<table>
<thead>
<tr>
<th>NUMBER</th>
<th>DATE</th>
<th>DESCRIPTION</th>
<th>NAME</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>January 13, 2013</td>
<td>Initial version.</td>
<td>HW</td>
</tr>
<tr>
<td>2</td>
<td>February 2016</td>
<td>Conversion to asciidoc, removal of sysmoBTS specific parts.</td>
<td>HW</td>
</tr>
</tbody>
</table>
# Contents

1 Foreword ................................................................. 1
   1.1 Acknowledgements ................................................. 1
   1.2 Endorsements ..................................................... 2

2 Preface ........................................................................... 2
   2.1 FOSS lives by contribution! ....................................... 2
   2.2 Osmocom and sysmocom ............................................ 2
   2.3 Corrections ............................................................ 3
   2.4 Legal disclaimers .................................................... 3
      2.4.1 Spectrum License ............................................. 3
      2.4.2 Software License ............................................. 3
      2.4.3 Trademarks ................................................... 3
      2.4.4 Liability ....................................................... 3
      2.4.5 Documentation License ..................................... 4

3 Introduction ...................................................................... 4
   3.1 Required Skills ...................................................... 4
   3.2 Getting assistance ................................................... 4

4 Overview ......................................................................... 5
   4.1 About OsmoSGSN .................................................. 5
   4.2 Software Components ............................................. 5
      4.2.1 Gb Implementation .......................................... 5
      4.2.2 GTP Implementation ........................................ 5
      4.2.3 GMM Implementation ....................................... 5
      4.2.4 LLC Implementation ......................................... 5
      4.2.5 Session Management Implementation .................. 6
   4.3 Limitations ............................................................ 6

5 Running OsmoSGSN ....................................................... 6
   5.1 SYNOPSIS .......................................................... 6
   5.2 OPTIONS ............................................................ 6

6 Control interface .......................................................... 7
   6.1 subscriber-list-active-v1 ........................................... 7
# The Osmocom VTY Interface

7.1 Accessing the telnet VTY ........................................... 8
7.2 VTY Nodes ............................................................... 8
7.3 Interactive help ......................................................... 9
  7.3.1 The question-mark (?) command ................................. 9
  7.3.2 TAB completion ................................................... 10
  7.3.3 The list command .................................................. 11

# libosmo-core Logging System

8.1 Log categories .......................................................... 13
8.2 Log levels .............................................................. 13
8.3 Log printing options .................................................... 14
8.4 Log filters ............................................................... 14
8.5 Log targets ............................................................. 14
  8.5.1 Logging to the VTY ............................................... 14
  8.5.2 Logging to the ring buffer ...................................... 15
  8.5.3 Logging via gsmtap ............................................... 15
  8.5.4 Logging to a file ................................................ 16
  8.5.5 Logging to syslog ................................................. 17
  8.5.6 Logging to stderr ............................................... 17

# Configuring OsmoSGSN

9.1 Configuring the Gp interface ......................................... 17
  9.1.1 Static GGSN/APN configuration ................................ 18
  9.1.2 Dynamic GGSN/APN configuration ................................ 18
9.2 Authorization Policy ................................................... 18
9.3 Subscriber Configuration ............................................... 19
  9.3.1 Accessing an external HLR via GSUP ........................... 20
9.4 CDR configuration ....................................................... 20
  9.4.1 CDR CTRL interface ............................................. 20
  9.4.2 CDR Format ....................................................... 20
9.5 User traffic compression ............................................... 21
  9.5.1 Header compression .............................................. 22
  9.5.2 Data compression ................................................ 22
9.6 Encryption ............................................................. 23
9.7 Configure SCCP/M3UA to accept IuPS links ..................... 23
10 Configure SCCP/M3UA 23
  10.1 Connect to STP Instance .............................................. 24
  10.2 Local Point-Code ................................................... 24
  10.3 Remote Point-Code .................................................. 25
  10.4 Point-Code Format .................................................. 26
  10.5 AS and ASP .......................................................... 26
  10.6 Subsystem Number (SSN) ............................................. 27
  10.7 Routing Context / Routing Key ..................................... 27

11 Gb interface using libosmog 27
  11.1 Gb interface configuration ......................................... 27
       11.1.1 NS-over-UDP configuration .................................. 27
       11.1.2 NS-over-FR-GRE configuration ............................... 28
       11.1.3 NS Timer configuration ....................................... 28
  11.2 Examining Gb interface status ..................................... 28
  11.3 FIXME ............................................................... 29
       11.3.1 Blocking / Unblocking / Resetting NS Virtual Connections ........................................... 29
  11.4 Gb interface logging filters ........................................ 29

12 Osmocom Control Interface 29
  12.1 Control Interface Protocol ........................................ 30
       12.1.1 GET operation ................................................ 31
       12.1.2 SET operation ............................................... 31
       12.1.3 TRAP operation .............................................. 31
  12.2 Common variables .................................................. 32
  12.3 Control Interface python examples ................................. 32
       12.3.1 Getting rate counters ....................................... 33
       12.3.2 Setting a value .............................................. 33
       12.3.3 Getting a value .............................................. 33
       12.3.4 Listening for traps .......................................... 33

13 Osmocom Authentication Protocol (OAP) 33
  13.1 General .............................................................. 33
  13.2 Connection .......................................................... 34
  13.3 Using IPA ............................................................ 34
  13.4 Procedures .......................................................... 34
       13.4.1 Register ....................................................... 34
       13.4.2 Challenge ...................................................... 35
       13.4.3 Challenge Result ............................................. 35
       13.4.4 Sync Request ................................................ 35
### 13.5 Message Format

<table>
<thead>
<tr>
<th>Subsection</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>13.5.1 Register Request</td>
<td>35</td>
</tr>
<tr>
<td>13.5.2 Register Error</td>
<td>35</td>
</tr>
<tr>
<td>13.5.3 Register Result</td>
<td>35</td>
</tr>
<tr>
<td>13.5.4 Challenge</td>
<td>36</td>
</tr>
<tr>
<td>13.5.5 Challenge Error</td>
<td>36</td>
</tr>
<tr>
<td>13.5.6 Challenge Result</td>
<td>36</td>
</tr>
<tr>
<td>13.5.7 Sync Request</td>
<td>36</td>
</tr>
<tr>
<td>13.5.8 Sync Error</td>
<td>36</td>
</tr>
<tr>
<td>13.5.9 Sync Result</td>
<td>36</td>
</tr>
</tbody>
</table>

### 13.6 Information Elements

<table>
<thead>
<tr>
<th>Subsection</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>13.6.1 Message Type</td>
<td>37</td>
</tr>
<tr>
<td>13.6.2 IE Identifier (informational)</td>
<td>37</td>
</tr>
<tr>
<td>13.6.3 Client ID</td>
<td>37</td>
</tr>
</tbody>
</table>

### 14 Generic Subscriber Update Protocol

<table>
<thead>
<tr>
<th>Subsection</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>14.1 General</td>
<td>37</td>
</tr>
<tr>
<td>14.2 Connection</td>
<td>38</td>
</tr>
<tr>
<td>14.3 Using IPA</td>
<td>38</td>
</tr>
<tr>
<td>14.4 Procedures</td>
<td>38</td>
</tr>
<tr>
<td>14.4.1 Authentication management</td>
<td>38</td>
</tr>
<tr>
<td>14.4.2 Reporting of Authentication Failure</td>
<td>38</td>
</tr>
<tr>
<td>14.4.3 Location Updating</td>
<td>39</td>
</tr>
<tr>
<td>14.4.4 Location Cancellation</td>
<td>39</td>
</tr>
<tr>
<td>14.4.5 Purge MS</td>
<td>40</td>
</tr>
<tr>
<td>14.4.6 Delete Subscriber Data</td>
<td>40</td>
</tr>
<tr>
<td>14.4.7 Check IMEI</td>
<td>40</td>
</tr>
<tr>
<td>14.5 Procedures (E Interface)</td>
<td>40</td>
</tr>
<tr>
<td>14.5.1 E Handover</td>
<td>40</td>
</tr>
<tr>
<td>14.5.2 E Subsequent Handover</td>
<td>41</td>
</tr>
<tr>
<td>14.5.3 E Forward and Process Access Signalling</td>
<td>41</td>
</tr>
<tr>
<td>14.5.4 E Routing Error</td>
<td>42</td>
</tr>
<tr>
<td>14.6 Message Format</td>
<td>42</td>
</tr>
<tr>
<td>14.6.1 General</td>
<td>42</td>
</tr>
<tr>
<td>14.6.2 Send Authentication Info Request</td>
<td>42</td>
</tr>
<tr>
<td>14.6.3 Send Authentication Info Error</td>
<td>43</td>
</tr>
<tr>
<td>14.6.4 Send Authentication Info Response</td>
<td>43</td>
</tr>
</tbody>
</table>
14.6.44 E Process Access Signalling Request
14.6.45 E Forward Access Signalling Request
14.6.46 E Close
14.6.47 E Abort
14.6.48 E Routing Error

14.7 Information Elements
14.7.1 Message Type
14.7.2 IP Address
14.7.3 PDP Info
14.7.4 PDP Type
14.7.5 PDP Context ID
14.7.6 Auth tuple
14.7.7 RAND
14.7.8 SRES
14.7.9 Kc
14.7.10 IK
14.7.11 CK
14.7.12 AUTN
14.7.13 AUTS
14.7.14 RES
14.7.15 CN Domain
14.7.16 Cancellation Type
14.7.17 IE Identifier (informational)
14.7.18 Empty field
14.7.19 IMSI
14.7.20 ISDN-AddressString / MSISDN / Called Party BCD Number
14.7.21 Access Point Name
14.7.22 Quality of Service Subscribed Service
14.7.23 PDP-Charging Characteristics
14.7.24 HLR Number encoded as 3GPP TS 09.02 ISDN-AddressString
14.7.25 Cause
14.7.26 Supplementary Service Info
14.7.27 IMEI
14.7.28 IMEI Check Result
14.7.29 Message Class
14.7.30 Source Name
14.7.31 Destination Name
14.7.32 AN-APDU
14.7.33 RR Cause
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>14.7.34 BSSAP Cause</td>
<td>62</td>
</tr>
<tr>
<td>14.7.35 Session Management Cause</td>
<td>62</td>
</tr>
<tr>
<td>14.8 Session (transaction) management</td>
<td>62</td>
</tr>
<tr>
<td>14.8.1 Session ID</td>
<td>62</td>
</tr>
<tr>
<td>14.8.2 Session State</td>
<td>63</td>
</tr>
<tr>
<td>14.8.3 SM-RP-MR (Message Reference)</td>
<td>64</td>
</tr>
<tr>
<td>14.8.4 SM-RP-DA (Destination Address)</td>
<td>64</td>
</tr>
<tr>
<td>14.8.5 SM-RP-OA (Originating Address)</td>
<td>64</td>
</tr>
<tr>
<td>14.8.6 Coding of SM-RP-DA / SM-RP-OA IEs</td>
<td>64</td>
</tr>
<tr>
<td>14.8.7 SM-RP-UI (SM TPDU)</td>
<td>65</td>
</tr>
<tr>
<td>14.8.8 SM-RP-Cause (RP Cause value)</td>
<td>65</td>
</tr>
<tr>
<td>14.8.9 SM-RP-MMS (More Messages to Send)</td>
<td>66</td>
</tr>
<tr>
<td>14.8.10 SM Alert Reason</td>
<td>66</td>
</tr>
<tr>
<td>15 Counters</td>
<td>66</td>
</tr>
<tr>
<td>15.1 Rate Counters</td>
<td>66</td>
</tr>
<tr>
<td>16 Osmo Stat Items</td>
<td>67</td>
</tr>
<tr>
<td>17 Osmo Counters</td>
<td>68</td>
</tr>
<tr>
<td>18 Glossary</td>
<td>68</td>
</tr>
<tr>
<td>A Osmocom TCP/UDP Port Numbers</td>
<td>75</td>
</tr>
<tr>
<td>B Bibliography / References</td>
<td>76</td>
</tr>
<tr>
<td>B.0.0.1 References</td>
<td>76</td>
</tr>
<tr>
<td>C GNU Free Documentation License</td>
<td>79</td>
</tr>
<tr>
<td>C.1 PREAMBLE</td>
<td>79</td>
</tr>
<tr>
<td>C.2 APPLICABILITY AND DEFINITIONS</td>
<td>80</td>
</tr>
<tr>
<td>C.3 VERBATIM COPYING</td>
<td>80</td>
</tr>
<tr>
<td>C.4 COPYING IN QUANTITY</td>
<td>81</td>
</tr>
<tr>
<td>C.5 MODIFICATIONS</td>
<td>81</td>
</tr>
<tr>
<td>C.6 COMBINING DOCUMENTS</td>
<td>82</td>
</tr>
<tr>
<td>C.7 COLLECTIONS OF DOCUMENTS</td>
<td>83</td>
</tr>
<tr>
<td>C.8 AGGREGATION WITH INDEPENDENT WORKS</td>
<td>83</td>
</tr>
<tr>
<td>C.9 TRANSLATION</td>
<td>83</td>
</tr>
<tr>
<td>C.10 TERMINATION</td>
<td>83</td>
</tr>
<tr>
<td>C.11 FUTURE REVISIONS OF THIS LICENSE</td>
<td>83</td>
</tr>
<tr>
<td>C.12 RELICENSING</td>
<td>84</td>
</tr>
<tr>
<td>C.13 ADDENDUM: How to use this License for your documents</td>
<td>84</td>
</tr>
</tbody>
</table>
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 Osmocore umbrella project, under which OpenBSC and the OsmocomBB projects were hosted.

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

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

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

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

1.1 Acknowledgements

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

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

All trademarks, service marks, trade names, trade dress, product names and logos appearing in this manual are the property of their respective owners. All rights not expressly granted herein are reserved.

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

*Osmocom®* and *OpenBSC®* are registered trademarks of Holger Freyther and Harald Welte.

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

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

2.4.4 Liability

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

Please see Appendix C for further information.

3 Introduction

3.1 Required Skills

Please note that even while the capital expenses of running mobile networks has decreased significantly due to Osmocom software and associated hardware like sysmoBTS, GSM networks are still primarily operated by large GSM operators. Neither the GSM specification nor the GSM equipment was ever designed for networks to be installed and configured by anyone but professional GSM engineers, specialized in their respective area like radio planning, radio access network, back-haul or core network.

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

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

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

Some of the useful skills we recommend are:

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

3.2 Getting assistance

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

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

4.1 About OsmoSGSN

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

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

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

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

4.2 Software Components

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

4.2.1 Gb Implementation

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

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

4.2.2 GTP Implementation

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

4.2.3 GMM Implementation

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

4.2.4 LLC Implementation

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

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

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

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

Multiple PDP contexts can be attached by a single MS.

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

4.3 Limitations

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

Known Limitations include:

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

5 Running OsmoSGSN

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

5.1 SYNOPSIS


5.2 OPTIONS

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

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

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

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

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

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

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

The actual protocol is described in Section 12, the variables common to all programs using it are described in Section 12.2. Here we describe variables specific to OsmoSGSN.

Table 1: Variables available over control interface

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

6.1 subscriber-list-active-v1

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

7 The Osmocom VTY Interface

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

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

The interactive telnet VTY is used to

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

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

Configuration file parsing during program start is actually performed the VTY’s CONFIG node, which is also available in the telnet VTY. Apart from that, the telnet VTY features various interactive commands to query and instruct a running Osmocom program. A main difference is that during config file parsing, consistent indenting of parent vs. child nodes is required, while the interactive VTY ignores indenting and relies on the exit command to return to a parent node.
Note
In the CONFIG node, it is not well documented which commands take immediate effect without requiring a program restart. To save your current config with changes you may have made, you may use the write file command to overwrite your config file with the current configuration, after which you should be able to restart the program with all changes taking effect.

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

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

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

7.1 Accessing the telnet VTY

The VTY of a given Osmocom program is implemented as a telnet server, listening to a specific TCP port. Please see Appendix A to check for the default TCP port number of the VTY interface of the specific Osmocom software you would like to connect to.

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

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

7.2 VTY Nodes

The VTY by default has the following minimal nodes:

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

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

7.3 Interactive help

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

Note

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

7.3.1 The question-mark (?) command

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

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

Example: Typing ? at start of OsmoMSC prompt

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

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

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

Example: Typing ? after a partial command

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

Copyright © 2013-2016 sysmocom - s.f.m.c. GmbH
<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>cs7</td>
<td>ITU-T Signaling System 7</td>
</tr>
<tr>
<td>logging</td>
<td>Show current logging configuration</td>
</tr>
<tr>
<td>alarms</td>
<td>Show current logging configuration</td>
</tr>
<tr>
<td>talloc-context</td>
<td>Show talloc memory hierarchy</td>
</tr>
<tr>
<td>stats</td>
<td>Show statistical values</td>
</tr>
<tr>
<td>asciidoc</td>
<td>Asciidoc generation</td>
</tr>
<tr>
<td>rate-counters</td>
<td>Show all rate counters</td>
</tr>
<tr>
<td>fsm</td>
<td>Show information about finite state machines</td>
</tr>
<tr>
<td>fsm-instances</td>
<td>Show information about finite state machine instances</td>
</tr>
<tr>
<td>sgs-connections</td>
<td>Show SGs interface connections / MMEs</td>
</tr>
<tr>
<td>subscriber</td>
<td>Operations on a Subscriber</td>
</tr>
<tr>
<td>bsc</td>
<td>BSC</td>
</tr>
<tr>
<td>connection</td>
<td>Subscriber Connections</td>
</tr>
<tr>
<td>transaction</td>
<td>Transactions</td>
</tr>
<tr>
<td>statistics</td>
<td>Display network statistics</td>
</tr>
<tr>
<td>sms-queue</td>
<td>Display SMSqueue statistics</td>
</tr>
<tr>
<td>smpp</td>
<td>SMPP Interface</td>
</tr>
</tbody>
</table>

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

You may pick the `bsc` object and type `?` again:

**Example: Typing `?` after show bsc**

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

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

### 7.3.2 TAB completion

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

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

```
OsmoMSC> s
show         sms         subscriber
```

⚠️ Type `<tab>` here.

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

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

```
OsmoMSC> show
version       online-help history cs7 logging alarms
```

⚠️ Type `<tab>` here.
7.3.3 The list command

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

Example: Typing list at start of OsmoMSC VIEW node prompt

```
OsmoMSC> list
show version
show online-help
list
exit
help
enable
terminal length <0-512>
terminal no length
who
show history
show cs7 instance <0-15> users
show cs7 (sua|m3ua|ipa) |<0-65534>|
show cs7 instance <0-15> asp
show cs7 instance <0-15> as (active|all|m3ua|sua)
show cs7 instance <0-15> scgp addressbook
show cs7 instance <0-15> scgp users
show cs7 instance <0-15> scgp snn <0-65535>
show cs7 instance <0-15> scgp connections
show cs7 instance <0-15> scgp timers
logging enable
logging disable
logging filter all (0|1)
logging color (0|1)
logging timestamp (0|1)
logging print extended-timestamp (0|1)
logging print category (0|1)
logging print category-hex (0|1)
logging print level (0|1)
logging print file (0|1|basename) [last]
logging set-log-mask MASK
logging level (rll|cc|mm|rr|mmcc|pag|m3ua|mgs|mcp|ho|db|ref|ctrl|smpp|ranap|vlr|iucs|bssap|sgs|lglobal|llap|lln|lmux|lmi|lmb|lsms|lctr1|lgtp|lstats|lgap|löap|lss7|lsccp|lsua|l3ua|m3gp|m3ua|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|sdcch)
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
```

8 libosmocore Logging System

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

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

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

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

### 8.1 Log categories

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

### 8.2 Log levels

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

- **fatal**
  
  Fatal messages, causing abort and/or re-start of a process. This \textit{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 \texttt{info}, then this really means that all events with a level of at least \texttt{info} will be logged, i.e. including events of \texttt{notice}, \texttt{error} and \texttt{fatal}.

So for example, in OsmoBSC, to set the log level of the Mobility Management category to info, you can use the following command: \texttt{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: \texttt{log level set-all notice}

Afterwards you can adjust specific categories as usual.

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

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

log color 1
With this option each log message will log with the color of its category. The color is hard-coded and cannot be changed. As with other options a 0 disables this functionality.

log timestamp 1
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.

8.4 Log filters

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

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

8.5 Log targets

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

8.5.1 Logging to the VTY

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

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

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

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

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

---

**Tip**

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

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

### 8.5.2 Logging to the ring buffer

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

It’s configured as follows:

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

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

### 8.5.3 Logging via gsmtap

When debugging complex issues it’s handy to be able to reconstruct exact chain of events. This is enabled by using GSMTAP log output where frames sent/received over the air are interspersed 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

8.5.4 Logging to a file

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

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

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

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

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

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

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

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

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

## 8.5.6 Logging to stderr

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

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

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

## 9 Configuring OsmoSGSN

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

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

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

### 9.1 Configuring the Gp interface

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

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

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

2. dynamic GGSN/APN configuration

### 9.1.1 Static GGSN/APN configuration

In this mode, there is a static list of GGSNs and APNs configured in OsmoSGSN via the VTY / config file. This is a non-standard method outside of the 3GPP specifications for the SGSN, and is typically only used in private/small GPRS networks without any access to a GRX.

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

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

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

### 9.1.2 Dynamic GGSN/APN configuration

In this mode, the SGSN will use a DNS-based method to perform the lookup from the APN (as specified by the MS) towards the GGSN IP address. This is the official method as per the 3GPP specifications for the SGSN, and what is used on GRX.

**Example: Dynamic GGSN/APN configuration**

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

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

### 9.2 Authorization Policy

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

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

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

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

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

Example: Assign or change authorization policy

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

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

Example: Access control list

```bash
sgsn
  auth-policy acl-only
  imsi-acl add 001010000000003
  imsi-acl add 001010000000002
  imsi-acl add 001010000000001
  imsi-acl add 90170000000068
```

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

9.3 Subscriber Configuration

As opposed to OsmoNITB, OsmoSGSN does not feature a built-in HLR.

It can thus operate only in the following two modes:

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

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

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

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

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

Example: Using an external HLR via GSUP

```plaintext
OsmoSGSN(config-sgsn)# gsup remote-ip 2.3.4.5
OsmoSGSN(config-sgsn)# gsup remote-port 10000
OsmoSGSN(config-sgsn)# gsup oap-k 000102030405060708090a0b0c0d0e0f
OsmoSGSN(config-sgsn)# gsup oap-opc 101112131415161718191a1b1c1d1e1f
```

1. Configure the IP address of the (remote) HLR or HLR-GW
2. Configure the TCP port of the (remote) HLR or HLR-GW
3. Specify the OAP shared key
4. Specify the OAP shared OPC

9.4 CDR configuration

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

Example: CDR log file configuration

```plaintext
OsmoSGSN(config-sgsn)# cdr filename /var/log/osmosgsn.cdr
OsmoSGSN(config-sgsn)# cdr interval 600
```

1. Periodically log existing PDP contexts every 600 seconds (10 min)

The CDR file is a simple CSV file including a header line naming the individual fields of each CSV line.

9.4.1 CDR CTRL interface

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

Example: CDR delivery through CTRL TRAP messages

```plaintext
OsmoSGSN(config-sgsn)# cdr trap
```

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

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

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

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

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

Table 5: Description of OsmoSGSN CDR Events

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

9.5 User traffic compression

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

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

```
compression rfc1144 passive
```

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

```
compression rfc1144 active slots <1-256>
```

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

**Example: Accept compression if requested**

```
sgsn
  compression rfc1144 passive
```

**Example: Actively promote compression**

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

**Example: Turn off compression**

```
sgsn
  no compression rfc1144
```

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

9.5.2 Data compression

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

```
compression v42bis passive
```

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

```
compression v42bis active direction (ms|sgsn|both) codewords <512-65535> strlen <6-250>
```

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

**Example: Accept compression if requested**

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

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

Example: Turn off compression

```sh
sgsn
no compression v42bis
```

## 9.6 Encryption

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

### Example: Turn on encryption (GEA3)

```sh
sgsn
encryption GEA3
```

### Example: Turn off encryption (GEA0)

```sh
sgsn
encryption GEA0
```

## 9.7 Configure SCCP/M3UA to accept IuPS links

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

An example configuration of OsmoSGSN’s SCCP link:

```sh
cs7 instance 0
point-code 0.23.4
asp asp-clnt-OsmoSGSN 2905 0 m3ua
remote-ip 127.0.0.1
sctp-role client
as as-clnt-OsmoSGSN m3ua
asp asp-clnt-OsmoSGSN
routing-key 0 0.23.4
```

This configuration is explained in detail in Section 10.

## 10 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.

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

### 10.1 Connect to STP Instance

By default, an STP instance is assumed to listen on the default M3UA port (2905) on the local host (127.0.0.1).

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

```
cs7 instance 0
  asp my-asp 2905 0 m3ua
  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 10.5.

### 10.2 Local Point-Code

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

```
point-code 7.65.4
```
If an explicit routing context is configured, this point-code is repeated in the `routing-key` configuration:

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

See also Section 10.4.

### 10.3 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:

```
cs7 instance 0
  sccp-address remote-pc-example
    point-code 1.23.1
```

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:

  ```
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:

  ```
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.
10.4 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.

```
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:

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

It is also possible to use a dash as delimiter.

```
cs7 instance 0
  point-code delimiter dash
  point-code 0-23-1
```

10.5 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:

```
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-asp
```

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:

```
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:

```
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
```
10.6 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.

10.7 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
```

11 Gb interface using libosmogb

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

This section describes the configuration that libosmogb exposes via the VTY.

11.1 Gb interface configuration

11.1.1 NS-over-UDP configuration

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

Example: GPRS NS-over-UDP configuration

```
OsmoSGSN(config-ns)# encapsulation udp local-ip 127.0.0.1 ⏳
OsmoSGSN(config-ns)# encapsulation udp local-port 23000 ⏳
```
The example above configures a libosmogb based application to listen for incoming connections from PCUs on the specified address and port.

- Set the local side IP address for NS-over-UDP
- Set the local side UDP port number for NS-over-UDP. 23000 is the default

11.1.2 NS-over-FR-GRE configuration

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

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

Example: GPRS NS-over-FR-GRE configuration

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

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

11.1.3 NS Timer configuration

The NS protocol features a number of configurable timers.

<table>
<thead>
<tr>
<th>Table 6: List of configurable NS timers</th>
</tr>
</thead>
<tbody>
<tr>
<td>tns-block</td>
</tr>
<tr>
<td>tns-block-retries</td>
</tr>
<tr>
<td>tns-reset</td>
</tr>
<tr>
<td>tns-reset-retries</td>
</tr>
<tr>
<td>tns-test</td>
</tr>
<tr>
<td>tns-alive</td>
</tr>
<tr>
<td>tns-alive-retries</td>
</tr>
</tbody>
</table>

11.2 Examining Gb interface status

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

Example: Inspecting NS state

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

Example: Inspecting NS statistics

```bash
OsmoSGSN> show ns stats
Encapsulation NS-UDP-IP   Local IP: 10.9.1.198, UDP Port: 23000
Encapsulation NS-FR-GRE-IP Local IP: 0.0.0.0
NSEI 101, NS-VC 101, Remote: BSS, ALIVE UNBLOCKED, UDP 10.9.1.119:23000
NSVC Peer Statistics:
```
### Example: Inspecting BSSGP state

```bash
OsmoSGSN> show bssgp

NSEI 101, BVCI 2, RA-ID: 1-2-1-0, CID: 0, STATE: UNBLOCKED
NSEI 101, BVCI 0, RA-ID: 0-0-0-0, CID: 0, STATE: UNBLOCKED
```

### 11.3 FIXME

#### 11.3.1 Blocking / Unblocking / Resetting NS Virtual Connections

The user can manually perform operations on individual NSVCs:

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

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

### 11.4 Gb interface logging filters

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

**Example: enabling a log filter for a given NSEI**

```bash
OsmoSGSN> logging filter nsvc nsei 23
```

**Example: enabling a log filter for a given NSVCI**

```bash
OsmoSGSN> logging filter nsvc nsvci 23
```

### 12 Osmocom Control Interface

The VTY interface as described in Section 7 is aimed at human interaction with the respective Osmocom program. Other programs **should not** use the VTY interface to interact with the Osmocom software, as parsing the textual representation is cumbersome, inefficient, and will break every time the formatting is changed by the Osmocom developers.

Instead, the **Control Interface** was introduced as a programmatic interface that can be used to interact with the respective program.
12.1 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).

![Figure 3: IPA header for control protocol](image)

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

![Figure 4: IPA extension header for control protocol](image)

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.
12.1.1 GET operation

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

![Figure 5: Control Interface GET operation (successful outcome)](image1)

![Figure 6: Control Interface GET operation (unsuccessful outcome)](image2)

12.1.2 SET operation

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

![Figure 7: Control Interface SET operation (successful outcome)](image3)

![Figure 8: Control Interface SET operation (unsuccessful outcome)](image4)

12.1.3 TRAP operation

The program can at any time issue a trap. The term is used in the spirit of SNMP.
12.2 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.

12.3 Control Interface python examples

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

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

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

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

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

$ ./scripts/osmo_rate_ctr2csv.py --header
Connecting to localhost:4249...
Getting rate counter groups info...
"group","counter","absolute","second","minute","hour","day"
"eel1.0","hdlc:abort","0","0","0","0","0"
"eel1.0","hdlc:bad_fcs","0","0","0","0","0"
"eel1.0","hdlc:overrun","0","0","0","0","0"
"eel1.0","alarm","0","0","0","0","0"
"eel1.0","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.

12.3.2 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

12.3.3 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

12.3.4 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

13 Osmocom Authentication Protocol (OAP)

13.1 General

The Osmocom Authentication Protocol employs mutual authentication to register a client with a server over an IPA connection. Milenage is used as the authentication algorithm, where client and server have a shared secret.

For example, an SGSN, as OAP client, may use its SGSN ID to register with a MAP proxy, an OAP server.
13.2 Connection

The protocol expects that a reliable, ordered, packet boundaries preserving connection is used (e.g. IPA over TCP).

13.3 Using IPA

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

13.4 Procedures

![Diagram](image1)

Figure 10: Ideal communication sequence

![Diagram](image2)

Figure 11: Variation “test setup”

![Diagram](image3)

Figure 12: Variation “invalid sequence nr”:

13.4.1 Register

The client sends a REGISTER_REQ message containing an identifier number.
13.4.2 Challenge

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

13.4.3 Challenge Result

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

13.4.4 Sync Request

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

13.4.5 Sync Result

If the server has received a valid Sync Request, it shall answer by directly sending another Challenge (see Section 13.4.2). If an invalid Sync Request is received, the server shall reply with a REGISTER_ERR message.

13.4.6 Register Result

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

13.5 Message Format

Every message is based on the following message format

<table>
<thead>
<tr>
<th>IEI</th>
<th>IE</th>
<th>Type</th>
<th>Presence</th>
<th>Format</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Message Type</td>
<td>Section 13.6.1</td>
<td>M</td>
<td>V</td>
<td>1</td>
</tr>
</tbody>
</table>

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

13.5.1 Register Request

Direction: Client → Server

<table>
<thead>
<tr>
<th>IEI</th>
<th>IE</th>
<th>Type</th>
<th>Presence</th>
<th>Format</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Message Type</td>
<td>Section 13.6.1</td>
<td>M</td>
<td>V</td>
<td>1</td>
</tr>
<tr>
<td>30</td>
<td>Client ID</td>
<td>Section 13.6.3</td>
<td>M</td>
<td>TLV</td>
<td>4</td>
</tr>
</tbody>
</table>

13.5.2 Register Error

Direction: Server → Client
### 13.5.3 Register Result

Direction: Server → Client

<table>
<thead>
<tr>
<th>IEI</th>
<th>IE</th>
<th>Type</th>
<th>Presence</th>
<th>Format</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>02</td>
<td></td>
<td>Message Type</td>
<td>Section 13.6.1</td>
<td>M</td>
<td>V</td>
</tr>
<tr>
<td>02</td>
<td></td>
<td>Cause</td>
<td>GMM Cause, TS 04.08: 10.5.5.14</td>
<td>M</td>
<td>TLV</td>
</tr>
</tbody>
</table>

### 13.5.4 Challenge

Direction: Server → Client

<table>
<thead>
<tr>
<th>IEI</th>
<th>IE</th>
<th>Type</th>
<th>Presence</th>
<th>Format</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td></td>
<td>Message Type</td>
<td>Section 13.6.1</td>
<td>M</td>
<td>V</td>
</tr>
<tr>
<td>20</td>
<td></td>
<td>RAND</td>
<td>octet string (16)</td>
<td>TLV</td>
<td>18</td>
</tr>
</tbody>
</table>

### 13.5.5 Challenge Error

Direction: Client → Server

<table>
<thead>
<tr>
<th>IEI</th>
<th>IE</th>
<th>Type</th>
<th>Presence</th>
<th>Format</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>02</td>
<td></td>
<td>Message Type</td>
<td>Section 13.6.1</td>
<td>M</td>
<td>V</td>
</tr>
</tbody>
</table>

### 13.5.6 Challenge Result

Direction: Client → Server

<table>
<thead>
<tr>
<th>IEI</th>
<th>IE</th>
<th>Type</th>
<th>Presence</th>
<th>Format</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>02</td>
<td></td>
<td>Message Type</td>
<td>Section 13.6.1</td>
<td>M</td>
<td>V</td>
</tr>
</tbody>
</table>

### 13.5.7 Sync Request

Direction: Client → Server

<table>
<thead>
<tr>
<th>IEI</th>
<th>IE</th>
<th>Type</th>
<th>Presence</th>
<th>Format</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>02</td>
<td></td>
<td>Message Type</td>
<td>Section 13.6.1</td>
<td>M</td>
<td>V</td>
</tr>
</tbody>
</table>

### 13.5.8 Sync Error

Not used.

### 13.5.9 Sync Result

Not used.
13.6 Information Elements

13.6.1 Message Type

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

13.6.2 IE Identifier (informational)

These are the standard values for the IEI.

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

13.6.3 Client ID

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

14 Generic Subscriber Update Protocol

14.1 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.

14.2 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.

14.3 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.

14.4 Procedures

14.4.1 Authentication management

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

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

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

14.4.2 Reporting of Authentication Failure

Using this procedure, the SGSN or VLR reports authentication failures to the HLR.
14.4.3 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)

14.4.4 Location Cancellation

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

Copyright © 2013-2016 sysmocom - s.f.m.c. GmbH
14.4.5 Purge MS

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

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

14.4.6 Delete Subscriber Data

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

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

14.4.7 Check IMEI

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

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

14.5 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.

14.5.1 E Handover

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

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

14.5.3 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.
14.5.4 E Routing Error

The GSUP server can not route any of the requests above, and responds with an E Routing Error. Possible reasons for not being able to route the message are missing routing IEs, a mismatching source name IE (Section 14.7.30), 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.

14.6 Message Format

14.6.1 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 14.7.19</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 received them in any order. Unknown IE shall be ignored.

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

14.6.2 Send Authentication Info Request

Direction: SGSN / VLR ⇒ HLR

<table>
<thead>
<tr>
<th>IEI</th>
<th>IE</th>
<th>Type</th>
<th>Presence</th>
<th>Format</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>IMSI</td>
<td>Section 14.7.19</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
<tr>
<td>28</td>
<td>CN Domain</td>
<td>Section 14.7.15</td>
<td>O</td>
<td>TLV</td>
<td>3</td>
</tr>
<tr>
<td>26</td>
<td>AUTS</td>
<td>Section 14.7.13</td>
<td>C</td>
<td>TLV</td>
<td>18</td>
</tr>
<tr>
<td>20</td>
<td>RAND</td>
<td>Section 14.7.7</td>
<td>C</td>
<td>TLV</td>
<td>18</td>
</tr>
</tbody>
</table>
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.

14.6.3  **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>Message Type</td>
<td>Section 14.7.1</td>
<td>M</td>
<td>V</td>
<td>1</td>
</tr>
<tr>
<td>02</td>
<td>IMSI</td>
<td>Section 14.7.19</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
</tbody>
</table>

14.6.4  **Send Authentication Info Response**

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 14.7.1</td>
<td>M</td>
<td>V</td>
<td>1</td>
</tr>
<tr>
<td>03</td>
<td>IMSI</td>
<td>Section 14.7.19</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
<tr>
<td>03</td>
<td>Auth Tuple</td>
<td>Section 14.7.6</td>
<td></td>
<td>TLV</td>
<td>36</td>
</tr>
</tbody>
</table>

14.6.5  **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>Message Type</td>
<td>Section 14.7.1</td>
<td>M</td>
<td>V</td>
<td>1</td>
</tr>
<tr>
<td>28</td>
<td>IMSI</td>
<td>Section 14.7.19</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
<tr>
<td>28</td>
<td>CN Domain</td>
<td>Section 14.7.15</td>
<td>O</td>
<td>TLV</td>
<td>3</td>
</tr>
</tbody>
</table>

14.6.6  **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>Message Type</td>
<td>Section 14.7.1</td>
<td>M</td>
<td>V</td>
<td>1</td>
</tr>
<tr>
<td>28</td>
<td>IMSI</td>
<td>Section 14.7.19</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
<tr>
<td>28</td>
<td>CN Domain</td>
<td>Section 14.7.15</td>
<td>O</td>
<td>TLV</td>
<td>3</td>
</tr>
</tbody>
</table>

14.6.7  **Update Location 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>Message Type</td>
<td>Section 14.7.1</td>
<td>M</td>
<td>V</td>
<td>1</td>
</tr>
<tr>
<td>02</td>
<td>IMSI</td>
<td>Section 14.7.19</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
<tr>
<td>02</td>
<td>Cause</td>
<td>Section 14.7.25</td>
<td>M</td>
<td>TLV</td>
<td>3</td>
</tr>
</tbody>
</table>

14.6.8  **Update Location 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>01</td>
<td>IMSI</td>
<td>Section 14.7.19</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
<tr>
<td>08</td>
<td>MSISDN</td>
<td>Section 14.7.20</td>
<td>O</td>
<td>TLV</td>
<td>0-9</td>
</tr>
<tr>
<td>09</td>
<td>HLR Number</td>
<td>Section 14.7.24</td>
<td>O</td>
<td>TLV</td>
<td>0-9</td>
</tr>
<tr>
<td>04</td>
<td>PDP info complete</td>
<td>Section 14.7.18</td>
<td>O</td>
<td>TLV</td>
<td>2</td>
</tr>
<tr>
<td>05</td>
<td>PDP info</td>
<td>Section 14.7.3</td>
<td>O</td>
<td>TLV</td>
<td>1-10</td>
</tr>
</tbody>
</table>

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

### 14.6.9 Location Cancellation Request

**Direction:** HLR ⇝ SGSN / VLR

<table>
<thead>
<tr>
<th>IEI</th>
<th>IE</th>
<th>Type</th>
<th>Presence</th>
<th>Format</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>IMSI</td>
<td>Section 14.7.19</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
<tr>
<td>28</td>
<td>CN Domain</td>
<td>Section 14.7.15</td>
<td>O</td>
<td>TLV</td>
<td>3</td>
</tr>
<tr>
<td>06</td>
<td>Cancellation type</td>
<td>Section 14.7.16</td>
<td>O</td>
<td>TLV</td>
<td>3</td>
</tr>
</tbody>
</table>

### 14.6.10 Location Cancellation Result

**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 14.7.19</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
<tr>
<td>28</td>
<td>CN Domain</td>
<td>Section 14.7.15</td>
<td>O</td>
<td>TLV</td>
<td>3</td>
</tr>
</tbody>
</table>

### 14.6.11 Purge MS Request

**Direction:** SGSN / VLR ⇝ HLR

<table>
<thead>
<tr>
<th>IEI</th>
<th>IE</th>
<th>Type</th>
<th>Presence</th>
<th>Format</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>IMSI</td>
<td>Section 14.7.19</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
<tr>
<td>28</td>
<td>CN Domain</td>
<td>Section 14.7.15</td>
<td>O</td>
<td>TLV</td>
<td>3</td>
</tr>
</tbody>
</table>

### 14.6.12 Purge MS Error

**Direction:** HLR ⇝ SGSN / VLR

<table>
<thead>
<tr>
<th>IEI</th>
<th>IE</th>
<th>Type</th>
<th>Presence</th>
<th>Format</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>IMSI</td>
<td>Section 14.7.19</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
<tr>
<td>02</td>
<td>Cause</td>
<td>Section 14.7.25</td>
<td>M</td>
<td>TLV</td>
<td>3</td>
</tr>
</tbody>
</table>

### 14.6.13 Purge MS Result

**Direction:** HLR ⇝ SGSN / VLR
### 14.6.14 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>IMSI</td>
<td>Section 14.7.19</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
<tr>
<td>07</td>
<td>Freeze P-TMSI</td>
<td>Section 14.7.18</td>
<td>M</td>
<td>TLV</td>
<td>2</td>
</tr>
</tbody>
</table>

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

### 14.6.15 Insert Subscriber Data Error

**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 14.7.19</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
<tr>
<td>02</td>
<td>Cause</td>
<td>Section 14.7.25</td>
<td>M</td>
<td>TLV</td>
<td>3</td>
</tr>
</tbody>
</table>

### 14.6.16 Insert Subscriber Data Result

**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 14.7.19</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
</tbody>
</table>

### 14.6.17 Delete 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>IMSI</td>
<td>Section 14.7.19</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
<tr>
<td>28</td>
<td>CN Domain</td>
<td>Section 14.7.15</td>
<td>O</td>
<td>TLV</td>
<td>3</td>
</tr>
<tr>
<td>08</td>
<td>MSISDN</td>
<td>Section 14.7.20</td>
<td>O</td>
<td>TLV</td>
<td>0-9</td>
</tr>
<tr>
<td>09</td>
<td>HLR Number</td>
<td>Section 14.7.24</td>
<td>O</td>
<td>TLV</td>
<td>0-9</td>
</tr>
<tr>
<td>04</td>
<td>PDP info complete</td>
<td>Section 14.7.18</td>
<td>M</td>
<td>TLV</td>
<td>2</td>
</tr>
<tr>
<td>05</td>
<td>PDP info</td>
<td>Section 14.7.23</td>
<td>C</td>
<td>TLV</td>
<td>0-10</td>
</tr>
</tbody>
</table>

### 14.6.18 Delete Subscriber Data Error

**Direction:** SGSN / VLR ⇒ HLR
### 14.6.19 Delete Subscriber Data 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>01</td>
<td>IMSI</td>
<td>Section 14.7.19</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
</tbody>
</table>

### 14.6.20 Process Supplementary Service Request

**Direction:** bidirectional

<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 14.7.19</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
<tr>
<td>30</td>
<td>Session ID</td>
<td>Section 14.8.1</td>
<td>M</td>
<td>TLV</td>
<td>6</td>
</tr>
<tr>
<td>31</td>
<td>Session State</td>
<td>Section 14.8.2</td>
<td>M</td>
<td>TLV</td>
<td>3</td>
</tr>
<tr>
<td>35</td>
<td>Supplementary Service Info</td>
<td>Section 14.7.26</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.

### 14.6.21 Process Supplementary Service Error

**Direction:** EUSE / HLR ⇒ MSC

<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 14.7.19</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
<tr>
<td>30</td>
<td>Session ID</td>
<td>Section 14.8.1</td>
<td>M</td>
<td>TLV</td>
<td>6</td>
</tr>
<tr>
<td>31</td>
<td>Session State</td>
<td>Section 14.8.2</td>
<td>M</td>
<td>TLV</td>
<td>3</td>
</tr>
<tr>
<td>02</td>
<td>Cause</td>
<td>Section 14.7.25</td>
<td>M</td>
<td>TLV</td>
<td>3</td>
</tr>
</tbody>
</table>

### 14.6.22 Process Supplementary Service Response

**Direction:** EUSE / HLR ⇒ MSC

<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 14.7.19</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
<tr>
<td>30</td>
<td>Session ID</td>
<td>Section 14.8.1</td>
<td>M</td>
<td>TLV</td>
<td>6</td>
</tr>
<tr>
<td>31</td>
<td>Session State</td>
<td>Section 14.8.2</td>
<td>M</td>
<td>TLV</td>
<td>3</td>
</tr>
<tr>
<td>35</td>
<td>Supplementary Service Info</td>
<td>Section 14.7.26</td>
<td>O</td>
<td>TLV</td>
<td>2-…</td>
</tr>
</tbody>
</table>

The purpose of this message is not clear yet. Probably, it can be used to notify the MSC that a structured supplementary service is successfully activated or deactivated, etc.
14.6.23 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 14.7.1</td>
<td>M</td>
<td>V</td>
</tr>
<tr>
<td>40</td>
<td>SM-RP-MR (Message Reference)</td>
<td>Section 14.8.3</td>
<td>M</td>
<td>TLV</td>
<td>1</td>
</tr>
<tr>
<td>41</td>
<td>SM-RP-DA (Destination Address)</td>
<td>Section 14.8.4</td>
<td>M</td>
<td>TLV</td>
<td>2-…</td>
</tr>
<tr>
<td>42</td>
<td>SM-RP-OA (Originating Address)</td>
<td>Section 14.8.5</td>
<td>M</td>
<td>TLV</td>
<td>2-…</td>
</tr>
<tr>
<td>43</td>
<td>SM-RP-UI (SM TPDU)</td>
<td>Section 14.8.7</td>
<td>M</td>
<td>TLV</td>
<td>1-…</td>
</tr>
</tbody>
</table>

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

14.6.24 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 14.7.1</td>
<td>M</td>
<td>V</td>
</tr>
<tr>
<td>40</td>
<td>SM-RP-MR (Message Reference)</td>
<td>Section 14.8.3</td>
<td>M</td>
<td>TLV</td>
<td>1</td>
</tr>
<tr>
<td>44</td>
<td>SM-RP-Cause (Cause value)</td>
<td>Section 14.8.8</td>
<td>M</td>
<td>TLV</td>
<td>1</td>
</tr>
<tr>
<td>43</td>
<td>SM-RP-UI (diagnostic field)</td>
<td>Section 14.8.7</td>
<td>O</td>
<td>TLV</td>
<td>1-…</td>
</tr>
</tbody>
</table>

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

14.6.25 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 14.7.1</td>
<td>M</td>
<td>V</td>
</tr>
<tr>
<td>40</td>
<td>SM-RP-MR (Message Reference)</td>
<td>Section 14.8.3</td>
<td>M</td>
<td>TLV</td>
<td>1</td>
</tr>
</tbody>
</table>

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

14.6.26 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 14.7.1</td>
<td>M</td>
<td>V</td>
</tr>
<tr>
<td>40</td>
<td>SM-RP-MR (Message Reference)</td>
<td>Section 14.8.3</td>
<td>M</td>
<td>TLV</td>
<td>1</td>
</tr>
<tr>
<td>41</td>
<td>SM-RP-DA (Destination Address)</td>
<td>Section 14.8.4</td>
<td>M</td>
<td>TLV</td>
<td>2-…</td>
</tr>
<tr>
<td>42</td>
<td>SM-RP-OA (Originating Address)</td>
<td>Section 14.8.5</td>
<td>M</td>
<td>TLV</td>
<td>2-…</td>
</tr>
<tr>
<td>43</td>
<td>SM-RP-UI (SM TPDU)</td>
<td>Section 14.8.7</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 14.8.9</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.

### 14.6.27 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>M</td>
<td>V</td>
<td>1</td>
</tr>
<tr>
<td>40</td>
<td>SM-RP-MR (Message Reference)</td>
<td>Section 14.7.1</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 14.8.3</td>
<td>M</td>
<td>TLV</td>
<td>1</td>
</tr>
<tr>
<td>43</td>
<td>SM-RP-UI (diagnostic field)</td>
<td>Section 14.8.7</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.

### 14.6.28 MT-forwardSM Result

**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>M</td>
<td>V</td>
<td>1</td>
</tr>
<tr>
<td>40</td>
<td>SM-RP-MR (Message Reference)</td>
<td>Section 14.7.1</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.

### 14.6.29 READY-FOR-SM 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>M</td>
<td>V</td>
<td>1</td>
</tr>
<tr>
<td>40</td>
<td>SM-RP-MR (Message Reference)</td>
<td>Section 14.7.1</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
<tr>
<td>46</td>
<td>SM Alert Reason</td>
<td>Section 14.8.10</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.

### 14.6.30 READY-FOR-SM 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>M</td>
<td>V</td>
<td>1</td>
</tr>
<tr>
<td>40</td>
<td>SM-RP-MR (Message Reference)</td>
<td>Section 14.7.1</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 14.8.3</td>
<td>M</td>
<td>TLV</td>
<td>1</td>
</tr>
<tr>
<td>43</td>
<td>SM-RP-UI (diagnostic field)</td>
<td>Section 14.8.7</td>
<td>O</td>
<td>TLV</td>
<td>1-...</td>
</tr>
</tbody>
</table>
This message is used to indicate a negative result of an earlier MO SMMA (Memory Available) indication. The corresponding MAP service is MAP-READY-FOR-SM, see 3GPP TS 29.002, section 12.4.

### 14.6.31 READY-FOR-SM 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>Message Type</td>
<td>Section 14.7.1</td>
<td>M</td>
<td>V</td>
<td>1</td>
</tr>
<tr>
<td>40</td>
<td>SM-RP-MR (Message Reference)</td>
<td>Section 14.8.3</td>
<td>M</td>
<td>TLV</td>
<td>1</td>
</tr>
</tbody>
</table>

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

### 14.6.32 CHECK-IMEI Request

**Direction**: VLR ⇒ EIR (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 14.7.19</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
<tr>
<td>50</td>
<td>IMEI</td>
<td>Section 14.7.27</td>
<td>M</td>
<td>TLV</td>
<td>11</td>
</tr>
</tbody>
</table>

### 14.6.33 CHECK-IMEI Error

**Direction**: EIR (via HLR) ⇒ 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 14.7.19</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
<tr>
<td>02</td>
<td>Cause</td>
<td>Section 14.7.25</td>
<td>M</td>
<td>TLV</td>
<td>3</td>
</tr>
</tbody>
</table>

### 14.6.34 CHECK-IMEI Result

**Direction**: EIR (via HLR) ⇒ 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 14.7.19</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
<tr>
<td>51</td>
<td>IMEI Check Result</td>
<td>Section 14.7.28</td>
<td>M</td>
<td>TLV</td>
<td>3</td>
</tr>
</tbody>
</table>

### 14.6.35 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 14.7.19</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
<tr>
<td>0a</td>
<td>Message Class</td>
<td>Section 14.7.29</td>
<td>M</td>
<td>TLV</td>
<td>3</td>
</tr>
<tr>
<td>60</td>
<td>Source Name</td>
<td>Section 14.7.30</td>
<td>M</td>
<td>TLV</td>
<td>2-...</td>
</tr>
<tr>
<td>61</td>
<td>Destination Name</td>
<td>Section 14.7.31</td>
<td>M</td>
<td>TLV</td>
<td>2-...</td>
</tr>
</tbody>
</table>
### 14.6.36 E Prepare Handover Error

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

<table>
<thead>
<tr>
<th>IEI</th>
<th>IE</th>
<th>Type</th>
<th>Presence</th>
<th>Format</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>62</td>
<td>AN-APDU</td>
<td>Section 14.7.32</td>
<td>M</td>
<td>TLV</td>
<td>2-...</td>
</tr>
</tbody>
</table>

### 14.6.37 E Prepare Handover Result

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

<table>
<thead>
<tr>
<th>IEI</th>
<th>IE</th>
<th>Type</th>
<th>Presence</th>
<th>Format</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>62</td>
<td>AN-APDU</td>
<td>Section 14.7.32</td>
<td>M</td>
<td>TLV</td>
<td>2-...</td>
</tr>
</tbody>
</table>

### 14.6.38 E Prepare Subsequent Handover Request

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

<table>
<thead>
<tr>
<th>IEI</th>
<th>IE</th>
<th>Type</th>
<th>Presence</th>
<th>Format</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>62</td>
<td>AN-APDU</td>
<td>Section 14.7.32</td>
<td>M</td>
<td>TLV</td>
<td>2-...</td>
</tr>
</tbody>
</table>

### 14.6.39 E Prepare Subsequent Handover Error

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

<table>
<thead>
<tr>
<th>IEI</th>
<th>IE</th>
<th>Type</th>
<th>Presence</th>
<th>Format</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>62</td>
<td>AN-APDU</td>
<td>Section 14.7.32</td>
<td>M</td>
<td>TLV</td>
<td>2-...</td>
</tr>
</tbody>
</table>
### 14.6.40 E Prepare Subsequent Handover Result

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

<table>
<thead>
<tr>
<th>IEI</th>
<th>IE</th>
<th>Type</th>
<th>Presence</th>
<th>Format</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>IMSI</td>
<td>Section 14.7.1</td>
<td>M</td>
<td>V</td>
<td>1</td>
</tr>
<tr>
<td>0a</td>
<td>Message Class</td>
<td>Section 14.7.29</td>
<td>M</td>
<td>TLV</td>
<td>3</td>
</tr>
<tr>
<td>60</td>
<td>Source Name</td>
<td>Section 14.7.30</td>
<td>M</td>
<td>TLV</td>
<td>2-...</td>
</tr>
<tr>
<td>61</td>
<td>Destination Name</td>
<td>Section 14.7.31</td>
<td>M</td>
<td>TLV</td>
<td>2-...</td>
</tr>
<tr>
<td>62</td>
<td>AN-APDU</td>
<td>Section 14.7.32</td>
<td>M</td>
<td>TLV</td>
<td>2-...</td>
</tr>
</tbody>
</table>

### 14.6.41 E Send End Signal Request

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

<table>
<thead>
<tr>
<th>IEI</th>
<th>IE</th>
<th>Type</th>
<th>Presence</th>
<th>Format</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>IMSI</td>
<td>Section 14.7.1</td>
<td>M</td>
<td>V</td>
<td>1</td>
</tr>
<tr>
<td>0a</td>
<td>Message Class</td>
<td>Section 14.7.29</td>
<td>M</td>
<td>TLV</td>
<td>3</td>
</tr>
<tr>
<td>60</td>
<td>Source Name</td>
<td>Section 14.7.30</td>
<td>M</td>
<td>TLV</td>
<td>2-...</td>
</tr>
<tr>
<td>61</td>
<td>Destination Name</td>
<td>Section 14.7.31</td>
<td>M</td>
<td>TLV</td>
<td>2-...</td>
</tr>
<tr>
<td>62</td>
<td>AN-APDU</td>
<td>Section 14.7.32</td>
<td>M</td>
<td>TLV</td>
<td>2-...</td>
</tr>
</tbody>
</table>

### 14.6.42 E Send End Signal Error

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

<table>
<thead>
<tr>
<th>IEI</th>
<th>IE</th>
<th>Type</th>
<th>Presence</th>
<th>Format</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>IMSI</td>
<td>Section 14.7.1</td>
<td>M</td>
<td>V</td>
<td>1</td>
</tr>
<tr>
<td>0a</td>
<td>Message Class</td>
<td>Section 14.7.29</td>
<td>M</td>
<td>TLV</td>
<td>3</td>
</tr>
<tr>
<td>60</td>
<td>Source Name</td>
<td>Section 14.7.30</td>
<td>M</td>
<td>TLV</td>
<td>2-...</td>
</tr>
<tr>
<td>61</td>
<td>Destination Name</td>
<td>Section 14.7.31</td>
<td>M</td>
<td>TLV</td>
<td>2-...</td>
</tr>
<tr>
<td>62</td>
<td>AN-APDU</td>
<td>Section 14.7.32</td>
<td>M</td>
<td>TLV</td>
<td>2-...</td>
</tr>
</tbody>
</table>

### 14.6.43 E Send End Signal Result

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

<table>
<thead>
<tr>
<th>IEI</th>
<th>IE</th>
<th>Type</th>
<th>Presence</th>
<th>Format</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>IMSI</td>
<td>Section 14.7.1</td>
<td>M</td>
<td>V</td>
<td>1</td>
</tr>
<tr>
<td>0a</td>
<td>Message Class</td>
<td>Section 14.7.29</td>
<td>M</td>
<td>TLV</td>
<td>3</td>
</tr>
<tr>
<td>60</td>
<td>Source Name</td>
<td>Section 14.7.30</td>
<td>M</td>
<td>TLV</td>
<td>2-...</td>
</tr>
<tr>
<td>61</td>
<td>Destination Name</td>
<td>Section 14.7.31</td>
<td>M</td>
<td>TLV</td>
<td>2-...</td>
</tr>
<tr>
<td>62</td>
<td>AN-APDU</td>
<td>Section 14.7.32</td>
<td>M</td>
<td>TLV</td>
<td>2-...</td>
</tr>
</tbody>
</table>

### 14.6.44 E Process Access Signalling Request

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

<table>
<thead>
<tr>
<th>IEI</th>
<th>IE</th>
<th>Type</th>
<th>Presence</th>
<th>Format</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>IMSI</td>
<td>Section 14.7.1</td>
<td>M</td>
<td>V</td>
<td>1</td>
</tr>
</tbody>
</table>
### 14.6.45 E Forward Access Signalling Request

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

<table>
<thead>
<tr>
<th>IEI</th>
<th>IE</th>
<th>Type</th>
<th>Presence</th>
<th>Format</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>IMSI</td>
<td>Section 14.7.19</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
<tr>
<td>0a</td>
<td>Message Class</td>
<td>Section 14.7.29</td>
<td>M</td>
<td>TLV</td>
<td>3</td>
</tr>
<tr>
<td>60</td>
<td>Source Name</td>
<td>Section 14.7.30</td>
<td>M</td>
<td>TLV</td>
<td>2-…</td>
</tr>
<tr>
<td>61</td>
<td>Destination Name</td>
<td>Section 14.7.31</td>
<td>M</td>
<td>TLV</td>
<td>2-…</td>
</tr>
<tr>
<td>62</td>
<td>AN-APDU</td>
<td>Section 14.7.32</td>
<td>M</td>
<td>TLV</td>
<td>2-…</td>
</tr>
</tbody>
</table>

### 14.6.46 E Close

Direction: MSC-A ⇒ MSC-B (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 14.7.19</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
<tr>
<td>0a</td>
<td>Message Class</td>
<td>Section 14.7.29</td>
<td>M</td>
<td>TLV</td>
<td>3</td>
</tr>
<tr>
<td>60</td>
<td>Source Name</td>
<td>Section 14.7.30</td>
<td>M</td>
<td>TLV</td>
<td>2-…</td>
</tr>
<tr>
<td>61</td>
<td>Destination Name</td>
<td>Section 14.7.31</td>
<td>M</td>
<td>TLV</td>
<td>2-…</td>
</tr>
<tr>
<td>62</td>
<td>AN-APDU</td>
<td>Section 14.7.32</td>
<td>M</td>
<td>TLV</td>
<td>2-…</td>
</tr>
</tbody>
</table>

### 14.6.47 E Abort

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

### 14.6.48 E Routing Error

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

<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 14.7.19</td>
<td>M</td>
<td>TLV</td>
<td>2-10</td>
</tr>
<tr>
<td>0a</td>
<td>Message Class</td>
<td>Section 14.7.29</td>
<td>M</td>
<td>TLV</td>
<td>3</td>
</tr>
<tr>
<td>60</td>
<td>Source Name</td>
<td>Section 14.7.30</td>
<td>M</td>
<td>TLV</td>
<td>2-…</td>
</tr>
<tr>
<td>61</td>
<td>Destination Name</td>
<td>Section 14.7.31</td>
<td>M</td>
<td>TLV</td>
<td>2-…</td>
</tr>
<tr>
<td>30</td>
<td>Session ID</td>
<td>Section 14.8.1</td>
<td>O</td>
<td>TLV</td>
<td>6</td>
</tr>
<tr>
<td>31</td>
<td>Session State</td>
<td>Section 14.8.2</td>
<td>O</td>
<td>TLV</td>
<td>3</td>
</tr>
</tbody>
</table>

### 14.7 Information Elements

#### 14.7.1 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>0x0c</td>
<td>Authentication Failure Report</td>
</tr>
<tr>
<td>0x0d</td>
<td>Purge MS Request</td>
</tr>
<tr>
<td>0x0e</td>
<td>Purge MS Error</td>
</tr>
<tr>
<td>0x0f</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>
</tr>
<tr>
<td>0x14</td>
<td>Delete Subscriber Data Request</td>
</tr>
<tr>
<td>0x15</td>
<td>Delete Subscriber Data Error</td>
</tr>
<tr>
<td>0x16</td>
<td>Delete Subscriber Data Result</td>
</tr>
<tr>
<td>0x1c</td>
<td>Location Cancellation Request</td>
</tr>
<tr>
<td>0x1d</td>
<td>Location Cancellation Error</td>
</tr>
<tr>
<td>0x1e</td>
<td>Location Cancellation Result</td>
</tr>
<tr>
<td>0x20</td>
<td>Supplementary Service Request</td>
</tr>
<tr>
<td>0x21</td>
<td>Supplementary Service Error</td>
</tr>
<tr>
<td>0x22</td>
<td>Supplementary Service Result</td>
</tr>
<tr>
<td>0x24</td>
<td>MO-forwardSM Request</td>
</tr>
<tr>
<td>0x25</td>
<td>MO-forwardSM Error</td>
</tr>
<tr>
<td>0x26</td>
<td>MO-forwardSM Result</td>
</tr>
<tr>
<td>0x28</td>
<td>MT-forwardSM Request</td>
</tr>
<tr>
<td>0x29</td>
<td>MT-forwardSM Error</td>
</tr>
<tr>
<td>0x2a</td>
<td>MT-forwardSM Result</td>
</tr>
<tr>
<td>0x2c</td>
<td>READY-FOR-SM Request</td>
</tr>
<tr>
<td>0x2d</td>
<td>READY-FOR-SM Error</td>
</tr>
<tr>
<td>0x2e</td>
<td>READY-FOR-SM Result</td>
</tr>
<tr>
<td>0x30</td>
<td>CHECK-IMEI Request</td>
</tr>
<tr>
<td>0x31</td>
<td>CHECK-IMEI Error</td>
</tr>
<tr>
<td>0x32</td>
<td>CHECK-IMEI Result</td>
</tr>
</tbody>
</table>

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

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

### 14.7.2 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**.

### 14.7.3 PDP Info

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

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

![PDP Type IEI Diagram](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

### 14.7.5 PDP Context ID

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

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

<table>
<thead>
<tr>
<th>IEI</th>
<th>IE</th>
<th>Type</th>
<th>Presence</th>
<th>Format</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auth Tuple IEI</td>
<td>Section 14.7.17</td>
<td>M</td>
<td>V</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Length of Auth Tuple IE</td>
<td>Section 14.7.17</td>
<td>M</td>
<td>V</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>RAND</td>
<td>Section 14.7.7</td>
<td>M</td>
<td>TLV</td>
<td>18</td>
</tr>
<tr>
<td>21</td>
<td>SRES</td>
<td>Section 14.7.8</td>
<td>M</td>
<td>TLV</td>
<td>6</td>
</tr>
<tr>
<td>22</td>
<td>Kc</td>
<td>Section 14.7.9</td>
<td>M</td>
<td>TLV</td>
<td>10</td>
</tr>
<tr>
<td>23</td>
<td>IK</td>
<td>Section 14.7.10</td>
<td>C</td>
<td>TLV</td>
<td>18</td>
</tr>
<tr>
<td>24</td>
<td>CK</td>
<td>Section 14.7.11</td>
<td>C</td>
<td>TLV</td>
<td>18</td>
</tr>
<tr>
<td>25</td>
<td>AUTN</td>
<td>Section 14.7.12</td>
<td>C</td>
<td>TLV</td>
<td>18</td>
</tr>
<tr>
<td>27</td>
<td>RES</td>
<td>Section 14.7.14</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.

14.7.7 RAND

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

14.7.8 SRES

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

14.7.9 Kc

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

14.7.10 IK

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

14.7.11 CK

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

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

14.7.13 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.

14.7.14 RES

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

14.7.15 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>

14.7.16 Cancellation Type

<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>
14.7.17  IE Identifier (informational)

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

Table 10: GSUP IE Identifiers

<table>
<thead>
<tr>
<th>IEI</th>
<th>Info Element</th>
<th>Type / Encoding</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x01</td>
<td>IMSI</td>
<td>Mobile Identity, 3GPP TS 04.08 Ch. 10.5.1.4</td>
</tr>
<tr>
<td>0x02</td>
<td>Cause</td>
<td>Section 14.7.25</td>
</tr>
<tr>
<td>0x03</td>
<td>Auth Tuple</td>
<td>Section 14.7.6</td>
</tr>
<tr>
<td>0x04</td>
<td>PDP Info Compl</td>
<td>Section 14.7.18</td>
</tr>
<tr>
<td>0x05</td>
<td>PDP Info</td>
<td>Section 14.7.3</td>
</tr>
<tr>
<td>0x06</td>
<td>Cancel Type</td>
<td>Section 14.7.16</td>
</tr>
<tr>
<td>0x07</td>
<td>Freeze P-TMSI</td>
<td>Section 14.7.18</td>
</tr>
<tr>
<td>0x08</td>
<td>MSISDN</td>
<td>ISDN-AddressString/octet, Section 14.7.20</td>
</tr>
<tr>
<td>0x09</td>
<td>HLR Number</td>
<td>Section 14.7.24</td>
</tr>
<tr>
<td>0x0a</td>
<td>Message Class</td>
<td>Section 14.7.29</td>
</tr>
<tr>
<td>0x10</td>
<td>PDP Context ID</td>
<td>Section 14.7.5</td>
</tr>
<tr>
<td>0x11</td>
<td>PDP Type</td>
<td>Section 14.7.4</td>
</tr>
<tr>
<td>0x12</td>
<td>Access Point Name</td>
<td>Section 14.7.21</td>
</tr>
<tr>
<td>0x13</td>
<td>QoS</td>
<td>Section 14.7.22</td>
</tr>
<tr>
<td>0x14</td>
<td>PDP-Charging Characteristics</td>
<td>Section 14.7.23</td>
</tr>
<tr>
<td>0x20</td>
<td>RAND</td>
<td>Section 14.7.7</td>
</tr>
<tr>
<td>0x21</td>
<td>SRES</td>
<td>Section 14.7.8</td>
</tr>
<tr>
<td>0x22</td>
<td>Kc</td>
<td>Section 14.7.9</td>
</tr>
<tr>
<td>0x23</td>
<td>IK</td>
<td>Section 14.7.10</td>
</tr>
<tr>
<td>0x24</td>
<td>CR</td>
<td>Section 14.7.11</td>
</tr>
<tr>
<td>0x25</td>
<td>AUTN</td>
<td>Section 14.7.12</td>
</tr>
<tr>
<td>0x26</td>
<td>AUTS</td>
<td>Section 14.7.13</td>
</tr>
<tr>
<td>0x27</td>
<td>RES</td>
<td>Section 14.7.14</td>
</tr>
<tr>
<td>0x28</td>
<td>CN Domain</td>
<td>Section 14.7.15</td>
</tr>
<tr>
<td>0x30</td>
<td>Session ID</td>
<td>Section 14.8.1</td>
</tr>
<tr>
<td>0x31</td>
<td>Session State</td>
<td>Section 14.8.2</td>
</tr>
<tr>
<td>0x35</td>
<td>Supplementary Service Info</td>
<td>Section 14.7.26</td>
</tr>
<tr>
<td>0x40</td>
<td>SM-RP-MR (Message Reference)</td>
<td>Section 14.8.3</td>
</tr>
<tr>
<td>0x41</td>
<td>SM-RP-DA (Destination Address)</td>
<td>Section 14.8.4</td>
</tr>
<tr>
<td>0x42</td>
<td>SM-RP-OA (Originating Address)</td>
<td>Section 14.8.5</td>
</tr>
<tr>
<td>0x43</td>
<td>SM-RP-UI (SM TPDU)</td>
<td>Section 14.8.7</td>
</tr>
<tr>
<td>0x44</td>
<td>SM-RP-Cause (RP Cause value)</td>
<td>Section 14.8.8</td>
</tr>
<tr>
<td>0x45</td>
<td>SM-RP-MMS (More Messages to Send)</td>
<td>Section 14.8.9</td>
</tr>
<tr>
<td>0x46</td>
<td>SM Alert Reason</td>
<td>Section 14.8.10</td>
</tr>
<tr>
<td>0x50</td>
<td>IMEI</td>
<td>Section 14.7.27</td>
</tr>
<tr>
<td>0x51</td>
<td>IMEI Check Result</td>
<td>Section 14.7.28</td>
</tr>
<tr>
<td>0x60</td>
<td>Source Name</td>
<td>Section 14.7.30</td>
</tr>
<tr>
<td>0x61</td>
<td>Destination Name</td>
<td>Section 14.7.31</td>
</tr>
<tr>
<td>0x62</td>
<td>AN-APDU</td>
<td>Section 14.7.32</td>
</tr>
<tr>
<td>0x63</td>
<td>RR Cause</td>
<td>Section 14.7.33</td>
</tr>
<tr>
<td>0x64</td>
<td>BSSAP Cause</td>
<td>Section 14.7.34</td>
</tr>
<tr>
<td>0x65</td>
<td>Session Management Cause</td>
<td>Section 14.7.35</td>
</tr>
</tbody>
</table>
14.7.18 Empty field

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

### Diagram

```
 0 4 8
```

- **PDP type IEI**
- **Res**
- **Length (0)**

14.7.19 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.

14.7.20 ISDN-AddressString / MSISDN / Called Party BCD Number

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

### Diagram

```
 0 4 8
```

- **PDP type IEI**
- **Res**
- **Length of IE content**
- **Digit 1** | **Digit 2**
- **Digit ...** | **Digit N**
- **see Note**
14.7.21 Access Point Name

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

14.7.22 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 then it is assumed that the first octet is the Allocation/Retention Priority and the reset are encoded as octets 3-N of 24.008.

14.7.23 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.
14.7.24 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.

14.7.25 Cause

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

14.7.26 Supplementary Service Info

This IE shall be used together with both Section 14.8.2 and Section 14.8.1 IEs. It is used to carry the payload of Supplementary Services encoded according to GSM TS 04.80.

14.7.27 IMEI

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

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

Table 11: IMEI Check Result

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

14.7.29 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>

14.7.30 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 27: Message forwarding example](image)

14.7.31 Destination Name

The receiving counterpart to source name (Section 14.7.30).

14.7.32 AN-APDU

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

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

14.7.33  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.

14.7.34  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.

14.7.35  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.

14.8  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.

14.8.1  Session ID

This auxiliary IE shall be used together with Section 14.8.2. The purpose of this IE is to identify a particular transaction using the 4-byte unique identifier.
14.8.2 Session State

This auxiliary IE shall be used together with Section 14.8.1. The purpose of this IE is to indicate a state of a particular transaction, i.e. initiate, continue or terminate it.
14.8.3 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 14.8.3 is used to carry the message reference value ’as-is’ (i.e. in range 0 through 255).

14.8.4 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 14.8.6. See 3GPP TS 29.002, section 7.6.8.1 for details.

14.8.5 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 14.8.6. See 3GPP TS 29.002, section 7.6.8.2 for details.

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

Basically, both Section 14.8.4 / Section 14.8.5 IEs contain a single TV of the following format:

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

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

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

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

Figure 28: ToN/NPI header coding (as per 3GPP TS 129.002, MSB first)

Please note that unlike both Section 14.7.19 and Section 14.7.20, where the value part is encoded as LV (i.e. contains an additional length), an identity in both Section 14.8.4 / Section 14.8.5 IEs shall not contain the redundant length octet.

14.8.7 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.

14.8.8 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 14.8.8 is used to carry the cause value ‘as-is’.
14.8.9 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.

14.8.10 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 16: SM Alert Reason 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>

15 Counters

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

15.1 Rate Counters

Table 17: bssgp:bss_ctx - BSSGP Peer Statistics

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

Table 18: sgsn - SGSN Overall Statistics

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

<table>
<thead>
<tr>
<th>Name</th>
<th>Reference</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>gprs:attach_accepted</td>
<td>[?]</td>
<td>Sent attach accepts</td>
</tr>
<tr>
<td>gprs:attach_rejected</td>
<td>[?]</td>
<td>Sent attach rejects</td>
</tr>
<tr>
<td>gprs:detach_requested</td>
<td>[?]</td>
<td>Received detach requests</td>
</tr>
<tr>
<td>gprs:detach_acked</td>
<td>[?]</td>
<td>Sent detach acks</td>
</tr>
<tr>
<td>gprs:routing_area_requested</td>
<td>[?]</td>
<td>Received routing area requests</td>
</tr>
<tr>
<td>gprs:routing_area_acked</td>
<td>[?]</td>
<td>Sent routing area acks</td>
</tr>
<tr>
<td>pdp:activate_requested</td>
<td>[?]</td>
<td>Received activate requests</td>
</tr>
<tr>
<td>pdp:activate_acked</td>
<td>[?]</td>
<td>Sent activate accepts</td>
</tr>
<tr>
<td>pdp:activate_rejected</td>
<td>[?]</td>
<td>Sent activate rejects</td>
</tr>
<tr>
<td>pdp:request_activated</td>
<td>[?]</td>
<td>Unused</td>
</tr>
<tr>
<td>pdp:request_activate_rejected</td>
<td>[?]</td>
<td>Unused</td>
</tr>
<tr>
<td>pdp:modify_accepted</td>
<td>[?]</td>
<td>Unused</td>
</tr>
<tr>
<td>pdp:modify_activate_rejected</td>
<td>[?]</td>
<td>Unused</td>
</tr>
<tr>
<td>pdp:dl_deactivate_requested</td>
<td>[?]</td>
<td>Sent deactivate requests</td>
</tr>
<tr>
<td>pdp:dl_deactivate_acked</td>
<td>[?]</td>
<td>Sent deactivate accepted</td>
</tr>
<tr>
<td>pdp:ul_deactivate_requested</td>
<td>[?]</td>
<td>Received deactivate requests</td>
</tr>
<tr>
<td>pdp:ul_deactivate_acked</td>
<td>[?]</td>
<td>Received deactivate accepts</td>
</tr>
</tbody>
</table>

### Table 19: ns:nsvc - NSVC Peer Statistics

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

### 16 Osmo Stat Items

NSVC Peer Statistics .ns:nsvc - NSVC Peer Statistics

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

18 Glossary

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

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

3GPP
3rd Generation Partnership Project

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

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

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

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

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

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

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

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

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

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

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

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

BTS
Base Transceiver Station

BSC
Base Station Controller

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

BVCI
BSSGP Virtual Circuit Identifier

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

CC
Call Control; Part of the GSM Layer 3 Protocol

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

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

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

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

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

dB
deci-Bel; relative logarithmic unit

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

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

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

DSP
Digital Signal Processor

dvnixload
Tool to program UBL and the Bootloader on a sysmoBTS

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

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

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

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

ETSI
European Telecommunications Standardization Institute

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

GERAN
GPRS/EDGE Radio Access Network

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

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

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

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

Gp
Gp interface between SGSN and GGSN; uses GTP protocol

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

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

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

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

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

GT
Global Title; an address in SCCP

GTP
GPRS Tunnel Protocol; used between SGSN and GGSN

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

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

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

IE
Information Element

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

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

IMSI
International Mobile Subscriber Identity; 15-digit unique identifier for the subscriber/SIM; starts with MCC/MNC of issuing operator
IP

Internet Protocol (IETF RFC 791 [])

IPA

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

Iu

Interface in 3G/UMTS between RAN and CN

IuCS

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

IuPS

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

LAC

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

LAPD

Link Access Protocol, D-Channel (ITU-T Q.921 [itu-t-q921])

LAPDm

Link Access Protocol Mobile (3GPP TS 44.006 [3gpp-ts-44-006])

LLC

Logical Link Control; GPRS protocol between MS and SGSN (3GPP TS 44.064 [3gpp-ts-44-064])

Location Area

Location Area; a geographic area containing multiple BTS

LU

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

M2PA

MTP2 Peer-to-Peer Adaptation; a SIGTRAN Variant (RFC 4165 [ietf-rfc4165])

M2UA

MTP2 User Adaptation; a SIGTRAN Variant (RFC 3331 [ietf-rfc3331])

M3UA

MTP3 User Adaptation; a SIGTRAN Variant (RFC 4666 [ietf-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

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

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

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](https://www.itu.int/rec/T-REC-Q.711))

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](https://tools.ietf.org/rfc/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](https://tools.ietf.org/rfc/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](https://tools.ietf.org/rfc/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](https://tools.ietf.org/rfc/rfc793))
TFTP
Trivial File Transfer Protocol; *(IETF RFC 1350 [ietf-rfc1350])*

TRX
Transceiver; element of a BTS serving a single carrier

TS
Technical Specification

u-Boot
Boot loader used in various embedded systems

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

UBL
Initial bootloader loaded by the TI Davinci SoC

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

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

Um interface
U mobile; Radio interface between MS and BTS

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

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

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

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

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

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

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

A Osmocom TCP/UDP Port Numbers

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

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

### B Bibliography / References

#### B.0.0.0.1 References


http://www.3gpp.org/DynaReport/31116.htm

[26] [3gpp-ts-35-205] 3GPP TS 35.205: 3G Security; Specification of the MILENAGE algorithm set: General

[27] [3gpp-ts-35-206] 3GPP TS 35.206: 3G Security; Specification of the MILENAGE algorithm set: Algorithm 
specification http://www.3gpp.org/DynaReport/35206.htm

[28] [3gpp-ts-44-006] 3GPP TS 44.006: Mobile Station - Base Station System (MS - BSS) interface; Data Link 
(DL) layer specification http://www.3gpp.org/DynaReport/44006.htm

[29] [3gpp-ts-44-018] 3GPP TS 44.018: Mobile radio interface layer 3 specification; Radio Resource Control (RRC) 
 protocol http://www.3gpp.org/DynaReport/44018.htm

[30] [3gpp-ts-44-064] 3GPP TS 44.064: Mobile Station - Serving GPRS Support Node (MS-SGSN); Logical Link 

[31] [3gpp-ts-48-008] 3GPP TS 48.008: Mobile Switching Centre - Base Station system (MSC-BSS) interface; 
Layer 3 specification http://www.3gpp.org/DynaReport/48008.htm

[32] [3gpp-ts-48-016] 3GPP TS 48.016: General Packet Radio Service (GPRS); Base Station System (BSS) - Serv- 
ing GPRS Support Node (SGSN) interface; Network service http://www.3gpp.org/DynaReport/48016.htm

[33] [3gpp-ts-48-018] 3GPP TS 48.018: General Packet Radio Service (GPRS); Base Station System (BSS) - Serv- 
ing GPRS Support Node (SGSN); BSS GPRS protocol (BSSGP) http://www.3gpp.org/DynaReport/48018.htm

[34] [3gpp-ts-48-056] 3GPP TS 48.056: Base Station Controller - Base Transceiver Station (BSC - BTS) interface; 
Layer 2 specification http://www.3gpp.org/DynaReport/48056.htm

[35] [3gpp-ts-48-058] 3GPP TS 48.058: Base Station Controller - Base Transceiver Station (BSC - BTS) Interface; 
Layer 3 specification http://www.3gpp.org/DynaReport/48058.htm

[36] [3gpp-ts-51-011] 3GPP TS 51.011: Specification of the Subscriber Identity Module - Mobile Equipment (SIM- 
ME) interface

[37] [3gpp-ts-51-014] 3GPP TS 51.014: Specification of the SIM Application Toolkit for the Subscriber Identity 

[38] [3gpp-ts-52-021] 3GPP TS 52.021: Network Management (NM) procedures and messages on the A-bis inter- 
face http://www.3gpp.org/DynaReport/52021.htm

03.00.00_60/tr_102216v030000p.pdf

[40] [etsi-ts102221] ETSI TS 102 221: Smart Cards; UICC-Terminal interface; Physical and logical characteristics 
http://www.etsi.org/deliver/etsi_ts/102200_102299/102221/13.01.00_60/ts_102221v130100p.pdf

[41] [etsi-ts101220] ETSI TS 101 220: Smart Cards; ETSI numbering system for telecommunication application 
providers http://www.etsi.org/deliver/etsi_ts/101200_101299/101220/12.00.00_60/ts_101220v120000p.pdf


rfc1035


rfc3331
C.2 APPLICABILITY AND DEFINITIONS

This License applies to any manual or other work, in any medium, that contains a notice placed by the copyright holder saying it can be distributed under the terms of this License. Such a notice grants a world-wide, royalty-free license, unlimited in duration, to use that work under the conditions stated herein. The “Document”, below, refers to any such manual or work. Any member of the public is a licensee, and is addressed as “you”. You accept the license if you copy, modify or distribute the work in a way requiring permission under copyright law.

A “Modified Version” of the Document means any work containing the Document or a portion of it, either copied verbatim, or with modifications and/or translated into another language.

A “Secondary Section” is a named appendix or a front-matter section of the Document that deals exclusively with the relationship of the publishers or authors of the Document to the Document’s overall subject (or to related matters) and contains nothing that could fall directly within that overall subject. (Thus, if the Document is in part a textbook of mathematics, a Secondary Section may not explain any mathematics.) The relationship could be a matter of historical connection with the subject or with related matters, or of legal, commercial, philosophical, ethical or political position regarding them.

The “Invariant Sections” are certain Secondary Section whose titles are designated, as being those of Invariant Sections, in the notice that says that the Document is released under this License. If a section does not fit the above definition of Secondary then it is not allowed to be designated as Invariant. The Document may contain zero Invariant Sections. If the Document does not identify any Invariant Sections then there are none.

The “Cover Texts” are certain short passages of text that are listed, as Front-Cover Texts or Back-Cover Texts, in the notice that says that the Document is released under this License. A Front-Cover Text may be at most 5 words, and a Back-Cover Text may be at most 25 words.

A “Transparent” copy of the Document means a machine-readable copy, represented in a format whose specification is available to the general public, that is suitable for revising the document straightforwardly with generic text editors or (for images composed of pixels) generic paint programs or (for drawings) some widely available drawing editor, and that is suitable for input to text formatters or for automatic translation to a variety of formats suitable for input to text formatters. A copy made in an otherwise Transparent file format whose markup, or absence of markup, has been arranged to thwart or discourage subsequent modification by readers is not Transparent. An image format is not Transparent if used for any substantial amount of text. A copy that is not Transparent is called “Opaque”.

Examples of suitable formats for Transparent copies include plain ASCII without markup, TeXinfo input format, LaTeX input format, SGML or XML using a publicly available DTD, and standard-conforming simple HTML, PostScript or PDF designed for human modification. Examples of transparent image formats include PNG, XCF and JPG. Opaque formats include proprietary formats that can be read and edited only by proprietary word processors, SGML or XML for which the DTD and/or processing tools are not generally available, and the machine-generated HTML, PostScript or PDF produced by some word processors for output purposes only.

The “Title Page” means, for a printed book, the title page itself, plus such following pages as are needed to hold, legibly, the material this License requires to appear in the title page. For works in formats which do not have any title page as such, Title Page means the text near the most prominent appearance of the work’s title, preceding the beginning of the body of the text.

The “publisher” means any person or entity that distributes copies of the Document to the public.

A section “Entitled XYZ” means a named subunit of the Document whose title either is precisely XYZ or contains XYZ in parentheses following text that translates XYZ in another language. (Here XYZ stands for a specific section name mentioned below, such as “Acknowledgements”, “Dedications”, “Endorsements”, or “History”.) To “Preserve the Title” of such a section when you modify the Document means that it remains a section “Entitled XYZ” according to this definition.

The Document may include Warranty Disclaimers next to the notice which states that this License applies to the Document. These Warranty Disclaimers are considered to be included by reference in this License, but only as regards disclaiming warranties: any other implication that these Warranty Disclaimers may have is void and has no effect on the meaning of this License.

C.3 VERBATIM COPYING

You may copy and distribute the Document in any medium, either commercially or noncommercially, provided that this License, the copyright notices, and the license notice saying this License applies to the Document are reproduced in all copies, and that you add no other conditions whatsoever to those of this License. You may not use technical measures to obstruct or control the
reading or further copying of the copies you make or distribute. However, you may accept compensation in exchange for copies. If you distribute a large enough number of copies you must also follow the conditions in section Section C.4.

You may also lend copies, under the same conditions stated above, and you may publicly display copies.

**C.4 COPYING IN QUANTITY**

If you publish printed copies (or copies in media that commonly have printed covers) of the Document, numbering more than 100, and the Document’s license notice requires Cover Texts, you must enclose the copies in covers that carry, clearly and legibly, all these Cover Texts: Front-Cover Texts on the front cover, and Back-Cover Texts on the back cover. Both covers must also clearly and legibly identify you as the publisher of these copies. The front cover must present the full title with all words of the title equally prominent and visible. You may add other material on the covers in addition. Copying with changes limited to the covers, as long as they preserve the title of the Document and satisfy these conditions, can be treated as verbatim copying in other respects.

If the required texts for either cover are too voluminous to fit legibly, you should put the first ones listed (as many as fit reasonably) on the actual cover, and continue the rest onto adjacent pages.

If you publish or distribute Opaque copies of the Document numbering more than 100, you must either include a machine-readable Transparent copy along with each Opaque copy, or state in or with each Opaque copy a computer-network location from which the general network-using public has access to download using public-standard network protocols a complete Transparent copy of the Document, free of added material. If you use the latter option, you must take reasonably prudent steps, when you begin distribution of Opaque copies in quantity, to ensure that this Transparent copy will remain thus accessible at the stated location until at least one year after the last time you distribute an Opaque copy (directly or through your agents or retailers) of that edition to the public.

It is requested, but not required, that you contact the authors of the Document well before redistributing any large number of copies, to give them a chance to provide you with an updated version of the Document.

**C.5 MODIFICATIONS**

You may copy and distribute a Modified Version of the Document under the conditions of sections 2 and 3 above, provided that you release the Modified Version under precisely this License, with the Modified Version filling the role of the Document, thus licensing distribution and modification of the Modified Version to whoever possesses a copy of it. In addition, you must do these things in the Modified Version:

a. Use in the Title Page (and on the covers, if any) a title distinct from that of the Document, and from those of previous versions (which should, if there were any, be listed in the History section of the Document). You may use the same title as a previous version if the original publisher of that version gives permission.

b. List on the Title Page, as authors, one or more persons or entities responsible for authorship of the modifications in the Modified Version, together with at least five of the principal authors of the Document (all of its principal authors, if it has fewer than five), unless they release you from this requirement.

c. State on the Title Page the name of the publisher of the Modified Version, as the publisher.

d. Preserve all the copyright notices of the Document.

e. Add an appropriate copyright notice for your modifications adjacent to the other copyright notices.

f. Include, immediately after the copyright notices, a license notice giving the public permission to use the Modified Version under the terms of this License, in the form shown in the Addendum below.

g. Preserve in that license notice the full lists of Invariant Sections and required Cover Texts given in the Document’s license notice.

h. Include an unaltered copy of this License.
i. Preserve the section Entitled “History”, Preserve its Title, and add to it an item stating at least the title, year, new authors, and publisher of the Modified Version as given on the Title Page. If there is no section Entitled “History” in the Document, create one stating the title, year, authors, and publisher of the Document as given on its Title Page, then add an item describing the Modified Version as stated in the previous sentence.

j. Preserve the network location, if any, given in the Document for public access to a Transparent copy of the Document, and likewise the network locations given in the Document for previous versions it was based on. These may be placed in the “History” section. You may omit a network location for a work that was published at least four years before the Document itself, or if the original publisher of the version it refers to gives permission.

k. For any section Entitled “Acknowledgements” or “Dedications”, Preserve the Title of the section, and preserve in the section all the substance and tone of each of the contributor acknowledgements and/or dedications given therein.

l. Preserve all the Invariant Sections of the Document, unaltered in their text and in their titles. Section numbers or the equivalent are not considered part of the section titles.

m. Delete any section Entitled “Endorsements”. Such a section may not be included in the [?].

n. Do not retile any existing section to be Entitled “Endorsements” or to conflict in title with any Invariant Sections.

o. Preserve any Warranty Disclaimers.

If the Modified Version includes new front-matter sections or appendices that qualify as Secondary Section and contain no material copied from the Document, you may at your option designate some or all of these sections as invariant. To do this, add their titles to the list of Invariant Sections in the Modified Version’s license notice. These titles must be distinct from any other section titles.

You may add a section Entitled “Endorsements”, provided it contains nothing but endorsements of your Modified Version by various parties—for example, statements of peer review or that the text has been approved by an organization as the authoritative definition of a standard.

You may add a passage of up to five words as a Front-Cover Text, and a passage of up to 25 words as a Back-Cover Text, to the end of the list of Cover Texts in the Modified Version. Only one passage of Front-Cover Text and one of Back-Cover Text may be added by (or through arrangements made by) any one entity. If the Document already includes a cover text for the same cover, previously added by you or by arrangement made by the same entity you are acting on behalf of, you may not add another; but you may replace the old one, on explicit permission from the previous publisher that added the old one.

The author(s) and publisher(s) of the Document do not by this License give permission to use their names for publicity for or to assert or imply endorsement of any Modified Version.

C.6 COMBINING DOCUMENTS

You may combine the Document with other documents released under this License, under the terms defined in section 4 above for modified versions, provided that you include in the combination all of the Invariant Sections of all of the original documents, unmodified, and list them all as Invariant Sections of your combined work in its license notice, and that you preserve all their Warranty Disclaimers.

The combined work need only contain one copy of this License, and multiple identical Invariant Sections may be replaced with a single copy. If there are multiple Invariant Sections with the same name but different contents, make the title of each such section unique by adding at the end of it, in parentheses, the name of the original author or publisher of that section if known, or else a unique number. Make the same adjustment to the section titles in the list of Invariant Sections in the license notice of the combined work.

In the combination, you must combine any sections Entitled “History” in the various original documents, forming one section Entitled “History”; likewise combine any sections Entitled “Acknowledgements”, and any sections Entitled “Dedications”. You must delete all sections Entitled “Endorsements”.

Copyright © 2013-2016 sysmocom - s.f.m.c. GmbH DRAFT 1.6.0-9-gb63e, 2020-Mar-18
C.7 COLLECTIONS OF DOCUMENTS

You may make a collection consisting of the Document and other documents released under this License, and replace the individual copies of this License in the various documents with a single copy that is included in the collection, provided that you follow the rules of this License for verbatim copying of each of the documents in all other respects.

You may extract a single document from such a collection, and distribute it individually under this License, provided you insert a copy of this License into the extracted document, and follow this License in all other respects regarding verbatim copying of that document.

C.8 AGGREGATION WITH INDEPENDENT WORKS

A compilation of the Document or its derivatives with other separate and independent documents or works, in or on a volume of a storage or distribution medium, is called an “aggregate” if the copyright resulting from the compilation is not used to limit the legal rights of the compilation’s users beyond what the individual works permit. When the Document is included in an aggregate, this License does not apply to the other works in the aggregate which are not themselves derivative works of the Document.

If the Cover Text requirement of section 3 is applicable to these copies of the Document, then if the Document is less than one half of the entire aggregate, the Document’s Cover Texts may be placed on covers that bracket the Document within the aggregate, or the electronic equivalent of covers if the Document is in electronic form. Otherwise they must appear on printed covers that bracket the whole aggregate.

C.9 TRANSLATION

Translation is considered a kind of modification, so you may distribute translations of the Document under the terms of section 4. Replacing Invariant Sections with translations requires special permission from their copyright holders, but you may include translations of some or all Invariant Sections in addition to the original versions of these Invariant Sections. You may include a translation of this License, and all the license notices in the Document, and any Warranty Disclaimers, provided that you also include the original English version of this License and the original versions of those notices and disclaimers. In case of a disagreement between the translation and the original version of this License or a notice or disclaimer, the original version will prevail.

If a section in the Document is Entitled “Acknowledgements”, “Dedications”, or “History”, the requirement (section 4) to Preserve its Title (section 1) will typically require changing the actual title.

C.10 TERMINATION

You may not copy, modify, sublicense, or distribute the Document except as expressly provided under this License. Any attempt otherwise to copy, modify, sublicense, or distribute it is void, and will automatically terminate your rights under this License.

However, if you cease all violation of this License, then your license from a particular copyright holder is reinstated (a) provisionally, unless and until the copyright holder explicitly and finally terminates your license, and (b) permanently, if the copyright holder fails to notify you of the violation by some reasonable means prior to 60 days after the cessation.

Moreover, your license from a particular copyright holder is reinstated permanently if the copyright holder notifies you of the violation by some reasonable means, this is the first time you have received notice of violation of this License (for any work) from that copyright holder, and you cure the violation prior to 30 days after your receipt of the notice.

Termination of your rights under this section does not terminate the licenses of parties who have received copies or rights from you under this License. If your rights have been terminated and not permanently reinstated, receipt of a copy of some or all of the same material does not give you any rights to use it.

C.11 FUTURE REVISIONS OF THIS LICENSE

The Free Software Foundation may publish new, revised versions of the GNU Free Documentation License from time to time. Such new versions will be similar in spirit to the present version, but may differ in detail to address new problems or concerns. See http://www.gnu.org/copyleft/.
Each version of the License is given a distinguishing version number. If the Document specifies that a particular numbered version of this License “or any later version” applies to it, you have the option of following the terms and conditions either of that specified version or of any later version that has been published (not as a draft) by the Free Software Foundation. If the Document does not specify a version number of this License, you may choose any version ever published (not as a draft) by the Free Software Foundation. If the Document specifies that a proxy can decide which future versions of this License can be used, that proxy’s public statement of acceptance of a version permanently authorizes you to choose that version for the Document.

C.12 RELICENSING

“Massive Multiauthor Collaboration Site” (or “MMC Site”) means any World Wide Web server that publishes copyrightable works and also provides prominent facilities for anybody to edit those works. A public wiki that anybody can edit is an example of such a server. A “Massive Multiauthor Collaboration” (or “MMC”) contained in the site means any set of copyrightable works thus published on the MMC site.

“CC-BY-SA” means the Creative Commons Attribution-Share Alike 3.0 license published by Creative Commons Corporation, a not-for-profit corporation with a principal place of business in San Francisco, California, as well as future copyleft versions of that license published by that same organization.

“Incorporate” means to publish or republish a Document, in whole or in part, as part of another Document.

An MMC is “eligible for relicensing” if it is licensed under this License, and if all works that were first published under this License somewhere other than this MMC, and subsequently incorporated in whole or in part into the MMC, (1) had no cover texts or invariant sections, and (2) were thus incorporated prior to November 1, 2008.

The operator of an MMC Site may republish an MMC contained in the site under CC-BY-SA on the same site at any time before August 1, 2009, provided the MMC is eligible for relicensing.

C.13 ADDENDUM: How to use this License for your documents

To use this License in a document you have written, include a copy of the License in the document and put the following copyright and license notices just after the title page:

```
Copyright (c) YEAR YOUR NAME.
Permission is granted to copy, distribute and/or modify this document
under the terms of the GNU Free Documentation License, Version 1.3
or any later version published by the Free Software Foundation;
with no Invariant Sections, no Front-Cover Texts, and no Back-Cover Texts.
A copy of the license is included in the section entitled "GNU
Free Documentation License".
```

If you have Invariant Sections, Front-Cover Texts and Back-Cover Texts, replace the “with…Texts.” line with this:

```
with the Invariant Sections being LIST THEIR TITLES, with the
Front-Cover Texts being LIST, and with the Back-Cover Texts being LIST.
```

If you have Invariant Sections without Cover Texts, or some other combination of the three, merge those two alternatives to suit the situation.

If your document contains nontrivial examples of program code, we recommend releasing these examples in parallel under your choice of free software license, such as the GNU General Public License, to permit their use in free software.