



Serving GPRS Support Node (SGSN) Overview

This section contains general overview information about the Serving GPRS Support Node (SGSN), including sections for:

- [Product Description, on page 1](#)
- [Network Deployments and Interfaces, on page 2](#)
- [SGSN Core Functionality, on page 9](#)
- [Features and Functionality, on page 16](#)
- [How the SGSN Works, on page 72](#)
- [Supported Standards, on page 79](#)

Product Description

StarOS provides a highly flexible and efficient Serving GPRS Support Node (SGSN) service to the wireless carriers. Functioning as an SGSN, the system readily handles wireless data services within 2.5G General Packet Radio Service (GPRS) and 3G Universal Mobile Telecommunications System (UMTS) data networks. The SGSN also can serve as an interface between GPRS and/or UMTS networks and the 4G Evolved Packet Core (EPC) network.



Important Throughout this section the designation for the subscriber equipment is referred to in various ways: UE for user equipment (common to 3G/4G scenarios), MS or mobile station (common to 2G/2.5G scenarios), and MN or mobile node (common to 2G/2.5G scenarios involving IP-level functions). Unless noted, these terms are equivalent and the term used usually complies with usage in the relevant standards.

In a GPRS/UMTS network, the SGSN works in conjunction with radio access networks (RANs) and Gateway GPRS Support Nodes (GGSNs) to:

- Communicate with home location registers (HLR) via a Gr interface and mobile visitor location registers (VLRs) via a Gs interface to register a subscriber's user equipment (UE), or to authenticate, retrieve or update subscriber profile information.
- Support Gd interface to provide short message service (SMS) and other text-based network services for attached subscribers.
- Activate and manage IPv4, IPv6, or point-to-point protocol (PPP) -type packet data protocol (PDP) contexts for a subscriber session.
- Setup and manage the data plane between the RAN and the GGSN providing high-speed data transfer with configurable GEA0-3 ciphering.

- Provide mobility management, location management, and session management for the duration of a call to ensure smooth handover.
- Provide various types of charging data records (CDRs) to attached accounting/billing storage mechanisms such as our SMC-based hard drive or a GTPP Storage Server (GSS) or a charging gateway function (CGF).
- Provide CALEA support for lawful intercepts.

The S4-SGSN is an SGSN configured with 2G and/or 3G services and then configured to interface with the 4G EPC network via the S4 interface. This enables the S4-SGSN to support handovers from UMTS/GPRS networks to the EPC network. The S4-SGSN works in conjunction with EPC network elements and gateways to:

- Interface with the EPC network S-GW (via the S4 interface) and MME (via the S3 interface) to enable handovers between 2G/3G networks and the EPC (4G) network.
- Interface with the Equipment Identity Registry via the S13' interface to perform the ME identity check.
- Interface with the HSS via the S6d interface to obtain subscription-related information.
- Communicate with S4-SGSNs via the S16 interface.
- Provide Idle Mode Signaling support for EPC-capable UEs.

This section catalogs many of the SGSN key components and features for data services within the GPRS/UMTS environment. Also, a range of SGSN operational and compliance information is summarized with pointers to other information sources.

Qualified Platforms

SGSN is a StarOS application that runs on Cisco® ASR 5500 and virtualized platforms. For additional platform information, refer to the appropriate *System Administration Guide* and/or contact your Cisco account representative.

Licenses

The SGSN is a licensed Cisco product and requires the purchase and installation of the SGSN Software License. Separate feature licenses may be required. Contact your Cisco account representative for detailed information on specific licensing requirements.

For information on installing and verifying licenses, refer to the *Managing License Keys* section of the *Software Management Operations* section in the *System Administration Guide*.

Network Deployments and Interfaces

The following logical connection maps illustrate the SGSN's ability to connect to various radio access network types, core network types, and network components:

- GSM edge radio access network (GERAN) provides access to the 2.5G general packet radio service (GPRS) network
- UMTS terrestrial radio access network (UTRAN) provides access to the 3G universal mobile telecommunications system (UMTS) network
- Evolved UTRAN (E-UTRAN) provides access to the 4G mobile evolved packet core (EPC) of the long term evolution/system architecture evolution (LTE/SAE) network
- Another SGSN

- Standalone gateway GPRS support node (GGSN)
- Co-located P-GW/GGSN
- Mobile Service Center (MSC)
- Visitor Location Register (VLR)
- Home Location Register (HLR)
- Charging Gateway (CF - sometimes referred to as a charging gateway function (CGF))
- GTPP Storage Server (GSS)
- Equipment Identity Registry (EIR)
- Home Subscriber Server (HSS)
- Mobility Management Entity (MME)
- Serving Gateway (S-GW)
- CAMEL service's GSM service control function (gsmSCF)
- Short Message Service server Center (SMS-C)
- Network devices in another PLMN

SGSN and Dual Access SGSN Deployments

SGSNs and GGSNs work in conjunction within the GPRS/UMTS network. As indicated earlier in the section on *System Configuration Options*, the flexible architecture of StarOS enables a single chassis to reduce hardware requirements by supporting integrated co-location of a variety of the SGSN services.

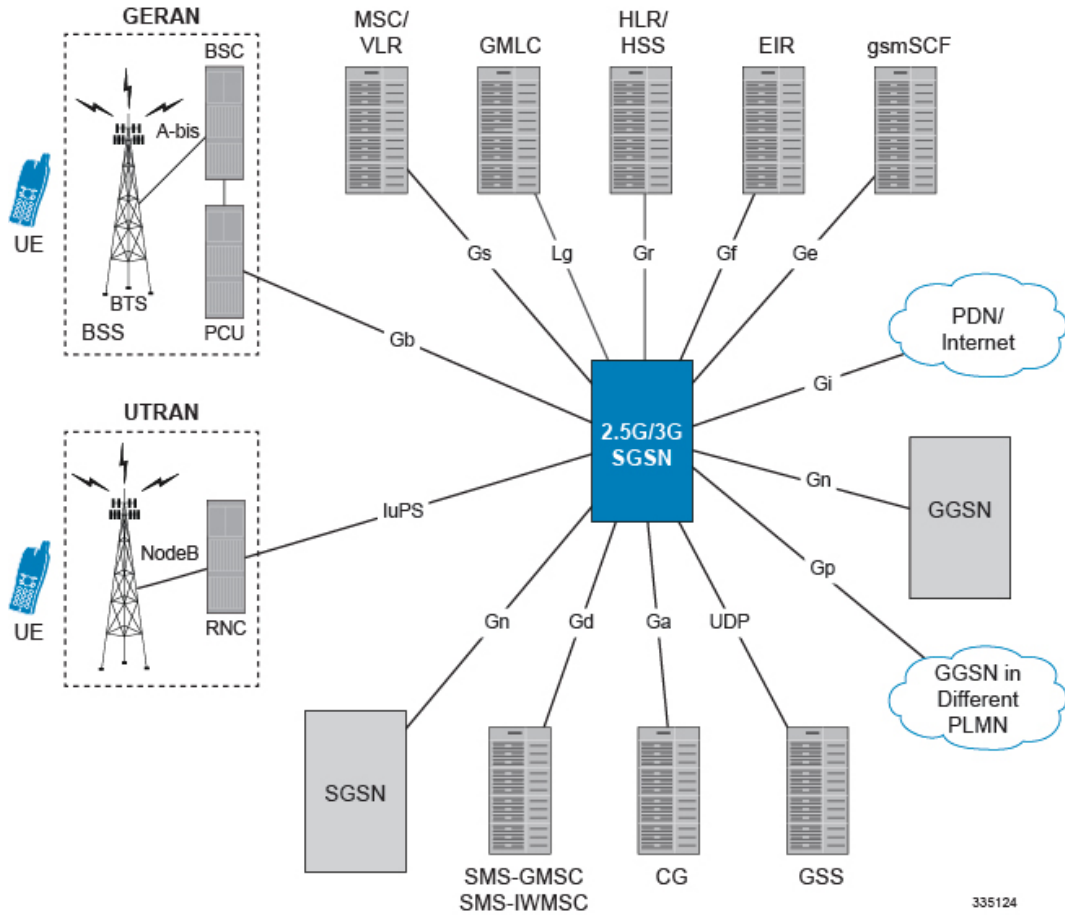
A chassis can be devoted solely to SGSN services or the SGSN system can include any co-location combination, such as multiple instances of 2.5G SGSNs (configured as GPRS services); or multiple instances of 3G SGSNs (configured as SGSN services); or a combination of 2.5G and 3G SGSN to comprise a dual access SGSN.



Important

The following illustrates the GPRS/UMTS Dual Access architecture with a display of all the interfaces supported as of Release 14.0. The *SGSN Logical Network Interfaces* section below lists the interfaces available for the release applicable to the version of this manual.

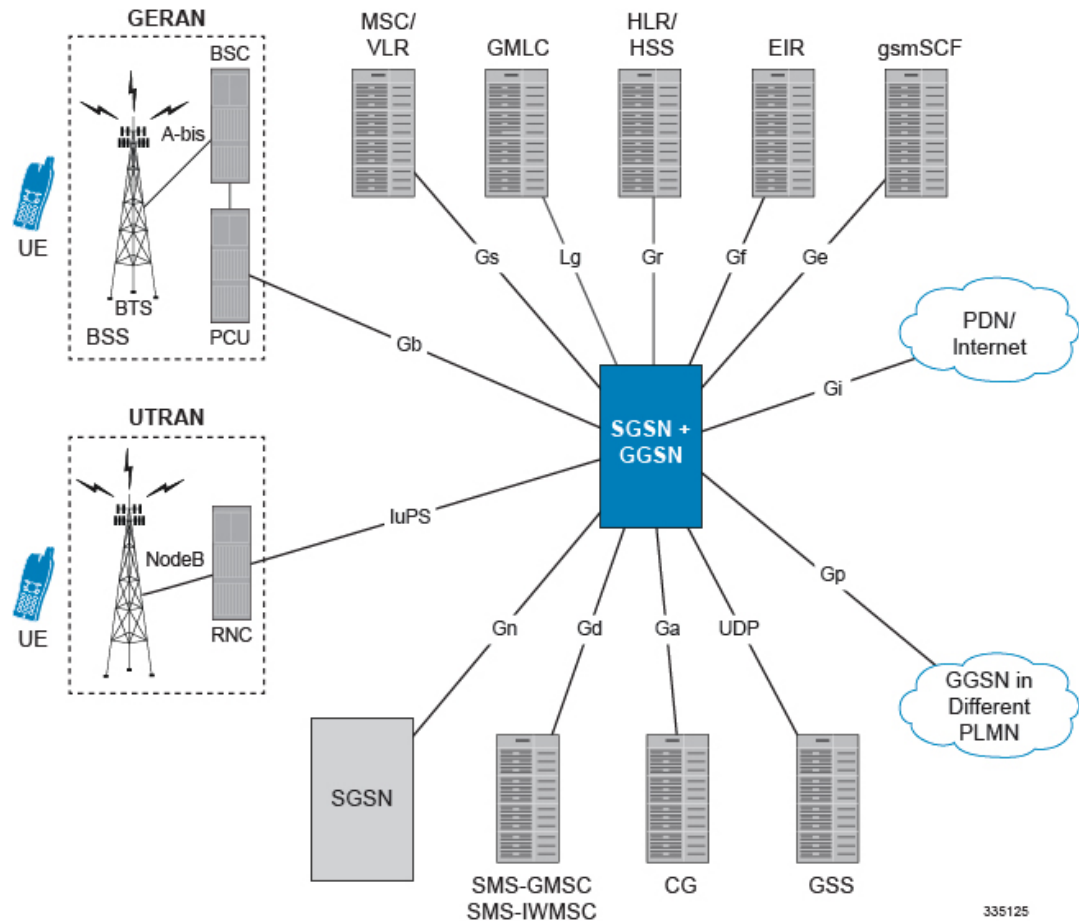
Figure 1: 2.5G and 3G Dual Access Architecture



SGSN/GGSN Deployments

The co-location of the SGSN and the GGSN in the same chassis facilitates handover. A variety of GSN combos is possible, 2.5G or 3G SGSN with the GGSN.

Figure 2: GSN Combo Architecture



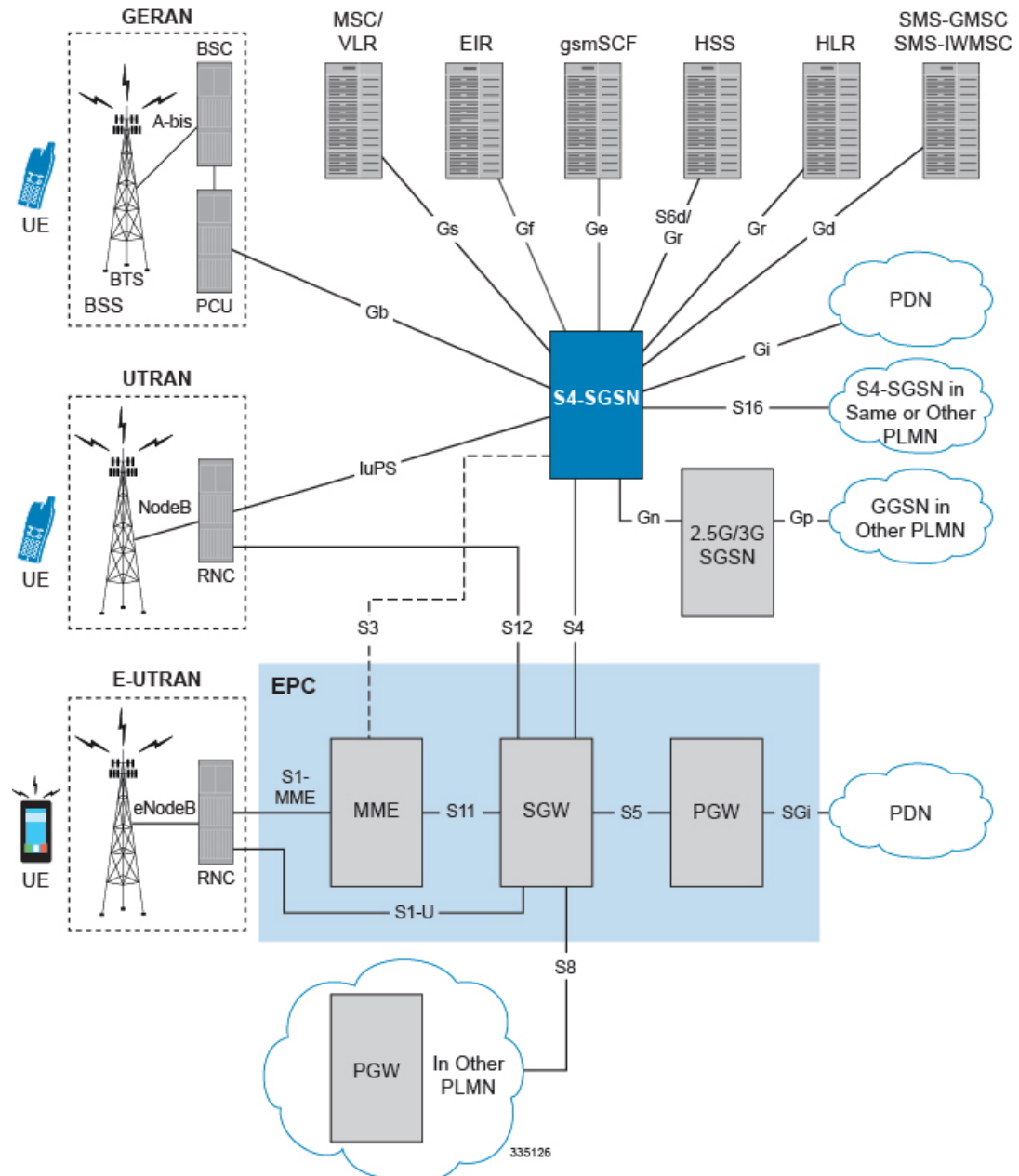
S4-SGSN Deployments

An S4-SGSN is an SGSN that is configured for S4 interface support to enable the soft handover of 2G and 3G subscribers to the EPC S-GW via the EPC S4 interface. Comprehensive S4-SGSN support includes interfaces to the following network elements and gateways:

- EPC serving gateway (S-GW) via the S4 interface
- Equipment identity registry (EIR) via the S13' interface
- Home subscriber server (HSS) via the S6d interface
- EPC mobility management entity (MME) via the S3 interface
- Peer S4-SGSN via the S16 interface

The S4, S13' and S6d interfaces are license-enabled features. Support for the S16 and S3 interfaces are included as part of the S4 license.

Figure 3: S4-SGSN Network Architecture



SGSN Logical Network Interfaces

The SGSN provides IP-based transport on all RAN and core network interfaces, in addition to the standard IP-based interfaces (Ga, Gn, Gp, Iu-PS). This means enhanced performance, future-proof scaling and reduction of inter-connectivity complexity. The all-IP functionality is key to facilitating evolution to the next generation technology requirements.

The SGSN provides the following functions over the logical network interfaces illustrated above:

- **Ga:** The SGSN uses the Ga interface with GPRS Transport Protocol Prime (GTPP) to communicate with the charging gateway (CG, also known as CGF) and/or the GTPP storage server (GSS). The interface transport layer is typically UDP over IP but can be configured as TCP over IP for:

- One or more Ga interfaces per system context, and
- An interface over Ethernet 10/100 or Ethernet 1000 interfaces

The charging gateway handles buffering and pre-processing of billing records and the GSS provides storage for Charging Data Records (CDRs). For additional information regarding SGSN charging, refer to the Charging section.

- **IuPS:** The SGSN provides an IP over ATM (IP over AAL5 over ATM) interface between the SGSN and the RNCs in the 3G UMTS radio access network (UTRAN). RANAP is the control protocol that sets up the data plane (GTP-U) between these nodes. SIGTRAN (M3UA/SCTP) or QSAAL (MTP3B/QSAAL) handle IuPS-C (control) for the RNCs.

Some of the procedures supported across this interface are:

- Control plane based on M3UA/SCTP
- Up to 128 Peer RNCs per virtual SGSN. Up to 256 peers per physical chassis
- SCTP Multi-Homing supported to facilitate network resiliency
- M3UA operates in and IPSP client/server and single/double-ended modes
- Multiple load shared M3UA instances for high-performance and redundancy
- Works over Ethernet and ATM (IPoA) interfaces
- Facilitates SGSN Pooling
- RAB (Radio Access Bearer) Assignment Request
- RAB Release Request
- Iu Release Procedure
- SGSN-initiated Paging
- Common ID
- Security Mode Procedures
- Initial MN Message
- Direct Transfer
- Reset Procedure
- Error Indication
- SRNS relocation

- **Gb:** This is the SGSN's interface to the base station system (BSS) in a 2G radio access network (RAN). It connects the SGSN via UDP/IP via an Ethernet interface. Gb-IP is the preferred interface as it improves control plane scaling as well as facilitates the deployment of SGSN Pools.

Some of the procedures supported across this interface are:

- BSS GSM at 900/1800/1900 MHz
- BSS Edge
- Frame Relay congestion handling
- Traffic management per Frame Relay VC
- NS load sharing
- NS control procedures
- BVC management procedures
- Paging for circuit-switched services
- Suspend/Resume

- Flow control
- Unacknowledged mode
- Acknowledged mode
- **Gn/Gp:** The Gn/Gp interfaces, comprised of GTP/UDP/IP-based protocol stacks, connect the SGSNs and GGSNs to other SGSNs and GGSNs within the same public land mobile network (PLMN) - the Gn - or to GGSNs in other PLMNs - the Gp.

This implementation supports:

- GTPv0 and GTPv1, with the capability to auto-negotiate the version to be used with any particular peer
- GTP-C (control plane) and GTP-U (user plane)
- One or more Gn/Gp interfaces configured per system context

As well, the SGSN can support the following IEs from later version standards:

- IMEI-SV
- RAT TYPE
- User Location Information
- Extended PDP Type (Release 9)
- Extended RNC ID (Release 9)
- **Ge:** This is the interface between the SGSN and the SCP that supports the CAMEL service. It supports both SS7 and SIGTRAN and uses the CAP protocol.
- **Gr:** This is the interface to the HLR. It supports SIGTRAN (M3UA/SCTP/IP) over Ethernet.

Some of the procedures supported by the SGSN on this interface are:

- Send Authentication Info
- Update Location
- Insert Subscriber Data
- Delete Subscriber Data
- Cancel Location
- Purge
- Reset
- Ready for SM Notification
- SIGTRAN based interfaces M3UA/SCTP
- Peer connectivity can be through an intermediate SGP or directly depending on whether the peer (HLR, EIR, SMSC, GMLC) is SIGTRAN enabled or not
- SCTP Multi-Homing supported to facilitate network resiliency
- M3UA operates in IPSP client/server and single/double-ended modes
- Multiple load shared M3UA instances for high-performance and redundancy
- Works over Ethernet (IPoA) interface
- **Gs:** This is the interface used by the SGSN to communicate with the visitor location register (VLR) or mobile switching center (MSC) to support circuit switching (CS) paging initiated by the MSC. This interface uses Signaling Connection Control Part (SCCP) connectionless service and BSSAP+ application protocols.
- **Gd:** This is the interface between the SGSN and the SMS Gateway (SMS-GMSC / SMS-IWMSC) for both 2G and 3G technologies through multiple interface mediums. Implementation of the Gd interface requires purchase of an additional license.

- **Gf:** Interface is used by the SGSN to communicate with the equipment identity register (EIR) which keeps a listing of UE (specifically mobile phones) being monitored. The SGSN's Gf interface implementation supports functions such as:
 - International Mobile Equipment Identifier-Software Version (IMEI-SV) retrieval
 - IMEI-SV status confirmation
- **Lg:** This is a Mobile Application Part (MAP) interface, between the SGSN and the gateway mobile location center (GMLC), supports 3GPP standards-compliant LoCation Services (LCS) for both 2G and 3G technologies. Implementation of the Lg interface requires purchase of an additional license.
- **S3:** On the S4-SGSN, this interface provides a GTPv2-C signaling path connection between the EPC mobility management entity (MME) and the SGSN. This functionality is part of the S4 interface feature license.
- **S4:** On the S4-SGSN, this interface provides a data and signaling interface between the EPC S-GW and the S4-SGSN for bearer plane transport (GTPv1-U). The S4-SGSN communicates with the P-GW via the S-GW. A separate feature license is required for S4 interface support.
- **S6d:** On the SGSN, this is the S6d interface between the SGSN and the HSS. This enables the SGSN to get subscription details of a user from the HSS when a user tries to register with the SGSN. A separate feature license is required for S6d Diameter interface support.
- **S13':** The SGSN supports the S13' interface between the SGSN and the EIR. This enables the SGSN to communicate with an Equipment Identity Registry (EIR) via the Diameter protocol to perform the Mobile Equipment (ME) identity check procedure between the SGSN and EIR. Performing this procedure enables the SGSN to verify the equipment status of the Mobile Equipment. A separate feature license is required for S13' interface support.
- **S16:** On the S4-SGSN, this interface provides a GTPv2 path to a peer S4-SGSN. Support for this interface is provided as part of the S4 interface license.

SGSN Core Functionality

The SGSN core functionality is comprised of:

- [All-IP Network \(AIPN\), on page 9](#)
- [SS7 Support](#)
- [PDP Context Support](#)
- [Mobility Management](#)
- [Location Management](#)
- [Session Management](#)
- [Charging](#)

All-IP Network (AIPN)

AIPN provides enhanced performance, future-proof scaling and reduction of inter-connectivity complexity.

In accordance with 3GPP, the SGSN provides IP-based transport on all RAN and core network interfaces, in addition to the standard IP-based interfaces (Ga, Gn, Gp, Iu-Data). The all-IP functionality is key to facilitating Iu and Gb Flex (SGSN pooling) functionality as well as evolution to the next generation technology requirements.

The following IP-based protocols are supported on the SGSN:

- SCTP

- M3UA over SCTP
- GTPv0 over UDP
- GTPv1 over UDP
- GTPv2 over UDP (S4-SGSN only)
- GTP-U over UDP
- Diameter over TCP and SCTP (S4-SGSN only)

SS7 Support

StarOS SGSN implements SS7 functionality to communicate with the various SS7 network elements, such as HLRs and VLRs.

The SGSN employs standard Signaling System 7 (SS7) addressing (point codes) and global title translation. SS7 feature support includes:

- Transport layer support includes:
 - Broadband SS7 (MTP3B/SSCF/SSCOP/AAL5)
 - SIGTRAN (M3UA/SCTP/IP)
- SS7 variants supported:
 - ITU-T (International Telecommunication Union - Telecommunications - Europe)
 - ANSI (American National Standards Institute - U.S.)
 - B-ICI (B-ISDN Inter-Carrier Interface)
 - China
 - TTC (Telecommunication Technology Committee - Japan)
 - NTT (Japan)
- SS7 protocol stack components supported:
 - MTP2 (Message Transfer Part, Level 2)
 - MTP3 (Message Transfer Part, Level 3)
 - SCCP (Signaling Connection Control Part) with BSSAP+ (Base Station System Application Part Plus) and RANAP (Radio Access Network Application Part)
 - ISUP (ISDN User Part)
 - TCAP (Transaction Capabilities Applications Part) and MAP (Mobile Application Part)

PDP Context Support

Support for subscriber primary and secondary Packet Data Protocol (PDP) contexts in compliance with 3GPP standards ensure complete end-to-end GPRS connectivity.

The SGSN supports a total of 11 PDP contexts per subscriber. Of the 11 PDP context, all can be primaries, or 1 primary and 10 secondaries or any combination of primary and secondary. Note that there must be at least one primary PDP context in order for secondaries to establish.

PDP context processing supports the following types and functions:

- Types: IPv4, IPv6, IPv4v6 (dual stack) and/or PPP
- GTPP accounting support
- PDP context timers

- Quality of Service (QoS)

Mobility Management

The SGSN supports mobility management (MM) in compliance with applicable 3GPP standards and procedures to deliver the full range of services to the mobile device. Some of the procedures are highlighted below:

GPRS Attach

The SGSN is designed to accommodate a very high rate of simultaneous attaches. The actual attach rate depends on the latencies introduced by the network and scaling of peers. In order to optimize the entire signaling chain, the SGSN eliminates or minimizes bottlenecks caused by large scale control signaling. For this purpose, the SGSN implements features such as an in-memory data-VLR and SuperCharger. Both IMSI and P-TMSI based attaches are supported.

The SGSN provides the following mechanisms to control MN attaches:

- **Attached Idle Timeout** - When enabled, if an MN has not attempted to setup a PDP context since attaching, this timer forces the MN to detach with a cause indicating that the MN need not re-attach. This timer is particularly useful for reducing the number of attached subscribers, especially those that automatically attach at power-on.
- **Detach Prohibit** - When enabled, this mechanism disables the Attached Idle Timeout functionality for selected MNs which aggressively re-attach when detached by the network.
- **Prohibit Reattach Timer** - When enabled, this timer mechanism prevents MNs, that were detached due to inactivity, from re-attaching for a configured period of time. Such MNs are remembered by the in-memory data-VLR until the record needs to be purged.
- **Attach Rate Throttle** - It is unlikely that the SGSN would become a bottleneck because of the SGSN's high signaling rates. However, other nodes in the network may not scale commensurately. To provide network overload protection, the SGSN provides a mechanism to control the number of attaches occurring through it on a per second basis.

Beside configuring the rate, it is possible to configure the action to be taken when the overload limit is reached. See the **network-overload-protection** command in the "Global Configuration Mode" section in the *Command Line Interface Reference*. Note, this is a soft control and the actual attach rate may not match exactly the configured value depending on the load conditions.

GPRS Detach

The SGSN is designed to accommodate a very high rate of simultaneous detaches. However, the actual detach rate is dependent on the latencies introduced by the network and scaling of peers. A GPRS detach results in the deactivation of all established PDP contexts.

There are a variety of detaches defined in the standards and the SGSN supports the following detaches:

- **MN Initiated Detach** - The MN requests to be detached.
- **SGSN Initiated Detach** - The SGSN requests the MN to detach due to expiry of a timer or due to administrative action.
- **HLR Initiated Detach** - The detach initiated by the receipt of a cancel location from the HLR.

Mass detaches triggered by administrative commands are paced in order to avoid flooding the network and peer nodes with control traffic.

Paging

CS-Paging is initiated by a peer node - such as the MSC - when there is data to be sent to an idle or unavailable UE. CS-paging requires the Gs interface. This type of paging is intended to trigger a service request from the UE. If necessary, the SGSN can use PS-Paging to notify the UE to switch channels. Once the UE reaches the connected state, the data is forwarded to it.

Paging frequency can be controlled by configuring a paging-timer.

Service Request

The Service Request procedure is used by the MN in the PMM Idle state to establish a secure connection to the SGSN as well as request resource reservation for active contexts.

The SGSN allows configuration of the following restrictions:

- Prohibition of services
- Enforce identity check
- PLMN restriction
- Roaming restrictions

Authentication

The SGSN authenticates the subscriber via the authentication procedure. This procedure is invoked on attaches, PDP activations, inter-SGSN routing Area Updates (RAUs), and optionally by configuration for periodic RAUs. The procedure requires the SGSN to retrieve authentication quintets/triplets from the HLR (AuC) and issuing an authentication and ciphering request to the MN. The SGSN implements an in-memory data-VLR functionality to pre-fetch and store authentication vectors from the HLR. This decreases latency of the control procedures.

Additional configuration at the SGSN allows for the following:

- Enforcing ciphering
- Retrieval of the IMEI-SV

P-TMSI Reallocation

The SGSN supports standard Packet-Temporary Mobile Identity (P-TMSI) Reallocation procedures to provide identity confidentiality for the subscriber.

The SGSN can be configured to allow or prohibit P-TMSI reallocation on the following events:

- Routing Area Updates
- Attaches
- Detaches
- Service Requests

The SGSN reallocates P-TMSI only when necessary.

P-TMSI Signature Reallocation

The SGSN supports operator definition of frequency and interval for Packet Temporary Mobile Subscriber Identity (P-TMSI) signature reallocation for all types of routing area update (RAU) events.

Identity Request

This procedure is used to retrieve IMSI and IMEI-SV from the MN. The SGSN executes this procedure only when the MN does not provide the IMSI and the MM context for the subscriber is not present in the SGSN's data-VLR.

Location Management

The SGSN's 3GPP compliance for location management ensures efficient call handling for mobile users.

The SGSN supports routing area updates (RAU) for location management. The SGSN implements standards based support for:

- Periodic RAUs
- Intra-SGSN RAUs
- Inter-SGSN RAUs.

The design of the SGSN allows for very high scalability of RAUs. In addition, the high capacity of the SGSN and Flex functionality provides a great opportunity to convert high impact Inter-SGSN RAUs to lower impact Intra-SGSN RAUs. The SGSN provides functionality to enforce the following RAU restrictions:

- Prohibition of GPRS services
- Enforce identity request
- Enforce IMEI check
- PLMN restriction
- Roaming restrictions

The SGSN also provides functionality to optionally supply the following information to the MN:

- P-TMSI Signature and Allocated P-TMSI
- List of received N-PDU numbers for loss less relocation
- Negotiated READY timer value
- Equivalent PLMNs
- PDP context status
- Network features supported

Session Management

Session management ensures proper PDP context setup and handling.

For session management, the SGSN supports four 3GPP-compliant procedures for processing PDP contexts:

- Activation
- Modification
- Deactivation
- Preservation

PDP Context Activation

The PDP context activation procedure establishes a PDP context with the required QoS from the MN to the GGSN. These can be either primary or secondary contexts. The SGSN supports a minimum of 1 PDP primary context per attached subscriber, and up to a maximum of 11 PDP contexts per attached subscriber.

The PDP context types supported are:

- PDP type IPv4
- PDP type IPv6
- PDP type IPv4v6
- PDP type PPP

Both dynamic and static addresses for the PDP contexts are supported.

The SGSN provides configuration to control the duration of active and inactive PDP contexts.

When activating a PDP context the SGSN can establish the GTP-U data plane from the RNC through the SGSN to the GGSN or directly between the RNC and the GGSN (one tunnel).

The SGSN is capable of interrogating the DNS infrastructure to resolve the specified APN to the appropriate GGSN. The SGSN also provides default and override configuration of QoS and APN.

PDP Context Modification

This procedure is used to update the MN and the GGSN. The SGSN is capable of initiating the context modification or negotiating a PDP context modification initiated by either the MN or the GGSN.

PDP Context Deactivation

This procedure is used to deactivate PDP contexts. The procedure can be initiated by the MN or the SGSN. The SGSN provides configurable timers to initiate PDP deactivation of idle contexts as well as active contexts.

PDP Context Preservation

The SGSN provides this functionality to facilitate efficient radio resource utilization. This functionality comes into play on the following triggers:

- **RAB (Radio Access Bearer) Release Request**

This is issued by the RAN to request the release of RABs associated with specific PDP contexts. The SGSN responds with a RAB assignment request, waits for the RAB assignment response and marks the RAB as having been released. The retention of the PDP contexts is controlled by configuration at the SGSN. If the PDP contexts are retained the SGSN is capable of receiving downlink packets on them.

- **Iu Release Request**

The RAN issues an Iu release request to release all RABs of an MN and the Iu connection. The retention of the PDP contexts is controlled by configuration at the SGSN. When PDP contexts are retained the SGSN is capable of receiving downlink packets on them.

When PDP contexts are preserved, the RABs can be restored on a service request from the MN without having to go through the PDP context establishment process again. The service request is issued by the MN either when it has some data to send or in response to a paging request, on downlink data, from the SGSN.

Charging

Charging functionality for the SGSN varies depending upon the type of network in which it is deployed.

SGSN in GPRS/UMTS Network

The SGSN provides an efficient and accurate billing system for all calls and SMSs passing through the SGSN. The charging-specific interfaces and 3GPP standards supported by the SGSN deployments are listed below:

- Allows the configuration of multiple CGFs and a single GSS in a single GTPP group along with their relative priorities.
- Implements the standardized Ga interface.
- Fully supports the GPRS Tunneling Protocol Prime (GTPP) over UDP/TCP.
- Supports the relevant charging information as defined in:
 - **3GPP TS 29.060 v7.9.0 (2008-09)**: Technical Specification; 3rd Generation Partnership Project; Technical Specification Group Core Network; General Packet Radio Service (GPRS); GPRS Tunneling Protocol (GTP) across the Gn and Gp interface (Release 6)
 - **3GPP TS 32.215 v5.9.0 (2005-06)**: 3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; Telecommunication management; Charging management; Charging data description for the Packet Switched (PS) domain (Release 4)
 - **3GPP TS.32.251 V8.8.0 (2009-12)**: 3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; Telecommunication management; Charging management; Packet Switched (PS) domain charging (Release 8)
 - **3GPP TS 32.298 V8.7.0 (2009-12)**: 3rd Generation Partnership Project; Technical Specification Group Service and System Aspects; Telecommunication management; Charging management; Charging Data Record (CDR) parameter description (Release 8)

Charging Data Records (CDRs)

The SGSN generates CDRs with the charging information. The following sections outline the types of CDRs generated by the SGSN.

For full dictionary, CDR and field information, refer to the *GTPP Accounting Overview*, the *SGSN and Mobility Management Charging Detail Record Field Reference Tables*, and the *S-CDR Field Descriptions* sections in the *AAA and GTPP Interface Administration and Reference*

SGSN Call Detail Records (S-CDRs)

These charging records are generated for PDP contexts established by the SGSN. They contain attributes as defined in TS 32.251 v7.2.0.

Mobility Call Detail Records (M-CDRs)

These charging records are generated by the SGSN's mobility management (MM) component and correspond to the mobility states. They contain attributes as defined in 3GPP TS 32.251 v7.2.0.

Short Message Service CDRs

SGSN supports following CDRs for SMS related charging:

- SMS-Mobile Originated CDRs (SMS-MO-CDRs)
- SMS Mobile Terminated CDRs (SMS-MT-CDRs)

These charging records are generated by the SGSN's Short Message Service component. They contain attributes as defined in 3GPP TS 32.215 v5.9.0.

Location Request CDRs

SGSN supports the following Location Request CDRs:

- Mobile terminated location request CDRs (LCS-MT-CDRs)
- Mobile originated location request CDRs (LCS-MO-CDRs)

SGSN in LTE/SAE Network

An SGSN can function in an LTE/SAE network using enhancements to support various other interfaces including an S4 interface. In these cases, the SGSN is referred to as an S4-SGSN.

Serving Gateway Call Detail Records (S-GW-CDRs)

The S4-SGSN does not support S-CDRs because the S4 interface is used, per PDP (or EPS bearer) and charging records are generated by the S-GW using the S-GW-CDR. The S-GW collects the charging information per user per IP-CAN bearer. The collected information is called as S-GW-CDR and sent to the Charging Gateway over the Gz interface.

Features and Functionality

It is impossible to list all of the features supported by the Gn/Gp SGSN (2.5G and 3G) or the S4-SGSN.

Those features listed below are only a few of the features that enable the operator to control the SGSN and their network. All of these features are either proprietary or comply with relevant 3GPP specifications.

Some of the proprietary features may require a separate license. Contact your Cisco account representative for detailed information on specific licensing requirements. For information on installing and verifying licenses, refer to the *Managing License Keys* section of the *Software Management Operations* section in the *System Administration Guide*.

3G-2G Location Change Reporting

With Location Change Reporting enabled, the SGSN facilitates location-based charging on the GGSN by providing the UE's geographical location information when the UE is in connected mode.

Location-based charging is a value-added function that ensures subscribers pay a premium for location-based services, such as service in a congested areas. With the required feature license installed, the operator uses the CLI to enable the reporting independently for each network access type: GPRS (2G) or UMTS (3G).

For more information about how the feature works and how to configure it, refer to the *3G-2G Location Change Reporting* feature section.



Important The "Location reporting in connected mode" license is required to enable this functionality.

Access Restriction Support on S6d Interface

The SGSN supports the below parameters added in the Update Location Request/Answer and Insert Subscriber Data Request/Answer messages on S6d interface:

- SGSN advertises the DCNR feature support by setting the 'NR as Secondary RAT feature bit' in Supported Features list 2 towards HSS if the DCNR feature is configured at SGSN and UE advertises DCNR capability in NAS
- SGSN also handles the new bit 'NR as Secondary RAT Not Allowed' in the Access-Restriction-Data bitmask sent by HSS to control if the subscriber is allowed to access NR via dual connectivity
- SGSN handles the Extended Bandwidth UL/DL parameters under AMBR sent by HSS

Gateway selection is improved to avoid SGSN from falling back and triggering an "A" query to get the normal GGSN information.

When no collocated PGW/GGSN with "+nc-nr" capability is found in DNS response, the SGSN will select the next collocated PGW/GGSN node. If "3gpp-pgw:x-gn+nc-nr/ x-3gpp-pgw:x-gp+nc-nr" is not present in DNS response, the SGSN will select "3gpp-pgw:x-gn / x-3gpp-pgw:x-gp" instead of triggering another to "A" query to get the GGSN information. "UP Function Selection Indication Flags" IE in Create PDP Context Request message will be set to "1" only when "+nc-nr" capable gateway is selected.

Accounting Path Framework, New for 14.0

As of Release 14.0, the SGSN uses a new accounting path framework to support PSC3 numbers of 8 million attached subs and 16 million PDP contexts. In the old accounting path framework, there was one AAA session per sub-session in the Session manager and one archive session per sub-session in AAA manager. As part of the new accounting path framework there is only one AAA session per call in the Session manager and one archive session per call in the AAA manager. Also, there is an additional accounting session in the Session manager and the AAA manager per sub-session. The new accounting path framework improves memory and CPU utilization and prevents tariff or time limit delay. There are no changes in the CLI syntax to support the new accounting path and the existing accounting behavior of SGSN is not modified.

AAA Changes To Support Location Services (LCS) Feature

The Location Services (LCS) feature in SGSN provides the mechanism to support mobile location services for operators, subscribers and third party service providers. AAA changes have been made to support the LCS feature. A new CDR type Mobile Originated Location Request CDRs (LCS-MO-CDR) is introduced. LCS-MO-CDRs support the standard dictionaries.

For detailed information on LCS-MO-CDRs, refer to the *GTPP Interface Administration and Reference*.

APN Aliasing

In many situations, the APN provided in the Activation Request is unacceptable perhaps it does not match with any of the subscribed APNs or it is misspelled and would result in the SGSN rejecting the Activation Request. The APN Aliasing feature enables the operator to override an incoming APN specified by a subscriber or provided during the APN selection procedure (TS 23.060) or replace a missing APN with an operator-preferred APN.

The APN Aliasing feature provides a set of override functions: Default APN, Blank APN, APN Remapping, and Wildcard APN to facilitate such actions as:

- overriding a mismatched APN with a default APN.
- overriding a missing APN (blank APN) with a default or preferred APN.
- overriding an APN on the basis of charging characteristics.

- overriding an APN by replacing part or all of the network or operator identifier with information defined by the operator, for example, MNC123.MCC456.GPRS could be replaced by MNC222.MCC333.GPRS.
- overriding an APN for specific subscribers (based on IMSI) or for specific devices (based on IMEI).

Default APN

Operators can configure a "default APN" for subscribers not provisioned in the HLR. The default APN feature will be used in error situations when the SGSN cannot select a valid APN via the normal APN selection process. Within an APN remap table, a default APN can be configured for the SGSN to:

- override a requested APN when the HLR does not have the requested APN in the subscription profile.
- provide a viable APN if APN selection fails because there was no "requested APN" and wildcard subscription was not an option.

In either of these instances, the SGSN can provide the default APN as an alternate behavior to ensure that PDP context activation is successful.

Recently, the SGSN's default APN functionality was enhanced so that if a required subscription APN is not present in the subscriber profile, then the SGSN will now continue the activation with another configured 'dummy' APN. The call will be redirected, via the GGSN, to a webpage informing the user of the error and prompting to subscribe for services.

Refer to the *APN Remap Table Configuration Mode* in the *Command Line Interface Reference* for the command to configure this feature.

APN Redirection per APN with Lowest Context-ID

The APN Redirection per APN with Lowest Context-ID feature adds the flexibility to select the subscription APN with the least context ID when the APN is not found in the subscription. SGSN already provides sophisticated APN replacement with support for first-in-subscription, default APN, blank APN, and wildcard APN. This latest feature works along similar lines providing further flexibility to the operator in allowing activations when the MS requested APN is incorrect, misspelled, or not present in the subscription.

The SGSN's APN selection procedure is based on 3GPP 23.060 Annex A, which this feature extends based on CLI controls under the APN Remap Table configuration mode.

APN Resolution with SCHAR or RNC-ID

It is now possible to append charging characteristic information to the DNS string. The SGSN includes the profile index value portion of the CC as binary/decimal/hexadecimal digits (type based on the configuration) after the APN network identification. The charging characteristic value is taken from the subscription record selected for the subscriber during APN selection. This enables the SGSN to select a GGSN based on the charging characteristics information.

After appending the charging characteristic the DNS string will take the following form:

<apn_network_id>.<profile_index>.<apn_operator_id>. The profile index in the following example has a value 10: quicknet.com.uk.1010.mnc234.mcc027.gprs.

If the RNC_ID information is configured to be a part of the APN name, and if inclusion of the profile index of the charging characteristics information is enabled before the DNS query is sent, then the profile index is included after the included RNC_ID and the DNS APN name will appear in the following form:

<apn_network_id>.<rnc_id>.<profile_index>.<apn_operator_id>. In the following example, the DNS query

for a subscriber using RNC 0321 with the profile index of value 8 would appear as:
quicknet.com.uk.0321.1000.mnc234.mcc027.gprs.

APN Restriction

The reception, storage, and transfer of APN Restriction values is used to determine whether a UE is allowed to establish PDP Context or EPS bearers with other APNs. This feature is supported by both the Gn/Gp-SGSN and the S4-SGSN.

During default bearer activation, the SGSN sends the current maximum APN restriction value for the UE to the GGSN/P-GW in a Create Session Request (CSR). The GGSN/P-GW retains an APN restriction value for each APN. The UE's APN Restriction value determines the type of application data the subscriber is allowed to send. If the maximum APN restriction of the UE (received in the CSR) and the APN Restriction value of the APN (for which activation is being request) do not concur, then the GGSN/P-GW rejects activation. The maximum APN restriction for a UE is the most restrictive based on all already active default EPS bearers.

This feature provides the operator with increased control to restrict certain APNs to UEs based on the type of APN. This feature requires no special license.

APN Restriction for SGSN is enabled/disabled in the **call-control-profile** configuration mode using the **apn-restriction** command. Refer to the *Command Line Interface Reference* for usage details.

Automatic Protection Switching (APS)

Automatic protection switching (APS is now available on an inter-card basis for SONET configured CLC2 (Frame Relay) and OLC2 (ATM) optical line cards. Multiple switching protection (MSP) version of is also available for SDH configured for the CLC2 and OLC2 (ATM) line cards.

APS/MSP offers superior redundancy for SONET/SDH equipment and supports recovery from card failures and fiber cuts. APS allows an operator to configure a pair of SONET/SDH lines for line redundancy. In the event of a line problem, the active line switches automatically to the standby line within 60 milliseconds (10 millisecond initiation and 50 millisecond switchover).

At this time, the Gn/Gp-SGSN supports the following APS/MSP parameters:

- 1+1 - Each redundant line pair consists of a working line and a protection line.
- uni-directional - Protection on one end of the connection.
- non-revertive - Upon restoration of service, this parameter prevents the network from automatically reverting to the original working line.

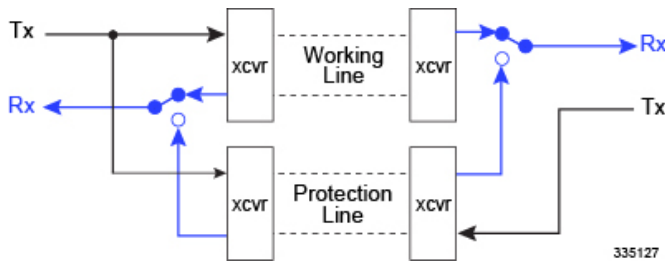
The protection mechanism used for the APS/MSP uses a linear 1+1 architecture, as described in the ITU-T G.841 standard and the Bellcore publication GR-253-CORE, SONET Transport Systems; Common Generic Criteria, Section 5.3. The connection is unidirectional.

With APS/MSP 1+1, each redundant line pair consists of a working line and a protection line. Once a signal fail condition or a signal degrade condition is detected, the hardware switches from the working line to the protection line.

With the non-revertive option, if a signal fail condition is detected, the hardware switches to the protection line and does not automatically revert back to the working line.

Since traffic is carried simultaneously by the working and protection lines, the receiver that terminates the APS/MSP 1+1 must select cells from either line and continue to forward one consistent traffic stream. The receiving ends can switch from working to protection line without coordinating at the transmit end since both lines transmit the same information.

Figure 4: SONET APS 1+1



Refer to the section on *Configuring APS/MSP Redundancy* in the *SGSN Service Configuration Procedures* section for configuration details.

Authentications and Reallocations -- Selective

Subscriber event authentication, P-TMSI reallocation, and P-TMSI signature reallocation are now selective rather than enabled by default.

The operator can enable and configure them to occur according to network requirements:

- every instance or every nth instance;
- on the basis of UMTS, GPRS or both;
- on the basis of elapsed time intervals between events.

There are situations in which authentication will be performed unconditionally:

- IMSI Attach all IMSI attaches will be authenticated
- When the subscriber has not been authenticated before and the SGSN does not have a vector
- When there is a P-TMSI signature mismatch
- When there is a CKSN mismatch

There are situation in which P-TMSI will be reallocated unconditionally:

- Inter SGSN Attach/RAU
- Inter-RAT Attach/RAU in 2G
- IMSI Attach

Avoiding PDP Context Deactivations

The SGSN can be configured to avoid increased network traffic resulting from bursts of service deactivations/activations resulting from erroneous restart counter change values in received messages (Create PDP Context Response or Update PDP Context Response or Update PDP Context Request). By default, the SGSN has the responsibility to verify possible GTP-C path failure by issuing an Echo Request/Echo Response to the GGSN. Path failure will only be confirmed if the Echo Response contains a new restart counter value. Only after this confirmation of the path failure does the SGSN begin deactivation of PDP contexts.

Backup and Recovery of Key KPI Statistics

This feature allows the backup of a small set of KPI counters for recovery of the counter values after a session manager crash.

Using the feature-specific CLI **statistics-backup sgsn backup-interval** command, in the Global configuration mode, the operator can enable the feature and define the frequency of the backup; range 1-60 minutes.

In support of this functionality, four schemas (gprs-bk, iups-bk, map-bk, sgtp-bk) have been defined with stats, derived from the SGSN and SGTP schemas, that will be backed up for recovery of their counter values.

For more information about the schema, refer to the *Statistics and Counters Reference*. For more information about this functionality and configuration for this feature, refer to the *Backup and Recovery of Key KPI Statistics* feature chapter in this Guide.

Bulk Statistics Support

System support for bulk statistics allows operators to choose which statistics to view and to configure the format in which the statistics are presented. This simplifies the post-processing of statistical data since it can be formatted to be parsed by external, back-end processors.

When used in conjunction with the Web Element Manager, the data can be parsed, archived, and graphed.

The system can be configured to collect bulk statistics (performance data) and send them to a collection server (called a receiver). Bulk statistics are statistics that are collected in a group. The individual statistics are grouped by schema. The following is the list of schemas supported for use by the SGSN:

- **System:** Provides system-level statistics
- **Card:** Provides card-level statistics
- **Port:** Provides port-level statistics
- **DLCI-Util:** Provides statistics specific to DLCIs utilization for CLC-type line cards
- **EGTPC:** Provides statistics specific to the configured ETPC service on the S4-SGSN
- **GPRS:** Provides statistics for LLC, BSSGP, SNDCP, and NS layers
- **SCCP:** Provides SCCP network layer statistics
- **SGTP:** Provides SGSN-specific GPRS Tunneling Protocol (GTP) statistics
- **SGSN:** Provides statistics for: mobility management (MM) and session management (SM) procedures; as well, MAP, TCAP, and SMS counters are captured in this schema. SGSN Schema statistic availability is per service (one of: SGSN, GPRS, MAP) and per routing area (RA)
- **SS7Link:** Provides SS7 link and linkset statistics
- **SS7RD:** Provides statistics specific to the proprietary SS7 routing domains

The following four schema are used by the SGSN for backed up / recovered counters (for details, see the *Backup and Recovery of Key KPI Statistics* section in this guide) :

- **iups-bk**
- **gprs-bk**
- **map-bk**
- **sgtp-bk**

The system supports the configuration of up to 4 sets (primary/secondary) of receivers. Each set can be configured with to collect specific sets of statistics from the various schemas. Statistics can be pulled manually from the chassis or sent at configured intervals. The bulk statistics are stored on the receiver(s) in files.

The format of the bulk statistic data files can be configured by the user. Users can specify the format of the file name, file headers, and/or footers to include information such as the date, chassis host name, chassis uptime, the IP address of the system generating the statistics (available for only for headers and footers), and/or the time that the file was generated.

When the Web Element Manager is used as the receiver, it is capable of further processing the statistics data through XML parsing, archiving, and graphing.

The Bulk Statistics Server component of the Web Element Manager parses collected statistics and stores the information in the PostgreSQL database. If XML file generation and transfer is required, this element generates the XML output and can send it to a Northbound NMS or an alternate bulk statistics server for further processing.

Additionally, if archiving of the collected statistics is desired, the Bulk Statistics server writes the files to an alternative directory on the server. A specific directory can be configured by the administrative user or the default directory can be used. Regardless, the directory can be on a local file system or on an NFS-mounted file system on the Web Element Manager server.

Bypassing APN Remap for Specific IMEI Ranges

An APN Remap Table associated with an IMEI profile overrides a remap table associated with an operator policy. This means activation will be rejected if a local default APN configured, in an APN Remap Table associated with an IMEI profile, cannot be used. This will occur even if a valid local default APN is available in an APN Remap Table associated with an operator policy.



Important To achieve the previous default behavior, customers already using an APN Remap Table that is associated with an IMEI profile *will have to change the existing configuration* to achieve the previous behavior. For details and sample configurations, see the Release 16 specific information for **apn-selection-default** in the *APN Remap Table Configuration Mode Commands* section of the *Command Line Interface Reference* for a Release 16 or higher.

CAMEL Service Phase 3, Ge Interface

The SGSN provides PDP session support as defined by Customized Applications for Mobile network Enhanced Logic (CAMEL) phase 3.

CAMEL Service

CAMEL service enables operators of 2.5G/3G networks to provide operator-specific services (such as prepaid GPRS service and prepaid SMS service) to subscribers, even when the subscribers are roaming outside their HPLMN.

CAMEL Support

SGSN support for CAMEL phase 3 services expands with each SGSN application release. Current support enables operators of 2.5G/3G networks to provide operator-specific services (such as prepaid GPRS service and prepaid SMS service) to subscribers, even when the subscribers are roaming outside their HPLMN.

For this release the SGSN has expanded its support for CAMEL Scenario 1 adding:

- Implementation of Scenario1 triggers (TDP-Attach, TDP-Attach-ChangeofPosition)
- Implementation of Scenario1 Dynamic triggers (DP-Detach, DP-ChangeofPosition)
- Expanded conformance to 3GPP spec 23.078 (Release 4)

The SGSN supports the following GPRS-related functionality in CAMEL phase 3:

- Control of GPRS PDP contexts

Functional support for CAMEL interaction includes:

- PDP Context procedures per 3GPP TS 29.002
 - GPRS TDP (trigger detection point) functions
 - Default handling codes, if no response received from SCP
 - GPRS EDP (event detection points) associated with SCP
 - Charging Procedures: Handle Apply Charging GPRS & Handle Apply Charging Report GPRS
- "GPRS Dialogue scenario 2" for CAMEL control with SCP
- CAMEL-related data items in an S-CDR:
 - SCF Address
 - Service Key
 - Default Transaction Handling
 - Level of CAMEL service (phase 3)
- Session Recovery for all calls have an ESTABLISHED CAMEL association.

Ge Interface

The SGSN's implementation of CAMEL uses standard CAP protocol over a Ge interface between the SGSN and the SCP. This interface can be deployed over SS7 or SIGTRAN.

The SGSN's Ge support includes use of the gprsSSF CAMEL component with the SGSN and the gsmSCF component with the SCP.

CAMEL Configuration

To provide the CAMEL interface on the SGSN, a new service configuration mode, called "CAMEL Service", has been introduced on the SGSN.

1. An SCCP Network configuration must be created or exist already.
2. A CAMEL Service instance must be created.
3. The CAMEL Service instance must be associated with either the SGSN Service configuration or the GPRS Service configuration in order to enable use of the CAMEL interface.
4. The CAMEL Service must be associated with the SCCP Network configuration.

Until a CAMEL Service is properly configured, the SGSN will not process any TDP for pdp-context or mo-sms.

For configuration details, refer to the *Serving GPRS Support Node Administration Guide* and the *Command Line Interface Reference*.

Commandguard

Operators can accidentally enter configuration mode via CLI or file replay. To protect against this, SGSN supports **commandguard** CLI command. Commandguard, which is disabled by default, can only be enabled or disabled from the Global Configuration mode. When Commandguard is enabled it affects the **configure** and **autoconfirm** CLI commands by causing them to prompt (Y/N) for confirmation. When **autoconfirm** is enabled Commandguard has no affect. The commandguard state is preserved in the SCT and, when enabled, is output by the various variants of the **show config** CLI.

Configurable RAB Asymmetry Indicator in RAB Assignment Request

The SGSN sets the value for the RAB Asymmetry Indicator that is included in the RAB Assignment Request.

The SGSN selects the value based on the symmetry of negotiated maximum bit rates as follows:

- If the uplink and downlink bit rates are equal then it is set to "Symmetric-Bidirectional",
- If uplink bit rate is set to 0 kbps, then it is set to "Asymmetric-Unidirectional-Downlink",
- If downlink bit rate is set to 0 kbps, then it is set to "Asymmetric-Unidirectional-Uplink",
- If the uplink and downlink bit rates are non-zero and different, then it is set to "Asymmetric-Bidirectional".

A change in CLI configuration allows the SGSN to override the above functionality and set the RAB Asymmetry Indicator to "Asymmetric-Bidirectional" when uplink and downlink bit rates are equal. As a result, two sets of bit rates - one for downlink and one for uplink - will be included in the RAB Assignment Requests as mandated in 3GPP TS 25.413.

Congestion Control

With Release 17, the SGSN supports several of the 3GPP TS23.060 R10 machine type communications (MTC) overload control mechanisms to be used in the handling of signaling bursts from machine-to-machine (M2M) devices:

- General congestion control applicable only for Mobility Management messages.
- APN-based congestion control for Mobility Management
- APN-based congestion control for Session Management
- Extended T3312 timer support
- MM (Mobility Management) T3346 - MM Back-off Timer and SM (Session Management) T3396 - SM Back-off Timer

For more information about the congestion control functionality and configuration, refer to the *MTC Congestion Control* section in this Guide.

Different NRIs for Pooled and Non-pooled RNCs/BSCs

The SGSN adds support for configuring different NRIs for pooled and non-pooled areas in order to load-balance subscribers coming from non-pooled RNCs to pooled RNCs.

Consider a scenario when two SGSNs support pooling and a RNC/BSC controlled by a SGSN is in pool but not the other, and both RNCs/BSCs are given same NRI(s), this leads to imbalance in subscriber distribution between the SGSNs. With this enhancement if an NRI is configured for both pooled and non-pooled, then the SGSN reuses the same NRI when moving from pooled to non-pooled areas and vice versa.

A new keyword **non-pooled-nri-value** is introduced in the NRI configuration for GPRS and SGSN services to configure set of NRI which should be used for non-pooled RNCs/BSCs. The NRIs configured under the existing keyword **nri-value** will be used for pooled RNCs/BSCs. If the new keyword **non-pooled-nri-value** is not configured, then NRIs configured under the keyword **nri-value** will be used for both pooled and non-pooled RNCs/BSCs.

If the new keyword **non-pooled-nri-value** is configured without pooling enabled at SGSN (null-nri-value is not configured), then SGSN will use NRIs under **non-pooled-nri-value** irrespective of BSC/RNCs being pooled or non-pooled, till pooling is enabled at SGSN. After pooling is enabled, NRIs under keyword **nri-value** will be for pooled RNC/BSCs and **non-pooled-nri-value** will be for non-pooled RNC/BSCs. This is applicable for both SGSN and GPRS service.

Direct Tunnel

In accordance with standards, one tunnel functionality enables the SGSN to establish a direct tunnel at the user plane level - a GTP-U tunnel, directly between the RAN and the GGSN. Feature details and configuration procedures are provided in the *Direct Tunnel* feature section in this guide.

Direct Tunnel Support on the S4-SGSN

Direct tunnelling of user plane data between the RNC and the S-GW can be employed to scale UMTS system architecture to support higher traffic rates. The direct tunnel (DT) approach optimizes core architecture without impact to UEs and can be deployed independently of the LTE/SAE architecture.

Now, DT support is added to the S4-SGSN to enable the establishment of a direct tunnel over the S12 interface between an RNC and an S-GW in a PS domain under a range of scenarios, such as (but not limited to):

- Primary PDP activation
- Secondary PDP activation
- Service Request Procedure
- Intra SGSN Routing Area Update without SGW change
- Intra SGSN Routing Area Update with SGW change
- Intra SGSN SRNS relocation without SGW change
- Intra SGSN SRNS relocation with SGW change
- New SGSN SRNS relocation with SGW change
- New SGSN SRNS relocation without SGW relocation
- E-UTRAN to UTRAN Iu mode IRAT handover - with application of S12U FTEID for Indirect Data Forwarding Tunnels as well
- UTRAN to E-UTRAN Iu mode IRAT handover - with application of S12U FTEID for Indirect Data Forwarding Tunnels as well
- Network-Initiated PDP Activation

The Direct Tunnel Support on the S4-SGSN feature is license controlled. Contact your Cisco Account or Support representative for information on how to obtain a license.

For a complete description of this feature and its configuration requirements, refer to the *S4-SGSN Direct Tunnel Solution* session in the *Serving GPRS Support Node Administration Guide*.

Downlink Data Lockout Timer

The Downlink Data Lockout Timer is a new, configurable timer added for both GPRS and SGSN services to reduce the frequency of mobile-initiated keep alive messages. If enabled, this timer starts whenever the paging procedure fails after the maximum number of retransmissions and the Page Proceed Flag (PPF) is cleared. If there is any downlink activity when the lockout timer is running, the packets are dropped and the drop cause is set as Page Failed. When the lockout timer expires, the PPF is set to true and further downlink packets are queued and paging is re-initiated. In order to avoid endless paging activity when there is no page response or uplink activity from the UE, an optional configurable *repeat* count value is used. If the repeat value is configured as 'y' then the lockout timer is started 'y' number of times after page failure. The implementation of the lockout timer is different for 2G/3G subscribers, but the behavior is the same.

DSCP Templates for Control and Data Packets - Iu or Gb over IP

The SGSN supports a mechanism for differentiated services code point (DSCP) marking of control packets and signaling messages for the SGSN's M3UA level on the Iu interface and for LLC messages for the Gb interface.

This DSCP marking feature enables the SGSN to perform classifying and managing of network traffic and to determine quality of service (QoS) for the interfaces to an IP network.

Implementation of this feature requires the use of several CLIs commands to create one or more reusable templates. These templates set DSCP parameter configuration for downlink control packets and data packets that can be associated with one or more configurations for at the GPRS service level, the peer-NSEI level, the IuPS service level, and the PSP instance level.

Dual PDP Addresses for Gn/Gp

In accordance with 3GPP Release 9.0 specifications, it is now possible to configure SGSN support for dual stack PDP type addressing (IPv4v6) for PDP context association with one IPv4 address and one IPv6 address/prefix when requested by the MS/UE.

ECMP over ATM

Iu Redundancy is the implementation of equal-cost multi-path routing (ECMP) over ATM.

Iu Redundancy is based on the standard ECMP multi-path principle of providing multiple next-hop-routes of equal cost to a single destination for packet transmission. ECMP works with most routing protocols and can provide increased bandwidth when traffic load-balancing is implemented over multiple paths.

ECMP over ATM will create an ATM ECMP group when multiple routes with different destination ATM interfaces are defined for the same destination IP address. When transmitting a packet with ECMP, the NPU performs a hash on the packet header being transmitted and uses the result of the hash to index into a table of next hops. The NPU looks up the ARP index in the ARP table (the ARP table contains the next-hop and egress interfaces) to determine the next-hop and interface for sending packets.

EDR Enhancements

A new event-logging handle has been introduced. The EDR module was used for event logging purpose, `CDR_MODULE_EVENT_RECORD` is used instead of `CDR_MODULE_EDR`. The CLI options present under the EDR Module are also present under the Session Event Module.

In Release 21.3, the following EDR enhancements are implemented:

- New fields for Activation EDR:

A new field - NSAPI, is added as a part of the Activation EDR. The location of this field is added at the end of the Activation EDR.

- New fields for ISRAU EDR:

A new field - PDN-Info, which consists of nsapi, ggsn-address, ipv4-pdp-address, ipv6-pdp-address, is added as a part of the ISRAU EDR and the location of this field is added at the end of the ISRAU EDR.

The PDN-Info field is optional and will be sent only if there are PDP contexts handled by the SGSN.

- EDR for Service Request parameter:

An EDR is now generated for a Service Request parameter. This EDR has the following fields listed in order:

- 1: Time-Stamp
- 2: Event-ID
- 3: Event-Result
- 4: RAT
- 5: Service-Request-Trigger
- 6: Service-Type
- 7: Paging-Attempts
- 8: Request-Retries
- Cause-Prot-Types
- Cause-Code
- Disconnect Reason
- Location (MCC+MNC+LAC+RAC+SAC)
- Subscriber's MSISDN, IMSI, PTMSI, IMEISV, HLR's MSISDN

EIR Selection for Roaming Subscribers

EIR selection for roaming subscribers functionality makes it possible for the SGSN to select an EIR based on the PLMN into which the subscriber has roamed and reduce signalling back to home PLMNs for roamers.

The Equipment Identity Register (EIR), used for authentication and authorization during an Attach, is the carrier's IMEI(SV) database of the unique numbers allocated to each subscriber's mobile station equipment (IMEI) and the manufacturer's software version (SV). An IMEI(SV) can be in one of three lists in the EIR:

- white list - the subscriber equipment is permitted access
- black list - the subscriber equipment is not permitted access
- grey list - the subscriber equipment is being tracked for evaluation or other purposes

As part of this function, the operator can create and use an EIR profile to define the parameters to:

- use a single EIR address for multiple EIRs,
- achieve the Check-IMEI-Request, and
- associate the EIR profile with a call control profile.

Equivalent PLMN

This feature is useful when an operator deploys both GPRS and UMTS access in the same radio area and each radio system broadcasts different PLMN codes. It is also useful when operators have different PLMN codes in different geographical areas, and the operators' networks in the various geographical areas need to be treated as a single HPLMN.

This feature allows the operator to consider multiple PLMN codes for a single subscriber belonging to a single home PLMN (HPLMN). This feature also allows operators to share infrastructure and it enables a UE with a subscription with one operator to access the network of another operator.

Fallback on DNS Failure

In releases prior to 21.5, on failure of DNS query with APN name and LAC-RAC extension, no more DNS queries were sent.

In release 21.5, SGSN sends DNS query with only APN name on failure of DNS query with APN name and LAC-RAC extension. The **dns-extn lac-rac fallback** command in the APN Profile Configuration mode can be configured to enable or disable fallback on DNS failure.



Important This enhancement is applicable only for Gn-SGSN.

First Vector Configurable Start for MS Authentication

Previously, the SGSN would begin authentication towards the MS only after the SGSN received all requested vectors. This could result in a radio network traffic problem when the end devices timed out and needed to re-send attach requests.

Now, the SGSN can be configured to start MS authentication as soon as it receives the first vector from the AuC/HLR while the SAI continues in parallel. After an initial attach request, some end devices restart themselves after waiting for the PDP to be established. In such cases, the SGSN restarts and a large number of end devices repeat their attempts to attach. The attach requests flood the radio network, and if the devices timeout before the PDP is established then they continue to retry, thus even more traffic is generated. This feature reduces the time needed to retrieve vectors over the GR interface to avoid the high traffic levels during PDP establishment and to facilitate increased attach rates.

Format Encoding of MNC and MCC in DNS Queries Enhanced

In order to provide effective control on DNS queries for particular type of procedures, existing CLI commands in GPRS and SGSN services have been deprecated and replaced with new enhanced commands. The command **dns israu-mcc-mnc-encoding [hexadecimal | decimal]** has been deprecated and a new CLI command **dns mcc-mnc-encoding { rai-fqdn | apn-fqdn | rnc-fqdn | mmec-fqdn | tai-fqdn }* {a-query | snaptr-query }* { decimal | hexadecimal }**. New keyword options **snaptr-query** and **a-Query** are provided to control different types of queries.

To ensure backward compatibility:

1. If the command **dns israu-mcc-mnc-encoding decimal** is executed, it will be auto converted to **dns mcc-mnc-encoding rai-fqdn a-query snaptr-query decimal**.
2. If the command **dns israu-mcc-mnc-encoding hexadecimal** is executed, it will be auto converted to **dns mcc-mnc-encoding rai-fqdn a-query snaptr-query hexadecimal**

For more information see, *Command Line Interface Reference*.

Gb Manager

A new SGSN proctlet has been developed. Now, all the link level procedures related to Gb -

- protocol (GPRS-NS and BSSGP) hosting, handling, administration, message distribution,
- keeping the other managers informed about the link/remote-node status,
- handling functionality of the Gb interface (all 2G signaling)

are removed from the Link Manager and moved to the SGSN's new Gb Manager proctlet.

The new Gb Manager provides increased flexibility in handling link level procedures for each access type independently and ensures scalability. The consequence of relieving the Link Manager, of a large amount of message handling, is to decrease delays in sending sscop STAT messages resulting in the detection of link failure at the remote end. Use of this separate new proctlet to handle 2G signaling messages means there will not be any MTP link fluctuation towards the RNS, which is seen during the BSC restart or extension activity in the network. As well, this improves the fluctuation towards the 3G connectivity.

GMM-SM Event Logging

To facilitate troubleshooting, the SGSN will capture procedure-level information per 2G or 3G subscriber (IMSI-based) in CSV formatted event data records (EDRs) that are stored on an external server.

This feature logs the following events:

- Attaches
- Activation of PDP Context
- RAU
- ISRAU
- Deactivation of PDP Context
- Detaches
- Authentications
- PDP Modifications

The new SGSN event logging feature is enabled/disabled per service via CLI commands. For more information on this feature, refer to the section *GMM/SM Event Logging* in this guide.

Gn/Gp Delay Monitoring

The SGSN measures the control plane packet delay for GTP-C signaling messages on the SGSN's Gn/Gp interface towards the GGSN.

If the delay crosses a configurable threshold, an alarm will be generated to prompt the operator.

A delay trap is generated when the GGSN response to an ECHO message request is delayed more than a configured amount of time and for a configured number of consecutive responses. When this occurs, the GGSN will be flagged as experiencing delay.

A clear delay trap is generated when successive ECHO Response (number of successive responses to detect a delay clearance is configurable), are received from a GGSN previously flagged as experiencing delay.

This functionality can assist with network maintenance, troubleshooting, and early fault discovery.

GTP-C Path Failure Detection and Management

The SGSN now provides the ability to manage GTP-C path failures detected as a result of spurious restart counter change messages received from the GGSN.

Previous Behavior: The old default behavior was to have the Session Manager (SessMgr) detect GTP-C path failure based upon receiving restart counter changes in messages (Create PDP Context Response or Update PDP Context Response or Update PDP Context Request) from the GGSN and immediately inform the SGTPC Manager (SGTPCMgr) to pass the path failure detection to all other SessMgrs so that PDP deactivation would begin.

New Behavior: The new default behavior has the SessMgr inform the SGTPCMgr of the changed restart counter value. The SGTPCMgr now has the responsibility to verify a possible GTP-C path failure by issuing an Echo Request/Echo Response to the GGSN. Path failure will only be confirmed if the Echo Response contains a new restart counter value. Only after this confirmation of the path failure does the SGTPCMgr inform all SessMgrs so that deactivation of PDP contexts begins.

GTPv0 Fallback, Disabling to Reduce Signalling

GTPv0 fallback can cause unnecessary signaling on the Gn/Gp interface in networks where all the GGSNs support GTPv1.

By default, the SGSN supports GTPv0 fallback and uses either GTPv1 or GTPv0. After exhausting all configured retry attempts for GTPv1, the SGSN retries the GTP-C Request using GTPv0. This fallback is conditional and is done only when the GTP version of a GGSN is unknown during the first attempt at activating a PDP context with the GGSN.

It is possible for the operator to disable the GTPv0 fallback for requests to GGSNs of specific APNs. Disabling the fallback function is configured under the APN profile and is applicable for GGSNs corresponding to that APN. If GTPv1 only is enabled in the APN profile, then the SGSN does not attempt fallback to GTPv0 (towards GGSNs corresponding to that APN) after all GTPv1 retries have been attempted. If more than one GGSN address is returned by the DNS server during activation, then the SGSN attempts activation with the next GGSN after exhausting all the GTPv1 retry attempts. If only one GGSN address is returned, then the SGSN rejects the activation after exhausting all the configured GTPv1 retries.

This change enables the operator to prevent unnecessary signaling on the Gn/Gp interface in networks where all the GGSNs support GTPv1. For example, if all the home GGSNs in an operator's network support GTPv1, then the unnecessary GTPv0 fallback can be avoided by enabling this feature for the APNs associated with home GGSNs.

Handling Multiple MS Attaches All with the Same Random TLLI

Some machine-to-machine (M2M) devices from the same manufacturer will all attempt PS Attaches using the same fixed random Temporary Logical Link Identifier (TLLI).

The SGSN cannot distinguish between multiple M2M devices trying to attach simultaneously using the same random TLLI and routing area ID (RAI). As a result, during the attach process of an M2M device, if a second device tries to attach with the same random TLLI, the SGSN interprets that as an indication that the original subscriber moved during the Attach process and the SGSN starts communicating with the second device and drops the first device.

The SGSN can be configured to allow only one subscriber at a time to attach using a fixed random TLLI. While an Attach procedure with a fixed random TLLI is ongoing (that is, until a new P-TMSI is accepted by the MS), all other attaches sent to the SGSN with the same random TLLI using a different IMSI will be dropped by the SGSN's Linkmgr.

To limit the wait-time functionality to only the fixed random TLLI subscribers, the TLLI list can be configured to control which subscribers will be provided this functionality.

HSPA Fallback

Besides enabling configurable support for either 3GPP Release 6 (HSPA) and 3GPP Release 7 (HSPA+) to match whatever the RNCs support, this feature enables configurable control of data rates on a per RNC basis. This means that operators can allow subscribers to roam in and out of coverage areas with different QoS levels.

The SGSN can now limit data rates (via QoS) on a per-RNC basis. Some RNCs support HSPA rates (up to 16 Mbps in the downlink and 8 Mbps in the uplink) and cannot support higher data rates - such as those enabled by HSPA+ (theoretically, up to 256 Mbps both downlink and uplink). Being able to specify the QoS individually for each RNC makes it possible for operators to allow their subscribers to move in-and-out of coverage areas with different QoS levels, such as those based on 3GPP Release 6 (HSPA) and 3GPP Release 7 (HSPA+).

For example, when a PDP context established from an RNC with 21 Mbps is handed off to an RNC supporting only 16 Mbps, the end-to-end QoS will be re-negotiated to 16 Mbps. Note that an MS/UE may choose to drop the PDP context during the QoS renegotiation to a lower value.

This data rate management per RNC functionality is enabled, in the radio network controller (RNC) configuration mode, by specifying the type of 3GPP release specific compliance, either release 7 for HSPA+ rates or pre-release 7 for HSPA rates. For configuration details, refer to the *RNC Configuration Mode* section in the *Command Line Interface Reference*.

Ignore Context-ID during 4G/3G Handovers

HSS and HLR, when operating as separate network nodes, are required to use the same context-ID for a given APN-configuration of a subscriber. During inter-RAT cell reselections and handovers between 2G/3G and 4G, if the SGSN does not find a matching APN-configuration for the given context-ID learnt from the peer node, then the PDP does not get established. This could result in SRNS relocation failures when none of the PDP's learnt from the SGSN has a matching context-ID in the HLR.

New commands have been added to enable the operator to configure the SGSN to ignore the context-ID provided by the peer and to use the PDP- type and address information to search through HLR subscription and to update the context-ID information within the PDP. For details, refer to the description for the **rau-inter** command under the *Call-Control Profile Configuration Mode Commands* section of the *Command Line Interface Reference*.

Interface Selection Based on UE Capability

The SGSN selects S6d/Gr interface based on whether hss-peer-service or map service is associated with the SGSN or GPRS service. If both the services are associated, then the selection is made based on configuration of the CLI command **prefer subscription-interface** under the Call Control Profile mode. With this feature enhancement, the SGSN now allows selection of S6d/ Gr interface only if the UE is EPC capable. A new CLI option **epc-ue** is added to the command **prefer subscription-interface** under the Call Control Profile mode

for this enhancement. If this keyword is configured the S6d/Gr interface is selected only if UE is EPC capable. If this keyword is not configured the SGSN selects the S6d/Gr interface based on whether hss-peer-service or map service is associated with the SGSN or GPRS service (this is also the default behavior). The interface selection based on UE capability is done only at the time of Attach / new SGSN RAU / SRNS. Interface selected during Attach / new SGSN RAU / SRNS may change while doing inter PLMN RAU (intra SGSN) procedures.

Intra- or Inter-SGSN Serving Radio Network Subsystem (SRNS) Relocation (3G only)

Implemented according to 3GPP standard, the SGSN supports both inter- and intra-SGSN RNS relocation (SRNS) to enable handover of an MS from one RNC to another RNC.

The relocation feature is triggered by subscribers (MS/UE) moving from one RNS to another. If the originating RNS and destination RNS are connected to the same SGSN but are in different routing areas, the behavior triggers an intra-SGSN Routing Area Update (RAU). If the RNS are connected to different SGSNs, the relocation is followed by an inter-SGSN RAU. This feature is configured through the Call-Control Profile Configuration Mode which is part of the feature set.

Lawful Intercept

The Cisco Lawful Intercept feature is supported on the SGSN. Lawful Intercept is a license-enabled, standards-based feature that provides telecommunications service providers with a mechanism to assist law enforcement agencies in monitoring suspicious individuals for potential illegal activity. SGSN supports use of IP Security (a separate license-enabled, standards-based feature) for the LI interface; for additional information on IPSec, refer to the *Cisco StarOS IP Security (IPSec) Reference*. For additional information and documentation on the Lawful Intercept feature, contact your Cisco account representative.

Link Aggregation - Horizontal

The SGSN supports enhanced link aggregation (LAG) within ports on different XGLCs. Ports can be from multiple XGLCs. LAG works by exchanging control packets (Link Aggregation Control Marker Protocol) over configured physical ports with peers to reach agreement on an aggregation of links. LAG sends and receives the control packets directly on physical ports attached to different XGLCs. The link aggregation feature provides higher aggregated bandwidth, auto-negotiation, and recovery when a member port link goes down.

Local DNS

Previously, the SGSN supported GGSN selection for an APN only through operator policy, and supported a single pool of up to 16 GGSN addresses which were selected in round robin fashion.

The SGSN now supports configuration of multiple pools of GGSNs; a primary pool and a secondary. As part of DNS resolution, the operator can use operator policies to prioritize local GGSNs versus remote ones. This function is built upon existing load balancing algorithms in which weight and priority are configured per GGSN, with the primary GGSN pool used first and the secondary used if no primary GGSNs are available.

The SGSN first selects a primary pool and then GGSNs within that primary pool; employing a round robin mechanism for selection. If none of the GGSNs in a pool are available for activation, then the SGSN proceeds with activation selecting a GGSN from a secondary pool on the basis of assigned weight. A GGSN is considered

unavailable when it does not respond to GTP Requests after a configurable number of retries over a configurable time period. Path failure is detected via GTP-echo.

Local Mapping of MBR

The SGSN provides the ability to map a maximum bit rate (MBR) value (provided by the HLR) to an HSPA MBR value.

The mapped value is selected based on the matching MBR value obtained from the HLR subscription. QoS negotiation then occurs based on the converted value.

This feature is available within the operator policy framework. MBR mapping is configured via new keywords added to the **qos class** command in the APN Profile configuration mode. A maximum of four values can be mapped per QoS per APN.



Important To enable this feature the **qos prefer-as-cap**, also a command in the APN Profile configuration mode, must be set to either **both-hlr-and-local** or to **hlr subscription**.

Local QoS Capping

The operator can configure a cap or limit for the QoS bit rate.

The SGSN can now be configured to cap the QoS bit rate parameter when the subscribed QoS provided by the HLR is lower than the locally configured value.

Depending upon the keywords included in the command, the SGSN can:

- take the QoS parameter configuration from the HLR configuration.
- take the QoS parameter configuration from the local settings for use in the APN profile.
- during session establishment, apply the lower of either the HLR subscription or the locally configured values.

Refer to the *APN Profile Configuration Mode* section of the *Command Line Interface Reference* for the **qos** command.

Location Change Reporting on the S4-SGSN

3G/2G Location Change Reporting on the SGSN facilitates location-based charging on the P-GW by providing the UE's location information when the UE is in connected mode.

The Gn-SGSN supports 2G and 3G location change reporting via user location information (ULI) reporting to the GGSN. For details, see the feature section *3G-2G Location Change Reporting*.

With Release 16.0, the S4-SGSN also supports 2G and 3G location change reporting per 3GPP 29.274 release 11.b, if the P-GW requests it. With this feature enhancement configured, the S4-SGSN is ready to perform ULI reporting per PDN connection via GTPv2. Reporting only begins after the S4-SGSN receives a reporting request from the P-GW. The P-GW generates a request based on charging enforcement and policy enforcement from the policy and charging rules function PCRF. Location Change Reporting is configured and enabled/disabled per APN.

The S4-SGSN's version of Location Change Reporting has been further enhanced with a network sharing option. If the network sharing license is installed and if the network sharing feature is enabled, then the operator can configure which PLMN information the SGSN sends to the P-GW in the ULI or Serving Network IEs.



Important The S3/S4 license is required to enable S4 functionality. The new "Location-reporting in connected-mode" license is required to enable Location Change Reporting functionality for the S4-SGSN. This new license is now required for Location Change Reporting on the Gn-SGSN.

Location Services

Location Services (LCS) on the SGSN is a 3GPP standards-compliant feature that enables the SGSN to collect and use or share location (geographical position) information for connected UEs in support of a variety of location services, such as location-based charging and positioning services.

The SGSN uses the Lg interface to the gateway mobile location center (GMLC), which provides the mechanisms to support specialized mobile location services for operators, subscribers, and third party service providers. Use of this feature and the Lg interface is license controlled. This functionality is supported on the 2G and 3G SGSN.

For details about basic location services and its configuration, refer to the *Location Services* section of the *SGSN Administration Guide*.

With Release 15.0, supported functionality has expanded to include:

- Mobile terminating deferred location requests are now supported
- Mobile originating requests are now supported, both immediate and deferred
- Differences between 2G and 3G LCS call flows are eliminated



Important With this release, expanded functionality for this feature is qualified for lab and field trials only.

Lock/Shutdown the BSC from the SGSN

When the SGSN returns to Active state, after scenarios such as rebooting or reloading, all the BSCs that had been connected to the SGSN would attempt to re-establish connections. This could result in two serious problems for operators:

1. High CPU usage in the SGSN where too many BSC/RNCs were connected.
2. Network overload when other network nodes cannot match the SGSN's capacity.

The SGSN now supports a Lock/Shutdown feature that provides a two prong solution. CPU Usage Solution: Staggering the BSC auto-learning procedures when the SGSN re-loads will help to reduce the high CPU usage. This can be achieved by the operator locking the NSE/BSCs from the SGSN before reboot/reload and then unlocking them one-by-one to avoid high CPU usage.

Network Overload Solution: A new timer, SNS-GUARD, has been added to clean-up resources if the SNS procedure does not complete properly, whether or not the BSC is administratively locked. Now the SGSN starts this timer after sending SNS-SIZE-ACK and the BSC information will be removed, if the auto-learning clean-up procedure does not complete before the timer expires.

A series of new commands and keywords has been added to enable the operator to configure this new administrative Lock/Shutdown the BSC functionality as part of 'interface management' configuration. For details, refer to the *SGSN Global Interface Management* section of the *Command Line Interface Reference*.

Multiple PLMN Support

With this feature, the 2.5G and 3G SGSNs now support more than one PLMN ID per SGSN. Multiple PLMN support facilitates MS handover from one PLMN to another PLMN.

Multiple PLMN support also means an operator can 'hire out' their infrastructure to other operators who may wish to use their own PLMN IDs. As well, multiple PLMN support enables an operator to assign more than one PLMN ID to a cell-site or an operator can assign each cell-site a single PLMN ID in a multi-cell network (typically, there are no more than 3 or 4 PLMN IDs in a single network).

This feature is enabled by configuring, within a single context, multiple instances of either an IuPS service for a single 3G SGSN service or multiple GPRS services for a 2.G SGSN. Each IuPS service or GPRS service is configured with a unique PLMN ID. Each of the SGSN and/or GPRS services must use the same MAP, SGTPU and GS services so these only need to be defined one-time per context.

Network Sharing

In accordance with 3GPP TS 23.251, the 2G and 3G SGSN provides an operator the ability to share the RAN and/or the core network with other operators. Depending upon the resources to be shared, there are 2 network sharing modes of operation: the Gateway Core Network (GWCN) and the Multi-Operator Core Network (MOCN).

Benefits of Network Sharing

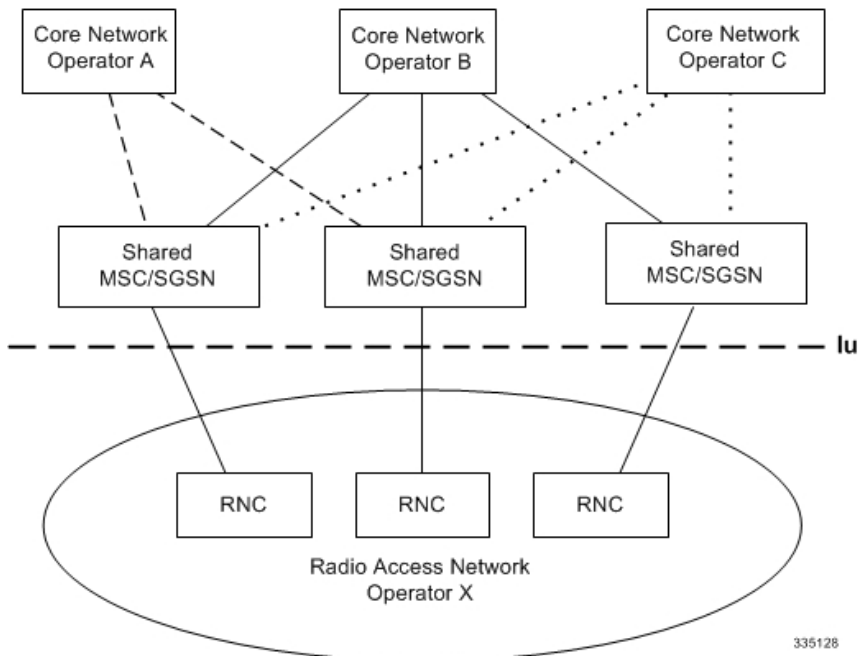
Network sharing provides operators with a range of logistical and operational benefits:

- Enables two or more network operators to share expensive common network infrastructure.
- A single operator with multiple MCC-MNC Ids can utilize a single physical access infrastructure and provide a single HPLMN view to the UEs.
- Facilitates implementation of MVNOs.

GWCN Configuration

For the 3G SGSN with a gateway core network configuration, the complete radio access network and part of the core network are shared (for example, MSC/SGSN) among different operators, while each operator maintains its own separate network nodes (for example, GGSN/HLR).

Figure 5: GWCN-type Network Sharing



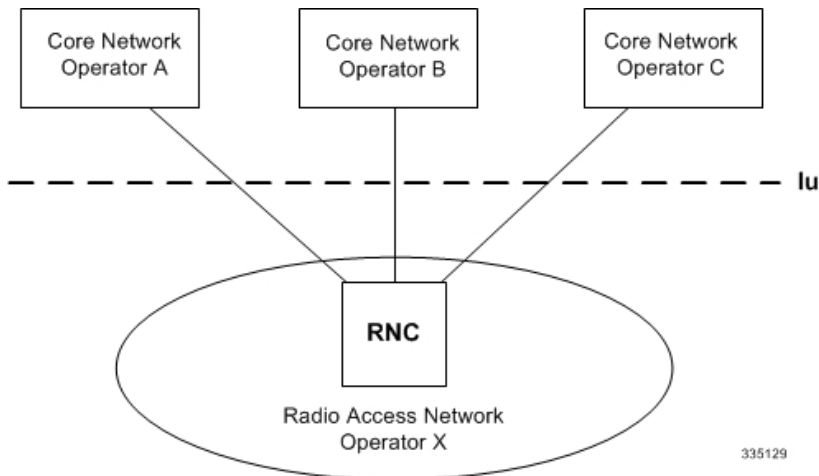
With the GWCN configuration, the SGSN supports two scenarios:

- GWCN with non-supporting UE
- GWCN with supporting UE

MOCN Configuration

In the multi-operator core network configuration, the complete radio network is shared among different operators, while each operators maintains its own separate core network. This functionality is available for both 2G and 3G SGSN.

Figure 6: MOCN-type Network Sharing



With the MOCN configuration, the SGSN supports the following scenarios:

- MOCN with non-supporting UE
- MOCN with supporting UE



Important The MOCN network sharing functionality now requires a separate feature license for both 2G and 3G scenarios. Contact your Cisco representative for licensing information.

Implementation

To facilitate network sharing, the SGSN implements the following key features:

- Multiple virtual SGSN services in a single physical node.
- Sharing operators can implement independent policies, such as roaming agreements.
- Equivalent PLMN configuration.
- RNC identity configuration allows RNC-ID + MCC-MNC instead of just RNC-ID.

Configuration for network sharing is accomplished by defining:

- NRI in the SGSN service configuration mode
- PLMN IDs and RNC IDs in the IuPS configuration mode
- Equivalent PLMN IDs and configured in the Call-Control Profile configuration mode.
- IMSI ranges are defined in the SGSN-Global configuration mode
- The Call-Control Profile and IMSI ranges are associated in the configuration mode.

For commands and information, refer to the *2G SGSN Multi-Operator Core Network* section in the *Serving GPRS Support Node Administration Guide* and the command details in the *Command Line Interface Reference*.

NRI-FQDN based DNS resolution for non-local RAIs (2G subscribers)

The SGSN now supports use of NRI-RAI based address resolution which includes both local lookup as well as DNS Query for non-local RAIs when selection of the call control profile is based on the old-RAI and the PLMN Id of the BSC where the subscriber originally attached. This feature was formerly supported only for 3G subscribers and is now extended to 2G subscribers. The command enables the SGSN to perform address resolution for peer SGSN with an NRI when an unknown PTMSI (Attach or RAU) comes from an SGSN outside the pool. The SGSN uses NRI-RAI based address resolution for the non-local RAIs for 2G subscribers in place of RAI based address resolution.

This functionality is applicable in situations for either inter- or intra-PLMN when the SGSN has not chosen a local NRI value (configured with SGSN Service commands) other than **local-pool-rai** or **nb-rai**. This means the RAI (outside pool but intra-PLMN) NRI length configured here will be applicable even for intra-PLMN with differently configured NRI lengths (different from the local pool). This functionality is not applicable to call control profiles with an associated MSIN range as ccprofile selection is not IMSI-based.

NRI Handling Enhancement

The SGSN's DNS lookup for SGSN pooling is supported in the call control profile. Previously, the SGSN's complete Gn DNS database had to be configured in the call control profile. If there was more than one SGSN in the local pool, then there would be multiple instances for every SGSN in the pool.

By using just the NRI value, this enhancement facilitates lookup for a peer SGSN in the local pool.

NRPCA - 3G

The SGSN supports the Network Requested Primary PDP Context Activation (NRPCA) procedure for 3G attachments.

There are no interface changes to support this feature. Support is configured with existing CLI commands (network-initiated-pdp-activation, location-area-list) in the call control profile configuration mode and timers (T3385-timeout and max-actv-retransmission) are set in the SGSN service configuration mode. For command details, see the *Command Line Interface Reference*

NRSPCA Support for S4-SGSN

The SGSN supports Secondary PDP context activation by the network. 3GPP TS 23.060 specifies two procedures for GGSN-initiated PDP Context Activation:

- Network Requested PDP Context Activation (NRPCA) - the SGSN already supports this but only for 3G access, and
- Network Requested Secondary PDP Context Activation (NRSPCA) Procedure.

NRSPCA allows the network to initiate Secondary PDP context activation if the network determines that the service requested by the user requires activation of an additional secondary PDP context. Network requested bearer control makes use of the NRSPCA procedure.

Network requested bearer control functionality is mandatory in EPC networks, requiring use of NRSPCA. The P-GW supports only the NRSPCA procedure. With this release, now the S4-SGSN supports network requested bearer control.

For a complete description of this feature and its configuration requirements, refer to the *Network Requested Secondary PDP Context Activation* chapter in the *Serving GPRS Support Node Administration Guide*

Operator Policy

This non-standard feature is unique to the StarOS. This feature empowers the carrier with unusual and flexible control to manage functions that are not typically used in all applications and to determine the granularity of the implementation of any: to groups of incoming calls or to simply one single incoming call. For details about the feature, its components, and how to configure it, refer to the *Operator Policy* section in this guide.



Important All configurations for SGSNs must be converted to enable them to operate with an SGSN. Your Cisco Representative can accomplish this conversion for you.

Some Features Managed by Operator Policies

The following is a list of some of the features and functions that can be controlled via configuration of Operator Policies:

- APN Aliasing
- Authentication
- Direct Tunnel - for feature description and configuration details, refer to the *Direct Tunnel* section in this guide
- Equivalent PLMN

- IMEI Override
- Intra- or Inter-SGSN Serving Radio Network Subsystem (SRNS) Relocation (3G only)
- Network Sharing
- QoS Traffic Policing per Subscriber
- SGSN Pooling - Gb/Iu Flex
- SuperCharger
- Subscriber Overcharging Protection - for feature description and configuration details for Gn-SGSN, refer to the *Subscriber Overcharging Protection* section in this guide.

Overcharging Protection

Overcharging Protection enables the Gn-SGSN to avoid overcharging the subscriber if/when a loss of radio coverage (LORC) occurs in a UMTS network. For details and configuration information, refer to the *Subscriber Overcharging Protection* section in this book.

QoS Traffic Policing per Subscriber

Traffic policing enables the operator to configure and enforce bandwidth limitations on individual PDP contexts for a particular traffic class.

Traffic policing typically deals with eliminating bursts of traffic and managing traffic flows in order to comply with a traffic contract.

The SGSN conforms to the DiffServ model for QoS by handling the 3GPP defined classes of traffic, QoS negotiation, DSCP marking, traffic policing, and support for HSDPA/HSUPA.

QoS Classes

The 3GPP QoS classes supported by the SGSN are:

- Conversational
- Streaming
- Interactive
- Background

The SGSN is capable of translating between R99 and R97/98 QoS attributes.

QoS Negotiation

On PDP context activation, the SGSN calculates the QoS allowed, based upon:

- **Subscribed QoS** - This is a per-APN configuration, obtained from the HLR on an Attach. It specifies the highest QoS allowed to the subscriber for that APN.
- **Configured QoS** - The SGSN can be configured with default and highest QoS profiles in the configuration.
- **MS requested QoS** - The QoS requested by the UE on pdp-context activation.

DSCP Marking

The SGSN performs diffserv code point (DSCP) marking of the GTP-U packets according to allowed-QoS to PHB mapping. The default mapping matches that of the UMTS to IP QoS mapping defined in 3GPP TS 29.208.

The SGSN also supports DSCP marking of the GTP control plane messages on the Gn/Gp interface. This allows QoS to be set on GTP-C messages, and is useful if Gn/Gp is on a less than ideal link. DSCP marking is configurable via the CLI, with default = Best Effort Forwarding.

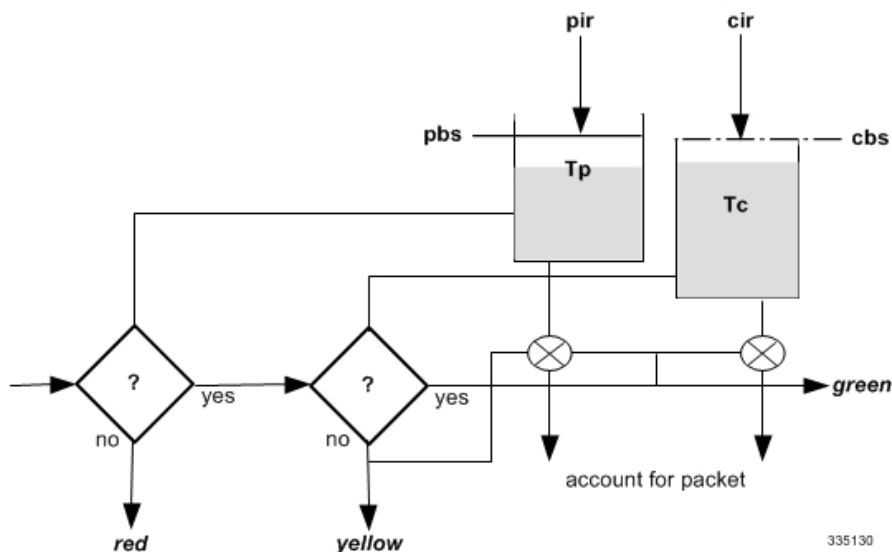
Traffic Policing

The SGSN can police uplink and downlink traffic according to predefined QoS negotiated limits fixed on the basis of individual contexts - either primary or secondary. The SGSN employs the Two Rate Three Color Marker (RFC2698) algorithm for traffic policing. The algorithm meters an IP packet stream and marks its packets either green, yellow, or red depending upon the following variables:

- **PIR** - Peak Information Rate (measured in bytes/second)
- **CIR** - Committed Information Rate (measured in bytes/second)
- **PBS** - Peak Burst Size (measured in bytes)
- **CBS** - Committed Burst Size (measured in bytes)

The following figure depicts the working of the TCM algorithm:

Figure 7: TCM Algorithm Logic for Traffic Policing



For commands and more information on traffic policing configuration, refer to the *Command Line Interface Reference*.

VPC-DI platform support for SGSN

The traditional proprietary Cisco ASR 5500 hardware platform provides carrier class hardware redundancy and have limited scalability. The VPC-SI model separates the StarOS from the proprietary hardware. It consists of the StarOS software running within a single VM. This provides the end user with low entry cost (software licenses and commodity hardware), simplified setup, and well-defined interfaces. The VPC-SI is ideally suited for small carriers, remote locations, lab testing, trials, demos, and other models where full functionality is needed. The Cisco VPC-Distributed Instance (VPC-DI) platform allows multiple VMs to act as a single StarOS instance with shared interfaces, shared service addresses, load balancing, redundancy, and a single point of management. The VPC-DI offers enhanced hardware capabilities and the SGSN is enhanced to support the VPC-DI platform.



Important For more information on the VPC-DI platform, see the *VPC-DI System Administration Guide*.

Reordering of SNDCP N-PDU Segments

The SGSN fully supports reordering of out-of-order segments coming from the same SNDCP N-PDU. The SGSN waits the configured amount of time for all segments of the N-PDU to arrive. If all the segments are not received before the timer expires, then all queued segments are dropped.

RAN Information Management (RIM)

RAN information is transferred from a source RAN node to a destination RAN node in a RIM container. This is a mechanism for the exchange of information between applications belonging to RAN nodes, for example two BSCs. The RIM container is transparent to the SGSN.

Support for RIM procedures is optional for both the SGSN and other RAN nodes (e.g., RNC). When the SGSN supports RIM procedures, the SGSN provides addressing, routing and relay functions. All RIM messages are routed independently by the SGSN. The SGSN performs relaying of RIM messages between BSSGP, RANAP, and GTP in accordance with 3GPP TS 48.018, TS25.413, and TS29.060 respectively.

On the Gb (BSSGP) interface, RIM procedures are negotiated at the start/restart of a Gb link as part of the signaling BVC reset procedure. On the Iu (RANAP) interface, there is no negotiation for using RIM procedures. Support for RIM procedures enhances the subscriber's user experience by minimizing the service outage during cell re-selection.

S4 Support on the SGSN

The SGSN can provide an interface between UMTS (3G) and/or GPRS (2.5G) networks and the evolved packet core (EPC) network. This functionality requires a special S4 feature license. Throughout the documentation the SGSN with this additional functionality is referred to as an S4-SGSN.

To facilitate communication with GPRS, UMTS, and EPC networks, the SGSN is configured with standard 2.5G SGSN, 3G SGSN or dual access SGSN services, and then configured with additional enhancements to enable communication with the EPC network.

The S4-SGSN communicates with other UMTS and GPRS core networks elements via the GTPv1 protocol, and communicates with EPC network elements and peer S4-SGSNs via the GTPv2 protocol. The S4-SGSN communicates with the UMTS (3G) / GPRS (2.5G) radio access network elements in the same manner as an SGSN.

Depending on the configured SGSN service type, the S4-SGSN can interface with some or all of the following UMTS/GPRS and EPC network elements:

- Serving Gateway (S-GW)
- Mobility Management Entity (MME)
- Peer S4-SGSN (2.5G or 3G with S4 support)
- Peer dual access S4-SGSN
- Peer SGSN (2.5G or 3G)
- Peer dual access SGSN
- GGSN

S3 and S4 Interface Support

S3 and S4 interface support is a license-enabled feature that enables 2G and 3G networks to interface with the 4G evolved packet core (EPC) network. The S3/S4 functionality ensures session continuity on handovers between 2G/3G subscribers and 4G LTE subscribers. S3/S4 functionality simplifies core network operations the following ways:

- Replaces the GGSN in the network with the P-GW
- Replaces the need for an HLR by providing connectivity to the HSS
- Optimized idle mode signaling during 3G/2G to 4G handovers (when the ISR feature is enabled)

The S3 and S4 interfaces provide control and bearer separation, and offload the backward compatibility requirement from the mobility management entity (MME) and serving gateway (S-GW) EPC elements to the UMTS core.

- **S3 Interface:** Provides a GTPv2-C signaling path connection between the MME and the SGSN (MPC). The S4-SGSN to MME RAU/TAU context handovers are supported via the S3 interface.
- **S4 Interface:** Provides a data and signaling interface between the S-GW and the S4-SGSN (MPC) for bearer plane transport (GTPv2-U). The S4-SGSN communicates with the P-GW via the S-GW.

With support for S3/S4 interface, soft-handoffs between 2G/3G and the EPC networks are possible for multi-mode UEs. Without this functionality, the Gn/Gp SGSN can still inter-work with the EPC core using GTPv1, but soft-handoffs cannot be achieved. Note that GTPv2 to GTPv1 conversions (for QoS and Context IDs) are lossy data conversions, so a subscriber doesn't encounter a similar type of network behavior while in 2G/3G and 4G networks.

S4-SGSN Support for "Higher Bit Rates than 16 Mbps"Flag

As per 3GPP R9 specifications, the SGSN can now be aware if the UE is capable of supporting extended R7 bit rates. The "higher bit rates than 16 Mbps" flag is used for this purpose. This flag is sent by the RNC in the Initial UE message or Re-location Complete message or by Peer S4-SGSN / MME in Forward Relocation Request / Context Response message. The SGSN also supports sending "higher Bit Rates than 16 Mbps flag" as part of MM Context in Context response/Forward Relocation request/Identification request during Old ISRAU/SRNS handover procedures. The SGSN stores the UE capability in the MM-context. During PDP context activation, the per bearer bit rate or APN-AMBR is capped based on the flag's value. If the RNC is not 3GPP R9 compliant, the SGSN does not receive this flag. A new CLI keyword **sm ue-3gpp-compliance-unknown restrict-16mbps** is introduced under the `sgsn-service` to support this functionality. When the CLI is configured, the SGSN caps the APN-AMBR for non-GBR bearers to "16" Mbps and rejects activation of GBR bearers with GBR higher than "16" Mbps. If not, APN-AMBR and GBR higher than "16" Mbps are allowed.

Consider the scenarios where UE 3GPP compliance is not known and the CLI is configured to restrict bitrate to 16 Mbps or it is known that UE is not capable of supporting bitrates higher than 16Mbps; the Session Manager uses the flag to perform the following actions:

1. The APN-AMBR is restricted to "16" Mbps during PDP activation of non-GBR bearers, particularly the default bearer.
2. If the PGW upgrades the APN-AMBR in Create Session Response during non-GBR bearer activation, then the APN-AMBR is retained as "16" Mbps and same is indicated to the UE in an Activate Accept.
3. If the PGW upgrades APN-AMBR in Update Bearer Request for non-GBR bearer, then the APN-AMBR is restricted to "16" Mbps and only if the APN-AMBR changes, the PGW init bearer modification procedure is continued. In case APN-AMBR does not change, then Update Bearer Response is sent immediately.
4. For GBR bearers, Update Bearer Request with GBR/MBR higher than "16" Mbps is rejected with "No resources available".

5. Activation of GBR bearers with MBR/GBR higher than "16" Mbps in Create Bearer Request is rejected with cause "No resources available".
6. After S3 SRNS, Modify Bearer Command is initiated to modify the APN-AMBR to "16" Mbps for Non-GBR bearers having bitrates higher than 16 Mbps.
7. After S3 SRNS, GBR bearers having bitrates higher than "16" Mbps are de-activated.

For more information on the CLI command see, *Command Line Interface Reference*.

S6d and Gr Interface Support

The S4-SGSN supports the Diameter based S6d interface to the HSS, in addition to the legacy Gr interface to the HLR (used by an SGSN configured to use the Gn/Gp interfaces). This is a license-enabled feature.

The S6d / Gr interface enhancements allow operators to consolidate the HLR/HSS functions into a single node, which improves operational efficiency and other overhead. With the deployment of the EPC core, many operators may consolidate the HLR/HSS functions into a single node. Until then, the S4-SGSN still supports the MAP-based Gr and the Diameter based S6d interfaces.

The SGSN selects the Gr interface / S6d interface based on the MAP or HSS service associated with the configured SGSN and/or GPRS services. If both the services are associated, then SGSN will use the following order of selection:

1. Select the appropriate interface based on any operator policy preference for S6d / Gr.
2. If no operator policy is present, then by use the Gr interface by default.

The S4-SGSN sets the following initiate UGL messages on a change of HSS service:

- Initial attach indicator bit in Update GPRS Location message, ISR information IE, if the UGL is sent for an initial attach or for a inbound routing area update without ISR activation and the selected interface is Gr.
- Initial attach indicator bit in Update Location Request message, ULR flags, if the ULR is sent for an initial attach or for a inbound routing area update without ISR activation and the selected interface is S6d.

Configurable Pacing of PDP Deactivations on the S4-SGSN

The S4-SGSN now supports configurable pacing of PDP de-activations towards UEs due to path failures. Previously in the S4-SGSN, the pacing of path failure delivery was started by the EGTP application and it used the generic session manager pacing mechanism. The generic pacing mechanism performed 1000 path failure initiated PDP de-activations per second per session manager. Since this may not be desirable for many operators based on their RAN's capability, the S4-SGSN now supports the configurable pacing of PDP deactivations via the SGSN application (the same mechanism used in the Gn/Gp SGSN).

The existing **pdp-activation-rate command** in *SGSN Global Configuration Mode* can be used to configure the pacing of PDP de-activations for both the connected-ready state and the idle-standby state.

This feature is included with the SGSN S3/S4 license. No additional feature license is required.

DNS SNAPTR Support

By default, the S4-SGSN supports the initiation of a DNS query after APN selection using a S-NAPTR query. The SGSN resolves a P-GW by sending an APN-FQDN query to the DNS client. Similarly, the SGSN resolves the S-GW by sending a RAI-FQDN query to the DNS client. The DNS Client then sends a query to the DNS server to retrieve NAPTR/SRV/A records and return the S-GW or P-GW IP address to the SGSN.

On the S4-SGSN, an additional configurable is available that identifies the context where DNS lookup for EPC-capable UEs must occur. This is accomplished by creating a call control profile that directs the system's DNS client to perform the lookup in the context where the SGSN's DNS client is configured.

If the CLI configurable is not used, or removed, the S4-SGSN chooses the DNS client from the context where the EGTP service is configured for performing P-GW DNS resolution, if the EGTP service is associated for a EPC capable UE.

If the EGTP service is not present and the UE is EPC-capable, and if **apn-resolve-dns-query snaptr** is configured in an APN profile, then the S4-SGSN uses the DNS client in the context where the SGTP service is present for resolving a co-located P-GW/GGSN and selects the Gn interface.

S4-SGSN Statistics Support

Statistics have been added to provide information on S4-SGSN functionality.

The statistics added track information related to:

- SGW Relocations
- ISR Deactivations
- Number of active PDPs using the S4 interface in 3G
- S3 Interface Selection Statistics
- Procedure Abort Statistics
- GTPU Statistics
- IDFT Statistics

In addition, support for EGTPC schema bulk statistics is implemented to provide information on communication between the S4-SGSN and the EPC S-GW over the S4 interface.

S13' Interface Support

In addition to the MAP-based Gf interface, the S4-SGSN supports the Diameter-based S13' (S13 prime) interface towards the equipment identify registry. The S13' interface support enables operators to consolidate the EIR functions into a single node, which increases operational efficiency. S13' interface support is a license-enabled feature.

The S13' interface enables the S4-SGSN to perform the ME Identity Check procedure to validate the IMEI with the EIR. The S4-SGSN selects Gf or S13' interface based on which interface is configured and the type of service (MAP or HSS) is associated with the SGSN and/or the GPRS service. If both services are associated, then the S4-SGSN will select the appropriate interface based on the following sequence:

1. An operator policy preference is configured for Gf or S13'
2. If no operator policy preference is set, then by default the S4-SGSN uses the Gf interface

By default, the IMSI is sent to the EIR as part of the IMEI Check procedure over the S13' interface.

Idle Mode Signaling Reduction

The Idle mode signaling reduction (ISR) feature on the S4-SGSN provides a mechanism to optimize and/or reduce signaling load during inter-RAT cell-reselection in idle mode (that is, in the ECM-IDLE, PMM-IDLE, and GPRS-STANDBY states). It is a mechanism that allows the UE to remain simultaneously registered in a UTRAN/GERAN Routing Area (RA) and an E-UTRAN Tracking Area (TA) list. This allows the UE to make cell reselections between E-UTRAN and UTRAN/GERAN without having to send any TAU or RAU requests, as long as the UE remains within the registered RA and TA list.

ISR is a feature that reduces the mobility signalling and improves the battery life of UEs. Also reduces the unnecessary signalling with the core network nodes and air interface. This is important especially in initial deployments when E-UTRAN coverage will be limited and inter-RAT changes will be frequent.

The benefit of the ISR functionality comes at the cost of more complex paging procedures for UEs, which must be paged on both the registered RA and all registered TAs. The HSS also must maintain two PS registrations (one from the MME and another from the SGSN).

ISR support for 3G subscribers was introduced for 2G subscribers.

ISR is not supported on the Gn/Gp SGSN.

For a detailed description of this feature, refer to the *Idle Mode Signaling Reduction on the S4-SGSN* chapter in this guide.



Important ISR is a license enabled feature. Contact your Cisco representative for details on licensing information.

ISR with Circuit Switched Fallback

Circuit-Switched Fallback (CSFB) is an alternative solution to using IMS and SRVCC to provide voice services to users of LTE. The IMS is not part of the solution, and voice calls are never served over LTE. Instead, the CSFB relies on a temporary inter-system that switches between LTE and a system where circuit-switched voice calls can be served.

The LTE terminals 'register' in the circuit switched domain when powered and attaching to LTE. This is handled through an interaction between the MME and the MSC-Server in the circuit-switched network domain over the SGs interface.

Consider the following scenarios:

- Voice calls initiated by the mobile user: If the user makes a voice call, the terminal switches from a LTE system to a system with circuit-switched voice support. Depending on where the UE latches on after completion of the voice call:
 - The packet-based services that are active on the end-user device at this time are handed over and continue to run in a system with circuit-switched voice support but with lower data speeds.

OR

- The packet-based services that are active on the end-user device at this time are suspended until the voice call is terminated and the terminal switches back to LTE again and the packet services are resumed.
- Voice calls received by the mobile user: If there is an incoming voice call to an end-user that is currently attached to the LTE system, the MSC-Server requests a paging in the LTE system for the specific user. This is done through the SGs interface between the MSC Server and the MME. The terminal receives the page, and temporarily switches from the LTE system to the system with circuit-switched voice support, where the voice call is received. Once the voice call is terminated, the terminal switches back to the LTE system.

For a detailed feature description of this feature refer to the chapter "ISR with Circuit Switched Fallback" in this document.

ISD / DSD Message Handling and HSS Initiated Bearer Modification

The Home Subscriber Server (HSS) / Home Location Register (HLR) maintains the subscriber database. Insert Subscriber Data (ISD) and Delete Subscriber Data (DSD) messages are generated by the HSS/HLR. These messages are used to communicate the subscribers current subscription data to the S4-SGSN. The subscription data for a subscriber can include one of the following:

- GPRS subscription data.
- EPS subscription data.
- Both GPRS and EPS subscription data.

The PDP is either modified or deleted based on the subscription data received by the S4-SGSN.

The S4-SGSN deletes the PDP context if any form of barring is detected or if the APN-name or PDP-type of the PDP address is changed. The S4-SGSN modifies the PDP if QoS is changed or APN-AMBR is changed (in case of EPS subscription).

If a PDP modification is required based on the subscription data received but the associated UE is disconnected or in an inactive state, such PDP contexts are deleted by the S4-SGSN.



Important The S4-SGSN does not delete the PDP contexts if Idle Mode Signalling Reduction (ISR) is activated or PDP is preserved. In such cases the S4-SGSN initiates a PDP modify only after UE activity is detected.

If the UE is connected or in a ready state, the S4-SGSN sends an updated bearer command (with subscribed QoS) to the S-SGW or P-GW and the P-GW initiates a PDP modify procedure.

HSS initiated bearer modification

The Modify bearer command is a notification sent to the S-GW/P-GW which notifies a change in the subscribed QoS. The message is sent to S-GW/P-GW if the UE is in ready or connected state. Modify Bearer command is not sent when the PDP is in preserved state and when ISR is active, in such cases the S4-SGSN initiated modify request using Modify Bearer Request updates the QoS to the S-GW/P-GW after the PDP is active or UE activity is detected on S4-SGSN respectively.

UMTS-GSM AKA Support on the S4-SGSN

The S4-SGSN provides support for the following UMTS/GSM Authentication and Key Agreement (AKA) procedures:

- SRNS relocation
- Attach
- PTMSI attach (foreign/local)
- Service Request
- Inter SGSN RAU
- Timers Handling
- Re-use of Vectors
- Using the Peer SGSN/MME vectors (ISRAU/PTMSI attach) in the same or different PLMN

3G and 2G SGSN Routing Area Update

The S4-SGSN supports outbound Routing Area Update (RAU) procedures for a subscriber already attached on that SGSN (that have PDP contexts anchored through S4 interface) and inbound RAU procedures for an

EPC capable UE. The RAU procedures are required to enable mobility across the UMTS and EPC core network coverage areas using the S3 interface for context transfers.

The S4-SGSN determines if the old peer node is an MME or SGSN based on the most significant bit of the LAC. If the most significant bit of the LAC is set then the old peer node is an MME (and the RAI is mapped from GUTI). If the bit is not set then the old RAI represents an SGSN.

However, some operators have already used LAC values greater than 32768 (most significant bit set) for their existing UMTS / GPRS networks. For such operators identification of a peer node through MSB bit of LAC will not work. In these cases, operators can use the [Configurable GUTI to RAI Conversion Mapping, on page 49](#) feature.

The following RAU procedures are supported for both 2G and 3G services:

- 2G and 3G Intra-SGSN RAU with and without S-GW relocation
- 2G and 3G Inter-SGSN/SGSN-MME RAU with and without S-GW relocation across S16 and S3 interfaces
- Intra-SGSN Inter-RAT RAU with and without S-GW relocation

2G and 3G Intra RAU with and without S-GW Relocation

The S4-SGSN supports the intra-SGSN routing area update (ISRAU), which can occur in the following scenarios:

- The MS changes its routing area
- The periodic RAU timer expires for the MS
- The MS changes its network capability

The S4-SGSN also supports intra SGSN, inter PLMN RAU requests. However, if the new PLMN's operator policy is configured to use the Gn interface, the PDP contexts are not transferred from the S4 interface to the Gn interface.



Important The S4-SGSN currently does not support the association of a different EGTP service for each PLMN.

2G and 3G Inter-SGSN and Inter SGSN-MME RAU with and without S-GW Relocation Across S16 and S3 Interfaces

The S4-SGSN supports both Inter-SGSN RAU and SGSN-MME RAU, which will be triggered when a UE sends Routing Area Update (RAU) request to a new SGSN in the following scenarios:

- The serving RAI changes from one SGSN coverage area to another SGSN coverage area
- During a handover from a E-UTRAN coverage area to a UMTS coverage area

Intra-SGSN Inter-RAT RAU with and without S-GW Relocation

The S4-SGSN supports intra-SGSN 3G to 2G routing area updates (RAU) and supports the handover of MM and PDP contexts from the SGSN service to the GPRS service. Similarly, it supports intra-SGSN 2G to 3G RAUs and supports the handover of MM and PDP contexts from the GPRS service to the SGSN service.



Important Currently, the S4-SGSN expects that both the SGSN and GPRS services will be associated with the same EGTP service for successful intra-SGSN inter-RAT handovers.

IPv4 and IPv6 PDP Type Override

The S4-SGSN supports the override of the IPv4/IPv6 PDP type by either IPv4 or IPv6 when the dual PDP feature is enabled. This is controlled via a call control profile, and is configured independently for 2G GPRS and 3G UMTS access.

Statistics are maintained to track successes and failures for IPv4 and IPv6 PDP activations with override.

NAPTR-based Dynamic HSS Discovery

The dynamic peer discovery is supported. The HSS address is resolved using NAPTR based DNS request-response method. The following commands have to be enabled for dynamic peer discovery:

- In the Context Configuration Mode, the command **diameter endpoint** *< endpoint_name >* has to be enabled.
- In the Diameter Endpoint Configuration Mode, the command **dynamic-peer-discovery** [**protocol** { **sctp** | **tcp** }] has to be enabled.
- In the Diameter Endpoint Configuration Mode, the command **dynamic-peer-realm** *< realm_name >* has to be enabled.
- In the Diameter Endpoint Configuration Mode, the command **dynamic-peer-failure-retry-count** *< no_of_retries >* has to be enabled.

The "realm name" is used for dynamic peer discovery. The "dynamic-peer-failure-retry-count" is used to configure the number of re-tries in peer discovery.

P-GW Initiated PDP Bearer Deactivation

The S4-SGSN supports the P-GW initiated PDP deactivation procedure in addition to the legacy MS initiated deactivation procedure.

The S4-SGSN processes Delete Bearer Requests received from the S-GW (sent by the P-GW) and deactivates the requested bearers (PDP contexts) by sending a Deactivate PDP Context Request to the UE and then deactivates the PDP context. If the S4-SGSN receives a Delete Bearer Request from the S-GW and the subscriber is in the PMM-IDLE / GPRS-STANDBY state, it pages the UE before deactivating the PDP context request.

In the case of 3G, the S4-SGSN will initiate RAB release procedures for the deactivated bearers. For 2G there is no RAB release procedure.

S-GW and P-GW Tunnel and EPS Subscription Recovery

The S4-SGSN supports session recovery procedures and recovers the S4 tunnel created for each subscriber assigned PDP contexts through S4 interface. This functionality is part of session recovery procedures and allows sessions to be reconstructed when the system recovers from a card-level software fault.

The SGSN side TEID and the S-GW side TEID for the S4 tunnel are check-pointed and recovered during session recovery. The S4-SGSN also recovers every PDN connection and their corresponding P-GW-side TEID.

The S4-SGSN session recovery procedures have been enhanced to support recovery of EPS subscription data received from the HLR / HSS. The EPS subscription information may contain a maximum of 50 APN profiles and each APN profile contains an APN name string and a PDN GW FQDN string, which is check-pointed and recovered as part of the enhanced session recovery procedures.

Local Configuration of S-GW and S4-SGSN per RAI

The SGSN already supports selection of the S-GW using DNS SNAPTR queries for the RAI FQDN. The S4-SGSN now provides the option to configure a local S-GW address for a RAI (LAC, RAC MCC and MNC). This functionality enhances the S-GW selection logic to allow the call to continue even if DNS lookup fails for any reason.

The S4-SGSN will select this local S-GW address based on the configured local policy. The local policy also can be configured to allow the selection of the locally configured S-GW address when the DNS lookup fails.

Local selection of the S-GW address applies in the following scenarios:

- First PDP context activation for a subscriber
- Intra SGSN routing area update
- New SGSN routing area update
- Intra SGSN inter RAT handover

Configurable GUTI to RAI Conversion Mapping

The S4-SGSN allows operators to configure mapping to an EPC MME for networks that already use LAC ranges between 32768 and 65535.

LAC ranges between 32768 to 65535 are currently being used in some UMTS/GPRS deployments although 3GPP TS 23.003 indicates that a UMTS / GPRS network should not use LACs in that range. This range is reserved for the MME group code.

In an LTE network, the MME group code is mapped to the LAC and therefore the LAC and MME group code should be separate. The S4-SGSN provides a customized solution for this problem by identifying the valid MME group codes, which it uses to identify whether the received LAC is a native LAC or a LAC mapped from GUTI (i.e., an MME group code part of GUTI).

S4-SGSN Support for Fallback to V1 Cause Code in GTPv2 Context Response

As per revised 3GPP TS 29.274 v8.6.0, the Context Response message received from a peer SGSN can have a cause code "Fallback to GTP-V1", if the peer SGSN had provided a Gn interface for a subscriber due to local policy. When a new SGSN receives a Context Response with cause code as "Fallback to GTP-v1" it performs a GTP-v1 SGSN Context Request, Context Response and Context Ack with the peer SGSN to obtain the subscribers MM and PDP contexts.

S4-SGSN Support for Mobility Management Procedures

To support the S6d/Gr interface, the S4-SGSN supports the following mobility management procedures over the those (HSS/HLR) interfaces:

- Attach
- Service request
- Detach
- Iu-Release procedures
- Operator policy override for the Gn/S4 interface for EPC subscribers
- Zone code
- ARD
- ADD
- Operator policy-based Mobility Management context handling

QoS Mapping Support

The S4-SGSN supports the configuration of QoS parameters to ensure proper QoS parameter mapping between the S4-SGSN and EPC S-GWs, P-GWs, and UEs.

The S4-SGSN communicates QoS parameters towards the S-GW and P-GW in EPC QoS. However, it sends QoS towards the UE in the QoS format defined in the GMM/SM specification (TS 24.008). 3GPP defines a mapping for EPS QoS to pre-release 8 QoS in TS 23.401, Annex E. On the S4-SGSN, operators can configure the quality of service (QoS) parameters as call-control-profiles that will ensure proper QoS mapping between the S4-SGSN and the EPC gateways (P-GW and S-GW) and UEs.

The configured call-control-profiles will be used if the S4 interface is chosen for PDP activation, but the subscription does not have an EPS subscription. Therefore, GPRS subscription data (which uses QoS in pre-release 8 format), will be mapped to EPS QoS behavior. The Allocation and Retention policy will be mapped to EPS ARP using the configured call control profiles.

If the QoS mapping configuration is not used, the following default mappings are used:

- Default ARP high-priority value = 5
- Default ARP medium-priority value = 10
- Default pre-emption capability = shall-not-trigger-pre-emption
- Default pre-emption vulnerability = not pre-emptable

MS Initiated Primary and Secondary Activation

The S4-SGSN supports default and dedicated bearer activation for:

- Default and dedicated activation - secondary PDP procedure trigger from MS).
- Lawful Intercept for activation rejects and failures
- Dual stack PDP handling
- APN-selection as per annex A.2/Spec 23.060 rel-9

Deactivation Procedure Support

The S4-SGSN supports the following deactivation procedures:

- 3G / 2G MS initiated bundle deactivation
- 3G / 2G MS initiated dedicated bearer deactivation
- 3G / 2G P-GW initiated dedicated bearer deactivation
- 3G / 2G P-GW initiated PDN deactivation

MS, PGW and HSS Initiated PDP Modification Procedure Support

The S4-SGSN supports the following packet data protocol (PDP) modification procedures:

- 2G and 3G MS initiated PDP modification procedures
- 2G and 3G P-GW Initiated PDP modification procedures
- 2G and 3G HSS initiated PDP modification procedures

The PDP context modification procedures are invoked by the network or by the MS to modify the parameters that were negotiated under the following conditions:

- During the PDP context activation procedure
- During the secondary PDP context activation procedure
- At a previously performed PDP context modification procedure

Depending on the selected Bearer Control Mode, the MS or the network may also create and delete a traffic flow template (TFT) in an active PDP context. The procedure can be initiated by the network or the MS at any time when a PDP context is active. Only the network may modify or delete a TFT packet filter that the network has created. Conversely, only the MS may modify or delete a TFT packet filter that the MS has created.

MS-Initiated PDP Context Modification

The Mobile Station (MS) initiated PDP context modification procedure MS allows for a change in negotiated QoS, the radio priority level, or the TFT negotiated during the PDP context activation procedure.

E-UTRAN capable MSs will not modify the QoS of the first PDP context that was established within the PDN connection.

The MS initiates the Modification procedure by sending a MODIFY PDP CONTEXT REQUEST message to the SGSN. The SGSN validates the received message and sends out a BEARER RESOURCE COMMAND message to the S-GW with a valid PTI value which is then sent to the PGW. On accepting the modification, the P-GW sends out an Update Bearer Request with the PTI copied from the received BEARER RESOURCE COMMAND message. Upon successful completion of the modification, the SGSN replies with the MODIFY PDP CONTEXT ACCEPT message.

P-GW-Initiated PDP Context Modification

The Packet Data Node Gateway (P-GW) initiated PDP context modification procedure is used in cases when:

- One or several of the EPS Bearer QoS parameters are to be modified
- To add/modify/delete the TFT related to the PDP Context or BCM-Mode change
- To modify the APN-AMBR

The P-GW can request the modification procedure by sending an UPDATE BEARER REQUEST message without a PTI field to the S-GW, and the S-GW will forward the request to SGSN. The SGSN validates the request and initiates a MODIFY PDP CONTEXT REQUEST message to the MS. On successful completion of the procedure, the SGSN will send an UPDATE BEARER RESPONSE with an appropriate cause value.

HSS Initiated PDP Context Modification

The Home Subscriber Server (HSS) initiated PDP context modification procedure is used when the HSS decides to modify the subscribed QoS, where typically QoS related parameters are changed. The parameters that may be modified are UE-AMBR, APN-AMBR QCI and Allocation/Retention Policy.

The HSS initiates the modification by sending an Insert Subscriber Data (IMSI, Subscription Data) message to the SGSN. The Subscription Data includes EPS subscribed QoS (QCI, ARP) and the subscribed UE-AMBR and APN AMBR.

The S4-SGSN then updates the stored Subscription Data and acknowledges the Insert Subscriber Data message by returning an Insert Subscriber Data Ack (IMSI) message to the HSS and sends the Modify Bearer Command (EPS Bearer Identity, EPS Bearer QoS, APN AMBR) message to the S-GW. The S-GW forwards the Modify Bearer Command (EPS Bearer Identity, EPS Bearer QoS, APN AMBR) message to the P-GW. Note that the EPS Bearer QoS sent in the Modify Bearer Command does not modify the per bearer bit-rate. It is sent to carry only a change in the ARP / QCI received from subscription. Also, the Modify Bearer Command can be sent only for the default bearer (primary PDP) in a PDN connection.

The P-GW modifies the default bearer of each PDN connection corresponding to the APN for which subscribed QoS has been modified. If the subscribed ARP parameter has been changed, the P-GW shall also modify all dedicated EPS bearers having the previously subscribed ARP value unless superseded by PCRF decision.

The P-GW then sends the Update Bearer Request (EPS Bearer Identity, EPS Bearer QoS [if QoS is changed], TFT, APN AMBR) message to the S-GW.

The S-GW sends the Update Bearer Request (EPS Bearer Identity, EPS Bearer QoS [if QoS is changed] APN-AMBR, TFT) message to the SGSN. On completion of modification S4-SGSN acknowledges the bearer modification by sending the "Update Bearer Response (EPS Bearer Identity)" message to P-GW via S-GW. If the bearer modification fails, the P-GW deletes the concerned EPS Bearer.

Fallback from the S4 Interface to the Gn Interface

The S4-SGSN supports fallback the S4 interface and selects the Gn interface for the 1st PDP context activation if the APN DNS-SNAPTR resolution returns only a Gn address. This functionality allows the PDP context request to be completed when DNS resolution returns a GGSN address instead of a P-GW address.

This mechanism is applicable in the following cases:

- The UE is EPC-capable
- The UE's subscription has a GPRS subscription only (and not an EPS subscription)

If the subscription has an EPS subscription for an APN, then it is assumed that the P-GW addresses are configured in the DNS for that APN.

Operator Policy Selection of S4 or Gn Interface

The S4-SGSN supports Operator Policy selection of either the S4 or the Gn interface for PDP context operations. This feature allows flexible operator control over interface selection for operational or administrative reasons.

This functionality overrides any other criteria for selection of the P-GW or the GGSN for PDP contexts. This feature is applicable only for EPC-capable UEs.

IDFT Support During Connected Mode Handovers

The S4-SGSN supports the setup of indirect data forwarding tunnels (IDFT) between the eNodeB and the RNC via the SGW during connected mode handovers. This allows the S4-SGSN to support connected mode handovers between the UTRAN and E-UTRAN networks across the S3 interface.

Once enabled, IDFT is employed under the following conditions:

- **If the SGSN is the old node participating in the connected mode handover, then indirect data forwarding tunnels is used if:**
 - The target node to which the connected mode handover is initiated should be an eNodeB (i.e., the SGSN performs the handover to the MME).
 - The **enb-direct-data-forward** CLI setting is not configured as the source RNC configuration (in RNC Configuration Mode).
- **If the SGSN is the new node participating in the connected mode handover, then indirect data forwarding tunnels is employed if:**
 - The source node from which connected mode handover is initiated is an eNodeB (i.e., the MME is performing a handover to the SGSN).
 - The **enb-direct-data-forward** setting is not configured in the source RNC configuration (in RNC Configuration Mode).
 - The source MME indicated that it does not support direct forwarding via a Forward Relocation Request.



Important If the target SGSN did **not** relocate to a new SGW, IDFT does not apply. The target SGSN sets up an indirect data forwarding tunnel with SGW only if the SGW is relocated. If the SGW is not relocated, then it is the source MME that sets up the indirect data forwarding tunnel between source the eNodeB and target RNC through the SGW.

Disassociated DSR Support

The S4-SGSN supports the disassociation of the SGSN and EGTP applications for a Delete Session Request in a certain scenario. In this scenario, the SGSN application instructs the EGTP facility to send the Delete Session Request to the SGW and not respond back to the SGSN application to confirm the action. In effect, the SGSN application disassociates itself from the EGTP facility. Since the SGSN application is no longer waiting for a response from the EGTP facility, there will be reduced internal communication between the SGSN and EGTP. The the EGTP facility will handle retransmissions of the DSR request, thereby eliminating the possibility of hanging sessions at the SGSN.

The behavior of the disassociated DSR feature for each of the applicable scenarios follows:

1. The SGSN / MME wants to send a DSR with OI=0 and SI=1 to an old SGW during SGW relocation.
2. The SGSN application instructs the EGTP facility to inform the old SGW of the DSR and the SGSN doesn't expect any response from EGTP.
3. The EGTP facility handles retransmissions of this DSR request.

SGSN Serving Radio Network Subsystem (SRNS) Relocation Support

SRNS relocation is the method defined in 3GPP TS 23.401 for connected mode inter-RAT handovers from E-UTRAN to UTRAN or UTRAN to E-UTRAN networks. The SGSN already supports SRNS relocation across the Gn interface. The SGSN now also supports SRNS relocation with the following cases across the S3 (S4-SGSN to MME) and S16 (S4-SGSN to S4-SGSN) interfaces:

- Intra-SGSN SRNS relocation
- Inter-SGSN SRNS relocation over the S16 interface
- UTRAN-to-E-UTRAN connected mode Inter-RAT handover over the S3 interface
- UTRAN-to-E-UTRAN connected mode Inter-RAT handover over the S3 interface

The relocation feature is triggered by subscribers (MS/UE) moving between an eNodeB and an RNC. If the originating and destination nodes are connected to the same S4-SGSN but are in different routing areas, the behavior triggers an intra-SGSN Routing Area Update (RAU). If the nodes are connected to different S4-SGSNs, the relocation is followed by an inter-SGSN RAU.

As part of the SRNS relocation feature implementation on the S4-SGSN, the SGSN application also supports the gtpv2 (egtp) protocol for:

- Inter-SGSN SRNS relocations over the S16 interface
- MME - SGSN SRNS relocations over the S3 interface

A command is available to enable the SGSN to support SRNS relocation when the source RNC is behaving as the target RNC.

Configuration and Maintenance

The existing **srns-inter** and **srns-intra** commands in *Call Control Profile Configuration Mode* are used to enable this feature.

In addition, the **enb-direct-data forward** command in *RNC Configuration Mode* can be used to enable the S4-SGSN to apply direct forwarding tunnels or indirect data forwarding tunnels (IDFT) between a particular eNodeB and RNC.

Statistics are also available with the **show s4-sgsn statistics all** command that enable operators to track SGW relocations and SRNS procedure aborts.

E-UTRAN Service Handover Support

The SGSN supports configuration-based enabling of the E-UTRAN Service Handover Information Element, which is optional in the following RANAP messages used during SRNS relocation:

- RAB Assignment Request
- Relocation Request

This feature is useful in the following scenarios:

1. A UE is E-UTRAN capable, the PLMN is E-UTRAN capable, but the UE has not subscribed to EPS services (no 4G subscription available).
2. The VPLMN is E-UTRAN-capable, and the UE of an inbound roamer is E-UTRAN capable, but the UE has only a UTRAN/GERAN roaming agreement in place.

The feature ensures that an SRNS relocation handover to E-UTRAN is not allowed for E-UTRAN capable UEs that have only a UTRAN/GERAN roaming agreement. This results in an elimination of potential service denial or disruption issues, and unnecessary signaling.

To implement this feature, CLI commands have been implemented so that the SGSN can be configured to:

- Override the "eutran-not-allowed" flag received from the HLR/HSS in the ISD/ULA request for the Access Restriction Data (ARD) parameter (for scenario 2 above).
- Enable the inclusion of the E-UTRAN Service Handover IE in RAB Assignment Request and Relocation Request RANAP messages for scenarios 1 and 2 above).



Important SRNS relocation must be configured via the **srns-inter** and/or **srns-intra** commands in *Call Control Profile Configuration Mode* before configuring E-UTRAN Service Handover Support.

Support for Gn Handoff from S4-SGSN to 2G/3G Gn SGSN

The S4-SGSN supports handoffs from the S4-SGSN to a 2G/3G peer Gn/Gp SGSN as follows:

- An EPC capable UE is attached to an S4-SGSN and has PDP contexts towards the EPC core using the S4 interface.
- When the UE hands off to a Gn/Gp SGSN, the S4-SGSN transfers the PDP contexts to the peer SGSN using the GTPv1 protocol.

No CLI commands are required to implement this functionality.

Suspend/Resume Support on the S4-SGSN

The S4-SGSN Suspend/Resume feature provides support for suspend/resume procedures from the BSS and a peer S4-SGSN.

When a UE is in a 2G coverage area wants to make a circuit switched voice call but the Class A mode of operation is not supported by the network, then the packet switched data session (PDP contexts) must be

suspended before the voice call can be made. In this case, the BSS sends a Suspend Request to the SGSN. If the UE is already attached at that SGSN then the suspend request is handled via an intra-SGSN suspend/resume procedure. If the UE is not attached at the SGSN then the Suspend Request is forwarded to a peer SGSN/MME through GTPv2 and an inter-SGSN/SGSN-MME suspend procedure occurs. Once the UE completes the voice call, either the BSS sends a resume request to resume the suspended PDPs or the UE directly sends a Routing Area Update Request (RAU) in 2G which will be treated as an implicit resume.

The ability for a GPRS user to access circuit-switched services depends on the subscription held, the network capabilities, and the MS capabilities.

For detailed information on this feature, refer to the *S4-SGSN Suspend/Resume Feature* chapter in this guide.

Flex Pooling (Iu / Gb over S16) Support on the S4-SGSN

This feature adds the SGSN Pooling functionality across S16 (peer S4-SGSN) interface, so that the default SGSN can forward the received Context Requests from the non-Pooled SGSN to the right pooled SGSN, based on the NRI in P-TMSI. Flex pooling provides better scalability and load balancing. A new CLI command for pooling has been provided under eGTP Service Configuration to enable S4-SGSN pooling across the S16 interface. For more information on the command, refer to the *Command Line Interface Reference Manual*.

This feature requires the SGSN S3/S4 license and Flex feature license - no additional feature licenses are required.

LORC Subscriber Overcharging Protection on S4-SGSN

With Release 17.0, the S4-SGSN now supports Subscriber Overcharging Protection to prevent both 2G and 3G subscribers from being overcharged when a loss of radio coverage (LORC) occurs over the S4 interface.

As a part of this functionality, the operator must configure all cause codes on the SGSN. If the SGSN receives a cause code via Iu/Gb interfaces that matches one of the cause codes configured on the SGSN, then the SGSN includes the ARRL (Abnormal Release of Radio Link) bit in the Release Access Bearer Request.

This feature ensures more accurate billing by protecting the subscriber from overcharging in instances where abnormal radio resource release occurs. For more information about this feature, refer to the feature chapter *LORC Subscriber Overcharging Protection on S4-SGSN* in this Guide.

Summary of Functional Differences between an S4-SGSN and an SGSN (Gn/Gp)

Since the S4-SGSN is configured with 2G, 3G, and/or dual access SGSN services before being configured with enhancements to enable communication with the EPC network, it shares similarities with a Gn/Gp SGSN. But, the S4-SGSN also contains a number of functional differences. The following table summarizes these differences.

Table 1: Summary of Functional Differences between SGSN and S4-SGSN

Procedure	Gn/Gp SGSN	S4-SGSN
MS Initiated First Primary PDP Context Activation	<ol style="list-style-type: none"> The requested QoS is negotiated with the subscribed QoS. The negotiated QoS is sent in the Create PDP Context Request. 	<ol style="list-style-type: none"> The requested QoS is ignored if UE has EPS subscription. If EPS subscription is available SGSN always uses the subscribed EPS QoS to send in the Create Session Request. If there is no EPS subscription but the UE is still granted access to the S4 interface, then the system negotiates the requested QoS with the subscribed GPRS QoS. The S4-SGSN maps the negotiated QoS to EPS QoS as per the mapping table given in TS 23.203 Table 6.1.7 and TS 23.401 Annex E. and sends the Create Session Request. If the requested traffic class is conversational / streaming, then the system maps it to the interactive class as a primary PDP context. In S4-SGSN if QoS is downgraded by RNC during RAB establishment, then by default the PDP activation is rejected. This is as per section 9.2.2.1A of 23.060 step A below figure 64b. But S4-SGSN provides a CLI to locally accept the RAB negotiated QoS to override this spec defined behavior. Two primary PDP contexts for the same APN must be selected for the same P-GW.
MS Initiated Secondary PDP Context Activation	<ol style="list-style-type: none"> Secondary PDP context's requested QoS will be capped to the subscribed QoS. Since the Create PDP Context is the message also used for creating the Secondary PDP context, ARP also is sent for secondary PDP context. 	<ol style="list-style-type: none"> ARP is not sent in the Bearer Resource command. But it is sent by the P-GW in the Create Bearer Request.

Procedure	Gn/Gp SGSN	S4-SGSN
MS Initiated PDP Context Deactivation	1. Both single and bundle deactivation is allowed.	1. If a primary PDP context must be deactivated, only bundle deactivation is allowed.
GGSN/P-GW Initiated PDP Context Deactivation	1. The GGSN can deactivate the primary PDP context alone without initiating a bundle deactivation.	1. If the P-GW deactivates the primary PDP context (default bearer), it is treated as a bundle deactivation.
PDP Context Preservation for conversational/streaming class.	1. The SGSN sends the Update PDP Context Request to the GGSN with 0kbps as the Maximum Bit Rate value.	
PDP Context Preservation for interactive/background class.	1. The SGSN preserves the PDP context as it is.	1. The S4-SGSN preserves the PDP context as it is. 2. If a direct tunnel was established, or if ISR is active, then the S4-SGSN sends a Release Access Bearer Request to the S-GW.
RNC Initiated QoS Modification	1. The SGSN initiates the PDP Context Modification procedure.	1. The S4-SGSN ignores the RAB Modify Request received from the RNC.
Intra-SGSN Routing Area Update in PMM-Idle Mode	1. The SGSN sends the Update PDP Context Request to the GGSN if the PLMN changes.	1. An intra-SGSN RAU may involve a change of S-GW. 2. An S4-SGSN sends a Modify Bearer Request to the S-GW/P-GW if the RAU involves a change of PLMN and if the S-GW doesn't change.

Procedure	Gn/Gp SGSN	S4-SGSN
Intra SGSN RAU in PMM-CONNECTED Mode	<ol style="list-style-type: none"> The SGSN sends the Update PDP Context Request to the GGSN if the PLMN changes or if QoS changed due to an RNC release change. 	<ol style="list-style-type: none"> An intra-SGSN RAU may involve a change of the S-GW. In 16.0 if QoS is changed during inter RNC handover (due to new RNC supporting a lower QoS range), then S4-SGSN internally caps the QoS towards RNC for non GBR bearers alone (interactive / background class). The changed QoS is not signalled to SGW / PGW. If there are GBR bearers (conversational / streaming class) that have a higher guaranteed bit rate than that can be supported by the target RNC, then such GBR bearers are deactivated. However, in an S4-SGSN, the SGSN initiated modification procedure is defined only for changing of APN-AMBR. A change of RNC release will initiate a per bearer QoS change. There is no way to communicate this to the S-GW / P-GW.

Procedure	Gn/Gp SGSN	S4-SGSN
<p>Old - Inter-SGSN RAU with no change in interface type across SGSNs.</p>	<p>Where both "old" and "new" refer to SGSNs (Gn/Gp):</p> <ol style="list-style-type: none"> 1. The old SGSN orders the PDP contexts as per priority in the SGSN Context Response message. If the UE is PMM-CONNECTED in the old SGSN, then the old SGSN initiates an SRNS Context Transfer before sending the SGSN context response. In addition, the old SGSN initiates an SRNS Data Forward Command to the SRNS to transfer the unsent data from the old SRNS to the old SGSN. 	<p>Where both "old" and "new" refer to S4-SGSNs.</p> <ol style="list-style-type: none"> 1. If the new S4-SGSN indicated that the S-GW has changed in the Context Ack message, then the old S4-SGSN has to initiate a Delete Session Request to the old S-GW with Scope Indication bit set. This Delete Session Request is locally consumed at old SGW and will not be forwarded to PGW. 2. The S4-SGSN does not support lossless PDCP for inter-SGSN handovers. If the UE was PMM-CONNECTED in the old S4-SGSN, then it will not initiate an SRNS Context Transfer before sending the Context Response. The assumption is that the SRNS relocation procedure had occurred prior to the inter-SGSN RAU for CONNECTED subscribers. 3. For inter S4-SGSN context transfers the Context Ack message doesn't carry any data TEID. That is, the GTPv2 protocol doesn't define any inter-SGSN data tunnel. Therefore, during connected mode, a RAU between two S4-SGSN without an SRNS relocation will result in packet losses. It is assumed that SRNS relocation is enabled in the UTRAN.

Procedure	Gn/Gp SGSN	S4-SGSN
Old - Inter SGSN RAU with change in interface across SGSN	<p>Where "old" is SGSN (Gn/Gp) and "new" is S4-SGSN:</p> <ol style="list-style-type: none"> 1. The old SGSN sends a SGSN context response with PDP contexts in prioritized order. 2. If the MS is in PMM-CONNECTED state in the old SGSN, it will initiate an SRNS Context Transfer towards the old SRNS and will initiate SRNS Data Forward Command to transfer unsent packets from old SRNS back to old SGSN. In the new SGSN, the PDPs will continue to use Gn interface. Promotion of PDPs to S4 post handover from a Gn SGSN is not yet supported. 	<p>Where "old" is S4-SGSN and "new" is SGSN (Gn/Gp):</p> <ol style="list-style-type: none"> 1. The old S4-SGSN receives a GTPv1 SGSN Context Request and it converts the EPS bearer information to PDP contexts and responds with a SGSN Context Response towards the new SGSN. 2. The old S4-SGSN prioritizes the PDP contexts as per ARP. PDP prioritization for EPS bearers is not supported.
New Inter SGSN RAU for a PMM-IDLE subscriber without a change of interface	<ol style="list-style-type: none"> 1. Uses the PDP context prioritized order in the SGSN Context Response to select high priority PDP contexts in the case of resource limitations at the new SGSN. 2. The SGSN ends the UPCQ to GGSN. 	<ol style="list-style-type: none"> 1. Performs the S-GW selection procedure. 2. Uses ARP to prioritize EPS bearers. In GTPv1 the PDP contexts sent in SGSN context response will be in prioritized order. But such an order is not defined for sending EPS bearers in Context Response. The idea is to use to ARP for prioritization. PDP prioritization for EPS bearers is not supported. 3. The new S4-SGSN alerts of any change in S-GW through the Context Ack to the old S4-SGSN. The PMM module will wait until the S-GW selection procedure is complete at the new S4-SGSN to alert of the context ack.

Procedure	Gn/Gp SGSN	S4-SGSN
New Inter SGSN RAU for a PMM-CONNECTED subscriber	<p>Where "old" is S4-SGSN and "new" is SGSN (Gn/Gp):</p> <ol style="list-style-type: none"> 1. The new SGSN receives PDP contexts in the SGSN Context Response in prioritized order. 2. RABs will be established at the new SGSN based on the ASI bit value for each PDP. 	<p>Where "new" is S4-SGSN and "old" is SGSN (Gn/Gp):</p> <ol style="list-style-type: none"> 1. The new S4-SGSN receives PDP contexts in the Context Response. There is no prioritized order. ARP is used to prioritize. PDP prioritization for EPS bearers is not supported. 2. New S4-SGSN performs S-GW selection. 3. The new S4-SGSN cannot establish RAB as there is no ASI bit in the GTPv2 Context Response. The assumption is that the Context Req / Response is used only for IDLE mode handover, and that for connected mode handover, the SRNS relocation procedure should be used.
New SGSN PMM-CONNECTED / PMM-IDLE subscriber handover with interface change	<p>Where "old" is S4-SGSN and "new" is SGSN (Gn/Gp):</p> <ol style="list-style-type: none"> 1. The new S4-SGSN sends a GTPv1 SGSN Context Request and receives the PDP contexts mapped from EPS bearers in the SGSN context response. 2. The old SGSN will establish an inter-SGSN tunnel for transferring queued packets. 	<p>Where "old" is SGSN (Gn/Gp) and "new" is S4-SGSN:</p> <ol style="list-style-type: none"> 1. The new S4-SGSN sends a GTPv1 SGSN context request, after learning that the old SGSN is an SGSN (Gn/Gp) based on a DNS S-NAPTR response. 2. The new S4-SGSN will continue to use the Gn interface for the PDPs. Conversion of PDPs to S4-SGSN is not supported at this time.
APN Selection Logic	<ol style="list-style-type: none"> 1. No concept of subscribed default APN. 	<ol style="list-style-type: none"> 1. One among the subscribed APN will be indicated as a default APN by the HSS. That APN will be used under the following cases: 1) No requested APN, 2) The requested APN is not in the subscription but the requested PDP type matches with default APN's PDP type.

Procedure	Gn/Gp SGSN	S4-SGSN
DNS Queries	<ol style="list-style-type: none"> 1. APN FQDN, RAI FQDN and RNC-ID FQDN are formed with a .gprs extension. 2. DNS A/AAAA records are queried. 3. Optionally, also uses S-NAPTR queries for EPC-capable UEs to select a co-located P-GW/GGSN 	<ol style="list-style-type: none"> 1. APN FQDN, RAI FQDN, RNC-ID FQDN are formed with a .3gppnetwork.org extension. 2. DNS S-NAPTR records are queried 3. If DNS SNAPTR response returns only Gn address, S4-SGSN will use Gn interface for selecting a PGW/GGSN.
Path Failure Detection	<ol style="list-style-type: none"> 1. Can be echo-based or non-echo-based. 	<ol style="list-style-type: none"> 1. Echo-based only.
Charging	<ol style="list-style-type: none"> 1. Applicable. 	<ol style="list-style-type: none"> 1. Charging for PDP contexts applicable only if CAMEL is used. However, the S4-SGSN will continue to generate M-CDRs. Also CAMEL is not supported in S4-SGSN now. Hence S4-SGSN only generates M-CDRs. PDP related CDRs are generated by SGW.

Procedure	Gn/Gp SGSN	S4-SGSN
Intra-SGSN Inter System Handover (2G to 3G or 3G to 2G Inter RAT handovers)	<ol style="list-style-type: none"> 1. For 2G to 3G handovers, the RABs are not established in 3G after handover. It is the function of the UE to initiate Service Request procedure to setup RAB. 2. For 3G to 2G handovers, the QoS is capped to 472 Kbps in 2G and the Update PDP Context Request initiated from 2G will carry the capped QoS to GGSN. 	<ol style="list-style-type: none"> 1. For 2G to 3G handovers, the RABs are not established in 3G after the handover. The S4-SGSN preserves the PDP without deactivation. For 3G to 2G handover, the QoS is not capped to 472 Kbps in 2G. The reason is that in GTPv2 the Modify Bearer Request initiated from S4-SGSN upon 3G to 2G RAU is defined only for informing S-GW / P-GW of a switch in tunnel IDs and change in RAT type. This message doesn't carry QoS. The S4-SGSN relies on the P-GW + PCRF to decide the best QoS for the informed RAT type and lets the P-GW initiate a separate modification procedure to set the right QoS. In 16.0, during 3G to 2G handover, SGSN internally caps the APN-AMBR to 472 kbps and post handover, it initiates a Modify Bearer Command message to SGW/PGW. If there are any GBR bearers (conversational / streaming class) with bit rate greater than 472 kbps then those GBR bearer PDPs will be deactivated.
Direct Tunnel (DT) Activation	<p>Configuration enabling DT is accomplished at various levels - the Call Control Profile level, the RNC level, and at the APN Profile level for DT per APN/GGSN.</p> <p>For a given UE, it is possible that one PDN connection to an APN to a GGSN uses DT while another PDN connection to a different APN to a different GGSN does not use DT. It all depends upon whether or not the target GGSN supports DT.</p>	<p>Configuration for DT is only available at Call Control Profile and RNC levels as the S4-SGSN's DT is between an SGW and an RNC.</p> <p>In an S4-SGSN, either all PDPs of a given UE use DT or none of them use DT. So, combinations of some PDPs using DT and some PDPs not using DT is not possible.</p>

Procedure	Gn/Gp SGSN	S4-SGSN
Handling Suspend from BSS / peer SGSN	PDPs are suspended at SGSN. Any downlink data received at this point will be queued by the SGSN.	PDPs are suspended at SGSN. Downlink data buffering happens at the PGW and not the SGSN because the PDP suspension is carried via a GTPv2 Suspend Notification message from the SGSN to the SGW to the PGW.

Session Recovery

Session recovery provides a seamless failover and reconstruction of subscriber session information in the event of a hardware or software fault that prevents a fully attached user session from having the PDP contexts removed or the attachments torn down.

Session recovery is performed by mirroring key software processes (e.g., session manager and AAA manager) within the system. These mirrored processes remain in an idle state (in standby-mode) until they may be needed in the case of a software failure (e.g., a session manager task aborts). The system spawns new instances of "standby mode" session and AAA managers for each active control processor (CP) being used.

As well, other key system-level software tasks, such as VPN manager, are performed on a physically separate packet processing card to ensure that a double software fault (e.g., session manager and VPN manager fail at the same time on the same card) cannot occur. The packet processing card used to host the VPN manager process is in active mode and is reserved by the operating system for this sole use when session recovery is enabled.

The additional hardware resources required for session recovery include a standby System Management Card and a standby packet processing card.

There are two modes for Session Recovery.

- **Task recovery mode:** One or more session manager failures occur and are recovered without the need to use resources on a standby packet processor card. In this mode, recovery is performed by using the mirrored "standby-mode" session manager task(s) running on active packet processor cards. The "standby-mode" task is renamed, made active, and is then populated using information from other tasks such as AAA manager.
- **Full packet processing card recovery mode:** Used when a packet processing card hardware failure occurs, or when a packet processor card migration failure happens. In this mode, the standby packet processor card is made active and the "standby-mode" session manager and AAA manager tasks on the newly activated packet processor card perform session recovery.

Session/Call state information is saved in the peer AAA manager task because each AAA manager and session manager task is paired together. These pairs are started on physically different packet processor cards to ensure task recovery.

When session recovery occurs, the system reconstructs the following subscriber information:

- Data and control state information required to maintain correct call behavior
- Subscriber data statistics that are required to ensure that accounting information is maintained
- A best-effort attempt to recover various timer values such as call duration, absolute time, and others

For more information on session recovery use and session recovery configuration, refer to the *Session Recovery* section in the *System Administration Guide*.

SCTP Parameters for SGSN

The details on the configurable values for SCTP parameters are provided in the table given below:

Parameter	Minimum value	Maximum value	Granularity
RTO.min	10ms	5s	10ms
RTO.max	500ms	120s	10ms
RTO.initial	RTO.min	RTO.max	10ms
RTO.alpha	1/8	1/8	-
RTO.beta	1/4	1/4	-
Valid.Cookie.Life	5s	120s	1s
HB.interval	1s	300s	1s
SACK period	0ms	500ms	10ms
SACK frequency	1	5	1
MTU size	508 bytes	65535 bytes	1 byte

The details on the default values for SCTP parameters are provided in the table given below:

Parameter	Default Value
RTO Alpha	5
RTO Beta	10
Valid Cookie Life	600
Max. associate retransmission value	10
Max. number of outgoing streams	16
Max. number of incoming streams	16
Max. retransmission initiations	5
Max. MTU size	1500
Min. MTU size	508
Start MTU	1500
Max. path retransmission	5
RTO Initial	30
RTO Max	600

Parameter	Default Value
RTO Min	10
HB interval	30
HB enable	True
SACK period	2
SACK frequency	2
Bundle valid	True
Bundle enable	False

SGSN Pooling and Iu-Flex / Gb-Flex

This implementation allows carriers to load balance sessions among pooled SGSNs, to improve reliability and efficiency of call handling, and to use Iu-Flex / Gb-Flex to provide carriers with deterministic failure recovery.

The SGSN, with its high capacity, signaling performance, and peering capabilities, combined with its level of fault tolerance, delivers many of the benefits of Flex functionality even without deploying SGSN pooling.

As defined by 3GPP TS 23.236, the SGSN implements Iu-Flex and Gb-Flex functionality to facilitate network sharing and to ensure SGSN pooling for 2.5G and 3G accesses as both separate pools and as dual-access pools.

SGSN pooling enables the following:

- Eliminates the single point of failure between an RNC and an SGSN or between a BSS and an SGSN.
- Ensures geographical redundancy, as a pool can be distributed across sites.
- Minimizes subscriber impact during service, maintenance, or node additions or replacements.
- Increases overall capacity via load sharing across the SGSNs in a pool.
- Reduces the need/frequency for inter-SGSN RAUs. This substantially reduces signaling load and data transfer delays.
- Supports load redistribution with the SGSN offloading procedure.

The SGSN Pooling and Iu-Flex / Gb-Flex feature is license controlled. Contact your Cisco Account or Support representative for information on how to obtain a license.

Gb/Iu Flex Offloading

The SGSN supports Gb/Iu Flex subscriber offloading from one SGSN to another specific SGSN in a 2G/3G pool.

In addition, the operator can configure the offloading Target NRI in P-TMSI, and the quantity to offload to the Target. This can be used to provide load balancing, or to offload a single node in pool, take it out of service for whatever reason (e.g., maintenance).

SGSN Supports Enhanced IMSI Range

The IMSI range supported has been enhanced to "2500" from "1000". The IMSI ranges configured must be unique; the SGSN selects the appropriate operator policy based on the IMSI range of the UE. The operator can verify the configured IMSI ranges and the associated operator policy by issuing the command "show config". The length of the description field in the imsi-range command under the SGSN Global Configuration mode has been reduced from a maximum of "100" alphanumeric characters to "50" alphanumeric characters. Reduction of the supported string size results in improvement of the boot up time.

SGSN Support for RAI Based Query

The SGSN now supports a RAI based query when NRI based query fails. A new CLI option **rai-fqdn-fallback** is provided in the **peer-nri-length** CLI under the Call Control Profile Configuration, which allows the operator to configure the SGSN's support to fallback on RAI based query when NRI based query fails.

This feature is not supported in the following scenarios:

- 2G Context Request and Identification Request messages are not supported.
- S4 support of this extensions for all applicable scenarios is not supported.

SGSN Support For Sending Extended Bits Bi-directionally

The SGSN now supports sending extended bitrates in both uplink and downlink directions. Extended bitrates are included in both uplink and downlink direction when the negotiated bitrate indicates that extended bitrates should be included in one direction. A new CLI **ranap bidirectional-always ext-mbr-ie** is added under the RNC Configuration mode to enable sending extended bitrates bi-directionally.

SGSN support to Ignore PDP Data Inactivity

The SGSN supports options to configure PDP Data Inactivity detection duration and actions to be performed on timeout under the APN-Profile. The following configurable actions are supported under APN-Profile in case of PDP Data Inactivity detection in the PDP context:

1. De-activate all PDPs of the subscriber
2. De-activate all PDPs of the bundle (all linked PDPs)
3. Detach the subscriber. This action is triggered when:
 - Data in-activity is detected for all PDPs
 - Data in-activity is detected for any of the PDPs

On the Detection of the PDP Data Inactivity, depending on the configuration option the SGSN either de-activates the PDP or detaches the subscriber.

A new CLI **ignore-pdp-data-inactivity** is added to provide an option under the IMEI-Profile to ignore PDP Data Inactivity configuration for one or more IMEIs. On configuring this CLI, the SGSN ignores the application of in-activity configuration (configured in the APN-Profile) for a specified set of IMEI's.



Important The IMEI range or set of IMEI's are mapped to specific IMEI-Profile using the CLI configuration option under Operator-policy.

For more information on the command see. Command Line Interface Reference.

Short Message Service (SMS over Gd)

The SGSN implements a configurable Short Message Service (SMS) to support sending and receiving text messages up to 140 octets in length. The SGSN handles multiple, simultaneous messages of both types: those sent from the MS/UE (SMS-MO: mobile originating) and those sent to the MS/UE (SMS-MT: mobile terminating). Short Message Service is disabled by default.

After verifying a subscription for the PLMN's SMS service, the SGSN connects with the SMSC (short message service center), via a Gd interface, to relay received messages (from a mobile) using MAP-MO-FORWARD-REQUESTs for store-and-forward.

In the reverse, the SGSN awaits messages from the SMSC via MAP-MT-FORWARD-REQUESTs and checks the subscriber state before relaying them to the target MS/UE.

The SGSN will employ both the Page procedure and MNRG (mobile not reachable for GPRS) flags in an attempt to deliver messages to subscribers that are absent.

The SGSN supports

- charging for SMS messages, and
- lawful intercept of SMS messages

For information on configuring and managing the SMS, refer to the *SMS Service Configuration Mode* section in the *Command Line Interface Reference*.

SMS Authentication Repetition Rate

The SGSN provides an authentication procedures for standard GMM events like Attach, Detach, RAU, and Service-Request, and SMS events such as Activate, all with support for 1-in-N Authenticate functionality. The SGSN did not provide the capability to authenticate MO/MT SMS events.

Now, the authentication functionality has been expanded to the Gs interface where the SGSN now supports configuration of the authentication repetition rate for SMS-MO and SMS-MT, for every nth event. This functionality is built on existing SMS CLI, with configurable MO and/or MT. The default is not to authenticate.

SMSC Address Denial

Previously, the SGSN supported restricting MO-SMS and MT-SMS only through SGSN operator policy configuration.

Now, the SGSN can restrict forwarding of SMS messages to specific SMSC addresses, in order to allow operators to block SMS traffic that cannot be charged for. This functionality supports multiple SMSCs and is configurable per SMSC address with a maximum of 10 addresses. It is also configurable for MO-SMS and/or MT-SMS messages.

Status Updates to RNC

During MMGR recovery due to memory overload or demux migration leads to missing status updates for RNC. As the result RNC status remains unavailable even when links towards RNC are up. The Session Controller allows the Standby Session Managers along with Active Session Managers to fetch the status updates.

Target Access Restricted for the Subscriber Cause Code

This enhancement is a 3GPP TS (29.274 and 29.060) release compliance enhancement. As per 3GPP TS 29.274 and TS 29.060, the source-serving node (MME/SGSN) is allowed to reject SGSN Context Request (GTPv1) and Context Request (GTPv2) mobility management messages with "Target Access Restricted for the subscriber" cause if target access is restricted for the subscriber based on the Access-Restriction-Data in the subscription profile. The target node (MME/SGSN) is allowed to reject RAU/TAU with anyone one of the following NAS Causes:

- 15 "No suitable cells in tracking area", or
- 13 "Roaming not allowed in this tracking area", or
- 12 "Tracking area not allowed"

New statistics have been introduced under "show egtpc statistics verbose" and "show sgtpc statistics verbose" to reflect the context response sent and received with the new reject cause "Target Access Restricted for the subscriber".

Rejecting RAU/TAU much early in call cycle results in reduced signaling.



Important No new CLI is provided for GTP cause code mapping to EMM/NAS cause. RAU Reject will always be sent with NAS cause "No suitable cells in location area" and TAU Reject will always be sent with EMM cause "No suitable cells in Tracking Area".

For more information refer to the 3GPP TS 29.274 (section 7.3.6), TS 29.060 (section 7.5.4), TS 29.060 Annex B (Table B.5: Mapping from Gn/Gp to NAS Cause values Rejection indication from SGSN) and TS 29.274 Annex C (Table C.5: Mapping from S3/S16 to NAS Cause values Rejection indication from MME/S4-SGSN)

Topology-based Gateway (GW) Selection

Topology-based gateway selection is a mechanism defined by 3GPP to choose a gateway based on the geographical (topological) proximity of the GGSN to the SGSN or the P-GW to the S-GW. The two being co-located would have the highest priority. Topology-based selection is not allowed for roamers connected to HPLMN access points (Home Routed Scenario).

DNS S-NAPTR returns a candidate list of GW nodes for each of the DNS queries. 3GPP TS 29.303 provides an algorithm to feed these candidate lists and choose the topologically closer nodes among them. S-NAPTR DNS query is supported by default on the S4-SGSN and, with Release 16, can be enabled for the Gn/Gp-SGSN.

The SGSN's Topology-based GW Selection feature supports two levels of sorting, first level is degree and second level is order/priority, where order is for NAPTR records and priority is for SRV Records. Degree has the highest preference.

For details on the use and configuration of this feature, refer to the *Topology-based Gateway Selection* section in the *SGSN Administration Guide*.

Threshold Crossing Alerts (TCA) Support

Thresholding on the system is used to monitor the system for conditions that could potentially cause errors or outage. Typically, these conditions are temporary (i.e high CPU utilization, or packet collisions on a network) and are quickly resolved. However, continuous or large numbers of these error conditions within a specific time interval may be indicative of larger, more severe issues. The purpose of thresholding is to help identify potentially severe conditions so that immediate action can be taken to minimize and/or avoid system downtime.

The system supports Threshold Crossing Alerts for certain key resources such as CPU, memory, number of sessions etc. With this capability, the operator can configure threshold on these resources whereby, should the resource depletion cross the configured threshold, a SNMP Trap would be sent.

The following thresholding models are supported by the system:

- **Alert:** A value is monitored and an alert condition occurs when the value reaches or exceeds the configured high threshold within the specified polling interval. The alert is generated then generated and/or sent at the end of the polling interval.
- **Alarm:** Both high and low threshold are defined for a value. An alarm condition occurs when the value reaches or exceeds the configured high threshold within the specified polling interval. The alert is generated then generated and/or sent at the end of the polling interval.

Thresholding reports conditions using one of the following mechanisms:

- **SNMP traps:** SNMP traps have been created that indicate the condition (high threshold crossing and/or clear) of each of the monitored values.

Generation of specific traps can be enabled or disabled on the chassis. Ensuring that only important faults get displayed. SNMP traps are supported in both Alert and Alarm modes.

- **Logs:** The system provides a facility called threshold for which active and event logs can be generated. As with other system facilities, logs are generated Log messages pertaining to the condition of a monitored value are generated with a severity level of WARNING.

Logs are supported in both the Alert and the Alarm models.

- **Alarm System:** High threshold alarms generated within the specified polling interval are considered "outstanding" until a the condition no longer exists or a condition clear alarm is generated. "Outstanding" alarms are reported to the system's alarm subsystem and are viewable through the Alarm Management menu in the Web Element Manager.

The Alarm System is used only in conjunction with the Alarm model.



Important

For more information on threshold crossing alert configuration, refer to the *Thresholding Configuration Guide*.

Tracking Usage of GEA Encryption Algorithms

GPRS encryption algorithm (GEA) significantly affects the SGSN processing capacity based on the GEA level used - GEA1, GEA2, or GEA3.

Operators would like to be able to identify the percentages of their customer base that are using the various GEA encryption algorithms. The same tool can also track the migration trend from GEA2 to GEA3 and allow an operator to forecast the need for additional SGSN capacity.

New fields and counters have been added to the output generated by the **show subscribers gprs-only|sgsn-only summary** command. This new information enables the operator to track the number of subscribers capable of GEA0-GEO3 and to easily see the number of subscribers with negotiated GEAX levels.

Validation of MCC/MNC Values in the Old RAI Field

This feature is developed to comply with 3GPP TS 24.008. As per 3GPP TS 24.008, in some abnormal instances the MCC stored in the Mobile Station (MS) contains elements which do not belong to the set {0, 1 ... 9}. In such cases the Mobile Station should transmit the stored values using full hexadecimal encoding. When receiving such an MCC, the network should treat the RAI as deleted. In some instances it is possible that the MNC stored in the Mobile Station has the following:

- Digit 1 or 2 not in the set {0, 1 ... 9}
- Digit 3 not in the set {0, 1 ... 9, F} hex

In such cases the MS should transmit the stored values using full hexadecimal encoding. When receiving such an MNC, the network should treat the RAI as deleted. The same handling is applicable for a network where a 3-digit MNC is sent by the mobile station to a network using only a 2-digit MNC.

A validation check has been introduced to verify the MCC and MNC fields received in the old RAI IE in Attach/RAU requests. When the MCC and MNC fields received in the RAU request (inter-SGSN) and are invalid, the RAU request is rejected by SGSN. When the MCC and MNC fields received in the Attach Request and are invalid, the identity of the MS is retrieved directly from the MS instead of sending identity request to the peer node where peer SGSN identity is derived from the old-RAI.



Important These feature is applicable for both 2G and 3G networks.

A new CLI command **[no] rai-skip-validation** has been introduced under both IuPS service and GPRS service configuration modes. This new command enables/disables rejection of RAU requests with invalid MCC/MNC values in the old RAI field. By default the old RAI MCC/MNC fields are validated. This command also impacts the PTMSI attaches where the old RAI field is invalid. If the OLD RAI field is invalid and if the validation is enabled through the new CLI command, the identity of the MS is requested directly from the MS instead of the peer SGSN.

VLR Pooling via the Gs Interface

VLR Pooling, also known as Gs Pooling, helps to reduce call delays and call dropping, when the MS/UE is in motion, by routing a service request to a core network (CN) node with available resources.

VLR pools are configured in the Gs Service, which supports the Gs interface configuration for communication with VLRs and MSCs.

A *pool area* is a geographical area within which an MS/UE can roam without the need to change the serving CN node. A pool area is served by one or more CN nodes in parallel. All the cells, controlled by an RNC or a BSC belong to the same one (or more) pool area(s).

VLR hash is used when a pool of VLRs is serving a particular LAC (or list of LACs). The selection of VLR from this pool is based on the IMSI digits. From the IMSI, the SGSN derives a hash value (V) using the algorithm: $[(\text{IMSI} \div 10) \bmod 1000]$. Every hash value (V) from the range 0 to 999 corresponds to a single MSC/VLR node. Typically many values of (V) may point to the same MSC/VLR node.

For commands to configure the VLR and pooling, refer to the "Gs Service Configuration Mode" section in the *Command Line Interface Reference*.

Synchronization of Crash Events and Minicores between Management Cards

The crash log is unique to each of the management cards, so if a crash occurs when card the "8" is active it will be logged on card "8". A subsequent switch-over would no longer display the crash in the log. To retrieve this crash, a switch back over to card "8" has to be done. The crash event log and dumps are unique to active and standby management cards, so if a crash occurs on an active card then the crash event log and related dumps will be stored on an active card only. This crash information is not available on the standby card. Whenever the cards switchover due to a crash in the active card, and crash information is no longer displayed on the card which takes over. Crash information can be retrieved only from the current active card. To retrieve the crash list of the other card a switch-over is required again. To avoid this switch-over and to obtain the crash information from the standby card, synchronization between two management cards and maintaining latest crash information is required.

The arriving crash event will be sent over to the standby SMC/MMIO and saved in the standby's crashlog file in the similar manner. Minicore, NPU or kernel dumps on flash of active SMC/MMIO needs to be synchronized to standby SMC/MMIO using the 'rsync' command. When a crash log entry or the whole list is deleted through the CLI command, it should be erased on both active and standby SMCs/MMIOs. There is no impact on memory. All the crash related synchronization activity will be done by the evlogd of standby SMC/MIO card, as the standby evlogd is less loaded and the standby card has enough room for synchronization activity. Therefore the performance of the system will not be affected.

Zero Volume S-CDR Suppression

This feature is developed to suppress the CDRs with zero byte data count, so that the OCG node is not overloaded with a flood of CDRs. The CDRs can be categorized as follows:

- Final-cdrs: These CDRs are generated at the end of a context.
- Internal-trigger-cdrs: These CDRs are generated due to internal triggers such as volume limit, time limit, tariff change or user generated interims through the CLI commands.
- External-trigger-cdrs: These CDRs are generated due to external triggers such as QoS Change, RAT change and so on. All triggers which are not considered as final-cdrs or internal-trigger-cdrs are considered as external-trigger-cdrs.

The customers can select the CDRs they want to suppress. A new CLI command **[no] [default] gtp suppress-cdrs zero-volume { external-trigger-cdr | final-cdr | internal-trigger-cdr }** is developed to enable this feature. This feature is disabled by default to ensure backward compatibility. For more information see, *Command Line Interface Reference* and *Statistics and Counters Reference*.



Important This is a license controlled feature.

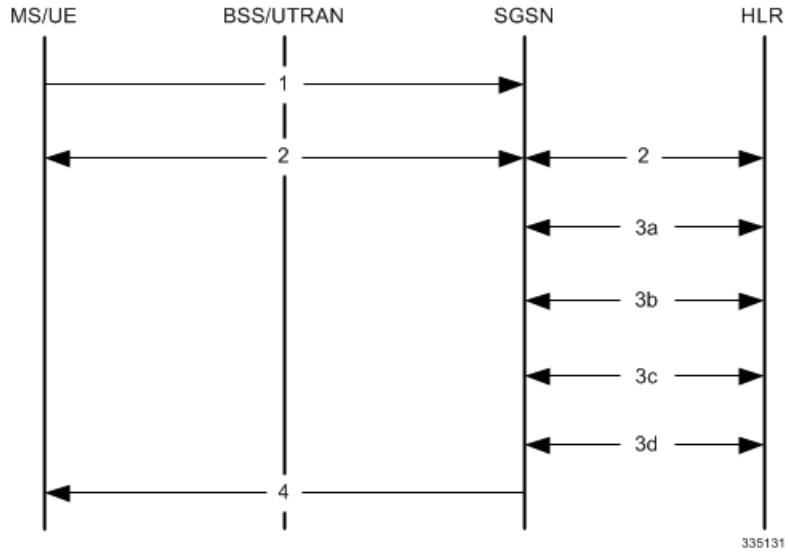
How the SGSN Works

This section illustrates some of the GPRS mobility management (GMM) and session management (SM) procedures the SGSN implements as part of the call handling process. All SGSN call flows are compliant with those defined by 3GPP TS 23.060.

First-Time GPRS Attach

The following outlines the setup procedure for a UE that is making an initial attach.

Figure 8: Simple First-Time GPRS Attach



This simple attach procedure can connect an MS via a BSS through the Gb interface (2.5G setup) or it can connect a UE via a UTRAN through the Iu interface in a 3G network with the following process:

Table 2: First-Time GPRS Attach Procedure

Step	Description
1	<p>The MS/UE sends an Attach Request message to the SGSN. Included in the message is information, such as:</p> <ul style="list-style-type: none"> • Routing area and location area information • Mobile network identity • Attach type

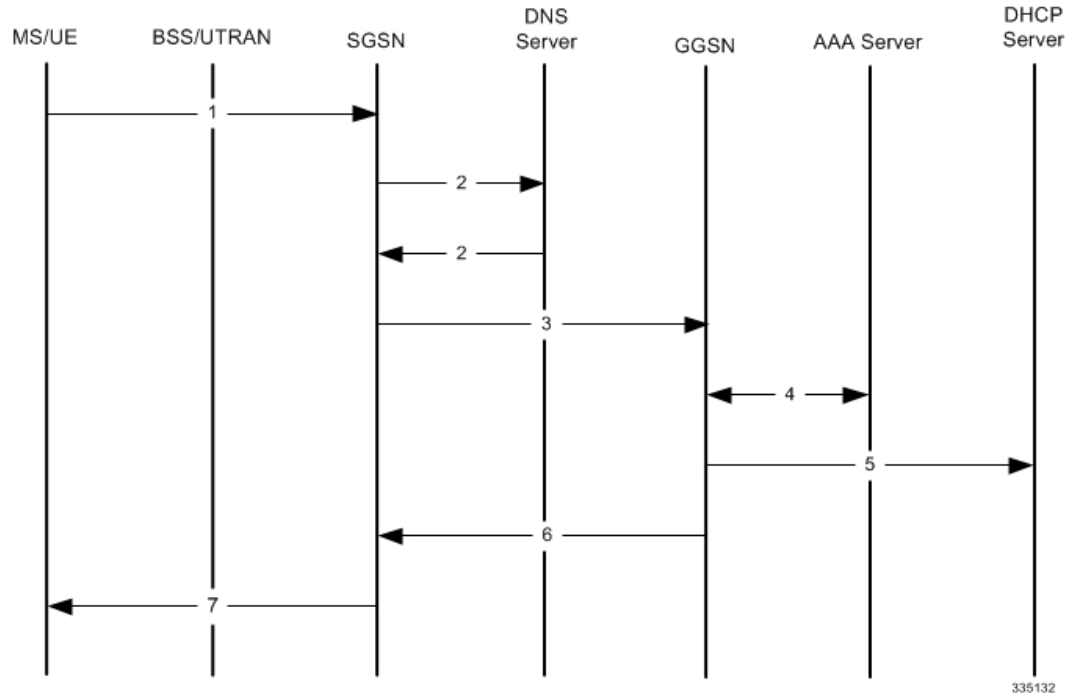
Step	Description
2	<p>Authentication is mandatory if no MM context exists for the MS/UE:</p> <ul style="list-style-type: none"> • The SGSN gets a random value (RAND) from the HLR to use as a challenge to the MS/UE. • The SGSN sends a Authentication Request message to the UE containing the random RAND. • The MS/UE contains a SIM that contains a secret key (Ki) shared between it and the HLR called a Individual Subscriber Key. The UE uses an algorithm to process the RAND and Ki to get the session key (Kc) and the signed response (SRES). • The MS/UE sends a Authentication Response to the SGSN containing the SRES.
3	<p>The SGSN updates location information for the MS/UE:</p> <p>a) The SGSN sends an Update Location message, to the HLR, containing the SGSN number, SGSN address, and IMSI.</p> <p>b) The HLR sends an Insert Subscriber Data message to the "new" SGSN. It contains subscriber information such as IMSI and GPRS subscription data.</p> <p>c) The "New" SGSN validates the MS/UE in new routing area:</p> <p>If invalid: The SGSN rejects the Attach Request with the appropriate cause code.</p> <p>If valid: The SGSN creates a new MM context for the MS/UE and sends a Insert Subscriber Data Ack back to the HLR.</p> <p>d) The HLR sends a Update Location Ack to the SGSN after it successfully clears the old MM context and creates new one</p>
4	<p>The SGSN sends an Attach Accept message to the MS/UE containing the P-TMSI (included if it is new), VLR TMSI, P-TMSI Signature, and Radio Priority SMS.</p> <p>At this point the GPRS Attach is complete and the SGSN begins generating M-CDRs.</p>

If the MS/UE initiates a second call, the procedure is more complex and involves information exchanges and validations between "old" and "new" SGSNs and "old" and "new" MSC/VLRs. The details of this combined GPRS/IMSI attach procedure can be found in 3GPP TS23.060.

PDP Context Activation Procedures

The following figure provides a high-level view of the PDP Context Activation procedure performed by the SGSN to establish PDP contexts for the MS with a BSS-Gb interface connection or a UE with a UTRAN-Iu interface connection.

Figure 9: Call Flow for PDP Context Activation



335132

The following table provides detailed explanations for each step indicated in the figure above.

Table 3: PDP Context Activation Procedure

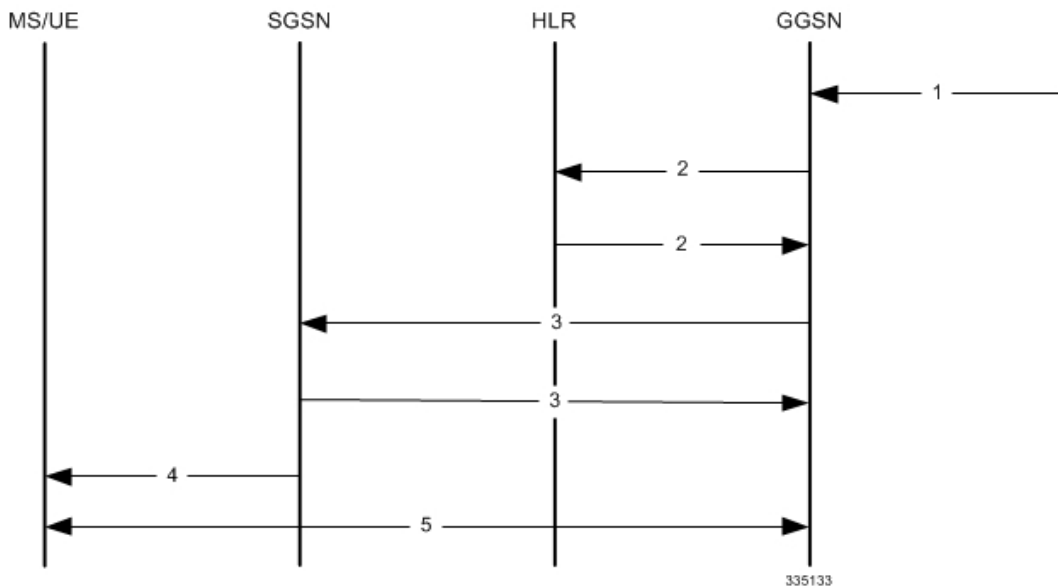
Step	Description
1	The MS/UE sends a PDP Activation Request message to the SGSN containing an Access Point Name (APN).
2	The SGSN sends a DNS query to resolve the APN provided by the MS/UE to a GGSN address. The DNS server provides a response containing the IP address of a GGSN.
3	The SGSN sends a Create PDP Context Request message to the GGSN containing the information needed to authenticate the subscriber and establish a PDP context.
4	If required, the GGSN performs authentication of the subscriber.

Step	Description
5	If the MS/UE requires an IP address, the GGSN may allocate one dynamically via DHCP.
6	The GGSN sends a Create PDP Context Response message back to the SGSN containing the IP Address assigned to the MS/UE.
7	The SGSN sends a Activate PDP Context Accept message to the MS/UE along with the IP Address. Upon PDP Context Activation, the SGSN begins generating S-CDRs. The S-CDRs are updated periodically based on Charging Characteristics and trigger conditions. A GTP-U tunnel is now established and the MS/UE can send and receive data.

Network-Initiated PDP Context Activation Process

In some cases, the GGSN receives information that requires it to request the MS/UE to activate a PDP context. The network, or the GGSN in this case, is not actually initiating the PDP context activation -- it is requesting the MS/UE to activate the PDP context in the following procedure:

Figure 10: Network-Initiated PDP Context Activation



The table below provides details describing the steps indicated in the graphic above.

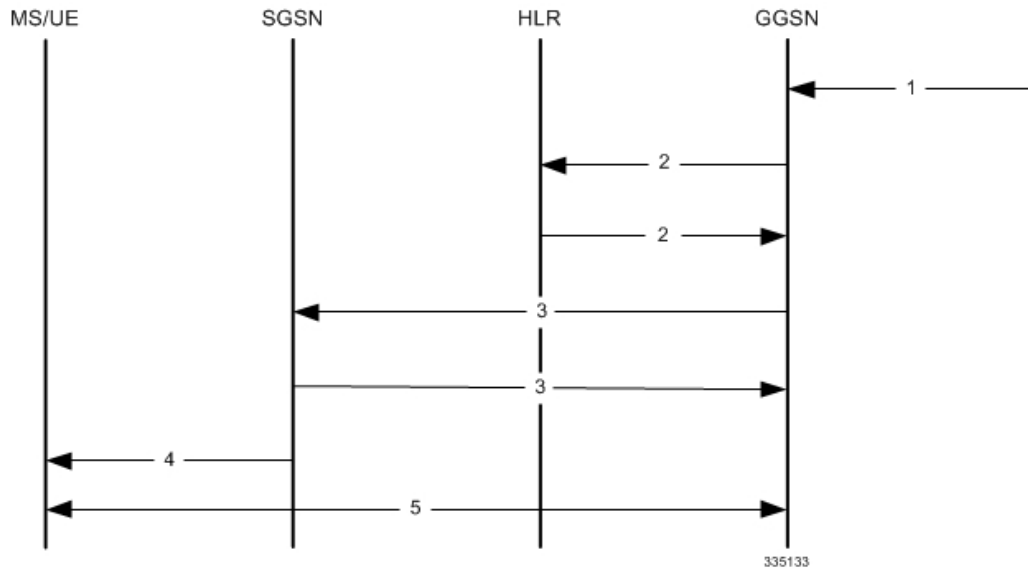
Table 4: Network Invites MS/UE to Activate PDP Context

Step	Description
1	The GGSN receives a PDU with a static PDP address that the GGSN 'knows' is for an MS/UE in its PLMN.
2	<p>The GGSN uses the IMSI in place of the PDP address and sends an SRI (send routing information for GPRS) to the HLR.</p> <p>The HLR sends an SRI response back to the GGSN. The response may include the access of the target SGSN and it may also indicate if the MS/UE is not reachable, in which case it will include the reason in the response message.</p>
3	<p>The GGSN sends a PDU Notification Request to the SGSN (if the address was received). If the address was not received or if the MS/UE continues to be unreachable, the GGSN sets a flag marking that the MS/UE was unreachable.</p> <p>The notified SGSN sends a PDU Notification Response to the GGSN.</p>
4	The SGSN determines the MS UE's location and sets up a NAS connection with the MS/UE. The SGSN then sends a Request PDP Context Activation message to the MS/UE.
5	If the MS/UE accepts the invitation to setup a PDP context, the MS/UE then begins the PDP context activation process indicated in the preceding procedure.

MS-Initiated Detach Procedure

This process is initiated by the MS/UE for a range of reasons and results in the MS/UE becoming inactive as far as the network is concerned.

Figure 11: MS-Initiated Combined GPRS/IMSI Detach



The following table provides details for the activity involved in each step noted in the diagram above.

Table 5: MS-Initiated Combined GPRS/IMSI Detach Procedure

Step	Description
1	The UE sends a Detach Request message to the SGSN containing the Detach Type, P-TMSI, P-TMSI Signature, and Switch off indicator (i.e. if UE is detaching because of a power off).
2	The SGSN sends Delete PDP Context Request message to the GGSN containing the TEID. The GGSN sends a Delete PDP Context Response back to the SGSN. The SGSN stops generating S-CDR info at the end of the PDP context.
3	The SGSN sends a IMSI Detach Indication message to the MSC/VLR.
4	The SGSN sends a GPRS Detach Indication message to the MSC/VLR. The SGSN stops generating M-CDR upon GPRS Detach.
5	If the detach is not due to a UE switch off, the SGSN sends a Detach Accept message to the UE.
6	Since the UE GPRS Detached, the SGSN releases the Packet Switched Signaling Connection.

Supported Standards

The SGSN services comply with the following standards for GPRS/UMTS and EPC wireless data services.

IETF Requests for Comments (RFCs)

- **RFC-1034**, Domain Names - Concepts and Facilities, November 1987; 3GPP TS 24.008 v7.8.0 (2007-06)
- **RFC-1035**, Domain Names - Implementation and Specification, November 1987; 3GPP TS 23.003 v7.4.0 (2007-06)
- **RFC-2960**, Stream Control Transmission Protocol (SCTP), October 2000; 3GPP TS 29.202 v6.0.0 (2004-12)
- **RFC-3332**, MTP3 User Adaptation Layer (M3UA), September 2002; 3GPP TS 29.202 v6.0.0 (2004-12)
- **RFC-4187**, Extensible Authentication Protocol Method for 3rd Generation Authentication and Key Agreement (EAP-AKA), January 2006
- **RFC-4666**, Signaling System 7 (SS7) Message Transfer Part 3 (MTP3) - User Adaptation Layer (M3UA), September 2006; 3GPP TS 29.202 v6.0.0 (2004-12)

3GPP Standards

Table 6: 3GPP Standards Supported

3GPP Standard	R21.2	R21.3	R21.4
3GPP TS 9.60 , 3rd Generation Partnership Project; Technical Specification Group Core Network; General Packet Radio Service (GPRS); GPRS Tunnelling Protocol (GTP) across the Gn and Gp Interface (R98).	v7.10.0 (2002-12)	v7.10.0 (2002-12)	v7.10.0 (2002-12)
3GPP TS 22.041 , 3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; Operator Determined Barring (ODB)	v9.0.0 (2009-12)	v9.0.0 (2009-12)	v9.0.0 (2009-12)

3GPP Standard	R21.2	R21.3	R21.4
3GPP TS 22.042 , 3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; Network Identity and Timezone (NITZ); Service description, Stage 1	v9.0.0 (2009-12)	v9.0.0 (2009-12)	v9.0.0 (2009-12)
3GPP TS 23.003 , 3rd Generation Partnership Project; Technical Specification Group Core Network and Terminals; Numbering, addressing and identification	v10.5.0 (2012-03)	v10.5.0 (2012-03)	v10.5.0 (2012-03)
3GPP TS 23.007 , 3rd Generation Partnership Project; Technical Specification Group Core Network; Restoration procedures	v11.8.0 (2014-03)	v11.8.0 (2014-03)	v11.8.0 (2014-03)
3GPP TS 23.015 , 3rd Generation Partnership Project; Technical Specification Group Core Network; Technical realization of Operator Determined Barring (ODB)	v9.0.0 (2009-12)	v9.0.0 (2009-12)	v9.0.0 (2009-12)
3GPP TS 23.016 , 3rd Generation Partnership Project; Technical Specification Group Core Network; Subscriber data management; Stage 2	v9.1.0 (2010-03)	v9.1.0 (2010-03)	v9.1.0 (2010-03)
3GPP TS 23.040 , 3rd Generation Partnership Project; Technical Specification Group Core Network and Terminals; Technical realization of the Short Message Service (SMS)	v9.3.0 (2010-09)	v9.3.2 (2010-09)	v9.3.2 (2010-09)

3GPP Standard	R21.2	R21.3	R21.4
3GPP TS 23.060 , 3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; General Packet Radio Service (GPRS); Service description; Stage 2	v11.9.0 (2014-03)	v11.9.0 (2014-03)	v11.9.0 (2014-03)
3GPP TS 23.078 , 3rd Generation Partnership Project; Technical Specification Group Core Network; Customized Applications for Mobile network Enhanced Logic (CAMEL) Phase 3 - Stage 2 (Release 4)	v4.11.1 (2004-04)	v4.11.1 (2004-04)	v4.11.1 (2004-04)
3GPP TS 23.107 , 3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; Quality of Service (QoS) concept and architecture	v9.3.0 (2011-12)	v12.0.0 (2011-12)	v12.0.0 (2011-12)
3GPP TS 23.236 , 3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; Intra-domain connection of Radio Access Network (RAN) nodes to multiple Core Network (CN) nodes	v11.0.0(2012-09)	v11.0.0(2012-09)	v11.0.0(2012-09)
3GPP TS 23.251 , 3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; Network Sharing; Architecture and functional description	v10.5.0 (2012-12)	v10.5.0 (2012-12)	v10.5.0 (2012-12)

3GPP Standard	R21.2	R21.3	R21.4
3GPP TS 23.271 , 3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; Functional stage 2 description of Location Services (LCS) (Release 9)	v9.6.0 (2011-03)	v9.6.0 (2011-03)	v9.6.0 (2011-03)
3GPP TS 23.401 , 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 9)	v11.9.0 (2014-03-10)	v10.8.0 (2014-03-10)	v10.8.0 (2014-03-10)
3GPP TS 24.007 , 3rd Generation Partnership Project; Technical Specification Group Core Network; Mobile radio interface signalling layer 3; General aspects	v10.0.0 (2011-03)	v10.0.0 (2011-03)	v10.0.0 (2011-03)
3GPP TS 24.008 , 3rd Generation Partnership Project; Technical Specification Group Core Network and Terminals; Mobile radio interface Layer 3 specification; Core network protocols; Stage 3	v11.8.0 (2013-09)	v11.8.0 (2013-09)	v11.8.0 (2013-09)
3GPP TS 24.011 , 3rd Generation Partnership Project; Technical Specification Group Core Network and Terminals; Point-to-Point (PP) Short Message Service (SMS) support on mobile radio interface (Release 7)	v7.1.0 (2009-2006)	v7.1.0 (2009-2006)	v7.1.0 (2009-2006)

3GPP Standard	R21.2	R21.3	R21.4
3GPP TS 24.030 , 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 9)	v10.0.0 (2011-04)	v10.0.0 (2011-04)	v10.0.0 (2011-04)
3GPP TS 24.080 , 3rd Generation Partnership Project; Technical Specification Group Core Network and Terminals; Mobile radio interface layer 3 supplementary services specification; Formats and coding (Release 9)	v9.2.0 (2010-06)	v9.2.0 (2010-06)	v9.2.0 (2010-06)
3GPP TS 25.410 , 3rd Generation Partnership Project; Technical Specification Group Radio Access Network; UTRAN Iu Interface: general aspects and principles	v9.0.1 (2011-03)	v9.0.1 (2011-03)	v9.0.1 (2011-03)
3GPP TS 25.411 , 3rd Generation Partnership Project; Technical Specification Group Radio Access Network; UTRAN Iu interface layer 1	v9.0.1 (2011-03)	v9.1.0 (2011-03)	v9.1.0 (2011-03)
3GPP TS 25.412 , 3rd Generation Partnership Project; Technical Specification Group Radio Access Network; UTRAN Iu interface signaling transport	v9.0.1 (2011-03)	v9.0.1 (2011-03)	v9.0.1 (2011-03)

3GPP Standard	R21.2	R21.3	R21.4
3GPP TS 25.413 , 3rd Generation Partnership Project; Technical Specification Group Radio Access Network; UTRAN Iu interface RANAP signalling (Release 9)	12.0.0 (2013-12)	12.0.0 (2013-12)	12.0.0 (2013-12)
3GPP TS 25.414 , 3rd Generation Partnership Project; Technical Specification Group Radio Access Network; UTRAN Iu interface data transport and transport signaling	v9.0.1 (2011-03)	v9.1.0 (2011-03)	v9.1.0 (2011-03)
3GPP TS 25.415 , 3rd Generation Partnership Project; Technical Specification Group Radio Access Network; UTRAN Iu interface user plane protocols	v9.0.1 (2011-03)	v9.0.1 (2011-03)	v9.0.1 (2011-03)
3GPP TS 29.002 , 3rd Generation Partnership Project; Technical Specification Group Core Network and Terminals; Mobile Application Part (MAP) specification	v12.0.0 (2013-03)	v12.0.0 (2013-03)	v12.0.0 (2013-03)
3GPP TS 29.016 , 3rd Generation Partnership Project; Technical Specification Group Core Network; General Packet Radio Service (GPRS); Serving GPRS Support Node (SGSN) - Visitors Location Register (VLR); Gs interface network service specification	v8.0.0 (2008-12)	v8.0.0 (2008-12)	v8.0.0 (2008-12)

3GPP Standard	R21.2	R21.3	R21.4
3GPP TS 29.018 , 3rd Generation Partnership Project; Technical Specification Group Core Network and Terminals; General Packet Radio Service (GPRS); Serving GPRS Support Node (SGSN) - Visitors Location Register (VLR) Gs interface layer 3 specification	v10.7.0 (2012-09)	v10.7.0 (2012-09)	v10.7.0 (2012-09)
3GPP TS 29.060 , 3rd Generation Partnership Project; Technical Specification Group Core Network and Terminals; General Packet Radio Service (GPRS); GPRS Tunnelling Protocol (GTP) across the Gn and Gp interface	v12.0.0 (2013-03)	v12.0.0 (2013-03)	v12.0.0 (2013-03)
3GPP TS 29.078 , 3rd Generation Partnership Project; Technical Specification Group Core Network; Customized Applications for Mobile network Enhanced Logic (CAMEL) Phase 3; CAMEL Application Part (CAP) specification (Release 4)	v4.9.0 (2009-2009)	v4.9.0 (2009-2009)	v4.9.0 (2009-2009)
3GPP TS 29.202 , 3rd Generation Partnership Project; Technical Specification Group Core Network and Terminals; SS7 Signalling Transport in Core Network; Stage 3	v8.0.0 (2007-06)	v8.0.0 (2007-06)	v8.0.0 (2007-06)

3GPP Standard	R21.2	R21.3	R21.4
3GPP TS 29.272 , 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 9)	v12.0.0 (2013-03)	v12.0.0 (2013-03)	v12.0.0 (2013-03)
3GPP TS 29.274 , 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 (Release 9)	v11.9.0 (2013-12)	v11.9.0 (2013-12)	v11.9.0 (2013-12)
3GPP TS 29.303 , 3rd Generation Partnership Project; Technical Specification Group Core Network and Terminals; Domain Name System Procedures; Stage 3 (Release 9)	v10.4.0 (2012-09)	v10.4.0 (2012-09)	v10.4.0 (2012-09)
3GPP TS 32.215 , 3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; Telecommunication management; Charging management; Charging data description for the Packet Switched (PS) domain	v5.9.0 (2007-10)	v5.9.0 (2007-10)	v5.9.0 (2007-10)

3GPP Standard	R21.2	R21.3	R21.4
3GPP TS 32.251 , 3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; Telecommunication management; Charging management; Packet Switched (PS) domain charging	v9.8.0	v9.8.0	v9.8.0
3GPP TS 32.298 , 3rd Generation Partnership Project; Technical Specification Group Service and System Aspects; Telecommunication management; Charging management; Charging Data Record (CDR) parameter description	v8.7.0 (2009-2012)- Fully compliant v9.6.0 (2010-2012) - Partially complaint (IMSI unAuth and CSG Information not supported)	v8.7.0 (2009-2012)- Fully compliant v9.6.0 (2010-2012) - Partially complaint (IMSI unAuth and CSG Information not supported)	v8.7.0 (2009-2012)- Fully compliant v9.6.0 (2010-2012) - Partially complaint (IMSI unAuth and CSG Information not supported)
3GPP TS 32.406 , 3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; Telecommunication management; Performance Management (PM); Performance measurements Core Network (CN) Packet Switched (PS) domain	v9.0.0 (2009-12)	v9.0.0 (2009-12)	v9.0.0 (2009-12)
3GPP TS 32.410 , 3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; Telecommunication management; Key Performance Indicators (KPI) for UMTS and GSM	v9.0.0 (2009-09)	v9.0.0 (2009-09)	v9.0.0 (2009-09)

3GPP Standard	R21.2	R21.3	R21.4
3GPP TS 33.102 , 3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; 3G Security; Security architecture	v9.4.0 (2010-12)	v9.4.0 (2010-12)	v9.4.0 (2010-12)
3GPP TS 33.106 , 3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; 3G security; Lawful Interception requirements	v9.0.0 (2009-12)	v9.0.0 (2009-12)	v9.0.0 (2009-12)
3GPP TS 33.107 , 3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; 3G security; Lawful interception architecture and functions	v9.4.0 (2011-03)	v9.4.0 (2011-03)	v9.4.0 (2011-03)
3GPP TS 33.108 , 3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; 3G security; Handover interface for Lawful Interception (LI) (Release 7)	v7.10.0 (2010-2012)	v7.10.0 (2010-2012)	v7.10.0 (2010-2012)
3GPP TS 44.064 , 3rd Generation Partnership Project; Technical Specification Group Core Network and Terminals; Mobile Station - Serving GPRS Support Node (MS-SGSN); Logical Link Control (LLC) layer specification	v9.1.0 (2011-12)	v9.1.0 (2011-12)	v9.1.0 (2011-12)

3GPP Standard	R21.2	R21.3	R21.4
3GPP TS 44.065 , 3rd Generation Partnership Project; Technical Specification Group Core Network and Terminals; Mobile Station (MS) - Serving GPRS Support Node (SGSN); Subnetwork Dependent Convergence Protocol (SND CP)	v9.0.0 (2009-12)	v9.0.0 (2009-12)	v9.0.0 (2009-12)
3GPP TS 48.014 , 3rd Generation Partnership Project; Technical Specification Group GSM EDGE Radio Access Network; General Packet Radio Service (GPRS); Base Station System (BSS) - Serving GPRS Support Node (SGSN) interface; Gb interface Layer 1	v9.0.0 (2009-12)	v9.0.0 (2009-12)	v9.0.0 (2009-12)
3GPP TS 48.016 , 3rd Generation Partnership Project; Technical Specification Group GSM EDGE Radio Access Network; General Packet Radio Service (GPRS); Base Station System (BSS) - Serving GPRS Support Node (SGSN) interface; Network Service	v9.0.0 (2009-12)	v9.0.0 (2009-12)	v9.0.0 (2009-12)

3GPP Standard	R21.2	R21.3	R21.4
3GPP TS 48.018 , 3rd Generation Partnership Project; Technical Specification Group GSM/EDGE Radio Access Network; General Packet Radio Service (GPRS); Base Station System (BSS) - Serving GPRS Support Node (SGSN); BSS GPRS Protocol (BSSGP) (Release 7)	v11.5.0 (2013-11)	v13.1.0 (2016-04)	v13.1.0 (2016-04)

ITU Standards

- **Q711**; 3GPP TS 29.002 v7.15.0 (2006-2010), 3GPP TS 29.016 v7.0.0 (2007-08), and 3GPP TS 25.410 v7.0.0 (2006-03)
- **Q712**; 3GPP TS 29.002 v7.15.0 (2006-2010), 3GPP TS 29.016 v7.0.0 (2007-08), and 3GPP TS 25.410 v7.0.0 (2006-03)
- **Q713**; 3GPP TS 29.002 v7.15.0 (2006-2010), 3GPP TS 29.016 v7.0.0 (2007-08), and 3GPP TS 25.410 v7.0.0 (2006-03)
- **Q714**; 3GPP TS 29.002 v7.15.0 (2006-2010), 3GPP TS 29.016 v7.0.0 (2007-08), and 3GPP TS 25.410 v7.0.0 (2006-03)
- **Q715**; 3GPP TS 29.002 v7.15.0 (2006-2010), 3GPP TS 29.016 v7.0.0 (2007-08), and 3GPP TS 25.410 v7.0.0 (2006-03)
- **Q716**; 3GPP TS 29.002 v7.15.0 (2006-2010), 3GPP TS 29.016 v7.0.0 (2007-08), and 3GPP TS 25.410 v7.0.0 (2006-03)
- **Q771**; 3GPP TS 29.002 v7.15.0 (2006-2010)
- **Q772**; 3GPP TS 29.002 v7.15.0 (2006-2010)
- **Q773**; 3GPP TS 29.002 v7.15.0 (2006-2010)
- **Q774**; 3GPP TS 29.002 v7.15.0 (2006-2010)
- **Q775**; 3GPP TS 29.002 v7.15.0 (2006-2010)

Object Management Group (OMG) Standards

- CORBA 2.6 Specification 01-09-35, Object Management Group