sysmocom

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e1-tracer 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
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Contents

1 Foreword

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

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

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

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

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

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

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

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

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

1.1 Acknowledgements

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

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

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 A) 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 benefiting 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, workarounds
- sharing any modifications to the software you may have made, whether bug fixes or new features, even experimental ones
- providing review of patches
- testing new versions of the related software, either in its current “master” branch or even more experimental feature branches
- sharing your part of the maintenance and/or development work, either by donating developer resources or by (partially) funding those people in the community who do.

We’re looking forward to receiving your contributions.

2.2 Osmocom and sysmocom

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

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

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

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

2.3 Corrections

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

2.4 Legal disclaimers

2.4.1 Spectrum License

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

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

2.4.2 Software License

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

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

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

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

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

2.4.3 Trademarks

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

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2.4.5 Documentation License

Please see Appendix A for further information.

3 Introduction

3.1 Required Skills

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

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

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

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

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

Some of the useful skills we recommend are:

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

3.2 Getting assistance

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

If you don't have a support package / contract, you have the option of using the resources put together by the Osmocom community at https://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.

If you would like to obtain professional/commercial support on Osmocom CNI, you can always reach out to sales@sysmocom.de to discuss your support needs. Purchasing support from sysmocom helps to cover the ongoing maintenance of the Osmocom CNI software stack.

4 e1-tracer Hardware

The e1-tracer Hardware consists of a single circuit board, mechanically either assembled into a desktop enclosure (KOH variant) or into a 3U component carrier module (BGT variant).

Figure 1: e1-tracer BGT variant

Figure 2: e1-tracer KOH variant

It's main building blocks are:

- an iCE40 FPGA
- two E1 Line Interface Unit ICs
- two E1 line interface analog (transformers, biasing networks and ESD protection)

4.1 Schematics / Board Layout

As e1-tracer is an OSHW (Open Source Hardware) project, the full schematics and design files are publicly available.

The design files in EAGLE format are available at https://git.osmocom.org/osmo-e1-hardware/tree/hardware/e1-tracer

PDF rendered schematics are available at https://gitea.osmocom.org/retronetworking/osmo-e1-hardware/raw/branch/master/hardware/-e1-tracer/e1-tracer_sch.pdf

4.2 Connectors / LEDs

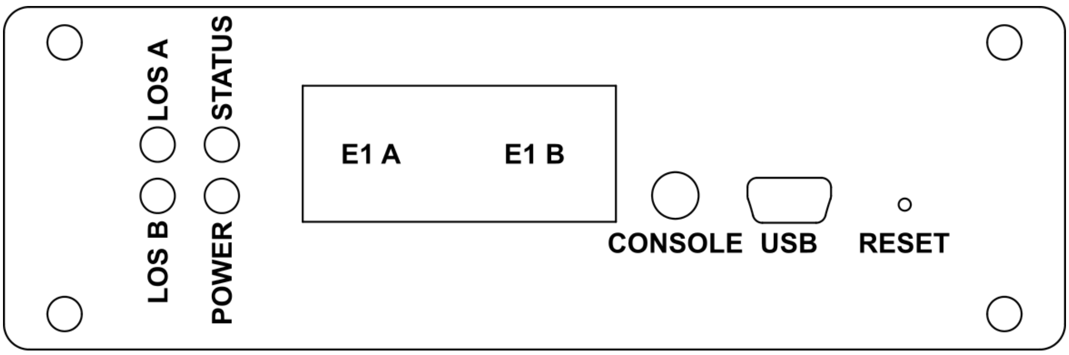

Figure 3: front side of e1-tracer

From left to right, there are the following LED indcators, connectors and buttons:

- LED block with 4 LED’s
- Primary E1 Port (E1 A)
- Secondary E1 Port (E1 B)
- Serial Console Connector
- USB Connector
- Bootloader Button

4.2.1 LEDs

The left-most column of LEDs consists of two red **LOS LEDs**. They indicate a LOS (Loss Of Signal) condition for the respective E1 direction. It is normal for the LEDs to be illuminated even in presence of a valid E1 signal until the host software has fully initialized the firmware for the first time after power-up.

The right column of LEDs consists of two further LEDs:

- a multi-color **STATUS LED** on the top
- a green **POWER LED** on the bottom

The **STATUS LED** is used by the firmware to indicate a variety of status information. Pleas see the firmware documentation in [firmware].

The green **POWER LED** is illuminated as soon as the device has DC power.

4.2.2 J1A and J1B: E1 Interface Connectors

There are two RJ45 connectors next to each other.

Those are the connections for your symmetric 120 Ohms E1 interface circuit. You insert the e1-tracer into your E1 link. The two ports are internally wired straight-through, so you can insert the e1-tracer into your E1 link.

The actual tracing functionality is implemented via a high-impedance tap, which will not disturb the normal E1 communications link. The link remains unaffected even if the e1-tracer is unpowered.

Table 1: Pin-out of RJ45 E1 connectors

Pin	Function (TE)	Function (NT Mode)
1	Pair A	Pair A
2	Pair A	Pair A
3	not used	not used
4	Pair B	Pair B
5	Pair B	Pair B
7	not used	not used
8	not used	not used

Note

E1 cables use RJ45 like Ethernet, but Ethernet cables have a different pin-out. Particularly, you cannot use an Ethernet cross-over cable as an E1 cross-over!

4.2.3 X1: USB Connector

The USB connector is a USB Mini B connector. The e1-tracer uses USB 1.1 full-speed signals. As the e1-tracer is a bus-powered device, 5V DC power is also sourced from this connector.

4.2.4 X2: Serial Console Connector

The serial console is used for development and debugging. It uses an Osmocom-style 2.5mm stereo TRS jack.

The serial console uses 3.3V CMOS logic levels

The serial console uses a rate of 1000000 bps.

The pin-out is as follows:

- Tip: Tx output from PC (Rx input of e1-tracer)
- Ring: Rx input of PC (Tx output of e1-tracer)
- Shield: GND

A compatible cable can be sourced from the sysmocom web-shop at http://shop.sysmocom.de/.

Note that CP2102 based cables require special programming to support the baud rate of 1000000 (as opposed to the more standard 921600).

4.3 Bootloader Button

There is a push-button next to the *USB B connector*. It is recessed to protect against accidental use. You will need to use a paper clip, pen tip or other similar object to push it.

The button, when pressed while power-up, can be used to force booting into the DFU loader in order to recover from a broken firmware installation.

5 e1-tracer Gateware

The e1-tracer *gateware* is where pretty much everything happens, from the E1 Line Interface Unit to the E1 Framer/Deframer, the picoRISCV soft-core running the as well as the USB device peripheral talking to the host PC.

The gateware is stored in binary form on the device-internal non-volatile memory (SPI flash). It is field-upgradeable via USB.

As an OSHW project, all of it is available in source code format at https://git.osmocom.org/osmo-e1-hardware/tree/gateware/e1-tracer

Please use `git clone --recursive` when cloning the git repository so you get all of the sub-modules for the various soft-cores.

6 e1-tracer Firmware

The e1-tracer *firmware* is a small amount of bare-iron software running on the picoRISCV soft-core of the *gateware*.

It mainly consists of drivers for the no2e1 E1 Framer IP core and the no2usb USB Device IP core which are part of the gateware described in Section 5.

6.1 Firmware Upgrade (DFU)

e1-tracer contains support for the USB DFU (Device Firmware Upgrade) standard.

As such, you can use any USB DFU compliant utility to upgrade the firmware of the e1-tracer device.

DFU mode can be entered in two ways:

1. by performing a DFU detach from the normal application firmware (obviously that requires a [still] working firmware present on the device). To do so, please use `dfu-util -e`
2. by pushing the push-button (see Section 4.3) during power-up. Simply disconnect the USB cable, then push that button and keep it pushed while re-attaching the USB cable.

The e1-tracer boot loader enumerates as VID:PID `1d50:6150`, while the normal application firmware enumerates as `1d50:6151`,

You can for example use `lsusb` to check the VID:PID:

Example output of dfu-util on a system with e1-tracer attached

```
$ lsusb -d 1d50:
Bus 001 Device 042: ID 1d50:6151❶ OpenMoko, Inc. e1-tracer
$ sudo dfu-util -d 1d50:6151 -e ❷
...
$ lsusb -d 1d50:
Bus 001 Device 043: ID 1d50:6150❸ OpenMoko, Inc. e1-tracer (DFU)
```

❶ initially the device is in normal runtime mode

❷ we use `dfu-util -e` to switch to DFU mode

❸ we can see, the device is now in DFU mode

6.1.1 Obtaining firmware upgrades

The latest firmware can be found at https://ftp.osmocom.org/binaries/e1-tracer/firmware/latest/ a backlog of earlier builds can be found at https://ftp.osmocom.org/binaries/e1-tracer/firmware/all/

The latest gateware can currently only be found at the personal developer directory of tnt at https://people.osmocom.org/tnt/e1-tracer/e1-tracer-gw-c7566442.bin A more official download location for the gateware will be provided shortly.

6.1.2 Upgrading the FPGA gateware

Gateware files are called `e1-tracer-gw-*.bin`. (without *fw* in the name)

The gateware can be upgraded by accessing the DFU *altsetting 0* using `dfu-util` **`-a 0`**

Assuming you already are in DFU mode, you would typically use a command like `dfu-util -d 1d50:6150 -a 0 -D e1-tracer-gw-c7566442.bin -R` to perform the upgrade.

Note

The `-R` will switch the device back to runtime mode after the upgrade. If you want to upgrade the firmware in the same session, skip the `-R` in the above command.

6.1.3 Upgrading the picoRISCV firmware

Firmware files are called `e1_tracer-fw*.bin`.

The firmware can be upgraded by accessing the DFU *altsetting 1* using `dfu-util` **`-a 1`**

Assuming you already are in DFU mode, you would typically use a command like `dfu-util -d 1d50:6150 -a 1 -D e1_tracer-fw-0.1-132-ga0df047.bin -R` to perform the upgrade.

Typical output during upgrade of the firmware

```
$ sudo dfu-util -d 1d50:6150 -a 1 -D e1_tracer-fw-0.1-132-ga0df047.bin -R
dfu-util 0.9

Copyright 2005-2009 Weston Schmidt, Harald Welte and OpenMoko Inc.
Copyright 2010-2016 Tormod Volden and Stefan Schmidt
This program is Free Software and has ABSOLUTELY NO WARRANTY
Please report bugs to http://sourceforge.net/p/dfu-util/tickets/

dfu-util: Invalid DFU suffix signature
dfu-util: A valid DFU suffix will be required in a future dfu-util release!!!
Opening DFU capable USB device...
ID 1d50:6150
Run-time device DFU version 0101
Claiming USB DFU Interface...
Setting Alternate Setting #1 ...
Determining device status: state = dfuIDLE, status = 0
dfuIDLE, continuing
DFU mode device DFU version 0101
Device returned transfer size 4096
Copying data from PC to DFU device
Download        [=========================] 100%        11256 bytes
Download done.
state(2) = dfuIDLE, status(0) = No error condition is present
Done!
Resetting USB to switch back to runtime mode
```

As the `-R` option was used, the device will reset and re-enumerate in the newly programmed firmware.

You can verify this as follows:

```
$ lsusb -d 1d50:
Bus 001 Device 042: ID 1d50:6151 OpenMoko, Inc. e1-tracer
```

or alternatively:

```
$ dfu-util -l -d 1d50:
dfu-util 0.9

Copyright 2005-2009 Weston Schmidt, Harald Welte and OpenMoko Inc.
Copyright 2010-2016 Tormod Volden and Stefan Schmidt
This program is Free Software and has ABSOLUTELY NO WARRANTY
Please report bugs to http://sourceforge.net/p/dfu-util/tickets/

Found Runtime: [1d50:6151] ver=0003, devnum=44, cfg=1, intf=1, path="1-2", alt=0, name="DFU ↩
     runtime", serial="dc697407e7881531"
```

6.2 Use of the LEDs

6.2.1 LOS LEDs

Each E1 channel has one red **LOS LED**. They are red if either

- the E1 framer has not yet been initialized (done by starting host software)
- there is an actual LOS (Loss of Signal) condition in the respective direction

6.2.2 Multi-Color RGB STATUS LED

The multi-color RGB **STATUS LED** is used to indicate overall hardware/firmware status.

Color	Pattern	Meaning
Red	On	E1 interface not active (no host software?)
Red	Blinking	E1 interface active, but error status (CRC, alignment)
Green	On	E1 Receiver B aligned
Green	Blinking	E1 Receiver A attempting to align
Blue	On	E1 Receiver B aligned
Blue	Blinking	E1 Receiver B attempting to align
Cyan	On	E1 Receiver A+B aligned
Cyan	Blinking	E1 Receiver A+B attempting to align

6.3 Firmware - USB Host Interface

The e1-tracer firmware provides a USB 1.1 full-speed (FS) device with two configurations

- legacy configuration (for use with `e1-tracer-record`)
  - 2 interfaces
    * combined interface for both E1 directions
    * DFU (device firmware upgrade)
- `osmo-e1d` compatible configuration
- 2 interfaces
  - E1 direction A→B
  - E1 direction A←B

The configurations and interfaces have self-explanatory string descriptors like

```
iInterface              8 E1 Direction A
iInterface              9 E1 Direction B
```

6.3.1 e1d compatible configuration: E1 ports

There are two physical E1 ports in the e1-tracer. Each represents one direction of the traced E1 circuit. Each is exposed via its own USB *interface*.

Each port/direction (USB *interface*) contains two *altsettings*:

- one altsetting with no data endpoints (E1 tracing disabled, this is the default)
- one altsetting with isochronous IN/OUT endpoints (E1 tracing enabled)

In order to activate one E1 port, the driver must perform a USB standard request to activate the *enabled* altsetting.

6.3.2 DFU (Device Firmware Upgrade)

There's a DFU interface available in order to update the e1-tracer gateware and firmware. For more information, see above.

7 Host Software

Host Software is software running on the USB host computer to which the e1-tracer is attached.

At the time of this writing, there are two options:

- legcay tools from the `software/e1-tracer` sub-directory of the `osmo-e1-hardware.git` repository
- `osmo-e1d`

7.1 Legacy Software

The legacy software was the initial software developed for the e1-tracer. Its purpose was raw trace recording for later offline analysis.

The source code of this software can be found in the `software/e1-tracer` sub-directory of the `osmo-e1-hardware.git` repository at https://gitea.osmocom.org/retronetworking/osmo-e1-hardware

7.1.1 e1-tracer-record

The `e1-tracer-record` program is used to create on-disk recordings of the full E1 interface in both directions.

You can use `e1-trace-record` to obtain a raw recording using the osmo-e1-tracer.

Once the program is started, it will open the USB device (via libusb), enable it and subsequently store all received E1 frames to a file on disk. The disk file format is a custom format containing chunks of data, each prefixed by a header containing metadata such as the receive timestamp and the direction of the data.

The program supports the following command line arguments:

Command line arguments of e1-tracer-record program

```
`-o FILE`  the name of the output file to which the recording is to be stored.
`-a`       append (instead of overwrite) the output file, if it already exists.
`-m`       set the PHY into monitor (high-impedance) mode.  You should always enable this.
`-r`       use SCHED_RR *realtime* scheduling to reduce the likelihood of lost data on ↩
    overloaded systems
```

A typical invocation of the program would look like this:

`` `e1-trace-record -o /tmp/my_recording.e1cap -m -r` ``

There are some additional low-level tuning parameters (`-n` and `-p`), but you should not need those under normal operation.

7.1.2 e1cap file format

The recording file format consists of **chunks** of data. Each chunk contains a number of E1 frames in one direction of the line.

The chunk header is prefixed with a 32bit magic value 0xE115600D, followed by two 64bit values as timestamp (seconds and microseconds), followed by a 16bit length value and an 8 bit USB endpoint number. The USB endpoint number signifies the direction; it can be either 0x81 or 0x82.

Definition of chunk header

```
struct e1_chunk_hdr {
        uint32_t magic;
        struct {
                uint64_t sec;
                uint64_t usec;
        } time;
        int16_t len;
        uint8_t ep;
} __attribute__((packed));
```

After the chunk header is a concatenation of multiple E1 frames, each 32bytes long (one byte for each timeslot in the frame).

7.2 osmo-e1d

`osmo-e1d` was originally implemented as a host software stack for the icE1usb E1 USB interface, which is *terminating* an E1 link and allows receive and transmit use by external software.

More recently, `osmo-e1d` and the e1-tracer firmware have been made compatible. This means that `osmo-e1d` can now be used by applications to get raw trace data from individual E1 timeslots in real-time using the same API/interface that was originally designed for icE1usb.

The e1-tracer appears to `osmo-e1d` as one *interface* which two *lines*. Each *line* represents one direction of the E1 traffic.

In theory, `osmo-e1d` should work on any operating system with libusb support for isochronous transfers. However, official support is limited to GNU/Linux at this point.

More information about `osmo-e1d` can be found at its homepage https://osmocom.org/projects/osmo-e1d/wiki

7.2.1 Example osmo-e1d configuration / start-up

Sample config file (pass as -c /path/to/my/osmo-e1d.cfg when starting osmo-e1d)

```
log stderr
 logging filter all 1
 logging color 1
 logging print category-hex 0
 logging print category 1
 logging print level 1
 logging timestamp 0
 logging print file 1 last
 logging level e1d info
 logging level linp info
e1d
```

Sample output of osmo-e1d starting with above config file and one e1-tracer attached to USB

```
DLGLOBAL NOTICE Available via telnet 127.0.0.1 4269 (telnet_interface.c:100)
DE1D NOTICE No configuration for e1-tracer serial 'dc696c80532f7d34' found, auto-generating ↩
     it (usb.c:868)
DE1D NOTICE (I0) Created (intf_line.c:184)
DE1D NOTICE (I0:L0) Created (intf_line.c:285)
DE1D NOTICE (I0:L0) Activated (intf_line.c:319)
DE1D NOTICE (I0:L1) Created (intf_line.c:285)
DE1D NOTICE (I0:L1) Activated (intf_line.c:319)
```

This means that a single e1-tracer device was found, and that it has been designated **interface 0** with **line 0** and **line 1** within that interface.

You can introspect the `osmo-e1d` state using its VTY interface:

Example VTY output when telnet-ing into the osmo-e1d VTY port 4269

```
$ telnet localhost 4269
Trying 127.0.0.1...
Connected to localhost.
Escape character is '^]'.
Welcome to the osmo-e1d VTY interface

(C) 2019-2022 by Sylvain Munaut, Harald Welte and contributors
osmo-e1d> show line ❶
Interface #0 (dc696c80532f7d34), Line #0, Mode CHANNELIZED:
 TS00: Mode off, FD -1, Peer PID -1
```

```
 TS01: Mode off, FD -1, Peer PID -1
 TS02: Mode off, FD -1, Peer PID -1
 TS03: Mode off, FD -1, Peer PID -1
 TS04: Mode off, FD -1, Peer PID -1
 TS05: Mode off, FD -1, Peer PID -1
 TS06: Mode off, FD -1, Peer PID -1
 TS07: Mode off, FD -1, Peer PID -1
 TS08: Mode off, FD -1, Peer PID -1
 TS09: Mode off, FD -1, Peer PID -1
 TS10: Mode off, FD -1, Peer PID -1
 TS11: Mode off, FD -1, Peer PID -1
 TS12: Mode off, FD -1, Peer PID -1
 TS13: Mode off, FD -1, Peer PID -1
 TS14: Mode off, FD -1, Peer PID -1
 TS15: Mode off, FD -1, Peer PID -1
 TS16: Mode off, FD -1, Peer PID -1
 TS17: Mode off, FD -1, Peer PID -1
 TS18: Mode off, FD -1, Peer PID -1
 TS19: Mode off, FD -1, Peer PID -1
 TS20: Mode off, FD -1, Peer PID -1
 TS21: Mode off, FD -1, Peer PID -1
 TS22: Mode off, FD -1, Peer PID -1
 TS23: Mode off, FD -1, Peer PID -1
 TS24: Mode off, FD -1, Peer PID -1
 TS25: Mode off, FD -1, Peer PID -1
 TS26: Mode off, FD -1, Peer PID -1
 TS27: Mode off, FD -1, Peer PID -1
 TS28: Mode off, FD -1, Peer PID -1
 TS29: Mode off, FD -1, Peer PID -1
 TS30: Mode off, FD -1, Peer PID -1
 TS31: Mode off, FD -1, Peer PID -1
 Counters for each line in e1d:
  Rx Signal Lost:        0 (0/s 0/m 0/h 0/d)
  Rx Alignment Lost:        0 (0/s 0/m 0/h 0/d)
  E1 Rx CRC Errors:        0 (0/s 0/m 0/h 0/d)
  E1 Rx Overflow:        0 (0/s 0/m 0/h 0/d)
  E1 Tx Underflow:        0 (0/s 0/m 0/h 0/d)
  Rx Frames Reporting Remote CRC Error:        0 (0/s 0/m 0/h 0/d)
  Rx Frames Reporting Remote Alarm:        0 (0/s 0/m 0/h 0/d)
  E1 Tx Frames multiplexed:        0 (0/s 0/m 0/h 0/d)
  E1 Rx Frames demultiplexed:   143680 (8000/s 142560/m 0/h 0/d)
Interface #0 (dc696c80532f7d34), Line #1, Mode CHANNELIZED:
 TS00: Mode off, FD -1, Peer PID -1
 TS01: Mode off, FD -1, Peer PID -1
 TS02: Mode off, FD -1, Peer PID -1
 TS03: Mode off, FD -1, Peer PID -1
 TS04: Mode off, FD -1, Peer PID -1
 TS05: Mode off, FD -1, Peer PID -1
 TS06: Mode off, FD -1, Peer PID -1
 TS07: Mode off, FD -1, Peer PID -1
 TS08: Mode off, FD -1, Peer PID -1
 TS09: Mode off, FD -1, Peer PID -1
 TS10: Mode off, FD -1, Peer PID -1
 TS11: Mode off, FD -1, Peer PID -1
 TS12: Mode off, FD -1, Peer PID -1
 TS13: Mode off, FD -1, Peer PID -1
 TS14: Mode off, FD -1, Peer PID -1
 TS15: Mode off, FD -1, Peer PID -1
 TS16: Mode off, FD -1, Peer PID -1
 TS17: Mode off, FD -1, Peer PID -1
 TS18: Mode off, FD -1, Peer PID -1
 TS19: Mode off, FD -1, Peer PID -1
```

```
TS20: Mode off, FD -1, Peer PID -1
TS21: Mode off, FD -1, Peer PID -1
TS22: Mode off, FD -1, Peer PID -1
TS23: Mode off, FD -1, Peer PID -1
TS24: Mode off, FD -1, Peer PID -1
TS25: Mode off, FD -1, Peer PID -1
TS26: Mode off, FD -1, Peer PID -1
TS27: Mode off, FD -1, Peer PID -1
TS28: Mode off, FD -1, Peer PID -1
TS29: Mode off, FD -1, Peer PID -1
TS30: Mode off, FD -1, Peer PID -1
TS31: Mode off, FD -1, Peer PID -1
Counters for each line in e1d:
 Rx Signal Lost:        0 (0/s 0/m 0/h 0/d)
 Rx Alignment Lost:        0 (0/s 0/m 0/h 0/d)
 E1 Rx CRC Errors:        0 (0/s 0/m 0/h 0/d)
 E1 Rx Overflow:        0 (0/s 0/m 0/h 0/d)
 E1 Tx Underflow:        0 (0/s 0/m 0/h 0/d)
 Rx Frames Reporting Remote CRC Error:        0 (0/s 0/m 0/h 0/d)
 Rx Frames Reporting Remote Alarm:        0 (0/s 0/m 0/h 0/d)
 E1 Tx Frames multiplexed:        0 (0/s 0/m 0/h 0/d)
 E1 Rx Frames demultiplexed:   143648 (8000/s 142560/m 0/h 0/d)
```

1. typing `show line` will produce the below output, indicating that all timeslots are currently *off* and 8000 E1 frames per second are received from both lines (i.e. directions)

Other applications on the system can not connect to `osmo-e1d` and open individual timeslots either in *RAW* or in *HDLC-FCS* mode.

An example program is included, it is called `osmo-e1d-pipe`. Using this program, you can get a raw output of an individual timeslot.

Command line reference of osmo-e1d-pipe utility

```
$ ./osmo-e1d-pipe --help
 -h --help                     This help message
 -p --path PATH                Path of the osmo-e1d control socket
 -i --interface <0-255>        E1 Interface Number
 -l --line <0-255>             E1 Line Number
 -t --timeslot <0-31>          E1 Timeslot Number
 -m --mode (RAW|HDLC-FCS)      E1 Timeslot Mode
 -f --force                    Force open of the timeslot (may disconnect other client)
 -r --read FILE                Read from FILE instead of STDIN
```

Sample output of one direction of a raw B-channel

```
$./osmo-e1d-pipe -i 0 -l 0 -t 3 -m RAW -r /dev/zero | hexdump -v
0000000 d5d5 d5d5 d5d5 d5d5 d5d5 d5d5 d5d5 d5d5
0000010 d5d5 d5d5 d5d5 d5d5 d5d5 d5d5 d5d5 d5d5
0000020 d5d5 d5d5 d5d5 d5d5 d5d5 d5d5 d5d5 d5d5
0000030 d5d5 d5d5 d5d5 d5d5 d5d5 d5d5 d5d5 d5d5
0000040 d5d5 d5d5 d5d5 d5d5 d5d5 d5d5 d5d5 d5d5
0000050 d5d5 d5d5 d5d5 d5d5 d5d5 d5d5 d5d5 d5d5
0000060 d5d5 d5d5 d5d5 d5d5 d5d5 d5d5 d5d5 d5d5
0000070 d5d5 d5d5 d5d5 d5d5 d5d5 d5d5 d5d5 d5d5
0000080 d5d5 d5d5 d5d5 d5d5 d5d5 d5d5 d5d5 d5d5
0000090 d5d5 d5d5 d5d5 d5d5 d5d5 d5d5 d5d5 d5d5
00000a0 d5d5 d5d5 d5d5 d5d5 d5d5 d5d5 d5d5 d5d5
...
```

Sample output of one direction of a HDLC-FCS D-channel

```
$ ./osmo-e1d-pipe -i 0 -l 1 -t 16 -m hdlc-fcs -r /dev/zero | hexdump -v
0000000 0102 027f 7f01 0102 027f 7f01 0102 027f
0000010 7f01 0102 027f 7f01 0102 027f 7f01 0102
0000020 027f 7f01 0102 027f 7f01 0102 027f 7f01
0000030 0102 027f 7f01 0102 027f 7f01 0102 027f
0000040 7f01 0102 027f 7f01 0102 027f 7f01 0102
```

7.3 Other / 3rd party software

you can interface 3rd party applications with osmo-e1d in the following mutually exclusive ways:

- by adding support for `osmo-e1d`, e.g. via `libosmo-e1d` to the respective application. This way your application can receive traffic one a per-timeslot basis.
- by directly implementing the USB protocol exposed by e1-tracer in your software. This is definitely more effort, as you have to parse the entire E1 frames, implement software HDLC decoders, etc. - all of which are already present in `osmo-e1d`
- by post-processing the raw disk recordings generated by the `e1-trace-recorder` program.

Should you require any related development/porting services, please do not hesitate to reach out to sysmocom.

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