



# S11U Interface Support on S-GW for CIoT Devices

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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>• P-GW</li><li>• SAEGW</li><li>• S-GW</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 - License Required
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

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 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 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 CIoT EPS Optimization** - transports user data passing through the user plane
2. **Control Plane CIoT 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 CIoT EPS optimizations are supported for a UE, the PDN connections that use only control plane CIoT optimizations are handled through the Control Plane CIoT 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 CIoT EPS optimization.

All other PDN connections are handled using Control Plane or User Plane CIoT EPS optimizations. In addition, the Control Plane CIoT 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 CIoT EPS Optimization and the Control Plane CIoT EPS Optimization.

This feature provides control plane CIoT 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 CIoT 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 CIoT features. This flag is received by the MME in Echo Request/Response message exchange and is used during the selection of S-GW for CIoT capability. A new CLI command cellular-iot has been added for enabling CIoT feature functionality. Please see section, [Configuring S11U Interface Support on S-GW for CIoT Devices, on page 9](#) 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"> <li>• EUTRAN-NB-IoT RAT type</li> <li>• Non-IP PDN type</li> <li>• S11-U tunneling</li> <li>• Serving PLMN Rate Control <ul style="list-style-type: none"> <li>• MO Exception Data indication</li> <li>• Extended PCO</li> </ul> </li> </ul>

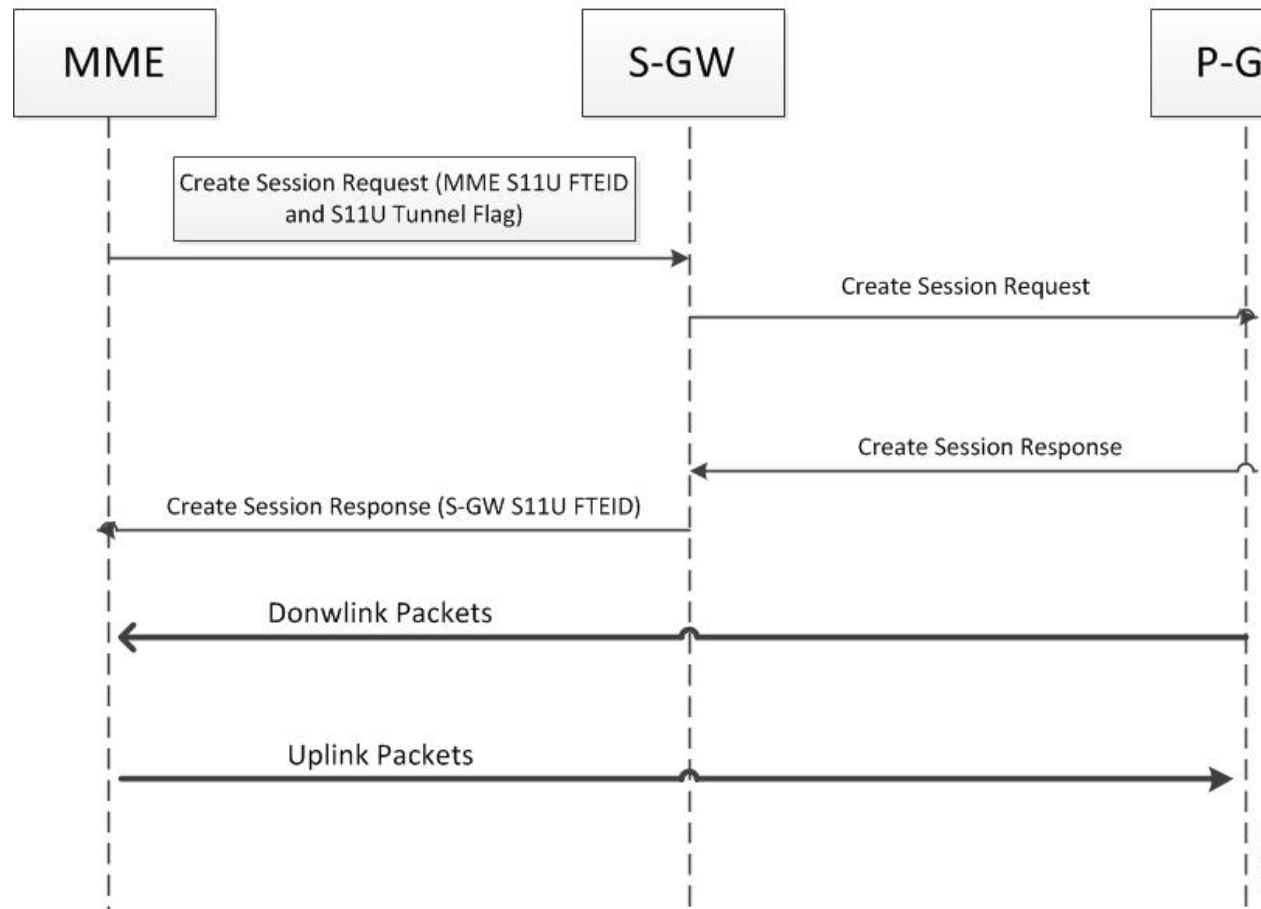
## How It Works

### 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 1: 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 CIoT 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 2: 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 CIoT Optimisization and UP means User Plane CIoT 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 CIoT Devices

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

### Configuring CIoT Feature Support Indication

A new CLI command **cellular-iot** has been introduced under the eGTP Service Configuration Mode to enable CIoT 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 CIoT 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

**show saegw-service statistics all function sgw verbose**

- 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 3: Main Level Attributes Added in S-GW CDR**

Attributes	Dictionary	Description
CP CIoT EPS Optimization Indicator	Custom24	This field contains the indication on whether Control Plane CIoT 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 CIoT 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 CIoT EPS Optimization is enabled.

**Table 4: 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.