indicator	Custom24	This field contains the indication on whether Control Plane ClIoT EPS optimization is used by the PDN connection during data transfer with the UE (that is Control Plane NAS PDU via S11-U between S-GW and MME) or not (that is User Plane via S1-U between SGW and eNB).
UNI PDU CP Only Flag	Custom24	This field contains an indication on whether this PDN connection is applied with "Control Plane Only flag", that is transfer using Control Plane NAS PDUs only, when Control Plane ClIoT EPS Optimization is enabled. This field is missing if both, user plane and control plane UNI for PDU transfer (that is S1-U and S11-U from S-GW) are allowed, when Control Plane ClIoT EPS Optimization is enabled.

Table 13: Container Level Attribute Added in S-GW CDR

Attributes	Dictionary	Description
CP CIoT EPS Optimisation Indicator	Custom24	This field contains the indication on whether Control Plane CIoT EPS optimization is used for the transfer of the data volume captured by the container. This is included in the Traffic data container only if previous container's change condition is "change in user plane to UE". Note the CP CIoT EPS Optimization indicator field in SGW-CDR main level contains the CP CIoT EPS optimization indicator value when SGW-CDR was opened.