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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:

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• 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 :)  
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• 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
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• sysmocom, for hosting and funding a lot of Osmocom development, the annual Osmocom Developer Conference and releasing this manual.
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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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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

This manual should help you getting started with OsmoMSC. It will cover aspects of configuring and running the OsmoMSC.
4.1 About OsmoMSC

OsmoMSC is the Osmocom implementation of a Mobile Switching Center (MSC) for 2G and 3G GSM and UMTS mobile networks. Its interfaces are:

- GSUP towards OsmoHLR (or a MAP proxy);
- A over IP towards a BSC (e.g. OsmoBSC);
- IuCS towards an RNC or HNB-GW (e.g. OsmoHNBGW) for 3G voice;
- MNCC (Mobile Network Call Control derived from GSM TS 04.07);
- SMPP 3.4 (Short Message Peer-to-Peer);
- The Osmocom typical telnet VTY and CTRL interfaces.

OsmoMSC originated from the OpenBSC project, which started as a minimalistic all-in-one implementation of the GSM Network. In 2017, OpenBSC had reached maturity and diversity (including M3UA SIGTRAN and 3G support in the form of IuCS and IuPS interfaces) that naturally lead to a separation of the all-in-one approach to fully independent separate programs as in typical GSM networks. Before it was split off, OsmoMSC originated from libmsc of the old openbsc.git. Since a true A interface and IuCS for 3G support is available, OsmoMSC exists only as a separate standalone entity.

Key differences of the new OsmoMSC compared to the old OsmoNITB are:

- The complete VLR implementation that communicates with the separate HLR (OsmoHLR) for subscriber management. In contrast to the OsmoNITB, HLR queries are fully asynchronous, and the separate HLR allows using centralized subscriber management for both circuit-switched and packet-switched domains (i.e. one OsmoHLR for both OsmoMSC and OsmoS-GSN).
- VLR and HLR brought full UMTS AKA (Authentication and Key Agreement) support, i.e. Milenage authentication in both the full 3G variant as well as the backwards compatible 2G variant.
- Addition of a true A interface for 2G voice services. Previously, OsmoBSC had an SCCPlite based A interface towards 3rd party MSC implementations. OsmoMSC features a true SCCP/M3UA A interface, which allows running OsmoBSC against this Osmocom based MSC implementation. The new SCCP/M3UA SIGTRAN for the A interface is implemented in libosmo-sccp, which is used by OsmoMSC and OsmoBSC (and others), to establish a link via an STP (e.g. OsmoSTP).
- Addition of an IuCS interface to allow operating 3G voice services, also via SCCP/M3UA SIGTRAN, for example connecting via OsmoHNBGW to a 3G small cell device.

Find the OsmoMSC issue tracker and wiki online at

- https://osmocom.org/projects/osmomsc
- https://osmocom.org/projects/osmomsc/wiki

![Figure 1: Typical GSM network architecture used with OsmoMSC](image)
4.2 Software Components

This is a brief description of OsmoMSC’s internal software components.

4.2.1 SMSC

A minimal store-and-forward server for SMS, supporting both MO and MT SMS service, as well as multi-part messages. The built-in SMSC also supports an external SMSC interface. For more information, see Section 15.

4.2.2 MSC

The MSC component implements the mobility management (MM) functions of the TS 04.08 and delegates to SMSC for SMS message handling and the VLR for subscriber management.

Furthermore, it can handle TS 04.08 Call Control (CC), either by use of an internal MNCC handler, or by use of an external MNCC agent. For more information see Section 16.

4.2.3 VLR

A fully featured Visitor Location Register handles the subscriber management and authentication, and interfaces via GSUP to the external HLR.

5 Running OsmoMSC

The OsmoMSC executable (osmo-msc) offers the following command-line arguments:

5.1 SYNOPSIS

```
```

5.2 OPTIONS

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

-\V, --version
   Print the compile-time version number of the 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 12 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-msc.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 12 for more information.
-T, --timestamp
Enable time-stamping of log messages to stderr. This has mostly been deprecated by VTY based logging configuration, see Section 12 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 12 for more information.

5.3 Multiple instances

Running multiple instances of osmo-msc on the same computer is possible if all interfaces (VTY, CTRL) are separated using the appropriate configuration options. The IP based interfaces are binding to local host by default. In order to separate the processes, the user has to bind those services to specific but different IP addresses and/or ports.

The VTY and the Control interface can be bound to IP addresses from the loopback address range, for example:

```
line vty
  bind 127.0.0.2

ctrl
  bind 127.0.0.2
```

If external SMPP is enabled, you may bind it to a different interface using:

```
smpp
  local-tcp-ip 10.23.42.1 2775
```

More on SMPP configuration in [?].

The external MNCC handler is a UNIX domain socket that is created when external MNCC handling is configured. A separate path must be used per osmo-msc instance:

```
msc
  mncc external /tmp/mncc_socket
```

More on MNCC in Section 16.2.

The SGs interface by default listens on 0.0.0.0:29118. Configure a different IP and/or port for each osmo-msc instance. You may also want to configure different VLR names:

```
sgs
  local-ip 127.0.0.1
  local-port 29118
  vlr-name vlr.example.net
```

For the following links, OsmoMSC acts as a client and does not listen/bind to a specific interface, and will hence not encounter conflicts for multiple instances running on the same interface:

- The SCCP/M3UA links are established by OsmoMSC contacting an STP.
- The GSUP link is established by OsmoMSC contacting an HLR.
- The MGCP link is established by OsmoMSC contacting an MGW.

5.4 Configure primary links

5.4.1 Configure SCCP/M3UA to accept A and luCS links

OsmoMSC acts as client to contact an STP instance and establish an SCCP/M3UA link.

An example configuration of OsmoMSC’s SCCP link:
This configuration is explained in detail in Section 13.

Note that A and IuCS may use different SCCP instances, if so desired:

```plaintext
cs7 instance 0
  asp my-OsmoMSC-A 2905 0 m3ua
  remote-ip 10.23.42.1
  asp my-OsmoMSC-Iu 2905 0 m3ua
  remote-ip 10.23.42.2
msc
  cs7-instance-a 0
  cs7-instance-iu 1
```

5.4.2 Configure GSUP to reach the HLR

OsmoMSC will assume a GSUP server (OsmoHLR) to run on the local host and the default GSUP port (4222). Contacting an HLR at a different IP address can be configured as follows:

```plaintext
hlr
  ! IP address of the remote HLR:
  remote-ip 10.23.42.1
  ! default port is 4222, optionally configurable by:
  remote-port 1234
```

5.4.3 Configure MGCP to connect to an MGW

OsmoMSC uses a media gateway (typically OsmoMGW) to direct RTP streams. By default, an MGW is expected to receive MGCP requests on the IANA-registered default port for MGCP (2427) on local host (127.0.0.1).

Here is an example configuration for a remote MGW:

```plaintext
msc
  mgw remote-ip 10.9.8.7
  mgw remote-port 2427
  mgw reset-endpoint rtpbridge/*/1
```

The `reset-endpoint` setting instructs the OsmoMGW to send a wildcarded DLCX to the media gateway. This helps to clear lingering calls from the media gateway when the OsmoMSC is restarted.

6 Control interface

The actual protocol is described in Section 18, the variables common to all programs using it are described in Section 18.2. This section describes the CTRL interface variables specific to OsmoMSC.
6.1 subscriber-list-active-v1

Return a list of subscribers that are successfully attached (including full successful authentication and ciphering if those are enabled).

The reply comprises of one subscriber per line, of the format

```
<IMSI>,<MSISDN>
[<IMSI>,<MSISDN>]
[...]
```

For example:

```
901700000015252,22801
901700000015253,22802
```

7 Osmocom Counters

The following gives an overview of all the types of counters available:

7.1 Osmo Counters (deprecated)

Osmo counters are the oldest type of counters added to Osmocom projects. They are not grouped.

- Printed as part of VTY show stats
- Increment, Decrement
- Accessible through the control interface: counter.<counter_name>

7.2 Rate Counters

Rate counters count rates of events.

- Printed as part of VTY show stats
- Intervals: per second, minute, hour, day or absolute value
- Increment only
- Accessible through the control interface
- Rate counters are grouped and different instances per group can exist

The control interface command to get a counter (group) is:

```
rate_ctr.per_{sec,min,hour,day,abs}.<group_name>.<idx>.<counter_name>
```

It is possible to get all counters in a group by omitting the counter name.
7.3 Stat Item

Stat items are a grouped replacement for osmo counters.

- Printed as part of VTY show stats
- Replacement for osmo counters
- Not yet available through the control interface
- Grouped and indexed like rate counters
- Items have a unit
- Keeps a list of the last values measured, so could return an average, min, max, std. deviation. So far this is not implemented in any of the reporting options.

7.4 Statistic Levels

There are three levels on which a statistic can be aggregated in Osmocom projects: globally, per-peer and per-subscriber.

7.4.1 Global

These are global statistics.

7.4.2 Peer

These statistics relate to a peer the program connects to such as the NSVC in an SGSN. This level also includes reporting global statistics.

7.4.3 Subscriber

These statistics are related to an individual mobile subscriber. An example would be bytes transferred in an SGSN PDP context. This level also includes global and peer-based statistics.

7.5 Stats Reporter

The stats reporter periodically collects osmo counter, rate counter and stat item values and sends them to a backend. Currently implemented are outputting to the configured log targets and a statsd connector.

7.5.1 Configuring a stats reporter

Periodically printing the statistics to the log can be done in the following way:
Example 7.1 Log statistics

```
OsmoBSC> enable
OsmoBSC# configure terminal
OsmoBSC(config)# stats interval 60
OsmoBSC(config)# stats reporter log
OsmoBSC(config-stats)# level global
OsmoBSC(config-stats)# enable
```

1. The interval determines how often the statistics are reported.
2. Write the statistic information to any configured log target.
3. Report only global statistics (can be global, peer, or subscriber).
4. Enable the reporter, disable will disable it again.

The counter values can also be sent to any aggregation/visualization tool that understands the statsd format, for example a statsd server with graphite or prometheus using the statsd_exporter together with grafana.

The statsd format is specified in [https://github.com/b/statsd_spec](https://github.com/b/statsd_spec)

Example 7.2 Report statistics to statsd

```
OsmoBSC> enable
OsmoBSC# configure terminal
OsmoBSC(config)# stats interval 10
OsmoBSC(config)# stats reporter statsd
OsmoBSC(config-stats)# prefix BSC1
OsmoBSC(config-stats)# level subscriber
OsmoBSC(config-stats)# remote-ip 1.2.3.4
OsmoBSC(config-stats)# remote-port 8125
OsmoBSC(config-stats)# enable
```

1. Configure the statsd reporter.
2. Prefix the reported statistics. This is useful to distinguish statistics from multiple instances of the same service.
3. Report only global statistics or include peer or subscriber statistics as well.
4. IP address of the statsd server.
5. UDP port of the statsd server. Statsd by default listens to port 8125.

Setting up a statsd server and configuring the visualization is beyond the scope of this document.

7.6 Socket stats

libosmocore provides features to monitor the status of TCP connections. This can be a helpful source of information when the links between network components are unreliable (e.g. satellite link between BTS and BSC).

**Note**
This feature is only available for certain types of TCP connections. At the moment only RSL/OML connections between OsmoBSC and the connected BTSs can be monitored.
7.6.1 Configuration

The gathering of the TCP connection statistics is done via syscalls. This has to be taken into account for the configuration. Since syscalls are rather expensive and time consuming the overall performance of the application may suffer when many TCP connections are present. This may be the case for BSCs with a large number of BTSs connected to it.

The statistics are gathered in batches per interval. A batch size of 5 would mean that only 5 TCP connections per interval are evaluated and the next 5 connections in the next interval and so on.

It is recommended to choose a large reporting interval and a reasonable small batch size to distribute the syscall load as even as possible.

Example 7.3 Report statistics to statsd

```
OsmoBSC> enable
OsmoBSC# configure terminal
stats-tcp interval 10
stats-tcp batch-size 5
```

- Set the gathering interval (sec.)
- Set how many TCP sockets statistics to gather per interval.

7.6.2 Generated stats items

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>tcp:unacked</td>
<td>unacknowledged packets.</td>
</tr>
<tr>
<td>tcp:lost</td>
<td>unacknowledged packets.</td>
</tr>
<tr>
<td>tcp:retrans</td>
<td>lost packets.</td>
</tr>
<tr>
<td>tcp:rtt</td>
<td>retransmitted packets.</td>
</tr>
<tr>
<td>tcp:rcv_rtt</td>
<td>roundtrip-time (receive).</td>
</tr>
<tr>
<td>tcp:notsent_bytes</td>
<td>bytes not yet sent.</td>
</tr>
<tr>
<td>tcp:rdw_limited</td>
<td>time (usec) limited by receive window.</td>
</tr>
<tr>
<td>tcp:sndbuf_limited</td>
<td>Time (usec) limited by send buffer.</td>
</tr>
<tr>
<td>tcp:reord_seen</td>
<td>reordering events seen.</td>
</tr>
</tbody>
</table>

The item group index is the file descriptor number. The item group name consists of a static prefix (e.g. "ipa-rsl"), followed by the IP addresses and ports of both peers.

Example 7.4 VTY output of a stats item group of a TCP connection

```
stats tcp (15)('ipa-rsl,r=10.9.1.143:38455<->l=10.9.1.162:3003'):
  unacknowledged packets: 0
  lost packets: 0
  retransmitted packets: 0
  roundtrip-time: 583
  roundtrip-time (receive): 0
  bytes not yet sent: 0
  time (usec) limited by receive window: 0
  Time (usec) limited by send buffer: 0
  reordering events seen: 0
```

8 Counters

These counters and their description based on OsmoMSC 1.4.0 (OsmoMSC).
### 8.1 Rate Counters

Table 2: msc - mobile switching center

<table>
<thead>
<tr>
<th>Name</th>
<th>Reference</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>loc_update_type:attach</td>
<td>[?]</td>
<td>Received Location Update (IMSI Attach) requests.</td>
</tr>
<tr>
<td>loc_update_type:normal</td>
<td>[?]</td>
<td>Received Location Update (LAC change) requests.</td>
</tr>
<tr>
<td>loc_update_type:periodic</td>
<td>[?]</td>
<td>Received (periodic) Location Update requests.</td>
</tr>
<tr>
<td>loc_update_type:detach</td>
<td>[?]</td>
<td>Received IMSI Detach indications.</td>
</tr>
<tr>
<td>loc_update_resp:failed</td>
<td>[?]</td>
<td>Rejected Location Updates requests.</td>
</tr>
<tr>
<td>loc_update_resp:completed</td>
<td>[?]</td>
<td>Successful Location Update procedures.</td>
</tr>
<tr>
<td>cm_service_request:rejected</td>
<td>[?]</td>
<td>Rejected CM Service Requests.</td>
</tr>
<tr>
<td>cm_service_request:accepted</td>
<td>[?]</td>
<td>Accepted CM Service Requests.</td>
</tr>
<tr>
<td>paging_resp:rejected</td>
<td>[?]</td>
<td>Rejected Paging Responses.</td>
</tr>
<tr>
<td>paging_resp:accepted</td>
<td>[?]</td>
<td>Accepted Paging Responses.</td>
</tr>
<tr>
<td>sms:submitted</td>
<td>[?]</td>
<td>Total MO SMS received from the MS.</td>
</tr>
<tr>
<td>sms:no_receiver</td>
<td>[?]</td>
<td>Failed MO SMS delivery attempts (no receiver found).</td>
</tr>
<tr>
<td>sms:deliver_unknown_error</td>
<td>[?]</td>
<td>Failed MO SMS delivery attempts (other reason).</td>
</tr>
<tr>
<td>sms:delivered</td>
<td>[?]</td>
<td>Total MT SMS delivery attempts.</td>
</tr>
<tr>
<td>sms:rp_err_mem</td>
<td>[?]</td>
<td>Failed MT SMS delivery attempts (no memory).</td>
</tr>
<tr>
<td>sms:rp_err_other</td>
<td>[?]</td>
<td>Failed MT SMS delivery attempts (other reason).</td>
</tr>
<tr>
<td>call:mo_setup</td>
<td>[?]</td>
<td>Received MO SETUP messages (MO call establishment).</td>
</tr>
<tr>
<td>call:mo_connect_ack</td>
<td>[?]</td>
<td>Received MO CONNECT messages (MO call establishment).</td>
</tr>
<tr>
<td>call:mt_setup</td>
<td>[?]</td>
<td>Sent MT SETUP messages (MT call establishment).</td>
</tr>
<tr>
<td>call:mt_connect</td>
<td>[?]</td>
<td>Sent MT CONNECT messages (MT call establishment).</td>
</tr>
<tr>
<td>call:active</td>
<td>[?]</td>
<td>Calls that ever reached the active state.</td>
</tr>
<tr>
<td>call:complete</td>
<td>[?]</td>
<td>Calls terminated by DISCONNECT message after reaching the active state.</td>
</tr>
<tr>
<td>call:incomplete</td>
<td>[?]</td>
<td>Calls terminated by any other reason after reaching the active state.</td>
</tr>
<tr>
<td>nc_ss:mo_requests</td>
<td>[?]</td>
<td>Received MS-initiated call independent SS/USSD requests.</td>
</tr>
<tr>
<td>nc_ss:moestablished</td>
<td>[?]</td>
<td>Established MS-initiated call independent SS/USSD sessions.</td>
</tr>
<tr>
<td>nc_ss:mt_requests</td>
<td>[?]</td>
<td>Received network-initiated call independent SS/USSD sessions.</td>
</tr>
<tr>
<td>nc_ss:mtestablished</td>
<td>[?]</td>
<td>Established network-initiated call independent SS/USSD sessions.</td>
</tr>
<tr>
<td>bssmap:cipher_mode_reject</td>
<td>[?]</td>
<td>Number of CIPHER MODE REJECT messages processed by BSSMAP layer</td>
</tr>
<tr>
<td>bssmap:cipher_mode_complete</td>
<td>[?]</td>
<td>Number of CIPHER MODE COMPLETE messages processed by BSSMAP layer</td>
</tr>
</tbody>
</table>
9 Osmo Stat Items

10 Osmo Counters

Table 3: ungrouped osmo counters

<table>
<thead>
<tr>
<th>Name</th>
<th>Reference</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>msc.active_calls</td>
<td>[?]</td>
<td></td>
</tr>
<tr>
<td>msc.active_nc_ss</td>
<td>[?]</td>
<td></td>
</tr>
</tbody>
</table>

11 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>A.B.C.D/M</td>
<td>192.168.1.0/24</td>
<td>An IPv4 address and mask</td>
</tr>
<tr>
<td>X:X::X:X</td>
<td>::1</td>
<td>An IPv6 address</td>
</tr>
<tr>
<td>X:X::X:X/M</td>
<td>::1/128</td>
<td>An IPv6 address and mask</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>

### 11.1 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.

### 11.2 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.

**CONFIG**

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.

11.3 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.

11.3.1 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 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
cs7 ITU-T Signaling System 7
logging Show current logging configuration
alarms Show current logging configuration
talloc-context Show talloc memory hierarchy
```

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Stats | Show statistical values
asciidoc | Asciidoc generation
rate-counters | Show all rate counters
fsm | Show information about finite state machines
fsm-classes | Show information about finite state machine instances
sgs-connections | Show SGs interface connections / MMEs
subscriber | Operations on a Subscriber
bsc | BSC
collection | Subscriber Connections
transaction | Transactions
statistics | Display network statistics
sms-queue | Display SMSqueue statistics
smpp | SMPP Interface

1. 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".

### 11.3.2 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>
show sms subscriber
```

Type `<tab>` here.

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

**Example: Use of `<tab>` pressed after show command**

```
OsmoMSC> show<tab>
version online-help history cs7 logging alarms
talloc-context stats asciidoc rate-counters fsm fsm-classes
sgs-connections subscriber bsc connection transaction statistics
sms-queue smpp
```

Type `<tab>` here.

### 11.3.3 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|su)
  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 level (0|1)
  logging print file (0|1|basename) [last]
  logging set-log-mask MASK
  logging level (rll|cc|mm|rr|mncc|pag|msc|mgcp|ho|db|ref|ctrl|smpp|ranap|v1r|iu|bssap|←
  sgs|lglobal|lapdp|lipp|lmux|lml|lmi|lms|lc|lgt|lstats|lgsup|loap|ls7|lsccp|lsua←
  |l3u|mncp|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
  sms delete expired
  subscriber create imsi ID
  subscriber (msisdn|extension|imsi|tmsi|id) ID sms sender (msisdn|extension|imsi|tmsi|id) ←
  SENDER_ID send .LINE
subscriber (msisdn|extension|imsi|tmsi|id) ID silent-sms sender (msisdn|extension|imsi|← tmsi|id) SENDER_ID send .LINE
subscriber (msisdn|extension|imsi|tmsi|id) ID silent-call start (any|tch/f|tch/any|sdccch)
subscriber (msisdn|extension|imsi|tmsi|id) ID silent-call stop
subscriber (msisdn|extension|imsi|tmsi|id) ID ussd-notify (0|1|2) .TEXT
subscriber (msisdn|extension|imsi|tmsi|id) ID ms-test close-loop (a|b|c|d|e|f|i)
subscriber (msisdn|extension|imsi|tmsi|id) ID ms-test open-loop
subscriber (msisdn|extension|imsi|tmsi|id) ID paging
show statistics
show sms-queue
logging filter imsi IMSI
show smpp esme

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

11.3.4 The attribute system

The VTY allows to edit the configuration at runtime. For many VTY commands the configuration change is immediately valid but for some commands a change becomes valid on a certain event only. In some cases it is even necessary to restart the whole process.

To give the user an overview, which configuration change applies when, the VTY implements a system of attribute flags, which can be displayed using the show command with the parameter vty-attributes

Example: Typing show vty-attributes at the VTY prompt

OsmoBSC> show vty-attributes
  Global attributes:
    ^ This command is hidden (check expert mode)
The attributes are symbolized through a single ASCII letter (flag) and do exist in three levels. This is more or less due to the technical aspects of the VTY implementation. For the user, the level of an attribute has only informative purpose.

The global attributes, which can be found under the same attribute letter in every osmocom application, exist on the top level. The Library specific attributes below are used in various osmocom libraries. Like with the global attributes the attribute flag letter stays the same throughout every osmocom application here as well. On the third level one can find the application specific attributes. Those are unique to each osmocom application and the attribute letters may have different meanings in different osmocom applications. To make the user more aware of this, lowercase letters were used as attribute flags.

The list command with the parameter with-flags displays a list of available commands on the current VTY node, along with attribute columns on the left side. Those columns contain the attribute flag letters to indicate to the user how the command behaves in terms of how and when the configuration change takes effect.

**Example: Typing list with-flags at the VTY prompt**

```
OsmoBSC(config-net-bts)# list with-flags
... help
... list [with-flags]
... show vty-attributes
... show vty-attributes (application|library|global)
... write terminal
... write file [PATH]
... write memory
... write
... show running-config
... exit
... end
0... type (unknown|bs11|nanobts|rbs2000|nokia_site|sysmobts)
... description .TEXT
... no description
0... band BAND
...r... cell_identity <0-65535>
...r... dtx uplink [force]
...r... dtx downlink
...r... no dtx uplink
...r... no dtx downlink
...r... location_area_code <0-65535>
... base_station_id_code <0-63>
... ipa unit-id <0-65534> <0-255>
... ipa rsl-ip A.B.C.D
... nokia_site skip-reset (0|1)
!... nokia_site no-local-rel-conf (0|1)
!... nokia_site bts-reset-timer <15-100>
```

1. This command has no attributes assigned.
2. This command applies on A-bis OML link (re)establishment.
3. This command applies on A-bis RSL link (re)establishment.
4. This command applies for newly created lchans.

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There are multiple columns because a single command may be associated with multiple attributes at the same time. To improve readability each flag letter gets a dedicated column. Empty spaces in the column are marked with a dot (".").

In some cases the listing will contain commands that are associated with no flags at all. Those commands either play an exceptional role (interactive commands outside "configure terminal", vty node navigation commands, commands to show / write the config file) or will require a full restart of the overall process to take effect.

11.3.5 The expert mode

Some VTY commands are considered relatively dangerous if used in production operation, so the general approach is to hide them. This means that they don’t show up anywhere but the source code, but can still be executed. On the one hand, this approach reduces the risk of an accidental invocation and potential service degradation; on the other, it complicates intentional use of the hidden commands.

The VTY features so-called expert mode, that makes the hidden commands appear in the interactive help, as well as in the XML VTY reference, just like normal ones. This mode can be activated from the VIEW node by invoking the enable command with the parameter expert-mode. It remains active for the individual VTY session, and gets disabled automatically when the user switches back to the VIEW node or terminates the session.

A special attribute in the output of the list with-flags command indicates whether a given command is hidden in normal mode, or is a regular command:

Example: Hidden commands in the output of the list with-flags command

```
OsmoBSC> enable expert-mode
OsmoBSC# list with-flags
...
 v 1 bts <0-255> (activate-all-lchan|deactivate-all-lchan)
 v 2 bts <0-255> trx <0-255> (activate-all-lchan|deactivate-all-lchan)
 . bts <0-255>trx <0-255> timeslot <0-7> sub-slot <0-7> mdcx A.B.C.D <0-65535>
 v 4 bts <0-255>trx <0-255> timeslot <0-7> sub-slot <0-7> (broken|unused)
 . bts <0-255>trx <0-255> timeslot <0-7> sub-slot <0-7> handover <0-255>
 . bts <0-255>trx <0-255> timeslot <0-7> sub-slot <0-7> assignment
 . bts <0-255> smscb-command (normal|schedule|default) <1-4> HEXSTRING
...
```

1 This command enables the expert mode.
2, 3 This is a hidden command (only shown in the expert mode).
0, 4, 5 This is a regular command that is always shown regardless of the mode.

12 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.

12.1 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 rsl, rr, mm, cc and many others. To get a list of categories interactively on the vty, type: `logging level ?`

12.2 Log levels

For each of the log categories (see Section 12.1), 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.

12.3 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 1
   In order to debug time-critical issues this option will print a timestamp with millisecond granularity.

log print category 1
   Prefix each log message with the category name.

log print category-hex 1
   Prefix each log message with the category number in hex (<000b>.

log print level 1
   Prefix each log message with the name of the log level.

log print file 1
   Prefix each log message with the source file and line number. Append the keyword last to append the file information instead of prefixing it.

12.4 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 1

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

12.5 Log targets
Each of the log targets represent certain destination for log messages. It can be configured independently by selecting levels (see Section 12.2) for categories (see Section 12.1) as well as filtering (see Section 12.4) and other options like logging timestamp for example.

12.5.1 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 12.1 for more details on categories and Section 12.2 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 12.4.

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`

### 12.5.2 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.

### 12.5.3 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 force-all fatal
```

12.5.4 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.
12.5.5 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.

12.5.6 Logging to systemd-journal

systemd has been adopted by the majority of modern GNU/Linux distributions. Along with various daemons and utilities it provides systemd-journald [1] - a daemon responsible for event logging (syslog replacement). libosmocore based applications can log messages directly to systemd-journald.

The key difference from other logging targets is that systemd based logging allows to offload rendering of the meta information, such as location (file name, line number), subsystem, and logging level, to systemd-journald. Furthermore, systemd allows to attach arbitrary meta fields to the logging messages [2], which can be used for advanced log filtering.


It was decided to introduce lib systemd as an optional dependency, so it needs to be enabled explicitly at configure/build time:

```
$ ./configure --enable-systemd-logging
```

**Note**
Recent libosmocore packages provided by Osmocom for Debian and CentOS are compiled with lib systemd (https://gerrit.osmocom.org/c/libosmocore/+/22651).

You can configure systemd based logging in two ways:

**Example: systemd-journal target with offloaded rendering**

```
log systemd-journal raw
logging filter all 1
logging level set-all notice
```
raw logging handler, rendering offloaded to systemd.

In this example, logging messages will be passed to systemd without any meta information (time, location, level, category) in the text itself, so all the printing parameters like logging print file will be ignored. Instead, the meta information is passed separately as fields which can be retrieved from the journal and rendered in any preferred way.

```
Show Osmocom specific fields
journalctl --fields | grep OSMO

Filter messages by logging subsystem at run-time
journalctl OSMO_SUBSYS=DMSC -f

Render specific fields only
journalctl --output=verbose \
   --output-fields=SYSLOG_IDENTIFIER,OSMO_SUBSYS,CODE_FILE,CODE_LINE,MESSAGE
```

See man 7 systemd.journal-fields for a list of default fields, and man 1 journalctl for general information and available formatters.

Example: systemd-journal target with libosmocore based rendering

```
log systemd-journal
logging filter all 1
logging print file basename
logging print category-hex 0
logging print category 1
logging print level 1
logging timestamp 0
logging color 1
logging level set-all notice
```

1. Generic logging handler, rendering is done by libosmocore.
2. Disable timestamping, systemd will timestamp every message anyway.
3. Colored messages can be rendered with journalctl --output=cat.

In this example, logging messages will be pre-processed by libosmocore before being passed to systemd. No additional fields will be attached, except the logging level (PRIORITY). This mode is similar to syslog and stderr.

12.5.7 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)#
```

13 Configure SCCP/M3UA

All CNI programs using SCCP/M3UA act as M3UA ASP role and SCTP client, expecting to connect to a Signalling Gateway (STP/SG) implementing the M3UA SG role as SCTP server. The STP/SG then routes M3UA messages between its ASPs, typically by point-codes.
For an introduction about SCCP/M3UA/SS7/SIGTRAN technology, please see the chapter *Signaling Networks: SS7 and SIGTRAN* in the OsmoSTP user manual.

In an all-Osmocom CNI, the typical simple/minimal usage is:

- OsmoSTP acts as the STP/SG (server role) and routes between the ASP.
- All other Osmocom CNI programs act as SCTP client and provide ASP implementations.

For example, in an all-Osmocom minimal setup,

- OsmoMSC contacts an OsmoSTP and subscribes its point-code 0.23.1;
- then OsmoBSC also contacts the same OsmoSTP, subscribes with its own point-code 1.23.3.
- Using these established links, OsmoBSC initiates an A-interface link by directing a BSSAP RESET message to the MSC’s point-code 0.23.1,
- and the RESET ACK response from the MSC is routed back to the BSC’s point-code 1.23.3.

The details of SCCP/M3UA are configured in the `cs7` section of the VTY configuration.

Osmocom programs automatically configure missing SCCP/M3UA configuration, by assuming sane defaults for small/minimal all-Osmocom installations, which may not be what you want in larger networks integrating with non-Osmocom core network elements.

If no explicit `routing-key` is set, it may be determined at runtime by negotiation with OsmoSTP — see OsmoSTP manual chapter "Osmocom M3UA Routing Key Management Extensions", regarding config option `accept-asp-connections dynamic-permitted`.

The complete active configuration of an Osmocom program can be obtained by the VTY command `show cs7 config` (the usual `show running-config` omits automatically configured items). Here is an example of OsmoMSC’s default configuration:

```
OsmoMSC> show cs7 config
cs7 instance 0
  point-code 0.23.1
  asp asp-clnt-OsmoMSC-A-Iu 2905 0 m3ua
    remote-ip 127.0.0.1
    sctp-role client
  as as-clnt-OsmoMSC-A-Iu m3ua
    asp asp-clnt-OsmoMSC-A-Iu
    routing-key 2 0.23.1
```

At the time of writing, SCCP/M3UA links involving Osmocom program are:

- A-interface: OsmoBSC to OsmoMSC
- IuCS-interface: OsmoHNBGW to OsmoMSC
- IuPS-interface: OsmoHNBGW to OsmoSGSN
- Lb-interface: OsmoSMLC to OsmoBSC

On the SCTP/IP level, those connections are actually all established from the respective program (BSC, MSC, HNBGW, SGSN, SMLC) to OsmoSTP. Hence, if you look at the traffic in a protocol analyzer like wireshark, at IP level, you will see each of those programs establishing an SCTP association from a random local IP to the well-known SCTP port for M3UA (2905) at the OsmoSTP.

Those star-connections for M3UA/SCTP then are the transport network for higher level protocols like SCCP. OsmoSTP then acts as central router for SCCP-level message exchange between all the connected programs.
13.1 Connect to STP Instance

Establishing an SCCP/M3UA link towards a remote STP instance can be configured as:

```bash
cs7 instance 0
asp my-asp 2905 0 m3ua
  # IP address of the remote STP:
  remote-ip 10.23.24.1
  # optional: local bind to a specific IP
  local-ip 10.9.8.7
```

Be aware that such an `asp` needs to be linked to an `as`, see Section 13.5.

By default, an STP instance is assumed to listen on the default M3UA port (2905) on the local host. That means in general `127.0.0.1` will be used as default remote SCTP address, and `::1` will be added to the SCTP association if IPv6 support is available on the system.

---

**Note**

OsmoSTP listens by default on `::` if IPv6 is enabled on the system, and on `0.0.0.0` otherwise. Address `::` actually superseeds `0.0.0.0`, meaning it will listen on all IPv4 and IPv6 addresses available on the system.

---

**Caution**

Some applications overwrite the default target remote address to be `localhost`. If IPv6 support is available on the system, `localhost` will usually resolve to `::1`, otherwise it will usually resolve to `127.0.0.1`.

13.2 Local Point-Code

Each CNI program on an SCCP/M3UA link typically has a local point-code, configurable by:

```bash
cs7 instance 0
point-code 7.65.4
```

If an explicit routing context is configured, this point-code is repeated in the `routing-key` configuration:

```bash
cs7 instance 0
point-code 0.23.1
asp my-as m3ua
routing-key 2 0.23.1
```

See also Section 13.4.

13.3 Remote Point-Code

Programs establishing communication across SCCP links need a remote SCCP address, typically by point-code, to contact. For example,

- OsmoBSC needs to know the MSC’s point-code, to be able to establish the A-interface.
- OsmoHNBGW needs to know the MSC’s point-code, to be able to establish the IuCS-interface.
- OsmoHNBGW needs to know the SGSN’s point-code, to be able to establish the IuPS-interface.

To maintain remote SCCP addresses, each `cs7` instance maintains an SCCP address book:
This address book entry on its own has no effect. It is typically referenced by specific configuration items depending on the individual programs.

Examples:

- An OsmoBSC configures the MSC’s remote SCCP address:

```plaintext
cs7 instance 0
  sccp-address my-remote-msc
  point-code 1.23.1
msc 0
  msc-addr my-remote-msc
```

- An HNBGW configures both the remote MSC’s and SGSN’s SCCP addresses:

```plaintext
cs7 instance 0
  sccp-address my-msc
  point-code 0.23.1
  sccp-address my-sgsn
  point-code 0.23.2
hnbgw
  iucs
    remote-addr my-msc
  iups
    remote-addr my-sgsn
```

Besides a point-code, an SCCP address can have several routing indicators:

- **PC**: routing by point-code is the default for Osmocom.
- **GT**: routing by Global Title is configurable by `routing-indicator GT`.
- **IP**: routing by IP address is configurable by `routing-indicator IP`.

In OsmoSTP, only routing by point-code is currently implemented.

### 13.4 Point-Code Format

Point-codes can be represented in various formats. For details, see OsmoSTP manual, chapter "Point Codes".

By default, Osmocom uses a point-code representation of 3.8.3, i.e. first digit of 3 bit, second digit of 8 bit, and third digit of 3 bit.

```plaintext
cs7 instance 0
  point-code format 3 8 3
  point-code 0.23.1
```

Often, point-codes are also represented as a single decimal number:

```plaintext
cs7 instance 0
  point-code format 24
  point-code 185
```

It is also possible to use a dash as delimiter.

```plaintext
cs7 instance 0
  point-code delimiter dash
  point-code 0-23-1
```
13.5 AS and ASP

Each CNI program needs at least one Application Server as and one Application Server Process asp configured on its cs7 to be able to communicate on SCCP/M3UA. An asp needs to be part of at least one as. For details, see the OsmoSTP manual, chapters "Application Server" and "Application Server Process".

In Osmocom’s cs7, any amount of as and asp can be configured by name, and an as references the asp entries belonging to it by their names.

In a simple/minimal Osmocom setup, an Osmocom CNI program would have exactly one as with one asp.

For example:

```plaintext
cs7 instance 0
  asp my-asp 2905 0 m3ua
  # where to reach the STP:
  remote-ip 127.0.0.1
  sctp-role client
  as my-as m3ua
  asp my-as
```

In Osmocom CNI programs, it is possible to omit the as and/or asp entries, which the program will then attempt to configure automatically.

When configuring both as and asp manually, make sure to link them by name. For example, the following configuration will fail, because as and asp are not linked:

```plaintext
cs7 instance 0
  asp my-asp 2905 0 m3ua
  remote-ip 127.0.0.1
  as my-as m3ua
  routing-key 2 0.23.1
```

To fix above config, link the asp to an as by adding asp my-asp:

```plaintext
cs7 instance 0
  asp my-asp 2905 0 m3ua
  remote-ip 127.0.0.1
  as my-as m3ua
  asp my-asp
  routing-key 2 0.23.1
```

13.6 Subsystem Number (SSN)

Osmocom CNI programs typically route SCCP/M3UA messages by PC+SSN: each ASP, having a given SCCP address, receives messages for one or more specific subsystems, identified by a Subsystem Number (SSN).

For example, the A-interface between BSC and MSC uses SSN = BSSAP (254). In Osmocom programs, SSNs do not need to be configured; they implicitly, naturally relate to the interfaces that a program implements.

For example, OsmoBSC takes the configured remote MSC’s SCCP address and adds the SSN = BSSAP to it in order to contact the MSC’s A-interface. To receive A-interface messages from the MSC, OsmoBSC subscribes a local user for this SSN on the ASP.

13.7 Routing Context / Routing Key

In SCCP/M3UA, messages can be routed by various Routing Indicators (PC+SSN, PC, GT, ...). Osmocom CNI programs typically use PC+SSN as Routing Indicator.

On the SG (for example OsmoSTP), each ASP’s distinct Routing Indicator needs to be indexed by a distinct Routing Context (a simple index number scoped per SG), to forward M3UA to the correct peer.
The Osmocom SG implementation employs Routing Key Management (RKM, see OsmoSTP manual) to automatically determine a distinct Routing Context index for each connected ASP. Routing Contexts can also be configured manually — some non-Osmocom SG implementations require this.

Each Routing Context is associated with a Routing Indicator and address; this association is called a Routing Key.

For example, to configure an OsmoBSC with a local point-code of 1.23.3 to receive M3UA with Routing Context of 2 and RI=PC:

```
cs7 instance 0  
point-code 1.23.3  
as my-as m3ua  
routing-key 2 1.23.3
```

Osmocom programs so far implement Routing Keys by Destination Point Code (DPC), plus optional Subsystem Number (SSN) and/or Service Indicator (SI):

```
routing-key RCONTEXT DPC  
routing-key RCONTEXT DPC si (aal2|bicc|b-isup|h248|isup|sat-isup|sccp|tup)  
routing-key RCONTEXT DPC ssn SSN  
routing-key RCONTEXT DPC si (aal2|bicc|b-isup|h248|isup|sat-isup|sccp|tup) ssn SSN
```

### 13.7.1 M3UA without Routing Context IE / Routing Context 0

As per the M3UA specification, the use of the routing context IE is optional as long as there is only one AS within an ASP. As soon as there are multiple different AS within one ASP, the routing context IE is mandatory, as it is the only clue to differentiate which of the ASs a given message belongs to.

In the Osmocom M3UA implementation, it is generally assumed that a routing context IE is always used, for the sake of clarity. However, the routing context ID of 0 has the special meaning of *do not encode a routing context IE on transmit*.

So if you configure an application like OsmoBSC to use routing context 0, then no routing context IE will be included in outbound M3UA messages.

This special interpretation of 0 within the Osmocom M3UA implementation however means that we can not represent M3UA with a routing context IE that actually contains 0 as a numeric identifier.

So you only have the following options: * Using M3UA with routing context (1..N) * Using M3UA without routing context (0)

### 14 Configuring the Core Network

The core network parameters are configured by the config file (as in `osmo-msc -c osmo-msc.cfg`). The config file is parsed by the VTY, which is also available via telnet in the running `osmo-msc` instance. Be aware that even though you may be able to change these parameters without restarting `osmo-msc`, some may not take immediate effect, and it is safest to use the config file to have these parameters set at startup time.

The core network parameters are found in the `config/network`.

A full reference to the available commands can be found in the *OsmoMSC VTY reference manual* [vty-ref-osmomsc]. This section describes only the most commonly used settings.

Here is an overview of the config items, described in more detail below:

```
network
network country code 262
mobile network code 89
mm info 1
short name OsmoMSC
long name OsmoMSC
authentication required
encryption a5 3
```
Tip
Use the telnet VTY interface to query the current configuration of a running osmo-msc process:

```
$ telnet localhost 4254
OsmoMSC> enable
OsmoMSC# show running-config
```

Some parameters may be changed without restarting osmo-msc. To reach the network node, enter:

```
OsmoMSC> enable
OsmoMSC# configure terminal
OsmoMSC(config)# network
OsmoMSC(config-net)# short name Example-Name
OsmoMSC(config-net)# exit
OsmoMSC(config)#
```

The telnet VTY features tab-completion as well as context sensitive help shown when entering a ? question mark.
You can always use the list VTY command or enter ? on the blank prompt to get a list of all possible commands at the current node.

14.1 MCC/MNC

The key identities of every GSM PLMN is the Mobile Country Code and the Mobile Network Code. They are identical over the entire network. In most cases, the MCC/MNC will be allocated to the operator by the respective local regulatory authority. For example, to set the MCC/MNC of 262-89, have this in your osmo-msc.cfg:

```
network
  network country code 262
  mobile network code 89
```

14.2 Configuring MM INFO

The MM INFO procedure can be used after a successful LOCATION UPDATE in order to transmit the human-readable network name as well as local time zone information to the MS. By default, MM INFO is not active, i.e. 0. Set to 1 to activate this feature:

```
network
  mm info 1
  short name OsmoMSC
  long name OsmoMSC
```

Note
Not all phones support the MM INFO procedure. If a phone is not factory-programmed to contain the name for your MCC/MNC, it will likely only provide a numeric display of the network name, such as 262-89, or show the country code transformed into a letter, such as D 89.

The time information transmitted is determined by the local system time of the operating system on which OsmoMSC is running.

14.3 Authentication

A subscriber’s IMSI must be entered in the HLR database to be able to attach. A subscriber-create-on-demand feature is also available, see the OsmoHLR reference manual [userman-osmohlr].

A known IMSI in the HLR may or may not have authentication keys associated, which profoundly affects the ability to attach and the algorithms used to negotiate authentication, as the following sections explain for 2G and 3G.
14.3.1 Authentication on 2G

If authentication tokens (such as KI for 2G, or K and OP/OPC for UMTS) are present in the HLR, OsmoMSC will only attach a subscriber after successful authentication. Note that the 3G authentication keys are also used on 2G when the MS indicates UMTS AKA capability, in which case the full UMTS style mutual authentication may indeed take place on 2G (GERAN).

On 2G, if no authentication keys are present in the HLR for a given subscriber, OsmoMSC will attach the subscriber without authentication. Subscribers that lack authentication keys can always be rejected with this setting:

```
network
authentication required
```

14.3.2 Authentication on 3G

3G (UTRAN) always requires authentication (a.k.a. Integrity Protection) by specification, and hence authentication keys must be present in the HLR for a subscriber to be able to attach on 3G.

OsmoMSC always indicates UIA1 and UIA2 as permitted Integrity Protection algorithms on 3G.

14.4 Ciphering

To enable ciphering on the radio link, authentication must take place first: the Kc resulting from authentication is the key used for ciphering. Hence, to be able to use ciphering, a subscriber must have authentication tokens available in the HLR.

14.4.1 Ciphering on 2G

The MS, BTS and MSC must agree on a ciphering algorithm to use.

- The MS sends its supported ciphering algorithms via Classmark IEs during Location Updating.
- Typically the BSC needs to know which A5 ciphers are supported by connected BTSes, see the `network / encryption a5` configuration item for OsmoBSC.
- Finally, OsmoMSC may impose that specific A5 ciphers shall not be considered.

It is the responsibility of the BSC to then pick an A5 cipher that satisfies all requirements.

- In OsmoMSC, A5/0 means that ciphering is turned off.

```
network
encryption a5 0
```

- A5/1 and A5/3 are currently supported by Osmocom.

```
network
encryption a5 1 3
```

- Never use A5/2: it is an "export grade cipher" and has been deprecated for its low ciphering strength.

- To allow either no encryption or any of A5/1 or A5/3 based on the presence of authentication keys and abilities of the MS, SIM and BSC configuration, it is recommended to enable all ciphers in OsmoMSC. The highest available A5 cipher will be used; the order in which the A5 options are configured does not affect the choice.

```
network
encryption a5 0 1 3
```
14.4.2 Ciphering on 3G

While authentication is always required on 3G, ciphering is optional.

So far OsmoMSC allows switching ciphering on 3G either on or off — the default behavior is to enable ciphering. (Individual choice of algorithms may be added in the future.)

Disable 3G ciphering:

```
network
  encryption uea 0
```

Enable 3G ciphering (default):

```
network
  encryption uea 1 2
```

OsmoMSC indicates UEA1 and UEA2 as permitted encryption algorithms on 3G.

15 Short Message Peer to Peer (SMPP)

The Short Message Peer to Peer (SMPP) Protocol [smpp-34] has been used for the communication with SMSCs. Osmocom implements version 3.4 of the protocol. Using this interface one can send MT-SMS to an attached subscriber or receive unrouted MO-SMS.

SMPP is served by the Osmocom MSC layer (both in the old OsmoNITB as well as the new OsmoMSC).

SMPP describes a situation where multiple ESMEs (External SMS Entities) interact with a SMSC (SMS Service Center) via the SMPP protocol. Each entity is identified by its System Id. The System ID is a character string which is configured by the system administrator.

OsmoMSC implements the SMSC side of SMPP and subsequently acts as a TCP server accepting incoming connections from ESME client programs.

Each ESME identifies itself to the SMSC with its system-id and an optional shared password.

15.1 Global SMPP configuration

There is a smpp vty node at the top level of the OsmoMSC configuration. Under this node, the global SMPP configuration is performed.

Use the local-tcp-ip command to define the TCP IP and port at which the OsmoMSC internal SMSC should listen for incoming SMPP connections. The default behaviour is to listen on all IPs (0.0.0.0), and the default port assigned to SMPP is 2775.

Use the system-id command to define the System ID of the SMSC.

Use the policy parameter to define whether only explicitly configured ESMEs are permitted to access the SMSC (closed), or whether any ESME should be accepted (accept-all).

Use the smpp-first command to define if SMPP routes have higher precedence than MSISDNs contained in the HLR (smpp-first), or if only MSISDNs found not in the HLR should be considered for routing to SMPP (no smpp-first).

15.2 ESME configuration

Under the smpp vty node, you can add any number of esme nodes, one for each ESME that you wish to configure.

Use the esme NAME command (where NAME corresponds to the system-id of the ESME to be configured) under the SMPP vty node to enter the configuration node for this given ESME.

Use the password command to specify the password (if any) for the ESME.
Use the `default-route` command to indicate that any MO-SMS without a more specific route should be routed to this ESME.

Use the `deliver-src-imsi` command to indicate that the SMPP DELIVER messages for MO SMS and the SMPP ALERT should state the IMSI (rather than the MSISDN) as source address.

Use the `osmocom-extensions` command to request that Osmocom specific extension TLVs shall be included in the SMPP PDUs. Those extensions include the ARFCN of the cell, the L1 transmit power of the MS, the timing advance, the uplink and downlink RxLev and RxQual, as well as the IMEI of the terminal at the time of generating the SMPP DELIVER PDU.

Use the `dcs-transparent` command to transparently pass the DCS value from the SMS Layer3 protocols to SMPP, instead of converting them to the SMPP-specific values.

Use the `route prefix` command to specify a route towards this ESME. Using routes, you specify which destination MSISDNs should be routed towards your ESME.

### 15.3 Example configuration snippet

The following example configuration snippet shows a single ESME *galactica* with a prefix-route of all national numbers stating with 2342:

```plaintext
smpp
  local-tcp-port 2775
  policy closed
  no smpp-first
  esme galactica
  password SoSayWeAll
  deliver-src-imsi
  osmocom-extensions
  route prefix national isdn 2342
```

### 15.4 Osmocom SMPP protocol extensions

Osmocom has implemented some extensions to the SMPP v3.4 protocol.

These extensions can be enabled using the `osmocom-extensions` VTY command at esme level.

The TLV definitions can be found in the `<osmocom/gsm/protocol/smpp34_osmocom.h>` header file provided by libosmocore.

#### 15.4.1 RF channel measurements

When the Osmocom SMPP extensions are enabled, we add the following TLVs to each SMPP DELIVER PDU:

<table>
<thead>
<tr>
<th>TLV</th>
<th>IEI</th>
<th>Length (Octets)</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>TLVID_osmo_arfcn</td>
<td>0x2300</td>
<td>2</td>
<td>GSM ARFCN of the radio interface</td>
</tr>
<tr>
<td>TLVID_osmo_ta</td>
<td>0x2301</td>
<td>1</td>
<td>Timing Advance on the radio interface</td>
</tr>
<tr>
<td>TLVID_osmo_rxlev_ul</td>
<td>0x2302</td>
<td>2</td>
<td>Uplink receive level as measured by BTS in dBm (int16_t)</td>
</tr>
<tr>
<td>TLVID_osmo_rxqual_ul</td>
<td>0x2303</td>
<td>1</td>
<td>Uplink RxQual value as measured by BTS</td>
</tr>
<tr>
<td>TLVID_osmo_rxlev_dl</td>
<td>0x2304</td>
<td>2</td>
<td>Downlink receive level as measured by MS in dBm (int16_t)</td>
</tr>
<tr>
<td>TLVID_osmo_rxqual_dl</td>
<td>0x2305</td>
<td>1</td>
<td>Downlink RxQual value as measured by MS</td>
</tr>
</tbody>
</table>

All of the above values reflect the **last measurement report** as received via A-bis RSL from the BTS. It is thus a snapshot value (of the average within one 480ms SACCH period), and not an average over all the SACCH periods during which the
channel was open or the SMS was received. Not all measurement reports contain all the values. So you might not get an
TLVID_osmo_rxlev_dl IE, as that particular uplink frame might have been lost for the given snapshot we report.

15.4.2 Equipment IMEI

If we know the IMEI of the subscriber’s phone, we add the following TLV to each SMPP DELIVER PDU:

<table>
<thead>
<tr>
<th>TLV</th>
<th>IEI</th>
<th>Length</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>TLVID_osmo_imei</td>
<td>0x2306</td>
<td>variable</td>
<td>IMEI of the subscriber’s phone (ME)</td>
</tr>
</tbody>
</table>

16 MNCC for External Call Control

The 3GPP GSM specifications define an interface point (service access point) inside the MSC between the call-control part and
the rest of the system. This service access point is called the MNCC-SAP. It is described in 3GPP TS 24.007 [3gpp-ts-24-007]
Chapter 7.1.

However, like for all internal interfaces, 3GPP does not give any specific encoding for the primitives passed at this SAP.
The MNCC protocol has been created by the Osmocom community and allows to control the call handling and audio processing
by an external application. The interface is currently exposed using Unix Domain Sockets. The protocol is defined in the
mncc.h header file.

It is exposed by the Osmocom MSC layer (both in the old OsmoNITB as well as the new OsmoMSC.

OsmoMSC can run in two different modes:

1. with internal MNCC handler
2. with external MNCC handler

16.1 Internal MNCC handler

When the internal MNCC handler is enabled, OsmoMSC will switch voice calls between GSM subscribers internally and auto-
matically based on the subscribers extension number. No external software is required.

---

**Note**

Internal MNCC is the default behavior.

---

16.1.1 Internal MNCC Configuration

The internal MNCC handler offers some configuration parameters under the mncc-int VTY configuration node.

16.1.1.1 default-codec tch-f (fr|efr|amr)

Using this command, you can configure the default voice codec to be used by voice calls on TCH/F channels.

16.1.1.2 default-codec tch-h (hr|amr)

Using this command, you can configure the default voice codec to be used by voice calls on TCH/H channels.
16.2 External MNCC handler

When the external MNCC handler is enabled, OsmoMSC will not perform any internal call switching, but delegate all call-control handling towards the external MNCC program connected via the MNCC socket.

If you intend to operate OsmoMSC with external MNCC handler, you have to disable the internal MNCC handler and specify the MNCC socket path in the configuration file.

At the time of this writing, the only external application implementing the MNCC interface compatible with the Osmocom MNCC socket is lcr, the Linux Call Router. More widespread integration of external call routing is available via the OsmoSIP-Connector.

16.3 DTMF considerations

In mobile networks, the signaling of DTMF tones is implemented differently, depending on the signaling direction. A mobile originated DTMF tone is signaled using START/STOP DTMF messages which are hauled through various protocols upwards into the core network.

Contrary to that, a mobile terminated DTMF tone is not transferred as an out of band message. Instead, in-band signaling is used, which means a tone is injected early inside a PBX or MGW.

When using OsmoMSC with its built in MNCC functionality a mobile originated DTMF message will not be translated into an in-band tone. Therefore, sending DTMF will not work when internal MNCC is used.

For external MNCC, the network integrator must make sure that the back-end components are configured properly in order to handle the two different signaling schemes depending on the signaling direction.

Note
osmo-sip-connector will translate MNCC DTMF signaling into sip-info messages. DTMF signaling in the opposite direction is not possible. osmo-sip-connector will reject sip-info messages that attempt to signal a DTMF tone.

16.4 MNCC protocol description

The protocol follows the primitives specified in 3GPP TS 04.07 Chapter 7.1. The encoding of the primitives is provided in the mncc.h header file in OsmoMSC’s source tree, which uses some common definitions from osmocom/gsm/mncc.h (part of libosmocore.git).

However, Osmocom’s MNCC specifies a number of additional primitives beyond those listed in the 3GPP specification.

The different calls in the network are distinguished by their callref (call reference), which is a unique unsigned 32bit integer.

16.4.1 MNCC_HOLD_IND

Direction: OsmoMSC → Handler

A CC HOLD message was received from the MS.

16.4.2 MNCC_HOLD_CNF

Direction: Handler → OsmoMSC

Acknowledge a previously-received CC HOLD message, causes the transmission of a CC HOLD ACK message to the MS.

16.4.3 MNCC_HOLD_REJ

Direction: Handler → OsmoMSC

Reject a previously-received CC HOLD message, causes the transmission of a CC HOLD REJ message to the MS.
16.4.4 MNCC_RETRIEVE_IND

Direction: OsmoMSC → Handler
A CC RETRIEVE message was received from the MS.

16.4.5 MNCC_RETRIEVE_CNF

Direction: Handler → OsmoMSC
Acknowledge a previously-received CC RETRIEVE message, causes the transmission of a CC RETRIEVE ACK message to the MS.

16.4.6 MNCC_RETRIEVE_REJ

Direction: Handler → OsmoMSC
Reject a previously-received CC RETRIEVE message, causes the transmission of a CC RETRIEVE REJ message to the MS.

16.4.7 MNCC_USERINFO_REQ

Direction: OsmoMSC → Handler
Causes a CC USER INFO message to be sent to the MS.

16.4.8 MNCC_USERINFO_IND

Direction: OsmoMSC → Handler
Indicates that a CC USER-USER message has been received from the MS.

16.4.9 MNCC_BRIDGE

Direction: Handler → OsmoMSC
Requests that the TCH (voice) channels of two calls shall be inter-connected. This is the old-fashioned way of using MNCC, historically required for circuit-switched BTSs whose TRAU frames are received via an E1 interface card, and works only when the TCH channel types match.

---

**Note**

Internal MNCC uses MNCC_BRIDGE to connect calls directly between connected BTSs or RNCs, in effect disallowing calls between mismatching TCH types and forcing all BTSs to be configured with exactly one TCH type and codec. This is a limitation that will probably remain for the old OsmoNITB. For the new OsmoMSC, the MNCC_BRIDGE command will instruct the separate OsmoMGW to bridge calls, which will be able to handle transcoding between different TCH as well as 3G (IuUP) payloads (but note: not yet implemented at the time of writing this). Hence an external MNCC may decide to bridge calls directly between BTSs or RNCs that both are internal to the OsmoMSC, for optimization reasons.

---

16.4.10 MNCC_FRAME_RECV

Direction: Handler → OsmoMSC
Enable the forwarding of TCH voice frames via the MNCC interface in OsmoMSC→Handler direction for the specified call.
16.4.11 **MNCC_FRAME_DROP**

Direction: Handler → OsmoMSC

Disable the forwarding of TCH voice frames via the MNCC interface in OsmoMSC→Handler direction for the specified call.

16.4.12 **MNCC_LCHAN_MODIFY**

Direction: Handler → OsmoMSC

Modify the current dedicated radio channel from signalling to voice, or if it is a signalling-only channel (SDCCH), assign a TCH to the MS.

16.4.13 **MNCC_RTP_CREATE**

Direction: Handler → OsmoMSC

Create a RTP socket for this call at the BTS/TRAU that serves this BTS.

16.4.14 **MNCC_RTP_CONNECT**

Direction: Handler → OsmoMSC

Connect the RTP socket of this call to the given remote IP address and port.

16.4.15 **MNCC_RTP_FREE**

Direction: Handler → OsmoMSC

Release a RTP connection for one given call.

16.4.16 **GSM_TCHF_FRAME**

Direction: both

Transfer the payload of a GSM Full-Rate (FR) voice frame between the OsmoMSC and an external MNCC handler.

16.4.17 **GSM_TCHF_FRAME_EFR**

Direction: both

Transfer the payload of a GSM Enhanced Full-Rate (EFR) voice frame between the OsmoMSC and an external MNCC handler.

16.4.18 **GSM_TCHH_FRAME**

Direction: both

Transfer the payload of a GSM Half-Rate (HR) voice frame between the OsmoMSC and an external MNCC handler.

16.4.19 **GSM_TCH_FRAE_AMR**

Direction: both

Transfer the payload of a GSM Adaptive-Multi-Rate (AMR) voice frame between the OsmoMSC and an external MNCC handler.
16.4.20  **GSM_BAD_FRAME**  
Direction: OsmoMSC → Handler  
Indicate that no valid voice frame, but a *bad frame* was received over the radio link from the MS.

16.4.21  **MNCC_START_DTMF_IND**  
Direction: OsmoMSC → Handler  
Indicate the beginning of a DTMF tone playback.

16.4.22  **MNCC_START_DTMF_RSP**  
Direction: Handler → OsmoMSC  
Acknowledge that the DTMF tone playback has been started.

16.4.23  **MNCC_START_DTMF_REJ**  
Direction: both  
Indicate that starting a DTMF tone playback was not possible.

16.4.24  **MNCC_STOP_DTMF_IND**  
Direction: OsmoMSC → Handler  
Indicate the ending of a DTMF tone playback.

16.4.25  **MNCC_STOP_DTMF_RSP**  
Direction: Handler → OsmoMSC  
Acknowledge that the DTMF tone playback has been stopped.

17  **Osmux**

Osmux is a protocol aimed at multiplexing and transmitting voice and signalling traffic from multiple sources in order to reduce the overall bandwidth consumption. This feature becomes specially meaningful in case of satellite based GSM systems, where the transmission cost on the back-haul is relatively expensive. In such environment, even seemingly small protocol optimizations, eg. message batching and trunking, can result in significant cost reduction.


In Osmocom satellite based GSM networks, the satellite link is envisioned to be in between the BSS and the core network, that is, between the BSC and the MSC (or BSC-NAT). Hence, Osmocom components can make use of Osmux protocol to multiplex payload audio streams from call legs between OsmoBSC and OsmoMSC (or OsmoBSCNAT). The MGW attached those components need of course also be aware of Osmux existence in order to properly set up the audio data plane.
17.1 Osmux and NAT

It is quite usual for satellite based links to use NATs, which means any or both of the two components at each side of the satellite link (BSC and MSC/BSC-NAT) may end up being behind a NAT and being unable to provide the real public address to its peer on the other side of the satellite.

As a result, upon call parameter negotiation (RTP/Osmux IP address and port), those parameters won’t be entirely useful and some specific logic needs to be introduced into the network components to circumvent the NAT under those cases.

For instance, if the BSC and its co-located MGW (BSC/MGW from now on) is under a NAT, it may end up providing its private address and port as RTP/Osmux parameters to the MSC/MGW through GSM protocols, but MSC will fail to send any message to that tuple because of the NAT or routing issues (due to IP address being a private address). In that scenario, MSC/MGW needs to be aware that there’s a NAT and wait until an RTP/Osmux message arrives from the BSC/MGW host. It then can, from that message source IP address and port (and CID in case of Osmux), discover the real public IP address and port of the peer (BSC/MGW). From that point on, the BSC/MGW punched a hole in the NAT (its connection table is updated) and MSC/MGW is able to send data back to it on that connection.

Moreover, NATs tend to drop connections from their connection tables after some inactivity time, meaning a peer may receive notice about the other end not being available while it actually is. This means the GSM network needs to be configured in a way to ensure inactivity periods are short enough that this cannot occur. That’s the reason why OsmoMGW provides the `osmux dummy` VTY command to enable sending dummy packets from time to time to keep the connections alive.

17.2 CID allocation

Each peer (BSC/MGW and MSC/MGW) allocates its own `recvCID`, and receives from the peer through the used GSM protocol the peer’s `recvCID`, which becomes the local `sendCID` for that connection.

```
BSC/MGW(recvCID=Y,sendCID=?)<--X--MSC/MGW(recvCID=X,sendCID=?)
```

```
BSC/MGW(recvCID=Y,sendCID=X)--Y-->MSC/MGW(recvCID=X,sendCID=Y)
```

This way each peer is responsible for allocating and managing their own local address (CID) space. This is basically the same that happens with regular IP address and port in the RTP case (and those also apply when Osmux is used, but an extra identifier, the CID, is allocated).

In an ideal scenario, without NAT, each BSC/MGW would have a public, differentiated and unique IP and port set tuple, And MSC/MGW should be able to identify messages coming from them by easily matching source IP address, port (and CID in Osmux case) against the parameters negotiated during call set up.

In this kind of scenario, MSC/MGW could easily open and manage one Osmux socket per BSC (based on SDP IPaddr and port parameters), with same `<localIPaddr, localPort>` tuple, allowing for 256 Osmux CIDs per BSC and hence call legs per BSC. Each of the peers could actually have more than one Osmux socket towards the other peer, by using a pool of ports or IP addresses, so there’s really not limit if required as long as there’s a way to infer the initially negotiated `<srcIP, srcPort, dstIP, dstPort, sendCID>` tuple from the received audio packets.

However, due to some constrains from in between NATs explained in section above, BSC/MGW IP address and port are not a priory known, and could change between different connections coming from it. As a result, it is difficult to infer the entire tuple, so for now MGW needs to allocate its Osmux `recvCID` in a clever way, in order to be able to identify the full tuple from it.

Hence, currently OsmoMGW CID allocation implementation shares CID between all connections, which means it can only handle up to 256 concurrent Osmux connections (call legs).

Future work in OsmoMGW (OS#4092) plans to use a set of local ports for Osmux sockets instead of only 1 currently used. This way local ports can be matched against specific `<remoteIP, remotePort>` tuples and have an entire 256 Osmux CID space per `<remoteIP, remotePort>` (aka per peer).
17.3 3GPP AoIP network setup with Osmux

Figure 3: Sample node diagram of a 3GPP AoIP network with Osmux enabled
Figure 4: MO-call with Osmux enable on 3GPP AoIP
17.4 SCCP Lite network setup with Osmux

Figure 5: Sample node diagram of a 3GPP AoIP using A/IP with IPA/SCCPlite network with Osmux enabled
Figure 6: MO-call with Osmux enable on 3GPP AoIP using A/IP with IPA/SCCPlite
17.5 SCCPLite network setup with Osmux + BSC-NAT

Figure 7: Sample node diagram of a 3GPP AoIP using A/IP with IPA/SCCPlite network and BSC-NAT with Osmux enabled
Figure 8: MO call with Osmux enable on 3GPP AoIP using A/IP with IPA/SCCPlite with a BSC-NAT between BSC and MSC.
17.6 Osmux and MGCP

X-Osmux indicates to OsmoMGW that a given connection of an rtpbridge endpoint has to be configured in order to handle Osmux frames instead of RTP messages on the data plane.

17.6.1 X-Osmux Format

The value part of X-Osmux must be one integer in range [0..255], or alternatively only on request messages, an asterisk (*) if the value is not yet known.

X-Osmux must be issued in the MGCP header section (typically as its last item), before the SDP section starts.

X-Osmux can be included inside CRCX and MDCX request messages, as well as their respective response messages.

In request messages, the value part of X-Osmux specifies the CID to be used by OsmoMGW to send Osmux frames to the remote peer for that connection, also known as sendCID.

In response messages, the value part of X-Osmux specifies the CID where OsmoMGW expect to receive Osmux frames from the remote peer for that connection, also known as recvCID.

Example: X-Osmux format with a known CID 3.

```
X-Osmux: 3
```

Example: X-Osmux format with a wildcard (not yet known) CID.

```
X-Osmux: *
```

17.6.2 X-Osmux Considerations

If the MGCP client is willing to use Osmux for a given connection, it shall specify so during CRCX time, and not later. If at CRCX time the MGCP client doesn’t yet know the sendCID, it can use an asterisk (*) and provide sendCID later within MDCX messages.

All subsequent MDCX messages sent towards an Osmux connection must contain the original sendCID sent during CRCX. The same way, all MDCX response shall contain the recvCID sent during CRCX.

The other required connection address parameters, such as IP address, port, and codecs, are negotiated through MGCP and SDP as usual, but in this case the IP address and port specific the Osmux socket IP address and port to use, that together with the Osmux CID conform the entire tuple identifying a Osmux stream.

Since Osmux only supports AMR codec payloads, the SDP must specify use of AMR codec.

Example: CRCX message that instructs OsmoMGW to create an Osmux connection

```
CRCX 189 rtpbridge/1@mgw MGCP 1.0
C: 36
M: sendrecv
X-Osmux: 2
v=0
o=-- 36 23 IN IP4 172.18.2.20
s=-
c=IN IP4 1.2.3.4
t=0 0
m=audio 2342 RTP/AVP 112
a=fmtp:112
a=rtpmap:112 AMR/8000/1
a=ptime:20
```

Example: response to CRCX containing the
17.6.3 X-Osmux Support

X-Osmux is known to be supported by OsmoMGW on the MGCP server side, and by OsmoBSC as well as OsmoMSC on the MGCP client side (through libosmo-mgcp-cli). No other programs supporting this feature are known or envisioned at the time of writing this document.

In OmoMGW, Osmux support is managed through VTY.

Example: Sample config file section with Osmux configuration

```plaintext
mgcp
...
osmux on
osmux bind-ip 172.18.1.20
osmux port 1984
osmux batch-factor 4
osmux dummy on
```

1. Allow clients to set allocate Osmux connections in `rtpbridge` endpoints, while still allowing RTP connections
2. Bind the Osmux socket to the provided IP address
3. Bind the Osmux socket to the provided UDP port
4. Batch up to 4 RTP payloads of the same stream on each Osmux frame
5. Periodically send Osmux dummy frames, useful to punch a hole in NATs and maintain connections opened.

17.7 Osmux Support in OsmoMSC

17.7.1 OsmoMSC in a A/IP with IPA/SCCPlite network setup

In this kind of setup, the CN side of BSC co-located MGW is managed by the MSC, meaning the use of Osmux is transparent to BSC since MSC takes care of both peer MGW connections. Moreover, in this case the MSC has no dynamic information on Osmux support in the BSC co-located MGW until CRCX time, which means configuration on both nodes need to be carefully set up so they can work together.

Osmux usage in OsmoMSC is managed through the VTY command `osmux (on|off|only)`. Since there’s no dynamic information on Osmux support, it may be required in the future to have an extra VTY command which can be set per BSC to fine-tune which ones should use Osmux and which shouldn’t.

OsmoMSC will behave differently during call set up based on the VTY command presented above:
• **off**: OsmoMSC won’t include an X-Osmux extension to CRCX sent to the BSC co-located MGW when configuring the CN side of the MGW endpoint. If the MGW answers with a CRCX ACK containing an X-Osmux, OsmoMSC will cancel the call establishment.

• **on**: OsmoMSC will initially configure its co-located MGW to use Osmux, then similarly send a CRCX with an X-Osmux extension towards the BSC co-located MGW. Under this configuration, if the BSC co-located MGW didn’t support Osmux, it could send a CRCX ACK without X-Osmux extension or fail (depending on its own configuration), and OsmoMSC could choose to re-create its local connection as non-Osmux (RTP) (and possibly try again against BSC co-located MGW), but this behavior is currently not implemented. As a result, currently on behaves the same as only.

• **only**: OsmoMSC will configure its co-located MGW as well as the BSC co-located MGW to use Osmux by including the X-Osmux MGCP extension. If MGW rejects to use Osmux, OsmoMSC will reject the call and the call establishment will fail.

### 17.7.2 OsmoMSC in a 3GPP AoIP network setup

Osmux usage in OsmoMSC in managed through the VTY command `osmux (on|off|only)`. Once enabled (on or only), OsmoMSC will start appending the vendor specific Osmux Support IE in BSSMAP RESET and BSSMAP RESET-ACK message towards the BSC in order to announce it supports Osmux, and BSC will do the same. This way, OsmoMSC can decide whether to use Osmux or not based on this information when setting up a call (this time using Osmux CID IE). It should be noted that this option should not be enabled unless BSCs managed by OsmoMSC support handling this extension IE (like OsmoBSC), 3rd-party BSCs might otherwise refuse the related RESET/RESET-ACK messages.

OsmoMSC will behave differently during call set up based on the VTY command presented above:

• **off**: OsmoMSC won’t use Osmux. That is, it will send a BSSMAP Assign Request without the Osmux CID IE, and will send a CRCX without X-Osmux extension towards its co-located MGW.

• **on**: If BSC announced Osmux support to OsmoMSC during BSSMAP RESET time, then OsmoMSC will set up the call to use Osmux (by adding X-Osmux to MGCP CRCX and Osmux CID IE to BSSMAP Assign Request). If the BSC didn’t announce Osmux support to OsmoMSC, then OsmoMSC will use RTP to set up the call (by avoiding addition of previously described bits).

• **only**: Same as per on, except that OsmoMSC will allow to set up only Osmux calls on the CN-side, this is, it will reject to set up voice calls for BSC which didn’t announce Osmux support.

### 18 Osmocom Control Interface

The VTY interface as described in Section 11 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.

#### 18.1 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).
Inside the IPA header is a single byte of extension header with protocol ID 0x00 which indicates the control interface.

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.

### 18.1.1 GET operation

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

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

18.1.3 TRAP operation

The program can at any time issue a trap. The term is used in the spirit of SNMP.
18.2 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.

18.3 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 Section 18.2 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.

18.3.1 Getting rate counters

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

18.3.2 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

18.3.3 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

18.3.4 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

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

19 Generic Subscriber Update Protocol

19.1 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.

### 19.2 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.

### 19.3 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*.

### 19.4 Procedures

#### 19.4.1 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 16: Send Authentication Info (Normal Case)](image1)

![Figure 17: Send Authentication Info (Erroneous Case)](image2)
19.4.2 Reporting of Authentication Failure

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

![Figure 18: Authentication Failure Report (Normal Case)](image)

19.4.3 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)

![Figure 19: Update Location (Normal Case)](image)

![Figure 20: Update Location (Error Case)](image)

19.4.4 Location Cancellation

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

![Figure 21: Cancel Location (Normal Case)](image)
19.4.5 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.

![Diagram of Purge MS (Normal Case)](image)

19.4.6 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.

![Diagram of Delete Subscriber Data (Normal Case)](image)

19.4.7 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.

![Diagram of Check IMEI (Normal Case)](image)

19.5 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.

19.5.1 E Handover

MSC-A has an active RAN connection and hands it over to MSC-B.

19.5.2 E Subsequent Handover

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

Figure 26: E Handover (Normal Case)

Figure 27: E Subsequent Handover (Normal Case)
19.5.3 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.

![E Forward and Process Access Signalling](image)

Figure 28: E Process and Forward Access Signalling (Normal Case)

19.5.4 E Routing Error

The GSUP server cannot 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 19.7.30), 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.

![E Routing Error](image)

Figure 29: E Routing Error example

19.6 Message Format

19.6.1 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 19.7.19</td>
<td>M</td>
<td>TLV</td>
<td>2-10</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 receive 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).

19.6.2 Send Authentication Info Request

Direction: SGSN / VLR ⇒ HLR
The conditional *AUTS* and *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.

### 19.6.3 Send Authentication Info 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>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>IMSI</td>
<td>Section 19.7.19</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
<tr>
<td>02</td>
<td>Cause</td>
<td>Section 19.7.25</td>
<td>M</td>
<td>TLV</td>
<td>3</td>
</tr>
</tbody>
</table>

### 19.6.4 Send Authentication Info Response

Direction: HLR ⇒ SGSN / VLR

<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>Section 19.7.19</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
<tr>
<td>03</td>
<td>Auth Tuple</td>
<td>Section 19.7.6</td>
<td>0-5</td>
<td>TLV</td>
<td>36</td>
</tr>
</tbody>
</table>

### 19.6.5 Authentication Failure Report

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 19.7.19</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
<tr>
<td>28</td>
<td>CN Domain</td>
<td>Section 19.7.15</td>
<td>O</td>
<td>TLV</td>
<td>3</td>
</tr>
</tbody>
</table>

### 19.6.6 Update Location 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 19.7.19</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
<tr>
<td>28</td>
<td>CN Domain</td>
<td>Section 19.7.15</td>
<td>O</td>
<td>TLV</td>
<td>3</td>
</tr>
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</table>

### 19.6.7 Update Location Error

Direction: HLR ⇒ SGSN / VLR

<table>
<thead>
<tr>
<th>IEI</th>
<th>IE</th>
<th>Type</th>
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<th>Format</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
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<td>Section 19.7.19</td>
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<td>TLV</td>
<td>2-10</td>
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### 19.6.8 Update Location Result

**Direction:** HLR ⇒ SGSN / VLR

<table>
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<th>IE</th>
<th>Type</th>
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<th>Format</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>02</td>
<td>Cause</td>
<td>Section 19.7.25</td>
<td>M</td>
<td>TLV</td>
<td>3</td>
</tr>
</tbody>
</table>

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

### 19.6.9 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>
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<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
<tr>
<td>06</td>
<td>CN Domain</td>
<td>Section 19.7.15</td>
<td>O</td>
<td>TLV</td>
<td>3</td>
</tr>
<tr>
<td>06</td>
<td>Cancellation type</td>
<td>Section 19.7.16</td>
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<td>TLV</td>
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</table>

### 19.6.10 Location Cancellation Result

**Direction:** SGSN / VLR ⇒ HLR

<table>
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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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<td>Section 19.7.19</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
<tr>
<td>28</td>
<td>CN Domain</td>
<td>Section 19.7.15</td>
<td>O</td>
<td>TLV</td>
<td>3</td>
</tr>
</tbody>
</table>

### 19.6.11 Purge MS Request

**Direction:** SGSN / VLR ⇒ HLR

<table>
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<th>IE</th>
<th>Type</th>
<th>Presence</th>
<th>Format</th>
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<td>CN Domain</td>
<td>Section 19.7.15</td>
<td>O</td>
<td>TLV</td>
<td>3</td>
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</tbody>
</table>

### 19.6.12 Purge MS Error

**Direction:** HLR ⇒ SGSN / VLR

<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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<tbody>
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<td>IMSI</td>
<td>Section 19.7.19</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
</tbody>
</table>
### 19.6.13 Purge MS Result

**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>02</td>
<td>Cause</td>
<td>Section 19.7.25</td>
<td>M</td>
<td>TLV</td>
<td>3</td>
</tr>
</tbody>
</table>

### 19.6.14 Insert Subscriber Data 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>
<td>Message Type</td>
<td>Section 19.7.1</td>
<td>M</td>
<td>V</td>
<td>1</td>
</tr>
<tr>
<td>28</td>
<td>IMSI</td>
<td>Section 19.7.19</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
<tr>
<td>08</td>
<td>CN Domain</td>
<td>Section 19.7.20</td>
<td>O</td>
<td>TLV</td>
<td>3</td>
</tr>
<tr>
<td>09</td>
<td>MSISDN</td>
<td>Section 19.7.24</td>
<td>O</td>
<td>TLV</td>
<td>0-9</td>
</tr>
<tr>
<td>04</td>
<td>HLR Number</td>
<td>Section 19.7.24</td>
<td>O</td>
<td>TLV</td>
<td>0-9</td>
</tr>
<tr>
<td>05</td>
<td>PDP info</td>
<td>Section 19.7.18</td>
<td>M</td>
<td>TLV</td>
<td>2</td>
</tr>
<tr>
<td>14</td>
<td>PDP info</td>
<td>Section 19.7.23</td>
<td>C</td>
<td>TLV</td>
<td>0-10</td>
</tr>
</tbody>
</table>

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

### 19.6.15 Insert Subscriber Data Error

**Direction:** SGSN / VLR ⇒ HLR

<table>
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<tbody>
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<td>IMSI</td>
<td>Section 19.7.19</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
<tr>
<td>02</td>
<td>Cause</td>
<td>Section 19.7.25</td>
<td>M</td>
<td>TLV</td>
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</tbody>
</table>

### 19.6.16 Insert Subscriber Data Result

**Direction:** SGSN / VLR ⇒ HLR

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<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>IMSI</td>
<td>Section 19.7.19</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
</tbody>
</table>

### 19.6.17 Delete Subscriber Data Request

**Direction:** HLR ⇒ SGSN / VLR

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<th>Length</th>
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</thead>
<tbody>
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<td>IMSI</td>
<td>Section 19.7.19</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
</tbody>
</table>
19.6.18 Delete Subscriber Data Error

Direction: SGSN / VLR ⇒ HLR

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<th>Presence</th>
<th>Format</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>28</td>
<td>CN Domain</td>
<td>Section 19.7.15</td>
<td>O</td>
<td>TLV</td>
<td>3</td>
</tr>
<tr>
<td>10</td>
<td>PDP Context ID</td>
<td>Section 19.7.5</td>
<td>C</td>
<td>TLV</td>
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</table>

19.6.19 Delete Subscriber Data Result

Direction: HLR ⇒ SGSN / VLR

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<th>Format</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>IMSI</td>
<td>Section 19.7.19</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
<tr>
<td>02</td>
<td>Cause</td>
<td>Section 19.7.25</td>
<td>M</td>
<td>TLV</td>
<td>3</td>
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</tbody>
</table>

19.6.20 Process Supplementary Service Request

Direction: bidirectional

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<th>Format</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>IMSI</td>
<td>Section 19.7.19</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
<tr>
<td>30</td>
<td>Session ID</td>
<td>Section 19.8.1</td>
<td>M</td>
<td>TLV</td>
<td>6</td>
</tr>
<tr>
<td>31</td>
<td>Session State</td>
<td>Section 19.8.2</td>
<td>M</td>
<td>TLV</td>
<td>3</td>
</tr>
<tr>
<td>35</td>
<td>Supplementary Service Info</td>
<td>Section 19.7.26</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.

19.6.21 Process Supplementary Service Error

Direction: EUSE / HLR ⇒ MSC

<table>
<thead>
<tr>
<th>IEI</th>
<th>IE</th>
<th>Type</th>
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<th>Format</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>IMSI</td>
<td>Section 19.7.19</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
<tr>
<td>30</td>
<td>Session ID</td>
<td>Section 19.8.1</td>
<td>M</td>
<td>TLV</td>
<td>6</td>
</tr>
<tr>
<td>31</td>
<td>Session State</td>
<td>Section 19.8.2</td>
<td>M</td>
<td>TLV</td>
<td>3</td>
</tr>
<tr>
<td>02</td>
<td>Cause</td>
<td>Section 19.7.25</td>
<td>M</td>
<td>TLV</td>
<td>3</td>
</tr>
</tbody>
</table>

19.6.22 Process Supplementary Service Response

Direction: EUSE / HLR ⇒ MSC

<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>Message Type</td>
<td>Section 19.7.1</td>
<td>M</td>
<td>V</td>
<td>1</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.

### 19.6.23 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>
<td>IMSI</td>
<td>Message Type</td>
<td>Section 19.7.1</td>
<td>M</td>
<td>V</td>
</tr>
<tr>
<td>40</td>
<td></td>
<td>SM-RP-MR (Message Reference)</td>
<td>Section 19.7.19</td>
<td>M</td>
<td>TLV</td>
</tr>
<tr>
<td>41</td>
<td></td>
<td>SM-RP-DA (Destination Address)</td>
<td>Section 19.8.4</td>
<td>M</td>
<td>TLV</td>
</tr>
<tr>
<td>42</td>
<td></td>
<td>SM-RP-OA (Originating Address)</td>
<td>Section 19.8.5</td>
<td>M</td>
<td>TLV</td>
</tr>
<tr>
<td>43</td>
<td></td>
<td>SM-RP-UI (SM TPDU)</td>
<td>Section 19.8.7</td>
<td>M</td>
<td>TLV</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.

### 19.6.24 MO-forwardSM Error

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

<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 19.7.1</td>
<td>M</td>
<td>V</td>
</tr>
<tr>
<td>40</td>
<td></td>
<td>SM-RP-MR (Message Reference)</td>
<td>Section 19.7.19</td>
<td>M</td>
<td>TLV</td>
</tr>
<tr>
<td>44</td>
<td></td>
<td>SM-RP-Cause (Cause value)</td>
<td>Section 19.8.8</td>
<td>M</td>
<td>TLV</td>
</tr>
<tr>
<td>43</td>
<td></td>
<td>SM-RP-UI (diagnostic field)</td>
<td>Section 19.8.7</td>
<td>O</td>
<td>TLV</td>
</tr>
</tbody>
</table>

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

### 19.6.25 MO-forwardSM Result

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

<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 19.7.1</td>
<td>M</td>
<td>V</td>
</tr>
<tr>
<td>40</td>
<td></td>
<td>SM-RP-MR (Message Reference)</td>
<td>Section 19.7.19</td>
<td>M</td>
<td>TLV</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.
19.6.26 MT-forwardSM Request

Direction: SMSC (via HLR) ⇒ MSC / SGSN

<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 19.7.1</td>
<td>M</td>
<td>V</td>
</tr>
<tr>
<td>40</td>
<td>SM-RP-MR (Message Reference)</td>
<td>Section 19.8.3</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
<tr>
<td>41</td>
<td>SM-RP-DA (Destination Address)</td>
<td>Section 19.8.4</td>
<td>M</td>
<td>TLV</td>
<td>2-...</td>
</tr>
<tr>
<td>42</td>
<td>SM-RP-OA (Originating Address)</td>
<td>Section 19.8.5</td>
<td>M</td>
<td>TLV</td>
<td>2-...</td>
</tr>
<tr>
<td>43</td>
<td>SM-RP-UI (SM TPDU)</td>
<td>Section 19.8.7</td>
<td>M</td>
<td>TLV</td>
<td>1-...</td>
</tr>
<tr>
<td>45</td>
<td>SM-RP-MMS (More Messages to Send)</td>
<td>Section 19.8.9</td>
<td>O</td>
<td>TLV</td>
<td>1</td>
</tr>
</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.

19.6.27 MT-forwardSM Error

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>
<td>IMSI</td>
<td>Message Type</td>
<td>Section 19.7.1</td>
<td>M</td>
<td>V</td>
</tr>
<tr>
<td>40</td>
<td>SM-RP-MR (Message Reference)</td>
<td>Section 19.8.3</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
<tr>
<td>44</td>
<td>SM-RP-Cause (Cause value)</td>
<td>Section 19.8.8</td>
<td>M</td>
<td>TLV</td>
<td>1</td>
</tr>
<tr>
<td>43</td>
<td>SM-RP-UI (diagnostic field)</td>
<td>Section 19.8.7</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 MT short message delivery. The corresponding MAP service is MAP-MT-FORWARD-SHORT-MESSAGE, see 3GPP TS 29.002, section 12.9.

19.6.28 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>
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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 19.7.1</td>
<td>M</td>
<td>V</td>
</tr>
<tr>
<td>40</td>
<td>SM-RP-MR (Message Reference)</td>
<td>Section 19.8.3</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 MT short message delivery. The corresponding MAP service is MAP-MT-FORWARD-SHORT-MESSAGE, see 3GPP TS 29.002, section 12.9.

19.6.29 READY-FOR-SM Request

Direction: MSC / SGSN ⇒ SMSC (via HLR)

<table>
<thead>
<tr>
<th>IEI</th>
<th>IE</th>
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<th>Presence</th>
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<th>Length</th>
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<tbody>
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<td>Message Type</td>
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<td>M</td>
<td>V</td>
</tr>
<tr>
<td>40</td>
<td>SM-RP-MR (Message Reference)</td>
<td>Section 19.8.3</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
<tr>
<td>46</td>
<td>SM Alert Reason</td>
<td>Section 19.8.10</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.

### 19.6.30 READY-FOR-SM Error

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

<table>
<thead>
<tr>
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<th>Presence</th>
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<tbody>
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<td>Message Type</td>
<td>M</td>
<td>V</td>
<td>1</td>
</tr>
<tr>
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<td></td>
<td>SM-RP-MR (Message Reference)</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
<tr>
<td>44</td>
<td></td>
<td>SM-RP-Cause (Cause value)</td>
<td>M</td>
<td>TLV</td>
<td>1</td>
</tr>
<tr>
<td>43</td>
<td></td>
<td>SM-RP-UI (diagnostic field)</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 SMMA (Memory Available) indication. The corresponding MAP service is MAP-READY-FOR-SM, see 3GPP TS 29.002, section 12.4.

### 19.6.31 READY-FOR-SM Result

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

<table>
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<td>Message Type</td>
<td>M</td>
<td>V</td>
<td>1</td>
</tr>
<tr>
<td>40</td>
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<td>SM-RP-MR (Message Reference)</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 SMMA (Memory Available) indication. The corresponding MAP service is MAP-READY-FOR-SM, see 3GPP TS 29.002, section 12.4.

### 19.6.32 CHECK-IMEI Request

**Direction:** VLR ⇒ EIR (via HLR)

<table>
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<th>IE</th>
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<th>Presence</th>
<th>Format</th>
<th>Length</th>
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<tbody>
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<td>01</td>
<td>IMSI</td>
<td>Message Type</td>
<td>M</td>
<td>V</td>
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</tr>
<tr>
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<td></td>
<td>M</td>
<td>TLV</td>
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</table>

### 19.6.33 CHECK-IMEI Error

**Direction:** EIR (via HLR) ⇒ VLR

<table>
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<th>Format</th>
<th>Length</th>
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<tbody>
<tr>
<td>01</td>
<td>IMSI</td>
<td>Message Type</td>
<td>M</td>
<td>V</td>
<td>1</td>
</tr>
<tr>
<td>02</td>
<td>Cause</td>
<td></td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
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</table>

### 19.6.34 CHECK-IMEI Result

**Direction:** EIR (via HLR) ⇒ VLR
### 19.6.35 E Prepare Handover Request

**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>Section 19.7.1</td>
<td>M</td>
<td>V</td>
<td>1</td>
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<tr>
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<td>Message Class</td>
<td>Section 19.7.29</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
<tr>
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<td>M</td>
<td>TLV</td>
<td>3</td>
</tr>
<tr>
<td>61</td>
<td>Destination Name</td>
<td>Section 19.7.31</td>
<td>M</td>
<td>TLV</td>
<td>2-…</td>
</tr>
<tr>
<td>62</td>
<td>AN-APDU</td>
<td>Section 19.7.32</td>
<td>M</td>
<td>TLV</td>
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### 19.6.36 E Prepare Handover Error

**Direction:** MSC-B=MSC-T ⇒ MSC-A=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>
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<tbody>
<tr>
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<td>Section 19.7.1</td>
<td>M</td>
<td>V</td>
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</tr>
<tr>
<td>0a</td>
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<td>Section 19.7.29</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
<tr>
<td>60</td>
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<td>Section 19.7.30</td>
<td>M</td>
<td>TLV</td>
<td>3</td>
</tr>
<tr>
<td>61</td>
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<td>Section 19.7.31</td>
<td>M</td>
<td>TLV</td>
<td>2-…</td>
</tr>
<tr>
<td>62</td>
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<td>Section 19.7.32</td>
<td>M</td>
<td>TLV</td>
<td>2-…</td>
</tr>
</tbody>
</table>

### 19.6.37 E Prepare Handover Result

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

<table>
<thead>
<tr>
<th>IEI</th>
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<th>Format</th>
<th>Length</th>
</tr>
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<tbody>
<tr>
<td>01</td>
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<td>Section 19.7.1</td>
<td>M</td>
<td>V</td>
<td>1</td>
</tr>
<tr>
<td>0a</td>
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<td>Section 19.7.29</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
<tr>
<td>60</td>
<td>Source Name</td>
<td>Section 19.7.30</td>
<td>M</td>
<td>TLV</td>
<td>3</td>
</tr>
<tr>
<td>61</td>
<td>Destination Name</td>
<td>Section 19.7.31</td>
<td>M</td>
<td>TLV</td>
<td>2-…</td>
</tr>
<tr>
<td>62</td>
<td>AN-APDU</td>
<td>Section 19.7.32</td>
<td>M</td>
<td>TLV</td>
<td>2-…</td>
</tr>
</tbody>
</table>

### 19.6.38 E Prepare Subsequent Handover Request

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

<table>
<thead>
<tr>
<th>IEI</th>
<th>IE</th>
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</thead>
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<tr>
<td>01</td>
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<td>Section 19.7.1</td>
<td>M</td>
<td>V</td>
<td>1</td>
</tr>
<tr>
<td>0a</td>
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<td>Section 19.7.29</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
<tr>
<td>60</td>
<td>Source Name</td>
<td>Section 19.7.30</td>
<td>M</td>
<td>TLV</td>
<td>3</td>
</tr>
<tr>
<td>61</td>
<td>Destination Name</td>
<td>Section 19.7.31</td>
<td>M</td>
<td>TLV</td>
<td>2-…</td>
</tr>
<tr>
<td>62</td>
<td>AN-APDU</td>
<td>Section 19.7.32</td>
<td>M</td>
<td>TLV</td>
<td>2-…</td>
</tr>
</tbody>
</table>
19.6.39  E Prepare Subsequent Handover Error

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

<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>
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<td>Section 19.7.1</td>
<td>M</td>
<td>V</td>
</tr>
<tr>
<td>0a</td>
<td>Message Class</td>
<td>Section 19.7.19</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
<tr>
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<td>Source Name</td>
<td>Section 19.7.29</td>
<td>M</td>
<td>TLV</td>
<td>3</td>
</tr>
<tr>
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<td>Section 19.7.30</td>
<td>M</td>
<td>TLV</td>
<td>2-…</td>
</tr>
<tr>
<td>62</td>
<td>AN-APDU</td>
<td>Section 19.7.31</td>
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<td>TLV</td>
<td>2-…</td>
</tr>
</tbody>
</table>

19.6.40  E Prepare Subsequent Handover Result

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

<table>
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<tr>
<th>IEI</th>
<th>IE</th>
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<th>Format</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
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<td>Message Type</td>
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<td>M</td>
<td>V</td>
</tr>
<tr>
<td>0a</td>
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<td>Section 19.7.19</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
<tr>
<td>60</td>
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<td>Section 19.7.29</td>
<td>M</td>
<td>TLV</td>
<td>3</td>
</tr>
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<td>Section 19.7.30</td>
<td>M</td>
<td>TLV</td>
<td>2-…</td>
</tr>
<tr>
<td>62</td>
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<td>TLV</td>
<td>2-…</td>
</tr>
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</table>

19.6.41  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>
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<th>Length</th>
</tr>
</thead>
<tbody>
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<td>M</td>
<td>V</td>
</tr>
<tr>
<td>0a</td>
<td>Message Class</td>
<td>Section 19.7.19</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
<tr>
<td>60</td>
<td>Source Name</td>
<td>Section 19.7.29</td>
<td>M</td>
<td>TLV</td>
<td>3</td>
</tr>
<tr>
<td>61</td>
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<td>Section 19.7.30</td>
<td>M</td>
<td>TLV</td>
<td>2-…</td>
</tr>
<tr>
<td>62</td>
<td>AN-APDU</td>
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<td>TLV</td>
<td>2-…</td>
</tr>
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</table>

19.6.42  E Send End Signal Error

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

<table>
<thead>
<tr>
<th>IEI</th>
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<th>Length</th>
</tr>
</thead>
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<td>M</td>
<td>V</td>
</tr>
<tr>
<td>0a</td>
<td>Message Class</td>
<td>Section 19.7.19</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
<tr>
<td>60</td>
<td>Source Name</td>
<td>Section 19.7.29</td>
<td>M</td>
<td>TLV</td>
<td>3</td>
</tr>
<tr>
<td>61</td>
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<td>Section 19.7.30</td>
<td>M</td>
<td>TLV</td>
<td>2-…</td>
</tr>
<tr>
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<td>2-…</td>
</tr>
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</table>

19.6.43  E Send End Signal Result

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

<table>
<thead>
<tr>
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<th>IE</th>
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<th>Format</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
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</table>
### 19.6.44 E Process Access Signalling Request

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

<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>
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<td>V</td>
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<td>0a</td>
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<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
<tr>
<td>60</td>
<td>Source Name</td>
<td>Section 19.7.29</td>
<td>M</td>
<td>TLV</td>
<td>3</td>
</tr>
<tr>
<td>61</td>
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<td>Section 19.7.30</td>
<td>M</td>
<td>TLV</td>
<td>2-...</td>
</tr>
<tr>
<td>62</td>
<td>AN-APDU</td>
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<td>M</td>
<td>TLV</td>
<td>2-...</td>
</tr>
</tbody>
</table>

### 19.6.45 E Forward Access Signalling Request

Direction: MSC-A ⇒ MSC-B=MSC-I (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>
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<tbody>
<tr>
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<td>M</td>
<td>V</td>
<td>1</td>
</tr>
<tr>
<td>0a</td>
<td>Message Class</td>
<td>Section 19.7.19</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
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<tr>
<td>60</td>
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<td>TLV</td>
<td>3</td>
</tr>
<tr>
<td>61</td>
<td>Destination Name</td>
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<td>M</td>
<td>TLV</td>
<td>2-...</td>
</tr>
<tr>
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<td>M</td>
<td>TLV</td>
<td>2-...</td>
</tr>
</tbody>
</table>

### 19.6.46 E Close

Direction: MSC-A ⇒ MSC-B (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>
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<tbody>
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<td>V</td>
<td>1</td>
</tr>
<tr>
<td>0a</td>
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<td>Section 19.7.19</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
<tr>
<td>60</td>
<td>Source Name</td>
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<td>M</td>
<td>TLV</td>
<td>3</td>
</tr>
<tr>
<td>61</td>
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<td>Section 19.7.30</td>
<td>M</td>
<td>TLV</td>
<td>2-...</td>
</tr>
</tbody>
</table>

### 19.6.47 E Abort

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

### 19.6.48 E Routing Error

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

<table>
<thead>
<tr>
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<th>Length</th>
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<td>M</td>
<td>V</td>
<td>1</td>
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</tbody>
</table>

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### 19.7 Information Elements

#### 19.7.1 Message Type

<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>0x0b</td>
<td>Authentication Failure Report</td>
</tr>
<tr>
<td>0x0c</td>
<td>Purge MS Request</td>
</tr>
<tr>
<td>0x0d</td>
<td>Purge MS Error</td>
</tr>
<tr>
<td>0x0e</td>
<td>Purge MS Result</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>
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<tr>
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<td>Delete Subscriber Data Request</td>
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</tr>
<tr>
<td>0x1c</td>
<td>Location Cancellation Request</td>
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<tr>
<td>0x1d</td>
<td>Location Cancellation Error</td>
</tr>
<tr>
<td>0x1e</td>
<td>Location Cancellation Result</td>
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<tr>
<td>0x20</td>
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<td>Supplementary Service Error</td>
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<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>
19.7.2 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*.

19.7.3 PDP Info

This is a container for information elements describing a single PDP.

<table>
<thead>
<tr>
<th>IEI</th>
<th>IE Type</th>
<th>Type</th>
<th>Presence</th>
<th>Format</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>PDP Context ID</td>
<td>Section 19.7.5</td>
<td>C</td>
<td>TLV</td>
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</tr>
<tr>
<td>11</td>
<td>PDP Type</td>
<td>Section 19.7.4</td>
<td>C</td>
<td>TLV</td>
<td>4</td>
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<tr>
<td>12</td>
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<td>3-102</td>
</tr>
<tr>
<td>13</td>
<td>Quality of Service</td>
<td>Section 19.7.22</td>
<td>O</td>
<td>TLV</td>
<td>1-20</td>
</tr>
<tr>
<td>14</td>
<td>PDP-Charging Characteristics</td>
<td>Section 19.7.23</td>
<td>O</td>
<td>TLV</td>
<td>4</td>
</tr>
</tbody>
</table>

The conditional IE are mandantory unless mentioned otherwise.

19.7.4 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.

![Diagram of PDP type encoding](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
19.7.5 PDP Context ID

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

```
    0 4 8
```

```
<table>
<thead>
<tr>
<th>PDP context ID IEI</th>
<th>Res</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length (1)</td>
<td></td>
</tr>
</tbody>
</table>
```

19.7.6 Auth tuple

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

<table>
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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 19.7.17</td>
<td>M M V V 1</td>
<td>M</td>
<td>V</td>
<td>1</td>
</tr>
<tr>
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<td></td>
<td>M M V V 1</td>
<td>M</td>
<td>V</td>
<td>1</td>
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<td>RAND</td>
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<td>M</td>
<td>TLV</td>
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<td>25</td>
<td>AUTN</td>
<td>Section 19.7.12</td>
<td>C</td>
<td>TLV</td>
<td>18</td>
</tr>
<tr>
<td>27</td>
<td>RES</td>
<td>Section 19.7.14</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.

19.7.7 RAND

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

19.7.8 SRES

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

19.7.9 Kc

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

19.7.10 IK

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

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

19.7.12 AUTN

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

19.7.13 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.

19.7.14 RES

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

19.7.15 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>

Table 6: CN Domain Number

19.7.16 Cancellation Type

![Cancellation Type Diagram]
Table 7: 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>

19.7.17 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 8: 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 19.7.25</td>
</tr>
<tr>
<td>0x03</td>
<td>Auth Tuple</td>
<td>Section 19.7.6</td>
</tr>
<tr>
<td>0x04</td>
<td>PDP Info Compl</td>
<td>Section 19.7.18</td>
</tr>
<tr>
<td>0x05</td>
<td>PDP Info</td>
<td>Section 19.7.3</td>
</tr>
<tr>
<td>0x06</td>
<td>Cancel Type</td>
<td>Section 19.7.16</td>
</tr>
<tr>
<td>0x07</td>
<td>Freeze P-TMSI</td>
<td>Section 19.7.18</td>
</tr>
<tr>
<td>0x08</td>
<td>MSISDN</td>
<td>ISDN-AddressString/octet, Section 19.7.20</td>
</tr>
<tr>
<td>0x09</td>
<td>HLR Number</td>
<td>Section 19.7.24</td>
</tr>
<tr>
<td>0x0a</td>
<td>Message Class</td>
<td>Section 19.7.29</td>
</tr>
<tr>
<td>0x10</td>
<td>PDP Context ID</td>
<td>Section 19.7.5</td>
</tr>
<tr>
<td>0x11</td>
<td>PDP Type</td>
<td>Section 19.7.4</td>
</tr>
<tr>
<td>0x12</td>
<td>Access Point Name</td>
<td>Section 19.7.21</td>
</tr>
<tr>
<td>0x13</td>
<td>QoS</td>
<td>Section 19.7.22</td>
</tr>
<tr>
<td>0x14</td>
<td>PDP-Charging Characteristics</td>
<td>Section 19.7.23</td>
</tr>
<tr>
<td>0x20</td>
<td>RAND</td>
<td>Section 19.7.7</td>
</tr>
<tr>
<td>0x21</td>
<td>SRES</td>
<td>Section 19.7.8</td>
</tr>
<tr>
<td>0x22</td>
<td>Kc</td>
<td>Section 19.7.9</td>
</tr>
<tr>
<td>0x23</td>
<td>IK</td>
<td>Section 19.7.10</td>
</tr>
<tr>
<td>0x24</td>
<td>CK</td>
<td>Section 19.7.11</td>
</tr>
<tr>
<td>0x25</td>
<td>AUTN</td>
<td>Section 19.7.12</td>
</tr>
<tr>
<td>0x26</td>
<td>AUTS</td>
<td>Section 19.7.13</td>
</tr>
<tr>
<td>0x27</td>
<td>RES</td>
<td>Section 19.7.14</td>
</tr>
<tr>
<td>0x28</td>
<td>CN Domain</td>
<td>Section 19.7.15</td>
</tr>
<tr>
<td>0x30</td>
<td>Session ID</td>
<td>Section 19.8.1</td>
</tr>
<tr>
<td>0x31</td>
<td>Session State</td>
<td>Section 19.8.2</td>
</tr>
<tr>
<td>0x35</td>
<td>Supplementary Service Info</td>
<td>Section 19.7.26</td>
</tr>
<tr>
<td>0x40</td>
<td>SM-RP-MR (Message Reference)</td>
<td>Section 19.8.3</td>
</tr>
<tr>
<td>0x41</td>
<td>SM-RP-DA (Destination Address)</td>
<td>Section 19.8.4</td>
</tr>
<tr>
<td>0x42</td>
<td>SM-RP-OA (Originating Address)</td>
<td>Section 19.8.5</td>
</tr>
<tr>
<td>0x43</td>
<td>SM-RP-UI (SM TPDU)</td>
<td>Section 19.8.7</td>
</tr>
<tr>
<td>0x44</td>
<td>SM-RP-Cause (RP Cause value)</td>
<td>Section 19.8.8</td>
</tr>
<tr>
<td>0x45</td>
<td>SM-RP-MMS (More Messages to Send)</td>
<td>Section 19.8.9</td>
</tr>
<tr>
<td>0x46</td>
<td>SM Alert Reason</td>
<td>Section 19.8.10</td>
</tr>
<tr>
<td>0x50</td>
<td>IMEI</td>
<td>Section 19.7.27</td>
</tr>
<tr>
<td>0x51</td>
<td>IMEI Check Result</td>
<td>Section 19.7.28</td>
</tr>
<tr>
<td>0x60</td>
<td>Source Name</td>
<td>Section 19.7.30</td>
</tr>
<tr>
<td>0x61</td>
<td>Destination Name</td>
<td>Section 19.7.31</td>
</tr>
<tr>
<td>0x62</td>
<td>AN-APDU</td>
<td>Section 19.7.32</td>
</tr>
<tr>
<td>0x63</td>
<td>RR Cause</td>
<td>Section 19.7.33</td>
</tr>
</tbody>
</table>
Table 8: (continued)

<table>
<thead>
<tr>
<th>IEI</th>
<th>Info Element</th>
<th>Type / Encoding</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x64</td>
<td>BSSAP Cause</td>
<td>Section 19.7.34</td>
</tr>
<tr>
<td>0x65</td>
<td>Session Management Cause</td>
<td>Section 19.7.35</td>
</tr>
</tbody>
</table>

19.7.18 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.

19.7.19 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.

---

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.
19.7.20 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.

19.7.21 Access Point Name

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

19.7.22 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 rest are encoded as octets 3-N of 24.008.
19.7.23 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.

![Profile Index and Behavior](image1)

19.7.24 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.

![PDP type IEI](image2)

19.7.25 Cause

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

19.7.26 Supplementary Service Info

This IE shall be used together with both Section 19.8.2 and Section 19.8.1 IEs. It is used to carry the payload of Supplementary Services encoded according to GSM TS 04.80.
19.7.27 IMEI

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

19.7.28 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 9: 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>

19.7.29 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>

19.7.30 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.

![Figure 30: Message forwarding example](image)

19.7.31 Destination Name

The receiving counterpart to source name (Section 19.7.30).
19.7.32 AN-APDU

This IE encodes the AN-APDU parameter described in 3GPP TS 29.002 7.6.9.1.

Table 10: 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>

19.7.33 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.

19.7.34 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.

19.7.35 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.

19.8 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.

19.8.1 Session ID

This auxiliary IE shall be used together with Section 19.8.2. The purpose of this IE is to identify a particular transaction using the 4-byte unique identifier.
19.8.2 Session State

This auxiliary IE shall be used together with Section 19.8.1. The purpose of this IE is to indicate a state of a particular transaction, i.e. initiate, continue or terminate it.

Table 11: 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>

19.8.3 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 19.8.3 is used to carry the message reference value ‘as-is’ (i.e. in range 0 through 255).

19.8.4 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 19.8.6. See 3GPP TS 29.002, section 7.6.8.1 for details.

19.8.5 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 19.8.6. See 3GPP TS 29.002, section 7.6.8.2 for details.

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

Basically, both Section 19.8.4 / Section 19.8.5 IEs contain a single TV of the following format:
Table 12: Coding of SM-RP-DA / SM-RP-OA IEs

<table>
<thead>
<tr>
<th>Field</th>
<th>Presence</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>T</td>
<td>M</td>
<td>1</td>
</tr>
<tr>
<td>V</td>
<td>O</td>
<td>1</td>
</tr>
<tr>
<td>V</td>
<td>O</td>
<td>{. . .}</td>
</tr>
</tbody>
</table>

Identity type

ToN/NPI header

BCD encoded (or alphanumeric) identity

where the identity type can be one of the following:

Table 13: 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:

![Figure 31: ToN/NPI header coding (as per 3GPP TS 129.002, MSB first)](image)

Please note that unlike both Section 19.7.19 and Section 19.7.20, where the value part is encoded as LV (i.e. contains an additional length), an identity in both Section 19.8.4 / Section 19.8.5 IEs shall not contain the redundant length octet.

19.8.7 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.
19.8.8 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 19.8.8 is used to carry the cause value 'as-is'.

19.8.9 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.

19.8.10 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>

Table 14: SM Alert Reason values

20 VTY Process and Thread management

Most Osmocom programs provide, some support to tune some system settings related to the running process, its threads, its scheduling policies, etc.

All of these settings can be configured through the VTY, either during startup by means of usual config files or through direct human interaction at the telnet VTY interface while the process is running.

20.1 Scheduling Policy

The scheduler to use as well as some of its properties (such as realtime priority) can be configured at any time for the entire process. This sort of functionality is useful in order to increase priority for processes running time-constrained procedures, such as those acting on the Um interface, like *osmo-trx* or *osmo-bts*, where use of this feature is highly recommended.

Example: Set process to use RR scheduler

```
cpu-sched
policy rr 1
```

Configure process to use *SCHED_RR* policy with real time priority 1
## 20.2 CPU-Affinity Mask

Most operating systems allow for some sort of configuration on restricting the amount of CPUs a given process or thread can run on. The procedure is sometimes called as **cpu-pinning** since it allows to keep different processes pinned on a subset of CPUs to make sure the scheduler won’t run two CPU-hungry processes on the same CPU.

The set of CPUs where each thread is allowed to run on is expressed by means of a bitmask in hexadecimal representation, where the right most bit relates to CPU 0, and the Nth most significant bit relates to CPU N-1. Setting the bit means the process is allowed to run on that CPU, while clearing it means the process is forbidden to run on that CPU.

Hence, for instance a cpu-affinity mask of 0x00 means the thread is not allowed on any CPU, which will cause the thread to stall until a new value is applied. A mask of 0x01 means the thread is only allowed to run on the 1st CPU (CPU 0). A mask of 0xff00 means CPUs 8-15 are allowed, while 0-7 are not.

For single-threaded processes (most of Osmocom are), it is usually enough to set this line in VTY config file as follows:

```
cpu-sched
cpu-affinity self 0x01
```

1. Allow main thread (the one managing the VTY) only on CPU 0

Or otherwise:

```
cpu-sched
cpu-affinity all 0x01
```

1. Allow all threads only on CPU 0

For multi-threaded processes, it may be desired to run some threads on a subset of CPUs while another subset may run on another one. In order to identify threads, one can either use the TID of the thread (each thread has its own PID in Linux), or its specific Thread Name in case it has been set by the application.

The related information on all threads available in the process can be listed through VTY. This allows identifying quickly the different threads, its current cpu-affinity mask, etc.

**Example: Get osmo-trx Thread list information from VTY**

```
OsmoTRX> show cpu-sched threads
Thread list for PID 338609:
TID: 338609, NAME: 'osmo-trx-uhd', cpu-affinity: 0x3
TID: 338610, NAME: 'osmo-trx-uhd', cpu-affinity: 0x3
TID: 338611, NAME: 'osmo-trx-uhd', cpu-affinity: 0x3
TID: 338629, NAME: 'osmo-trx-uhd', cpu-affinity: 0x3
TID: 338630, NAME: 'osmo-trx-uhd', cpu-affinity: 0x3
TID: 338631, NAME: 'osmo-trx-uhd', cpu-affinity: 0x3
TID: 338634, NAME: 'UHDAasyncEvent', cpu-affinity: 0x3
TID: 338635, NAME: 'TxLower', cpu-affinity: 0x3
TID: 338636, NAME: 'RxLower', cpu-affinity: 0x3
TID: 338637, NAME: 'RxUpper0', cpu-affinity: 0x3
TID: 338638, NAME: 'TxUpper0', cpu-affinity: 0x3
TID: 338639, NAME: 'RxUpper1', cpu-affinity: 0x3
TID: 338640, NAME: 'TxUpper1', cpu-affinity: 0x3
```

At runtime, one can change the cpu-affinity mask for a given thread identifying it by either TID or name:

**Example: Set CPU-affinity from VTY telnet interface**

```
OsmoTRX> cpu-affinity TxLower 0x02
OsmoTRX> cpu-affinity TxLower 0x03
```
Allow thread named \textit{TxLower} (338635) only on CPU 1

Allow with TID 338636 (\textit{RxLower}) only on CPU 0 and 1

Since thread names are set dynamically by the process during startup or at a later point after creating the thread itself, one may need to specify in the config file that the mask must be applied by the thread itself once being configured rather than trying to apply it immediately. To specify so, the \textit{delay} keyword is using when configuring in the VTY. If the \textit{delay} keyword is not used, the VTY will report and error and fail at startup when trying to apply a cpu-affinity mask for a yet-to-be-created thread.

\textbf{Example: Set CPU-affinity from VTY config file}

cpu-sched
cpu-affinity TxLower 0x01 delay

Allow thread named \textit{TxLower} (338635) only on CPU 1. It will be applied by the thread itself when created.

\section{Glossary}

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

\textbf{3FF}
3rd Generation Form Factor; the so-called microSIM form factor

\textbf{3GPP}
3rd Generation Partnership Project

\textbf{4FF}
4th Generation Form Factor; the so-called nanoSIM form factor

\textbf{A Interface}
Interface between BTS and BSC, traditionally over E1 (3GPP TS 48.008 \cite{3gpp-ts-48-008})

\textbf{A3/A8}
Algorithm 3 and 8; Authentication and key generation algorithm in GSM and GPRS, typically COMP128v1/v2/v3 or MILENAGE are typically used

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

\textbf{Abis Interface}
Interface between BTS and BSC, traditionally over E1 (3GPP TS 48.058 \cite{3gpp-ts-48-058} and 3GPP TS 52.021 \cite{3gpp-ts-52-021})

\textbf{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

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

\textbf{AGPL}
GNU Affero General Public License, a copyleft-style Free Software License

\textbf{AQPSK}
Adaptive QPSK, a modulation scheme used by VAMOS channels on Downlink

\textbf{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])

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

DSCP
Differentiated Services Code Point (IETF RFC 2474 [ietf-rfc2474])

DSP
Digital Signal Processor
dvnxload
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

GF DL
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

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](https://www.itu.int/itu-t/rec/q/q.921/en))

LAPDm
Link Access Protocol Mobile ([3GPP TS 44.006](https://www.3gpp.org/ftp/Specs/archive/44_series/44.006.pdf))

LLC
Logical Link Control; GPRS protocol between MS and SGSN ([3GPP TS 44.064](https://www.3gpp.org/ftp/Specs/archive/44_series/44.064.pdf))

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](https://tools.ietf.org/html/rfc4165))

M2UA
MTP2 User Adaptation; a SIGTRAN Variant ([RFC 3331](https://tools.ietf.org/html/rfc3331))

M3UA
MTP3 User Adaptation; a SIGTRAN Variant ([RFC 4666](https://tools.ietf.org/html/rfc4666))
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

MSC pool
A number of redundant MSCs serving the same core network, which a BSC / RNC distributes load across; see also the "MSC Pooling" chapter in OsmoBSC’s user manual [userman-osmobsc] and 3GPP TS 23.236 [3gpp-ts-23-236]

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 [itu-t-q701])

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

NRI
Network Resource Indicator, typically 10 bits of a TMSI indicating which MSC of an MSC pool attached the subscriber; see also the "MSC Pooling" chapter in OsmoBSC’s user manual [userman-osmobsc] and 3GPP TS 23.236 [3gpp-ts-23-236]

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 [3gpp-ts-48-016])

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

OML
Operation & Maintenance Link (ETSI/3GPP TS 52.021 [3gpp-ts-52-021])

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 MOBILE 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

PCP
Priority Code Point (IEEE 802.1Q [?])

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])

TOS
    Type Of Service; bit-field in IPv4 header, now re-used as DSCP (*IETF RFC 791* [ietf-rfc791])

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

VAMOS
Voice services over Adaptive Multi-user channels on One Slot; an optional extension for GSM specified in Release 9 of 3GPP GERAN specifications (3GPP TS 48.018 [3gpp-ts-48-018]) allowing two independent UEs to transmit and receive simultaneously on traffic channels

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

VLAN
Virtual LAN in the context of Ethernet (IEEE 802.1Q [ieee-802.1q])

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>
<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>
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<tr>
<td>TCP</td>
<td>4227</td>
<td>telnet (VTY)</td>
<td>osmo-pcap-client</td>
</tr>
<tr>
<td>TCP</td>
<td>4228</td>
<td>telnet (VTY)</td>
<td>osmo-pcap-server</td>
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<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>
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<td>TCP</td>
<td>4243</td>
<td>telnet (VTY)</td>
<td>osmo-bsc_mgcp, osmo-mgw</td>
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<tr>
<td>TCP</td>
<td>4244</td>
<td>telnet (VTY)</td>
<td>osmo-bsc_nat</td>
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<tr>
<td>TCP</td>
<td>4245</td>
<td>telnet (VTY)</td>
<td>osmo-sgsn</td>
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</table>
Table 15: (continued)

<table>
<thead>
<tr>
<th>Protocol</th>
<th>Port Number</th>
<th>Purpose</th>
<th>Software</th>
</tr>
</thead>
<tbody>
<tr>
<td>TCP</td>
<td>4246</td>
<td>telnet (VTY)</td>
<td>osmo-gbproxy</td>
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<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>
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<tr>
<td>TCP</td>
<td>4252</td>
<td>telnet (VTY)</td>
<td>osmo-gtphub</td>
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<td>TCP</td>
<td>4253</td>
<td>telnet (VTY)</td>
<td>osmo-mgc</td>
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<td>TCP</td>
<td>4254</td>
<td>telnet (VTY)</td>
<td>osmo-mgc</td>
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<tr>
<td>TCP</td>
<td>4255</td>
<td>Control Interface</td>
<td>osmo-mgc</td>
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<tr>
<td>TCP</td>
<td>4256</td>
<td>telnet (VTY)</td>
<td>osmo-sip-connector</td>
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<td>TCP</td>
<td>4257</td>
<td>Control Interface</td>
<td>osmo-ggsn, ggsn (OpenGGSN)</td>
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<td>TCP</td>
<td>4258</td>
<td>telnet (VTY)</td>
<td>osmo-hlr</td>
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<td>TCP</td>
<td>4259</td>
<td>Control Interface</td>
<td>osmo-hlr</td>
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<td>TCP</td>
<td>4260</td>
<td>telnet (VTY)</td>
<td>osmo-ggsn</td>
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<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>
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<td>TCP</td>
<td>4263</td>
<td>Control Interface</td>
<td>osmo-gbproxy</td>
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<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>
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<td>TCP</td>
<td>4266</td>
<td>D-GSM MS Lookup: mDNS serve</td>
<td>osmo-hlr</td>
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<tr>
<td>TCP</td>
<td>4267</td>
<td>Control Interface</td>
<td>osmo-mgw</td>
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<td>TCP</td>
<td>4268</td>
<td>telnet (VTY)</td>
<td>osmo-uecups</td>
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<td>4269</td>
<td>telnet (VTY)</td>
<td>osmo-uecups</td>
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<td>TCP</td>
<td>4271</td>
<td>telnet (VTY)</td>
<td>osmo-smc</td>
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<td>TCP</td>
<td>4272</td>
<td>Control Interface</td>
<td>osmo-smc</td>
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<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>23000</td>
<td>GFRS-NS over IP default port</td>
<td>osmo-pcu, osmo-sgsn, osmo-gbproxy</td>
</tr>
</tbody>
</table>

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