



# 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.

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## Feature Summary and Revision History

### Summary Data

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

**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.




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

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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 CIoT 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 taids1
    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 CIoT optimization information:

- CIoT 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.

<b>Counter</b>	<b>Description</b>
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.

