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1 Foreword

Digital cellular networks based on the GSM specification were designed in the late 1980ies and first deployed in the early 1990ies in Europe. Over the last 25 years, hundreds of networks were established globally and billions of subscribers have joined the associated networks.

The technological foundation of GSM was based on multi-vendor interoperable standards, first created by government bodies within CEPT, then handed over to ETSI, and now in the hands of 3GPP. Nevertheless, for the first 17 years of GSM technology, the associated protocol stacks and network elements have only existed in proprietary black-box implementations and not as Free Software.

In 2008 Dieter Spaar and I started to experiment with inexpensive end-of-life surplus Siemens GSM BTSs. We learned about the A-bis protocol specifications, reviewed protocol traces and started to implement the BSC-side of the A-bis protocol as something originally called bs11-abis. All of this was just for fun, in order to learn more and to boldly go where no Free Software developer has gone before. The goal was to learn and to bring Free Software into a domain that despite its ubiquity, had not yet seen any Free / Open Source software implementations.

bs11-abis quickly turned into bsc-hack, then OpenBSC and its OsmoNITB variant: A minimal implementation of all the required functionality of an entire GSM network, exposing A-bis towards the BTS. The project attracted more interested developers, and surprisingly quickly also commercial interest, contribution and adoption. This allowed adding support for more BTS models.

After having implemented the network-side GSM protocol stack in 2008 and 2009, in 2010 the same group of people set out to create a telephone-side implementation of the GSM protocol stack. This established the creation of the Osmocom umbrella project, under which OpenBSC and the OsmocomBB projects were hosted.

Meanwhile, more interesting telecom standards were discovered and implemented, including TETRA professional mobile radio, DECT cordless telephony, GMR satellite telephony, some SDR hardware, a SIM card protocol tracer and many others.

Increasing commercial interest particularly in the BSS and core network components has lead the way to 3G support in Osmocom, as well as the split of the minimal OsmoNITB implementation into separate and fully featured network components: OsmoBSC, OsmoMSC, OsmoHLR, OsmoMGW and OsmoSTP (among others), which allow seamless scaling from a simple “Network In The Box” to a distributed installation for serious load.

It has been a most exciting ride during the last eight-odd years. I would not have wanted to miss it under any circumstances.

— Harald Welte, Osmocom.org and OpenBSC founder, December 2017.

1.1 Acknowledgements

My deep thanks to everyone who has contributed to Osmocom. The list of contributors is too long to mention here, but I’d like to call out the following key individuals and organizations, in no particular order:

• Dieter Spaar for being the most amazing reverse engineer I’ve met in my career
• Holger Freyther for his many code contributions and for shouldering a lot of the maintenance work, setting up Jenkins - and being crazy enough to co-start sysmocom as a company with me :) 
• Andreas Eversberg for taking care of Layer2 and Layer3 of OsmocomBB, and for his work on OsmoBTS and OsmoPCU
• Sylvain Munaut for always tackling the hardest problems, particularly when it comes closer to the physical layer
• Chaos Computer Club for providing us a chance to run real-world deployments with tens of thousands of subscribers every year
• Bernd Schneider of Netzing AG for funding early ip.access nanoBTS support
• On-Waves ehf for being one of the early adopters of OpenBSC and funding a never ending list of features, fixes and general improvement of pretty much all of our GSM network element implementations
• sysmocom, for hosting and funding a lot of Osmocom development, the annual Osmocom Developer Conference and releasing this manual.
• Jan Luebbe, Stefan Schmidt, Daniel Willmann, Pablo Neira, Nico Golde, Kevin Redon, Ingo Albrecht, Alexander Huemer, Alexander Chemeris, Max Suraev, Tobias Engel, Jacob Erlbeck, Ivan Kluchnikov

May the source be with you!
— Harald Welte, Osmocom.org and OpenBSC founder, January 2016.

1.2 Endorsements

This version of the manual is endorsed by Harald Welte as the official version of the manual. While the GFDL license (see Appendix C) permits anyone to create and distribute modified versions of this manual, such modified versions must remove the above endorsement.

2 Preface

First of all, we appreciate your interest in Osmocom software.

Osmocom is a Free and Open Source Software (FOSS) community that develops and maintains a variety of software (and partially also hardware) projects related to mobile communications.

Founded by people with decades of experience in community-driven FOSS projects like the Linux kernel, this community is built on a strong belief in FOSS methodology, open standards and vendor neutrality.

2.1 FOSS lives by contribution!

If you are new to FOSS, please try to understand that this development model is not primarily about “free of cost to the GSM network operator”, but it is about a collaborative, open development model. It is about sharing ideas and code, but also about sharing the effort of software development and maintenance.

If your organization is benefitting from using Osmocom software, please consider ways how you can contribute back to that community. Such contributions can be many-fold, for example

• sharing your experience about using the software on the public mailing lists, helping to establish best practises in using/operating it,
• providing qualified bug reports, work-arounds
• sharing any modifications to the software you may have made, whether bug fixes or new features, even experimental ones
• providing review of patches
• testing new versions of the related software, either in its current “master” branch or even more experimental feature branches
• sharing your part of the maintenance and/or development work, either by donating developer resources or by (partially) funding those people in the community who do.

We’re looking forward to receiving your contributions.

2.2 Osmocom and sysmocom

Some of the founders of the Osmocom project have established sysmocom - systems for mobile communications GmbH as a company to provide products and services related to Osmocom.

sysmocom and its staff have contributed by far the largest part of development and maintenance to the Osmocom mobile network infrastructure projects.

As part of this work, sysmocom has also created the manual you are reading.

At sysmocom, we draw a clear line between what is the Osmocom FOSS project, and what is sysmocom as a commercial entity. Under no circumstances does participation in the FOSS projects require any commercial relationship with sysmocom as a company.
2.3 Corrections

We have prepared this manual in the hope that it will guide you through the process of installing, configuring and debugging your deployment of cellular network infrastructure elements using Osmocom software. If you do find errors, typos and/or omissions, or have any suggestions on missing topics, please do take the extra time and let us know.

2.4 Legal disclaimers

2.4.1 Spectrum License

As GSM and UMTS operate in licensed spectrum, please always double-check that you have all required licenses and that you do not transmit on any ARFCN or UARFCN that is not explicitly allocated to you by the applicable regulatory authority in your country.

⚠️ Warning
Depending on your jurisdiction, operating a radio transmitter without a proper license may be considered a felony under criminal law!

2.4.2 Software License

The software developed by the Osmocom project and described in this manual is Free / Open Source Software (FOSS) and subject to so-called copyleft licensing.

Copyleft licensing is a legal instrument to ensure that this software and any modifications, extensions or derivative versions will always be publicly available to anyone, for any purpose, under the same terms as the original program as developed by Osmocom.

This means that you are free to use the software for whatever purpose, make copies and distribute them - just as long as you ensure to always provide/release the complete and corresponding source code.

Every Osmocom software includes a file called COPYING in its source code repository which explains the details of the license. The majority of programs is released under GNU Affero General Public License, Version 3 (AGPLv3).

If you have any questions about licensing, don’t hesitate to contact the Osmocom community. We’re more than happy to clarify if your intended use case is compliant with the software licenses.

2.4.3 Trademarks

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For your convenience we have listed below some of the registered trademarks referenced herein. This is not a definitive or complete list of the trademarks used.

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sysmocom® and sysmoBTS® are registered trademarks of sysmocom - systems for mobile communications GmbH.

ip.access® and nanoBTS® are registered trademarks of ip.access Ltd.

2.4.4 Liability

The software is distributed in the hope that it will be useful, but WITHOUT ANY WARRANTY; without even the implied warranty of MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE. See the License text included with the software for more details.
2.4.5 Documentation License

Please see Appendix C for further information.

3 Introduction

3.1 Required Skills

Please note that even while the capital expenses of running mobile networks has decreased significantly due to Osmocom software and associated hardware like sysmoBTS, GSM networks are still primarily operated by large GSM operators.

Neither the GSM specification nor the GSM equipment was ever designed for networks to be installed and configured by anyone but professional GSM engineers, specialized in their respective area like radio planning, radio access network, back-haul or core network.

If you do not share an existing background in GSM network architecture and GSM protocols, correctly installing, configuring and optimizing your GSM network will be tough, irrespective whether you use products with Osmocom software or those of traditional telecom suppliers.

GSM knowledge has many different fields, from radio planning through site installation to core network configuration/administration.

The detailed skills required will depend on the type of installation and/or deployment that you are planning, as well as its associated network architecture. A small laboratory deployment for research at a university is something else than a rural network for a given village with a handful of cells, which is again entirely different from an urban network in a dense city.

Some of the useful skills we recommend are:

- general understanding about RF propagation and path loss in order to estimate coverage of your cells and do RF network planning.
- general understanding about GSM network architecture, its network elements and key transactions on the Layer 3 protocol
- general understanding about voice telephony, particularly those of ISDN heritage (Q.931 call control)
- understanding of GNU/Linux system administration and working on the shell
- understanding of TCP/IP networks and network administration, including tcpdump, tshark, wireshark protocol analyzers.
- ability to work with text based configuration files and command-line based interfaces such as the VTY of the Osmocom network elements

3.2 Getting assistance

If you do have a support package / contract with sysmocom (or want to get one), please contact support@sysmocom.de with any issues you may have.

If you don’t have a support package / contract, you have the option of using the resources put together by the Osmocom community at http://projects.osmocom.org/, checking out the wiki and the mailing-list for community-based assistance. Please always remember, though: The community has no obligation to help you, and you should address your requests politely to them. The information (and software) provided at osmocom.org is put together by volunteers for free. Treat them like a friend whom you’re asking for help, not like a supplier from whom you have bought a service.
4 Overview

4.1 About OsmoSGSN

OsmoSGSN is the Osmocom implementation of the GPRS SGSN (Serving Gprs Support Node) element inside the GPRS network. The SGSN plays a similar central function to the GPRS network as the MSC plays in the GSM network.

The SGSN is connected on the downlink side to Gb interfaces of the BSS, specifically the PCU inside the BSS. The SGSN is further connected by the GTP protocol to the GGSN which terminates the tunnels towards the external packet data network (e.g. IPv4).

OsmoSGSN supports both a PCU that is co-located with(in) the BTS, as well as a PCU that is co-located with(in) the BSC. In combination with OsmoNITB/OsmoBSC/OsmoBTS, the PCU is co-located within the BTS.

![Figure 1: GPRS network architecture with PCU in BTS](image_url)

4.2 Software Components

OsmoSGSN contains a variety of different software components, which we’ll quickly describe in this section.

4.2.1 Gb Implementation

OsmoSGSN implements the ETSI/3GPP specified Gb interface, including TS 08.16 (NS), TS 08.18 (BSSGP) and TS 08.64 (LLC) protocols. As transport layers for NS, it supports NS/IP (NS encapsulated in UDP/IP), as well as NS/FR/GRE/IP. The latter is provided in order to use a Router with Ethernet and Frame Relay interface to convert to actual physical Frame Relay medium, which is not directly supported by OsmoSGSN.

The actual Gb Implementation is part of the libosmogb library, which is in turn part of the libosmocore software package. This allows the same Gb implementation to be used from osmo-pcu, osmo-gbproxy as well as OsmoSGSN.

4.2.2 GTP Implementation

OsmoSGSN uses the libgtp implementation originating from OsmoGGSN. It supports both GTPv0 and GTPv1.

4.2.3 GMM Implementation

The GPRS Mobility Management implementation is quite simplistic at this point. It supports the GPRS ATTACH and GPRS ROUTING AREA UPDATE procedures, as well as GPRS ATTACH and GPRS DETACH.

4.2.4 LLC Implementation

The LLC (Logical Link Control) implementation of OsmoSGSN only supports non-acknowledged mode, as this is the most common use case in real-world GPRS networks.

It supports both TCP/IP header compression according to RFC1144 and payload compression according to V.42bis.

The LLC implementation does support LLC encryption with ciphers GEA3 and GEA4. For encryption to work the auth policy needs to be set to remote and the SGSN connected to an HLR containing the subscriber data including key material. Other auth policies will not work with encryption.
4.2.5 Session Management Implementation

The session management procedures ACTIVATE PDP CONTEXT and DEACTIVATE PDP CONTEXT are supported. However, no MODIFY PDP CONTEXT and no Network-initiated PDP context activation is possible. This is again covering the predominant use cases and configurations in GPRS real-world networks while skipping the more esoteric features.

Multiple PDP contexts can be attached by a single MS.

Multiple GGSNs can be configured and routing to a GGSN can be configured based on APN. Dynamic lookup of GGSNs though DNS-based APN resolving is also possible.

4.3 Limitations

At the time of writing, OsmoSGSN still has a number of limitations, which are a result of the demand-driven Open Source development model. If you require any of those features, please consider implementing and contributing them, or contracting the existing OsmoSGSN developers for performing that work.

Known Limitations include:

- No paging coordination between SGSN and MSC
- No SMS over Ps support

5 Running OsmoSGSN

The OsmoSGSN executable (osmo-sgsn) offers the following command-line options:

5.1 SYNOPSIS

```bash
```

5.2 OPTIONS

- **-h, --help**
  
  Print a short help message about the supported options

- **-V, --version**
  
  Print the compile-time version number of the OsmoSGSN program

- **-d, --debug DBGMASK,DBGLEVELS**
  
  Set the log subsystems and levels for logging to stderr. This has mostly been superseded by VTY-based logging configuration, see Section 8 for further information.

- **-D, --daemonize**
  
  Fork the process as a daemon into background.

- **-c, --config-file CONFIGFILE**
  
  Specify the file and path name of the configuration file to be used. If none is specified, use osmo_sgsn.cfg in the current working directory.

- **-s, --disable-color**
  
  Disable colors for logging to stderr. This has mostly been deprecated by VTY based logging configuration, see Section 8 for more information.

- **-e, --log-level LOGLEVEL**
  
  Set the global log level for logging to stderr. This has mostly been deprecated by VTY based logging configuration, see Section 8 for more information.
6 Control interface

The actual protocol is described in Section 11, the variables common to all programs using it are described in Section 11.2. Here we describe variables specific to OsmoSGSN.

Table 1: Variables available over control interface

<table>
<thead>
<tr>
<th>Name</th>
<th>Access</th>
<th>Trap</th>
<th>Value</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>subscriber-list-active-v1</td>
<td>RO</td>
<td>No</td>
<td>&quot;&lt;imsi&gt;,&lt;addr&gt;&quot;</td>
<td>See Section 6.1 for details.</td>
</tr>
</tbody>
</table>

6.1 subscriber-list-active-v1

Return the list of active subscribers as a concatenated set of pairs "<imsi>", "addr" where first element of the pair is subscriber’s IMSI and the second element (which might be empty) is the subscriber’s address. The address value might be "none", "invalid" and "PPP" in addition to actual IP address. In case of IP address it will be prefixed with "IPv4" or "IPv6" string depending on the version of IP protocol.

7 The Osmocom VTY Interface

All human interaction with Osmocom software is typically performed via an interactive command-line interface called the VTY.

Note

Integration of your programs and scripts should not be done via the telnet VTY interface, which is intended for human interaction only: the VTY responses may arbitrarily change in ways obvious to humans, while your scripts’ parsing will likely break often. For external software to interact with Osmocom programs (besides using the dedicated protocols), it is strongly recommended to use the Control interface instead of the VTY, and to actively request / implement the Control interface commands as required for your use case.

The interactive telnet VTY is used to

- explore the current status of the system, including its configuration parameters, but also to view run-time state and statistics,
- review the currently active (running) configuration,
- perform interactive changes to the configuration (for those items that do not require a program restart),
- store the current running configuration to the config file,
- enable or disable logging; to the VTY itself or to other targets.

The Virtual Tele Type (VTY) has the concept of nodes and commands. Each command has a name and arguments. The name may contain a space to group several similar commands into a specific group. The arguments can be a single word, a string, numbers, ranges or a list of options. The available commands depend on the current node. there are various keyboard shortcuts to ease finding commands and the possible argument values.

Configuration file parsing during program start is actually performed the VTY’s CONFIG node, which is also available in the telnet VTY. Apart from that, the telnet VTY features various interactive commands to query and instruct a running Osmocom program. A main difference is that during config file parsing, consistent indenting of parent vs. child nodes is required, while the interactive VTY ignores indenting and relies on the exit command to return to a parent node.
Note

In the CONFIG node, it is not well documented which commands take immediate effect without requiring a program restart. To save your current config with changes you may have made, you may use the write file command to overwrite your config file with the current configuration, after which you should be able to restart the program with all changes taking effect.

This chapter explains most of the common nodes and commands. A more detailed list is available in various programs’ VTY reference manuals, e.g. see [vty-ref-osmomsc].

There are common patterns for the parameters, these include IPv4 addresses, number ranges, a word, a line of text and choice. The following will explain the commonly used syntactical patterns:

<table>
<thead>
<tr>
<th>Pattern</th>
<th>Example</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.B.C.D</td>
<td>127.0.0.1</td>
<td>An IPv4 address</td>
</tr>
<tr>
<td>TEXT</td>
<td>example01</td>
<td>A single string without any spaces, tabs</td>
</tr>
<tr>
<td>.TEXT</td>
<td>Some information</td>
<td>A line of text</td>
</tr>
<tr>
<td>(OptionA</td>
<td>OptionB</td>
<td>OptionC)</td>
</tr>
<tr>
<td>&lt;0-10&gt;</td>
<td>5</td>
<td>A number from a range</td>
</tr>
</tbody>
</table>

7.1 Accessing the telnet VTY

The VTY of a given Osmocom program is implemented as a telnet server, listening to a specific TCP port.

Please see Appendix A to check for the default TCP port number of the VTY interface of the specific Osmocom software you would like to connect to.

As telnet is insecure and offers neither strong authentication nor encryption, the VTY by default only binds to localhost (127.0.0.1) and will thus not be reachable by other hosts on the network.

Warning

By default, any user with access to the machine running the Osmocom software will be able to connect to the VTY. We assume that such systems are single-user systems, and anyone with local access to the system also is authorized to access the VTY. If you require stronger security, you may consider using the packet filter of your operating system to restrict access to the Osmocom VTY ports further.

7.2 VTY Nodes

The VTY by default has the following minimal nodes:

**VIEW**

When connecting to a telnet VTY, you will be on the VIEW node. As its name implies, it can only be used to view the system status, but it does not provide commands to alter the system state or configuration. As long as you are in the non-privileged VIEW node, your prompt will end in a > character.

**ENABLE**

The ENABLE node is entered by the enable command, from the VIEW node. Changing into the ENABLE node will unlock all kinds of commands that allow you to alter the system state or perform any other change to it. The ENABLE node and its children are signified by a # character at the end of your prompt.

You can change back from the ENABLE node to the VIEW node by using the disable command.
The **CONFIG** node is entered by the `configure terminal` command from the **ENABLE** node. The config node is used to change the run-time configuration parameters of the system. The prompt will indicate that you are in the config node by a `(config)#` prompt suffix.

You can always leave the **CONFIG** node or any of its children by using the `end` command. This node is also automatically entered at the time the configuration file is read. All configuration file lines are processed as if they were entered from the VTY **CONFIG** node at start-up.

**Other**

Depending on the specific Osmocom program you are running, there will be few or more other nodes, typically below the **CONFIG** node. For example, the OsmoBSC has nodes for each BTS, and within the BTS node one for each TRX, and within the TRX node one for each Timeslot.

### 7.3 Interactive help

The VTY features an interactive help system, designed to help you to efficiently navigate is commands.

**Note**

The VTY is present on most Osmocom GSM/UMTS/GPRS software, thus this chapter is present in all the relevant manuals. The detailed examples below assume you are executing them on the OsmoMSC VTY. They will work in similar fashion on the other VTY interfaces, while the node structure will differ in each program.

#### 7.3.1 The question-mark (?) command

If you type a single `?` at the prompt, the VTY will display possible completions at the exact location of your currently entered command.

If you type `?` at an otherwise empty command (without having entered even only a partial command), you will get a list of the first word of all possible commands available at this node:

**Example: Typing ? at start of OsmoMSC prompt**

```
OsmoMSC> ?
  show Show running system information
  list Print command list
  exit Exit current mode and down to previous mode
  help Description of the interactive help system
  enable Turn on privileged mode command
  terminal Set terminal line parameters
  who Display who is on vty
  logging Configure logging
  no Negate a command or set its defaults
  sms SMS related commands
  subscriber Operations on a Subscriber
```

Type `?` here at the prompt, the `?` itself will not be printed.

If you have already entered a partial command, `?` will help you to review possible options of how to continue the command. Let’s say you remember that `show` is used to investigate the system status, but you don’t remember the exact name of the object. Hitting `?` after typing `show` will help out:

**Example: Typing ? after a partial command**

```
OsmoMSC> show ?
  version Displays program version
  online-help Online help
  history Display the session command history
```

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cs7
logging
alarms
talloc-context
stats
asciidoc
rate-counters
fsm
fsm-instances
sgs-connections
subscriber
bsc
counter
transaction
statistics
sms-queue
smpp

Type ? after the show command, the ? itself will not be printed.

You may pick the bsc object and type ? again:

Example: Typing ? after show bsc

```
OsmoMSC> show bsc
<cr>
```

By presenting <cr> as the only option, the VTY tells you that your command is complete without any remaining arguments being available, and that you should hit enter, a.k.a. "carriage return".

7.3.2 TAB completion

The VTY supports tab (tabulator) completion. Simply type any partial command and press <tab>, and it will either show you a list of possible expansions, or completes the command if there’s only one choice.

Example: Use of <tab> pressed after typing only s as command

```
OsmoMSC> s<tab>
```

Type <tab> here.

At this point, you may choose show, and then press <tab> again:

Example: Use of <tab> pressed after typing show command

```
OsmoMSC> show<tab>
```

Type <tab> here.
7.3.3 The list command

The list command will give you a full list of all commands and their arguments available at the current node:

Example: Typing list at start of OsmoMSC VIEW node prompt

```
OsmoMSC> list
  show version
  show online-help
  list
  exit
  help
  enable
terminal length <0-512>
terminal no length
  who
  show history
  show cs7 instance <0-15> users
  show cs7 (sua|m3ua|ipa) [<0-65534>]
  show cs7 instance <0-15> asp
  show cs7 instance <0-15> as (active|all|m3ua|sua)
  show cs7 instance <0-15> sccp addressbook
  show cs7 instance <0-15> sccp users
  show cs7 instance <0-15> sccp ssn <0-65535>
  show cs7 instance <0-15> sccp connections
  show cs7 instance <0-15> sccp timers
  logging enable
  logging disable
  logging filter all (0|1)
  logging color (0|1)
  logging timestamp (0|1)
  logging print extended-timestamp (0|1)
  logging print category (0|1)
  logging print category-hex (0|1)
  logging print level (0|1)
  logging print file [0|1|basename] [last]
  logging set-log-mask MASK
  logging level (rll|cc|mm|rr|mncc|pag|mgcp|ho|db|ref|ctrl|smpp|ranap|vlr|iu|ucs|bssap|←
  sgs|lglobal|llap|lmp|lmux|lmi|lmib|lsms|ltr|lgtp|lstats|lgup|lop|ls7|lsccp|lsa|←
  lms3a|mcc|lgcm|ljibuf|lrspro) (debug|info|notice|error|fatal)
  logging level set-all (debug|info|notice|error|fatal)
  logging level force-all (debug|info|notice|error|fatal)
  no logging level force-all
  show logging vty
  show alarms
  show talloc-context (application|all) (full|brief|DEPTH)
  show talloc-context (application|all) (full|brief|DEPTH) tree ADDRESS
  show talloc-context (application|all) (full|brief|DEPTH) filter REGEXP
  show stats
  show stats level (global|peer|subscriber)
  show asciidoc counters
  show rate-counters
  show fsm NAME
  show fsm all
  show fsm-instances NAME
  show fsm-instances all
  show sgs-connections
  show subscriber (msisdn|extension|imsi|tmsi|id) ID
  show subscriber cache
  show bsc
  show connection
  show transaction
  sms send pending
```
Tip
Remember, the list of available commands will change significantly depending on the Osmocom program you are accessing, its software version and the current node you’re at. Compare the above example of the OsmoMSC VIEW node with the list of the OsmoMSC NETWORK config node:

Example: Typing list at start of OsmoMSC NETWORK config node prompt

OsmoMSC(config-net)# list
help
list
write terminal
write file
write memory
write
show running-config
exit
end
network country code <1-999>
mobile network code <0-999>
short name NAME
long name NAME
encryption a5 <0-3> [<0-3>] [<0-3>] [<0-3>]
authentication (optional|required)
rrlp mode (none|ms-based|ms-preferred|ass-preferred)
mm info (0|1)
timezone <-19-19> (0|15|30|45)
timezone <-19-19> (0|15|30|45) <0-2>
no timezone
periodic location update <6-1530>
no periodic location update

8 libosmocore Logging System

In any reasonably complex software it is important to understand how to enable and configure logging in order to get a better insight into what is happening, and to be able to follow the course of action. We therefore ask the reader to bear with us while we explain how the logging subsystem works and how it is configured.

Most Osmocom Software (like osmo-bts, osmo-bsc, osmo-nitb, osmo-sgsn and many others) uses the same common logging system.
This chapter describes the architecture and configuration of this common logging system. The logging system is composed of

- log targets (where to log),
- log categories (who is creating the log line),
- log levels (controlling the verbosity of logging), and
- log filters (filtering or suppressing certain messages).

All logging is done in human-readable ASCII-text. The logging system is configured by means of VTY commands that can either be entered interactively, or read from a configuration file at process start time.

### 8.1 Log categories

Each sub-system of the program in question typically logs its messages as a different category, allowing fine-grained control over which log messages you will or will not see. For example, in OsmoBSC, there are categories for the protocol layers `rs1`, `rr`, `mm`, `cc` and many others. To get a list of categories interactively on the vty, type: `logging level ?`

### 8.2 Log levels

For each of the log categories (see Section 8.1), you can set an independent log level, controlling the level of verbosity. Log levels include:

- **fatal**  
  Fatal messages, causing abort and/or re-start of a process. This *shouldn’t* happen.

- **error**  
  An actual error has occurred, its cause should be further investigated by the administrator.

- **notice**  
  A noticeable event has occurred, which is not considered to be an error.

- **info**  
  Some information about normal/regular system activity is provided.

- **debug**  
  Verbose information about internal processing of the system, used for debugging purpose. This will log the most.

The log levels are inclusive, e.g. if you select `info`, then this really means that all events with a level of at least `info` will be logged, i.e. including events of `notice`, `error` and `fatal`.

So for example, in OsmoBSC, to set the log level of the Mobility Management category to `info`, you can use the following command: `log level mm info`.

There is also a special command to set all categories as a one-off to a desired log level. For example, to silence all messages but those logged as `notice` and above issue the command: `log level set-all notice`

Afterwards you can adjust specific categories as usual.

A similar command is `log level force-all <level>` which causes all categories to behave as if set to log level `<level>` until the command is reverted with `no log level force-all` after which the individually-configured log levels will again take effect. The difference between `set-all` and `force-all` is that `set-all` actually changes the individual category settings while `force-all` is a (temporary) override of those settings and does not change them.
8.3 Log printing options

The logging system has various options to change the information displayed in the log message.

**log color**
With this option each log message will log with the color of its category. The color is hard-coded and can not be changed. As with other options a `0` disables this functionality.

**log timestamp**
Includes the current time in the log message. When logging to syslog this option should not be needed, but may come in handy when debugging an issue while logging to file.

**log print extended-timestamp**
In order to debug time-critical issues this option will print a timestamp with millisecond granularity.

**log print category**
Prefix each log message with the category name.

**log print category-hex**
Prefix each log message with the category number in hex (\texttt{<000b>}).

**log print level**
Prefix each log message with the name of the log level.

**log print file**
Prefix each log message with the source file and line number. Append the keyword `last` to append the file information instead of prefixing it.

8.4 Log filters

The default behavior is to filter out everything, i.e. not to log anything. The reason is quite simple: On a busy production setup, logging all events for a given subsystem may very quickly be flooding your console before you have a chance to set a more restrictive filter.

To request no filtering, i.e. see all messages, you may use: `log filter all`

In addition to generic filtering, applications can implement special log filters using the same framework to filter on particular context.

For example in OsmoBSC, to only see messages relating to a particular subscriber identified by his IMSI, you may use: `log filter imsi 262020123456789`

8.5 Log targets

Each of the log targets represent certain destination for log messages. It can be configured independently by selecting levels (see Section 8.2) for categories (see Section 8.1) as well as filtering (see Section 8.4) and other options like `logging timestamp` for example.

8.5.1 Logging to the VTY

Logging messages to the interactive command-line interface (VTY) is most useful for occasional investigation by the system administrator.

Logging to the VTY is disabled by default, and needs to be enabled explicitly for each such session. This means that multiple concurrent VTY sessions each have their own logging configuration. Once you close a VTY session, the log target will be destroyed and your log settings be lost. If you re-connect to the VTY, you have to again activate and configure logging, if you wish.
To create a logging target bound to a VTY, you have to use the following command: `logging enable` This doesn’t really activate the generation of any output messages yet, it merely creates and attaches a log target to the VTY session. The newly-created target still doesn’t have any filter installed, i.e. all log messages will be suppressed by default.

Next, you can configure the log levels for desired categories in your VTY session. See Section 8.1 for more details on categories and Section 8.2 for the log level details.

For example, to set the log level of the Call Control category to debug, you can use: `log level cc debug`

Finally, after having configured the levels, you still need to set the filter as it’s described in Section 8.4.

---

**Tip**

If many messages are being logged to a VTY session, it may be hard to impossible to still use the same session for any commands. We therefore recommend to open a second VTY session in parallel, and use one only for logging, while the other is used for interacting with the system. Another option would be to use different log target.

---

To review the current vty logging configuration, you can use: `show logging vty`

### 8.5.2 Logging to the ring buffer

To avoid having separate VTY session just for logging output while still having immediate access to them, one can use `alarms` target. It lets you store the log messages inside the ring buffer of a given size which is available with `show alarms` command.

It’s configured as follows:

```
OsmoBSC> enable
OsmoBSC# configure terminal
OsmoBSC(config)# log alarms 98
OsmoBSC(config-log)#
```

In the example above 98 is the desired size of the ring buffer (number of messages). Once it’s filled, the incoming log messages will push out the oldest messages available in the buffer.

### 8.5.3 Logging via gsmtap

When debugging complex issues it’s handy to be able to reconstruct exact chain of events. This is enabled by using GSMTAP log output where frames sent/received over the air are intersperced with the log lines. It also simplifies the bug handling as users don’t have to provide separate .pcap and .log files anymore - everything will be inside self-contained packet dump.

It’s configured as follows:

```
OsmoBSC> enable
OsmoBSC# configure terminal
OsmoBSC(config)# log gsmtap 192.168.2.3
OsmoBSC(config-log)#
```

The hostname/ip argument is optional: if omitted the default 127.0.0.1 will be used. The log strings inside GSMTAP are already supported by Wireshark. Capturing for port 4729 on appropriate interface will reveal log messages including source file name and line number as well as application. This makes it easy to consolidate logs from several different network components alongside the air frames. You can also use Wireshark to quickly filter logs for a given subsystem, severity, file name etc.
Figure 2: Wireshark with logs delivered over GSMTAP

Note: the logs are also duplicated to stderr when GSMTAP logging is configured because stderr is the default log target which is initialized automatically. To decrease stderr logging to absolute minimum, you can configure it as follows:

```
OsmoBSC> enable
OsmoBSC# configure terminal
OsmoBSC(config)# log stderr
OsmoBSC(config-log)# logging level all fatal
```

8.5.4 Logging to a file

As opposed to Logging to the VTY, logging to files is persistent and stored in the configuration file. As such, it is configured in sub-nodes below the configuration node. There can be any number of log files active, each of them having different settings regarding levels / subsystems.

To configure a new log file, enter the following sequence of commands:

```
OsmoBSC> enable
OsmoBSC# configure terminal
OsmoBSC(config)# log file /path/to/my/file
```

This leaves you at the config-log prompt, from where you can set the detailed configuration for this log file. The available commands at this point are identical to configuring logging on the VTY, they include logging filter, logging level as well as logging color and logging timestamp.

**Tip**

Don't forget to use the `copy running-config startup-config` (or its short-hand `write file`) command to make your logging configuration persistent across application re-start.
8.5.5 Logging to syslog

syslog is a standard for computer data logging maintained by the IETF. Unix-like operating systems like GNU/Linux provide several syslog compatible log daemons that receive log messages generated by application programs.

libosmocore based applications can log messages to syslog by using the syslog log target. You can configure syslog logging by issuing the following commands on the VTY:

```
OsmoBSC> enable
OsmoBSC# configure terminal
OsmoBSC(config)# log syslog daemon
OsmoBSC(config-log)#
```

This leaves you at the config-log prompt, from where you can set the detailed configuration for this log file. The available commands at this point are identical to configuring logging on the VTY, they include `logging filter`, `logging level` as well as `logging color` and `logging timestamp`.

```
Note
Syslog daemons will normally automatically prefix every message with a time-stamp, so you should disable the libosmocore time-stamping by issuing the `logging timestamp 0` command.
```

8.5.6 Logging to stderr

If you’re not running the respective application as a daemon in the background, you can also use the stderr log target in order to log to the standard error file descriptor of the process.

In order to configure logging to stderr, you can use the following commands:

```
OsmoBSC> enable
OsmoBSC# configure terminal
OsmoBSC(config)# log stderr
OsmoBSC(config-log)#
```

9 Configuring OsmoSGSN

Contrary to other network elements (like OsmoBSC, OsmoNITB), the OsmoSGSN has a relatively simple configuration.

On the one hand, this is primary because the PCU configuration happens from the BSC side.

On the other hand, it is because the Gb interface does not need an explicit configuration of each PCU connecting to the SGSN. The administrator only has to ensure that the NS and BSSGP layer identities (NSEI, NSVCI, BVCI) are unique for each PCU connecting to the SGSN.

9.1 Configuring the Gp interface

The Gp interface is the GTP-C and GTP-U based interface between the SGSN and the GGSNs. It is implemented via UDP on well-known source and destination ports.

When an MS requests establishment of a PDP context, it specifies the APN (Access Point Name) to which the context shall be established. This APN determines which GGSN shall be used, and that in turn determines which external IP network the MS will be connected to.

There are two modes in which GGSNs can be configured:
1. static GGSN/APN configuration
2. dynamic GGSN/APN configuration

9.1.1 Static GGSN/APN configuration

In this mode, there is a static list of GGSNs and APNs configured in OsmoSGSN via the VTY / config file.

This is a non-standard method outside of the 3GPP specifications for the SGSN, and is typically only used in private/small GPRS networks without any access to a GRX.

Example: Static GGSN/APN configuration (single catch-all GGSN)

```
OsmoSGSN(config-sgsn)# gtp local-ip 172.0.0.1
OsmoSGSN(config-sgsn)# ggsn 0 remote-ip 127.0.0.2
OsmoSGSN(config-sgsn)# ggsn 0 gtp-version 1
OsmoSGSN(config-sgsn)# apn * ggsn 0
```

- Configure the local IP address at the SGSN used for Gp/GTP
- Specify the remote IP address of the GGSN (for GGSN 0)
- Specify the GTP protocol version used for GGSN 0
- Route all APN names to GGSN 0

9.1.2 Dynamic GGSN/APN configuration

In this mode, the SGSN will use a DNS-based method to perform the lookup from the APN (as specified by the MS) towards the GGSN IP address.

This is the official method as per the 3GPP specifications for the SGSN, and what is used on GRX.

Example: Dynamic GGSN/APN configuration

```
OsmoSGSN(config-sgsn)# gtp local-ip 192.168.0.11
OsmoSGSN(config-sgsn)# ggsn dynamic
OsmoSGSN(config-sgsn)# grx-dns-add 1.2.3.4
```

- Configure the local IP address at the SGSN used for Gp/GTP
- Enable the dynamic GGSN resolving mode
- Specify the IP address of a DNS server for APN resolution

9.2 Authorization Policy

The authorization policy controls by which rules a subscriber is accepted or rejected. The possible options range from accepting just all subscribers without further checking, to a fine grained access-control, handled by an external HLR.

- **accept-all**
  All subscribers that attempt to attach to the GPRS network are accepted without further checking. This option is intended to be used for testing in a controlled environment only. A wide-open network may attract subscribers from foreign networks and disrupt their service. It is highly recommended to pick one of the options below.

- **remote**
  This option allows to connect OsmoSGSN to an external HLR via the GSUP protocol. This will be the preferred option in larger networks.
acl-only
If no external HLR is available, the network operator has the option to control the access using an access control list. The access control list contains the IMSI numbers of the allowed subscribers. This method offers fine grained access control and is ideal for small networks and lab test environments.

closed
This policy mode softens the strict acl-only only mode by also implicitly accepting home network subscribers. The decision is made by the MCC and MNC part of the IMSI number. The combination of MCC and MNC fully identifies a subscribers home network, also known as a Home Network Identity (HNI, i.e. MCC and MNC found at the start of the IMSI, e.g. MCC 901 and MNC 700 with IMSI 901700000003080).

Note
The policy mode closed must not be confused with the equally named policy that is defined for osmo-nitb!

Example: Assign or change authorization policy

```
OsmoSGSN> enable
OsmoSGSN# configure terminal
OsmoSGSN(config)# sgsn
OsmoSGSN(config-sgsn)# auth-policy acl-only
OsmoSGSN(config-sgsn)# write
Configuration saved to sgsn.cfg
OsmoSGSN(config-sgsn)# end
OsmoSGSN>
```

1. acl-only is selected as authorization policy
2. Saves current changes to configuration to make this policy persistent

Example: Access control list

```
sgsn
auth-policy acl-only
imsi-acl add 001010000000003
imsi-acl add 001010000000002
imsi-acl add 001010000000001
imsi-acl add 901700000000068
```

1. Set the authorization policy
2. Add as many subscribers as required

9.3 Subscriber Configuration

As opposed to OsmoNITB, OsmoSGSN does not feature a built-in HLR. It can thus operate only in the following two modes:

1. Accessing an external HLR (or HLR gateway) via the GSUP protocol
2. Accepting subscribers based on internal ACL (access control list), see also Section 9.2
9.3.1 Accessing an external HLR via GSUP

The non-standard GSUP protocol was created to provide OsmoSGSN with access to an external HLR while avoiding the complexities of the TCAP/MAP protocol stack commonly used by HLRs.

A custom HLR could either directly implement GSUP, or an external gateway can be used to convert GSUP to the respective MAP operations.

The primitives/operations of GSUP are modelled to have a 1:1 correspondence to their MAP counterparts. However, the encoding is much simplified by use of a binary TLV encoding similar to Layer 3 of GSM/GPRS.

GSUP performs a challenge-response authentication protocol called OAP, which uses the standard MILENAGE algorithm for mutual authentication between OsmoSGSN and the HLR/HLR-GW.

Example: Using an external HLR via GSUP

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>osmosgsn(config-sgsn)# gsup remote-ip 2.3.4.5</code></td>
<td>Configure the IP address of the (remote) HLR or HLR-GW</td>
</tr>
<tr>
<td><code>osmosgsn(config-sgsn)# gsup remote-port 10000</code></td>
<td>Configure the TCP port of the (remote) HLR or HLR-GW</td>
</tr>
<tr>
<td><code>osmosgsn(config-sgsn)# gsup oap-k 000102030405060708090a0b0c0d0e0f</code></td>
<td>Specify the OAP shared key</td>
</tr>
<tr>
<td><code>osmosgsn(config-sgsn)# gsup oap-opc 101112131415161718191a1b1c1d1e1f</code></td>
<td>Specify the OAP shared OPC</td>
</tr>
</tbody>
</table>

9.4 CDR configuration

OsmoSGSN can write a text log file containing CDR (call data records), which are commonly used for accounting/billing purpose.

Example: CDR log file configuration

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>osmosgsn(config-sgsn)# cdr filename /var/log/osmosgsn.cdr</code></td>
<td>Periodically log existing PDP contexts every 600 seconds (10 min)</td>
</tr>
<tr>
<td><code>osmosgsn(config-sgsn)# cdr interval 600</code></td>
<td>The CDR file is a simple CSV file including a header line naming the individual fields of each CSV line.</td>
</tr>
</tbody>
</table>

9.4.1 CDR CTRL interface

Independently of whether logging CDR to a file is enabled or not, OsmoSGSN can also provide delivery of CDR through the CTRL interface. CDR are sent by means of TRAP messages with variable name `cdr-v1`, and its value is filled using the same CSV line format as in the log file, but without CSV header line.

Example: CDR delivery through CTRL TRAP messages

`osmosgsn(config-sgsn)# cdr trap`

9.4.2 CDR Format
Table 3: Description of CSV fields in OsmoSGSN CDR file

<table>
<thead>
<tr>
<th>Field Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>timestamp</td>
<td>Timestamp in YYYYMMDDhhmmssXXX where XXX are milli-seconds</td>
</tr>
<tr>
<td>imsi</td>
<td>IMSI causing this CDR</td>
</tr>
<tr>
<td>imei</td>
<td>IMEI causing this CDR</td>
</tr>
<tr>
<td>msisdn</td>
<td>MSISDN causing this CDR (if known)</td>
</tr>
<tr>
<td>cell_id</td>
<td>Cell ID in which the MS was registered last</td>
</tr>
<tr>
<td>lac</td>
<td>Location Area Code in which the MS was registered last</td>
</tr>
<tr>
<td>hlr</td>
<td>HLR of the subscriber</td>
</tr>
<tr>
<td>event</td>
<td>Possible events are explained below in Table 5</td>
</tr>
</tbody>
</table>

If the event field describes a pdp context related action (starts with pdp-), then the following extra CSV fields are appended to the line:

Table 4: Description of extra CSV fields for pdp context related events

<table>
<thead>
<tr>
<th>Field Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>pdp_duration</td>
<td>duration of the PDP context so far</td>
</tr>
<tr>
<td>ggsn_addr</td>
<td>GGSN related to the PDP context</td>
</tr>
<tr>
<td>sgsn_addr</td>
<td>SGSN related to the PDP context</td>
</tr>
<tr>
<td>apni</td>
<td>APN identifier of the PDP context</td>
</tr>
<tr>
<td>euq_addr</td>
<td>IP address allocated to the PDP context</td>
</tr>
<tr>
<td>vol_in</td>
<td>Number of bytes in MO direction</td>
</tr>
<tr>
<td>vol_out</td>
<td>Number of bytes in MT direction</td>
</tr>
<tr>
<td>charging_id</td>
<td>Related charging ID</td>
</tr>
</tbody>
</table>

Table 5: Description of OsmoSGSN CDR Events

<table>
<thead>
<tr>
<th>Event</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>attach</td>
<td>GMM ATTACH COMPLETE about to be sent to MS</td>
</tr>
<tr>
<td>update</td>
<td>GMM ROUTING AREA UPDATE COMPLETE about to be sent to MS</td>
</tr>
<tr>
<td>detach</td>
<td>GMM DETACH REQUEST received from MS</td>
</tr>
<tr>
<td>free</td>
<td>Release of the MM context memory</td>
</tr>
<tr>
<td>pdp-act</td>
<td>GTP CREATE PDP CONTEXT CONFIRM received from GGSN</td>
</tr>
<tr>
<td>pdp-deact</td>
<td>GTP DELETE PDP CONTEXT CONFIRM received from GGSN</td>
</tr>
<tr>
<td>pdp-terminate</td>
<td>Forced PDP context termination during MM context release</td>
</tr>
<tr>
<td>pdp-free</td>
<td>Release of the PDP context memory</td>
</tr>
<tr>
<td>pdp-periodic</td>
<td>Triggered by periodic timer, see VTY cmd cdr interval</td>
</tr>
</tbody>
</table>

9.5 User traffic compression

In order to save GPRS bandwidth, OsmoSGSN implements header and data compression schemes which will reduce the packet length.
9.5.1 Header compression

On TCP/IP connections, each packet is prepended with a fairly long TCP/IP header. The header contains a lot of static information that never changes throughout the connection. (source and destination address, port numbers etc.) OsmoSGSN implements a TCP/IP header compression scheme called RFC1144, also known as SLHC. This type of header compression removes the TCP/IP header entirely and replaces it with a shorter version, that only contains the information that is absolutely necessary to identify and check the packet. The receiving part then restores the original header and forwards it to higher layers.

- **compression rfc1144 passive**
  TCP/IP header compression has to be actively requested by the modem. The network will not promote compression by itself. This is the recommended mode of operation.

- **compression rfc1144 active slots <1-256>**
  TCP/IP header compression is actively promoted by the network. Modems may still actively request different compression parameters or reject the offered compression parameters entirely. The number of slots is the maximum number of packet headers per subscriber that can be stored in the codebook.

**Example: Accept compression if requested**

```
sgsn
compression rfc1144 passive
```

**Example: Actively promote compression**

```
sgsn
compression rfc1144 active slots 8
```

**Example: Turn off compression**

```
sgsn
no compression rfc1144
```

**Note**
The usage of TCP/IP options may disturb the RFC1144 header compression scheme. TCP/IP options may render RFC1144 ineffective if variable data is encoded into the option section of the TCP/IP packet. (e.g. TCP option 8, Timestamp)

9.5.2 Data compression

Data compression works on the raw packet data, including the header part of the packet. If enabled, header compression is applied first before data compression is applied. OsmoSGSN implements the V.42bis data compression scheme.

- **compression v42bis passive**
  V.42bis data compression has to be actively requested by the modem. The network will not promote compression by itself. This is the recommended mode of operation.

- **compression v42bis active direction (ms|sgsn|both) codewords <512-65535> strlen <6-250>**
  V.42bis data compression is actively promoted by the network. Modems may still actively request different compression parameters or reject the offered compression parameters entirely. The direction configures which sides are allowed to send compressed packets. For most cases, compressing both directions will be the preferred option. The following to parameters configure the codebook size by the maxium number (codewords) and size (strlen) of entries.

**Example: Accept compression if requested**

```
sgsn
compression v42bis passive
```
Example: Actively promote compression

```
sgsn
  compression v42bis active direction both codewords 512 strlen 20
```

Example: Turn off compression

```
sgsn
  no compression v42bis
```

### 9.6 Encryption

Encryption can be enabled if the auth-policy is set to remote and the HLR subscriber entries contain the keys of the SIM card. See Example: Using an external HLR via GSUP on how to connect to an external HLR.

Example: Turn on encryption (GEA3)

```
sgsn
  encryption GEA3
```

Example: Turn off encryption (GEA0)

```
sgsn
  encryption GEA0
```

### 10 Gb interface using libosmogb

`libosmogb` is part of the libosmocore.git repository and implements the Gb interface protocol stack consisting of the NS and BSSGP layers. It is used in a variety of Osmocom project, including OsmoSGSN, OsmoGbProxy and OsmoPCU. This section describes the configuration that libosmogb exposes via the VTY.

#### 10.1 Gb interface configuration

##### 10.1.1 NS-over-UDP configuration

The GPRS-NS protocol can be encapsulated in UDP/IP. This is the default encapsulation for IP based GPRS systems.

Example: GPRS NS-over-UDP configuration

```
OsmoSGSN(config-ns)# encapsulation udp local-ip 127.0.0.1 ①
OsmoSGSN(config-ns)# encapsulation udp local-port 23000 ②
```

The example above configures a libosmogb based application to listen for incoming connections from PCUs on the specified address and port.

1. Set the local side IP address for NS-over-UDP
2. Set the local side UDP port number for NS-over-UDP. 23000 is the default
10.1.2 NS-over-FR-GRE configuration

The GPRS-NS protocol can alternatively be encapsulated over Frame Relay (FR). Traditionally this is communicated over SDH/PDH media, which we don’t support. However, we can encapsulate the FR in GRE, and then that in IP.

The resulting NS-FR-GRE-IP stack can be converted by an off-the-shelf router with FR and IP support.

Example: GPRS NS-over-FR-GRE configuration

```
OsmoSGSN(config-ns)# encapsulation framerelay-gre enabled 1
OsmoSGSN(config-ns)# encapsulation framerelay-gre local-ip 127.0.0.1
```

1. Enable FR-GRE encapsulation
2. Set the local side IP address for NS-over-FR-GRE

10.1.3 NS Timer configuration

The NS protocol features a number of configurable timers.

Table 6: List of configurable NS timers

<table>
<thead>
<tr>
<th>timer</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>tns-block</td>
<td>(un)blocking timer timeout (secs)</td>
</tr>
<tr>
<td>tns-block-retries</td>
<td>(un)blocking timer; number of retries</td>
</tr>
<tr>
<td>tns-reset</td>
<td>reset timer timeout (secs)</td>
</tr>
<tr>
<td>tns-reset-retries</td>
<td>reset timer; number of retries</td>
</tr>
<tr>
<td>tns-test</td>
<td>test timer timeout (secs)</td>
</tr>
<tr>
<td>tns-alive</td>
<td>alive timer timeout (secs)</td>
</tr>
<tr>
<td>tns-alive-retries</td>
<td>alive timer; number of retries</td>
</tr>
</tbody>
</table>

10.2 Examining Gb interface status

There are several commands that can help to inspect and analyze the currently running system status with respect to the Gb interfaces.

Example: Inspecting NS state

```
OsmoSGSN> show ns
Encapsulation NS-UDP-IP   Local IP: 127.0.0.1, UDP Port: 23000
Encapsulation NS-FR-GRE-IP Local IP: 0.0.0.0
```

Example: Inspecting NS statistics

```
OsmoSGSN> show ns stats
Encapsulation NS-UDP-IP   Local IP: 10.9.1.198, UDP Port: 23000
Encapsulation NS-FR-GRE-IP Local IP: 0.0.0.0
NSEI 101, NS-VC 101, Remote: BSS, ALIVE UNBLOCKED, UDP 10.9.1.119:23000
NSVC Peer Statistics:
  Packets at NS Level ( In): 1024 (2/s 123/m 911/h 0/d)
  Packets at NS Level (Out): 1034 (0/s 151/m 894/h 0/d)
  Bytes at NS Level ( In): 296638 (1066/s 22222/m 274244/h 0/d)
  Bytes at NS Level (Out): 139788 (0/s 48225/m 91710/h 0/d)
  NS-VC Block count : 0 (0/s 0/m 0/h 0/d)
  NS-VC gone dead count : 0 (0/s 0/m 0/h 0/d)
  NS-VC replaced other count: 0 (0/s 0/m 0/h 0/d)
  NS-VC changed NSEI count : 0 (0/s 0/m 0/h 0/d)
```
Example: Inspecting BSSGP state

OsmoSGSN> show bssgp
NSEI  101, BVCI  2, RA-ID: 1-2-1-0, CID: 0, STATE: UNBLOCKED
NSEI  101, BVCI  0, RA-ID: 0-0-0-0, CID: 0, STATE: UNBLOCKED

10.3  FIXME

10.3.1  Blocking / Unblocking / Resetting NS Virtual Connections

The user can manually perform operations on individual NSVCs:

- blocking a NSVC
- unblocking a NSVC
- resetting a NSVC

The VTY command used for this is the `nsvc (nsei|nsvci) <0-65535> (block|unblock|reset)` command available from the ENABLE node.

10.4  Gb interface logging filters

There are some Gb-interface specific filters for the libosmocore logging subsystem, which can help to reduce the logged output to messages pertaining to a certain NS or BSSGP connection only.

Example: enabling a log filter for a given NSEI

OsmoSGSN> logging filter nsvc nsei 23

Example: enabling a log filter for a given NSVCI

OsmoSGSN> logging filter nsvc nsvci 23

11  Osmocom Control Interface

The VTY interface as described in Section 7 is aimed at human interaction with the respective Osmocom program.

Other programs should not use the VTY interface to interact with the Osmocom software, as parsing the textual representation is cumbersome, inefficient, and will break every time the formatting is changed by the Osmocom developers.

Instead, the Control Interface was introduced as a programmatic interface that can be used to interact with the respective program.
11.1 Control Interface Protocol

The control interface protocol is a mixture of binary framing with text based payload.

The protocol for the control interface is wrapped inside the IPA multiplex header with the stream identifier set to IPAC_PROTO_OSMO (0xEE).

![IPA header for control protocol](image)

Figure 3: IPA header for control protocol

Inside the IPA header is a single byte of extension header with protocol ID 0x00 which indicates the control interface.

![IPA extension header for control protocol](image)

Figure 4: IPA extension header for control protocol

After the concatenation of the two above headers, the plain-text payload message starts. The format of that plain text is illustrated for each operation in the respective message sequence chart in the chapters below.

The fields specified below follow the following meaning:

- `<id>`
  A numeric identifier, uniquely identifying this particular operation. Value 0 is not allowed unless it’s a TRAP message. It will be echoed back in any response to a particular request.

- `<var>`
  The name of the variable / field affected by the GET / SET / TRAP operation. Which variables/fields are available is dependent on the specific application under control.

- `<val>`
  The value of the variable / field

- `<reason>`
  A text formatted, human-readable reason why the operation resulted in an error.
11.1.1 GET operation

The GET operation is performed by an external application to get a certain value from inside the Osmocom application.

![Figure 5: Control Interface GET operation (successful outcome)](image)

![Figure 6: Control Interface GET operation (unsuccessful outcome)](image)

11.1.2 SET operation

The SET operation is performed by an external application to set a value inside the Osmocom application.

![Figure 7: Control Interface SET operation (successful outcome)](image)

![Figure 8: Control Interface SET operation (unsuccessful outcome)](image)

11.1.3 TRAP operation

The program can at any time issue a trap. The term is used in the spirit of SNMP.
11.2 Common variables

There are several variables which are common to all the programs using control interface. They are described in the following table.

<table>
<thead>
<tr>
<th>Name</th>
<th>Access</th>
<th>Value</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>counter.*</td>
<td>RO</td>
<td></td>
<td>Get counter value.</td>
</tr>
<tr>
<td>rate_ctr.*</td>
<td>RO</td>
<td></td>
<td>Get list of rate counter groups.</td>
</tr>
<tr>
<td>rate_ctr.IN.GN.GI.name</td>
<td>RO</td>
<td></td>
<td>Get value for interval IN of rate counter name which belong to group named GN with index GI.</td>
</tr>
</tbody>
</table>

Those read-only variables allow to get value of arbitrary counter using its name.

For example "rate_ctr.per_hour.bsc.0.handover:timeout" is the number of handover timeouts per hour.

Of course for that to work the program in question have to register corresponding counter names and groups using libosmocore functions.

In the example above, "bsc" is the rate counter group name and "0" is its index. It is possible to obtain all the rate counters in a given group by requesting "rate_ctr.per_sec.bsc.*" variable.

The list of available groups can be obtained by requesting "rate_ctr.*" variable.

The rate counter group name have to be prefixed with interval specification which can be any of "per_sec", "per_min", "per_hour", "per_day" or "abs" for absolute value.

The old-style counters available via "counter.*" variables are superseded by "rate_ctr.abs" so its use is discouraged. There might still be some applications not yet converted to rate_ctr.

11.3 Control Interface python examples

In the osmo-python-tests repository, there is an example python script called scripts/osmo_ctrl.py which implements the Osmocom control interface protocol.

You can use this tool either stand-alone to perform control interface operations against an Osmocom program, or you can use it as a reference for developing your own python software talking to the control interface.

Another implementation is in scripts/osmo_rate_ctr2csv.py which will retrieve performance counters for a given Osmocom program and output it in csv format. This can be used to periodically (using systemd timer for example) retrieve data to build KPI and evaluate how it changes over time.

Internally it uses "rate_ctr.*" variable described in [?] to get the list of counter groups and than request all the counters in each group. Applications interested in individual metrics can request it directly using rate_ctr2csv.py as an example.
11.3.1 Getting rate counters

Example: Use rate_ctr2csv.py to get rate counters from OsmoBSC

```
$ ./scripts/osmo_rate_ctr2csv.py --header
Connecting to localhost:4249...
Getting rate counter groups info...
"group","counter","absolute","second","minute","hour","day"
"e1inp.0","hdlc:abort","0","0","0","0","0"
"e1inp.0","hdlc:bad_fcs","0","0","0","0","0"
"e1inp.0","hdlc:overrun","0","0","0","0","0"
"e1inp.0","alarm","0","0","0","0","0"
"e1inp.0","removed","0","0","0","0","0"
"bsc.0","chreq:total","0","0","0","0","0"
"bsc.0","chreq:no_channel","0","0","0","0","0"
..."msc.0","call:active","0","0","0","0","0"
"msc.0","call:complete","0","0","0","0","0"
"msc.0","call:incomplete","0","0","0","0","0"
Completed: 44 counters from 3 groups received.
```

11.3.2 Setting a value

Example: Use osmo_ctrl.py to set the short network name of OsmoBSC

```
$ ./osmo_ctrl.py -d localhost -s short-name 32C3
Got message: SET_REPLY 1 short-name 32C3
```

11.3.3 Getting a value

Example: Use osmo_ctrl.py to get the mnc of OsmoBSC

```
$ ./osmo_ctrl.py -d localhost -g mnc
Got message: GET_REPLY 1 mnc 262
```

11.3.4 Listening for traps

You can use osmo_ctrl.py to listen for traps the following way:

Example: Using osmo_ctrl.py to listen for traps:

```
$ ./osmo_ctrl.py -d localhost -m v
```

the command will not return and wait for any TRAP messages to arrive

12 Osmocom Authentication Protocol (OAP)

12.1 General

The Osmocom Authentication Protocol employs mutual authentication to register a client with a server over an IPA connection. Milenage is used as the authentication algorithm, where client and server have a shared secret. For example, an SGSN, as OAP client, may use its SGSN ID to register with a MAP proxy, an OAP server.
12.2 Connection
The protocol expects that a reliable, ordered, packet boundaries preserving connection is used (e.g. IPA over TCP).

12.3 Using IPA
By default, the following identifiers should be used: - IPA protocol: 0xee (OSMO) - IPA OSMO protocol extension: 0x06 (OAP)

12.4 Procedures

Figure 10: Ideal communication sequence

Figure 11: Variation “test setup”

Figure 12: Variation “invalid sequence nr”:

12.4.1 Register
The client sends a REGISTER_REQ message containing an identifier number.
12.4.2 Challenge

The OAP server (optionally) sends back a CHALLENGE_REQ, containing random bytes and a milenage authentication token generated from these random bytes, using a shared secret, to authenticate itself to the OAP client. The server may omit this challenge entirely, based on its configuration, and immediately reply with a Register Result response. If the client cannot be registered (e.g. id is invalid), the server sends a REGISTER_ERR response.

12.4.3 Challenge Result

When the client has received a Challenge, it may verify the server’s authenticity and validity of the sequence number (included in AUTN), and, if valid, reply with a CHALLENGE_RES message. This shall contain an XRES authentication token generated by milenage from the same random bytes received from the server and the same shared secret. If the client decides to cancel the registration (e.g. invalid AUTN), it shall not reply to the CHALLENGE_REQ; a CHALLENGE_ERR message may be sent, but is not mandatory. For example, the client may directly start with a new REGISTER_REQ message.

12.4.4 Sync Request

When the client has received a Challenge but sees an invalid sequence number (embedded in AUTN, according to the milenage algorithm), the client may send a SYNC_REQ message containing an AUTS synchronisation token.

12.4.5 Sync Result

If the server has received a valid Sync Request, it shall answer by directly sending another Challenge (see Section 12.4.2). If an invalid Sync Request is received, the server shall reply with a REGISTER_ERR message.

12.4.6 Register Result

The server sends a REGISTER_RES message to indicate that registration has been successful. If the server cannot register the client (e.g. invalid challenge response), it shall send a REGISTER_ERR message.

12.5 Message Format

Every message is based on the following message format

<table>
<thead>
<tr>
<th>IEI</th>
<th>IE</th>
<th>Type</th>
<th>Presence</th>
<th>Format</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>IE</td>
<td>Message Type</td>
<td>Section 12.6.1</td>
<td>M</td>
<td>V</td>
</tr>
</tbody>
</table>

The receiver shall be able to receive IEs in any order. Unknown IEs shall be ignored.

12.5.1 Register Request

Direction: Client → Server

<table>
<thead>
<tr>
<th>IEI</th>
<th>IE</th>
<th>Type</th>
<th>Presence</th>
<th>Format</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>IE</td>
<td>Message Type</td>
<td>Section 12.6.1</td>
<td>M</td>
<td>V</td>
</tr>
<tr>
<td>30</td>
<td>Client ID</td>
<td>Section 12.6.3</td>
<td>M</td>
<td>TLV</td>
<td>4</td>
</tr>
</tbody>
</table>

12.5.2 Register Error

Direction: Server → Client
### 12.5.3 Register Result

Direction: Server → Client

<table>
<thead>
<tr>
<th>IEI</th>
<th>IE</th>
<th>Type</th>
<th>Presence</th>
<th>Format</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>02</td>
<td>Cause</td>
<td>GMM Cause, TS 04.08: 10.5.5.14</td>
<td>M</td>
<td>TLV</td>
<td>3</td>
</tr>
</tbody>
</table>

### 12.5.4 Challenge

Direction: Server → Client

<table>
<thead>
<tr>
<th>IEI</th>
<th>IE</th>
<th>Type</th>
<th>Presence</th>
<th>Format</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>RAND</td>
<td>octet string (16)</td>
<td>M</td>
<td>V</td>
<td>1</td>
</tr>
</tbody>
</table>

### 12.5.5 Challenge Error

Direction: Client → Server

<table>
<thead>
<tr>
<th>IEI</th>
<th>IE</th>
<th>Type</th>
<th>Presence</th>
<th>Format</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>02</td>
<td>Cause</td>
<td>GMM Cause, TS 04.08: 10.5.5.14</td>
<td>M</td>
<td>TLV</td>
<td>3</td>
</tr>
</tbody>
</table>

### 12.5.6 Challenge Result

Direction: Client → Server

<table>
<thead>
<tr>
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<th>IE</th>
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<th>Presence</th>
<th>Format</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Section 12.6.1</td>
<td>M</td>
<td>V</td>
<td>1</td>
</tr>
</tbody>
</table>

### 12.5.7 Sync Request

Direction: Client → Server

<table>
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<tr>
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<th>IE</th>
<th>Type</th>
<th>Presence</th>
<th>Format</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Section 12.6.1</td>
<td>M</td>
<td>V</td>
<td>1</td>
</tr>
</tbody>
</table>

### 12.5.8 Sync Error

Not used.

### 12.5.9 Sync Result

Not used.
12.6 Information Elements

12.6.1 Message Type

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x04</td>
<td>Register Request</td>
</tr>
<tr>
<td>0x05</td>
<td>Register Error</td>
</tr>
<tr>
<td>0x06</td>
<td>Register Result</td>
</tr>
<tr>
<td>0x08</td>
<td>Challenge Request</td>
</tr>
<tr>
<td>0x09</td>
<td>Challenge Error</td>
</tr>
<tr>
<td>0x0a</td>
<td>Challenge Result</td>
</tr>
<tr>
<td>0x0c</td>
<td>Sync Request</td>
</tr>
<tr>
<td>0x0d</td>
<td>Sync Error (not used)</td>
</tr>
<tr>
<td>0x0e</td>
<td>Sync Result (not used)</td>
</tr>
</tbody>
</table>

12.6.2 IE Identifier (informational)

These are the standard values for the IEI.

<table>
<thead>
<tr>
<th>IEI</th>
<th>Info Element</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x02</td>
<td>Cause</td>
<td>GMM Cause, 04.08: 10.5.5.14</td>
</tr>
<tr>
<td>0x20</td>
<td>RAND</td>
<td>Octet String</td>
</tr>
<tr>
<td>0x23</td>
<td>AUTN</td>
<td>Octet Strong</td>
</tr>
<tr>
<td>0x24</td>
<td>XRES</td>
<td>Octet String</td>
</tr>
<tr>
<td>0x25</td>
<td>AUTS</td>
<td>Octet String</td>
</tr>
<tr>
<td>0x30</td>
<td>Client ID</td>
<td>big endian integer, 16 bit</td>
</tr>
</tbody>
</table>

12.6.3 Client ID

The Client ID number shall be interpreted as an unsigned 16bit integer, where 0 indicates an invalid / unset ID.

13 Generic Subscriber Update Protocol

13.1 General

This chapter describes the remote protocol that is used by OsmoSGSN and OsmoMSC to update and manage the local subscriber list in OsmoHLR. Functionally, it resembles the interface between the SGSN/VLR on the one hand side, and HLR/AUC on the other side.

For more information, see the specification of the Gr interface (3GPP TS 03.60).

Traditionally, the GSM MAP (Mobile Application Part) protocol is used for this purpose, running on top of a full telecom signalling protocol stack of MTP2/MTP3/SCCP/TCAP, or any of the SIGTRAN alternatives.

In order to avoid many of the complexities of MAP, which are difficult to implement in the plain C language environment of the Osmocom cellular network elements like the SGSN, we introduce the GSUP protocol.

The GSUP protocol and the messages are designed after the corresponding MAP messages (see 3GPP TS 09.02) with the following main differences:
• The encoding uses TLV structures instead of ASN.1 BER
• Segmentation is not used, i.e. we rely on the fact that the underlying transport protocol can transport signalling messages of any size.

13.2 Connection

The protocol expects that a reliable, ordered, packet boundaries preserving connection is used (e.g. IPA over TCP). The remote peer is either a service that understands the protocol natively or a wrapper service that maps the messages to/from real MAP messages that can be used to directly communicate with an HLR.

13.3 Using IPA

By default, the following identifiers should be used:

• IPA Stream ID: 0xEE (OSMO)
• IPA OSMO protocol extension: 0x05

For more information about the IPA multiplex, please see the OsmoBTS Abis/IP Specification.

13.4 Procedures

13.4.1 Authentication management

The SGSN or VLR sends a SEND_AUTHENTICATION_INFO_REQ message containing the MS’s IMSI to the peer. On errors, especially if authentication info is not available for that IMSI, the peer returns a SEND_AUTHENTICATION_INFO_ERR message. Otherwise the peer returns a SEND_AUTHENTICATION_INFO_RES message. If this message contains at least one authentication tuple, the SGSN or VLR replaces all tuples that are assigned to the subscriber. If the message doesn’t contain any tuple the SGSN or VLR may reject the Attach Request. (see 3GPP TS 09.02, 25.5.6)

![Figure 13: Send Authentication Info (Normal Case)](image)

![Figure 14: Send Authentication Info (Erroneous Case)](image)

13.4.2 Reporting of Authentication Failure

Using this procedure, the SGSN or VLR reports authentication failures to the HLR.
13.4.3 Location Updating

The SGSN or VLR sends a UPDATE_LOCATION_REQ to the peer. If the request is denied by the network, the peer returns an UPDATE_LOCATION_ERR message to the SGSN or VLR. Otherwise the peer returns an UPDATE_LOCATION_RES message containing all information fields that shall be inserted into the subscriber record. If the PDP info complete information element is set in the message, the SGSN or VLR clears existing PDP information fields in the subscriber record first. (see 3GPP TS 09.02, 19.1.1.8)

13.4.4 Location Cancellation

Using the Location Cancellation procedure, the Network Peer (HLR) can request the SGSN or VLR to remove a subscriber record.
13.4.5 Purge MS

Using the Purge MS procedure, the SGSN or VLR can request purging of MS related state from the HLR. It is used after the SGSN or VLR detects that no radio contact has been established for a prolonged duration (i.e. longer than the periodic LU timeout). See 3GPP TS 23.012 Section 3.6.1.4 for a description of this procedure.

![Figure 20: Purge MS (Normal Case)](image)

13.4.6 Delete Subscriber Data

Using the Delete Subscriber Data procedure, the Peer (HLR) can remove some of the subscriber data from the SGSN or VLR. This is used in case the subscription details (e.g. PDP Contexts / APNs) change while the subscriber is registered to that SGSN VLR.

![Figure 21: Delete Subscriber Data (Normal Case)](image)

13.4.7 Check IMEI

The VLR asks the EIR to check if a new ME's IMEI is acceptable or not. The EIR may implement a blacklist or whitelist and reject the IMEI based on that. Against the original purpose of the Check IMEI Procedure, this could also be used to save the IMEI in the HLR DB.

![Figure 22: Check IMEI (Normal Case)](image)

13.5 Procedures (E Interface)

The E interface connects two MSCs in the traditional GSM MAP world. It is used for the inter-MSC handover. In GSUP, we don’t need that extra connection, as we route the messages over the GSUP server (OsmoHLR) instead.

Whenever MSC-A is sending to MSC-B, and vice-versa, the message needs to pass through the GSUP server. In order to make the following message sequence charts easier to read, this step has been omitted.

13.5.1 E Handover

MSC-A has an active RAN connection and hands it over to MSC-B.
13.5.2 E Subsequent Handover

MSC-B has an active RAN connection, and asks MSC-A to hand it over to MSC-B'.

13.5.3 E Forward and Process Access Signalling

MSC-A is forwarding a message from its BSS (Base Station Subsystem) to MSC-B. MSC-B forwards the message to its BSS, and answers to MSC-A with a Process Access Signalling Request.
13.5.4 E Routing Error

The GSUP server can not route any of the requests above, and responds with an E Routing Error. Possible reasons for not being able to route the message are missing routing IEs, a mismatching source name IE (Section 13.7.30), the destination not being connected to the GSUP server or a failed attempt to send the message from the GSUP server to the destination. To figure out what went wrong in detail, refer to the GSUP server’s logs.

In the traditional GSM MAP world, the participants of an E procedure are directly connected, hence this routing error message does not exist in MAP.

13.6 Message Format

13.6.1 General

Every message is based on the following message format

<table>
<thead>
<tr>
<th>IEI</th>
<th>IE</th>
<th>Type</th>
<th>Presence</th>
<th>Format</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>IMSI</td>
<td>Section 13.7.19</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
<tr>
<td>26</td>
<td>AUTS</td>
<td>Section 13.7.13</td>
<td>C</td>
<td>TLV</td>
<td>18</td>
</tr>
<tr>
<td>28</td>
<td>CN Domain</td>
<td>Section 13.7.15</td>
<td>O</td>
<td>TLV</td>
<td>3</td>
</tr>
</tbody>
</table>

If a numeric range is indicated in the presence column, multiple information elements with the same tag may be used in sequence. The information elements shall be sent in the given order. Nevertheless after the generic part the receiver shall be able to received them in any order. Unknown IE shall be ignored.

Besides a numeric range, the presence column may have M (Mandatory), O (Optional) or C (Conditional). The format column holds either V (Value) or TLV (Tag Length Value).

13.6.2 Send Authentication Info Request

Direction: SGSN / VLR ⇒ HLR

<table>
<thead>
<tr>
<th>IEI</th>
<th>IE</th>
<th>Type</th>
<th>Presence</th>
<th>Format</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>IMSI</td>
<td>Section 13.7.19</td>
<td>M</td>
<td>V</td>
<td>1</td>
</tr>
<tr>
<td>28</td>
<td>CN Domain</td>
<td>Section 13.7.15</td>
<td>O</td>
<td>TLV</td>
<td>3</td>
</tr>
<tr>
<td>26</td>
<td>AUTS</td>
<td>Section 13.7.13</td>
<td>C</td>
<td>TLV</td>
<td>18</td>
</tr>
<tr>
<td>20</td>
<td>RAND</td>
<td>Section 13.7.7</td>
<td>C</td>
<td>TLV</td>
<td>18</td>
</tr>
</tbody>
</table>
The conditional \textit{AUTS} and \textit{RAND} IEs are both present in case the SIM (via UE) requests an UMTS AKA re-synchronization procedure. Either both optional IEs are present, or none of them.

### 13.6.3 Send Authentication Info Error

**Direction:** HLR $\Rightarrow$ SGSN / VLR

<table>
<thead>
<tr>
<th>IEI</th>
<th>IE</th>
<th>Type</th>
<th>Presence</th>
<th>Format</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>IMSI</td>
<td>Section 13.7.19</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
<tr>
<td>02</td>
<td>Cause</td>
<td>Section 13.7.25</td>
<td>M</td>
<td>TLV</td>
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</tbody>
</table>

### 13.6.4 Send Authentication Info Response

**Direction:** HLR $\Rightarrow$ SGSN / VLR

<table>
<thead>
<tr>
<th>IEI</th>
<th>IE</th>
<th>Type</th>
<th>Presence</th>
<th>Format</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>IMSI</td>
<td>Section 13.7.19</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
<tr>
<td>03</td>
<td>Auth Tuple</td>
<td>Section 13.7.6</td>
<td>0-5</td>
<td>TLV</td>
<td>36</td>
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</tbody>
</table>

### 13.6.5 Authentication Failure Report

**Direction:** SGSN / VLR $\Rightarrow$ HLR

<table>
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<th>IE</th>
<th>Type</th>
<th>Presence</th>
<th>Format</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>IMSI</td>
<td>Section 13.7.19</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
<tr>
<td>28</td>
<td>CN Domain</td>
<td>Section 13.7.15</td>
<td>O</td>
<td>TLV</td>
<td>3</td>
</tr>
</tbody>
</table>

### 13.6.6 Update Location Request

**Direction:** SGSN / VLR $\Rightarrow$ HLR

<table>
<thead>
<tr>
<th>IEI</th>
<th>IE</th>
<th>Type</th>
<th>Presence</th>
<th>Format</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>IMSI</td>
<td>Section 13.7.19</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
<tr>
<td>28</td>
<td>CN Domain</td>
<td>Section 13.7.15</td>
<td>O</td>
<td>TLV</td>
<td>3</td>
</tr>
</tbody>
</table>

### 13.6.7 Update Location Error

**Direction:** HLR $\Rightarrow$ SGSN / VLR

<table>
<thead>
<tr>
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<th>IE</th>
<th>Type</th>
<th>Presence</th>
<th>Format</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>IMSI</td>
<td>Section 13.7.19</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
<tr>
<td>02</td>
<td>Cause</td>
<td>Section 13.7.25</td>
<td>M</td>
<td>TLV</td>
<td>3</td>
</tr>
</tbody>
</table>

### 13.6.8 Update Location Result

**Direction:** HLR $\Rightarrow$ SGSN / VLR
If the PDP info complete IE is present, the old PDP info list shall be cleared.

### 13.6.9 Location Cancellation Request

**Direction:** HLR ⇒ SGSN / VLR

<table>
<thead>
<tr>
<th>IEI</th>
<th>IE</th>
<th>Type</th>
<th>Presence</th>
<th>Format</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
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<td>V</td>
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<tr>
<td>08</td>
<td>MSISDN</td>
<td>Section 13.7.20</td>
<td>O</td>
<td>TLV</td>
<td>0-9</td>
</tr>
<tr>
<td>09</td>
<td>HLR Number</td>
<td>Section 13.7.24</td>
<td>O</td>
<td>TLV</td>
<td>0-9</td>
</tr>
<tr>
<td>04</td>
<td>PDP info complete</td>
<td>Section 13.7.18</td>
<td>O</td>
<td>TLV</td>
<td>2</td>
</tr>
<tr>
<td>05</td>
<td>PDP info</td>
<td>Section 13.7.3</td>
<td>O</td>
<td>TLV</td>
<td>1-10</td>
</tr>
</tbody>
</table>

### 13.6.10 Location Cancellation Result

**Direction:** SGSN / VLR ⇒ HLR

<table>
<thead>
<tr>
<th>IEI</th>
<th>IE</th>
<th>Type</th>
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<th>Format</th>
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</tr>
<tr>
<td>28</td>
<td>CN Domain</td>
<td>Section 13.7.15</td>
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<td>3</td>
</tr>
</tbody>
</table>

### 13.6.11 Purge MS Request

**Direction:** SGSN / VLR ⇒ HLR

<table>
<thead>
<tr>
<th>IEI</th>
<th>IE</th>
<th>Type</th>
<th>Presence</th>
<th>Format</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>IMSI</td>
<td>Section 13.7.14</td>
<td>M</td>
<td>V</td>
<td>1</td>
</tr>
<tr>
<td>28</td>
<td>CN Domain</td>
<td>Section 13.7.15</td>
<td>O</td>
<td>TLV</td>
<td>3</td>
</tr>
<tr>
<td>09</td>
<td>HLR Number</td>
<td>Section 13.7.24</td>
<td>M</td>
<td>TLV</td>
<td>0-9</td>
</tr>
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</table>

### 13.6.12 Purge MS Error

**Direction:** HLR ⇒ SGSN / VLR

<table>
<thead>
<tr>
<th>IEI</th>
<th>IE</th>
<th>Type</th>
<th>Presence</th>
<th>Format</th>
<th>Length</th>
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</thead>
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<td>IMSI</td>
<td>Section 13.7.14</td>
<td>M</td>
<td>V</td>
<td>1</td>
</tr>
<tr>
<td>02</td>
<td>Cause</td>
<td>Section 13.7.25</td>
<td>M</td>
<td>TLV</td>
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</tr>
</tbody>
</table>

### 13.6.13 Purge MS Result

**Direction:** HLR ⇒ SGSN / VLR
<table>
<thead>
<tr>
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<th>IE</th>
<th>Type</th>
<th>Presence</th>
<th>Format</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>IMSI</td>
<td>Section 13.7.19</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
<tr>
<td>07</td>
<td>Freeze P-TMSI</td>
<td>Section 13.7.18</td>
<td>M</td>
<td>TLV</td>
<td>2</td>
</tr>
</tbody>
</table>

### 13.6.14 Insert Subscriber Data Request

**Direction:** HLR $\Rightarrow$ SGSN / VLR

<table>
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<tr>
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<th>IE</th>
<th>Type</th>
<th>Presence</th>
<th>Format</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>IMSI</td>
<td>Section 13.7.19</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
<tr>
<td>28</td>
<td>CN Domain</td>
<td>Section 13.7.15</td>
<td>O</td>
<td>TLV</td>
<td>3</td>
</tr>
<tr>
<td>08</td>
<td>MSISDN</td>
<td>Section 13.7.20</td>
<td>O</td>
<td>TLV</td>
<td>0-9</td>
</tr>
<tr>
<td>09</td>
<td>HLR Number</td>
<td>Section 13.7.24</td>
<td>O</td>
<td>TLV</td>
<td>0-9</td>
</tr>
<tr>
<td>04</td>
<td>PDP info complete</td>
<td>Section 13.7.18</td>
<td>M</td>
<td>TLV</td>
<td>2</td>
</tr>
<tr>
<td>05</td>
<td>PDP info</td>
<td>Section 13.7.3</td>
<td>C</td>
<td>TLV</td>
<td>0-10</td>
</tr>
<tr>
<td>14</td>
<td>PDP-Charging Characteristics</td>
<td>Section 13.7.23</td>
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<td>TLV</td>
<td>4</td>
</tr>
</tbody>
</table>

If the PDP info complete IE is present, the old PDP info list shall be cleared.

### 13.6.15 Insert Subscriber Data Error

**Direction:** SGSN / VLR $\Rightarrow$ HLR

<table>
<thead>
<tr>
<th>IEI</th>
<th>IE</th>
<th>Type</th>
<th>Presence</th>
<th>Format</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>IMSI</td>
<td>Section 13.7.19</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
<tr>
<td>02</td>
<td>Cause</td>
<td>Section 13.7.25</td>
<td>M</td>
<td>TLV</td>
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</tbody>
</table>

### 13.6.16 Insert Subscriber Data Result

**Direction:** SGSN / VLR $\Rightarrow$ HLR

<table>
<thead>
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<th>IE</th>
<th>Type</th>
<th>Presence</th>
<th>Format</th>
<th>Length</th>
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<tr>
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<td>IMSI</td>
<td>Section 13.7.19</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
</tbody>
</table>

### 13.6.17 Delete Subscriber Data Request

**Direction:** HLR $\Rightarrow$ SGSN / VLR

<table>
<thead>
<tr>
<th>IEI</th>
<th>IE</th>
<th>Type</th>
<th>Presence</th>
<th>Format</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>IMSI</td>
<td>Section 13.7.19</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
<tr>
<td>28</td>
<td>CN Domain</td>
<td>Section 13.7.15</td>
<td>O</td>
<td>TLV</td>
<td>3</td>
</tr>
<tr>
<td>10</td>
<td>PDP Context ID</td>
<td>Section 13.7.5</td>
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</tr>
</tbody>
</table>

### 13.6.18 Delete Subscriber Data Error

**Direction:** SGSN / VLR $\Rightarrow$ HLR
<table>
<thead>
<tr>
<th>IEI</th>
<th>IE</th>
<th>Type</th>
<th>Presence</th>
<th>Format</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>IMSI</td>
<td>Section 13.7.1</td>
<td>M</td>
<td>V</td>
<td>1</td>
</tr>
<tr>
<td>02</td>
<td>Cause</td>
<td>Section 13.7.19</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
</tbody>
</table>

13.6.19  Delete Subscriber Data Result

Direction: HLR ⇒ SGSN / VLR

<table>
<thead>
<tr>
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<th>IE</th>
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<th>Format</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>IMSI</td>
<td>Section 13.7.19</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
</tbody>
</table>

13.6.20  Process Supplementary Service Request

Direction: bidirectional

<table>
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<th>Format</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>IMSI</td>
<td>Section 13.7.1</td>
<td>M</td>
<td>V</td>
<td>1</td>
</tr>
<tr>
<td>30</td>
<td>Session ID</td>
<td>Section 13.8.1</td>
<td>M</td>
<td>TLV</td>
<td>6</td>
</tr>
<tr>
<td>31</td>
<td>Session State</td>
<td>Section 13.8.2</td>
<td>M</td>
<td>TLV</td>
<td>3</td>
</tr>
<tr>
<td>35</td>
<td>Supplementary Service Info</td>
<td>Section 13.7.26</td>
<td>O</td>
<td>TLV</td>
<td>2-...</td>
</tr>
</tbody>
</table>

This message is used in both directions in case of USSD, because it is not known is it request or response without parsing the GSM 04.80 payload.

13.6.21  Process Supplementary Service Error

Direction: EUSE / HLR ⇒ MSC

<table>
<thead>
<tr>
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<th>Length</th>
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<tbody>
<tr>
<td>01</td>
<td>IMSI</td>
<td>Section 13.7.19</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
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<tr>
<td>30</td>
<td>Session ID</td>
<td>Section 13.8.1</td>
<td>M</td>
<td>TLV</td>
<td>6</td>
</tr>
<tr>
<td>31</td>
<td>Session State</td>
<td>Section 13.8.2</td>
<td>M</td>
<td>TLV</td>
<td>3</td>
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<tr>
<td>02</td>
<td>Cause</td>
<td>Section 13.7.25</td>
<td>M</td>
<td>TLV</td>
<td>3</td>
</tr>
</tbody>
</table>

13.6.22  Process Supplementary Service Response

Direction: EUSE / HLR ⇒ MSC

<table>
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<th>Format</th>
<th>Length</th>
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</thead>
<tbody>
<tr>
<td>01</td>
<td>IMSI</td>
<td>Section 13.7.19</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
<tr>
<td>30</td>
<td>Session ID</td>
<td>Section 13.8.1</td>
<td>M</td>
<td>TLV</td>
<td>6</td>
</tr>
<tr>
<td>31</td>
<td>Session State</td>
<td>Section 13.8.2</td>
<td>M</td>
<td>TLV</td>
<td>3</td>
</tr>
<tr>
<td>35</td>
<td>Supplementary Service Info</td>
<td>Section 13.7.26</td>
<td>O</td>
<td>TLV</td>
<td>2-...</td>
</tr>
</tbody>
</table>

The purpose of this message is not clear yet. Probably, it can be used to notify the MSC that a structured supplementary service is successfully activated or deactivated, etc.
13.6.23 MO-forwardSM Request

Direction: MSC / SGSN ⇒ SMSC (via HLR)

<table>
<thead>
<tr>
<th>IEI</th>
<th>IE</th>
<th>Type</th>
<th>Presence</th>
<th>Format</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
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<td>Message Type</td>
<td>Section 13.7.1</td>
<td>M</td>
<td>V</td>
</tr>
<tr>
<td>04</td>
<td>SM-RP-MR (Message Reference)</td>
<td>Section 13.8.3</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
<tr>
<td>05</td>
<td>SM-RP-DA (Destination Address)</td>
<td>Section 13.8.4</td>
<td>M</td>
<td>TLV</td>
<td>2-...</td>
</tr>
<tr>
<td>06</td>
<td>SM-RP-OA (Originating Address)</td>
<td>Section 13.8.5</td>
<td>M</td>
<td>TLV</td>
<td>2-...</td>
</tr>
<tr>
<td>07</td>
<td>SM-RP-UI (SM TPDU)</td>
<td>Section 13.8.7</td>
<td>M</td>
<td>TLV</td>
<td>1-...</td>
</tr>
</tbody>
</table>

This message is used to forward MO short messages from MSC / SGSN to an SMSC. The corresponding MAP service is MAP-MO-FORWARD-SHORT-MESSAGE, see 3GPP TS 29.002, section 12.2.

13.6.24 MO-forwardSM Error

Direction: SMSC (via HLR) ⇒ MSC / SGSN

<table>
<thead>
<tr>
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<th>IE</th>
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<th>Presence</th>
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<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>IMSI</td>
<td>Message Type</td>
<td>Section 13.7.1</td>
<td>M</td>
<td>V</td>
</tr>
<tr>
<td>04</td>
<td>SM-RP-MR (Message Reference)</td>
<td>Section 13.8.3</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
<tr>
<td>05</td>
<td>SM-RP-Cause (Cause value)</td>
<td>Section 13.8.8</td>
<td>M</td>
<td>TLV</td>
<td>1</td>
</tr>
<tr>
<td>06</td>
<td>SM-RP-UI (diagnostic field)</td>
<td>Section 13.8.7</td>
<td>O</td>
<td>TLV</td>
<td>1-...</td>
</tr>
</tbody>
</table>

This message is used to indicate a negative result of an earlier MO short message delivery. The corresponding MAP service is MAP-MO-FORWARD-SHORT-MESSAGE, see 3GPP TS 29.002, section 12.2.

13.6.25 MO-forwardSM Result

Direction: SMSC (via HLR) ⇒ MSC / SGSN

<table>
<thead>
<tr>
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<th>IE</th>
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<th>Presence</th>
<th>Format</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>IMSI</td>
<td>Message Type</td>
<td>Section 13.7.1</td>
<td>M</td>
<td>V</td>
</tr>
<tr>
<td>04</td>
<td>SM-RP-MR (Message Reference)</td>
<td>Section 13.8.3</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
</tbody>
</table>

This message is used to indicate a successful result of an earlier MO short message delivery. The corresponding MAP service is MAP-MO-FORWARD-SHORT-MESSAGE, see 3GPP TS 29.002, section 12.2.

13.6.26 MT-forwardSM Request

Direction: SMSC (via HLR) ⇒ MSC / SGSN

<table>
<thead>
<tr>
<th>IEI</th>
<th>IE</th>
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<th>Presence</th>
<th>Format</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>IMSI</td>
<td>Message Type</td>
<td>Section 13.7.1</td>
<td>M</td>
<td>V</td>
</tr>
<tr>
<td>04</td>
<td>SM-RP-MR (Message Reference)</td>
<td>Section 13.8.3</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
<tr>
<td>05</td>
<td>SM-RP-DA (Destination Address)</td>
<td>Section 13.8.4</td>
<td>M</td>
<td>TLV</td>
<td>2-...</td>
</tr>
<tr>
<td>06</td>
<td>SM-RP-OA (Originating Address)</td>
<td>Section 13.8.5</td>
<td>M</td>
<td>TLV</td>
<td>2-...</td>
</tr>
<tr>
<td>07</td>
<td>SM-RP-UI (SM TPDU)</td>
<td>Section 13.8.7</td>
<td>M</td>
<td>TLV</td>
<td>1-...</td>
</tr>
<tr>
<td>08</td>
<td>SM-RP-MMS (More Messages to Send)</td>
<td>Section 13.8.9</td>
<td>O</td>
<td>TLV</td>
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</tbody>
</table>
This message is used to forward MT short messages from an SMSC to MSC / SGSN. The corresponding MAP service is MAP-MT-FORWARD-SHORT-MESSAGE, see 3GPP TS 29.002, section 12.9.

### 13.6.27 MT-forwardSM Error

**Direction:** MSC / SGSN ⇒ SMSC (via HLR)

<table>
<thead>
<tr>
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<th>IE</th>
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<th>Presence</th>
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<th>Length</th>
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<tbody>
<tr>
<td>01</td>
<td>IMSI</td>
<td>Message Type</td>
<td>Section 13.7.1</td>
<td>M</td>
<td>V</td>
</tr>
<tr>
<td>40</td>
<td>SM-RP-MR</td>
<td>(Message Reference)</td>
<td>Section 13.8.3</td>
<td>M</td>
<td>TLV</td>
</tr>
<tr>
<td>44</td>
<td>SM-RP-Cause</td>
<td>(Cause value)</td>
<td>Section 13.8.8</td>
<td>M</td>
<td>TLV</td>
</tr>
<tr>
<td>43</td>
<td>SM-RP-UI</td>
<td>(diagnostic field)</td>
<td>Section 13.8.7</td>
<td>O</td>
<td>TLV</td>
</tr>
</tbody>
</table>

This message is used to indicate a negative result of an earlier MT short message delivery. The corresponding MAP service is MAP-MT-FORWARD-SHORT-MESSAGE, see 3GPP TS 29.002, section 12.9.

### 13.6.28 MT-forwardSM Result

**Direction:** MSC / SGSN ⇒ SMSC (via HLR)

<table>
<thead>
<tr>
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<th>IE</th>
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<th>Presence</th>
<th>Format</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>IMSI</td>
<td>Message Type</td>
<td>Section 13.7.1</td>
<td>M</td>
<td>V</td>
</tr>
<tr>
<td>40</td>
<td>SM-RP-MR</td>
<td>(Message Reference)</td>
<td>Section 13.8.3</td>
<td>M</td>
<td>TLV</td>
</tr>
</tbody>
</table>

This message is used to indicate a successful result of an earlier MT short message delivery. The corresponding MAP service is MAP-MT-FORWARD-SHORT-MESSAGE, see 3GPP TS 29.002, section 12.9.

### 13.6.29 READY-FOR-SM Request

**Direction:** MSC / SGSN ⇒ SMSC (via HLR)

<table>
<thead>
<tr>
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<th>IE</th>
<th>Type</th>
<th>Presence</th>
<th>Format</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>IMSI</td>
<td>Message Type</td>
<td>Section 13.7.1</td>
<td>M</td>
<td>V</td>
</tr>
<tr>
<td>40</td>
<td>SM-RP-MR</td>
<td>(Message Reference)</td>
<td>Section 13.8.3</td>
<td>M</td>
<td>TLV</td>
</tr>
<tr>
<td>46</td>
<td>SM Alert Reason</td>
<td>Section 13.8.10</td>
<td>M</td>
<td>TLV</td>
<td>1-...</td>
</tr>
</tbody>
</table>

This message is used between the MSC / SGSN and an SMSC when a subscriber indicates memory available situation (see TS GSM 04.11, section 7.3.2). The corresponding MAP service is MAP-READY-FOR-SM, see 3GPP TS 29.002, section 12.4.

### 13.6.30 READY-FOR-SM Error

**Direction:** SMSC (via HLR) ⇒ MSC / SGSN

<table>
<thead>
<tr>
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<th>IE</th>
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<th>Presence</th>
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<th>Length</th>
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<tbody>
<tr>
<td>01</td>
<td>IMSI</td>
<td>Message Type</td>
<td>Section 13.7.1</td>
<td>M</td>
<td>V</td>
</tr>
<tr>
<td>40</td>
<td>SM-RP-MR</td>
<td>(Message Reference)</td>
<td>Section 13.8.3</td>
<td>M</td>
<td>TLV</td>
</tr>
<tr>
<td>44</td>
<td>SM-RP-Cause</td>
<td>(Cause value)</td>
<td>Section 13.8.8</td>
<td>M</td>
<td>TLV</td>
</tr>
<tr>
<td>43</td>
<td>SM-RP-UI</td>
<td>(diagnostic field)</td>
<td>Section 13.8.7</td>
<td>O</td>
<td>TLV</td>
</tr>
</tbody>
</table>
This message is used to indicate a negative result of an earlier MO SMMA (Memory Available) indication. The corresponding MAP service is MAP-READY-FOR-SM, see 3GPP TS 29.002, section 12.4.

13.6.31 READY-FOR-SM Result

Direction: SMSC (via HLR) ⇒ MSC / SGSN

<table>
<thead>
<tr>
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<th>IE</th>
<th>Type</th>
<th>Presence</th>
<th>Format</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Message Type</td>
<td>Section 13.7.1</td>
<td>M</td>
<td>V</td>
<td>1</td>
</tr>
<tr>
<td>40</td>
<td>SM-RP-MR (Message Reference)</td>
<td>Section 13.8.3</td>
<td>M</td>
<td>TLV</td>
<td>1</td>
</tr>
</tbody>
</table>

This message is used to indicate a successful result of an earlier MO SMMA (Memory Available) indication. The corresponding MAP service is MAP-READY-FOR-SM, see 3GPP TS 29.002, section 12.4.

13.6.32 CHECK-IMEI Request

Direction: VLR ⇒ EIR (via HLR)

<table>
<thead>
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<th>Type</th>
<th>Presence</th>
<th>Format</th>
<th>Length</th>
</tr>
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<tbody>
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</table>

13.6.33 CHECK-IMEI Error

Direction: EIR (via HLR) ⇒ VLR

<table>
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<th>Length</th>
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<tbody>
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<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
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<td>Cause</td>
<td>Section 13.7.25</td>
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<td>TLV</td>
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</table>

13.6.34 CHECK-IMEI Result

Direction: EIR (via HLR) ⇒ VLR

<table>
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<th>Format</th>
<th>Length</th>
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<tbody>
<tr>
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<td>IMSI</td>
<td>Section 13.7.19</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
<tr>
<td>51</td>
<td>IMEI Check Result</td>
<td>Section 13.7.28</td>
<td>M</td>
<td>TLV</td>
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</table>

13.6.35 E Prepare Handover Request

Direction: MSC-A=MSC-I ⇒ MSC-B=MSC-T (via HLR)

<table>
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<th>Type</th>
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<th>Format</th>
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</thead>
<tbody>
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<td>TLV</td>
<td>2-10</td>
</tr>
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<td>0a</td>
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<td>Section 13.7.29</td>
<td>M</td>
<td>TLV</td>
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<td>M</td>
<td>TLV</td>
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<tr>
<td>61</td>
<td>Destination Name</td>
<td>Section 13.7.31</td>
<td>M</td>
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</table>
### 13.6.36 E Prepare Handover Error

Direction: MSC-B=MSC-T ⇒ MSC-A=MSC-I (via HLR)

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<th>Length</th>
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<tbody>
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<td>62</td>
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<td>Section 13.7.32</td>
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<td>TLV</td>
<td>2-…</td>
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### 13.6.37 E Prepare Handover Result

Direction: MSC-B=MSC-T ⇒ MSC-A=MSC-I (via HLR)

<table>
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<th>Type</th>
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<th>Format</th>
<th>Length</th>
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</thead>
<tbody>
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<td>Section 13.7.32</td>
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<td>TLV</td>
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</tr>
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</table>

### 13.6.38 E Prepare Subsequent Handover Request

Direction: MSC-B=MSC-I ⇒ MSC-A (via HLR)

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<th>IE</th>
<th>Type</th>
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<th>Length</th>
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</thead>
<tbody>
<tr>
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<td>TLV</td>
<td>2-…</td>
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</table>

### 13.6.39 E Prepare Subsequent Handover Error

Direction: MSC-A ⇒ MSC-B=MSC-I (via HLR)

<table>
<thead>
<tr>
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<th>IE</th>
<th>Type</th>
<th>Presence</th>
<th>Format</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
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<td>Section 13.7.32</td>
<td>M</td>
<td>TLV</td>
<td>2-…</td>
</tr>
</tbody>
</table>
### 13.6.40  E Prepare Subsequent Handover Result

**Direction:** MSC-A ⇒ MSC-B=MSC-I (via HLR)

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<th>IE</th>
<th>Type</th>
<th>Presence</th>
<th>Format</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>IMSI</td>
<td>Message Type</td>
<td>Section 13.7.1</td>
<td>M</td>
<td>V</td>
</tr>
<tr>
<td>0a</td>
<td>Message Class</td>
<td>Section 13.7.29</td>
<td>M</td>
<td>TLV</td>
<td>3</td>
</tr>
<tr>
<td>60</td>
<td>Source Name</td>
<td>Section 13.7.30</td>
<td>M</td>
<td>TLV</td>
<td>2-...</td>
</tr>
<tr>
<td>61</td>
<td>Destination Name</td>
<td>Section 13.7.31</td>
<td>M</td>
<td>TLV</td>
<td>2-...</td>
</tr>
<tr>
<td>62</td>
<td>AN-APDU</td>
<td>Section 13.7.32</td>
<td>M</td>
<td>TLV</td>
<td>2-...</td>
</tr>
</tbody>
</table>

### 13.6.41  E Send End Signal Request

**Direction:** MSC-B=MSC-T ⇒ MSC-A=MSC-I (via HLR)

<table>
<thead>
<tr>
<th>IEI</th>
<th>IE</th>
<th>Type</th>
<th>Presence</th>
<th>Format</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>IMSI</td>
<td>Message Type</td>
<td>Section 13.7.1</td>
<td>M</td>
<td>V</td>
</tr>
<tr>
<td>0a</td>
<td>Message Class</td>
<td>Section 13.7.29</td>
<td>M</td>
<td>TLV</td>
<td>3</td>
</tr>
<tr>
<td>60</td>
<td>Source Name</td>
<td>Section 13.7.30</td>
<td>M</td>
<td>TLV</td>
<td>2-...</td>
</tr>
<tr>
<td>61</td>
<td>Destination Name</td>
<td>Section 13.7.31</td>
<td>M</td>
<td>TLV</td>
<td>2-...</td>
</tr>
<tr>
<td>62</td>
<td>AN-APDU</td>
<td>Section 13.7.32</td>
<td>M</td>
<td>TLV</td>
<td>2-...</td>
</tr>
</tbody>
</table>

### 13.6.42  E Send End Signal Error

**Direction:** MSC-A=MSC-I ⇒ MSC-B=MSC-T (via HLR)

<table>
<thead>
<tr>
<th>IEI</th>
<th>IE</th>
<th>Type</th>
<th>Presence</th>
<th>Format</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>IMSI</td>
<td>Message Type</td>
<td>Section 13.7.1</td>
<td>M</td>
<td>V</td>
</tr>
<tr>
<td>0a</td>
<td>Message Class</td>
<td>Section 13.7.29</td>
<td>M</td>
<td>TLV</td>
<td>3</td>
</tr>
<tr>
<td>60</td>
<td>Source Name</td>
<td>Section 13.7.30</td>
<td>M</td>
<td>TLV</td>
<td>2-...</td>
</tr>
<tr>
<td>61</td>
<td>Destination Name</td>
<td>Section 13.7.31</td>
<td>M</td>
<td>TLV</td>
<td>2-...</td>
</tr>
<tr>
<td>62</td>
<td>AN-APDU</td>
<td>Section 13.7.32</td>
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<td>TLV</td>
<td>2-...</td>
</tr>
</tbody>
</table>

### 13.6.43  E Send End Signal Result

**Direction:** MSC-A ⇒ MSC-B=MSC-I (via HLR)

<table>
<thead>
<tr>
<th>IEI</th>
<th>IE</th>
<th>Type</th>
<th>Presence</th>
<th>Format</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>IMSI</td>
<td>Message Type</td>
<td>Section 13.7.1</td>
<td>M</td>
<td>V</td>
</tr>
<tr>
<td>0a</td>
<td>Message Class</td>
<td>Section 13.7.29</td>
<td>M</td>
<td>TLV</td>
<td>3</td>
</tr>
<tr>
<td>60</td>
<td>Source Name</td>
<td>Section 13.7.30</td>
<td>M</td>
<td>TLV</td>
<td>2-...</td>
</tr>
<tr>
<td>61</td>
<td>Destination Name</td>
<td>Section 13.7.31</td>
<td>M</td>
<td>TLV</td>
<td>2-...</td>
</tr>
<tr>
<td>62</td>
<td>AN-APDU</td>
<td>Section 13.7.32</td>
<td>M</td>
<td>TLV</td>
<td>2-...</td>
</tr>
</tbody>
</table>

### 13.6.44  E Process Access Signalling Request

**Direction:** MSC-B=MSC-T ⇒ MSC-A=MSC-I (via HLR)

<table>
<thead>
<tr>
<th>IEI</th>
<th>IE</th>
<th>Type</th>
<th>Presence</th>
<th>Format</th>
<th>Length</th>
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<tbody>
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<td>V</td>
</tr>
</tbody>
</table>
13.6.45  E Forward Access Signalling Request

Direction: MSC-A ⇒ MSC-B=MSC-I (via HLR)

<table>
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<th>IE</th>
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<th>Presence</th>
<th>Format</th>
<th>Length</th>
</tr>
</thead>
<tbody>
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<td>01</td>
<td>IMSI</td>
<td>Section 13.7.19</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
<tr>
<td>0a</td>
<td>Message Class</td>
<td>Section 13.7.29</td>
<td>M</td>
<td>TLV</td>
<td>3</td>
</tr>
<tr>
<td>60</td>
<td>Source Name</td>
<td>Section 13.7.30</td>
<td>M</td>
<td>TLV</td>
<td>2-…</td>
</tr>
<tr>
<td>61</td>
<td>Destination Name</td>
<td>Section 13.7.31</td>
<td>M</td>
<td>TLV</td>
<td>2-…</td>
</tr>
<tr>
<td>62</td>
<td>AN-APDU</td>
<td>Section 13.7.32</td>
<td>M</td>
<td>TLV</td>
<td>2-…</td>
</tr>
</tbody>
</table>

13.6.46  E Close

Direction: MSC-A ⇒ MSC-B (via HLR)

<table>
<thead>
<tr>
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<th>IE</th>
<th>Type</th>
<th>Presence</th>
<th>Format</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
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<td>M</td>
<td>V</td>
<td>1</td>
</tr>
<tr>
<td>0a</td>
<td>IMSI</td>
<td>Section 13.7.19</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
<tr>
<td>60</td>
<td>Source Name</td>
<td>Section 13.7.29</td>
<td>M</td>
<td>TLV</td>
<td>3</td>
</tr>
<tr>
<td>61</td>
<td>Destination Name</td>
<td>Section 13.7.30</td>
<td>M</td>
<td>TLV</td>
<td>2-…</td>
</tr>
<tr>
<td>62</td>
<td>AN-APDU</td>
<td>Section 13.7.31</td>
<td>M</td>
<td>TLV</td>
<td>2-…</td>
</tr>
</tbody>
</table>

13.6.47  E Abort

This message was added to GSUP for the inter-MSC handover. But so far it is not used yet.

13.6.48  E Routing Error

Direction: GSUP Server (HLR) ⇒ GSUP Client (MSC)

<table>
<thead>
<tr>
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<th>IE</th>
<th>Type</th>
<th>Presence</th>
<th>Format</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Message Type</td>
<td>Section 13.7.1</td>
<td>M</td>
<td>V</td>
<td>1</td>
</tr>
<tr>
<td>0a</td>
<td>IMSI</td>
<td>Section 13.7.19</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
<tr>
<td>60</td>
<td>Source Name</td>
<td>Section 13.7.29</td>
<td>M</td>
<td>TLV</td>
<td>3</td>
</tr>
<tr>
<td>61</td>
<td>Destination Name</td>
<td>Section 13.7.30</td>
<td>M</td>
<td>TLV</td>
<td>2-…</td>
</tr>
<tr>
<td>30</td>
<td>Session ID</td>
<td>Section 13.8.1</td>
<td>M</td>
<td>TLV</td>
<td>6</td>
</tr>
<tr>
<td>31</td>
<td>Session State</td>
<td>Section 13.8.2</td>
<td>M</td>
<td>TLV</td>
<td>3</td>
</tr>
</tbody>
</table>

13.7  Information Elements

13.7.1  Message Type
### Type Description

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x04</td>
<td>Update Location Request</td>
</tr>
<tr>
<td>0x05</td>
<td>Update Location Error</td>
</tr>
<tr>
<td>0x06</td>
<td>Update Location Result</td>
</tr>
<tr>
<td>0x08</td>
<td>Send Auth Info Request</td>
</tr>
<tr>
<td>0x09</td>
<td>Send Auth Info Error</td>
</tr>
<tr>
<td>0x0a</td>
<td>Send Auth Info Result</td>
</tr>
<tr>
<td>0x0c</td>
<td>Authentication Failure Report</td>
</tr>
<tr>
<td>0x0d</td>
<td>Purge MS Request</td>
</tr>
<tr>
<td>0x0e</td>
<td>Purge MS Error</td>
</tr>
<tr>
<td>0x10</td>
<td>Insert Subscriber Data Request</td>
</tr>
<tr>
<td>0x11</td>
<td>Insert Subscriber Data Error</td>
</tr>
<tr>
<td>0x12</td>
<td>Insert Subscriber Data Result</td>
</tr>
<tr>
<td>0x14</td>
<td>Delete Subscriber Data Request</td>
</tr>
<tr>
<td>0x15</td>
<td>Delete Subscriber Data Error</td>
</tr>
<tr>
<td>0x16</td>
<td>Delete Subscriber Data Result</td>
</tr>
<tr>
<td>0x1c</td>
<td>Location Cancellation Request</td>
</tr>
<tr>
<td>0x1d</td>
<td>Location Cancellation Error</td>
</tr>
<tr>
<td>0x1e</td>
<td>Location Cancellation Result</td>
</tr>
<tr>
<td>0x20</td>
<td>Supplementary Service Request</td>
</tr>
<tr>
<td>0x21</td>
<td>Supplementary Service Error</td>
</tr>
<tr>
<td>0x22</td>
<td>Supplementary Service Result</td>
</tr>
<tr>
<td>0x24</td>
<td>MO-forwardSM Request</td>
</tr>
<tr>
<td>0x25</td>
<td>MO-forwardSM Error</td>
</tr>
<tr>
<td>0x26</td>
<td>MO-forwardSM Result</td>
</tr>
<tr>
<td>0x28</td>
<td>MT-forwardSM Request</td>
</tr>
<tr>
<td>0x29</td>
<td>MT-forwardSM Error</td>
</tr>
<tr>
<td>0x2a</td>
<td>MT-forwardSM Result</td>
</tr>
<tr>
<td>0x2c</td>
<td>READY-FOR-SM Request</td>
</tr>
<tr>
<td>0x2d</td>
<td>READY-FOR-SM Error</td>
</tr>
<tr>
<td>0x2e</td>
<td>READY-FOR-SM Result</td>
</tr>
<tr>
<td>0x30</td>
<td>CHECK-IMEI Request</td>
</tr>
<tr>
<td>0x31</td>
<td>CHECK-IMEI Error</td>
</tr>
<tr>
<td>0x32</td>
<td>CHECK-IMEI Result</td>
</tr>
</tbody>
</table>

The category of the message is indicated by the last two bits of the type. Request, Error and Result messages only differ in these last two bits, so it is trivial to transform them.

<table>
<thead>
<tr>
<th>Ending Bits</th>
<th>Message Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>00</td>
<td>Request</td>
</tr>
<tr>
<td>01</td>
<td>Error</td>
</tr>
<tr>
<td>10</td>
<td>Result</td>
</tr>
<tr>
<td>11</td>
<td>Other</td>
</tr>
</tbody>
</table>

#### 13.7.2 IP Address

The value part is encoded like in the Packet data protocol address IE defined in 3GPP TS 04.08, Chapter 10.5.6.4. PDP type organization must be set to *IETF allocated address*.

#### 13.7.3 PDP Info

This is a container for information elements describing a single PDP.
### 13.7.4 PDP Type

The PDP type value consists of 2 octets that are encoded like octet 4-5 of the End User Address defined in 3GPP TS 09.60, 7.9.18.

![PDP type IEI](image)

The spare bits are left undefined. While 09.60 defines them as 1 1 1 1, there are MAP traces where these bits are set to 0 0 0 0. So the receiver shall ignore these bits.

Examples:

- IPv4: PDP type org: 1 (IETF), PDP type number: 0x21
- IPv6: PDP type org: 1 (IETF), PDP type number: 0x57

### 13.7.5 PDP Context ID

The PDP type context ID IE consists of a single integer byte wrapped in a TLV.
13.7.6 Auth tuple

This is a container for information elements describing a single authentication tuple.

<table>
<thead>
<tr>
<th>IEI</th>
<th>IE</th>
<th>Type</th>
<th>Presence</th>
<th>Format</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auth Tuple IEI</td>
<td>Section 13.7.17</td>
<td>M</td>
<td>V</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Length of Auth Tuple IE</td>
<td></td>
<td>M</td>
<td>V</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>RAND</td>
<td>Section 13.7.7</td>
<td>M</td>
<td>TLV</td>
<td>18</td>
</tr>
<tr>
<td>21</td>
<td>SRES</td>
<td>Section 13.7.8</td>
<td>M</td>
<td>TLV</td>
<td>6</td>
</tr>
<tr>
<td>22</td>
<td>Kc</td>
<td>Section 13.7.9</td>
<td>M</td>
<td>TLV</td>
<td>10</td>
</tr>
<tr>
<td>23</td>
<td>IK</td>
<td>Section 13.7.10</td>
<td>C</td>
<td>TLV</td>
<td>18</td>
</tr>
<tr>
<td>24</td>
<td>CK</td>
<td>Section 13.7.11</td>
<td>C</td>
<td>TLV</td>
<td>18</td>
</tr>
<tr>
<td>25</td>
<td>AUTN</td>
<td>Section 13.7.12</td>
<td>C</td>
<td>TLV</td>
<td>18</td>
</tr>
<tr>
<td>27</td>
<td>RES</td>
<td>Section 13.7.14</td>
<td>C</td>
<td>TLV</td>
<td>2-18</td>
</tr>
</tbody>
</table>

The conditional IEs IK, CK, AUTN and RES are only present in case the subscriber supports UMTS AKA.

13.7.7 RAND

The 16-byte Random Challenge of the GSM Authentication Algorithm.

13.7.8 SRES

The 4-byte Authentication Result of the GSM Authentication Algorithm.

13.7.9 Kc

The 8-byte Encryption Key of the GSM Authentication and Key Agreement Algorithm.

13.7.10 IK

The 16-byte Integrity Protection Key generated by the UMTS Authentication and Key Agreement Algorithm.

13.7.11 CK

The 16-byte Ciphering Key generated by the UMTS Authentication and Key Agreement Algorithm.
13.7.12 AUTN

The 16-byte Authentication Nonce sent from network to USIM in the UMTS Authentication and Key Agreement Algorithm.

13.7.13 AUTS

The 14-byte Authentication Synchronization Nonce generated by the USIM in case the UMTS Authentication and Key Agreement Algorithm needs to re-synchronize the sequence counters between AUC and USIM.

13.7.14 RES

The (variable length, but typically 16 byte) Authentication Result generated by the USIM in the UMTS Authentication and Key Agreement Algorithm.

13.7.15 CN Domain

This single-byte information element indicates the Core Network Domain, i.e. if the message is related to Circuit Switched or Packet Switched services.

For backwards compatibility reasons, if no CN Domain IE is present within a request, the PS Domain is assumed.

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x01</td>
<td>PS Domain</td>
</tr>
<tr>
<td>0x02</td>
<td>CS Domain</td>
</tr>
</tbody>
</table>

13.7.16 Cancellation Type

![Cancellation Type Diagram]

Table 9: Cancellation Type Number

<table>
<thead>
<tr>
<th>Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x00</td>
<td>Update Procedure</td>
</tr>
<tr>
<td>0x01</td>
<td>Subscription Withdrawn</td>
</tr>
</tbody>
</table>
13.7.17 IE Identifier (informational)

These are the standard values for the IEI. See the message definitions for the IEI that shall be used for the encoding.

Table 10: GSUP IE Identifiers

<table>
<thead>
<tr>
<th>IEI</th>
<th>Info Element</th>
<th>Type / Encoding</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x01</td>
<td>IMSI</td>
<td>Mobile Identity, 3GPP TS 04.08 Ch. 10.5.1.4</td>
</tr>
<tr>
<td>0x02</td>
<td>Cause</td>
<td>Section 13.7.25</td>
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<td>0x03</td>
<td>Auth Tuple</td>
<td>Section 13.7.6</td>
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<tr>
<td>0x04</td>
<td>PDP Info Compl</td>
<td>Section 13.7.18</td>
</tr>
<tr>
<td>0x05</td>
<td>PDP Info</td>
<td>Section 13.7.3</td>
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<td>Cancel Type</td>
<td>Section 13.7.16</td>
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<td>0x07</td>
<td>Freeze P-TMSI</td>
<td>Section 13.7.18</td>
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<td>0x08</td>
<td>MSISDN</td>
<td>ISDN-AddressString/octet, Section 13.7.20</td>
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<td>0x09</td>
<td>HLR Number</td>
<td>Section 13.7.24</td>
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<td>Message Class</td>
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<td>QoS</td>
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<td>RAND</td>
<td>Section 13.7.7</td>
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<td>CN Domain</td>
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<td>Section 13.8.1</td>
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<td>Supplementary Service Info</td>
<td>Section 13.7.26</td>
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<tr>
<td>0x40</td>
<td>SM-RP-MR (Message Reference)</td>
<td>Section 13.8.3</td>
</tr>
<tr>
<td>0x41</td>
<td>SM-RP-DA (Destination Address)</td>
<td>Section 13.8.4</td>
</tr>
<tr>
<td>0x42</td>
<td>SM-RP-OA (Originating Address)</td>
<td>Section 13.8.5</td>
</tr>
<tr>
<td>0x43</td>
<td>SM-RP-UI (SM TPDU)</td>
<td>Section 13.8.7</td>
</tr>
<tr>
<td>0x44</td>
<td>SM-RP-Cause (RP Cause value)</td>
<td>Section 13.8.8</td>
</tr>
<tr>
<td>0x45</td>
<td>SM-RP-MMS (More Messages to Send)</td>
<td>Section 13.8.9</td>
</tr>
<tr>
<td>0x46</td>
<td>SM Alert Reason</td>
<td>Section 13.8.10</td>
</tr>
<tr>
<td>0x50</td>
<td>IMEI</td>
<td>Section 13.7.27</td>
</tr>
<tr>
<td>0x51</td>
<td>IMEI Check Result</td>
<td>Section 13.7.28</td>
</tr>
<tr>
<td>0x60</td>
<td>Source Name</td>
<td>Section 13.7.30</td>
</tr>
<tr>
<td>0x61</td>
<td>Destination Name</td>
<td>Section 13.7.31</td>
</tr>
<tr>
<td>0x62</td>
<td>AN-APDU</td>
<td>Section 13.7.32</td>
</tr>
<tr>
<td>0x63</td>
<td>RK Cause</td>
<td>Section 13.7.33</td>
</tr>
<tr>
<td>0x64</td>
<td>BSSAP Cause</td>
<td>Section 13.7.34</td>
</tr>
<tr>
<td>0x65</td>
<td>Session Management Cause</td>
<td>Section 13.7.35</td>
</tr>
</tbody>
</table>
13.7.18 Empty field

This is used for flags, if and only if this IE is present, the flag is set. The semantics depend on the IEI and the context.

![Diagram showing empty field](image)

13.7.19 IMSI

The IMSI is encoded like in octet 4-N of the Called Party BCD Number defined in 3GPP TS 04.08, 10.5.4.7.

![Diagram showing IMSI encoding](image)

Note
Either 1 1 1 1 | Number digit N (N odd) or Number digit N | Number digit N-1 (N even), where N is the number of digits.

13.7.20 ISDN-AddressString / MSISDN / Called Party BCD Number

The MSISDN is encoded as an ISDN-AddressString in 3GPP TS 09.02 and Called Party BCD Number in 3GPP TS 04.08. It will be stored by the SGSN or VLR and then passed as is to the GGSN during the activation of the primary PDP Context.

![Diagram showing ISDN-AddressString](image)
13.7.21 Access Point Name

This encodes the Access Point Name of a PDP Context. The encoding is defined in 3GPP TS 23.003.

13.7.22 Quality of Service Subscribed Service

This encodes the subscribed QoS of a subscriber. It will be used by the SGSN during the PDP Context activation. If the length of the QoS data is 3 (three) octets it is assumed that these are octets 3-5 of the TS 3GPP TS 24.008 Quality of Service Octets. If it is more than three then it is assumed that the first octet is the Allocation/Retention Priority and the reset are encoded as octets 3-N of 24.008.

13.7.23 PDP-Charging Characteristics

This encodes the ChargingCharacteristics of 3GPP TS 32.215. A HLR may send this as part of the InsertSubscriberData or within a single PDP context definition. If the HLR supplies this information it must be used by the SGSN or VLR when activating a PDP context.
13.7.24 HLR Number encoded as 3GPP TS 09.02 ISDN-AddressString

The HLR Number is encoded as an ISDN-AddressString in 3GPP TS 09.02. It will be stored by the SGSN or VLR can be used by the CDR module to keep a record.

13.7.25 Cause

This IE shall be encoded according to the GMM Cause as described in Chapter 10.5.5.14 of 3GPP TS 04.08.

13.7.26 Supplementary Service Info

This IE shall be used together with both Section 13.8.2 and Section 13.8.1 IEs. It is used to carry the payload of Supplementary Services encoded according to GSM TS 04.80.

13.7.27 IMEI

The IMEI encoded as Called Party BCD Number in 3GPP TS 04.08.
13.7.28 IMEI Check Result

Result of the Check IMEI request. A NACK could be sent in theory, if the ME is not permitted on the network (e.g. because it is on a blacklist).

Table 11: IMEI Check Result

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x01</td>
<td>ACK</td>
</tr>
<tr>
<td>0x02</td>
<td>NACK</td>
</tr>
</tbody>
</table>

13.7.29 Message Class

Indicate, which kind of message is being sent. This allows to trivially dispatch incoming GSUP messages to the right code paths, and should make writing a GSUP to MAP converter easier.

This IE was introduced together with inter-MSC handover code. Inter-MSC messages must include this IE and set it to the appropriate type. The intention of creating this IE was to use it with all GSUP messages eventually.

<table>
<thead>
<tr>
<th>Type</th>
<th>Always present</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>no</td>
<td>Subscriber Management</td>
</tr>
<tr>
<td>2</td>
<td>no</td>
<td>SMS</td>
</tr>
<tr>
<td>3</td>
<td>no</td>
<td>USSD</td>
</tr>
<tr>
<td>4</td>
<td>yes</td>
<td>Inter-MSC</td>
</tr>
</tbody>
</table>

13.7.30 Source Name

When the GSUP server is asked to forward a message between two GSUP clients, the source name is the IPA name of the client where the message is coming from. The source name IE is present, when the GSUP server forwards the message to the destination. Although redundant, the source name IE is also sent from the source to the GSUP server (so it is easier to follow the network traces).

Source and destination names are sent as nul-terminated strings.

![Message forwarding example](image)

13.7.31 Destination Name

The receiving counterpart to source name (Section 13.7.30).

13.7.32 AN-APDU

This IE encodes the AN-APDU parameter described in 3GPP TS 29.002 7.6.9.1.
Table 12: Access Network Protocol

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x01</td>
<td>BSSAP</td>
</tr>
<tr>
<td>0x02</td>
<td>RANAP</td>
</tr>
</tbody>
</table>

13.7.33 RR Cause

This IE contains the reason for release or completion of an assignment or handover. See 3GPP TS 44.018 10.5.2.31 for reference.

13.7.34 BSSAP Cause

This IE indicates why an event is happening on the BSSAP interface. See 3GPP TS 48.008 3.2.2.5 for reference.

13.7.35 Session Management Cause

This IE contains the reason for rejecting a session management request. See 3GPP TS 24.008 10.5.6.6 / Table 10.5.157 for reference.

13.8 Session (transaction) management

Unlike TCAP/MAP, GSUP is just a transport layer without the dialogue/context. All communication is usually happening over a single connection. In order to fill this gap, there is a few optional IEs, which allow both communication sides to establish and terminate TCAP-like transactions over GSUP.

13.8.1 Session ID

This auxiliary IE shall be used together with Section 13.8.2. The purpose of this IE is to identify a particular transaction using the 4-byte unique identifier.
13.8.2 Session State

This auxiliary IE shall be used together with Section 13.8.1. The purpose of this IE is to indicate a state of a particular transaction, i.e. initiate, continue or terminate it.
Table 13: Session state

<table>
<thead>
<tr>
<th>State</th>
<th>TCAP alternative</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x00</td>
<td>Undefined</td>
<td>Used when session management is not required</td>
</tr>
<tr>
<td>0x01</td>
<td>BEGIN</td>
<td>Used to initiate a new session</td>
</tr>
<tr>
<td>0x02</td>
<td>CONTINUE</td>
<td>Used to continue an existing session</td>
</tr>
<tr>
<td>0x03</td>
<td>END</td>
<td>Used to terminate an existing session</td>
</tr>
</tbody>
</table>

13.8.3 SM-RP-MR (Message Reference)

According to TS GSM 04.11, section 8.2.3, every single message on the SM-RL (SM Relay Layer) has a unique message reference, that is used to link an RP-ACK or RP-ERROR message to the associated (preceding) RP-DATA or RP-SMMA message transfer attempt.

In case of TCAP/MAP, this message reference is being mapped to the Invoke ID. But since GSUP has no Invoke ID IE, and it is not required for other applications (other than SMS), a special Section 13.8.3 is used to carry the message reference value ‘as-is’ (i.e. in range 0 through 255).

13.8.4 SM-RP-DA (Destination Address)

This IE represents the destination address used by the short message service relay sub-layer protocol. It can be one of the following:

- IMSI (see 3GPP TS 29.002, clause 7.6.2.1);
- MSISDN (see 3GPP TS 29.002, clause 7.6.2.17);
- service centre address (see 3GPP TS 29.002, clause 7.6.2.27).

Coding of this IE is described in Section 13.8.6. See 3GPP TS 29.002, section 7.6.8.1 for details.

13.8.5 SM-RP-OA (Originating Address)

This IE represents the originating address used by the short message service relay sub-layer protocol. It can be either of the following:

- MSISDN (see 3GPP TS 29.002, clause 7.6.2.17);
- service centre address (see 3GPP TS 29.002, clause 7.6.2.27).

Coding of this IE is described in Section 13.8.6. See 3GPP TS 29.002, section 7.6.8.2 for details.

13.8.6 Coding of SM-RP-DA / SM-RP-OA IEs

Basically, both Section 13.8.4 / Section 13.8.5 IEs contain a single TV of the following format:

Table 14: Coding of SM-RP-DA / SM-RP-OA IEs

<table>
<thead>
<tr>
<th>Field</th>
<th>Presence Length</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>T</td>
<td>M 1</td>
<td>Identity type</td>
</tr>
<tr>
<td>V</td>
<td>O 1</td>
<td>ToN/NPI header</td>
</tr>
<tr>
<td>V</td>
<td>O . .</td>
<td>BCD encoded (or alphanumeric) identity</td>
</tr>
</tbody>
</table>
where the identity type can be one of the following:

Table 15: Identity types of SM-RP-DA / SM-RP-OA IEs

<table>
<thead>
<tr>
<th>Type</th>
<th>ToN/NPI Header</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x01</td>
<td>No</td>
<td>IMSI (see 3GPP TS 29.002, clause 7.6.2.1)</td>
</tr>
<tr>
<td>0x02</td>
<td>Yes</td>
<td>MSISDN (see 3GPP TS 29.002, clause 7.6.2.17)</td>
</tr>
<tr>
<td>0x03</td>
<td>Yes</td>
<td>Service centre address (see 3GPP TS 29.002, clause 7.6.2.27)</td>
</tr>
<tr>
<td>0xff</td>
<td>No</td>
<td>Omit value for noSM-RP-DA and noSM-RP-OA</td>
</tr>
</tbody>
</table>

Coding of the optional ToN/NPI header, as well as all possible ToN/NPI values, is described in 3GPP TS 129.002, section 17.7.8 "Common data types", and can be summarized as follows:

Please note that unlike both Section 13.7.19 and Section 13.7.20, where the value part is encoded as LV (i.e. contains an additional length), an identity in both Section 13.8.4 / Section 13.8.5 IEs shall not contain the redundant length octet.

13.8.7 SM-RP-UI (SM TPDU)

This IE represents the user data field carried by the short message service relay sub-layer (i.e. SM-TL (Transfer Layer)) protocol. In case of errors (i.e. MO-/MT-forwardSM Error messages), this IE may contain optional diagnostic field payload from RP-ERROR message.

See 3GPP TS 29.002, section 7.6.8.4 for details.

13.8.8 SM-RP-Cause (RP Cause value)

According to TS GSM 04.11, RP-Cause is a variable length element always included in the RP-ERROR message, conveying a negative result of an RP-DATA message transfer attempt or RP-SMMA notification attempt.

The mapping between error causes in TS GSM 04.11 and TS GSM 09.02 (MAP) is specified in TS GSM 03.40. But since GSUP has no generic User Error IE, and it is not required for other applications (other than SMS), a special Section 13.8.8 is used to carry the cause value 'as-is'.
13.8.9 SM-RP-MMS (More Messages to Send)

This is an optional IE of MT-ForwardSM-Req message, that is used by SMSC to indicate that there are more MT SMS messages to be sent, so the network should keep the RAN connection open. See 3GPP TS 29.002, section 7.6.8.7.

13.8.10 SM Alert Reason

According to 3GPP TS 29.002, section 7.6.8.8, Alert Reason is used to indicate the reason why the service centre is alerted, e.g. the MS has got some memory to store previously rejected incoming SMS.

It can take one of the following values:

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x01</td>
<td>MS present</td>
</tr>
<tr>
<td>0x02</td>
<td>Memory Available</td>
</tr>
</tbody>
</table>

14 Counters

These counters and their description based on OsmoSGSN 1.4.0.31-05fe (OsmoSGSN).

14.1 Rate Counters

Table 17: bssgp:bss_ctx - BSSGP Peer Statistics

<table>
<thead>
<tr>
<th>Name</th>
<th>Reference</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>packets:in</td>
<td>[?]</td>
<td>Packets at BSSGP Level (In)</td>
</tr>
<tr>
<td>packets:out</td>
<td>[?]</td>
<td>Packets at BSSGP Level (Out)</td>
</tr>
<tr>
<td>bytes:in</td>
<td>[?]</td>
<td>Bytes at BSSGP Level (In)</td>
</tr>
<tr>
<td>bytes:out</td>
<td>[?]</td>
<td>Bytes at BSSGP Level (Out)</td>
</tr>
<tr>
<td>blocked</td>
<td>[?]</td>
<td>BVC Blocking count</td>
</tr>
<tr>
<td>discarded</td>
<td>[?]</td>
<td>BVC LLC Discarded count</td>
</tr>
<tr>
<td>status</td>
<td>[?]</td>
<td>BVC Status count</td>
</tr>
</tbody>
</table>

Table 18: sgsn - SGSN Overall Statistics

<table>
<thead>
<tr>
<th>Name</th>
<th>Reference</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>llc:dl_bytes</td>
<td>[?]</td>
<td>Count sent LLC bytes before giving it to the bssgp layer</td>
</tr>
<tr>
<td>llc:ul_bytes</td>
<td>[?]</td>
<td>Count successful received LLC bytes (encrypt &amp; fcs correct)</td>
</tr>
<tr>
<td>llc:dl_packets</td>
<td>[?]</td>
<td>Count successful sent LLC packets before giving it to the bssgp layer</td>
</tr>
<tr>
<td>llc:ul_packets</td>
<td>[?]</td>
<td>Count successful received LLC packets (encrypt &amp; fcs correct)</td>
</tr>
<tr>
<td>gprs:attach_requested</td>
<td>[?]</td>
<td>Received attach requests</td>
</tr>
</tbody>
</table>
Table 18: (continued)

<table>
<thead>
<tr>
<th>Name</th>
<th>Reference</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>gprs:attach_accepted</td>
<td>[?]</td>
<td>Sent attach accepts</td>
</tr>
<tr>
<td>gprs:attach_rejected</td>
<td>[?]</td>
<td>Sent attach rejects</td>
</tr>
<tr>
<td>gprs:detach_requested</td>
<td>[?]</td>
<td>Received detach requests</td>
</tr>
<tr>
<td>gprs:detach_acked</td>
<td>[?]</td>
<td>Sent detach acks</td>
</tr>
<tr>
<td>gprs:routing_area_requested</td>
<td>[?]</td>
<td>Received routing area requests</td>
</tr>
<tr>
<td>gprs:routing_area_requested</td>
<td>[?]</td>
<td>Sent routing area acks</td>
</tr>
<tr>
<td>pdp:activate_requested</td>
<td>[?]</td>
<td>Received activate requests</td>
</tr>
<tr>
<td>pdp:activate_rejected</td>
<td>[?]</td>
<td>Sent activate rejects</td>
</tr>
<tr>
<td>pdp:activate_accepted</td>
<td>[?]</td>
<td>Sent activate accepts</td>
</tr>
<tr>
<td>pdp:request_activated</td>
<td>[?]</td>
<td>unused</td>
</tr>
<tr>
<td>pdp:request_activate_rejected</td>
<td>[?]</td>
<td>unused</td>
</tr>
<tr>
<td>pdp:modify_requested</td>
<td>[?]</td>
<td>unused</td>
</tr>
<tr>
<td>pdp:modify_accepted</td>
<td>[?]</td>
<td>unused</td>
</tr>
<tr>
<td>pdp:dl_deactivate_requested</td>
<td>[?]</td>
<td>Sent deactivate requests</td>
</tr>
<tr>
<td>pdp:dl_deactivate_accepted</td>
<td>[?]</td>
<td>Sent deactivate accepted</td>
</tr>
<tr>
<td>pdp:ul_deactivate_requested</td>
<td>[?]</td>
<td>Received deactivate requests</td>
</tr>
<tr>
<td>pdp:ul_deactivate_accepted</td>
<td>[?]</td>
<td>Received deactivate accepts</td>
</tr>
</tbody>
</table>

Table 19: ns:nsvc - NSVC Peer Statistics

<table>
<thead>
<tr>
<th>Name</th>
<th>Reference</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>packets:in</td>
<td>[?]</td>
<td>Packets at NS Level (In)</td>
</tr>
<tr>
<td>packets:out</td>
<td>[?]</td>
<td>Packets at NS Level (Out)</td>
</tr>
<tr>
<td>bytes:in</td>
<td>[?]</td>
<td>Bytes at NS Level (In)</td>
</tr>
<tr>
<td>bytes:out</td>
<td>[?]</td>
<td>Bytes at NS Level (Out)</td>
</tr>
<tr>
<td>blocked</td>
<td>[?]</td>
<td>NS-VC Block count</td>
</tr>
<tr>
<td>dead</td>
<td>[?]</td>
<td>NS-VC gone dead count</td>
</tr>
<tr>
<td>replaced</td>
<td>[?]</td>
<td>NS-VC replaced other count</td>
</tr>
<tr>
<td>nsei-chg</td>
<td>[?]</td>
<td>NS-VC changed NSEI count</td>
</tr>
<tr>
<td>inv-nsvci</td>
<td>[?]</td>
<td>NS-VCI was invalid count</td>
</tr>
<tr>
<td>inv-nsei</td>
<td>[?]</td>
<td>NSEI was invalid count</td>
</tr>
<tr>
<td>lost:alive</td>
<td>[?]</td>
<td>ALIVE ACK missing count</td>
</tr>
<tr>
<td>lost:reset</td>
<td>[?]</td>
<td>RESET ACK missing count</td>
</tr>
</tbody>
</table>

15 Osmo Stat Items

NSVC Peer Statistics .ns.nsvc - NSVC Peer Statistics

<table>
<thead>
<tr>
<th>Name</th>
<th>Reference</th>
<th>Description</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>alive:delay</td>
<td>[?]</td>
<td>ALIVE response time</td>
<td>ms</td>
</tr>
</tbody>
</table>
16 Osmo Counters

17 Glossary

2FF
2nd Generation Form Factor; the so-called plug-in SIM form factor

3FF
3rd Generation Form Factor; the so-called microSIM form factor

3GPP
3rd Generation Partnership Project

4FF
4th Generation Form Factor; the so-called nanoSIM form factor

A Interface
Interface between BTS and BSC, traditionally over E1 (3GPP TS 48.008 [3gpp-ts-48-008])

A3/A8
Algorithm 3 and 8; Authentication and key generation algorithm in GSM and GPRS, typically COMP128v1/v2/v3 or MILANEGE are typically used

A5
Algorithm 5; Air-interface encryption of GSM; currently only A5/0 (no encryption), A5/1 and A5/3 are in use

Abis Interface
Interface between BTS and BSC, traditionally over E1 (3GPP TS 48.058 [3gpp-ts-48-058] and 3GPP TS 52.021 [3gpp-ts-52-021])

ACC
Access Control Class; every BTS broadcasts a bit-mask of permitted ACC, and only subscribers with a SIM of matching ACC are permitted to use that BTS

AGCH
Access Grant Channel on Um interface; used to assign a dedicated channel in response to RACH request

AGPL
GNU Affero General Public License, a copyleft-style Free Software License

ARFCN
Absolute Radio Frequency Channel Number; specifies a tuple of uplink and downlink frequencies

AUC
Authentication Center; central database of authentication key material for each subscriber

BCCH
Broadcast Control Channel on Um interface; used to broadcast information about Cell and its neighbors

BCC
Base Station Color Code; short identifier of BTS, lower part of BSIC

BTS
Base Transceiver Station

BSC
Base Station Controller

BSIC
Base Station Identity Code; 16bit identifier of BTS within location area
BSSGP
Base Station Subsystem Gateway Protocol (3GPP TS 48.018 [3gpp-ts-48-018])

BVCI
BSSGP Virtual Circuit Identifier

CBCH
Cell Broadcast Channel; used to transmit Cell Broadcast SMS (SMS-CB)

CC
Call Control; Part of the GSM Layer 3 Protocol

CCCH
Common Control Channel on Um interface; consists of RACH (uplink), BCCH, PCH, AGCH (all downlink)

Cell
A cell in a cellular network, served by a BTS

CEPT
Conférence européenne des administrations des postes et des télécommunications; European Conference of Postal and Telecommunications Administrations.

CGI
Cell Global Identifier comprised of MCC, MNC, LAC and BSIC

CSFB
Circuit-Switched Fall Back; Mechanism for switching from LTE/EUTRAN to UTRAN/GERAN when circuit-switched services such as voice telephony are required.

dB
deci-Bel; relative logarithmic unit

dBm
deci-Bel (milliwatt); unit of measurement for signal strength of radio signals

DHCP
Dynamic Host Configuration Protocol (IETF RFC 2131 [ietf-rfc2131])

downlink
Direction of messages / signals from the network core towards the mobile phone

DSP
Digital Signal Processor

dvnixload
Tool to program UBL and the Bootloader on a sysmoBTS

EDGE
Enhanced Data rates for GPRS Evolution; Higher-speed improvement of GPRS; introduces 8PSK

EGPRS
Enhanced GPRS; the part of EDGE relating to GPRS services

EIR
Equipment Identity Register; core network element that stores and manages IMEI numbers

ESME
External SMS Entity; an external application interfacing with a SMSC over SMPP

ETSI
European Telecommunications Standardization Institute

FPGA
Field Programmable Gate Array; programmable digital logic hardware
Gb
Interface between PCU and SGSN in GPRS/EDGE network; uses NS, BSSGP, LLC

GERAN
GPRS/EDGE Radio Access Network

GFDL
GNU Free Documentation License; a copyleft-style Documentation License

GGSN
GPRS Gateway Support Node; gateway between GPRS and external (IP) network

GMSK
Gaussian Minimum Shift Keying; modulation used for GSM and GPRS

GPL
GNU General Public License, a copyleft-style Free Software License

Gp
Gp interface between SGSN and GGSN; uses GTP protocol

GPRS
General Packet Radio Service; the packet switched 2G technology

GPS
Global Positioning System; provides a highly accurate clock reference besides the global position

GSM
Global System for Mobile Communications. ETSI/3GPP Standard of a 2G digital cellular network

GSMTAP
GSM tap; pseudo standard for encapsulating GSM protocol layers over UDP/IP for analysis

GSUP
Generic subscriber Update Protocol. Osmocom-specific alternative to TCAP/MAP

GT
Global Title; an address in SCCP

GTP
GPRS Tunnel Protocol; used between SGSN and GGSN

HLR
Home Location Register; central subscriber database of a GSM network

HNB-GW
Home NodeB Gateway. Entity between femtocells (Home NodeB) and CN in 3G/UMTS.

HPLMN
Home PLMN; the network that has issued the subscriber SIM and has his record in HLR

IE
Information Element

IMEI
International Mobile Equipment Identity; unique 14-digit decimal number to globally identify a mobile device, optionally with a 15th checksum digit

IMEISV
IMEI software version; unique 14-digit decimal number to globally identify a mobile device (same as IMEI) plus two software version digits (total digits: 16)

IMSI
International Mobile Subscriber Identity; 15-digit unique identifier for the subscriber/SIM; starts with MCC/MNC of issuing operator
IP
Internet Protocol (IETF RFC 791)

IPA
ip.access GSM over IP protocol; used to multiplex a single TCP connection

Iu
Interface in 3G/UMTS between RAN and CN

IuCS
Iu interface for circuit-switched domain. Used in 3G/UMTS between RAN and MSC

IuPS
Iu interface for packet-switched domain. Used in 3G/UMTS between RAN and SGSN

LAC
Location Area Code; 16bit identifier of Location Area within network

LAPD
Link Access Protocol, D-Channel (ITU-T Q.921)

LAPDm
Link Access Protocol Mobile (3GPP TS 44.006)

LLC
Logical Link Control; GPRS protocol between MS and SGSN (3GPP TS 44.064)

Location Area
Location Area; a geographic area containing multiple BTS

LU
Location Updating; can be of type IMSI-Attach or Periodic. Procedure that indicates a subscriber’s physical presence in a given radio cell.

M2PA
MTP2 Peer-to-Peer Adaptation; a SIGTRAN Variant (RFC 4165)

M2UA
MTP2 User Adaptation; a SIGTRAN Variant (RFC 3331)

M3UA
MTP3 User Adaptation; a SIGTRAN Variant (RFC 4666)

MCC
Mobile Country Code; unique identifier of a country, e.g. 262 for Germany

MFF
Machine-to-Machine Form Factor; a SIM chip package that is soldered permanently onto M2M device circuit boards.

MGW
Media Gateway

MM
Mobility Management; part of the GSM Layer 3 Protocol

MNC
Mobile Network Code; identifies network within a country; assigned by national regulator

MNCC
Mobile Network Call Control; Unix domain socket based Interface between MSC and external call control entity like osmo-sip-connector

MNO
Mobile Network Operator; operator with physical radio network under his MCC/MNC
MO
Mobile Originated. Direction from Mobile (MS/UE) to Network

MS
Mobile Station; a mobile phone / GSM Modem

MSC
Mobile Switching Center; network element in the circuit-switched core network

MSISDN
Mobile Subscriber ISDN Number; telephone number of the subscriber

MT
Mobile Terminated. Direction from Network to Mobile (MS/UE)

MTP
Message Transfer Part; SS7 signaling protocol ([ITU-T Q.701](https://www.itu.int/rec/T-REC-Q.701))

MVNO
Mobile Virtual Network Operator; Operator without physical radio network

NCC
Network Color Code; assigned by national regulator

NITB
Network In The Box; combines functionality traditionally provided by BSC, MSC, VLR, HLR, SMSC functions; see OsmoNITB

NSEI
NS Entity Identifier

NVCI
NS Virtual Circuit Identifier

NWL
Network Listen; ability of some BTS to receive downlink from other BTSs

NS
Network Service; protocol on Gb interface ([3GPP TS 48.016](https://www.3gpp.org/Specs?doc疏导=2227))

OCXO
Oven Controlled Crystal Oscillator; very high precision oscillator, superior to a VCTCXO

OML
Operation & Maintenance Link ([ETSI/3GPP TS 52.021](https://www.etsi.org/deliver/etsi_3gpp/052/021/01.01.03_60/e.01.01.03_60))

OpenBSC
Open Source implementation of GSM network elements, specifically OsmoBSC, OsmoNITB, OsmoSGSN

OpenGGSN
Open Source implementation of a GPRS Packet Control Unit

OpenVPN
Open-Source Virtual Private Network; software employed to establish encrypted private networks over untrusted public networks

Osmocom
Open Source MOible COMmunications; collaborative community for implementing communications protocols and systems, including GSM, GPRS, TETRA, DECT, GMR and others

OsmoBSC
Open Source implementation of a GSM Base Station Controller
OsmoNITB
Open Source implementation of a GSM Network In The Box, combines functionality traditionally provided by BSC, MSC, VLR, HLR, AUC, SMSC

OsmoSGSN
Open Source implementation of a Serving GPRS Support Node

OsmoPCU
Open Source implementation of a GPRS Packet Control Unit

OTA
Over-The-Air; Capability of operators to remotely reconfigure/reprogram ISM/USIM cards

PC
Point Code; an address in MTP

PCH
Paging Channel on downlink Um interface; used by network to page an MS

PCU
Packet Control Unit; used to manage Layer 2 of the GPRS radio interface

PDCH
Packet Data Channel on Um interface; used for GPRS/EDGE signalling + user data

PIN
Personal Identification Number; a number by which the user authenticates to a SIM/USIM or other smart card

PLMN
Public Land Mobile Network; specification language for a single GSM network

PUK
PIN Unblocking Code; used to unblock a blocked PIN (after too many wrong PIN attempts)

RAC
Routing Area Code; 16bit identifier for a Routing Area within a Location Area

RACH
Random Access Channel on uplink Um interface; used by MS to request establishment of a dedicated channel

RAM
Remote Application Management; Ability to remotely manage (install, remove) Java Applications on SIM/USIM Card

RF
Radio Frequency

RFM
Remote File Management; Ability to remotely manage (write, read) files on a SIM/USIM card

Roaming
Procedure in which a subscriber of one network is using the radio network of another network, often in different countries; in some countries national roaming exists

Routing Area
Routing Area; GPRS specific sub-division of Location Area

RR
Radio Resources; Part of the GSM Layer 3 Protocol

RSL
Radio Signalling Link (3GPP TS 48.058 [3gpp-ts-48-058])

RTP
Real-Time Transport Protocol (IETF RFC 3550 [ietf-rfc3550]); Used to transport audio/video streams over UDP/IP
**SACCH**
Slow Associate Control Channel on Um interface; bundled to a TCH or SDCCH, used for signalling in parallel to active dedicated channel

**SCCP**
Signaling Connection Control Part; SS7 signaling protocol ([ITU-T Q.711](itu-t-q711))

**SDCCH**
Slow Dedicated Control Channel on Um interface; used for signalling and SMS transport in GSM

**SDK**
Software Development Kit

**SGs**
Interface between MSC (GSM/UMTS) and MME (LTE/EPC) to facilitate CSFB and SMS.

**SGSN**
Serving GPRS Support Node; Core network element for packet-switched services in GSM and UMTS.

**SIGTRAN**
Signaling Transport over IP ([IETF RFC 2719](ietf-rfc2719))

**SIM**
Subscriber Identity Module; small chip card storing subscriber identity

**Site**
A site is a location where one or more BTSs are installed, typically three BTSs for three sectors

**SMPP**
Short Message Peer-to-Peer; TCP based protocol to interface external entities with an SMSC

**SMSC**
Short Message Service Center; store-and-forward relay for short messages

**SS7**
Signaling System No. 7; Classic digital telephony signaling system

**SS**
Supplementary Services; query and set various service parameters between subscriber and core network (e.g. USSD, 3rd-party calls, hold/retrieve, advice-of-charge, call deflection)

**SSH**
Secure Shell; ([IETF RFC 4250](ietf-rfc4251) to 4254)

**SSN**
Sub-System Number; identifies a given SCCP Service such as MSC, HLR

**STP**
Signaling Transfer Point; A Router in SS7 Networks

**SUA**
SCCP User Adaptation; a SIGTRAN Variant ([RFC 3868](ietf-rfc3868))

**syslog**
System logging service of UNIX-like operating systems

**System Information**
A set of downlink messages on the BCCH and SACCH of the Um interface describing properties of the cell and network

**TCH**
Traffic Channel; used for circuit-switched user traffic (mostly voice) in GSM

**TCP**
Transmission Control Protocol; ([IETF RFC 793](ietf-rfc793))
TFTP
Trivial File Transfer Protocol; *(IETF RFC 1350 [ietf-rfc1350])*

TRX
Transceiver; element of a BTS serving a single carrier

TS
Technical Specification

u-Boot
Boot loader used in various embedded systems

UBI
An MTD wear leveling system to deal with NAND flash in Linux

UBL
Initial bootloader loaded by the TI Davinci SoC

UDP
User Datagram Protocol *(IETF RFC 768 [ietf-rfc768])*

UICC
Universal Integrated Chip Card; A smart card according to *ETSI TR 102 216 [etsi-tr102216]*

Um interface
U mobile; Radio interface between MS and BTS

uplink
Direction of messages: Signals from the mobile phone towards the network

USIM
Universal Subscriber Identity Module; application running on a UICC to provide subscriber identity for UMTS and GSM networks

USSD
Unstructured Supplementary Service Data; textual dialog between subscriber and core network, e.g. *100 → Your extension is 1234*

VCTCXO
Voltage Controlled, Temperature Compensated Crystal Oscillator; a precision oscillator, superior to a classic crystal oscillator, but inferior to an OCXO

VLR
Visitor Location Register; volatile storage of attached subscribers in the MSC

VPLMN
Visited PLMN; the network in which the subscriber is currently registered; may differ from HPLMN when on roaming

VTY
Virtual TeletYpe; a textual command-line interface for configuration and introspection, e.g. the OsmoBSC configuration file as well as its telnet link on port 4242

A Osmocom TCP/UDP Port Numbers

The Osmocom GSM system utilizes a variety of TCP/IP based protocols. The table below provides a reference as to which port numbers are used by which protocol / interface.
### Table 20: TCP/UDP port numbers

<table>
<thead>
<tr>
<th>L4 Protocol</th>
<th>Port Number</th>
<th>Purpose</th>
<th>Software</th>
</tr>
</thead>
<tbody>
<tr>
<td>UDP</td>
<td>2427</td>
<td>MGCP GW</td>
<td>osmo-bsc_mgcp, osmo-mgw</td>
</tr>
<tr>
<td>TCP</td>
<td>2775</td>
<td>SMPP (SMS interface for external programs)</td>
<td>osmo-nitb</td>
</tr>
<tr>
<td>TCP</td>
<td>3002</td>
<td>A-bis/IP OML</td>
<td>osmo-bts, osmo-bsc, osmo-nitb</td>
</tr>
<tr>
<td>TCP</td>
<td>3003</td>
<td>A-bis/IP RSL</td>
<td>osmo-bts, osmo-bsc, osmo-nitb</td>
</tr>
<tr>
<td>TCP</td>
<td>4236</td>
<td>Control Interface</td>
<td>osmo-trx</td>
</tr>
<tr>
<td>TCP</td>
<td>4237</td>
<td>telnet (VTY)</td>
<td>osmo-trx</td>
</tr>
<tr>
<td>TCP</td>
<td>4238</td>
<td>Control Interface</td>
<td>osmo-bts</td>
</tr>
<tr>
<td>TCP</td>
<td>4239</td>
<td>telnet (VTY)</td>
<td>osmo-stp</td>
</tr>
<tr>
<td>TCP</td>
<td>4240</td>
<td>telnet (VTY)</td>
<td>osmo-pcu</td>
</tr>
<tr>
<td>TCP</td>
<td>4241</td>
<td>telnet (VTY)</td>
<td>osmo-bts</td>
</tr>
<tr>
<td>TCP</td>
<td>4242</td>
<td>telnet (VTY)</td>
<td>osmo-nitb, osmo-bsc, cellmgr-ng</td>
</tr>
<tr>
<td>TCP</td>
<td>4243</td>
<td>telnet (VTY)</td>
<td>osmo-bsc_mgcp, osmo-mgw</td>
</tr>
<tr>
<td>TCP</td>
<td>4244</td>
<td>telnet (VTY)</td>
<td>osmo-bsc_nat</td>
</tr>
<tr>
<td>TCP</td>
<td>4245</td>
<td>telnet (VTY)</td>
<td>osmo-sgsn</td>
</tr>
<tr>
<td>TCP</td>
<td>4246</td>
<td>telnet (VTY)</td>
<td>osmo-gbproxy</td>
</tr>
<tr>
<td>TCP</td>
<td>4247</td>
<td>telnet (VTY)</td>
<td>OsmocomBB</td>
</tr>
<tr>
<td>TCP</td>
<td>4249</td>
<td>Control Interface</td>
<td>osmo-nitb, osmo-bsc</td>
</tr>
<tr>
<td>TCP</td>
<td>4250</td>
<td>Control Interface</td>
<td>osmo-bsc_nat</td>
</tr>
<tr>
<td>TCP</td>
<td>4251</td>
<td>Control Interface</td>
<td>osmo-sgsn</td>
</tr>
<tr>
<td>TCP</td>
<td>4252</td>
<td>telnet (VTY)</td>
<td>symobts-mgr</td>
</tr>
<tr>
<td>TCP</td>
<td>4253</td>
<td>telnet (VTY)</td>
<td>osmo-gtphub</td>
</tr>
<tr>
<td>TCP</td>
<td>4254</td>
<td>telnet (VTY)</td>
<td>osmo-msc</td>
</tr>
<tr>
<td>TCP</td>
<td>4255</td>
<td>Control Interface</td>
<td>osmo-msc</td>
</tr>
<tr>
<td>TCP</td>
<td>4256</td>
<td>telnet (VTY)</td>
<td>osmo-sip-connector</td>
</tr>
<tr>
<td>TCP</td>
<td>4257</td>
<td>Control Interface</td>
<td>osmo-ggsn, ggsn (OpenGGSN)</td>
</tr>
<tr>
<td>TCP</td>
<td>4258</td>
<td>telnet (VTY)</td>
<td>osmo-hlr</td>
</tr>
<tr>
<td>TCP</td>
<td>4259</td>
<td>Control Interface</td>
<td>osmo-hlr</td>
</tr>
<tr>
<td>TCP</td>
<td>4260</td>
<td>telnet (VTY)</td>
<td>osmo-ggsn</td>
</tr>
<tr>
<td>TCP</td>
<td>4261</td>
<td>telnet (VTY)</td>
<td>osmo-hnbgw</td>
</tr>
<tr>
<td>TCP</td>
<td>4262</td>
<td>Control Interface</td>
<td>osmo-hnbgw</td>
</tr>
<tr>
<td>TCP</td>
<td>4263</td>
<td>Control Interface</td>
<td>osmo-gbproxy</td>
</tr>
<tr>
<td>TCP</td>
<td>4264</td>
<td>telnet (VTY)</td>
<td>osmo-cbc</td>
</tr>
<tr>
<td>TCP</td>
<td>4265</td>
<td>Control Interface</td>
<td>osmo-cbc</td>
</tr>
<tr>
<td>TCP</td>
<td>4266</td>
<td>D-GSM MS Lookup: mDNS serve</td>
<td>osmo-hlr</td>
</tr>
<tr>
<td>TCP</td>
<td>4267</td>
<td>Control Interface</td>
<td>osmo-mgw</td>
</tr>
<tr>
<td>UDP</td>
<td>4729</td>
<td>GSMTAP</td>
<td>Almost every osmocom project</td>
</tr>
<tr>
<td>TCP</td>
<td>5000</td>
<td>A/IP</td>
<td>osmo-bsc, osmo-bsc_nat</td>
</tr>
<tr>
<td>UDP</td>
<td>2427</td>
<td>GSMTAP</td>
<td>osmo-pcu, osmo-bts</td>
</tr>
<tr>
<td>UDP</td>
<td>23000</td>
<td>GPRS-NS over IP default port</td>
<td>osmo-pcu, osmo-sgsn, osmo-gbproxy</td>
</tr>
</tbody>
</table>

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