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

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).

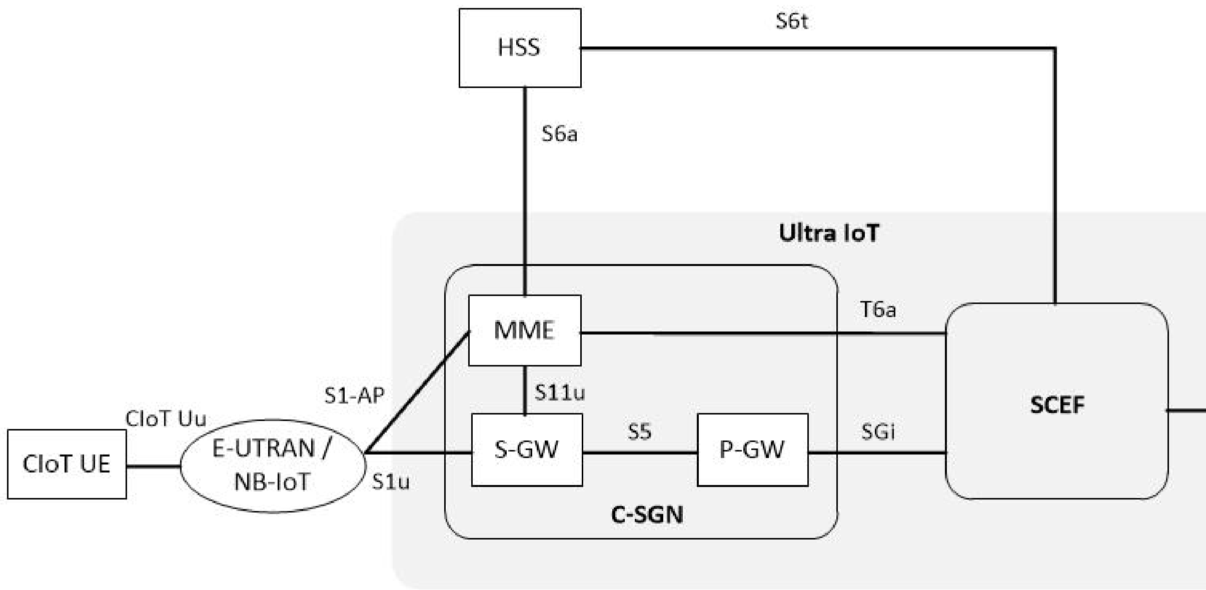
The C-SGN is a combined node EPC implementation option that minimizes the number of physical entities by collocating EPS entities in the control plane and user plane paths in CIoT deployments.

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) SLg 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) Tunnelling 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 CIoT EPS Optimization (for example, the MME that has Control Plane Only Indicator in ESM request) will only be handled by the Control Plane CIoT EPS optimization. All other PDN connections are handled using Control Plane or User Plane CIoT EPS optimizations.

The Control Plane CIoT 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 SGi PDN connections of a UE will use S11-U or S1-U at any point in time. Support for the SGi based delivery of Non-IP data can also be 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.

CIoT EPS Optimizations on Control Plane Node

The CIoT 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 CIoT 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 SGi interfaces as part of the CIoT 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 (SGi) or to the SCEF. Downlink data is also transmitted over the same paths in the reverse direction.
  - IP and non-IP Data Delivery over SGi - Small data delivery via SGi 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 UE 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.