

# **sysmocom**

sysmocom - s.f.m.c. GmbH



# **osmocom**

## **OsmoPCU User Manual**

by Harald Welte

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The AsciiDoc source code of this manual can be found at <http://git.osmocom.org/osmo-gsm-manuals/>

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## Foreword

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

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

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

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

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

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

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

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

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

## Acknowledgements

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

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

- Jan Luebbe, Stefan Schmidt, Daniel Willmann, Pablo Neira, Nico Golde, Kevin Redon, Ingo Albrecht, Alexander Huemer, Alexander Chemeris, Max Suraev, Tobias Engel, Jacob Erlbeck, Ivan Kluchnikov

May the source be with you!

— Harald Welte, Osmocom.org and OpenBSC founder, January 2016.

## 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.

## 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.

## 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.

## 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.

## 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.

## Legal disclaimers

### 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!

---

### 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.

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## Documentation License

Please see Appendix C for further information.

## Introduction

### 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

### Getting assistance

If you do have a support package / contract with sysmocom (or want to get one), please contact [support@sysmocom.de](mailto: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.

## Overview

### About OsmoPCU

OsmoPCU is the Osmocom implementation of the GPRS PCU (Packet Control Unit) element inside the GPRS network.

The OsmoPCU is co-located within the BTS and connects to OsmoBTS via its PCU socket interface.

On the other side, OsmoPCU is connected via the Gb interface to the SGSN.

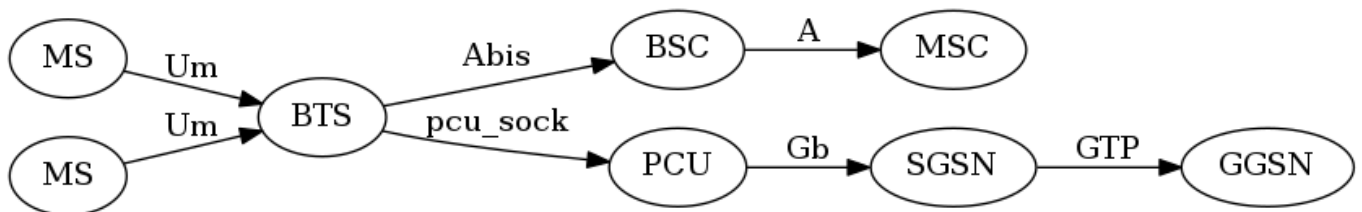


Figure 1: GPRS network architecture with PCU in BTS

### Software Components

OsmoPCU consists of a variety of components, including

- Gb interface (NS/BSSGP protocol)
- `pcu_sock` interface towards OsmoBTS
- TBF management for uplink and downlink TBF
- RLC/MAC protocol implementation
- per-MS context for each MS currently served
- CSN.1 encoding/decoding routines

### Gb Implementation

OsmoPCU implements the ETSI/3GPP specified Gb interface, including TS 08.16 (NS), TS 08.18 (BSSGP) protocols. As transport layer for NS, it supports NS/IP (NS encapsulated in UDP/IP).

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 OsmoPCU, OsmoGbProxy as well as OsmoSGSN.

### `pcu_sock` Interface to OsmoBTS

The interface towards OsmoBTS is called `pcu_sock` and implemented as a set of non-standardized primitives over a unix domain socket. The default file system path for this socket is `/tmp/pcu_bts`.

The PCU socket can be changed on both OsmoBTS and OsmoPCU to a different file/path name, primarily to permit running multiple independent BTS+PCU pairs on a single Linux machine without having to use filesystem namespaces or other complex configurations.

---

#### Note

If you change the PCU socket path on OsmoBTS by means of the `pcu-socket` VTY configuration command, you must ensure to make the identical change on the OsmoPCU side.

---

## Running OsmoPCU

The OsmoPCU executable (`osmo-pcu`) offers the following command-line options:

### SYNOPSIS

**osmo-pcu** [-hl-V] [-D] [-c *CONFIGFILE*] [-r *PRIO*] [-m *MCC*] [-n *MNC*] [-i A.B.C.D]

### OPTIONS

**-h, --help**

Print a short help message about the supported options

**-V, --version**

Print the compile-time version number of the program

**-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-pcu.cfg` in the current working directory.

**-r, --realtime *PRIO***

Enable use of the Linux kernel realtime priority scheduler with the specified priority. It is recommended you use this option on low-performance embedded systems or systems that encounter high non-GSM/GPRS load.

**-m, --mcc *MCC***

Use the given MCC instead of that provided by BTS via PCU socket

**-n, --mnc *MNC***

Use the given MNC instead of that provided by BTS via PCU socket

**-i, --gsmtap-ip *A.B.C.D***

Send Um interface trace via GSMTAP to specified IP address

## 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 1: VTY Parameter Patterns

Pattern	Example	Explanation
A.B.C.D	127.0.0.1	An IPv4 address
TEXT	example01	A single string without any spaces, tabs
.TEXT	Some information	A line of text
(OptionA OptionB OptionC)	OptionA	A choice between a list of available options
<0-10>	5	A number from a range

## 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.

## 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.

## 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.

---

## 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> ❶
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
```

❶ 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 ❶
  version          Displays program version
  online-help      Online help
  history          Display the session command history
  cs7              ITU-T Signaling System 7
  logging          Show current logging configuration
  alarms           Show current logging configuration
  talloc-context   Show talloc memory hierarchy
  stats            Show statistical values
  asciidoc         Asciidoc generation
  rate-counters    Show all rate counters
  fsm              Show information about finite state machines
  fsm-instances    Show information about finite state machine instances
  sgs-connections  Show SGs interface connections / MMEs
  subscriber       Operations on a Subscriber
  bsc              BSC
  connection       Subscriber Connections
  transaction       Transactions
  statistics        Display network statistics
  sms-queue        Display SMSQueue statistics
  smpp             SMPP Interface
```

❶ 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".

#### 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 ❶
show      sms      subscriber
```

❶ 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 ❶
version      online-help history      cs7          logging      alarms
talloc-context stats      asciidoc   rate-counters fsm          fsm-instances
sgs-connections subscriber bsc          connection transaction statistics
sms-queue smpp
```

❶ Type <tab> here.

## The `list` command

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

### Example: Typing `list` at start of OsmoMSC VIEW node prompt

```
OsmoMSC> list
  show version
  show online-help
  list
  exit
  help
  enable
  terminal length <0-512>
  terminal no length
  who
  show history
  show cs7 instance <0-15> users
  show cs7 (sua|m3ua|ipa) [<0-65534>]
  show cs7 instance <0-15> asp
  show cs7 instance <0-15> as (active|all|m3ua|sua)
  show cs7 instance <0-15> sccp addressbook
  show cs7 instance <0-15> sccp users
  show cs7 instance <0-15> sccp ssn <0-65535>
  show cs7 instance <0-15> sccp connections
  show cs7 instance <0-15> sccp timers
  logging enable
  logging disable
  logging filter all (0|1)
  logging color (0|1)
  logging timestamp (0|1)
  logging print extended-timestamp (0|1)
  logging print category (0|1)
  logging print category-hex (0|1)
  logging print level (0|1)
  logging print file (0|1|basename) [last]
  logging set-log-mask MASK
  logging level (rll|cc|mm|rr|mncc|pag|msc|mgcp|ho|db|ref|ctrl|smpp|ranap|vlr|iucs|bssap| ←
    sgs|lglobal|llapd|linp|lmux|lmi|lmib|lsms|lctrl|lgtp|lstats|lgsup|loap|lss7|lsccp|lsua ←
    |lm3ua|lmgcp|ljibuf|lrspro) (debug|info|notice|error|fatal)
  logging level set-all (debug|info|notice|error|fatal)
  logging level force-all (debug|info|notice|error|fatal)
  no logging level force-all
  show logging vty
  show alarms
  show talloc-context (application|all) (full|brief|DEPTH)
  show talloc-context (application|all) (full|brief|DEPTH) tree ADDRESS
  show talloc-context (application|all) (full|brief|DEPTH) filter REGEXP
  show stats
  show stats level (global|peer|subscriber)
  show asciidoc counters
  show rate-counters
  show fsm NAME
  show fsm all
  show fsm-instances NAME
  show fsm-instances all
  show sgs-connections
  show subscriber (msisdn|extension|imsi|tmsi|id) ID
  show subscriber cache
  show bsc
  show connection
  show transaction
  sms send pending
```

```

sms delete expired
subscriber create imsi ID
subscriber (msisdn|extension|imsi|tmsi|id) ID sms sender (msisdn|extension|imsi|tmsi|id) ←
    SENDER_ID send .LINE
subscriber (msisdn|extension|imsi|tmsi|id) ID silent-sms sender (msisdn|extension|imsi| ←
    tmsi|id) SENDER_ID send .LINE
subscriber (msisdn|extension|imsi|tmsi|id) ID silent-call start (any|tch/f|tch/any|sdccch)
subscriber (msisdn|extension|imsi|tmsi|id) ID silent-call stop
subscriber (msisdn|extension|imsi|tmsi|id) ID ussd-notify (0|1|2) .TEXT
subscriber (msisdn|extension|imsi|tmsi|id) ID ms-test close-loop (a|b|c|d|e|f|i)
subscriber (msisdn|extension|imsi|tmsi|id) ID ms-test open-loop
subscriber (msisdn|extension|imsi|tmsi|id) ID paging
show statistics
show sms-queue
logging filter imsi IMSI
show smpp esme

```

---

**Tip**

Remember, the list of available commands will change significantly depending on the Osmocom program you are accessing, its software version and the current node you're at. Compare the above example of the OsmoMSC *VIEW* node with the list of the OsmoMSC *NETWORK* config node:

---

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

```

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

```

## 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.

## Log categories

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

## Log levels

For each of the log categories (see Section 7.1), you can set an independent log level, controlling the level of verbosity. Log levels include:

### **fatal**

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

### **error**

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

### **notice**

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

### **info**

Some information about normal/regular system activity is provided.

### **debug**

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

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

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

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

Afterwards you can adjust specific categories as usual.

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

## 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 can not 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.

## 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`

## Log targets

Each of the log targets represent certain destination for log messages. It can be configured independently by selecting levels (see Section 7.2) for categories (see Section 7.1) as well as filtering (see Section 7.4) and other options like `logging timestamp` for example.

### 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 7.1 for more details on categories and Section 7.2 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 7.4.

---

**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`

### 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.

### Logging via gsmmap

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 gsmmap 192.168.2.3
OsmoBSC(config-log)#
```

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



Figure 2: Wireshark with logs delivered over GSMTAP

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

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

### 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.

---

**Note**

libosmocore provides file close-and-reopen support by SIGHUP, as used by popular log file rotating solutions such as <https://github.com/logrotate/logrotate> found in most GNU/Linux distributions.

---

## 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.

---

## 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)#
```

## Configuring OsmoPCU

Contrary to other network elements (like OsmoBSC, OsmoNITB), the OsmoPCU has a relatively simple minimum configuration. This is primarily because most of the PCU configuration happens indirectly from the BSC, who passes the configuration over A-bis OML via OsmoBTS and its PCU socket into OsmoPCU.

A minimal OsmoPCU configuration file is provided below for your reference:

### Example: Minimal OsmoPCU configuration file (osmo-pcu.cfg)

```
pcu
flow-control-interval 10 ❶
cs 2 ❷
alloc-algorithm dynamic ❸
alpha 0 ❹
gamma 0
```

- ❶ send a BSSGP flow-control PDU every 10 seconds
- ❷ start a TBF with the initial coding scheme 2
- ❸ dynamically chose between single-slot or multi-slot TBF allocations depending on system load
- ❹ disable MS power control loop

However, there are plenty of tuning parameters for people interested to optimize PCU throughput or latency according to their requirements.

## Configuring the Coding Schemes and Rate Adaption

The BSC includes a bit-mask of permitted [E]GPRS coding schemes as part of the A-bis OML configuration. This is passed from the BTS via the PCU socket into OsmoPCU.

Some additional parameters can be set as described below.

### Initial Coding Scheme

You can use the `cs <1-4> [<1-4>]` command at the `pcu VTY config` node to set the initial GPRS coding scheme to be used. The optional second value allows to specify a different initial coding scheme for uplink.

### Maximum Coding Scheme

You can use the `cs max <1-4> [<1-4>]` command at the `pcu VTY config` node to set the maximum coding scheme that should be used as part of the rate adaption.

### Rate Adaption Error Thresholds

You can use the `cs threshold <0-100> <0-100>` command at the `pcu VTY config` node to determine the upper and lower limit for the error rate percentage to use in the rate adaption. If the upper threshold is reached, a lower coding scheme is chosen, and if the lower threshold is reached, a higher coding scheme is chosen.

### Rate Adaption Link Quality Thresholds

You can use the `cs link-quality-ranges cs1 <0-35> cs2 <0-35> <0-35> cs3 <0-35> <0-35> cs4 <0-35>` command at the `pcu VTY config` node to tune the link quality ranges for the respective coding schemes.

### Data Size based CS downgrade Threshold

You can use the `cs downgrade-threshold <1-10000>` command at the `pcu VTY config` node to ask the PCU to down-grade the coding scheme if less than the specified number of octets are left to be transmitted.

## Miscellaneous Configuration / Tuning Parameters

### Downlink TBF idle time

After a down-link TBF is idle (all data in the current LLC downlink queue for the MS has been transmitted), we can keep the TBF established for a configurable time. This avoids having to go through a new one or two phase TBF establishment once the next data for downlink arrives.

You can use the `dl-tbf-idle-time <1-5000>` to specify that time in units of milli-seconds. The default is 2 seconds.

## MS idle time

Using the `ms-idle-time <1-7200>` command at the `pcu` VTY config node you can configure the number of seconds for which the PCU should keep the MS data structure alive before releasing it if there are no active TBF for this MS.

The OsmoPCU default value is 60 seconds, which is slightly more than what 3GPP TS 24.008 recommends for T3314 (44s).

The MS data structure only consumes memory in the PCU and does not require any resources of the air interface.

## Forcing two-phase access

If the MS is using a single-phase access, you can still force it to use a two-phase access using the `two-phase-access` VTY configuration command at the `pcu` VTY config node.

## Configuring BSSGP flow control

BSSGP between SGSN and PCU contains a two-level nested flow control mechanism:

1. one global flow control instance for the overall (downlink) traffic from the SGSN to this PCU
2. a per-MS flow control instance for each individual MS served by this PCU

Each of the flow control instance is implemented as a TBF (token bucket filter).

### Normal BSSGP Flow Control Tuning parameters

You can use the following commands at the `pcu` VTY config node to tune the BSSGP flow control parameters:

#### **flow-control-interval <1-10>**

configure the interval (in seconds) between subsequent flow control PDUs from PCU to SGSN

#### **flow-control bucket-time <1-65534>**

set the target downlink maximum queueing time in centi-seconds. The PCU will attempt to adjust the advertised bucket size to match this target.

### Extended BSSGP Flow Control Tuning parameters

There are some extended flow control related parameters at the `pcu` VTY config node that override the automatic flow control as specified in the BSSGP specification. Use them with care!

#### **flow-control force-bvc-bucket-size <1-6553500>**

force the BVC (global) bucket size to the given number of octets

#### **flow-control force-bvc-leak-rate <1-6553500>**

force the BVC (global) bucket leak rate to the given number of bits/s

#### **flow-control force-ms-bucket-size <1-6553500>**

force the per-MS bucket size to the given number of octets

#### **flow-control force-ms-leak-rate <1-6553500>**

force the per-MS bucket leak rate to the given number of bits/s

## Configuring LLC queue

The downlink LLC queue in the PCU towards the MS can be tuned with a variety of parameters at the `pcu` VTY config node, depending on your needs.

### **queue lifetime <1-65534>**

Each downlink LLC PDU is assigned a lifetime by the SGSN, which is respected by the PDU **unless** you use this command to override the PDU lifetime with a larger value (in centi-seconds)

### **queue lifetime infinite**

Never drop LLC PDUs, i.e. give them an unlimited lifetime.

### **queue hysteresis <1-65535>**

When the downlink LLC queue is full, the PCU starts dropping packets. Using this parameter, we can set the lifetime hysteresis in centi-seconds, i.e. it will continue discarding until "lifetime - hysteresis" is reached.

### **queue codel**

Use the *CoDel* (Controlled Delay) scheduling algorithm, which is designed to overcome buffer bloat. It will use a default interval of 4 seconds.

### **queue codel interval <1-1000>**

Use the *CoDel* (Controlled Delay) scheduling algorithm, which is designed to overcome buffer bloat. Use the specified interval in centi-seconds.

### **queue idle-ack-delay <1-65535>**

Delay the request for an ACK after the last downlink LLC frame by the specified amount of centi-seconds.

## Configuring MS power control

GPRS MS power control works completely different than the close MS power control loop in circuit-switched GSM.

Rather than instructing the MS constantly about which transmit power to use, some parameters are provided to the MS by which the MS-based power control algorithm is tuned.

See 3GPP TS 05.08 for further information on the algorithm and the parameters.

You can set those parameters at the `pcu` VTY config node as follows:

### **alpha <0-10>**

Alpha parameter for MS power control in units of 0.1. Make sure to set the alpha value at System Information 13 (in the BSC), too!

### **gamma <0-62>**

Set the gamma parameter for MS power control in units of dB.

## Enabling EGPRS

If you would like to test the currently (experimental) EGPRS support of OsmoPCU, you can enable it using the `egprs` command at the `pcu` VTY config node.



### **Warning**

EGPRS functionality is highly experimental at the time of this writing. Please only use if you actively would like to participate in the OsmoPCU EGPRS development and/or testing. You will also need an EGPRS capable OsmoBTS+PHY, which means `osmo-bts-sysmo` or `osmo-bts-litecell115` with their associated PHY.

## Counters

These counters and their description based on Osmo-PCU 0.4.0.4-8d55 (Osmo-PCU).



Table 2: bssgp:bss\_ctx - BSSGP Peer Statistics

Name	Reference	Description
packets:in	[?]	Packets at BSSGP Level ( In)
packets:out	[?]	Packets at BSSGP Level (Out)
bytes:in	[?]	Bytes at BSSGP Level ( In)
bytes:out	[?]	Bytes at BSSGP Level (Out)
blocked	[?]	BVC Blocking count
discarded	[?]	BVC LLC Discarded count
status	[?]	BVC Status count

Table 3: ns:nsvc - NSVC Peer Statistics

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

Table 4: ns:nsvc - NSVC Peer Statistics

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

Table 5: bts - BTS Statistics

Name	Reference	Description
tbf:dl:alloc	[?]	TBF DL Allocated
tbf:dl:freed	[?]	TBF DL Freed

Table 5: (continued)

Name	Reference	Description
tbf:dl:aborted	[?]	TBF DL Aborted
tbf:ul:alloc	[?]	TBF UL Allocated
tbf:ul:freed	[?]	TBF UL Freed
tbf:ul:aborted	[?]	TBF UL Aborted
tbf:reused	[?]	TBF Reused
tbf:alloc:algo-a	[?]	TBF Alloc Algo A
tbf:alloc:algo-b	[?]	TBF Alloc Algo B
tbf:failed:egprs-only	[?]	TBF Failed EGPRS-only
rlc:sent	[?]	RLC Sent
rlc:resent	[?]	RLC Resent
rlc:restarted	[?]	RLC Restarted
rlc:stalled	[?]	RLC Stalled
rlc:nacked	[?]	RLC Nacked
rlc:final_block_resent	[?]	RLC Final Blk resent
rlc:ass:timeout	[?]	RLC Assign Timeout
rlc:ass:failed	[?]	RLC Assign Failed
rlc:ack:timeout	[?]	RLC Ack Timeout
rlc:ack:failed	[?]	RLC Ack Failed
rlc:rel:timeout	[?]	RLC Release Timeout
rlc:late-block	[?]	RLC Late Block
rlc:sent-dummy	[?]	RLC Sent Dummy
rlc:sent-control	[?]	RLC Sent Control
rlc:dl_bytes	[?]	RLC DL Bytes
rlc:dl_payload_bytes	[?]	RLC DL Payload Bytes
rlc:ul_bytes	[?]	RLC UL Bytes
rlc:ul_payload_bytes	[?]	RLC UL Payload Bytes
decode:errors	[?]	Decode Errors
sba:allocated	[?]	SBA Allocated
sba:freed	[?]	SBA Freed
sba:timeout	[?]	SBA Timeout
llc:timeout	[?]	Timeout Frames
llc:dropped	[?]	Dropped Frames
llc:scheduled	[?]	Scheduled Frames
llc:dl_bytes	[?]	RLC encapsulated PDUs
llc:ul_bytes	[?]	full PDUs received
rach:requests	[?]	RACH requests
11bit_rach:requests	[?]	11BIT_RACH requests
spb:uplink_first_segment	[?]	First seg of UL SPB
spb:uplink_second_segment	[?]	Second seg of UL SPB
spb:downlink_first_segment	[?]	First seg of DL SPB
spb:downlink_second_segment	[?]	Second seg of DL SPB
immediate:assignment_UL	[?]	Immediate Assign UL
immediate:assignment_rej	[?]	Immediate Assign Rej
immediate:assignment_DL	[?]	Immediate Assign DL
channel:request_description	[?]	Channel Request Desc
pkt:ul_assignment	[?]	Packet UL Assignment
pkt:access_reject	[?]	Packet Access Reject
pkt:dl_assignment	[?]	Packet DL Assignment
ul:control	[?]	UL control Block
ul:assignment_poll_timeout	[?]	UL Assign Timeout
ul:assignment_failed	[?]	UL Assign Failed
dl:assignment_timeout	[?]	DL Assign Timeout
dl:assignment_failed	[?]	DL Assign Failed
pkt:ul_ack_nack_timeout	[?]	PUAN Poll Timeout

Table 5: (continued)

Name	Reference	Description
pkt:ul_ack_nack_failed	[?]	PUAN poll Failed
pkt:dl_ack_nack_timeout	[?]	PDAN poll Timeout
pkt:dl_ack_nack_failed	[?]	PDAN poll Failed
gprs:downlink_cs1	[?]	CS1 downlink
gprs:downlink_cs2	[?]	CS2 downlink
gprs:downlink_cs3	[?]	CS3 downlink
gprs:downlink_cs4	[?]	CS4 downlink
egprs:downlink_mcs1	[?]	MCS1 downlink
egprs:downlink_mcs2	[?]	MCS2 downlink
egprs:downlink_mcs3	[?]	MCS3 downlink
egprs:downlink_mcs4	[?]	MCS4 downlink
egprs:downlink_mcs5	[?]	MCS5 downlink
egprs:downlink_mcs6	[?]	MCS6 downlink
egprs:downlink_mcs7	[?]	MCS7 downlink
egprs:downlink_mcs8	[?]	MCS8 downlink
egprs:downlink_mcs9	[?]	MCS9 downlink
gprs:uplink_cs1	[?]	CS1 Uplink
gprs:uplink_cs2	[?]	CS2 Uplink
gprs:uplink_cs3	[?]	CS3 Uplink
gprs:uplink_cs4	[?]	CS4 Uplink
egprs:uplink_mcs1	[?]	MCS1 Uplink
egprs:uplink_mcs2	[?]	MCS2 Uplink
egprs:uplink_mcs3	[?]	MCS3 Uplink
egprs:uplink_mcs4	[?]	MCS4 Uplink
egprs:uplink_mcs5	[?]	MCS5 Uplink
egprs:uplink_mcs6	[?]	MCS6 Uplink
egprs:uplink_mcs7	[?]	MCS7 Uplink
egprs:uplink_mcs8	[?]	MCS8 Uplink
egprs:uplink_mcs9	[?]	MCS9 Uplink

## NSVC Peer Statistics .ns.nsvc - NSVC Peer Statistics

Name	Reference	Description	Unit
alive.delay	[?]	ALIVE response time	ms

## NSVC Peer Statistics .ns.nsvc - NSVC Peer Statistics

Name	Reference	Description	Unit
alive.delay	[?]	ALIVE response time	ms

## BTS Statistics .bts - BTS Statistics

Name	Reference	Description	Unit
ms.present	[?]	MS Present	

Table 6: ungrouped osmo counters

Name	Reference	Description
------	-----------	-------------

## 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.

### Gb interface configuration

#### 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 ❶
OsmoSGSN(config-ns) # encapsulation udp local-port 23000 ❷
```

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

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

#### NS-over-FR-GRE configuration

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

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

##### Example: GPRS NS-over-FR-GRE configuration

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

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

### NS Timer configuration

The NS protocol features a number of configurable timers.

Table 7: List of configurable NS timers

tns-block	(un)blocking timer timeout (secs)
tns-block-retries	(un)blocking timer; number of retries
tns-reset	reset timer timeout (secs)
tns-reset-retries	reset timer; number of retries
tns-test	test timer timeout (secs)
tns-alive	alive timer timeout(secs)
tns-alive-retries	alive timer; number of retries

## Examining Gb interface status

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

### Example: Inspecting NS state

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

### Example: Inspecting NS statistics

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

### Example: Inspecting BSSGP state

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

FIXME: show nse

## FIXME

### 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.

## Gb interface logging filters

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

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

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

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

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

## 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

**dnixload**

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* [[itu-t-q711](#)])

**SDCCH**

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

**SDK**

Software Development Kit

**SGs**

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

**SGSN**

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

**SIGTRAN**

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

**SIM**

Subscriber Identity Module; small chip card storing subscriber identity

**Site**

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

**SMPP**

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

**SMSC**

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

**SS7**

Signaling System No. 7; Classic digital telephony signaling system

**SS**

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

**SSH**

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

**SSN**

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

**STP**

Signaling Transfer Point; A Router in SS7 Networks

**SUA**

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

**syslog**

System logging service of UNIX-like operating systems

**System Information**

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

**TCH**

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

**TCP**

Transmission Control Protocol; (*IETF RFC 793* [\[ietf-rfc793\]](#))

**TFTP**

Trivial File Transfer Protocol; (*IETF RFC 1350* [\[ietf-rfc1350\]](#))

**TRX**

Transceiver; element of a BTS serving a single carrier

**TS**

Technical Specification

**u-Boot**

Boot loader used in various embedded systems

**UBI**

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

**UBL**

Initial bootloader loaded by the TI Davinci SoC

**UDP**

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

**UICC**

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

**Um interface**

U mobile; Radio interface between MS and BTS

**uplink**

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

**USIM**

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

**USSD**

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

**VCTCXO**

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

**VLR**

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

**VPLMN**

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

**VTY**

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

## 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 8: TCP/UDP port numbers

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

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