sysmocom

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OsmoPCU User Manual

by Harald Welte

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

HISTORY			
NUMBER	DATE	DESCRIPTION	NAME
1	February 13, 2016	Initial version.	HW

Contents

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 and Free / Open Source software implementations.

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

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

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

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

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

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

1.1 Acknowledgements

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

- Dieter Spaar for being the most amazing reverse engineer I've met in my career
- Holger Freyther for his many code contributions and for shouldering a lot of the maintenance work, setting up Jenkins - and being crazy enough to co-start sysmocom as a company with me ;)
- Andreas Eversberg for taking care of Layer2 and Layer3 of OsmocomBB, and for his work on OsmoBTS and OsmoPCU
- Sylvain Munaut for always tackling the hardest problems, particularly when it comes closer to the physical layer
- Chaos Computer Club for providing us a chance to run real-world deployments with tens of thousands of subscribers every year
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- sysmocom, for hosting and funding a lot of Osmocom development, the annual Osmocom Developer Conference and releasing this manual.

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

May the source be with you!

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

1.2 Endorsements

This version of the manual is endorsed by Harald Welte as the official version of the manual.

While the GFDL license (see Appendix C) permits anyone to create and distribute modified versions of this manual, such modified versions must remove the above endorsement.

2 Preface

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

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

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

2.1 FOSS lives by contribution!

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

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

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

We're looking forward to receiving your contributions.

2.2 Osmocom and sysmocom

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

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

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

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

2.3 Corrections

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

2.4 Legal disclaimers

2.4.1 Spectrum License

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

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

2.4.2 Software License

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

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

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

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

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

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2.4.5 Documentation License

Please see Appendix C for further information.

3 Introduction

3.1 Required Skills

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

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

If you do not share an existing background in GSM network architecture, 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 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.

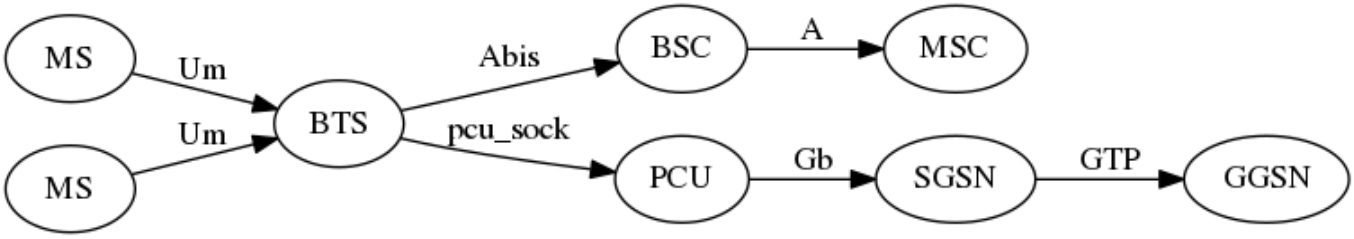

Figure 1: GPRS network architecture with PCU in BTS

4.2 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

4.2.1 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.

4.2.2 `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 OmsoBTS 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.

---

5 Running OsmoPCU

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

5.1 SYNOPSIS

osmo-pcu [-hl-V] [-D] [-c *CONFIGFILE*] [-r *PRIO*] [-m *MCC*] [-n *MNC*]

5.2 OPTIONS

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

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

-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

6 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

6.1 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.

6.2 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.

6.3 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 OsmoNITB VTY. They will work in similar fashion on the other VTY interfaces, while the node structure will differ in each program.

6.3.1 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 OsmoNITB prompt

```
OpenBSC> 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 log message to this terminal
  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

```
OpenBSC> show ❶
  version       Displays program version
  online-help   Online help
  history       Display the session command history
  network       Display information about a GSM NETWORK
  bts           Display information about a BTS
  trx           Display information about a TRX
  timeslot      Display information about a TS
  lchan         Display information about a logical channel
  paging        Display information about paging requests of a BTS
  paging-group  Display the paging group
  logging       Show current logging configuration
  alarms        Show current logging configuration
  stats         Show statistical values
  e1_driver     Display information about available E1 drivers
  e1_line       Display information about a E1 line
  e1_timeslot   Display information about a E1 timeslot
  subscriber    Operations on a Subscriber
  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 `network` object and type `?` again:

Example: Typing ? after show network

```
OpenBSC> show network
  <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".

6.3.2 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

```
OpenBSC> s❶
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

```
OpenBSC> show ❶
version    online-help history    network    bts        trx
timeslot   lchan      paging     paging-group logging    alarms
stats      e1_driver  e1_line    e1_timeslot subscriber statistics
sms-queue  smpp
```

❶ Type `<tab>` here.

6.3.3 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 OsmoNITB VIEW node prompt

```
OpenBSC> list
  show version
  show online-help
  list
  exit
  help
  enable
  terminal length <0-512>
  terminal no length
  who
  show history
  show network
  show bts [<0-255>]
  show trx [<0-255>] [<0-255>]
  show timeslot [<0-255>] [<0-255>] [<0-7>]
  show lchan [<0-255>] [<0-255>] [<0-7>] [lchan_nr]
  show lchan summary [<0-255>] [<0-255>] [<0-7>] [lchan_nr]
  show paging [<0-255>]
  show paging-group <0-255> IMSI
  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 set-log-mask MASK
  logging level (all|rll|cc|mm|rr|rsl|nm|mncc|pag|meas|sccp|msc|mgcp|ho|db|ref|gprs|ns| ↩
      bssgp|llc|sndcp|nat|ctrl|smpp|filter|lglobal|llapd|linp|lmux|lmi|lmib|lsms|lctrl|lgtp| ↩
      lstats) (debug|info|notice|error|fatal)
  show logging vty
  show alarms
  show stats
  show stats level (global|peer|subscriber)
  show e1_driver
  show e1_line [line_nr] [stats]
  show e1_timeslot [line_nr] [ts_nr]
  show subscriber (extension|imsi|tmsi|id) ID
  show subscriber cache
  sms send pending
  subscriber create imsi ID
  subscriber (extension|imsi|tmsi|id) ID sms sender (extension|imsi|tmsi|id) SENDER_ID send ↩
       .LINE
  subscriber (extension|imsi|tmsi|id) ID silent-sms sender (extension|imsi|tmsi|id)  ↩
      SENDER_ID send .LINE
  subscriber (extension|imsi|tmsi|id) ID silent-call start (any|tch/f|tch/any|sdcch)
  subscriber (extension|imsi|tmsi|id) ID silent-call stop
  subscriber (extension|imsi|tmsi|id) ID ussd-notify (0|1|2) .TEXT
  subscriber (extension|imsi|tmsi|id) ID update
  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 OsmoNITB *VIEW* node with the list of the OsmoNITB *TRX* config node:

Example: Typing list at start of OsmoNITB TRX config node prompt

```
OpenBSC(config-net-bts-trx)# list
  help
  list
  write terminal
  write file
  write memory
  write
  show running-config
  exit
  end
  arfcn <0-1023>
  description .TEXT
  no description
  nominal power <0-100>
  max_power_red <0-100>
  rsl e1 line E1_LINE timeslot <1-31> sub-slot (0|1|2|3|full)
  rsl e1 tei <0-63>
  rf_locked (0|1)
  timeslot <0-7>
```

7 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.

7.1 Log categories

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

7.2 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.

7.3 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 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.

7.4 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`

7.5 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.

7.5.1 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 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`

7.5.2 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.

7.5.3 Logging via gsmtap

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

It's configured as follows:

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

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

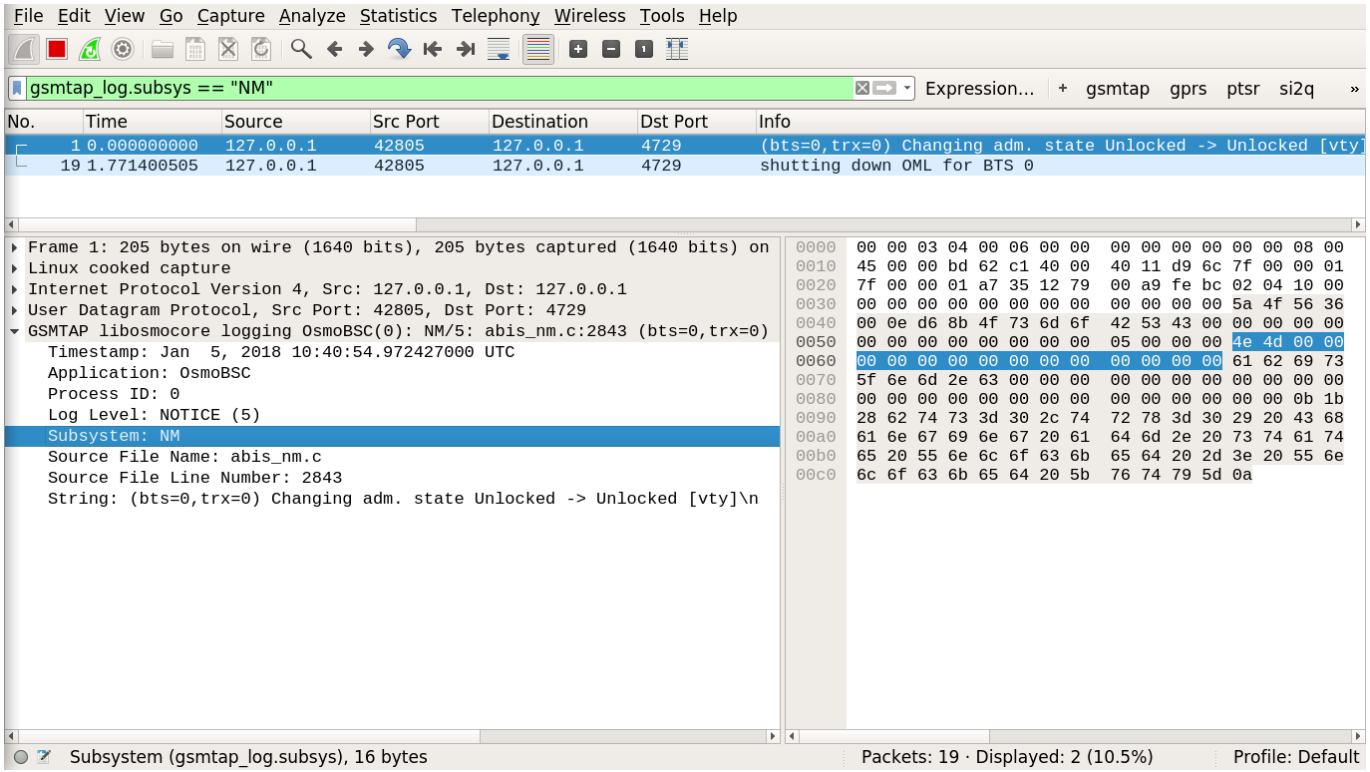

Figure 2: Wireshark with logs delivered over GSMTAP

Note: the logs are also duplicated to stderr when GSMTAP logging is configured because stderr is the default log target which is initialized automatically. To descrease 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
```

7.5.4 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.

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.

7.5.5 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.

7.5.6 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)#
```


8 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 configuation 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.

8.1 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.

8.1.1 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.

8.1.2 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.

8.1.3 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 sheme is chosen, and if the lower threshold is reached, a higher coding scheme is chosen.

8.1.4 Rate Adation 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.

8.1.5 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.

8.2 Miscellaneous Configuration / Tuning Parameters

8.2.1 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.

8.2.2 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.

8.2.3 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.

8.3 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).

8.3.1 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.

8.3.2 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

8.4 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.

8.5 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.

8.6 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
EPGRS 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-litecell15` with their associated PHY.

9 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)

Table 4: (continued)

Name	Reference	Description
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
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:timedout	[?]	RLC Assign Timeout
rlc:ass:failed	[?]	RLC Assign Failed
rlc:ack:timedout	[?]	RLC Ack Timeout
rlc:ack:failed	[?]	RLC Ack Failed
rlc:rel:timedout	[?]	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:timedout	[?]	SBA Timeout
llc:timeout	[?]	Timedout 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

Table 5: (continued)

Name	Reference	Description
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
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

10 Gb interface using libosmogb

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

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

10.1 Gb interface configuration

10.1.1 NS-over-UDP configuration

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

Example: GPRS NS-over-UDP configuration

```
OsmoSGSN(config-ns)# encapsulation udp local-ip 127.0.0.1 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

10.1.2 NS-over-FR-GRE configuration

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

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

Example: GPRS NS-over-FR-GRE configuration

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

10.1.3 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

10.2 Examining Gb interface status

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

Example: Inspecting NS state

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

Example: Inspecting NS statistics

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

10.3 FIXME

10.3.1 Blocking / Unblocking / Resetting NS Virtual Connections

The user can manually perform operations on individual NSVCs:

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

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

10.4 Gb interface logging filters

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

Example: enabling a log filter for a given NSEI

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

Example: enabling a log filter for a given NSVCI

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

11 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

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

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

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

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

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 identifier for the mobile phone

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

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

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

MNO
Mobile Network Operator; operator with physical radio network under his MCC/MNC

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

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

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

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

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

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

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 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

Table 8: (continued)

L4 Protocol	Port Number	Purpose	Software
TCP	4262	Control Interface	osmo-hnbgw
TCP	4263	Control Interface	osmo-gbproxy
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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C.1 PREAMBLE

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