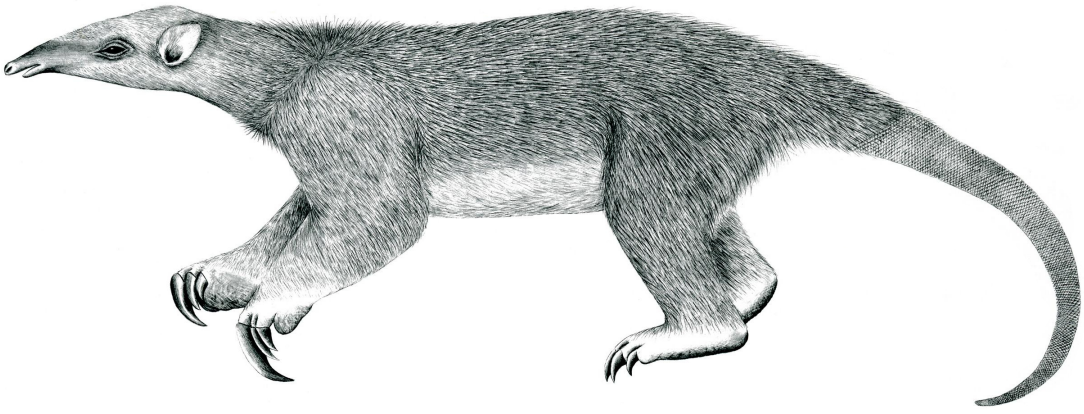
# Tranalyzer2

**Version 0.9.2 (Cobra)**

Flow based forensic and network troubleshooting traffic analyzer



Tranalyzer Development Team

# Contents

# 1 Introduction

Tranalyzer2 is a lightweight flow generator and packet analyzer designed for simplicity, performance and scalability. The program is written in C and built upon the *libpcap* library. It provides functionality to pre- and post-process IPv4/IPv6 data into flows and enables a trained user to see anomalies and network defects even in very large datasets. It supports analysis with special bit coded fields and generates statistics from key parameters of IPv4/IPv6 tcpdump traces either being live-captured from an Ethernet interface or one or several pcap files. The quantity of binary and text based output of Tranalyzer2 depends on enabled modules, herein denoted as **plugins**. Hence, users have the possibility to tailor the output according to their needs and developers can develop additional plugins independent of the functionality of other plugins.

## 1.1 Getting Tranalyzer

Tranalyzer can be downloaded from: https://tranalyzer.com/downloads.html

## 1.2 Dependencies

Tranalyzer2 requires the following tools and libraries:

**Kali/Ubuntu:**

```
sudo apt-get install autoconf autoconf-archive automake libbsd-dev libpcap-dev
    libreadline-dev libtool make meson zlib1g-dev
```

**Arch/Manjaro:**

```
sudo pacman -S autoconf autoconf-archive automake bash-completion gcc libpcap
    libtool make meson pkgconf zlib
```

**CentOS/Fedora/Red Hat:**

```
sudo dnf install autoconf autoconf-archive automake bzip2 libbsd-devel
    libpcap-devel libtool meson readline-devel zlib-devel [1]
```

**Gentoo:**

```
sudo emerge autoconf autoconf-archive automake bash-completion libpcap libtool meson zlib
```

**openSUSE:**

```
sudo zypper install autoconf autoconf-archive automake gcc libbsd-devel
    libpcap-devel libtool meson readline-devel zlib-devel
```

**macOS:**

```
brew install autoconf autoconf-archive automake libpcap libtool meson readline zlib [2]
```

Note that `meson` is optional, but recommended as it is much faster than the autotools (`autoconf`, `automake`, ...).

[1] If the `dnf` command could not be found, try with `yum` instead

[2] Brew is a packet manager for macOS that can be found here: https://brew.sh

## 1.3 Compilation

To build Tranalyzer2 and the plugins, run one of the following commands:

- Tranalyzer2 only:
  `cd "$T2HOME"; ./autogen.sh tranalyzer2`
  (alternative: `cd "$T2HOME/tranalyzer2"; ./autogen.sh`)
- A specific plugin only, e.g., `myPlugin`:
  `cd "$T2HOME"; ./autogen.sh myPlugin`
  (alternative 1: `cd "$T2PLHOME/myPlugin"; ./autogen.sh`)
  (alternative 2: `cd "$T2HOME/plugins/myPlugin"; ./autogen.sh`)
- Tranalyzer2 and a default set of plugins:
  `cd "$T2HOME"; ./autogen.sh`
- Tranalyzer2 and all the plugins in `T2HOME`:
  `cd "$T2HOME"; ./autogen.sh -a`
- Tranalyzer2 and a custom set of plugins (listed in plugins.build) (Section 1.3.1):
  `cd "$T2HOME"; ./autogen.sh -b`

where `T2HOME` points to the root folder of Tranalyzer, i.e., where the file `README.md` is located.

For finer control of which plugins to load, refer to Enabling/Disabling Plugins .

Note that if `t2_aliases` is installed, the `t2build` command can be used instead of `autogen.sh`. The command can be run from anywhere, so just replace the above commands with `t2build tranalyzer2`, `t2build myPlugin`, `t2build -a` and `t2build -b`. Run `t2build --help` for the full list of options accepted by the script.

### 1.3.1 Custom Build

The `-b` option of the `autogen.sh` script takes an optional file name as argument. If none is provided, then the default `plugins.build` is used. The format of the file is as follows:

- Empty lines and lines starting with a `'#'` are ignored (can be used to prevent a plugin from being built)
- One plugin name per row
- Example:

```
# Do not build the tcpStates plugin
#tcpStates

# Build the txtSink plugin
txtSink
```

A `plugins.ignore` file can also be used to prevent specific plugins from being built. A different filename can be used with the `-I` option.

## 1.4 Installation

The `-i` option of the `autogen.sh` script installs Tranalyzer in `/usr/local/bin` (as `tranalyzer`) and the man page in `/usr/local/man/man1`. Note that root rights are required for the installation.

Alternatively, use the file `t2_aliases` or add the following alias to your `~/.bash_aliases`:

```
alias tranalyzer="$T2HOME/tranalyzer2/src/tranalyzer"
```

where `T2HOME` points to the root folder of Tranalyzer, i.e., where the file `README.md` is located.

The man page can also be installed manually, by calling (as root):

```
mkdir -p /usr/local/man/man1 && gzip -c man/tranalyzer.1 > /usr/local/man/man1/tranalyzer.1.gz
```

### 1.4.1 Aliases

The file `t2_aliases` documented in `$T2HOME/scripts/doc/scripts.pdf` contains a set of aliases and functions to facilitate working with Tranalyzer. To install it, append the following code to `~/.bashrc` or `~/.bash_aliases` (make sure to replace `$T2HOME` with the actual path, e.g., `$HOME/tranalyzer2-0.9.2`):

```
if [ -f "$T2HOME/scripts/t2_aliases" ]; then
    . "$T2HOME/scripts/t2_aliases"            # Note the leading `.'
fi
```

## 1.5 Getting Started

Run Tranalyzer as follows:

```
tranalyzer -r file.pcap -w outfolder/outprefix
```

For a full list of options, use Tranalyzer `-h` option: `tranalyzer -h` or refer to the complete documentation.

## 1.6 Getting Help

### 1.6.1 Documentation

Tranalyzer and every plugin come with their own documentation, which can be found in the `doc` subfolder. The complete documentation of Tranalyzer2 and all the locally available plugins can be generated by running `make` in `$T2HOME/doc`. The file `t2_aliases` provides the function `t2doc` to allow easy access to the different parts of the documentation from anywhere.

### 1.6.2 Man Page

If the man page was installed (Section 1.4), then accessing the man page is as simple as calling

```
man tranalyzer
```

If it was not installed, then the man page can be invoked by calling

```
man $T2HOME/tranalyzer2/man/tranalyzer.1
```

### 1.6.3 Help

For a full list of options, use Tranalyzer `-h` option: `tranalyzer -h`

### 1.6.4 FAQ

Refer to the complete documentation in `$T2HOME/doc` for a list of frequently asked questions.

### 1.6.5 Contact

Any feedback, feature requests and questions are welcome and can be sent to the development team via email at:

andy@tranalyzer.com

# 2 Tranalyzer2

Tranalyzer2 is designed in a modular way. Thus, the packet flow aggregation and the flow statistics are separated. While the main program performs the header dissection and flow organization, the plugins produce specialized output such as packet statistics, mathematical transformations, signal analysis and result file generation.

## 2.1 Supported Link-Layer Header Types

Tranalyzer handles most PCAP link-layer header types automatically. Some specific types can be analyzed by switching on flags in `linktypes.h`. The following table summarizes the link-layer header types handled by Tranalyzer:

| Linktype | Description | Flags |
|---|---|---|
| DLT_C_HDLC | Cisco PPP with HDLC framing | |
| DLT_C_HDLC_WITH_DIR | Cisco PPP with HDLC framing preceded by one byte direction | |
| DLT_EN10MB | IEEE 802.3 Ethernet (10Mb, 100Mb, 1000Mb and up) | |
| DLT_FRELAY | Frame Relay | |
| DLT_FRELAY_WITH_DIR | Frame Relay preceded by one byte direction | |
| DLT_IEEE802_11 | IEEE802.11 wireless LAN | |
| DLT_IEEE802_11_RADIO | Radiotap link-layer information followed by an 802.11 header | |
| DLT_IPV4 | Raw IPv4 | |
| DLT_IPV6 | Raw IPv6 | |
| DLT_JUNIPER_ATM1 | Juniper ATM1 PIC (experimental) | LINKTYPE_JUNIPER=1 |
| DLT_JUNIPER_ETHER | Juniper Ethernet (experimental) | LINKTYPE_JUNIPER=1 |
| DLT_JUNIPER_PPPOE | Juniper PPPoE PIC (experimental) | LINKTYPE_JUNIPER=1 |
| DLT_LAPD | Raw LAPD | LAPD_ACTIVATE=1 |
| DLT_LINUX_LAPD | LAPD (Q.921) frames, with a DLT_LINUX_SLL header | LAPD_ACTIVATE=1 |
| DLT_LINUX_SLL | Linux “cooked” capture encapsulation | |
| DLT_NULL | BSD loopback encapsulation | |
| DLT_PPI | Per-Packet Information | |
| DLT_PPP | Point-to-Point Protocol | |
| DLT_PPP_SERIAL | PPP in HDLC-like framing | |
| DLT_PPP_WITH_DIR | PPP preceded by one byte direction | |
| DLT_PRISM_HEADER | Prism monitor mode information followed by an 802.11 header | |
| DLT_RAW | Raw IP | |
| DLT_SYMANTEC_FIREWALL | Symantec Enterprise Firewall | |

## 2.2 Enabling/Disabling Plugins

The plugins are stored under *~/.tranalyzer/plugins*. This folder can be changed with the `-p` option.

By default, all the plugins found in the plugin folder are loaded. This behavior can be changed by altering the value of `USE_PLLIST` in *loadPlugins.h:35*. The valid options are:

| USE_PLLIST | Description |
|---|---|
| 0 | disable `-b` option and load all plugins from the plugin folder (default) |
| 1 | only load plugins present in the list (whitelist) |

| USE_PLLIST | **Description** |
|---|---|
| 2 | do not load plugins present in the list (blacklist) |

This following sections discuss the various ways to selectively enable/disable plugins.

### 2.2.1 Default

By default, all the files in the plugin folder named according to the following pattern are loaded:

```
^[0-9]{3}_[a-zA-Z0-9]+.so$
```

To disable a plugin, it must be removed from the plugin folder. A subfolder, e.g., *disabled*, can be used to store unused plugins.

### 2.2.2 Whitelisting Plugins

If `USE_PLLIST=1`, the whitelist (loading list) is searched under the plugins folder with the name `plugins.txt`. The name can be changed by adapting the value `PLLIST` in *loadPlugins.h:36*. If the file is stored somewhere else, Tranalyzer2 `-b` option can be used.

The format of the whitelist is as follows (empty lines and lines starting with a `'#'` are ignored):

```
# This is a comment

# This plugin is whitelisted (will be loaded)
001_protoStats.so

# This plugin is NOT whitelisted (will NOT be loaded)
#010_basicFlow.so
```

Note that if a plugin is not present in the list, it will **NOT** be loaded.

### 2.2.3 Blacklisting Plugins

If `USE_PLLIST=2`, the blacklist is searched under the plugins folder with the name `plugins.txt`. The name can be changed by adapting the value `PLLIST` in *loadPlugins.h:36*. If the file is stored somewhere else, Tranalyzer2 `-b` option can be used.

The format of the blacklist is as follows (empty lines and lines starting with a `'#'` are ignored):

```
# This is a comment

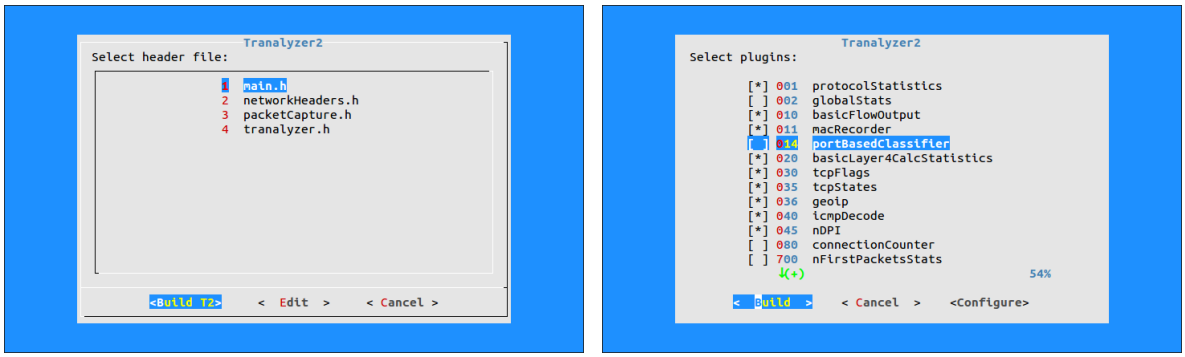
# This plugin is blacklisted (will NOT be loaded)
001_protoStats.so

# This plugin is NOT blacklisted (will be loaded)
#010_basicFlow.so
```

Note that if a plugin is not present in the list, it will be loaded.

### 2.2.4 Graphical Configuration and Building of T2 and Plugins

Tranalyzer2 comes with a script named `t2conf` allowing easy configuration of all the plugins through a command line based graphical menu:




Use the arrows on your keyboard to navigate up and down and between the buttons. The first window is only displayed if the `-t2` option is used. The `Edit` and `Configure` buttons will launch a text editor (`$EDITOR` or vim[3] if the environment variable is not defined). The second window can be used to activate and deactivate plugins (toggle the active/inactive state with the space key).

To access the script from anywhere, use the provided `install.sh` script, install `t2_aliases` or manually add the following alias to `~/.bash_aliases`:

```
alias t2conf="$T2HOME/scripts/t2conf/t2conf"
```

Where `$T2HOME` is the folder containing the source code of Tranalyzer2 and its plugins.

A man page for `t2conf` is also provided and can be installed with the `install.sh` script.

## 2.3 Man Page

If the man page was installed (Section 1.4), then accessing the man page is as simple as calling

```
man tranalyzer
```

If it was not installed, then the man page can be invoked by calling

```
man $T2HOME/tranalyzer2/man/tranalyzer.1
```

## 2.4 Invoking Tranalyzer

As stated earlier Tranalyzer2 either operates on Ethernet/DAG interfaces or pcap files. It may be invoked using a BPF if only certain flows are interesting. The required arguments are listed below. Note that the `-i`, `-r`, `-R` and `-D` options cannot be used at the same time.

[3] The default editor can be changed by editing the variable `DEFAULT_EDITOR` (line 7)

### 2.4.1 Help

For a full list of options, use the `-h` option: `tranalyzer -h`

```
Tranalyzer 0.9.2 - High performance flow based network traffic analyzer

Usage:
    tranalyzer [OPTION...] <INPUT>

Input arguments:
    -i IFACE     Listen on interface IFACE
    -r PCAP      Read packets from PCAP file or from stdin if PCAP is "-"
    -R FILE      Process every PCAP file listed in FILE
    -D EXPR[:SCHR][,STOP]
                 Process every PCAP file whose name matches EXPR, up to an
                 optional last index STOP. If STOP is omitted, then Tranalyzer
                 never stops. EXPR can be a filename, e.g., file.pcap0, or an
                 expression, such as "dump*.pcap00", where the star matches
                 anything (note the quotes to prevent the shell from
                 interpreting the expression). SCHR can be used to specify
                 the last character before the index (default: 'p')

Output arguments:
    -w PREFIX    Append PREFIX to any output file produced. If the option is
                 omitted, derive PREFIX from the input. Use '-w -' to output
                 the flow file to stdout (other files will be saved as if the
                 '-w' option had been omitted and the '-l' and '-m' options used)
    -W PREFIX[:SIZE][,START]
                 Like -w, but fragment flow files according to SIZE, producing
                 files starting with index START. SIZE can be specified in bytes
                 (default), KB ('K'), MB ('M') or GB ('G'). Scientific notation,
                 i.e., 1e5 or 1E5 (=100000), can be used as well. If a 'f' is
                 appended, e.g., 10Kf, then SIZE denotes the number of flows.
    -l           Print end report in PREFIX_log.txt instead of stdout
    -m           Print monitoring output in PREFIX_monitoring.txt instead of stdout
    -s           Packet forensics mode

Interface capture arguments:
    -S SNAPLEN   Set the snapshot length (used with -i option)
    -B BUFSIZE   Set the live Rx buffer size (used with -i option)

Optional arguments:
    -p PATH      Load plugins from PATH instead of ~/.tranalyzer/plugins
    -b FILE      Use plugin list FILE instead of plugin_folder/plugins.txt
    -e FILE      Create a PCAP file by extracting all packets belonging to
                 flow indexes listed in FILE (require pcapd plugin)
    -f FACTOR    Set hash multiplication factor
    -x ID        Sensor ID
    -c CPU       Bind tranalyzer to one core. If CPU is 0 then OS selects the
```

```
                core to bind
    -P PRIO     Set tranalyzer priority to PRIO (int) instead of 0
                (PRIO [highest, lowest]: [-20, 20] (root), [0, 20] (user))
    -M FLT      Set monitoring interval to FLT seconds
    -F FILE     Read BPF filter from FILE

Help and documentation arguments:
    -V          Show the version of the program and exit
    -h          Show help options and exit

Remaining arguments:
    BPF         Berkeley Packet Filter command, as in tcpdump
```

### 2.4.2 –i INTERFACE

Capture data from an Ethernet interface `INTERFACE` (requires *root* privileges). If high volume of traffic is expected, then enable internal buffering in ioBuffer.h.

```
sudo tranalyzer -i eth0
```

### 2.4.3 –r FILE

Capture data from a pcap file `FILE`.

```
tranalyzer -r file.pcap
```

The special file `'-'` can be used to read data from *stdin*. This can be used, e.g., to process compressed pcap files, e.g., *file.pcap.gz*, using the following command:

```
zcat file.pcap.gz | tranalyzer -r - -w out
```

### 2.4.4 –R FILE

Process all the pcap files listed in `FILE`. All files are being treated as one large file. The life time of a flow can extend over many files. The processing order is defined by the location of the filenames in the text file. The absolute path has to be specified. The `t2caplist` script documented in `$T2HOME/scripts/scripts.pdf` can be used to generate such a list. All lines starting with a `'#'` are considered as comments and thus ignored.

```
$ t2caplist directory > pcap_list.txt
$ tranalyzer -R pcap_list.txt
```

### 2.4.5 –D FILE[*][.ext]#1[:SCHR][,#2]

Process files in a directory using file start and stop index, defined by `#1` and `#2` respectively. `ext` can be anything, e.g., `.pcap`, and can be omitted. If `#2` is omitted and not in round robin mode, then Tranalyzer2 never stops and waits until the next file in the increment is available. If leading zeroes are used, `#2` defaults to $10^{\text{number\_length}} - 1$. Note that only the last occurrence of `SCHR` is considered, e.g., if `SCHR='p'`, then out.pca**p**001 will work, but out001pca**p**, will not. with the `:[SCHR]` option a new separation character can be set, superseding `SCHR` defined in tranalyzer.h.

The following variables in tranalyzer.h can be used to configure this mode:

| Name | Default | Description |
|---|---|---|
| RROP | 0 | Activate round robin operations<br>WARNING: if set to 1, then findexer will not work anymore |
| POLLTM | 5 | Poll timing (in seconds) for files |
| MFPTMOUT | 0 | > 0: timeout for poll > POLLTM, 0: no poll timeout |
| SCHR | 'p' | Separating character for file number |

For example, when using tcpdump to capture traffic from an interface (eth0) and produce 100MB files as follows:

```
sudo tcpdump -C 100 -i eth0 -w out.pcap
```

The following files are generated: *out.pcap, out.pcap1, out.pcap2, . . . , out.pcap10, . . .*

Then SCHR must be set to 'p', i.e., the last character before the file number (out.pca**p**NUM) and Tranalyzer must be run as follows:

```
tranalyzer -D out.pcap
```

Or to process files 10 to 100:

```
tranalyzer -D out.pcap10,100
```

Or to process files 10 to 100 in another format:

```
tranalyzer -D out10.pcap,100 -w out
```

Or to process files from 0 to $2^{32} - 1$ using regex characters:

```
tranalyzer -D "out*.pcap" -w out
```

The last command can be shortened further, the only requirement being the presence of SCHR (the last character before the file number) in the pattern:

```
tranalyzer -D "*p" -w out
```

Note the quotes (") which are necessary to avoid preemptive interpretation of regex characters and SCHR which MUST appear in the pattern. The same configuration can be used for filenames using one or more leading zeros, e.g., *out.pcap000, out.pcap001, out.pcap002, . . . , out.pcap010, . . .*

The following table summarizes the supported naming patterns and the configuration required:

| Filenames | SCHR | Command |
|---|---|---|
| out.pca**p**, out.pca**p**1, out.pca**p**2, . . . | 'p' | `tranalyzer -D out.pcap -w out` |
| out.pca**p**00, out.pca**p**01, out.pca**p**02, . . . | 'p' | `tranalyzer -D out.pcap00 -w out` |
| ou**t**0.pcap, ou**t**1.pcap, ou**t**2.pcap, . . . | 't' | `tranalyzer -D out0.pcap -w out` |
| ou**t**00.pcap, ou**t**01.pcap, ou**t**02.pcap, . . . | 't' | `tranalyzer -D out00.pcap -w out` |
| out_24.04.2016.20h00.pca**p**,<br>out_24.04.2016.20h00.pca**p**1, . . . | 'p' | `tranalyzer -D "out*.pcap" -w out` |

| Filenames | SCHR | Command |
|---|---|---|
| out_24.04.2016.20h00.pca**p**00, out_24.04.2016.20h00.pca**p**01, ... | 'p' | `tranalyzer -D "out*.pcap00" -w out` |
| ou**t**0.pcap, ou**t**1.pcap, ou**t**2.pcap, ... | 't' | `tranalyzer -D out0.pcap:t -w out` |
| out.pca**p**00, out.pca**p**01, out.pca**p**02, ... | 'p' | `tranalyzer -D out.pcap00:p -w out` |

### 2.4.6 –w PREFIX

Use a `PREFIX` for all output file types. The number of files being produced vary with the number of activated plugins. The file suffixes are defined in the file tranalyzer.h (see Section 2.15.13) or in the header files for the plugins. If you forget to specify an output file, Tranalyzer will use the input interface name or the file name as file prefix and print the flows to *stdout*. Thus, Tranalyzer output can be piped into other command line tools, such as netcat in order to produce centralized logging to another host or an AWK script for further post processing without intermediate writing to a slow disk storage.

### 2.4.7 –W PREFIX[:SIZE][,START]

This option allows the fragmentation of flow files produced by Tranalyzer independent of the input mode. The expression before the `':'` is the output prefix, the expression after the `':'` denotes the maximal file size for each fragment and the number after the `','` denotes the start index of the first file. If omitted it defaults to `0`. The size of the files can be specified in bytes (default), KB (`'K'`), MB (`'M'`) or GB (`'G'`). Scientific notation, i.e., 1e5 or 1E5 (=100000), can be used as well. If no size is specified, the default value of 500MB, defined by `OFRWFILELN` in tranalyzer.h is used. If no size is specified, then the `':'` can be omitted. The same happens if no start index is specified. If an additional `'f'` is appended the unit is flow count. This enables the user to produce file chunks containing the same amount of flows. Some typical examples are shown below.

| Command | Fragment Size | Start Index | Output Files |
|---|---|---|---|
| `tranalyzer -r nudel.pcap -W out:1.5E9,10` | 1.5GB | 10 | out10, out11, ... |
| `tranalyzer -r nudel.pcap -W out:1.5e9,5` | 1.5GB | 5 | out5, out6, ... |
| `tranalyzer -r nudel.pcap -W out:1.5G,1` | 1.5GB | 1 | out1, out2, ... |
| `tranalyzer -r nudel.pcap -W out:5000K` | 0.5MB | 0 | out0, out1, ... |
| `tranalyzer -r nudel.pcap -W out:5Kf` | 5000 Flows | 0 | out0, out1, ... |
| `tranalyzer -r nudel.pcap -W out:180M` | 180MB | 0 | out0, out1, ... |
| `tranalyzer -r nudel.pcap -W out:2.5G` | 2.5GB | 0 | out0, out1, ... |
| `tranalyzer -r nudel.pcap -W out,6` | `OFRWFILELN` | 0 | out6, out7, ... |
| `tranalyzer -r nudel.pcap -W out` | `OFRWFILELN` | 0 | out0, out1, ... |

### 2.4.8 –l

All Tranalyzer command line and report output is diverted to the log file: `PREFIX_log.txt`. Fatal error messages still appear on the command line.

### 2.4.9 –m

All Tranalyzer monitoring output is diverted to the monitoring file: `PREFIX_monitoring.txt`.

### 2.4.10 –s

Initiates the packet mode where a file with the suffix `PREFIX_packets.txt` is created. The content of the file depends on the plugins loaded. The display of the packet number (first column is controlled by `SPKTMD_PKTNO` in main.h. The payload can be displayed in hexadecimal and/or as characters by using the `SPKTMD_PCNTH` and `SPKTMD_PCNTC` respectively. The start of the payload (full packet, L2/3/4/7) to print is controlled by `SPKTMD_PCNTL`. A tab separated header description line is printed at the beginning of the packet file. The first two lines then read as follows:

```
%pktNo    time    pktIAT    duration    flowInd    flowStat    numHdrDesc    hdrDesc    vlanID
    ethType    srcMac    dstMac    srcIP4    srcPort    dstIP4    dstPort    l4Proto    ipTOS
    ipID    ipIDDiff    ipFrag    ipTTL    ipHdrChkSum    ipCalChkSum    l4HdrChkSum
    l4CalChkSum    ipFlags    pktLen    ipOptLen    ipOpts    seq    ack    seqDiff    ackDiff
    seqPktLen    ackPktLen    tcpStat    tcpFlags    tcpAnomaly    tcpWin    tcpOptLen    tcpOpts
       l7Content
...
25    1291753225.446846    0.000000    0.000000    23    0x00006000    6    eth:vlan:mpls{2}:ipv4:
    tcp    20    0x0800    00:11:22:33:44:55    66:77:88:99:aa:bb    X.Y.Z.U    62701    M.N.O.P
       80    6    0x00    0x26f6    0    0x4000    62    0x6ca6    0x6ca6    0x0247    0x0247    0
    x0040    460    0    0xb2a08909    0x90314073    0    0    0    0    0x59    0x18    0
    x0000    65535    12    0x01 0x01 0x08 0x0a 0x29 0x2d 0xc3 0x6e 0x83 0x63 0xc5 0x76    GET /
    images/I/01TnJ0+mhnL.png HTTP/1.1\r\nHost: ecx.images-amazon.com\r\nUser-Agent: Mozilla/5.0 (
    Macintosh; U; Intel Mac OS X 10.6; de; rv:1.9.2.8) Gecko/20100722 Firefox/3.6.8\r\nAccept:
    image/png,image/*;q=0.8,*/*;q=0.5\r\nAccept-Language: de-de,de;q=0.8,en-us;q=0.5,en;q=0.3\r\
    nAccept-Encoding: gzip,deflate\r\nAccept-Charset: ISO-8859-1,utf-8;q=0.7,*;q=0.7\r\nKeep-Alive
    : 115\r\nConnection: keep-alive\r\nReferer: http://z-ecx.images-amazon.com/images/I/11
    J5cf408UL.css\r\n\r\n
...
```

### 2.4.11 –p FOLDER

Changes the plugin folder from standard *~/.tranalyzer/plugins* to `FOLDER`.

### 2.4.12 –b FILE

Changes the plugin blacklist file from *plugin_folder/plugin_blacklist.txt* to `FILE`, where `plugin_folder` is either *~/.tranalyzer/plugins* or the folder specified with the `-p` option.

### 2.4.13 –e FLOWINDEXFILE

Denotes the filename and path of the flow index file when the pcapd plugin is loaded. The path and name of the pcap file depends on `FLOWINDEXFILE`. If omitted the default names for the PCAP file are defined in *pcapd.h*. The format of the `FLOWINDEXFILE` is a list of 64 bit flow indices which define the packets to be extracted from the pcap being read by the `-r` option. In general the user should use a plain file with the format displayed below:

```
# Comments (ignored)
% Flow file info (ignored)
30
3467
656697
5596
```

For more information on the pcapd plugin please refer to its documentation.

#### 2.4.14 –f HASHFACTOR

Sets and supersedes the `HASHFACTOR` constant in tranalyzer.h.

#### 2.4.15 –x SENSORID

Each T2 can have a separate sensor ID which can be listed in a flow file in order to differentiate flows originating from several interfaces during post processing, e.g., in a DB. If not specified `T2_SENSORID` (`666`), defined in tranalyzer.h, will be the default value.

#### 2.4.16 –c CPU

Bind Tranalyzer to core number `CPU`; if `CPU == 0` then the operating system selects the core to bind.

#### 2.4.17 –P PRIO

Set Tranalyzer priority to `PRIO` instead of 0 (int). `PRIO` MUST belong in [-20, 20] for root and in [0, 20] for standard users. The lower the number, the higher the priority, i.e., -20 has higher priority than 20.

#### 2.4.18 –M FLT

Set monitoring interval to `FLT` seconds.

#### 2.4.19 –F FILE

Read BPF filter from FILE. A filter can span multiple lines and can be commented using the `'#'` character (everything following a `'#'` is ignored).

#### 2.4.20 BPF Filter

A Berkeley Packet Filter (BPF) can be specified at any time in order to reduce the amount of flows being produced and to increase speed during life capture ops. All rules of pcap BPF apply.

### 2.5 hashTable.h

| Name | Default | Description |
|---|---|---|
| `T2_HASH_FUNC` | 10 | Hash function to use:<br>0: standard<br>1: Murmur3 32-bits<br>2: Murmur3 128-bits (truncated to 64-bits)<br>3: xxHash 32-bits<br>4: xxHash 64-bits<br>5: XXH3 64-bits<br>6: XXH3 128-bits (truncated to lower 64-bits)<br>7: CityHash64<br>8: MUM-hash version 3 64-bits<br>9: hashlittle 32-bits<br>10: wyhash 64-bits |

| Name | Default | Description |
|---|---|---|
| | | 11: FastHash32<br>12: FastHash64<br>13: t1ha0 (Linux only) [meson build backend only]<br>14: t1ha2 [meson build backend only] |
| HASHTABLE_DEBUG | 0 | Print debug information |
| HASHTABLE_NAME_LEN | 7 | Maximum length of a hashTable's name |

## 2.6 ioBuffer.h

| Name | Default | Description |
|---|---|---|
| IO_BUFFERING | 0 | Enables buffering of the packets in a queue |
| If IO_BUFFERING == 1, the following flags are available: | | |
| IO_BUFFER_FULL_WAIT_MS | 200 | Number of milliseconds to wait if queue is full |
| IO_BUFFER_SIZE | 8192 | Maximum number of packets that can be stored in the buffer (power of 2) |
| IO_BUFFER_MAX_MTU | 2048 | Maximum size of a packet (divisible by 4) |

## 2.7 loadPlugins.h

| Name | Default | Description |
|---|---|---|
| USE_PLLIST | 1 | Behavior of -b option (plugin loading list):<br>0: disable -b option and load all plugins from the plugin folder<br>1: only load plugins present in the list (whitelist)<br>2: do not load plugins present in the list (blacklist) |

## 2.8 main.h

| Name | Default | Description | Flags |
|---|---|---|---|
| The following four flags apply to the packet mode (-s option): | | | |
| SPKTMD_PKTNO | 1 | Print the packet number | |
| SPKTMD_PCNTC | 1 | Print packet payload as characters | |
| SPKTMD_PCNTH | 0 | Print packet payload as hex | |
| SPKTMD_PCNTL | 4 | Content field:<br>0: Print the full payload of the packet<br>1: Print payload from L2<br>2: Print payload from L3<br>3: Print payload from L4 | |

| Name | Default | Description | Flags |
|---|---|---|---|
| | | 4: Print payload from L7 | |
| SPKTMD_BOPS | 0x00 | Bit operations on content:<br>0x00: MSB, no bit inverse, no shift<br>0x01: LSB, bit inverse<br>0x02: Nibble swap<br>0x10: Shift right<br>0x20: shift from last byte into extra trailing byte (requires SPKTMD_BOPS & 0x10) | |
| SPKTMD_BSHFT_POS | 5 | Shift SPKTMD_BSHFT_POS-1 at 8-SPKTMD_BSHFT into following bytes | |
| SPKTMD_BSHFT | 2 | Bitshift | SPKTMD_BOPS&0x10 |
| SPKTMD_PCNTH_PREF | "0x" | Prefix to add to every byte in packet mode as hex ("" → ab cd instead of 0xab 0xcd) | SPKTMD_PCNTH=1 |
| SPKTMD_PCNTH_SEP | " " | Byte separator in packet mode as hex (",", → 0xab,0xcd instead of 0xab 0xcd) | SPKTMD_PCNTH=1 |
| MIN_MAX_ESTIMATE | 0 | Min/Max bandwidth statistics | |
| MMXLAGTMS | 0.1 | Min Max interval [s] | MIN_MAX_ESTIMATE=1 |
| MMXNO0 | 0 | Suppress 0 in MIN estimation | MIN_MAX_ESTIMATE=1 |
| The following flags control the monitoring mode: | | | |
| MONINTTHRD | 1 | Activate threaded interrupt handling | |
| MONINTBLK | 0 | Block interrupts in main loop during packet processing (disables MONINTTHRD) | |
| MONINTPSYNC | 1 | 0: Interrupt printing,<br>1: pcap main loop synchronized printing | |
| MONINTTMPCP | 0 | 0: real time base, 1: pcap time base | |
| MONINTTMPCP_ON | 0 | Startup monitoring. 0: off, 1: on | MONINTTMPCP=1 |
| MONINTV | 1.0 | $\geq 1$ sec interval of monitoring output if USR2 is sent or MONINTTMPCP=0 | |
| POLLENV | 0 | Change monitoring interval via env var $T2MTIME | |
| MONPROTMD | 1 | 0: report protocol numbers,<br>1: report protocol names | |
| MONPROTFL | "proto.txt" | proto file | |
| The following flags control the DPDK multi-process mode: | | | |
| DPDK_MP | 0 | Use DPDK multi-process mode instead of libpcap | |

The MONPROTL2 and MONPROTL3 flags can be used to configure the L2 and L3 protocols to monitor. Their default values are

- MONPROTL2: ETHERTYPE_ARP,ETHERTYPE_RARP
- MONPROTL3: L3_TCP,L3_UDP,L3_ICMP,L3_ICMP6,L3_SCTP

## 2.9 networkHeaders.h

| Name | Default | Description | Flags |
|---|---|---|---|
| IPV6_ACTIVATE | 2 | 0: IPv4 only<br>1: IPv6 only<br>2: Dual mode | |
| ETH_ACTIVATE | 1 | 0: No Ethernet flows<br>1: Activate Ethernet flows generation<br>2: Also use Ethernet addresses for IPv4/6 flows | |
| LAPD_ACTIVATE | 0 | 0: No LAPD/Q.931 flows<br>1: Activate LAPD/Q.931 flow generation | |
| LAPD_OVER_UDP | 0 | 0: Do not try dissecting LAPD over UDP<br>1: Dissect LAPD over UDP (experimental) | LAPD_ACTIVATE=1 |
| SCTP_ACTIVATE | 0 | 1: standard flows<br>1: activate SCTP chunk streams → flow<br>2: activate SCTP association → flow<br>3: activate SCTP chunk & association → flow | |
| SCTP_STATFINDEX | 0 | 1: findex constant for all SCTP streams in a packet<br>0: findex increments | SCTP_ACTIVATE=1 |
| MULTIPKTSUP | 0 | Multi-packet suppression (discard duplicated packets) | IPV6_ACTIVATE=0 |
| T2_PRI_HDRDESC | 1 | 1: keep track of the headers traversed | |
| T2_HDRDESC_AGGR | 1 | 1: aggregate repetitive headers, e.g., vlan{2} | T2_PRI_HDRDESC=1 |
| T2_HDRDESC_LEN | 128 | max length of the headers description | T2_PRI_HDRDESC=1 |

## 2.10 proto/capwap.h

| Name | Default | Description | Flags |
|---|---|---|---|
| CAPWAP_SWAP_FC | 1 | Swap CAPWAP frame control (required for Cisco) | CAPWAP=1 |

## 2.11 proto/ethertype.h

| Name | Default | Description | Flags |
|---|---|---|---|
| PW_ETH_CW | 1 | Detect Pseudowire (PW) Ethernet Control Word (Heuristic, experimental) | |

## 2.12 proto/linktype.h

| Name | Default | Description | Flags |
|---|---|---|---|
| LINKTYPE_JUNIPER | 1 | Dissect PCAP with Juniper linktypes (Experimental) | |

## 2.13 proto/lwapp.h

| Name | Default | Description | Flags |
|---|---|---|---|
| LWAPP_SWAP_FC | 1 | Swap LWAPP frame control (required for Cisco) | LWAPP=1 |

## 2.14 packetCapture.h

The config file *packetCapture.h* provides control about the packet capture and packet structure process of Tranalyzer2. The most important fields are described below. Please note that after changing any value in define statements a rebuild is required. Note that the PACKETLENGTH switch controls the len variable in the packet structure, from where the packet length is measured from. So statistical plugins such as basicStats can have a layer dependent output. If only L7 length is needed, use the l7Len variable in the packet structure.

| Name | Default | Description | Flags |
|---|---|---|---|
| PACKETLENGTH | 3 | 0: including L2, L3 and L4 header<br>1: including L3 and L4 header<br>2: including L4 header<br>3: only higher layer payload (Layer 7) | |
| FRGIPPKTLENVIEW | 1 | 0: IP header stays with 2nd++ fragmented packets<br>1: IP header stripped from 2nd++ fragmented packets | PACKETLENGTH=1 |
| NOLAYER2 | 0 | 0: Automatic L3 header discovery<br>1: Manual L3 header positioning | |
| NOL2_L3HDROFFSET | 0 | Offset of L3 header | NOLAYER2=1 |
| MAXHDRCNT | 5 | Maximal header count (MUST be $\geq 3$) | IPV6_ACTIVATE=1 |
| SALRM | 0 | 1: enable sending FL_ALARM bit for pcapd | |
| SALRMINV | 0 | 1: invert selection | SALRM=1 |

## 2.15 tranalyzer.h

| Name | Default | Description | Flags |
|---|---|---|---|
| T2_SENSORID | 666 | Sensor ID (can be overwritten with t2 -x option) | |
| ENVCNTRL | 2 | Plugins configuration mode:<br>0: Values from header file during compilation<br>1: Values from header file at runtime<br>2: Values from environment if defined, otherwise from header file at runtime | |
| REPSUP | 0 | Activate alive mode | |
| PID_FNM_ACT | 0 | Save the PID into a file PID_FNM (default: "tranalyzer.pid") | |

| Name | Default | Description | Flags |
|---|---|---|---|
| PKT_CB_STATS | 0 | Compute stats about time spent in perPacketCallback() | |
| DEBUG | 0 | 0: no debug output<br>1: debug output which occurs only once or very seldom<br>2: + debug output which occurs in special situations, but not regularly<br>3: + debug output which occurs regularly (every packet) | |
| VERBOSE | 2 | 0: no output<br>1: basic pcap report<br>2: + full traffic statistics<br>3: + info about fragmentation anomalies | |
| MEMORY_DEBUG | 0 | 0: no memory debug<br>1: detect leaks and overflows (see *utils/memdebug.h*) | |
| NO_PKTS_DELAY_US | 1000 | If no packets are available, sleep for *n* microseconds | |
| NON_BLOCKING_MODE | 1 | Non-blocking mode | |
| MAIN_OUTBUF_SIZE | 1000000 | Size of the main output buffer | |
| SNAPLEN | BUFSIZ | Snapshot length (live capture) | |
| CAPTURE_TIMEOUT | 1000 | Read timeout in milliseconds (live capture) | |
| BPF_OPTIMIZE | 0 | 1: Optimize BPF filters | |
| TSTAMP_PREC | 1 | Timestamp precision: 0: microseconds, 1: nanoseconds | |
| TSTAMP_UTC | 1 | Time representation: 0: localtime, 1: UTC | |
| TSTAMP_R_UTC | 0 | Time report representation: 0: localtime, 1: UTC | |
| ALARM_MODE | 0 | Only output flow if an alarm-based plugin fires | |
| ALARM_AND | 0 | 0: logical OR, 1: logical AND | ALARM_MODE=1 |
| FORCE_MODE | 0 | Parameter induced flow termination (NetFlow mode) | |
| BLOCK_BUF | 0 | Block unnecessary buffer output when non Tranalyzer format event based plugins are active | |
| USE_T2BUS | 0 | Use t2Bus communication backend (experimental) | |
| PLUGIN_REPORT | 1 | Enable plugins to contribute to Tranalyzer end report | |
| DIFF_REPORT | 0 | 0: absolute Tranalyzer command line USR1 report<br>1: differential report | |
| MACHINE_REPORT | 0 | USR1 report:<br>0: human compliant,<br>1: machine compliant | |
| REPORT_HIST | 0 | Store statistical report history in REPORT_HIST_FILE after shutdown and reload it when restarted | |
| ESOM_DEP | 0 | Allow plugins to globally access other plugins variables | |
| AYIYA | 1 | Process AYIYA | |
| GENEVE | 1 | Process GENEVE | |
| TEREDO | 1 | Process TEREDO | |
| L2TP | 1 | Process L2TP | |
| GRE | 1 | Process GRE | |
| GTP | 1 | Process GTP (GPRS Tunneling Protocol) | |
| VXLAN | 1 | Process VXLAN | |
| IPIP | 1 | Process IPv4/6 in IPv4/6 | |
| ETHIP | 1 | Process Ethernet within IP | |
| CAPWAP | 1 | Process CAPWAP | |

| Name | Default | Description | Flags |
|---|---|---|---|
| LWAPP | 1 | Process LWAPP | |
| DTLS | 1 | Process DTLS | |
| FRAGMENTATION | 1 | Activate fragmentation processing | |
| FRAG_HLST_CRFT | 1 | Enables crafted packet processing | FRAGMENTATION=1 |
| FRAG_ERROR_DUMP | 0 | Dumps flawed fragmented packet to stdout | FRAGMENTATION=1 |
| IPVX_INTERPRET | 0 | Interpret bogus IPvX packets | |
| ANONYM_IP | 0 | 1: No output of IP information | |
| ETH_STAT_MODE | 0 | 0: use the innermost layer 2 type for the statistics<br>1: use the outermost layer 2 type for the statistics | |
| SUBNET_ON | 1 | Core control of subnet function for plugins | |
| RELTIME | 0 | 0: absolute time<br>1: relative time | |
| FDURLIMIT | 0 | If $> 0$, force flow life span to $n \pm 1$ seconds | |
| FDLSFINDEX | 0 | Findex for flows of a superflow<br>0: different findex<br>1: same findex | FDURLIMIT=1 |
| FLOW_TIMEOUT | 182 | Flow timeout after a packet is not seen after $n$ seconds | |
| NOFLWCRT | 1 | SIGINT 1 create no flow,<br>SIGINT 2 release all flows, end report | |
| ZPKTITMUPD | 1 | 0: update if packets received<br>1: Zero Pkt actTime update active | |
| ZPKTTMO | 1500 | Number of loops until actTime update | ZPKTITMUPD=1 |
| HASHFACTOR | 1 | default multiplication factor for HASHTABLE_BASE_SIZE<br>(can be overwritten with -f option) | |
| HASH_CHAIN_FACTOR | 2 | default multiplication factor for<br>HASHCHAINTABLE_BASE_SIZE | |
| HASH_AUTOPILOT | 1 | When main hash map is full:<br>0: terminate<br>1: flushes oldest NUMFLWRM flow(s) | |
| NUMFLWRM | 1 | Number of flows to flush when main hash map is full | HASH_AUTOPILOT=1 |

Note that the PLUGIN_FOLDER flag (".tranalyzer/plugins/") can be either set in this file or set at runtime with t2 -p option.
Although not recommended, the suffix for the generated files can also be changed by editing the PACKETS_SUFFIX ("_packets.txt"), LOG_SUFFIX ("_log.txt") and MON_SUFFIX ("_monitoring.txt") flags.

### 2.15.1 -D constants

the following constants influence the file name convention:

| Name | Default | Description |
|---|---|---|
| RROP | 0 | round robin operations |

| Name | Default | Description |
|---|---|---|
| POLLTM | 5 | poll timing for files |
| SCHR | 'p' | separating character for file number |

### 2.15.2 alive signal

The alive signal is a derivative of the passive monitoring mode by the USR1 signal, where the report is deactivated. If REPSUP=1 then only the command defined by REPCMDAS/W is sent to the control program defined by ALVPROG as defined below:

| Name | Default | Description |
|---|---|---|
| REPSUP | 0 | 0: alive mode off,<br>1: alive mode on, monitoring report suppressed |
| ALVPROG | "t2alive" | name of control program |
| REPCMDAS | "a=`pgrep " ALVPROG "`; \<br>if [ $a ]; then kill -USR1 $a; fi" | alive and stall USR1 signal (no packets) |
| REPCMDAW | "a=`pgrep " ALVPROG "`; \<br>if [ $a ]; then kill -USR2 $a; fi" | alive and well USR2 signal (working) |

If T2 crashes or is stopped a syslog message is issued by the t2alive daemon. Same if T2 gets started.

### 2.15.3 FORCE_MODE

A 1 enables the force mode which enables any plugin to force the output of flows independent of the timeout value. Hence, Cisco NetFlow similar periodic output can be produced or overflows of counters can produce a flow and restart a new one. The macro which has to be present in the t2OnLayer4() function is shown below:

```
T2_RM_FLOW(flowP);
```

**Figure 1:** *Force code line in the* t2OnFlowTerminate() *plugin routine*

### 2.15.4 ALARM_MODE

A 1 enables the alarm mode which differs from the default flow mode by the plugin based control of the Tranalyzer core flow output. It is useful for classification plugins generating alarms, thus emulating alarm based SW such as Snort, etc. The default value is 0. The plugin sets the global output suppress variable supOut=1 in the t2OnFlowTerminate() function before any output is generated. This mode also allows multiple classification plugins producing an 'AND' or an 'OR' operation if many alarm generating plugins are loaded. The variable ALARM_AND controls the logical alarm operation. The macro which has to be present in the t2OnFlowTerminate() function is shown below:

```
T2_REPORT_ALARMS(tcpWinFlowP->winThCnt);
```

**Figure 2:** *Alarm code line in the* t2OnFlowTerminate() *plugin routine*

### 2.15.5 BLOCK_BUF

if set to '1' unnecessary buffered output from all plugins is blocked when non Tranalyzer format event based plugins are active, e.g., text-based or binary output plugins are not loaded.

### 2.15.6 Report Modes

Tranalyzer provides a user interrupt based report and a final report. The interrupt based mode can be configured in a variety of ways being defined below.

| Name | Default | Description |
|---|---|---|
| PLUGIN_REPORT | 0 | enable plugins to contribute to the tranalyzer command line end report |
| DIFF_REPORT | 0 | 1: differential, 0: Absolute tranalyzer command line USR1 report |
| MACHINE_REPORT | 0 | USR1 Report 1: machine compliant; 0: human compliant |

The following interrupts are being caught by Tranalyzer2:

| Signal Name | Description |
|---|---|
| SIGINT | like ^C terminates new flow production[4] |
| SIGTERM | terminates tranalyzer |
| SIGUSR1 | prints statistics report |
| SIGUSR2 | toggles repetitive statistics report |

### 2.15.7 State and statistical save mode

T2 is capable to preserve its internal statistical state and certain viable global variables, such as the findex.

| Name | Default | Description |
|---|---|---|
| REPORT_HIST | 0 | Store statistical report history after shutdown, reload it upon restart |
| REPORT_HIST_FILE | "stat_hist.txt" | default statistical report history filename |

The history file is stored by default under ./tranalyzer/plugins or under the directory defined by a -p option.

### 2.15.8 L2TP

A '1' activates the L2TP processing of the Tranalyzer2 core. All L2TP headers either encapsulated in MPLS or not will be processed and followed down via PPP headers to the IP header and then passed to the IP processing. The default value of the variable is '0'. Then the stack will be parsed until the first IP header is detected. So all L2TP UDP headers having source and destination port 1701 will be processed as normal UDP packets.

### 2.15.9 GRE

A '1' activates the L3 General Routing Encapsulation (GRE, l4proto=47) processing of the Tranalyzer2 core. All GRE headers either encapsulated in MPLS or not will be processed and followed down via PPP headers to the IP header and then passed to the IP processing. The default value of the variable is 0. Then the stack will be parsed until the first IP header is detected. If the following content is not existing or compressed the flow will contain only l4Proto=47 information.

[4] If two SIGINT interrupts are being sent in short order Tranalyzer will be terminated instantly.

### 2.15.10 FRAGMENTATION

A '1' activates the fragmentation processing of the Tranalyzer2 core. All packets following the header packet will be assembled in the same flow. The core and the plugin tcpFlags will provide special flags for fragmentation anomalies. If `FRAGMENTATION` is set to 0 only the initial fragment will be processed; all later fragments will be ignored.

### 2.15.11 FRAG_HLST_CRFT

A '1' enables crafted packet processing even when the lead fragment is missing or packets contain senseless flags as being used in attacks or equipment failure.

### 2.15.12 FRAG_ERROR_DUMP

A '1' activates the dump of packet information on the command line for time based identification of ill-fated or crafted fragments in tcpdump or Wireshark. It provides the Unix timestamp, the six tuple, IPID and fragID as outlined in figure below.

```
MsgType   msg   time   vlan   srcIP   srcPort   dstIP   dstPort   proto   fragID   fragOffset
[WRN] packetCapture: 1. frag not found @ 1291753225.449690 20 X.Y.Z.U 42968 M.N.O.P 52027 17 - 0
    x191F 0x00A0
[WRN] packetCapture: 1. frag not found @ 1291753225.482611 20 X.Y.Z.U 43044 M.N.O.P 1719 17 - 0
    x1922 0x00A0
[WRN] packetCapture: 1. frag not found @ 1291753225.492830 20 X.Y.Z.U 55841 M.N.O.P 28463 17 - 0
    x1923 0x00A0
[WRN] packetCapture: 1. frag not found @ 1291753225.503955 20 X.Y.Z.U 25668 M.N.O.P 8137 17 - 0
    x1924 0x00A0
[WRN] packetCapture: 1. frag not found @ 1291753225.551094 20 X.W.Z.T 41494 T.V.W.Z 27796 17 - 0
    x5A21 0x00A0
[WRN] packetCapture: 1. frag not found @ 1291753225.639627 20 A.B.C.D 38824 E.F.G.H 55133 17 - 0
    x0DAE 0x00AC
```

**Figure 3:** *A sample report on stdout for packets with an elusive first fragment*

**WARNING:** If `FRAG_HLST_CRFT == 1` then every fragmented headerless packet will be reported!

### 2.15.13 *_SUFFIX

This constant defines the suffix of all plugin output files. For example if you specify the output *foo.foo* (with the `-w` option), the generated file for the per-packet output will be in the default setting *foo.foo_packets*.

### 2.15.14 RELTIME

`RELTIME` renders all time based plugin output into relative to the beginning of the pcap or start of packet capture. In `-D` or `-R` read operation the first file defines the start time.

### 2.15.15 FLOW_TIMEOUT

This constant specifies the default time in seconds (182) after which a flow will be considered as terminated since the last packet is captured. Note: Plugins are able to change the timeout values of a flow. For example the tcpStates plugin adjusts the timeout of a flow according to the TCP state machine. A reduction of the flow timeout has an effect on the necessary flow memory defined in `HASHCHAINTABLE_SIZE`, see below.

### 2.15.16 FDURLIMIT

`FDURLIMIT` defines the maximum flow duration in seconds which is then forced to be released. It is a special force mode for the duration of flows and a special feature for Dalhousie University. If `FDURLIMIT > 0` then `FLOW_TIMEOUT` is overwritten if `FURLIMIT` seconds are reached.

### 2.15.17 HASHFACTOR

A factor to be multiplied with the `HASHTABLE_SIZE` described below. It facilitates the correct setting of the hash space. Moreover, if T2 runs out of hash it will give an upper estimate the user can choose for `HASHFACTOR`. Set it to this value, recompile and rerun T2. This constant is superseded by the `-f` option.

### 2.15.18 HASHTABLE_SIZE

The number of buckets in the hash table. As a separate chaining hashing method is used, this value does not denote the amount of elements the hash table is able to manage! The larger, the less likely are hash collisions. The current default value is $2^{18}$. Its value should be selected at least two times larger as the value of `HASHCHAINTABLE_SIZE` discussed in the following chapter.

### 2.15.19 HASH_CHAIN_FACTOR

A factor to be multiplied with the `HASHCHAINTABLE_SIZE` described below.

### 2.15.20 HASHCHAINTABLE_SIZE

Specifies the amount of flows the main hash table is able to manage. The default value is $2^{19}$, so roughly half the size of `HASHTABLE_SIZE`. T2 supplies information about the hash space in memory in: `Max number of IPv4 flows in memory: 113244 (50.220%)`. Together with the amount of traffic already processed the total value can be computed. An example is given in Figure 1.

### 2.15.21 HASH_AUTOPILOT

Default 1. Avoids overrun of main hash, flushes oldest flow on every flow insert if hash map is full. 0 disables hash overrun protection. If speed is an issue avoid overruns by invoking T2 with the `-f` option set to the value recommended by T2.

### 2.15.22 SUBNET_ON

Since the version 0.8.8 the core controls the subnet functions instead of basicFlow as now the aggregation mode according to countries or organization is possible.

### 2.15.23 utils.h

The following flags can be used to configure the subnet files and the output of the plugins:

| Name | Default | Description |
|---|---|---|
| `SUBRNG` | 0 | Subnet definition:<br>0: CIDR only<br>1: Begin-End |

| Name | Default | Description |
|---|---|---|
| CNTYCTY | 0 | 1: Add the county and city |
| CNTYLEN | 14 | length of County record |
| CTYLEN | 14 | length of City record |
| WHOLEN | 27 | length of Organization record |

If any of those flags is changed, `tranalyzer` **MUST** be recompiled with `t2build -f` in order to generate a new binary subnet file, as we only load the info the user needs.

### 2.15.24 Format of the Subnet Files

The text format of the `subnets4.txt` and `subnets6.txt` files is defined as follows:

- A `'-'` in the first column (`prefix/mask`) denotes a non-CIDR range. In this case, Tranalyzer reads the 2nd column instead of the 1st when `SUBRNG=1` in utils.h.
- If `SUBRNG=0`, the 2nd column is ignored and only CIDR ranges are accepted.
- Country and Whois 32 bit hex code: `cccc cccc cTww wwww wwww wwww wwww wwww` where `c`: Country, `T` Tor address bit, `w`: Organization
- Autonomous System Number (ASN)
- Uncertainty of location in km
- Latitude
- Longitude
- Country
- County
- City
- Organization

An extraction of `subnets4.txt` is depicted below:
The text files `subnets4.txt` and `subnets6.txt` can be edited and manually converted, just move to `utils/subnet` directory and invoke the following command:

`./subconv subnets4.txt` and `./subconv subnets6.txt`

### 2.15.25 Tor Information

Since 0.8.8 Tor information is also available for IPv6. The conversion programs from the raw files to T2 format can be found under `utils/subnet/tor`. It can be controlled also by `subconv`, see options below:

```
#       5       16122020
# IPCIDR        IPrange CtryWhoCode     ASN     Uncert  Latitude        Longitude       Country
    County  City    Org
# Begin IPv4 private address space
10.0.0.0/8      10.0.0.0-10.255.255.255 0x0301c2a7      0       -1.0    666.000000      666.000000
          04      -       -       Private network
14.0.0.0/8      14.0.0.0-14.255.255.255 0x00000000      0       -1.0    666.000000      666.000000
          03      -       -       Public data networks
24.0.0.0/8      24.0.0.0-24.255.255.255 0x00000000      0       -1.0    666.000000      666.000000
          09      -       -       Cable television networks
127.0.0.0/8     127.0.0.0-127.255.255.255       0x01014fe7      0       -1.0    666.000000
    666.000000      01      -       -       Loopback
100.64.0.0/10   100.64.0.0-100.127.255.255       0x0702041f      0       -1.0    666.000000
    666.000000      20      -       -       Shared address space
169.254.0.0/16  169.254.0.0-169.254.255.255     0x02014965      0       -1.0    666.000000
    666.000000      02      -       -       Link-local
172.16.0.0/12   172.16.0.0-172.31.255.255        0x0381c2a7      0       -1.0    666.000000
    666.000000      05      -       -       Private network
192.0.0.0/24    192.0.0.0-192.0.0.255   0x0401c2a7      0       -1.0    666.000000      666.000000
          06      -       -       Private network
192.0.2.0/24    192.0.2.0-192.0.2.255   0x07823fb8      0       -1.0    666.000000      666.000000
          21      -       -       TEST-NET-1
192.88.99.0/24  192.88.99.0-192.88.99.255       0x0b011c29      0       -1.0    666.000000
    666.000000      60      -       -       IPv6 to IPv4 relay
192.168.0.0/16  192.168.0.0-192.168.255.255     0x0481c2a7      0       -1.0    666.000000
    666.000000      07      -       -       Private network
198.18.0.0/15   198.18.0.0-198.19.255.255        0x0501c2a7      0       -1.0    666.000000
    666.000000      08      -       -       Private network
198.51.100.0/24 198.51.100.0-198.51.100.255     0x08023fb9      0       -1.0    666.000000
    666.000000      22      -       -       TEST-NET-2
203.0.113.0/24  203.0.113.0-203.0.113.255       0x08823fba      0       -1.0    666.000000
    666.000000      23      -       -       TEST-NET-3
224.0.0.0/4     224.0.0.0-239.255.255.255       0x06017598      0       -1.0    666.000000
    666.000000      10      -       -       Multicast
...
240.0.0.0/4     240.0.0.0-255.255.255.254       0x0901dd04      0       -1.0    666.000000
    666.000000      24      -       -       Reserved
255.255.255.255/32      255.255.255.255-255.255.255.255 0x06804ca0      0       -1.0    666.000000
          666.000000      11      -       -       Broadcast
# End IPv4 private address space
1.0.0.0/24      1.0.0.0-1.0.0.255       0x8480205e      13335   80.000000       34.052231
    -118.243683     us      California      Los Angeles     APNIC Research and Development
1.0.1.0/24      1.0.1.0-1.0.1.255       0x260062cc      0       80.000000       26.061390
    119.306107      cn      Fujian  Fuzhou  CHINANET FUJIAN PROVINCE NETWORK
1.0.2.0/23      1.0.2.0-1.0.3.255       0x260062cc      0       80.000000       26.061390
    119.306107      cn      Fujian  Fuzhou  CHINANET FUJIAN PROVINCE NETWORK
1.0.4.0/24      1.0.4.0-1.0.4.255       0x148284d8      56203   80.000000       -37.813999
    144.963318      au      Victoria        Melbourne       Wirefreebroadband Pty Ltd
...
```

```
$ ./subconv -h
Usage:
    subconv [OPTION...] <subnets.txt>

Optional arguments:
    -4                Generate subnet file for IPv4
```

```
-6                Generate subnet file for IPv6

-t                Add Tor info to subnet file
-a                Download and add Tor info to subnet file
-c                Convert from Tor JSON info to subnet file

-h, --help        Show this help, then exit
```

So to convert the IPv4 subnet file and add existing Tor info invoke the following command:

```
./subconv -t subnets4.txt
```

### 2.15.26 Aggregation Mode

The aggregation mode enables the user to confine certain IP, port or protocol ranges into a single flow. The variable AGGREGATIONFLAG in tranalyzer.h defines a bit field which enables specific aggregation modes according to the six tuple values listed below.

| Aggregation Flag | Value |
|---|---|
| L4PROT | 0x01 |
| DSTPORT | 0x02 |
| SRCPORT | 0x04 |
| DSTIP | 0x08 |
| SRCIP | 0x10 |
| VLANID | 0x20 |
| SUBNET | 0x80 |

If a certain aggregation mode is enabled the following variables in tranalyzer.h define the aggregation range.

| Aggregation Flag | Type | Description |
|---|---|---|
| SRCIP4CMSK | uint8_t | src IPv4 aggregation CIDR mask |
| DSTIP4CMSK | uint8_t | dst IPv4 aggregation CIDR mask |
| SRCIP6CMSK | uint8_t | src IPv6 aggregation CIDR mask |
| DSTIP6CMSK | uint8_t | dst IPv6 aggregation CIDR mask |
| SRCPORTLW | uint16_t | src port lower bound |
| SRCPORTHW | uint16_t | src port upper bound |
| DSTPORTLW | uint16_t | dst port lower bound |
| DSTPORTHW | uint16_t | dst port upper bound |

If SUBNET is chosen then all flows are aggregated according to a 32-bit hex subnet mask of the organization country hex code.

```
// SUBNET mode: IP flow aggregation network masks
#define CNTRY_MSK 0xff800000
#define TOR_MSK   0x00400000
#define ORG_MSK   0x003fffff
#define NETIDMSK  (CNTRY_MSK | ORG_MSK) // netID mask
```

## 2.16 bin2txt.h

| Name | Default | Description |
|---|---|---|
| IP4_FORMAT | 0 | IPv4 addresses representation:<br>0: normal,<br>1: normalized (padded with zeros),<br>2: one 32-bits hex number<br>3: one 32-bits unsigned number |
| IP6_FORMAT | 0 | IPv6 addresses representation:<br>0: compressed,<br>1: uncompressed,<br>2: one 128-bits hex number,<br>3: two 64-bits hex numbers |
| MAC_FORMAT | 0 | MAC addresses representation:<br>0: normal (edit MAC_SEP to change the separator),<br>1: one 64-bits hex number, |
| MAC_SEP | ":" | Separator to use in MAC addresses: 11:22:33:44:55:66 |
| B2T_NON_IP_STR | "-" | Representation of non-IPv4/IPv6 addresses in IP columns |
| HEX_CAPITAL | 0 | Hex output: 0: lower case; 1: upper case |
| TFS_EXTENDED_HEADER | 0 | Extended header in flow file |
| TFS_NC_TYPE | 2 | Types in header file: 0: none, 1: numbers, 2: C types |
| TFS_SAN_UTF8 | 1 | Activates the UTF-8 sanitizer for strings |
| B2T_TIMESTR | 0 | Print Unix timestamps as human readable dates |
| HDR_CHR | "%" | start character(s) of comments |
| SEP_CHR | "\t" | column separator in the flow file<br>";", ".", "_" and "\"" should not be used |
| JSON_KEEP_EMPTY | 0 | Output empty fields |
| JSON_PRETTY | 0 | Add spaces to make the output more readable |

## 2.17 gz2txt.h

| Name | Default | Description |
|---|---|---|
| USE_ZLIB | 1 | Activate code for gzip-(de)compression |

## 2.18 outputBuffer.h

| Name | Default | Description | Flags |
|---|---|---|---|
| BUF_DATA_SHFT | 0 | Adds for each binary output record the length and shifts the record by *n* uint32_t words to the right (see binSink and socketSink plugin) | |
| OUTBUF_AUTOPILOT | 1 | Automatically increase the output buffer when required | |
| OUTBUF_MAXSIZE_F | 5 | Maximal factor to increase the output buffer size to | OUTBUF_AUTOPILOT=1 |

## 2.19 rbTree.h

| Name | Default | Description |
|---|---|---|
| RBT_DEBUG | 0 | Enable debug output |
| RBT_ROTATION | 0 | Activate the Red-Black Tree feature of rotating an unbalanced tree |

## 2.20 subnetHL.h

| Name | Default | Description |
|---|---|---|
| SUBRNG | 0 | IP range definition:<br>0: CIDR only,<br>1: Begin-End |
| CNTYCTY | 0 | Output the county and the city |
| WHOADDR | 0 | Add whois address info |
| SUB_MAP | 1 | Use mmap to load the subnet file |
| CNTYLEN | 14 | Length of County record |
| CTYLEN | 14 | Length of City record |
| WHOLEN | 30 | Length of Organization record |
| ADDRLEN | 30 | Length of Address record |
| SUBNET_UNK | "-" | Representation of unknown locations |

## 2.21 t2log.h

| Name | Default | Description |
|---|---|---|
| T2_LOG_COLOR | 1 | Whether or not to color messages |

## 2.22 Tranalyzer2 Output

As stated before, the functionality and output of Tranalyzer2 is defined by the activated plugins. Basically, there are two ways a plugin can generate output. First, it can generate its own output file and write any arbitrary content into any stream. The second way is called standard output or per-flow output. After flow termination Tranalyzer2 provides an output buffer and appends the direction of the flow to it. For example, in case of textual output, an "A" flow is normally followed by a "B" flow or if the "B" flow does not exist it is followed by the next "A" flow. Then, the output buffer is passed to the plugins providing their per-flow output. Finally the buffer is sent to the activated output plugins. This process repeats itself for the "B" flow. For detailed explanation about the functionality of the output plugins refer to the section plugins.

### 2.22.1 Hierarchical Ordering of Numerical or Text Output

Tranalyzer2 provides a hierarchical ordering of each output. Each plugin controls the:

- volume of its output
- number of values or bins

- hierarchical ordering of the data
- repetition of data substructures

Thus, complex structures such as lists or matrices can be presented in a single line.
The following sample of text output shows the hierarchical ordering for four data outputs, separated by tabulators:

```
A    0.3    2.0_3.4_2.1    2;4;2;1    (1_2_9)_(1_3_1)_(7_5_3)_(2_3_7)
```

The `A` indicates the direction of the flow; in this case it is the initial flow. The next number denotes a singular descriptive statistical result. Output number two consists of three values separated by "_" characters. Output number three consists of one value, that can be repeated, indicated by the character ";". Output number four is a more complex example: It consists of four values containing three subvalues indicated by the braces. This could be interpreted as a matrix of size $4 \times 3$.

## 2.23 Final Report

Standard configuration of Tranalyzer2 produces a statistical report to *stdout* about timing, packets, protocol encapsulation type, average bandwidth, dump length, etc. A sample report including some current protocol relevant warnings is depicted in the figure below. Warnings are not fatal hence are listed at the end of the statistical report when Tranalyzer2 terminates naturally. The *Average total Bandwidth* estimation refers to the processed bandwidth during the data acquisition process. It is only equivalent to the actual bandwidth if the total packet length including all encapsulations is not truncated and all traffic is IP. The *Average IP Traffic Bandwidth* is an estimate comprising all IP traffic actually present on the wire. Plugins can report extra information when `PLUGIN_REPORT` is activated. This report can be saved in a file, by using one of the following command:

```
tranalyzer -r file.pcap -w out -l (See Section 2.4.8)
 tranalyzer -r file.pcap -w out | tee out_stdout.txt
   tranalyzer -r file.pcap -w out > out_stdout.txt
```

Both commands will create a file `out_stdout.txt` containing the report. The only difference between those two commands is that the first one still outputs the report to stdout.

Fatal errors regarding the invocation, configuration and operation of Tranalyzer2 are printed to *stderr* after the plugins are loaded, thus before the processing is activated, see the *Hash table error* example in Listing 1. These errors terminate Tranalyzer2 immediately and are located before the final statistical report as being indicated by the *"Shutting down..."* key phrase. If the final report is to be used in a following script a pipe can be appended and certain lines can be filtered using grep or awk.

```
$ ./tranalyzer -r ~/data/knoedel.pcap -w ~/results/
================================================================================
Tranalyzer 0.8.9 (Anteater), Tarantula. PID: 3426
================================================================================
[INF] Creating flows for L2, IPv4, IPv6
Active plugins:
    01: protoStats, 0.8.9
    02: basicFlow, 0.8.9
    03: macRecorder, 0.8.9
    04: portClassifier, 0.8.9
    05: basicStats, 0.8.9
    06: tcpFlags, 0.8.9
    07: tcpStates, 0.8.9
    08: icmpDecode, 0.8.9
    09: dnsDecode, 0.8.9
```

```
    10: httpSniffer, 0.8.9
    11: connStat, 0.8.9
    12: txtSink, 0.8.9
[INF] IPv4 Ver: 5, Rev: 16122020, Range Mode: 0, subnet ranges loaded: 406027 (406.03 K)
[INF] IPv6 Ver: 5, Rev: 17122020, Range Mode: 0, subnet ranges loaded: 50974 (50.97 K)
Processing file: /home/wurst/knoedel.pcap
Link layer type: Ethernet [EN10MB/1]
Dump start: 1291753225.446732 sec (Tue 07 Dec 2010 20:20:25 GMT)
[WRN] snapL2Length: 1550 - snapL3Length: 1484 - IP length in header: 1492
[WRN] Hash Autopilot: main HashMap full: flushing 1 oldest flow(s)
[INF] Hash Autopilot: Fix: Invoke Tranalyzer with '-f 5'
Dump stop : 1291753452.373884 sec (Tue 07 Dec 2010 20:24:12 GMT)
Total dump duration: 226.927152 sec (3m 46s)
Finished processing. Elapsed time: 171.835756 sec (2m 51s)
Finished unloading flow memory. Time: 182.101116 sec (3m 2s)
Percentage completed: 100.00%
Number of processed packets: 53982409 (53.98 M)
Number of processed bytes: 42085954664 (42.09 G)
Number of raw bytes: 42101578296 (42.10 G)
Number of pad bytes: 25023 (25.02 K)
Number of pcap bytes: 42949673232 (42.95 G)
Number of IPv4 packets: 53768017 (53.77 M) [99.60%]
Number of IPv6 packets: 214107 (214.11 K) [0.40%]
Number of A packets: 31005806 (31.01 M) [57.44%]
Number of B packets: 22976603 (22.98 M) [42.56%]
Number of A bytes: 14211017503 (14.21 G) [33.77%]
Number of B bytes: 27874937161 (27.87 G) [66.23%]
Average A packet load: 458.33
Average B packet load: 1213.19 (1.21 K)
--------------------------------------------------------------------------------
macRecorder: MAC pairs per flow: min: 1, max: 3, average: 1.00
basicStats: Biggest L2 talker: xx:xx:xx:xx:xx:xx: 68 [0.00%] packets
basicStats: Biggest L2 talker: xx:xx:xx:xx:xx:xx: 85480 (85.48 K) [0.00%] bytes
basicStats: Biggest L3 talker: v.v.v.v (GB): 154922 (154.92 K) [0.29%] packets
basicStats: Biggest L3 talker: w.w.w.w (GB): 236308004 (236.31 M) [0.56%] bytes
tcpFlags: Aggregated ipFlags: 0x3d6e
tcpFlags: Aggregated tcpAnomaly: 0xfe07
tcpFlags: Number of TCP scans attempted, successful: 88849 (88.85 K), 140408 (140.41 K) [158.03%]
tcpFlags: Number of TCP SYN retries, seq retries: 65369 (65.37 K), 15783 (15.78 K)
tcpFlags: Number WinSz below 1: 162725 (162.72 K) [0.38%]
tcpFlags: Number of MPTCP packets: 6 [0.00%]
tcpFlags: Aggregated MPTCP types: 0x0008 and flags: 0x00
tcpStates: Aggregated tcpStates anomalies: 0xdf
icmpDecode: Aggregated icmpStat: 0x31
icmpDecode: Number of ICMP echo request packets: 14979 (14.98 K) [12.00%]
icmpDecode: Number of ICMP echo reply packets: 2690 (2.69 K) [2.16%]
icmpDecode: ICMP echo reply / request ratio: 0.18
icmpDecode: Number of ICMPv6 echo request packets: 1440 (1.44 K) [9.63%]
icmpDecode: Number of ICMPv6 echo reply packets: 951 [6.36%]
icmpDecode: ICMPv6 echo reply / request ratio: 0.66
dnsDecode: Number of DNS packets: 237597 (237.60 K) [0.44%]
dnsDecode: Number of DNS Q packets: 125260 (125.26 K) [52.72%]
dnsDecode: Number of DNS R packets: 112337 (112.34 K) [47.28%]
dnsDecode: Aggregated dnsStat: 0xf72f
httpSniffer: Number of HTTP packets: 36623492 (36.62 M) [67.84%]
httpSniffer: Number of HTTP GET  requests: 426825 (426.82 K) [1.17%]
httpSniffer: Number of HTTP POST requests: 39134 (39.13 K) [0.11%]
httpSniffer: HTTP GET/POST ratio: 10.91
httpSniffer: Aggregated httpStat     : 0x003f
httpSniffer: Aggregated httpAFlags   : 0x5143
```

```
httpSniffer: Aggregated httpCFlags   : 0x007a
httpSniffer: Aggregated httpHeadMimes: 0x80ef
httpSniffer: Number of files img_vid_aud_msg_txt_app_unk: 192890_5262_401_95_149772_91634_1958
connStat: Number of unique source IPs: 275311 (275.31 K)
connStat: Number of unique destination IPs: 301003 (301.00 K)
connStat: Number of unique source/destination IPs connections: 1242 (1.24 K)
connStat: Max unique number of source IP / destination port connections: 1521 (1.52 K)
connStat: IP prtcon/sdcon, prtcon/scon: 1.224638, 0.005525
connStat: Source IP with max connections: X.Y.Z.U (HU): 1515 (1.51 K) connections
connStat: Destination IP with max connections: L.M.N.O (FI): 3241 (3.24 K) connections
--------------------------------------------------------------------------------
Headers count: min: 4, max: 13, average: 7.10
Max VLAN header count: 1
Max MPLS header count: 2
Number of LLC packets: 285 [0.00%]
Number of GRE packets: 285 [0.00%]
Number of Teredo packets: 213876 (213.88 K) [0.40%]
Number of AYIYA packets: 231 [0.00%]
Number of IGMP packets: 401 [0.00%]
Number of ICMP packets: 124800 (124.80 K) [0.23%]
Number of ICMPv6 packets: 14946 (14.95 K) [0.03%]
Number of TCP packets: 43273341 (43.27 M) [80.16%]
Number of TCP bytes: 36129271238 (36.13 G) [85.85%]
Number of UDP packets: 10311931 (10.31 M) [19.10%]
Number of UDP bytes: 5832263590 (5.83 G) [13.86%]
Number of IPv4 fragmented packets: 19155 (19.16 K) [0.04%]
Number of IPv6 fragmented packets: 9950 (9.95 K) [4.65%]
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
Number of processed   flows: 1438758 (1.44 M)
Number of processed A flows: 1209354 (1.21 M) [84.06%]
Number of processed B flows: 229404 (229.40 K) [15.94%]
Number of request     flows: 930585 (930.59 K) [64.68%]
Number of reply       flows: 508173 (508.17 K) [35.32%]
Total   A/B    flow asymmetry: 0.68
Total req/rply flow asymmetry: 0.29
Number of processed   packets/flows: 37.52
Number of processed A packets/flows: 25.64
Number of processed B packets/flows: 100.16
Number of processed total packets/s: 237884.31 (237.88 K)
Number of processed A+B   packets/s: 237884.31 (237.88 K)
Number of processed A     packets/s: 136633.30 (136.63 K)
Number of processed   B   packets/s: 101251.01 (101.25 K)
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
Number of average processed flows/s: 6340.18 (6.34 K)
Average full raw bandwidth: 1484232320 b/s (1.48 Gb/s)
Average snapped bandwidth : 1483681536 b/s (1.48 Gb/s)
Average full bandwidth : 1483899136 b/s (1.48 Gb/s)
Max number of flows in memory: 262144 (262.14 K) [100.00%]
Number of flows terminated by autopilot: 815749 (815.75 K) [56.70%]
Memory usage: 2.49 GB [3.70%]
Aggregate flow status: 0x0c00bcfad298fb04
[WRN] L3 SnapLength < Length in IP header
[WRN] L4 header snapped
[WRN] Consecutive duplicate IP ID
[WRN] IPv4/6 payload length > framing length
[WRN] IPv4/6 fragmentation header packet missing
[WRN] IPv4/6 packet fragmentation sequence not finished
[INF] Ethernet flows
[INF] IPv4 flows
[INF] IPv6 flows
```

```
[INF] VLAN encapsulation
[INF] IPv4/6 fragmentation
[INF] MPLS encapsulation
[INF] L2TP encapsulation
[INF] PPP/HDLC encapsulation
[INF] GRE encapsulation
[INF] AYIYA tunnel
[INF] Teredo tunnel
[INF] CAPWAP/LWAPP tunnel
[INF] IPsec AH
[INF] IPsec ESP
[INF] SSDP/UPnP
[INF] SIP/RTP
```

**Listing 1:** *A sample Tranalyzer2 final report including encapsulation warning, Hash Autopilot engagement when hash table full*

T2 runs in IPv4 mode, but warns the user that there is IPv6 encapsulated. Note that the new Hash Autopilot warns you when the main hash map is full. T2 then removes the oldest flow and continues processing your pcap. To avoid that, run T2 again, but this time, use the `-f 5` option as indicated in the warning message:

```
[INF] Hash Autopilot: Fix: Invoke Tranalyzer with '-f 5'
   $ t2 -r ~/wurst/data/knoedel.pcap -w ~/results -f 5
```

or just let it run to the finish.

## 2.24 Monitoring Modes During Runtime

:If debugging is deactivated or the verbose level is zero (see Section 2.15), Tranalyzer2 prints no status information or end report. Since 0.8.8 the control of T2 can be achieved without the knowledge of the PID via `t2stat`:

```
t2stat -h
Usage:
    t2stat [OPTION...]

Optional arguments:
    INTERVAL     Send a signal to Tranalyzer every INTERVAL seconds
    -SIGNAME     Send SIGNAME signal instead of USR1
    -s           Run the command as root (with sudo)
    -p           Print Tranalyzer PID(s) and exit
    -l           List Tranalyzer PID(s), commands, running time and exit
    -i           Interactively cycle through all Tranalyzer processes

Help and documentation arguments:
    -h           Show help options and exit
```

Here are some examples

| Command | Description |
|---|---|
| `t2stat` | T2 sends configured monitoring report to stdout |
| `t2stat 5` | T2 sends configured monitoring report to stdout every 5 seconds |
| `t2stat -USR2` | T2 toggles between on demand and continuous monitoring operation |
| `t2stat -SIGINT` | stop flow creation (like `^C` in the shell) |
| `t2stat -TERM` | terminate T2 immediately (Like two times `^C` in the shell) |

The script `t2stat` has the same function as `kill -USR1 PID`. An example of a typical signal requested report (`MACHINE_REPORT=0`) is shown in Listing 2.

```
                                    @      @
                                     |    |
================================vVv==(a    a)==vVv================================
====================================\    /====================================
=====================================\  /=====================================
                                      oo
USR1 A type report: Tranalyzer 0.8.9 (Anteater), Tarantula. PID: 3434
PCAP time: 1291753338.831347 sec (Tue 07 Dec 2010 20:22:18 GMT)
PCAP duration: 113.384615 sec (1m 53s)
Time: 1613737828.648459 sec (Fri 19 Feb 2021 13:30:28 CET)
Elapsed time: 66.478134 sec (1m 6s)
Processing file: /home/wurst/knoedel.pcap
Total bytes to process: 42949673232 (42.95 G)
Percentage completed: 50.60%
Total bytes processed so far: 21730424832 (21.73 G)
Remaining time: 64.914335 sec (1m 4s)
ETF: 1613737893.562794 sec (Fri 19 Feb 2021 13:31:33 CET)
Number of processed packets: 27154806 (27.15 M)
Number of processed bytes: 21295948035 (21.30 G)
Number of raw bytes: 21303536835 (21.30 G)
Number of pad bytes: 12158 (12.16 K)
Number of IPv4 packets: 27051228 (27.05 M) [99.62%]
Number of IPv6 packets: 103450 (103.45 K) [0.38%]
Number of A packets: 15590982 (15.59 M) [57.42%]
Number of B packets: 11563824 (11.56 M) [42.58%]
Number of A bytes: 7188873480 (7.19 G) [33.76%]
Number of B bytes: 14107074555 (14.11 G) [66.24%]
Average A packet load: 461.09
Average B packet load: 1219.93 (1.22 K)
--------------------------------------------------------------------------------
tcpFlags: Number of TCP scans attempted, successful: 29501 (29.50 K), 51309 (51.31 K) [173.92%]
tcpFlags: Number of TCP SYN retries, seq retries: 32048 (32.05 K), 7843 (7.84 K)
icmpDecode: Aggregated icmpStat: 0x21
icmpDecode: Number of ICMP echo request packets: 8244 (8.24 K) [11.58%]
icmpDecode: Number of ICMP echo reply packets: 1948 (1.95 K) [2.74%]
dnsDecode: Number of DNS packets: 122201 (122.20 K) [0.45%]
dnsDecode: Number of DNS Q packets: 64102 (64.10 K) [52.46%]
dnsDecode: Number of DNS R packets: 58099 (58.10 K) [47.54%]
dnsDecode: Aggregated dnsStat: 0x0201
httpSniffer: Number of HTTP packets: 18450263 (18.45 M) [67.94%]
connStat: Number of unique source IPs: 136530 (136.53 K)
connStat: Number of unique destination IPs: 151775 (151.78 K)
connStat: Number of unique source/destination IPs connections: 1456 (1.46 K)
connStat: Max unique number of source IP / destination port connections: 2019 (2.02 K)
connStat: IP prtcon/sdcon, prtcon/scon: 1.386676, 0.014788
connStat: Source IP with max connections: x.x.x.x (CH): 1165 (1.17 K) connections
connStat: Destination IP with max connections: y.y.y.y (CH): 5028 (5.03 K) connections
--------------------------------------------------------------------------------
Headers count: min: 4, max: 13, average: 7.10
Max VLAN header count: 1
Max MPLS header count: 2
Number of LLC packets: 128 [0.00%]
Number of GRE packets: 128 [0.00%]
Number of Teredo packets: 103318 (103.32 K) [0.38%]
Number of AYIYA packets: 132 [0.00%]
Number of IGMP packets: 168 [0.00%]
Number of ICMP packets: 63517 (63.52 K) [0.23%]
```

```
Number of ICMPv6 packets: 7691 (7.69 K) [0.03%]
Number of TCP packets: 21820890 (21.82 M) [80.36%]
Number of TCP bytes: 18347271411 (18.35 G) [86.15%]
Number of UDP packets: 5137175 (5.14 M) [18.92%]
Number of UDP bytes: 2890294860 (2.89 G) [13.57%]
Number of IPv4 fragmented packets: 8295 (8.29 K) [0.03%]
Number of IPv6 fragmented packets: 3238 (3.24 K) [3.13%]
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
Number of processed   flows: 707800 (707.80 K)
Number of processed A flows: 593821 (593.82 K) [83.90%]
Number of processed B flows: 113979 (113.98 K) [16.10%]
Number of request     flows: 582056 (582.06 K) [82.23%]
Number of reply       flows: 125744 (125.74 K) [17.77%]
Total   A/B    flow asymmetry: 0.68
Total req/rply flow asymmetry: 0.64
Number of processed   packets/flows: 38.37
Number of processed A packets/flows: 26.26
Number of processed B packets/flows: 101.46
Number of processed total packets/s: 239492.87 (239.49 K)
Number of processed A+B   packets/s: 239492.87 (239.49 K)
Number of processed A     packets/s: 137505.27 (137.50 K)
Number of processed   B   packets/s: 101987.60 (101.99 K)
~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
Number of average processed flows/s: 6242.47 (6.24 K)
Average full raw bandwidth: 1503099136 b/s (1.50 Gb/s)
Average snapped bandwidth : 1502563456 b/s (1.50 Gb/s)
Average full bandwidth : 1502764416 b/s (1.50 Gb/s)
Fill size of main hash map: 582178 [44.42%]
Max number of flows in memory: 582178 (582.18 K) [44.42%]
Memory usage: 5.61 GB [8.32%]
Aggregate flow status: 0x0c00b872d298fb04
[WRN] L3 SnapLength < Length in IP header
[WRN] Consecutive duplicate IP ID
[WRN] IPv4/6 payload length > framing length
[WRN] IPv4/6 fragmentation header packet missing
[INF] Ethernet flows
[INF] IPv4 flows
[INF] IPv6 flows
[INF] VLAN encapsulation
[INF] IPv4/6 fragmentation
[INF] MPLS encapsulation
[INF] L2TP encapsulation
[INF] PPP/HDLC encapsulation
[INF] GRE encapsulation
[INF] AYIYA tunnel
[INF] Teredo tunnel
[INF] CAPWAP/LWAPP tunnel
[INF] IPsec AH
[INF] IPsec ESP
[INF] SSDP/UPnP
[INF] SIP/RTP
================================================================================
```

**Listing 2:** *A sample Tranalyzer2 human readable report aggregate mode*

Note at the beginning `USR1 A type` denotes that there was a signal received and all reporting is aggregated from the beginning of T2 operation, almost like the end report. Note, that the reaction to signals depends to internal core configuration, discussed in a later chapter below. For the time being we stick with the default. If you require now a report every 30s then type `t2stat 30`. Then a signal is sent to T2 every 30s, hence a remote control. Nevertheless, he can do it

also by himself, more later. Note that the report does not only tell you all about packet statistics but also the

1. pcap duration
2. Elapsed time
3. Total bytes to process
4. Percentage completed
5. Total bytes processed so far
6. Remaining time
7. Estimated Time Finish (ETF)

Especially the ETF is very valuable for large or multiple large pcap operations, e.g., multiple 10TB files. So the Anteater tells you when to come back from your coffee break.

Listing 3 illustrates the output of the header line and subsequent data lines generated when `MACHINE_REPORT=1`.

```
%repTyp   time                sensorID  dur           memUsageKB  fillSzHashMap  numFlows  ...
USR1MR_A  1022171702.125000   666       0.308953000   31686       2152           2152      ...
USR1MR_A  1022171703.027000   666       1.308855000   33914       3919           3919      ...
USR1MR_A  1022171704.334000   666       2.309162000   34750       5031           5031      ...
USR1MR_A  1022171705.030000   666       3.308858000   35258       5847           5847      ...
```

**Listing 3:** *A sample Tranalyzer2 machine report aggregate mode*

### 2.24.1 Configuration for Monitoring Mode on interface real time mode

To enable monitoring mode, configure Tranalyzer as follows:

| main.h | | tranalyzer.h | |
|---|---|---|---|
| `#define MONINTTMPCP` | `0` | `#define DIFF_REPORT` | `1` |
| `#define MONINTTHRD` | `1` | `#define MACHINE_REPORT` | `1` |

The following plugins contribute to the output:

- arpDecode
- basicStats
- cdpDecode
- connStat
- dnsDecode
- ftpDecode
- httpSniffer
- icmpDecode
- lldpDecode
- modbus
- mqttDecode
- ntpDecode
- radiusDecode
- sshDecode
- stpDecode
- t2PSkel
- tcpFlags
- vrrpDecode

The generated output is illustrated in Figure 3. The columns are as follows:

1. repType
2. sensorID
3. time
4. dur
5. pktsRec (`t2 -i` option only)
6. pktsDrp (`t2 -i` option only)
7. ifDrp (`t2 -i` option only)
8. memUsageKB
9. fillSzHashMap
10. numFlows
11. numAFlows
12. numBFlows
13. numPkts
14. numAPkts
15. numBPkts
16. numV4Pkts
17. numV6Pkts
18. numVxPkts
19. numBytes
20. numABytes
21. numBBytes
22. numFrgV4Pkts
23. numFrgV6Pkts
24. numAlarms
25. rawBandwidth
26. globalWarn
27. Layer 2 protocols stats (see `MONPROTL2` in *main.h*):
    - 0x0806Pkts (ARP)
    - 0x0806Bytes (ARP)
    - 0x8035Pkts (RARP)
    - 0x8035Bytes (RARP)
28. Layer 3 protocols stats (see `MONPROTL3` in *main.h*):
    - TCPPkts
    - TCPBytes
    - UDPPkts
    - UDPBytes
    - ICMPPkts
    - ICMPBytes
    - ICMPv6Pkts
    - ICMPv6Bytes
    - SCTPPkts
    - SCTPBytes

### 2.24.2 Monitoring Mode to Syslog

In order to send monitoring info to a syslog server T2 must be configured in machine mode as indicated above. Then the output has to be piped into the following script:

```
t2 -D ... -w ... | gawk -F"\t" `{ print "<25> ", strftime("%b %d %T"), "Monitoring: " $0 }' | \
        nc -u w.x.y.z 514
```

Netcat will send it to the syslog server at address `w.x.y.z`. Specific columns from the monitoring output can be selected in the awk script.

### 2.24.3 RRD Graphing of Monitoring Output

The monitoring output can be stored in a RRD database using the `t2rrd` script. To start creating a RRD database, launch Tranalyzer2 (in monitoring mode) as follows:

```
t2 -r file.pcap -l | t2rrd -m
```

Or for monitoring from a live interface:

```
st2 -i eth0 -l | t2rrd -m
```

Plots for the various fields can then be generated using the same `t2rrd` script:

```
t2rrd -i 30s numAFlows numBFlows
```

To specify intervals, use `s` (seconds), `m` (minutes), `h` (hour), `d` (day), `w` (week), `mo` (month), `y` (year). For example, to plot the data from the last two weeks, use `-i 2w` or `-s -2w`.

An example graph is depicted in Figure 4.

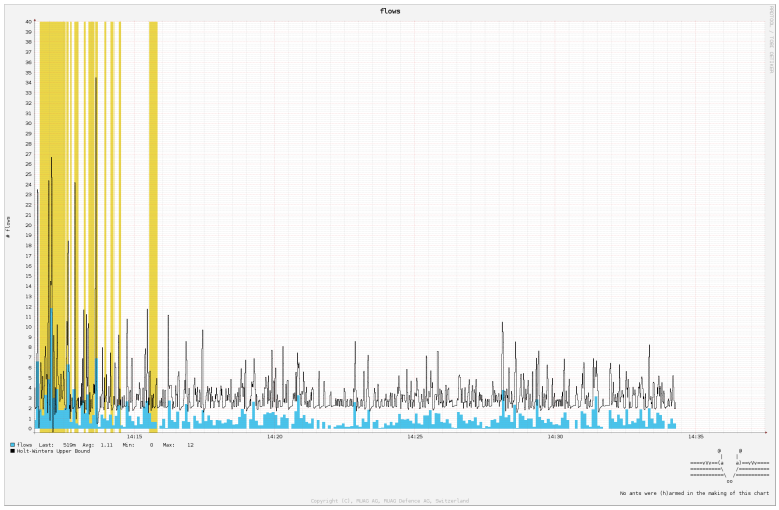



**Figure 4:** *T2 monitoring using RRD*

## 2.25 Cancellation of the Sniffing Process

Processing of a pcap file stops upon end of file. In case of live capture from an interface Tranalyzer2 stops upon `CTRL+C` interrupt or a `kill -9 PID` signal. The disconnection of the interface cable will stop Tranalyzer2 also after a timeout of 182 seconds. The console based `CTRL+C` interrupt does not immediately terminate the program to avoid corrupted entries in the output files. It stops creating additional flows and finishes only currently active flows. Note that waiting the termination of active flow depends on the activity or the lifetime of a connection and can take a very long time. In order to mitigate that problem the user can issue the `CTRL+C` for `GI_TERM_THRESHOLD` times to immediately terminate the program.

# 3 arpDecode

## 3.1 Description

The arpDecode plugin analyzes ARP traffic.

## 3.2 Dependencies

### 3.2.1 Core Configuration

This plugin requires the following core configuration:

- *$T2HOME/tranalyzer2/src/networkHeaders.h*:
  - `ETH_ACTIVATE>0`

## 3.3 Configuration Flags

The following flags can be used to control the output of the plugin:

| Name | Default | Description |
|---|---|---|
| `ARP_MAX_IP` | 10 | Max. number of MAC/IP pairs to list [1 - 255] |

## 3.4 Flow File Output

The arpDecode plugin outputs the following columns:

| Column | Type | Description |
|---|---|---|
| `arpStat` | H8 | Status |
| `arpHwType` | U16 | Hardware type |
| `arpOpcode` | H16 | Operational code |
| `arpIpMacCnt` | U16 | Number of distinct MAC / IP pairs |
| `arpMac_Ip_Cnt` | R(MAC_IP4_U16) | MAC/IP pairs found and number of times the pair appeared (a count of zero may appear in case of ARP spoofing and indicate the pair was discovered in a different flow) |

### 3.4.1 arpStat

The `arpStat` column is to be interpreted as follows:

| arpStat | Description |
|---|---|
| `0x01` | ARP detected |
| `0x02` | Gratuitous ARP (sender IP same as target IP) |
| `0x04` | ARP Probe |
| `0x08` | ARP Announcement |
| `0x10` | — |

| arpStat | Description |
|---|---|
| 0x20 | MAC/IP list truncated... increase ARP_MAX_IP |
| 0x40 | — |
| 0x80 | ARP spoofing (same MAC assigned to multiple IPs) |

### 3.4.2 arpHwType

The arpHwType column is to be interpreted as follows:

| Type | Description |
|---|---|
| 1 | Ethernet |
| 2 | Experimental Ethernet |
| 3 | Amateur Radio AX.25 |
| 4 | Proteon ProNET Token Ring |
| 5 | Chaos |
| 6 | IEEE 802 |
| 7 | ARCNET |
| 8 | Hyperchannel |
| 9 | Lanstar |
| 10 | Autonet Short Address |
| 11 | LocalTalk |
| 12 | LocalNet (IBM PCNet or SYTEK LocalNET) |
| 13 | Ultra link |
| 14 | SMDS |
| 15 | Frame Relay |
| 16 | ATM (Asynchronous Transmission Mode) |
| 17 | HDLC |
| 18 | Fibre Channel |

| Type | Description |
|---|---|
| 19 | ATM (Asynchronous Transmission Mode) |
| 20 | Serial Line |
| 21 | ATM (Asynchronous Transmission Mode) |
| 22 | MIL-STD-188-220 |
| 23 | Metricom |
| 24 | IEEE 1394.1995 |
| 25 | MAPOS |
| 26 | Twinaxial |
| 27 | EUI-64 |
| 28 | HIPARP |
| 29 | IP and ARP over ISO 7816-3 |
| 30 | ARPSec |
| 31 | IPsec tunnel |
| 32 | Infiniband |
| 33 | CAI (TIA-102 Project 25 Common Air Interface) |
| 34 | Wiegand Interface |
| 35 | Pure IP |

### 3.4.3 arpOpcode

The arpOpcode column is to be interpreted as follows:

| arpOpcode | Description |
|---|---|
| $2^0$ (=0x0001) | — |
| $2^1$ (=0x0002) | ARP Request |
| $2^2$ (=0x0004) | ARP Reply |
| $2^3$ (=0x0008) | Reverse ARP (RARP) Request |
| $2^4$ (=0x0010) | Reverse ARP (RARP) Reply |
| $2^5$ (=0x0020) | Dynamic RARP (DRARP) Request |
| $2^6$ (=0x0040) | Dynamic RARP (DRARP) Reply |
| $2^7$ (=0x0080) | Dynamic RARP (DRARP) Error |

| arpOpcode | Description |
|---|---|
| $2^8$ (=0x0100) | Inverse ARP (InARP) Request |
| $2^9$ (=0x0200) | Inverse ARP (InARP) Reply |
| $2^{10}$ (=0x0400) | ARP NAK |
| $2^{11}$ (=0x0800) | — |
| $2^{12}$ (=0x1000) | — |
| $2^{13}$ (=0x2000) | — |
| $2^{14}$ (=0x4000) | — |
| $2^{15}$ (=0x8000) | — |

## 3.5 Packet File Output

In packet mode (`-s` option), the arpDecode plugin outputs the following columns:

| Column | Type | Description |
|---|---|---|
| arpStat | H8 | Status |
| arpHwType | U16 | Hardware type |
| arpProtoType | H16 | Protocol type |
| arpHwSize | U8 | Hardware size |
| arpProtoSize | U8 | Protocol size |
| arpOpcode | U16 | Operational code |
| arpSenderMAC | MAC | Sender MAC address |
| arpSenderIP | IP4 | Sender IP address |
| arpTargetMAC | MAC | Target MAC address |
| arpTargetIP | IP4 | Target IP address |

## 3.6 Monitoring Output

In monitoring mode, the arpDecode plugin outputs the following columns:

| Column | Type | Description |
|---|---|---|
| arpStat | H8 | Status |

## 3.7 Plugin Report Output

The following information is reported:

- Aggregated arpStat

# 4 basicFlow

## 4.1 Description

The basicFlow plugin provides host identification fields and timing information.

## 4.2 Configuration Flags

### 4.2.1 basicFlow.h

The following flags can be used to control the output of the plugin:

| Name | Default | Description | Flags |
|---|---|---|---|
| BFO_SENSORID | 0 | Output sensorID | |
| BFO_HDRDESC_PKTCNT | 0 | Include packet count for header description | |
| BFO_MAC | 1 | Output MAC addresses | |
| BFO_ETHERTYPE | 1 | Output EtherType | IPV6_ACTIVATE=2\|\| ETH_ACTIVATE>0 |
| BFO_VLAN | 1 | 0: Do not output VLAN information,<br>1: Output VLAN numbers,<br>2: Output VLAN headers as hex<br>3: Output decoded VLAN headers as TPID_PCP_DEI_VID | |
| BFO_MPLS | 0 | 0: Do not output MPLS information,<br>1: Output MPLS labels,<br>2: Output MPLS labels as hex,<br>3: Output MPLS headers as hex,<br>4: Output decoded MPLS headers | |
| BFO_GRE | 0 | Enable GRE output | |
| BFO_L2TP | 0 | Enable L2TP output | |
| BFO_PPP | 0 | Enable PPP output | |
| BFO_LAPD | 0 | Enable LAPD output | LAPD_ACTIVATE=1 |
| BFO_TEREDO | 0 | Enable Teredo output | |
| BFO_SUBNET_IPLIST | 0 | Display a list of IP aggregated | |
| BFO_SUBNET_TEST | 1 | Enable subnet test | |
| BFO_SUBNET_TEST_GRE | 0 | Enable subnet test on GRE addresses | IPV6_ACTIVATE!=1 |
| BFO_SUBNET_TEST_L2TP | 0 | Enable subnet test on L2TP addresses | IPV6_ACTIVATE!=1 |
| BFO_SUBNET_TEST_TEREDO | 0 | Enable subnet test on Teredo addresses | |
| BFO_SUBNET_HEX | 0 | Output the country code and organization as one 32-bit hex number | |
| BFO_SUBNET_ASN | 0 | Output Autonomous System Numbers (ASN) | |

| Name | Default | Description | Flags |
|---|---|---|---|
| BFO_SUBNET_LL | 0 | Output position (latitude, longitude and reliability) | |
| BFO_MAX_HDRDESC | 4 | Max. number of headers descriptions to store | T2_PRI_HDRDESC=1 |
| BFO_MAX_MAC | 2 | Max. different MAC addresses to store | |
| BFO_MAX_IP | 2 | Max. different IP addresses to store | |
| BFO_MAX_MPLS | 3 | Max. MPLS headers/tags to store | |
| BFO_MAX_VLAN | 3 | Max. VLAN headers/numbers to store | |

### 4.2.2 bin2txt.h

Additional configuration options can be found in `$T2HOME/utils/bin2txt.h`. Refer to Tranalyzer2 documentation for more details.

### 4.2.3 subnetHL.h

Additional configuration options can be found in `$T2HOME/utils/subnetHL.h`. Refer to Tranalyzer2 documentation for more details.

## 4.3 Flow File Output

The basicFlow plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| dir | C | Flow direction A / B | |
| flowInd | U64 | Flow index | |
| sensorID | U32 | Sensor ID | BFO_SENSORID=1 |
| flowStat | H64 | Flow status and warnings | |
| timeFirst | TS | Date time of first packet | |
| timeLast | TS | Date time of last packet | |
| duration | U64.U32 | Flow duration | |
| If T2_PRI_HDRDESC=1 and BFO_MAX_HDRDESC>0, the following columns are displayed: | | | |
| numHdrDesc | U8 | Number of different headers descriptions | |
| numHdrs | R(U16) | Number of headers (depth) in hdrDesc | |
| hdrDesc | RS | Headers description | BFO_HDRDESC_PKTCNT=0 |
| hdrDesc_PktCnt | R(S_U64) | Headers description and packet count | BFO_HDRDESC_PKTCNT=1 |
| srcMac | R(MAC) | Source MAC address | BFO_MAC=1 |
| dstMac | R(MAC) | Destination MAC address | BFO_MAC=1 |
| ethType | H16 | Ethernet type | BFO_ETHERTYPE=1&&(ETH_ACTIVATE>0\|\|IPV6_ACTIVATE=2) |

| Column | Type | Description | Flags |
|---|---|---|---|
| If BFO_VLAN>0 and BFO_MAX_VLAN>0, the columns described in Section 4.3.1 are displayed here. | | | |
| If BFO_MPLS>0 and BFO_MAX_MPLS>0, the columns described in Section 4.3.2 are displayed here. | | | |
| If BFO_PPP=1, the columns described in Section 4.3.3 are displayed here. | | | |
| If LAPD_ACTIVATE=1 and BFO_LAPD=1, the columns described in Section 4.3.4 are displayed here. | | | |
| If BFO_L2TP=1, the columns described in Section 4.3.5 are displayed here. | | | |
| If BFO_GRE=1, the columns described in Section 4.3.6 are displayed here. | | | |
| If BFO_TEREDO=1, the columns described in Section 4.3.7 are displayed here. | | | |
| **Standard five tuple output including geo-information** | | | |
| srcIP | IP | Source IP address | BFO_SUBNET_IPLIST=0 |
| srcIP | R(IP) | Source IP addresses | BFO_SUBNET_IPLIST=1 |
| If BFO_SUBNET_TEST=1, the following columns are displayed: | | | |
| srcIPASN | U32 | Source IP ASN | BFO_SUBNET_ASN=1 |
| srcIPCOC | H32 | Source IP country organization code | BFO_SUBNET_HEX=1 |
| srcIPCC | SC | Source IP country | |
| srcIPCnty | S | Source IP county | CNTYCTY=1 |
| srcIPCty | S | Source IP city | CNTYCTY=1 |
| srcIPOrg | S | Source IP organization | BFO_SUBNET_ORG=1 |
| srcIPLat_Lng_relP | F_F_F | Source IP lat., long. and reliability | BFO_SUBNET_LL=1 |
| srcPort | U16 | Source Port | |
| dstIP | IP | Destination IP address | BFO_SUBNET_IPLIST=0 |
| dstIP | R(IP) | Destination IP addresses | BFO_SUBNET_IPLIST=1 |
| If BFO_SUBNET_TEST=1, the following columns are displayed: | | | |
| dstIPASN | U32 | Dest. IP ASN | BFO_SUBNET_ASN=1 |
| dstIPCOC | H32 | Dest. IP country organization code | BFO_SUBNET_HEX=1 |
| dstIPCC | SC | Dest. IP country | |
| dstIPCnty | S | Dest. IP county | CNTYCTY=1 |
| dstIPCty | S | Dest. IP city | CNTYCTY=1 |
| dstIPOrg | S | Dest. IP organization | BFO_SUBNET_ORG=1 |

| Column | Type | Description | Flags |
|---|---|---|---|
| dstIPLat_Lng_relP | F_F_F | Dest. IP lat., long. and reliability | BFO_SUBNET_LL=1 |
| dstPort | U16 | Destination port | |
| l4Proto | U8 | Layer 4 protocol | |

### 4.3.1 VLAN

If BFO_VLAN>0 and BFO_MAX_VLAN>0, the following additional column is displayed:

| Column | Type | Description | Flags |
|---|---|---|---|
| vlanID | R(U16) | VLAN IDs | BFO_VLAN=1 |
| vlanHdr | R(H32) | VLAN headers (hex) | BFO_VLAN=2 |

### 4.3.2 MPLS

If BFO_MPLS>0 and BFO_MAX_MPLS>0, the following additional column is displayed:

| Column | Type | Description | Flags |
|---|---|---|---|
| mplsLabels | R(U32) | MPLS labels | BFO_MPLS=1 |
| mplsLabelsHex | R(H32) | MPLS labels (hex) | BFO_MPLS=2 |
| mplsHdrsHex | R(H32) | MPLS headers (hex) | BFO_MPLS=3 |
| mplsLabel_ToS_S_TTL | R(U32_U8_U8_U8) | MPLS headers details | BFO_MPLS=4 |

### 4.3.3 PPP

If BFO_PPP=1, the following additional column is displayed:

| Column | Type | Description | Flags |
|---|---|---|---|
| pppHdr | H32 | PPP header | |

### 4.3.4 LAPD

If BFO_LAPD=1 and LAPD_ACTIVATE=1, the following additional column is displayed:

| Column | Type | Description | Flags |
|---|---|---|---|
| lapdSAPI | U8 | LAPD SAPI | |
| lapdTEI | U8 | LAPD TEI | |

### 4.3.5 L2TP

If BFO_L2TP=1, the following additional columns are displayed:

| Column | Type | Description | Flags |
|---|---|---|---|
| l2tpHdr | H16 | L2TP header | |
| l2tpTID | U16 | L2TP tunnel ID | |
| l2tpSID | U16 | L2TP session ID | |
| l2tpCCSID | U32 | L2TP control connection/session ID | |
| l2tpSrcIP | IP4 | L2TP source IP address | |
| If BFO_SUBNET_TEST_L2TP=1, the following columns are displayed: | | | |
| l2tpSrcIPASN | U32 | L2TP source IP ASN | BFO_SUBNET_ASN=1 |
| l2tpSrcIPCOC | H32 | L2TP source IP country organization code | BFO_SUBNET_HEX=1 |
| l2tpSrcIPCC | SC | L2TP source IP country | |
| l2tpSrcIPCnty | S | L2TP source IP county | CNTYCTY=1 |
| l2tpSrcIPCty | S | L2TP source IP city | CNTYCTY=1 |
| l2tpSrcIPOrg | S | L2TP source IP organization | BFO_SUBNET_ORG=1 |
| l2tpSrcIPLat_Lng_relP | F_F_F | L2TP source IP lat., long. and reliability | BFO_SUBNET_LL=1 |
| l2tpDstIP | IP4 | L2TP destination IP address | |
| If BFO_SUBNET_TEST_L2TP=1, the following columns are displayed: | | | |
| l2tpDstIPASN | U32 | L2TP dest. IP ASN | BFO_SUBNET_ASN=1 |
| l2tpDstIPCOC | H32 | L2TP dest. IP country organization code | BFO_SUBNET_HEX=1 |
| l2tpDstIPCC | SC | L2TP dest. IP country | |
| l2tpDstIPCnty | S | L2TP dest. IP county | CNTYCTY=1 |
| l2tpDstIPCty | S | L2TP dest. IP city | CNTYCTY=1 |
| l2tpDstIPOrg | S | L2TP dest. IP organization | BFO_SUBNET_ORG=1 |
| l2tpDstIPLat_Lng_relP | F_F_F | L2TP dest. IP lat., long. and reliability | BFO_SUBNET_LL=1 |

### 4.3.6 GRE

If BFO_GRE=1, the following additional columns are displayed:

| Column | Type | Description | Flags |
|---|---|---|---|
| greHdr | H32 | GRE header | |
| greSrcIP | IP4 | GRE source IP address | |
| If BFO_SUBNET_TEST_GRE=1, the following columns are displayed: | | | |
| greSrcIPASN | U32 | GRE source IP ASN | BFO_SUBNET_ASN=1 |
| greSrcIPCOC | H32 | GRE source IP country organization code | BFO_SUBNET_HEX=1 |
| greSrcIPCC | SC | GRE source IP country | |
| greSrcIPCnty | S | GRE source IP county | CNTYCTY=1 |

| Column | Type | Description | Flags |
|---|---|---|---|
| greSrcIPCty | S | GRE source IP city | CNTYCTY=1 |
| greSrcIPOrg | S | GRE source IP organization | BFO_SUBNET_ORG=1 |
| greSrcIPLat_Lng_relP | F_F_F | GRE source IP lat., long. and reliability | BFO_SUBNET_LL=1 |
| greDstIP | IP4 | GRE destination IP address | |
| If BFO_SUBNET_TEST_GRE=1, the following columns are displayed: | | | |
| greDstIPASN | U32 | GRE dest. IP ASN | BFO_SUBNET_ASN=1 |
| greDstIPCOC | H32 | GRE dest. IP country organization code | BFO_SUBNET_HEX=1 |
| greDstIPCC | SC | GRE dest. IP country | |
| greDstIPCnty | S | GRE dest. IP county | CNTYCTY=1 |
| greDstIPCty | S | GRE dest. IP city | CNTYCTY=1 |
| greDstIPOrg | S | GRE dest. IP organization | BFO_SUBNET_ORG=1 |
| greDstIPLat_Lng_relP | F_F_F | GRE dest. IP lat., long. and reliability | BFO_SUBNET_LL=1 |

### 4.3.7 Teredo

If BFO_TEREDO=1, the following additional columns are displayed:

| Column | Type | Description | Flags |
|---|---|---|---|
| trdoDstIP | IP4 | Next Teredo flow: dest IPv4 address | |
| If BFO_SUBNET_TEST_TEREDO=1, the following columns are displayed: | | | |
| trdoDstIPASN | U32 | Teredo dest. IP ASN | BFO_SUBNET_ASN=1 |
| trdoDstIPCOC | H32 | Teredo dest. IP country organization code | BFO_SUBNET_HEX=1 |
| trdoDstIPCC | SC | Teredo dest. IP country | |
| trdoDstIPCnty | S | Teredo dest. IP county | CNTYCTY=1 |
| trdoDstIPCty | S | Teredo dest. IP city | CNTYCTY=1 |
| trdoDstIPOrg | S | Teredo dest. IP organization | BFO_SUBNET_ORG=1 |
| trdoDstIPLat_Lng_relP | F_F_F | Teredo dest. IP lat., long. and reliability | BFO_SUBNET_LL=1 |
| trdoDstPort | U16 | Next Teredo flow: destination port | |
| If IPV6_ACTIVATE=0, then no further column is displayed. | | | |
| **Teredo IPv6 source address decode** | | | |
| trdo6SrcFlgs | H8 | Flags | |
| trdo6SrcSrvIP4 | IP4 | Server IPv4 | |
| If BFO_SUBNET_TEST_TEREDO=1, the following columns are displayed: | | | |
| trdo6SrcSrvIP4ASN | U32 | Server IP ASN | BFO_SUBNET_ASN=1 |
| trdo6SrcSrvIP4COC | H32 | Server IP country organization code | BFO_SUBNET_HEX=1 |
| trdo6SrcSrvIP4CC | SC | Server IP country | |
| trdo6SrcSrvIP4Cnty | S | Server IP county | CNTYCTY=1 |
| trdo6SrcSrvIP4Cty | S | Server IP city | CNTYCTY=1 |
| trdo6SrcSrvIP4Org | S | Server IP organization | BFO_SUBNET_ORG=1 |
| trdo6SrcSrvIP4Lat_Lng_relP | F_F_F | Server IP lat., long. and reliability | BFO_SUBNET_TEST_LL=1 |
| trdo6SrcCPIP4 | IP4 | Client public IPv4 | |
| If BFO_SUBNET_TEST_TEREDO=1, the following columns are displayed: | | | |
| trdo6SrcCPIP4ASN | U32 | Client public IP ASN | BFO_SUBNET_ASN=1 |
| trdo6SrcCPIP4COC | H32 | Client public IP country organization code | BFO_SUBNET_HEX=1 |
| trdo6SrcCPIP4CC | SC | Client public IP country | |
| trdo6SrcCPIP4Cnty | S | Client public IP county | CNTYCTY=1 |
| trdo6SrcCPIP4Cty | S | Client public IP city | CNTYCTY=1 |
| trdo6SrcCPIP4Org | S | Client public IP organization | BFO_SUBNET_ORG=1 |
| trdo6SrcCPIP4Lat_Lng_relP | F_F_F | Client public IP lat., long. and reliability | BFO_SUBNET_LL=1 |

| Column | Type | Description | Flags |
|---|---|---|---|
| trdo6SrcCPPort | U16 | Client public port | |
| | **Teredo IPv6 destination address decode** | | |
| trdo6DstFlgs | H8 | Flags | |
| trdo6DstSrvIP4 | IP4 | Server IPv4 | |
| If BFO_SUBNET_TEST_TEREDO=1, the following columns are displayed: | | | |
| trdo6DstSrvIP4ASN | U32 | Server IP ASN | BFO_SUBNET_ASN=1 |
| trdo6DstSrvIP4COC | H32 | Server IP country organization code | BFO_SUBNET_HEX=1 |
| trdo6DstSrvIP4CC | SC | Server IP country | |
| trdo6DstSrvIP4Cnty | S | Server IP county | CNTYCTY=1 |
| trdo6DstSrvIP4Cty | S | Server IP city | CNTYCTY=1 |
| trdo6DstSrvIP4Org | S | Server IP organization | BFO_SUBNET_ORG=1 |
| trdo6DstSrvIP4Lat_Lng_relP | F_F_F | Server IP lat., long. and reliability | BFO_SUBNET_LL=1 |
| trdo6DstCPIP4 | IP4 | Client public IPv4 | |
| If BFO_SUBNET_TEST_TEREDO=1, the following columns are displayed: | | | |
| trdo6DstCPIP4ASN | U32 | Client public IP ASN | BFO_SUBNET_ASN=1 |
| trdo6DstCPIP4COC | H32 | Client public IP country organization code | BFO_SUBNET_HEX=1 |
| trdo6DstCPIP4CC | SC | Client public IP country | |
| trdo6DstCPIP4Cnty | S | Client public IP county | CNTYCTY=1 |
| trdo6DstCPIP4Cty | S | Client public IP city | CNTYCTY=1 |
| trdo6DstCPIP4Org | S | Client public IP organization | BFO_SUBNET_ORG=1 |
| trdo6DstCPIP4Lat_Lng_relP | F_F_F | Client public IP lat., long. and reliability | BFO_SUBNET_LL=1 |
| trdo6DstCPPort | U16 | Client public port | |

### 4.3.8 flowInd

It is useful to identify flows when post processing operations, such as sort or filters are applied to a flow file and only a B or an A flow is selected. Moreover a packet file generated with the -s option supplies the flow index which simplifies the mapping of singular packets to the appropriate flow.

### 4.3.9 flowStat

The flowStat column is to be interpreted as follows:

| flowStat | Description |
|---|---|
| $2^{00}$ (=0x00000000 00000001) | Inverted flow, did not initiate connection |
| $2^{01}$ (=0x00000000 00000002) | No Ethernet header |

| | flowStat | Description |
|---|---|---|
| $2^{02}$ | (=0x00000000 00000004) | Pure L2 flow |
| $2^{03}$ | (=0x00000000 00000008) | Point to Point Protocol over Ethernet Discovery (PPPoED) |
| $2^{04}$ | (=0x00000000 00000010) | Point to Point Protocol over Ethernet Service (PPPoES) |
| $2^{05}$ | (=0x00000000 00000020) | Link Layer Discovery Protocol (LLDP) |
| $2^{06}$ | (=0x00000000 00000040) | ARP |
| $2^{07}$ | (=0x00000000 00000080) | Reverse ARP |
| $2^{08}$ | (=0x00000000 00000100) | VLANs |
| $2^{09}$ | (=0x00000000 00000200) | MPLS unicast |
| $2^{10}$ | (=0x00000000 00000400) | MPLS multicast |
| $2^{11}$ | (=0x00000000 00000800) | L2TP v2/3 |
| $2^{12}$ | (=0x00000000 00001000) | GRE v1/2 |
| $2^{13}$ | (=0x00000000 00002000) | PPP header after L2TP or GRE |
| $2^{14}$ | (=0x00000000 00004000) | IPv4 flow |
| $2^{15}$ | (=0x00000000 00008000) | IPv6 flow |
| $2^{16}$ | (=0x00000000 00010000) | IPvX bogus packet |
| $2^{17}$ | (=0x00000000 00020000) | IPv4/6 in IPv4/6 |
| $2^{18}$ | (=0x00000000 00040000) | Ethernet over IP |
| $2^{19}$ | (=0x00000000 00080000) | Teredo tunnel |
| $2^{20}$ | (=0x00000000 00100000) | Anything in Anything (AYIYA) tunnel |
| $2^{21}$ | (=0x00000000 00200000) | GPRS Tunneling Protocol (GTP) |
| $2^{22}$ | (=0x00000000 00400000) | Virtual eXtensible Local Area Network (VXLAN) |
| $2^{23}$ | (=0x00000000 00800000) | Control and Provisioning of Wireless Access Points (CAPWAP), Lightweight Access Point Protocol (LWAPP) |
| $2^{24}$ | (=0x00000000 01000000) | Stream Control Transmission Protocol (SCTP) |
| $2^{25}$ | (=0x00000000 02000000) | SSDP/UPnP |
| $2^{26}$ | (=0x00000000 04000000) | Encapsulated Remote Switch Packet ANalysis (ERSPAN) |
| $2^{27}$ | (=0x00000000 08000000) | Cisco Web Cache Communication Protocol (WCCP) |
| $2^{28}$ | (=0x00000000 10000000) | SIP/RTP |
| $2^{29}$ | (=0x00000000 20000000) | Generic Network Virtualization Encapsulation (GENEVE) |
| $2^{30}$ | (=0x00000000 40000000) | IPsec Authentication Header (AH) |
| $2^{31}$ | (=0x00000000 80000000) | IPsec Encapsulating Security Payload (ESP) |
| $2^{32}$ | (=0x00000001 00000000) | Acquired packet length < minimal L2 datagram |
| $2^{33}$ | (=0x00000002 00000000) | Acquired packet length < packet length in L3 header |
| $2^{34}$ | (=0x00000004 00000000) | Acquired packet length < minimal L3 header |
| $2^{35}$ | (=0x00000008 00000000) | Acquired packet length < minimal L4 header |
| $2^{36}$ | (=0x00000010 00000000) | IPv4 fragmentation present |
| $2^{37}$ | (=0x00000020 00000000) | IPv4 fragmentation error (refer to the tcpFlags plugin for more details) |

| | flowStat | Description |
|---|---|---|
| $2^{38}$ | (=0x00000040 00000000) | IPv4 1. fragment out of sequence or missing |
| $2^{39}$ | (=0x00000080 00000000) | Packet fragmentation pending or<br>Fragmentation sequence not completed when flow timed-out |
| $2^{40}$ | (=0x00000100 00000000) | Flow timeout instead of protocol termination |
| $2^{41}$ | (=0x00000200 00000000) | Alarm mode: remove this flow instantly |
| $2^{42}$ | (=0x00000400 00000000) | Autopilot: flow removed to free space in main hash map |
| $2^{43}$ | (=0x00000800 00000000) | Stop dissecting, error or unhandled protocol |
| $2^{44}$ | (=0x00001000 00000000) | Consecutive duplicate IP ID |
| $2^{45}$ | (=0x00002000 00000000) | PPPL3 header not readable, compressed |
| $2^{46}$ | (=0x00004000 00000000) | IPv4 header length < 20 bytes |
| $2^{47}$ | (=0x00008000 00000000) | IP payload length > framing length |
| $2^{48}$ | (=0x00010000 00000000) | Header description overrun |
| $2^{49}$ | (=0x00020000 00000000) | pcapd and PD_ALARM=1: if set dumps the packets from this flow to a new pcap |
| $2^{50}$ | (=0x00040000 00000000) | Land attack: same srcIP && dstIP && srcPort && dstPort |
| $2^{51}$ | (=0x00080000 00000000) | Timestamp jump, probably due to multi-path delay or NTP operation |
| $2^{52}$ | (=0x00100000 00000000) | RESERVED, do not use |
| $2^{55}$ | (=0x00800000 00000000) | Subnet tested for that flow |
| $2^{56}$ | (=0x01000000 00000000) | Tor address detected |
| $2^{57}$ | (=0x02000000 00000000) | A packet had a priority tag (VLAN tag with ID 0) |
| $2^{58}$ | (=0x04000000 00000000) | IPv4 packet |
| $2^{59}$ | (=0x08000000 00000000) | IPv6 packet |
| $2^{62}$ | (=0x40000000 00000000) | Flow duration limit, same findex for all subflows |
| $2^{63}$ | (=0x80000000 00000000) | PCAP packet length > MAX_MTU in *ioBuffer.h*, caplen reduced |

### 4.3.10 hdrDesc

The hdrDesc column describes the protocol stack in the flow in a human readable way. Note that it gives the user a lookahead of what is to be expected, even if not in the appropriate IPv4/6 mode. For example, in IPv4 several different headers stacks can be displayed by one flow if Teredo or different fragmentation is involved. T2 then dissects only to the last header above the said protocol and sets the *Stop dissecting* bit in the flow status ($2^{41}$ (=0x00000400 00000000)).

### 4.3.11 lapdFType

The lapdFType column is to be interpreted as follows:

| lapdFType | Description |
|---|---|
| 0 | Information frame |
| 1 | Supervisory frame |
| 3 | Unnumbered frame |

### 4.3.12 lapdFunc

The `lapdFunc` column is to be interpreted as follows:

| lapdFunc | Description |
|---|---|
| REJ | Supervisory frame – REJect |
| RNR | Supervisory frame – Receive Not Ready |
| RR | Supervisory frame – Receive Ready |
| CFGR | Unnumbered frame – ConFiGuRe |
| DISC | Unnumbered frame – DISConnect |
| DM | Unnumbered frame – Disconnected Mode |
| FRMR | Unnumbered frame – FRaMe Reject |
| SABME | Unnumbered frame – Set Asynchronous Balanced Mode Extended |
| SIM | Unnumbered frame – Set Initialization Mode |
| TEST | Unnumbered frame – Test |
| UA | Unnumbered frame – Unnumbered Acknowledgement |
| UI | Unnumbered frame – Unnumbered Information |
| UP | Unnumbered frame – Unnumbered Poll |
| XID | Unnumbered frame – eXchange IDentification |

### 4.3.13 trdo6SrcFlgs and trdo6DstFlgs

The `trdo6SrcFlgs` and `trdo6DstFlgs` columns are to be interpreted as follows:

| trdo6{Src,Dst}Flgs | Description |
|---|---|
| $2^0$ (=0x01) | Group/individual |
| $2^1$ (=0x02) | Universal/local |
| $2^2$ (=0x04) | — |
| $2^3$ (=0x08) | — |
| $2^4$ (=0x10) | — |
| $2^5$ (=0x20) | — |
| $2^6$ (=0x40) | Currently unassigned |
| $2^7$ (=0x80) | Behind NAT, new versions do not set this bit anymore |

### 4.3.14 Geo labeling

The country and organization coding scheme are defined in the following files:

- `utils/subnet/whoCntryCds.txt`
- `utils/subnet/whoOrgCds.txt`

The special country code (CC) values `[0-9][0-9]` are used to represent private addresses or special address ranges such as Teredo or multicast:

| CC | IPv4 addresses | IPv6 addresses | Description |
|---|---|---|---|
| 00 | 0.0.0.0/32 | ::/128 | Unspecified address |
| 01 | 127.0.0.0/8 | ::1/128 | Loopback address |
| 02 | 169.254.0.0/16 | fe80::/10 | Link-local address |
| 03 | | fc00::/7 | Unique local address |
| 04 | 10.0.0.0/8 | | Private network |
| 05 | 172.16.0.0/12 | | Private network |
| 06 | 192.0.0.0/24 | | Private network |
| 07 | 192.168.0.0/16 | | Private network |
| 08 | 198.18.0.0/15 | | Private network |
| 10 | 224.0.0.0/4 | ff00::/8 | Multicast |
| 11 | 255.255.255.255/32 | | Broadcast |
| 20 | 100.64.0.0/10 | | Shared address space |
| 21 | 192.0.2.0/24 | | TEST-NET-1 |
| 22 | 198.51.100.0/16 | | TEST-NET-2 |
| 23 | 203.0.113.0/24 | | TEST-NET-3 |
| 24 | 240.0.0.0/4 | | Reserved |
| 25 | | 100::/64 | Discard prefix |
| 26 | | 2001:20::/28 | ORCHIDv2 |
| 27 | | 2001:db8::/32 | Address used in documentation and example source code |
| 60 | 192.88.99.0/24 | | Reserved (formerly used for IPv6 to IPv4 relay) |
| 61 | | ::ffff:0:0/96 | IPv4 mapped address |
| 62 | | ::ffff:0:0:0/96 | IPv4 translated address |
| 63 | | 64:ff9b::/96 | IPv4/IPv6 translation |
| 64 | | 2001::/32 | Teredo tunneling |
| 65 | | 2002::/16 | The 6to4 addressing scheme (now deprecated) |

The country organization codes (BFO_SUBNET_HEX=1) can be decoded with t2netID, e.g., t2netID 0x138020a5. Try t2netID --help for more information.

## 4.4 Packet File Output

In packet mode (-s option), the basicFlow plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| flowInd | U64 | Flow index | |
| flowStat | H64 | Flow status | |
| time | TS | Time | |
| relTime | U64.U32 | Duration since start of pcap or interface sniffing | RELTIME=1 |
| pktIAT | F | Packet inter-arrival time | |
| pktTrip | F | Packet round-trip time | |
| flowDuration | F | Flow duration | |
| numHdrs | U16 | Number of headers (depth) in hdrDesc | T2_PRI_HDRDESC=1 |
| hdrDesc | S | Headers description | T2_PRI_HDRDESC=1 |
| tpID_pcp_dei_vlanID | H16_U8_U8_U16 | tpID_pcp_dei_vlanID | BFO_VLAN=3 |
| vlanHdr | H32 | vlan Header 32bit | BFO_VLAN=2 |

| Column | Type | Description | Flags |
|---|---|---|---|
| vlanID | U16 | VLAN number (inner VLAN) | BFO_VLAN=1 |
| If BFO_MPLS>0 and BFO_MAX_MPLS>0, one of the following column is displayed: | | | |
| mplsLabels | R(U32) | MPLS labels | BFO_MPLS=1 |
| mplsLabelsHex | R(H32) | MPLS labels (hex) | BFO_MPLS=2 |
| mplsHdrsHex | R(H32) | MPLS headers (hex) | BFO_MPLS=3 |
| mplsLabel_ToS_S_TTL | R(U32_U8_U8_U8) | MPLS headers details | BFO_MPLS=4 |
| srcMac | MAC | Source MAC address | |
| dstMac | MAC | Destination MAC address | |
| ethType | H16 | Ethernet type | |
| If LAPD_ACTIVATE=1 and BFO_LAPD=1, the following six columns are displayed: | | | |
| lapdSAPI | U8 | LAPD SAPI | |
| lapdTEI | U8 | LAPD TEI | |
| lapdFType | U8 | LAPD frame type | |
| lapdFunc | S | LAPD command (U-Frame) or Supervisory frame type | |
| lapdNR | U8 | LAPD Receive Sequence Number | |
| lapdNS | U8 | LAPD Send Sequence Number | |
| srcIP | IP | Source IP address | |
| srcIPCC | SC | Source IP country | BFO_SUBNET_TEST=1 |
| srcIPOrg | S | Source IP organization | BFO_SUBNET_TEST=1&& BFO_SUBNET_ORG=1 |
| srcPort | U16 | Source port | |
| dstIP | IP | Destination IP address | |
| dstIPCC | SC | Destination IP country | BFO_SUBNET_TEST=1 |
| dstIPOrg | S | Destination IP organization | BFO_SUBNET_TEST=1&& BFO_SUBNET_ORG=1 |
| dstPort | U16 | Destination port | |
| l4Proto | U8 | Layer 4 protocol | |

## 4.5 Post-Processing

The t2whois program provides an offline whois and geolocation query option using T2 subnet files. It can be found in $T2HOME/utils/t2whois/ and can be compiled by typing make. The use of the program is straightforward:

```
t2whois 1.2.3.4
```

Try t2whois -h for more information.

# 5 basicStats

## 5.1 Description

The basicStats plugin supplies basic layer four statistics for each flow.

## 5.2 Configuration Flags

The following flags can be used to control the output of the plugin:

| Name | Default | Description | Flags |
|---|---|---|---|
| BS_AGGR_CNT | 0 | 0: A+B counts off, | |
| | 0 | 1: add A+B counts | |
| BS_REV_CNT | 1 | 0: native send counts, | |
| | | 1: add reverse counts from opposite flow | |
| BS_MOD | 0 | > 1: modulo factor of packet length; else: off | |
| BS_STATS | 1 | Output statistics (min, max, average, ...) | |
| BS_PL_STATS | 1 | 1: Packet Length statistics | |
| BS_IAT_STATS | 1 | 1: IAT statistics | |
| If BS_STATS==1, the following additional flags can be used: | | | |
| BS_VAR | 0 | Output the variance | |
| BS_STDDEV | 1 | Output the standard deviation | |
| BS_XCLD | 0 | 0: do not exclude any value from statistics, | |
| | | 1: include (BS_XMIN, UINT16_MAX], | |
| | | 2: include [0, BS_XMAX), | |
| | | 3: include [BS_XMIN, BS_XMAX], | |
| | | 4: exclude (BS_XMIN, BS_XMAX) | |
| BS_XMIN | 1 | minimal included/excluded from statistics | BS_XCLD>0 |
| BS_XMAX | UINT16_MAX | maximal included/excluded from statistics | BS_XCLD>0 |

### 5.2.1 Environment Variable Configuration Flags

The following configuration flags can also be configured with environment variables (ENVCNTRL>0):

- BS_XMIN
- BS_XMAX

## 5.3 Flow File Output

The basicStats plugin outputs the following fields:

| Column | Type | Description | Flags |
|---|---|---|---|
| numPktsSnt | U64 | Number of transmitted packets | |

| Column | Type | Description | Flags |
|---|---|---|---|
| numPktsRcvd | U64 | Number of received packets | BS_REV_CNT=1 |
| numPktsRTAggr | U64 | Number of received + transmitted packets | BS_AGGR_CNT=1 |
| numBytesSnt | U64 | Number of transmitted bytes | |
| numBytesRcvd | U64 | Number of received bytes | BS_REV_CNT=1 |
| numBytesRTAggr | U64 | Number of received + transmitted bytes | BS_AGGR_CNT=1 |
| If BS_STATS=1, the following columns, whose value depends on BS_XCLD, are provided | | | |
| If BS_PL_STATS=1, the following five columns are displayed | | | |
| minPktSz | U16 | Minimum layer 3 packet size | |
| maxPktSz | U16 | Maximum layer 3 packet size | |
| avePktSize | F | Average layer 3 packet size | |
| varPktSize | F | Variance layer 3 packet size | BS_VAR=1 |
| stdPktSize | F | Standard deviation layer 3 packet size | BS_STDDEV=1 |
| If BS_IAT_STATS=1, the following five columns are displayed | | | |
| minIAT | F | Minimum IAT | |
| maxIAT | F | Maximum IAT | |
| aveIAT | F | Average IAT | |
| varIAT | F | Variance IAT | BS_VAR=1 |
| stdIAT | F | Standard deviation IAT | BS_STDDEV=1 |
| pktps | F | Sent packets per second | |
| bytps | F | Sent bytes per second | |
| pktAsm | F | Packet stream asymmetry | |
| bytAsm | F | Byte stream asymmetry | |

## 5.4 Packet File Output

In packet mode (-s option), the basicStats plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| pktLen | U32 | Packet size on the wire | |
| udpLen | U16 | Length in UDP/UDP-Lite header | |
| snapL4Len | U16 | Snapped layer 4 length | |
| snapL7Len | U16 | Snapped layer 7 length | |
| l7Len | U16 | L7 length | |
| pktLenMod | U16 | Modulo factor of packet length | BS_MOD>1 |
| padLen | I64 | Number of padding bytes | |

## 5.5 Plugin Report Output

The following information is reported:

- MAC of biggest packets/bytes talker and packets/bytes counts
- IP of biggest packets/bytes talker and packets/bytes counts (`ANONYM_IP=0`)

# 6 bayesClassifier

## 6.1 Description

The bayesClassifier plugin classifies flows based on different models and different source plugins.

## 6.2 Dependencies

### 6.2.1 External Libraries

This plugin depends on the **jansson** library.

| | | |
|---|---|---|
| **Ubuntu:** | `sudo apt-get install` | `libjansson-dev` |
| **Arch:** | `sudo pacman -S` | `jansson` |
| **Gentoo:** | `sudo emerge` | `jansson` |
| **openSUSE:** | `sudo zypper install` | `libjansson` |
| **Red Hat/Fedora**[5]**:** | `sudo dnf install` | `jansson` |
| **macOS**[6]**:** | `brew install` | `jansson` |

### 6.2.2 Other Plugins

This plugin requires the nFrstPkts plugin.

### 6.2.3 Required Files

The file `bayes_config.json` is required.

## 6.3 Configuration Flags

The following flags can be used to control the output of the plugin:

| Name | Default | Description |
|---|---|---|
| `BAYES_CFG` | `"bayes_config.cfg"` | Name of the Bayes config file |
| `BAYES_UNKNOWN` | `"unknown"` | Default class name |
| `BAYES_MIN_POST_PROB` | 0.0001 | Minimum post-probability |
| `BAYES_MIN_NUM_PKT` | 1 | Minimum amount of packets per flow |

## 6.4 Flow File Output

The bayesClassifier plugin outputs the following columns:

[5] If the `dnf` command could not be found, try with `yum` instead
[6] Brew is a packet manager for macOS that can be found here: `https://brew.sh`

| Column | Type | Description | Flags |
|---|---|---|---|
| bayesClass | SC | Naive Bayes Class Name | |

## 6.5 Known Bugs and Limitations

Currently the naivebayes library only supports discrete input features.

# 7 bgpDecode

## 7.1 Description

The bgpDecode plugin analyzes BGP traffic.

## 7.2 Dependencies

None.

## 7.3 Configuration Flags

The following flags can be used to control the output of the plugin:

| Name | Default | Description |
|---|---|---|
| BGP_DEBUG | 0 | Activate debug output |
| BGP_IP_FORMAT | 1 | IP addresses representation:<br>0: hex,<br>1: IP,<br>2: int |
| BGP_AS_FORMAT | 0 | AS number representation:<br>0: ASPLAIN,<br>1: ASDOT,<br>2: ASDOT+ |
| BGP_NOTIF_FORMAT | 0 | Notifications representation:<br>0: uint8,<br>1: string (code only),<br>2: string (code and subcode) (not implemented) |
| BGP_TRAD_BOGONS | 1 | Flag traditional bogons |
| BGP_RT | 1 | Store routing information in a hashtable<br>(required for MOAS detection) |
| BGP_DEBUG_RT | 0 | Activate debug output for routing information |
| BGP_OUTPUT_RT | 1 | Output routing tables |
| BGP_RT_MASK | 0 | Use the mask as part of the key for the routing table |

If BGP_OUTPUT_RT=1 then the following flags can be used:

| | | |
|---|---|---|
| BGP_ORIG_ID | 0 | Output originator id |
| BGP_AGGR | 0 | Output aggregator |
| BGP_CLUSTER | 0 | Output cluster list |
| BGP_COMMUNITIES | 0 | Output communities |
| BGP_MASK_FORMAT | 1 | Netmask representation:<br>0: hex,<br>1: IP,<br>2: int |
| BGP_AS_PATH_AGGR | 0 | Aggregate repetitions of the same AS |
| BGP_ASIZE | 255 | Size of arrays for update records |

| Name | Default | Description |
|---|---|---|
| BGP_SUFFIX | "_bgp.txt" | Suffix to use for routing table information |
| BGP_ANOM_SUFFIX | "_bgp_anomalies.txt" | Suffix for anomaly file |
| BGP_MOAS_SUFFIX | "_bgp_moas.txt" | Suffix for multiple origin AS (MOAS) file |

### 7.3.1 Environment Variable Configuration Flags

The following configuration flags can also be configured with environment variables (ENVCNTRL>0):

- BGP_SUFFIX
- BGP_ANOM_SUFFIX
- BGP_MOAS_SUFFIX

## 7.4 Flow File Output

The bgpDecode plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| bgpStat | H16 | BGP status | |
| bgpAFlgs | H16 | BGP anomalies | |
| bgpMsgT | H8 | BGP message types | |
| bgpNOpen_ | U32_ | Number of BGP OPEN messages, | |
| Upd_ | U32_ | UPDATE messages, | |
| Notif_ | U32_ | NOTIFICATION messages, | |
| KeepAl_ | U32_ | KEEPALIVE messages, | |
| RteRefr | U32 | ROUTE-REFRESH messages | |
| bgpVersion | U8 | BGP version | |
| bgpSrcAS_dstAS | U32_U32 | Source and destination AS | BGP_AS_FORMAT=0 |
| bgpSrcAS_dstAS | SC_SC | Source and destination AS | BGP_AS_FORMAT>0 |
| bgpSrcId_dstId | IP_IP | Source and destination BGP ID | BGP_IP_FORMAT=0 |
| bgpSrcId_dstId | U32_U32 | Source and destination BGP ID | BGP_IP_FORMAT=1 |
| bgpSrcId_dstId | H32_H32 | Source and destination BGP ID | BGP_IP_FORMAT=2 |
| bgpHTime | U16 | BGP hold time (sec) | |
| bgpCaps | H16 | Capabilities | |
| bgpPAttr | H32 | Path attributes | |
| bgpNAdver | U32 | Total number of advertised routes | |
| bgpNWdrwn | U32 | Total number of withdrawn routes | |
| bgpMaxAdver | U32 | Max. num. of advertised routes per record | |
| bgpAvgAdver | D | Average num. of advertised routes per record | |
| bgpMaxWdrwn | U32 | Max. num. of withdrawn routes per record | |
| bgpAvgWdrwn | D | Average num. of withdrawn routes per record | |
| bgpAdvPref | H32 | Advertised prefixes | |
| bgpWdrnPref | H32 | Withdrawn prefixes | |
| bgpNIGP_ | U32_ | Number of routes from origin IGP | |

| Column | Type | Description | Flags |
|---|---|---|---|
| EGP_ | U32_ | EGP, | |
| INC | U32 | INCOMPLETE | |
| bgpMinASPLen | U8 | Minimum AS path length | |
| bgpMaxASPLen | U8 | Maximum AS path length | |
| bgpAvgASPLen | D | Average AS path length | |
| bgpMaxNPrepAS | U32 | Maximum number of prepended AS | |
| bgpMinIatUp | D | Minimum inter-arrival time for update | |
| bgpMaxIatUp | D | Maximum inter-arrival time for update | |
| bgpAvgIatUp | D | Average inter-arrival time for update | |
| bgpMinIatKA | D | Minimum inter-arrival time for keep-alive | |
| bgpMaxIatKA | D | Maximum inter-arrival time for keep-alive | |
| bgpAvgIatKA | D | Average inter-arrival time for keep-alive | |
| bgpNotifCode_Subcode | U8_U8 | Notification (fatal error) code and subcode | BGP_NOTIF_FORMAT=0 |
| bgpNotifCode_Subcode | SC_U8 | Notification (fatal error) code and subcode | BGP_NOTIF_FORMAT=1 |

### 7.4.1 bgpStat

The bgpStat column is to be interpreted as follows:

| bgpStat | Description |
|---|---|
| 0x0001 | Flow is BGP |
| 0x0002 | Connection Not Synchronized |
| 0x0004 | Bad Message Length |
| 0x0008 | Bad Message Type |
| 0x0010 | Unsupported Version Number |
| 0x0040 | Unacceptable Hold Time |
| 0x0080 | Invalid network mask (> 32) |
| 0x0100 | Inter-arrival time for update or keep-alive < 0 |
| 0x0200 | AS Mismatch |
| 0x0400 | Atomic Aggregate |
| 0x4000 | One of the array was full... increase BGP_ASIZE |
| 0x8000 | Malformed packet (snapped or segmented) |

### 7.4.2 bgpAFlgs

The bgpAFlgs column is to be interpreted as follows:

| bgpAFlgs | Description |
|---|---|
| 0x0001 | Bogons advertisement |
| 0x0002 | Prefix more specific than /24 was advertised |
| 0x0004 | Prefix less specific than /8 was advertised |

| bgpAFlgs | Description |
|---|---|
| 0x0008 | Possible blackhole: community with tag 666 |
| 0x0010 | Possible loop: My AS in AS path |
| 0x0020 | Multiple Origin AS (same prefix announced by more than one origin AS) |
| 0x0040 | AS prepended more than 10 times in AS path |
| 0x0080 | AS number reserved for private use in AS path (AS: 64512-65534, AS4: 4200000000-4294967294) |
| 0x0100 | Route for more specific prefix advertised |

### 7.4.3 bgpMsgT

The bgpMsgT column is to be interpreted as follows:

| bgpMsgT | Description |
|---|---|
| 0x01 | — |
| 0x02 | OPEN Message |
| 0x04 | UPDATE Message |
| 0x08 | NOTIFICATION Message |
| 0x10 | KEEPALIVE Message |
| 0x20 | ROUTE-REFRESH Message |
| 0x40 | — |
| 0x80 | — |

### 7.4.4 bgpHTime

The bgpHTime column indicates the number of seconds which can elapse without receiving a message. It should be three times the frequency of keep-alive messages (the default is to send one keep-alive message every 30 seconds, thus having a hold-time of 90s). Common values for the bgpHTime column are:

| bgpHTime | Description |
|---|---|
| 0 | Infinite hold-time (no keep-alive messages are sent) |
| 1,2 | Illegal values |
| 3 | Minimum legal value |
| < 20 | Warning: A hold-time of less than 20 seconds increases the chances of peer flapping |
| 90 | Juniper |
| 180 | Cisco |

### 7.4.5 bgpCaps

The bgpCaps column is to be interpreted as follows:

| bgpCaps | Description |
|---|---|
| 0x0001 | Multiprotocol Extensions for BGP-4 |
| 0x0002 | Route Refresh Capability for BGP-4 |
| 0x0004 | Outbound Route Filtering Capability |
| 0x0008 | Multiple routes to a destination capability |
| 0x0010 | Extended Next Hop Encoding |
| 0x0020 | Graceful Restart Capability |
| 0x0040 | Support for 4-octet AS number capability |
| 0x0080 | Support for Dynamic Capability (capability specific) |
| 0x0100 | Multisession BGP Capability |
| 0x0200 | ADD-PATH Capability |
| 0x0400 | Enhanced Route Refresh Capability |
| 0x0800 | Long-Lived Graceful Restart (LLGR) Capability |
| 0x1000 | FQDN Capability |
| 0x8000 | Unhandled Capability, i.e., none of the above |

### 7.4.6 bgpPAttr

The bgpPAttr column is to be interpreted as follows (bold attributes are mandatory, attributes in italic are deprecated):

| bgpPAttr | Description |
|---|---|
| 0x00000001 | **ORIGIN** |
| 0x00000002 | **AS_PATH** |
| 0x00000004 | **NEXT_HOP** |
| 0x00000008 | MULTI_EXIT_DISC (MED) |
| 0x00000010 | LOCAL_PREF |
| 0x00000020 | ATOMIC_AGGREGATE |
| 0x00000040 | AGGREGATOR |
| 0x00000080 | COMMUNITIES |
| 0x00000100 | ORIGINATOR_ID |
| 0x00000200 | CLUSTER_LIST |
| 0x00000400 | DPA (Designation Point Attribute) |
| 0x00000800 | ADVERTISER |
| 0x00001000 | RCID_PATH / CLUSTER_ID |
| 0x00002000 | MP_REACH_NLRI |
| 0x00004000 | MP_UNREACH_NLRI |
| 0x00008000 | EXTENDED_COMMUNITIES |

| bgpPAttr | Description |
|---|---|
| 0x00010000 | NEW_AS_PATH |
| 0x00020000 | NEW_AGGREGATOR |
| 0x00040000 | *SSA, SAFI Specific Attribute* |
| 0x00080000 | Connector Attribute |
| 0x00100000 | *AS_PATHLIMIT* |
| 0x00200000 | PMSI_TUNNEL |
| 0x00400000 | Tunnel Encapsulation Attribute |
| 0x00800000 | Traffic Engineering |
| 0x01000000 | IPv6 Address Specific Extended Community |
| 0x02000000 | – |
| 0x04000000 | PE Distinguisher Labels |

### 7.4.7 bgpAdvPref and bgpWdrnPref

The `bgpAdvPref` and `bgpWdrnPref` columns are to be interpreted as follows:

| bgpAdvPref | Description |
|---|---|
| 0x00000001 | /1 |
| 0x00000002 | /2 |
| 0x00000004 | /3 |
| 0x00000008 | /4 |
| 0x00000010 | /5 |
| 0x00000020 | /6 |
| 0x00000040 | /7 |
| 0x00000080 | /8 |
| 0x00000100 | /9 |
| 0x00000200 | /10 |
| 0x00000400 | /11 |
| 0x00000800 | /12 |

| bgpAdvPref | Description |
|---|---|
| 0x00001000 | /13 |
| 0x00002000 | /14 |
| 0x00004000 | /15 |
| 0x00008000 | /16 |
| 0x00010000 | /17 |
| 0x00020000 | /18 |
| 0x00040000 | /19 |
| 0x00080000 | /20 |
| 0x00100000 | /21 |
| 0x00200000 | /22 |
| 0x00400000 | /23 |
| 0x00800000 | /24 |

| bgpAdvPref | Description |
|---|---|
| 0x01000000 | /25 |
| 0x02000000 | /26 |
| 0x04000000 | /27 |
| 0x08000000 | /28 |
| 0x10000000 | /29 |
| 0x20000000 | /30 |
| 0x40000000 | /31 |
| 0x80000000 | /32 |

### 7.4.8 bgpNotifCode_Subcode

The `bgpNotifCode_Subcode` column is to be interpreted as follows:

| Code | Subcode | Description |
|---|---|---|
| 1 | | Message Header Error |
| | 1 | Connection Not Synchronized |
| | 2 | Bad Message Length |
| | 3 | Bad Message Type |
| 2 | | OPEN Message Error |
| | 1 | Unsupported Version Number |
| | 2 | Bad Peer AS |
| | 3 | Bad BGP Identifier |
| | 4 | Unsupported Optional Parameter |
| | 5 | Deprecated |
| | 6 | Unacceptable Hold time |
| | 7 | Unsupported capability |
| 3 | | UPDATE Message Error |
| | 1 | Malformed Attribute List |
| | 2 | Unrecognized Well-known Attribute |
| | 3 | Missing Well-known Attribute |
| | 4 | Attribute Flags Error |
| | 5 | Attribute Length Error |
| | 6 | Invalid ORIGIN Attribute |
| | 7 | Deprecated |

| Code | Subcode | Description |
|---|---|---|
| | 8 | Invalid NEXT_HOP Attribute |
| | 9 | Optional Attribute Error |
| | 10 | Invalid Network Field |
| | 11 | Malformed AS_PATH |
| 4 | | Hold Timer Expired (no subcode) |
| 5 | | Finite State Machine Error |
| | 1 | Receive Unexpected Message in OpenSent State |
| | 2 | Receive Unexpected Message in OpenConfirm State |
| | 3 | Receive Unexpected Message in Established State |
| 6 | | Cease |
| | 1 | Maximum Number of Prefixes Reached |
| | 2 | Administrative Shutdown |
| | 3 | Peer De-configured |
| | 4 | Administrative Reset |
| | 5 | Connection Rejected |
| | 6 | Other Configuration Change |
| | 7 | Connection Collision Resolution |
| | 8 | Out of Resources |
| 7 | | ROUTE-REFRESH Message Error |
| | 1 | Invalid Message Length |

## 7.5 Additional Output

If `BGP_OUTPUT_RT=1`, then a `PREFIX_bgp.txt` file is created. Note that the suffix can be configured with `BGP_SUFFIX`. This file uses the configuration options defined in Section 7.3.

| Column | Type | Description | Flags |
|---|---|---|---|
| `NLRI` | R(S) | Target network | |
| `AS` | U32/S | Originating AS | `BGP_AS_FORMAT` |
| `NextHop` | IP4 | Next hop | |
| `MED` | U32 | Multi Exit Discriminator (MED) | |
| `LocPref` | U32 | Local Preference | |
| `Origin` | S | Origin (IGP, EGP, INCOMPLETE, UNKNOWN) | |
| `OriginatorID` | IP4 | Originator ID | `BGP_ORIG_ID=1` |
| `OriginAS` | R(U32) | Origin AS | |
| `UpstreamAS` | R(U32) | Upstream AS | |
| `DestAS` | U32 | Destination AS | |
| `Aggregator` | S | Aggregator (AS:Origin) | `BGP_AGGR=1` |
| `ASPath` | S | List of AS to visit to reach target network | |
| `ASPathLen` | U32 | Length of the AS path | |
| `MaxNPrepAS` | U32 | Maximum number of prepended AS | |

| Column | Type | Description | Flags |
|---|---|---|---|
| ClusterList | R(IP4) | Cluster list | BGP_CLUSTER=1 |
| ClusterListLen | U32 | Cluster list length | BGP_CLUSTER=1 |
| Communities | R(S) | List of communities (AS:tag) | BGP_COMMUNITIES=1 |
| WithdrawnRoutes | R(S) | List of withdrawn routes | |
| flowIndex | U64 | Flow index of the advertisement | |
| Packet | U64 | Packet index of the advertisement | |
| Record | U64 | Record index (within the packet) of the advertisement | |
| Timestamp | U32 | Timestamp of the advertisement | |

## 7.6 Plugin Report Output

The number of BGP packets and OPEN, UPDATE, NOTIFICATION, KEEP-ALIVE and ROUTE-REFRESH messages is reported. In addition, the aggregated bgpAFlgs anomalies are reported.

## 7.7 Post-Processing

### 7.7.1 bgpR

The bgpR script creates a PREFIX_bgp_s.txt file, which is similar to the input file, but easier to process. The target networks are split and sorted, redundant records are omitted and the list of countries and continents to visit to reach the target network is added (ASPathCountries and ASPathContinents).

In addition, the following files are created:

- PREFIX_bgp_mpath.txt: outputs, for all networks which have more than one path, the number of distinct paths.
- PREFIX_bgp_conf.txt: lists possible configuration errors, e.g., an AS number prepended *N* times, followed by AS number *N*.

The script can also be used to plot AS paths between AS numbers, countries and continents (Figure 5).

**Usage:**
The bgpR script uses the PREFIX_bgp.txt file described in Section 7.5 as input: ./bgpR PREFIX_bgp.txt
For a complete list of options, use the -h or --help option: bgpR --help.

**Plot Configuration:**
To color specific countries, edit the bgpR script (search for *colorN*), by adding a case for the missing country or by changing the color. For example, to color Switzerland in red, add the following line in the switch:

```
case "CH": color = "red"; break;
```

For the coloring of the edges, search for *cstr* and edit the semi-colon separated string. A complete list of colors can be found at http://www.graphviz.org/doc/info/colors.html.

### 7.7.2 ASPathCountries

For a list of countries, refer to countrycodes.txt in the doc folder.

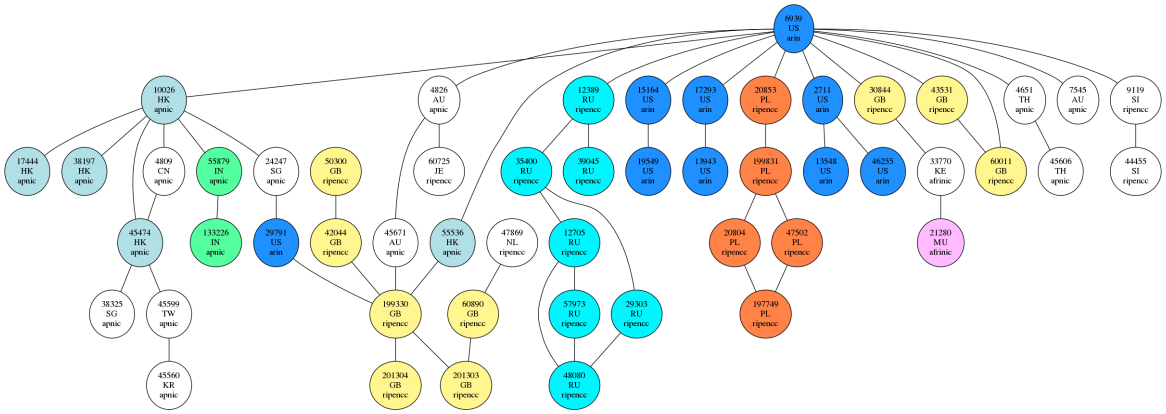



**Figure 5:** *Paths between AS*

### 7.7.3 ASPathContinents

The `ASPathContinents` column is to be interpreted as follows:

| ASPathContinents | Description |
|---:|---|
| afrinic | Africa Region |
| apnic | Asia/Pacific Region |
| arin | Canada, USA and some Caribbean Islands |
| ietf | Reserved/Unknown |
| lacnic | Latin America and some Caribbean Islands |
| ripencc | Europe, the Middle East and Central Asia |

### 7.7.4 bgp2ng

The `bgp2ng` script can be used to generate plots similar to `bgpR` but readable by netgraph (Figure 6). It uses the `PREFIX_bgp_s.txt` file described in Section 7.7.1 as input:

```
./bgp2ng PREFIX_bgp_s.txt
```

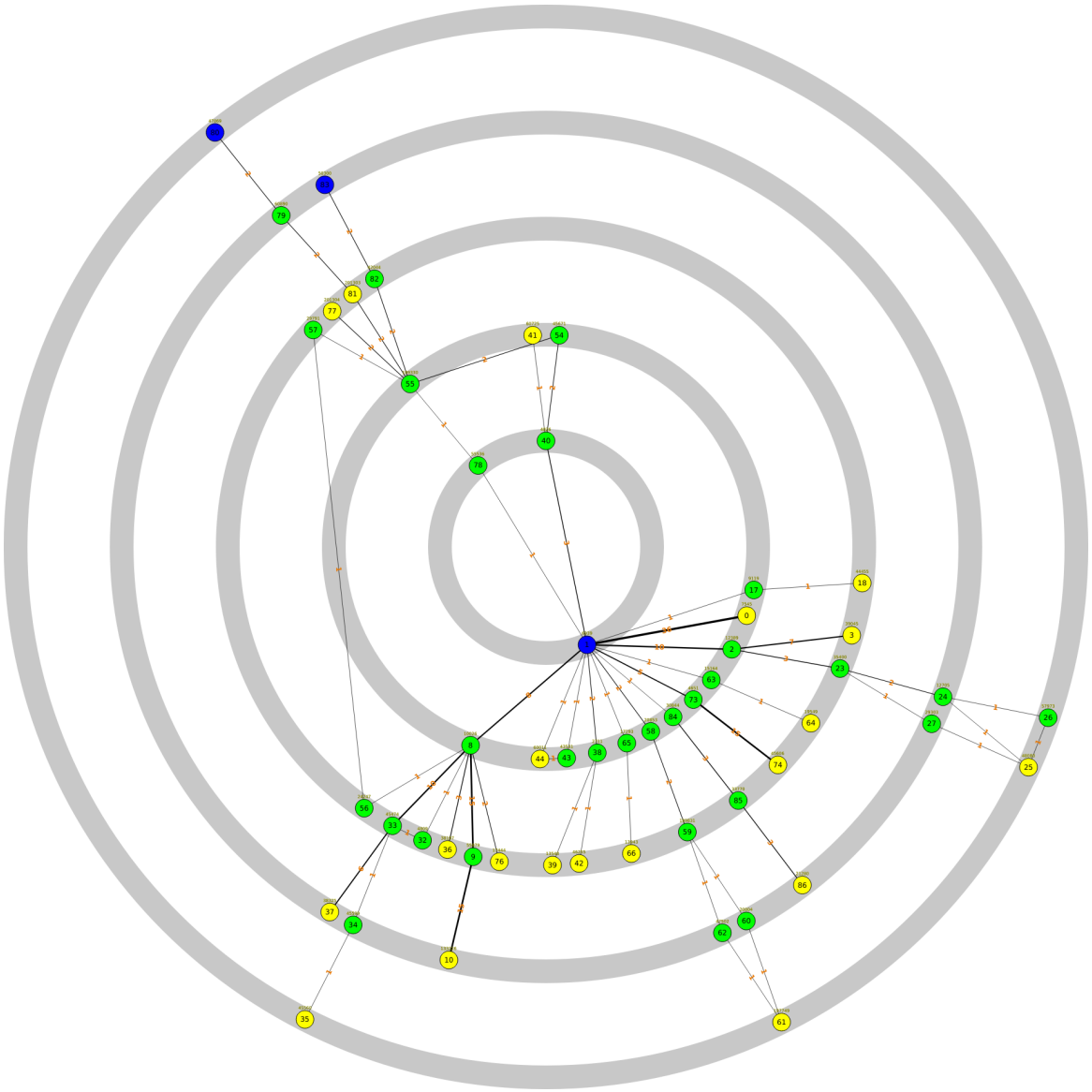


**Figure 6:** *Paths between AS*

It creates the following files:

- `PREFIX_bgp_netgraph0.txt`: connections between network and next hop

- `PREFIX_bgp_netgraph1.txt`: connections between first and last AS
- `PREFIX_bgp_netgraph2.txt`: connections between all AS
- `PREFIX_bgp_netgraph3.txt`: connections between first and last country
- `PREFIX_bgp_netgraph4.txt`: connections between all countries
- `PREFIX_bgp_netgraph5.txt`: connections between first and last continent
- `PREFIX_bgp_netgraph6.txt`: connections between all countries
- `PREFIX_bgp_netgraph7.txt`: connections between network, next hop, first and last AS, country and continent, ASPath

### 7.7.5 bgpMOAScn

The bgpMOAScn script adds information regarding the country of the multiple origins AS (MOAS) reported in the file FILE_moas.txt. Save the results in FILE_moas_cn.txt. Use bgpMOAScn -h for more information. Note that it is best to validate the countries using whois on the AS number and network to ensure the information is up to date, e.g., whois AS1234 or whois 1.2.3.4/24.

## 7.8 Anomalies

Anomalies are summarized in the bgpAFlgs columns and in FILE_bgp_anomalies.txt.

- Bogons advertisement:
  `awk '/^BOGON/' FILE_bgp_anomalies.txt`
- Prefix more specific than /24:
  `awk '/^SPEC24/' FILE_bgp_anomalies.txt`
- Prefix less specific than /8:
  `awk '/^SPEC8/' FILE_bgp_anomalies.txt`
- Possible blackhole:
  `awk '/^BLACKHOLE/' FILE_bgp_anomalies.txt`
- Possible loop:
  `awk '/^LOOP/' FILE_bgp_anomalies.txt`
- Multiple Origin AS (MOAS) are reported in FILE_moas.txt (see also bgpMOAScn)
- AS number prepended more than 10 times in AS path:
  `awk '/^NPREPAS/' FILE_bgp_anomalies.txt`
- Private/Reserved AS numbers:
  `awk '/^PRIVAS/' FILE_bgp_anomalies.txt`
- More specific prefix to existing network:
  `awk '/^MSPEC/' FILE_bgp_anomalies.txt`

In addition, the number of distinct paths (if bigger than one) to reach a specific network is summarized in the file FILE_bgp_mpath.txt along with some statistics regarding the different AS path lengths (minimum, maximum, range, mean, median, standard deviation and mode). The file also highlights whether a MOAS was detected for the network. Possible misconfigurations are reported in FILE_bgp_conf.txt. Note that the last two files are created by the bgpR script.

## 7.9 Examples

- BGP flows can be extracted from a flow file by using the bgpStat column as follows:

```
tawk 'hdr() || strtonum($bgpStat)' FILE_flows.txt
```

- BGP flows with anomalies can be extracted from a flow file by using the bgpAFlgs column as follows:

```
tawk 'hdr() || strtonum($bgpAFlgs)' FILE_flows.txt
```

- More details about the anomalies listed in `FILE_bgp_anomalies.txt` can be found by using the `flowInd`, `PktNum` and `RecNum` columns and `FILE_bgp_s.txt` or `FILE_bgp.txt` files as follows, e.g., for `flowInd=1`, `PktNum=2` and `RecNum=3`:

```
tawk '$flowIndex == 1 && $Packet == 2 && $Record == 3' FILE_bgp_s.txt
```

  Alternatively, the following command can be used to achieve similar results:

```
grep -P "1\t2\t3" FILE_bgp_s.txt
```

- Display the 10 networks which experienced the most more specific prefix advertisements:

```
tawk '/^MSPEC/ { a[$ASorNet]++ } END { for (i in a) print i, a[i] }'
          FILE_bgp_anomalies.txt | sort -nrk2 | head -10
```

- To plot the AS paths for a specific network, proceed as follows:

  1. Run the bgpR script: `bgpR FILE_bgp.txt`
  2. Run the bgp2ng script: `bgp2ng FILE_bgp_s.txt`
  3. Use `tawk` as follows, e.g., to keep network 123.123.123.0/24 only:

```
tawk '
    hdr() {
        printf "%s\t%s\t%s\n", chomp($0), "ASP1", "ASP2"
        next
    }

    $NLRI ~ /^123\.123\.123\.0\/24$/ {
        l = split($ASPath, asp, ";")
        for (i = 1; i < l; i++) {
           printf "%s\t%s\t%s\n", chomp($0), asp[i], asp[i+1]
        }
    }
' FILE_bgp_netgraph7.txt
```

  4. Open the file with Traviz/Netgraph

## 7.10 References

- RFC4271: A Border Gateway Protocol 4 (BGP-4)
- IPv4 traditional bogons list
- https://www.iana.org/assignments/

# 8 binSink

## 8.1 Description

The binSink plugin is one of the basic output plugin for Tranalyzer2. It uses the output prefix (`-w` option) to generate a binary flow file with suffix `_flows.bin`. All standard output from every plugin is stored in binary format in this file.

## 8.2 Dependencies

### 8.2.1 External Libraries

If gzip compression is activated (`BFS_GZ_COMPRESS=1`), then **zlib** must be installed.

| | | **BFS_GZ_COMPRESS=1** |
|---|---|---|
| **Ubuntu:** | `sudo apt-get install` | `zlib1g-dev` |
| **Arch:** | `sudo pacman -S` | `zlib` |
| **Gentoo:** | `sudo emerge` | `zlib` |
| **openSUSE:** | `sudo zypper install` | `zlib-devel` |
| **Red Hat/Fedora**[7]**:** | `sudo dnf install` | `zlib-devel` |
| **macOS**[8]**:** | `brew install` | `zlib` |

### 8.2.2 Core Configuration

This plugin requires the following core configuration:

- *$T2HOME/tranalyzer2/src/tranalyzer.h*:
  - `BLOCK_BUF=0`

## 8.3 Configuration Flags

The following flags can be used to control the output of the plugin:

| Name | Default | Description |
|---|---|---|
| `BFS_GZ_COMPRESS` | 0 | Compress (gzip) the output |
| `BFS_SFS_SPLIT` | 1 | Split the output file (Tranalyzer `-W` option) |
| `BFS_FLOWS_SUFFIX` | `"_flows.bin"` | Suffix to use for the output file |

### 8.3.1 Environment Variable Configuration Flags

The following configuration flags can also be configured with environment variables (`ENVCNTRL>0`):

- `BFS_FLOWS_SUFFIX`

[7] If the `dnf` command could not be found, try with `yum` instead
[8] Brew is a packet manager for macOS that can be found here: https://brew.sh

## 8.4 Post-Processing

## 8.5 t2b2t

The program `t2b2t` can be used to transform binary Tranalyzer files generated by the binSink or socketSink plugin into text or JSON files. The converted files use the same format as the ones generated by the txtSink or jsonSink plugin.

The program can be found in `$T2HOME/utils/t2b2t` and can be compiled by typing `make`.

The use of the program is straightforward:

- bin→txt: `t2b2t -r FILE_flows.bin -w FILE_flows.txt`
- bin→JSON: `t2b2t -r FILE_flows.bin -j -w FILE_flows.json`
- bin→compressed txt: `t2b2t -r FILE_flows.bin -c -w FILE_flows.txt.gz`
- bin→compressed JSON: `t2b2t -r FILE_flows.bin -c -j -w FILE_flows.json.gz`

If the `-w` option is omitted, the destination is inferred from the input file, e.g., the examples above would produce the same output files with or without the `-w` option. Note that `-w -` can be used to output to stdout.
Additionally, the `-n` option can be used **not** to print the name of the columns as the first row.
Try `t2b2t -h` for more information.

## 8.6 Custom File Output

- `PREFIX_flows.bin`: Binary representation of Tranalyzer output

# 9 cdpDecode

## 9.1 Description

The cdpDecode plugin analyzes CDP traffic.

## 9.2 Dependencies

### 9.2.1 Core Configuration

This plugin requires the following core configuration:

- *$T2HOME/tranalyzer2/src/networkHeaders.h*:
  - `ETH_ACTIVATE>0`

## 9.3 Configuration Flags

The following flags can be used to control the output of the plugin:

| Name | Default | Description |
|---|---|---|
| `CDP_NADDR` | 5 | Maximum number of IPv4 addresses |
| `CDP_NMADDR` | 5 | Maximum number of management addresses |
| `CDP_NIPPG` | 5 | Maximum number of IP prefix gateways |
| `CDP_STRLEN` | 25 | Maximum length of strings to store |
| `CDP_LSTRLEN` | 100 | Maximum length of long strings to store |

## 9.4 Flow File Output

The cdpDecode plugin outputs the following columns:

| Column | Type | Description |
|---|---|---|
| `cdpStat` | H8 | Status |
| `cdpVer` | U8 | Version |
| `cdpTTL` | U8 | Time To Live (sec) |
| `cdpTLVTypes` | H32 | TLV types |
| `cdpDevice` | SC | Device ID |
| `cdpPlatform` | S | Platform |
| `cdpSWVersion` | S | Software Version |
| `cdpPortID` | SC | Port ID |
| `cdpCaps` | H32 | Capabilities |
| `cdpDuplex` | H8 | Duplex |
| `cdpNVLAN` | U16 | Native VLAN |
| `cdpVoipVLAN` | U16 | VoIP VLAN |
| `cdpVTPMngmtDmn` | SC | VTP management domain |
| `cdpMAddrs` | R(IP4) | Management Addresses |
| `cdpAddrs` | R(IP4) | Addresses |

| Column | Type | Description |
|---|---|---|
| cdpIPPref_cdr | R(IP4_U8) | IP Prefix, CIDR |

### 9.4.1 cdpStat

The cdpStat column is to be interpreted as follows:

| cdpStat | Description |
|---|---|
| 0x01 | Flow is CDP |
| 0x02 | — |
| 0x04 | — |
| 0x08 | — |
| 0x10 | — |
| 0x20 | String truncated... increase CDP_STRLEN |
| 0x40 | Invalid TLV length |
| 0x80 | Snapped payload |

### 9.4.2 cdpTLVTypes

The cdpTLVTypes column is to be interpreted as follows:

| cdpTLVTypes | | Description |
|---|---|---|
| $2^0$ | (=0x0000 0001) | — |
| $2^1$ | (=0x0000 0002) | Device ID |
| $2^2$ | (=0x0000 0004) | Addresses |
| $2^3$ | (=0x0000 0008) | Port ID |
| $2^4$ | (=0x0000 0010) | Capabilities |
| $2^5$ | (=0x0000 0020) | Software Version |
| $2^6$ | (=0x0000 0040) | Platform |
| $2^7$ | (=0x0000 0080) | IP Prefixes |
| $2^8$ | (=0x0000 0100) | Protocol Hello |
| $2^9$ | (=0x0000 0200) | VTP Management Domain |
| $2^{10}$ | (=0x0000 0400) | Native VLAN |
| $2^{11}$ | (=0x0000 0800) | Duplex |
| $2^{12}$ | (=0x0000 1000) | — |
| $2^{13}$ | (=0x0000 2000) | — |
| $2^{14}$ | (=0x0000 4000) | VoIP VLAN Reply |
| $2^{15}$ | (=0x0000 8000) | VoIP VLAN Query |

| cdpTLVTypes | | Description |
|---|---|---|
| $2^{16}$ | (=0x0001 0000) | Power Consumption |
| $2^{17}$ | (=0x0002 0000) | MTU |
| $2^{18}$ | (=0x0004 0000) | Trust Bitmap |
| $2^{19}$ | (=0x0008 0000) | Untrusted Port CoS |
| $2^{20}$ | (=0x0010 0000) | System Name |
| $2^{21}$ | (=0x0020 0000) | System OID |
| $2^{22}$ | (=0x0040 0000) | Management Address |
| $2^{23}$ | (=0x0080 0000) | Location |
| $2^{24}$ | (=0x0100 0000) | External Port ID |
| $2^{25}$ | (=0x0200 0000) | Power Requested |
| $2^{26}$ | (=0x0400 0000) | Power Available |
| $2^{27}$ | (=0x0800 0000) | Port Unidirectional |
| $2^{28}$ | (=0x1000 0000) | Energy Wise |
| $2^{29}$ | (=0x2000 0000) | Spare Pair POE |
| $2^{30}$ | (=0x4000 0000) | — |
| $2^{31}$ | (=0x8000 0000) | Any type $\geq 31$ |

### 9.4.3 cdpCaps

The `cdpCaps` column is to be interpreted as follows:

| cdpCaps | Description |
|---|---|
| 0x0000 0001 | Router |
| 0x0000 0002 | Transparent Bridge |
| 0x0000 0004 | Source Route Bridge |
| 0x0000 0008 | Switch |
| 0x0000 0010 | Host |
| 0x0000 0020 | IGMP capable |
| 0x0000 0040 | Repeater |
| 0x00000100-0x80000000 | Reserved |

### 9.4.4 cdpDuplex

The `cdpDuplex` column is to be interpreted as follows:

| cdpDuplex | Description |
|---|---|
| 0x0001 | Half |
| 0x0002 | Full |

## 9.5 Packet File Output

In packet mode (`-s` option), the cdpDecode plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| cdpStat | H8 | Status | |
| cdpVer | U8 | Version | |
| cdpTTL | U8 | Time To Live (sec) | |
| cdpTLVTypes | H16 | TLV types | |
| cdpDevice | SC | Device ID | |
| cdpPlatform | S | Platform | |
| cdpPortID | SC | Port ID | |
| cdpCaps | H32 | Capabilities | |
| cdpDuplex | H8 | Duplex | |
| cdpNVLAN | U16 | Native VLAN | |
| cdpVoipVLAN | U16 | VoIP VLAN | |
| cdpVTPMngmtDmn | SC | VTP management domain | |
| cdpMAddrs | IP4 | Management Addresses | |
| cdpAddrs | IP4 | Addresses | |

## 9.6 Monitoring Output

In monitoring mode, the cdpDecode plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| cdpPkts | U64 | Number of CDP packets | |

## 9.7 Plugin Report Output

The following information is reported:

- Aggregated cdpStat
- Aggregated cdpTLVTypes
- Aggregated cdpCaps
- Number of CDP packets

# 10 clickhouseSink

## 10.1 Description

The clickhouseSink plugin outputs flows to a ClickHouse database.

## 10.2 Dependencies

### 10.2.1 External Libraries

This plugin depends on the **clickhouse-cpp** and **clickhouse** libraries.

On macOS, the **clickhouse-cpp** library can be installed with Brew[9] (see below). Unfortunately, there is no package for the **clickhouse-cpp** library on Linux, but you can install it from source with the following commands:

```
$ git clone https://github.com/clickhouse/clickhouse-cpp
$ cd clickhouse-cpp
$ mkdir build
$ cd build
$ cmake ..
$ make
$ sudo make install
$ sudo ldconfig
```

Make sure `/usr/local/lib/` is in your library path:

```
$ ldconfig -p | tail -n +2 | grep -o '/.*/' | sort -u
```

If `/usr/local/lib/` is **NOT** in your library path, you can add it with

```
$ echo "/usr/local/lib/" | sudo tee -a /etc/ld.so.conf.d/mylibs.conf
$ sudo ldconfig
```

ClickHouse packages are available, but repositories must be added in most cases:

### 10.2.2 Ubuntu

Make sure to run **ALL** the commands below. Otherwise an old version of the clickhouse server (incompatible with the plugin) will be installed.

```
$ sudo apt install libabsl-dev
$ sudo apt-get install apt-transport-https ca-certificates dirmngr
$ sudo apt-key adv --keyserver hkp://keyserver.ubuntu.com:80 --recv E0C56BD4
$ echo "deb https://repo.clickhouse.com/deb/stable/ main/" | sudo tee \
        /etc/apt/sources.list.d/clickhouse.list
$ sudo apt-get update
$ sudo apt-get install -y clickhouse-server clickhouse-client
$ sudo service clickhouse-server start
```

[9] Brew is a packet manager for macOS that can be found here: https://brew.sh

### 10.2.3 CentOS or RedHat

```
$ sudo yum install abseil-cpp
$ sudo yum install yum-utils
$ sudo rpm --import https://repo.clickhouse.com/CLICKHOUSE-KEY.GPG
$ sudo yum-config-manager --add-repo https://repo.clickhouse.com/rpm/clickhouse.repo
$ sudo yum install clickhouse-server clickhouse-client
$ sudo /etc/init.d/clickhouse-server start
```

### 10.2.4 Arch Linux

Replace `yay` with your favorite AUR helper.

```
$ sudo pacman -S abseil-cpp
$ yay -S clickhouse-server-bin clickhouse-client-bin clickhouse-common-static-bin
$ sudo systemctl start clickhouse-server
```

### 10.2.5 openSUSE

```
$ sudo zypper install abseil-cpp
$ sudo zypper install clickhouse
```

### 10.2.6 macOS

```
$ brew install clickhouse-cpp
$ wget 'https://builds.clickhouse.com/master/macos/clickhouse'
$ chmod a+x ./clickhouse
$ ./clickhouse
```

### 10.2.7 Core Configuration

This plugin requires the following core configuration:

- *$T2HOME/tranalyzer2/src/tranalyzer.h*:
  - `BLOCK_BUF=0`

## 10.3 Configuration Flags

The following flags can be used to control the output of the plugin:

| Name | Default | Description |
|---|---|---|
| `CLICKHOUSE_OVERWRITE_DB` | 2 | 0: abort if DB already exists<br>1: overwrite DB if it already exists<br>2: reuse DB if it already exists |
| `CLICKHOUSE_OVERWRITE_TABLE` | 2 | 0: abort if table already exists<br>1: overwrite table if it already exists<br>2: append to table if it already exists |
| `CLICKHOUSE_TRANSACTION_NFLOWS` | 10000 | 0: one transaction<br>> 0: one transaction every *n* flows |

| Name | Default | Description |
|---|---|---|
| CLICKHOUSE_HOST | "127.0.0.1" | Address of the database |
| CLICKHOUSE_DBPORT | 9000 | Port the DB is listening to |
| CLICKHOUSE_USER | "default" | Username to connect to DB |
| CLICKHOUSE_PASS | "" | Password to connect to DB |
| CLICKHOUSE_DBNAME | "tranalyzer" | Name of the database |
| CLICKHOUSE_TABLE_NAME | "flow" | Name of the table |

### 10.3.1 Environment Variable Configuration Flags

The following configuration flags can also be configured with environment variables (ENVCNTRL>0):

- CLICKHOUSE_HOST
- CLICKHOUSE_DBPORT
- CLICKHOUSE_USER
- CLICKHOUSE_PASSWORD
- CLICKHOUSE_DBNAME
- CLICKHOUSE_TABLE_NAME

## 10.4 Example

```
# Run Tranalyzer
$ t2 -r file.pcap

# Connect to the ClickHouse database
$ clickhouse-client -d tranalyzer

# Number of flows
:) SELECT count(*) FROM flow;

# 10 first srcIP/dstIP pairs
:) SELECT "srcIP", "dstIP" FROM flow LIMIT 10;

# All flows from 1.2.3.4 to 1.2.3.5
:) SELECT * FROM flow WHERE "srcIP.1" = 4 AND "srcIP.2" = toIPv6('1.2.3.4') AND
                            "dstIP.1" = 4 AND "dstIP.2" = toIPv6('1.2.3.5');
```

For examples of more complex queries, have a look in $T2HOME/scripts/t2fm/clickhouse/.

### 10.4.1 Clean up an existing database

```
# Connect to the ClickHouse database
$ clickhouse-client
```

```
# Drop the database
:) DROP DATABASE tranalyzer;
```

# 11 connStat

## 11.1 Description

The connStat plugin counts the connections between different IPs and ports per flow and during the pcap lifetime in order to produce an operational picture for anomaly detection.

## 11.2 Configuration Flags

The following flags can be used to control the output of the plugin:

| Name | Default | Description |
|---|---|---|
| CS_HSDRM | 1 | Decrement IP counters when flows die |
| CS_SDIPMAX | 1 | 0: Number of src dst IP connections,<br>1: IP src dst connection with the highest count |
| CS_MR_SPOOF | 0 | 1: Activate MAC spoof detector |
| CS_PBNMAX | 1 | 1: Report packet/byte biggest talker |

## 11.3 Flow File Output

The connStat plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| connSip | U32 | Number of unique source IPs | |
| connDip | U32 | Number of unique destination IPs | |
| connSipDip | U32 | Number of connections between source and destination IPs | |
| connSipDprt | U32 | Number of connections between source IP and destination port | |
| connMacSpf | U32 | Number of MAC addresses per source IP | CS_MR_SPOOF=1 |
| connF | F | The *f* number: connSipDprt/connSip [EXPERIMENTAL] | |
| connG | F | The *g* number: connSipDprt/connSipDip [EXPERIMENTAL] | |
| connNumPCnt | U64 | Number of unique IP's source packet count | CS_PBNMAX=1 |
| connNumBCnt | U64 | Number of unique IP's source byte count | CS_PBNMAX=1 |

## 11.4 Monitoring Output

In monitoring mode, the connStat plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| connSip | U32 | Number of unique source IPs | |
| connDip | U32 | Number of unique destination IPs | |
| connSipDip | U32 | Number of connections between source and destination IPs | |
| connSipDprt | U32 | Number of connections between source IP and destination port | |
| connF | F | The *f* number: connSipDprt/connSip [EXPERIMENTAL] | |
| connG | F | The *g* number: connSipDprt/connSipDip [EXPERIMENTAL] | |

## 11.5 Plugin Report Output

The following information is reported:

- Number of unique source IPs
- Number of unique destination IPs
- Number of unique source/destination IPs connections
- Max unique number of source IP / destination port connections
- IP connF=connSipDprt/connSip
- IP connG=connSipDprt/connSipDip
- Source IP with max connections (`ANONYM_IP=0`)
- Destination IP with max connections (`ANONYM_IP=0`)
- Biggest L3 packets talker (`CS_PBNMAX=1`)
- Biggest L3 bytes talker (`CS_PBNMAX=1`)

# 12 descriptiveStats

## 12.1 Description

The descriptiveStats plugin calculates various statistics about a flow. Because the inter-arrival time of the first packet is per definition always zero, it is removed from the statistics. Therefore the inter-arrival time statistics values for flows with only one packet is set to zero.

## 12.2 Dependencies

### 12.2.1 Other Plugins

This plugin requires the pktSIATHisto plugin.

## 12.3 Configuration Flags

The following flags can be used to control the output of the plugin:

| Name | Default | Description | Flags |
|---|---|---|---|
| DS_PS_CALC | 1 | Compute statistics for packet sizes | |
| DS_IAT_CALC | 1 | Compute statistics for inter-arrival times | |
| DS_QUARTILES | 0 | Quartiles calculation:<br>0: Use linear interpolation<br>1: Use the mean | DS_PS_CALC=1 |

## 12.4 Flow File Output

The descriptiveStats plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| dsMinPl | F | Minimum packet length | DS_PS_CALC=1 |
| dsMaxPl | F | Maximum packet length | DS_PS_CALC=1 |
| dsMeanPl | F | Mean packet length | DS_PS_CALC=1 |
| dsLowQuartilePl | F | Lower quartile of packet lengths | DS_PS_CALC=1 |
| dsMedianPl | F | Median of packet lengths | DS_PS_CALC=1 |
| dsUppQuartilePl | F | Upper quartile of packet lengths | DS_PS_CALC=1 |
| dsIqdPl | F | Inter quartile distance of packet lengths | DS_PS_CALC=1 |
| dsModePl | F | Mode of packet lengths | DS_PS_CALC=1 |
| dsRangePl | F | Range of packet lengths | DS_PS_CALC=1 |
| dsStdPl | F | Standard deviation of packet lengths | DS_PS_CALC=1 |
| dsRobStdPl | F | Robust standard deviation of packet lengths | DS_PS_CALC=1 |
| dsSkewPl | F | Skewness of packet lengths | DS_PS_CALC=1 |
| dsExcPl | F | Excess of packet lengths | DS_PS_CALC=1 |
| dsMinIat | F | Minimum inter-arrival time | DS_IAT_CALC=1 |
| dsMaxIat | F | Maximum inter-arrival time | DS_IAT_CALC=1 |
| dsMeanIat | F | Mean inter-arrival time | DS_IAT_CALC=1 |

| Column | Type | Description | Flags |
|---|---|---|---|
| dsLowQuartileIat | F | Lower quartile of inter-arrival times | DS_IAT_CALC=1 |
| dsMedianIat | F | Median of inter-arrival times | DS_IAT_CALC=1 |
| dsUppQuartileIat | F | Upper quartile of inter-arrival times | DS_IAT_CALC=1 |
| dsIqdIat | F | Inter quartile distance of inter-arrival times | DS_IAT_CALC=1 |
| dsModeIat | F | Mode of inter-arrival times | DS_IAT_CALC=1 |
| dsRangeIat | F | Range of inter-arrival times | DS_IAT_CALC=1 |
| dsStdIat | F | Standard deviation of inter-arrival times | DS_IAT_CALC=1 |
| dsRobStdIat | F | Robust standard deviation of inter-arrival times | DS_IAT_CALC=1 |
| dsSkewIat | F | Skewness of inter-arrival times | DS_IAT_CALC=1 |
| dsExcIat | F | Excess of inter-arrival times | DS_IAT_CALC=1 |

## 12.5 Known Bugs and Limitations

Because the pktSIATHisto plugin stores the inter-arrival times in statistical bins, the original time information is lost. Therefore, the calculation of the inter-arrival times statistics is, due to its logarithmic binning, only a rough approximation of the original timing information. Nevertheless, this representation has shown to be useful in practical cases of anomaly and application classification.

# 13 dhcpDecode

## 13.1 Description

This dhcpDecode plugin analyzes DHCP traffic.

## 13.2 Configuration Flags

The following flags can be used to control the output of the plugin:

| Name | Default | Description | Flags |
|---|---|---|---|
| DHCPMOTOUT | 1 | Message types/options representation:<br>0: bitfield,<br>1: numbers,<br>2: names | |
| DHCPOPTMAX | 20 | maximum stored options | DHCPMOTOUT=0 |
| DHCPMSGMAX | 20 | maximum stored message types | DHCPMOTOUT=0 |
| DHCPNMMAX | 10 | maximal number of domain/host names per flow | |
| DHCPMASKFRMT | 1 | Netmask representation: 0: hex, 1: IP | |
| DHCP_ADD_CNT | 0 | Print the number of times a given mac/domain/host appeared | |
| DHCP_FLAG_MAC | 0 | Store a global mapping IP→MAC and add the source and destination MAC address to every flow [EXPERIMENTAL] | |
| DHCP_FM_DEBUG | 0 | print debug information about DHCP_FLAG_MAC operations | |

## 13.3 Flow File Output

The dhcpDecode plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| dhcpStat | H16 | Status, warnings and errors | |
| dhcpMTypeBF | H32 | Message type bitfield | DHCPMOTOUT=0 |
| dhcpMType | R(U8) | Message type number list | DHCPMOTOUT=1 |
| dhcpMTypeNms | R(SC) | Message type name list | DHCPMOTOUT=2 |
| dhcpHWType | H64 | Hardware type | |
| dhcpCHWAdd | R(MAC) | Client hardware addresses | DHCP_ADD_CNT=0 |
| dhcpCHWAdd_HWCnt | R(MAC_U32) | Client hardware addresses and count | DHCP_ADD_CNT=1 |
| If IPV6_ACTIVATE=0\|2, the following columns are output: | | | |
| dhcpNetmask | H32/IP4 | Network mask | DHCPMASKFRMT=0/1 |
| dhcpGWIP | IP4 | Gateway IP | |
| dhcpDnsIP | IP4 | DNS IP | |
| dhcpHopCnt | H32 | Hop Count | |
| dhcpSrvName | S | Server host name | |
| dhcpBootFile | S | Boot file name | |
| dhcpOptCnt | U16 | Option Count | |
| dhcpOptBF1_BF2_BF3 | H64_H64_H64 | Options bitfield | DHCPMOTOUT=0 |

| Column | Type | Description | Flags |
|---|---|---|---|
| dhcpOpts | R(U8) | Options | DHCPMOTOUT=1 |
| dhcpOptNms | R(S) | Options names | DHCPMOTOUT=2 |
| dhcpOptBF1_BF2_BF3 | H64_H64_H64 | Option bitfield | DHCPBITFLD=1 |
| dhcpHosts | R(S) | Maximal DHCPNMMAX hosts | DHCP_ADD_CNT=0 |
| dhcpHosts_HCnt | R(S_U16) | Maximal DHCPNMMAX hosts and count | DHCP_ADD_CNT=1 |
| dhcpDomains | R(S) | Maximal DHCPNMMAX domains | DHCP_ADD_CNT=0 |
| dhcpDomains_DCnt | R(S_U16) | Maximal DHCPNMMAX domains and count | DHCP_ADD_CNT=1 |
| dhcpMaxSecEl | U16 | Maximum seconds elapsed | |
| dhcpLeaseT | U32 | Lease time | |
| dhcpRenewT | U32 | Renewal time | |
| dhcpRebindT | U32 | Rebind time | |
| dhcpCliIP | IP4 | DHCP client IP | |
| dhcpYourIP | IP4 | DHCP your (client) IP | |
| dhcpNextServer | IP4 | DHCP next server IP | |
| dhcpRelay | IP4 | DHCP relay agent IP | |
| dhcpLFlow | U64 | DHCP linked flow | |
| dhcpSrcMac | MAC | DHCP source MAC address | DHCP_FLAG_MAC=1 |
| dhcpDstMac | MAC | DHCP destination MAC address | DHCP_FLAG_MAC=1 |

### 13.3.1 dhcpStat

The dhcpStat status bit field is to be interpreted as follows:

| dhcpStat | Description |
|---|---|
| 0x0001 | DHCP detected |
| 0x0002 | Boot request |
| 0x0004 | Boot reply |
| 0x0008 | Broadcast |
| 0x0010 | Client ID (option 61) different from client MAC address (DHCP header) |
| 0x0020 | Option overload: server host name and/or boot file name carry options |
| 0x0040 | Seconds elapsed probably encoded as little endian |
| 0x0080 | Non Ethernet hardware |
| 0x0100 | Option list truncated... increase DHCPOPTMAX or DHCPMSGMAX |
| 0x0200 | Client HW address, domain or host name list truncated... increase DHCPNMMAX |
| 0x0400 | — |
| 0x0800 | Warning: unknown message type |
| 0x1000 | Error: DHCP invalid length |
| 0x2000 | Error: DHCP magic number corrupt |
| 0x4000 | Error: DHCP options corrupt |
| 0x8000 | Something weird happened... |

### 13.3.2 dhcpMType and dhcpMTypeBF

For IPv4, the `dhcpMType` and `dhcpMTypeBF` columns are to be interpreted as follows:

| dhcpMType | dhcpMTypeBF | Description |
|---|---|---|
| 0 | 0x0000 0001 | — |
| 1 | 0x0000 0002 | DHCP Discover Message |
| 2 | 0x0000 0004 | DHCP Offer Message |
| 3 | 0x0000 0008 | DHCP Request Message |
| 4 | 0x0000 0010 | DHCP Decline Message |
| 5 | 0x0000 0020 | DHCP Acknowledgment Message |
| 6 | 0x0000 0040 | DHCP Negative Acknowledgment Message |
| 7 | 0x0000 0080 | DHCP Release Message |
| 8 | 0x0000 0100 | DHCP Informational Message |
| 9 | 0x0000 0200 | DHCP Force Renew Message |
| 10 | 0x0000 0400 | DHCP Lease Query Message |
| 11 | 0x0000 0800 | DHCP Lease Unassigned Message |
| 12 | 0x0000 1000 | DHCP Lease Unknown Message |
| 13 | 0x0000 2000 | DHCP Lease Active Message |
| 14 | 0x0000 4000 | DHCP Bulk Lease Query Message |
| 15 | 0x0000 8000 | DHCP Lease Query Done Message |
| 16 | 0x0001 0000 | DHCP Active Lease Query Message |
| 17 | 0x0002 0000 | DHCP Lease Query Status Message |
| 18 | 0x0004 0000 | DHCP TLS Message |
| 19 | 0x0008 0000 | — |
| – | 0x8000 0000 | All values bigger than 30 are reported here |

For IPv6, the `dhcpMType` and `dhcpMTypeBF` columns are to be interpreted as follows:

| dhcpMType | dhcpMTypeBF | Description |
|---|---|---|
| 0 | 0x0000 0001 | DHCPv6 Reserved |
| 1 | 0x0000 0002 | DHCPv6 SOLICIT |
| 2 | 0x0000 0004 | DHCPv6 ADVERTISE |
| 3 | 0x0000 0008 | DHCPv6 REQUEST |
| 4 | 0x0000 0010 | DHCPv6 CONFIRM |
| 5 | 0x0000 0020 | DHCPv6 RENEW |
| 6 | 0x0000 0040 | DHCPv6 REBIND |
| 7 | 0x0000 0080 | DHCPv6 REPLY |
| 8 | 0x0000 0100 | DHCPv6 RELEASE |

| dhcpMType | dhcpMTypeBF | Description |
|---|---|---|
| 9 | 0x0000 0200 | DHCPv6 DECLINE |
| 10 | 0x0000 0400 | DHCPv6 RECONFIGURE |
| 11 | 0x0000 0800 | DHCPv6 INFORMATION-REQUEST |
| 12 | 0x0000 1000 | DHCPv6 RELAY-FORW |
| 13 | 0x0000 2000 | DHCPv6 RELAY-REPL |
| 14 | 0x0000 4000 | DHCPv6 LEASEQUERY |
| 15 | 0x0000 8000 | DHCPv6 LEASEQUERY-REPLY |
| 16 | 0x0000 1000 | DHCPv6 RELAY-FORW |
| 17 | 0x0000 2000 | DHCPv6 RELAY-REPL |
| 18 | 0x0000 4000 | DHCPv6 LEASEQUERY |
| 19 | 0x0000 8000 | DHCPv6 LEASEQUERY-REPLY |
| 20 | 0x0001 0000 | DHCPv6 LEASEQUERY-DONE |
| 21 | 0x0002 0000 | DHCPv6 LEASEQUERY-DATA |
| 22 | 0x0004 0000 | DHCPv6 RECONFIGURE-REQUEST |
| 23 | 0x0008 0000 | DHCPv6 RECONFIGURE-REPLY |
| 24 | 0x0010 0000 | DHCPv6 DHCPV4-QUERY |
| 25 | 0x0020 0000 | DHCPv6 DHCPV4-RESPONSE |
| 26 | 0x0040 0000 | DHCPv6 ACTIVELEASEQUERY |
| 27 | 0x0080 0000 | DHCPv6 STARTTLS |

### 13.3.3 dhcpHWType

The dhcpHWType column is to be interpreted as follows:

| | dhcpHWType | Description |
|---|---|---|
| $2^0$ | (=0x0000 0000 0000 0001) | — |
| $2^1$ | (=0x0000 0000 0000 0002) | Ethernet |
| $2^2$ | (=0x0000 0000 0000 0004) | Experimental Ethernet |
| $2^3$ | (=0x0000 0000 0000 0008) | Amateur Radio AX.25 |
| $2^4$ | (=0x0000 0000 0000 0010) | Proteon ProNET Token Ring |
| $2^5$ | (=0x0000 0000 0000 0020) | Chaos |
| $2^6$ | (=0x0000 0000 0000 0040) | IEEE 802 |
| $2^7$ | (=0x0000 0000 0000 0080) | ARCNET |
| $2^8$ | (=0x0000 0000 0000 0100) | Hyperchannel |
| $2^9$ | (=0x0000 0000 0000 0200) | Lanstar |
| $2^{10}$ | (=0x0000 0000 0000 0400) | Autonet Short Address |
| $2^{11}$ | (=0x0000 0000 0000 0800) | LocalTalk |
| $2^{12}$ | (=0x0000 0000 0000 1000) | LocalNet (IBM PCNet or SYTEK LocalNET) |

| dhcpHWType | | Description |
|---|---|---|
| $2^{13}$ | (=0x0000 0000 0000 2000) | Ultra link |
| $2^{14}$ | (=0x0000 0000 0000 4000) | SMDS |
| $2^{15}$ | (=0x0000 0000 0000 8000) | Frame Relay |
| $2^{16}$ | (=0x0000 0000 0001 0000) | ATM, Asynchronous Transmission Mode |
| $2^{17}$ | (=0x0000 0000 0002 0000) | HDLC |
| $2^{18}$ | (=0x0000 0000 0004 0000) | Fibre Channel |
| $2^{19}$ | (=0x0000 0000 0008 0000) | ATM, Asynchronous Transmission Mode |
| $2^{20}$ | (=0x0000 0000 0010 0000) | Serial Line |
| $2^{21}$ | (=0x0000 0000 0020 0000) | ATM, Asynchronous Transmission Mode |
| $2^{22}$ | (=0x0000 0000 0040 0000) | MIL-STD-188-220 |
| $2^{23}$ | (=0x0000 0000 0080 0000) | Metricom |
| $2^{24}$ | (=0x0000 0000 0100 0000) | IEEE 1394.1995 |
| $2^{25}$ | (=0x0000 0000 0200 0000) | MAPOS |
| $2^{26}$ | (=0x0000 0000 0400 0000) | Twinaxia |
| $2^{27}$ | (=0x0000 0000 0800 0000) | EUI-64 |
| $2^{28}$ | (=0x0000 0000 1000 0000) | HIPARP |
| $2^{29}$ | (=0x0000 0000 2000 0000) | IP and ARP over ISO 7816-3 |
| $2^{30}$ | (=0x0000 0000 4000 0000) | ARPSec |
| $2^{31}$ | (=0x0000 0000 8000 0000) | IPsec tunnel |
| $2^{32}$ | (=0x0000 0001 0000 0000) | Infiniband |
| $2^{33}$ | (=0x0000 0002 0000 0000) | CAI, TIA-102 Project 25 Common Air Interface |
| $2^{34}$ | (=0x0000 0004 0000 0000) | Wiegand Interface |
| $2^{35}$ | (=0x0000 0008 0000 0000) | Pure IP |
| $2^{63}$ | (=0x8000 0000 0000 0000) | All values bigger than 62 are reported here |

### 13.3.4 dhcpHopCnt

The `dhcpHopCnt` column is to be interpreted as follows:

| dhcpHopCnt | Description |
|---|---|
| 0x00000000-0x00010000 | Number of hops (0–16) $\left(2^{\text{HopCount}}\right)$ |
| 0x80000000 | Invalid hop count (> 16) |

### 13.3.5 dhcpOptBF1_BF2_BF3

The `dhcpOptBF1_BF2_BF3` column is to be interpreted as follows:

| | dhcpOptBF1 | Description |
|---|---|---|
| $2^0$ | (=0x0000.0000.0000.0001) | Pad |
| $2^1$ | (=0x0000.0000.0000.0002) | Subnet Mask |
| $2^2$ | (=0x0000.0000.0000.0004) | Time Offset (deprecated) |
| $2^3$ | (=0x0000.0000.0000.0008) | Router |
| $2^4$ | (=0x0000.0000.0000.0010) | Time Server |
| $2^5$ | (=0x0000.0000.0000.0020) | Name Server |
| $2^6$ | (=0x0000.0000.0000.0040) | Domain Name Server |
| $2^7$ | (=0x0000.0000.0000.0080) | Log Server |
| $2^8$ | (=0x0000.0000.0000.0100) | Quote Server |
| $2^9$ | (=0x0000.0000.0000.0200) | LPR Server |
| $2^{10}$ | (=0x0000.0000.0000.0400) | Impress Server |
| $2^{11}$ | (=0x0000.0000.0000.0800) | Resource Location Server |
| $2^{12}$ | (=0x0000.0000.0000.1000) | Host Name |
| $2^{13}$ | (=0x0000.0000.0000.2000) | Boot File Size |
| $2^{14}$ | (=0x0000.0000.0000.4000) | Merit Dump File |
| $2^{15}$ | (=0x0000.0000.0000.8000) | Domain Name |
| $2^{16}$ | (=0x0000.0000.0001.0000) | Swap Server |
| $2^{17}$ | (=0x0000.0000.0002.0000) | Root Path |
| $2^{18}$ | (=0x0000.0000.0004.0000) | Extensions Path |
| $2^{19}$ | (=0x0000.0000.0008.0000) | IP Forwarding enable/disable |
| $2^{20}$ | (=0x0000.0000.0010.0000) | Non-local Source Routing enable/disable |
| $2^{21}$ | (=0x0000.0000.0020.0000) | Policy Filter |
| $2^{22}$ | (=0x0000.0000.0040.0000) | Maximum Datagram Reassembly Size |
| $2^{23}$ | (=0x0000.0000.0080.0000) | Default IP Time-to-live |
| $2^{24}$ | (=0x0000.0000.0100.0000) | Path MTU Aging Timeout |
| $2^{25}$ | (=0x0000.0000.0200.0000) | Path MTU Plateau Table |
| $2^{26}$ | (=0x0000.0000.0400.0000) | Interface MTU |
| $2^{27}$ | (=0x0000.0000.0800.0000) | All Subnets are Local |
| $2^{28}$ | (=0x0000.0000.1000.0000) | Broadcast Address |
| $2^{29}$ | (=0x0000.0000.2000.0000) | Perform Mask Discovery |
| $2^{30}$ | (=0x0000.0000.4000.0000) | Mask supplier |
| $2^{31}$ | (=0x0000.0000.8000.0000) | Perform router discovery |
| $2^{32}$ | (=0x0000.0001.0000.0000) | Router solicitation address |
| $2^{33}$ | (=0x0000.0002.0000.0000) | Static routing table |
| $2^{34}$ | (=0x0000.0004.0000.0000) | Trailer encapsulation |
| $2^{35}$ | (=0x0000.0008.0000.0000) | ARP cache timeout |
| $2^{36}$ | (=0x0000.0010.0000.0000) | Ethernet encapsulation |
| $2^{37}$ | (=0x0000.0020.0000.0000) | Default TCP TTL |
| $2^{38}$ | (=0x0000.0040.0000.0000) | TCP keepalive interval |
| $2^{39}$ | (=0x0000.0080.0000.0000) | TCP keepalive garbage |

| | dhcpOptBF1 | Description |
|---|---|---|
| $2^{40}$ | (=0x0000.0100.0000.0000) | Network Information Service Domain |
| $2^{41}$ | (=0x0000.0200.0000.0000) | Network Information Servers |
| $2^{42}$ | (=0x0000.0400.0000.0000) | NTP servers |
| $2^{43}$ | (=0x0000.0800.0000.0000) | Vendor specific information |
| $2^{44}$ | (=0x0000.1000.0000.0000) | NetBIOS over TCP/IP name server |
| $2^{45}$ | (=0x0000.2000.0000.0000) | NetBIOS over TCP/IP Datagram Distribution Server |
| $2^{46}$ | (=0x0000.4000.0000.0000) | NetBIOS over TCP/IP Node Type |
| $2^{47}$ | (=0x0000.8000.0000.0000) | NetBIOS over TCP/IP Scope |
| $2^{48}$ | (=0x0001.0000.0000.0000) | X Window System Font Server |
| $2^{49}$ | (=0x0002.0000.0000.0000) | X Window System Display Manager |
| $2^{50}$ | (=0x0004.0000.0000.0000) | Requested IP Address |
| $2^{51}$ | (=0x0008.0000.0000.0000) | IP address lease time |
| $2^{52}$ | (=0x0010.0000.0000.0000) | Option overload |
| $2^{53}$ | (=0x0020.0000.0000.0000) | DHCP message type |
| $2^{54}$ | (=0x0040.0000.0000.0000) | Server identifier |
| $2^{55}$ | (=0x0080.0000.0000.0000) | Parameter request list |
| $2^{56}$ | (=0x0100.0000.0000.0000) | Message |
| $2^{57}$ | (=0x0200.0000.0000.0000) | Maximum DHCP message size |
| $2^{58}$ | (=0x0400.0000.0000.0000) | Renew time value |
| $2^{59}$ | (=0x0800.0000.0000.0000) | Rebinding time value |
| $2^{60}$ | (=0x1000.0000.0000.0000) | Class-identifier |
| $2^{61}$ | (=0x2000.0000.0000.0000) | Client-identifier |
| $2^{62}$ | (=0x4000.0000.0000.0000) | NetWare/IP Domain Name |
| $2^{63}$ | (=0x8000.0000.0000.0000) | NetWare/IP information |

| | dhcpOptBF2 | Description |
|---|---|---|
| $2^{64}$ | (=0x0000.0000.0000.0001) | Network Information Service+ Domain |
| $2^{65}$ | (=0x0000.0000.0000.0002) | Network Information Service+ Servers |
| $2^{66}$ | (=0x0000.0000.0000.0004) | TFTP server name |
| $2^{67}$ | (=0x0000.0000.0000.0008) | Bootfile name |
| $2^{68}$ | (=0x0000.0000.0000.0010) | Mobile IP Home Agent |
| $2^{69}$ | (=0x0000.0000.0000.0020) | Simple Mail Transport Protocol Server |
| $2^{70}$ | (=0x0000.0000.0000.0040) | Post Office Protocol Server |
| $2^{71}$ | (=0x0000.0000.0000.0080) | Network News Transport Protocol Server |
| $2^{72}$ | (=0x0000.0000.0000.0100) | Default World Wide Web Server |
| $2^{73}$ | (=0x0000.0000.0000.0200) | Default Finger Server |
| $2^{74}$ | (=0x0000.0000.0000.0400) | Default Internet Relay Chat Server |
| $2^{75}$ | (=0x0000.0000.0000.0800) | StreetTalk Server |

| | dhcpOptBF2 | Description |
|---|---|---|
| $2^{76}$ | (=0x0000.0000.0000.1000) | StreetTalk Directory Assistance Server |
| $2^{77}$ | (=0x0000.0000.0000.2000) | User Class Information |
| $2^{78}$ | (=0x0000.0000.0000.4000) | SLP Directory Agent |
| $2^{79}$ | (=0x0000.0000.0000.8000) | SLP Service Scope |
| $2^{80}$ | (=0x0000.0000.0001.0000) | Rapid Commit |
| $2^{81}$ | (=0x0000.0000.0002.0000) | FQDN, Fully Qualified Domain Name |
| $2^{82}$ | (=0x0000.0000.0004.0000) | Relay Agent Information |
| $2^{83}$ | (=0x0000.0000.0008.0000) | Internet Storage Name Service |
| $2^{84}$ | (=0x0000.0000.0010.0000) | — |
| $2^{85}$ | (=0x0000.0000.0020.0000) | — |
| $2^{86}$ | (=0x0000.0000.0040.0000) | — |
| $2^{87}$ | (=0x0000.0000.0080.0000) | — |
| $2^{88}$ | (=0x0000.0000.0100.0000) | — |
| $2^{89}$ | (=0x0000.0000.0200.0000) | — |
| $2^{90}$ | (=0x0000.0000.0400.0000) | — |
| $2^{91}$ | (=0x0000.0000.0800.0000) | — |
| $2^{92}$ | (=0x0000.0000.1000.0000) | — |
| $2^{93}$ | (=0x0000.0000.2000.0000) | — |
| $2^{94}$ | (=0x0000.0000.4000.0000) | — |
| $2^{95}$ | (=0x0000.0000.8000.0000) | — |
| $2^{96}$ | (=0x0000.0001.0000.0000) | — |
| $2^{97}$ | (=0x0000.0002.0000.0000) | — |
| $2^{98}$ | (=0x0000.0004.0000.0000) | — |
| $2^{99}$ | (=0x0000.0008.0000.0000) | — |
| $2^{100}$ | (=0x0000.0010.0000.0000) | — |
| $2^{101}$ | (=0x0000.0020.0000.0000) | — |
| $2^{102}$ | (=0x0000.0040.0000.0000) | — |
| $2^{103}$ | (=0x0000.0080.0000.0000) | — |
| $2^{104}$ | (=0x0000.0100.0000.0000) | — |
| $2^{105}$ | (=0x0000.0200.0000.0000) | — |
| $2^{106}$ | (=0x0000.0400.0000.0000) | — |
| $2^{107}$ | (=0x0000.0800.0000.0000) | — |
| $2^{108}$ | (=0x0000.1000.0000.0000) | — |
| $2^{109}$ | (=0x0000.2000.0000.0000) | — |
| $2^{110}$ | (=0x0000.4000.0000.0000) | — |
| $2^{111}$ | (=0x0000.8000.0000.0000) | — |
| $2^{112}$ | (=0x0001.0000.0000.0000) | — |
| $2^{113}$ | (=0x0002.0000.0000.0000) | — |
| $2^{114}$ | (=0x0004.0000.0000.0000) | — |
| $2^{115}$ | (=0x0008.0000.0000.0000) | — |

| dhcpOptBF2 | | Description |
|---|---|---|
| $2^{116}$ | (=0x0010.0000.0000.0000) | — |
| $2^{117}$ | (=0x0020.0000.0000.0000) | — |
| $2^{118}$ | (=0x0040.0000.0000.0000) | — |
| $2^{119}$ | (=0x0080.0000.0000.0000) | — |
| $2^{120}$ | (=0x0100.0000.0000.0000) | — |
| $2^{121}$ | (=0x0200.0000.0000.0000) | — |
| $2^{122}$ | (=0x0400.0000.0000.0000) | — |
| $2^{123}$ | (=0x0800.0000.0000.0000) | — |
| $2^{124}$ | (=0x1000.0000.0000.0000) | — |
| $2^{125}$ | (=0x2000.0000.0000.0000) | — |
| $2^{126}$ | (=0x4000.0000.0000.0000) | — |
| $2^{127}$ | (=0x8000.0000.0000.0000) | — |

| dhcpOptBF3 | | Description |
|---|---|---|
| $2^{128}$ | (=0x0000.0000.0000.0001) | TFTP Server IP address |
| $2^{129}$ | (=0x0000.0000.0000.0002) | Call Server IP address |
| $2^{130}$ | (=0x0000.0000.0000.0004) | Discrimination string |
| $2^{131}$ | (=0x0000.0000.0000.0008) | Remote statistics server IP address |
| $2^{132}$ | (=0x0000.0000.0000.0010) | 802.1P VLAN ID |
| $2^{133}$ | (=0x0000.0000.0000.0020) | 802.1Q L2 Priority |
| $2^{134}$ | (=0x0000.0000.0000.0040) | Diffserv Code Point |
| $2^{135}$ | (=0x0000.0000.0000.0080) | HTTP Proxy for phone-specific applications |
| $2^{136}$ | (=0x0000.0000.0000.0100) | PANA Authentication Agent |
| $2^{137}$ | (=0x0000.0000.0000.0200) | LoST Server |
| $2^{138}$ | (=0x0000.0000.0000.0400) | CAPWAP Access Controller addresses |
| $2^{139}$ | (=0x0000.0000.0000.0800) | OPTION-IPv4_Address-MoS |
| $2^{140}$ | (=0x0000.0000.0000.1000) | OPTION-IPv4_FQDN-MoS |
| $2^{141}$ | (=0x0000.0000.0000.2000) | SIP UA Configuration Service Domains |
| $2^{142}$ | (=0x0000.0000.0000.4000) | OPTION-IPv4_Address-ANDSF |
| $2^{143}$ | (=0x0000.0000.0000.8000) | OPTION-IPv6_Address-ANDSF |
| $2^{144}$ | (=0x0000.0000.0001.0000) | — |
| $2^{145}$ | (=0x0000.0000.0002.0000) | — |
| $2^{146}$ | (=0x0000.0000.0004.0000) | — |
| $2^{147}$ | (=0x0000.0000.0008.0000) | — |
| $2^{148}$ | (=0x0000.0000.0010.0000) | — |
| $2^{149}$ | (=0x0000.0000.0020.0000) | — |
| $2^{150}$ | (=0x0000.0000.0040.0000) | TFTP server address or Etherboot-GRUB configuration path name |
| $2^{151}$ | (=0x0000.0000.0080.0000) | status-code |

| | dhcpOptBF3 | Description |
|---|---|---|
| $2^{152}$ | (=0x0000.0000.0100.0000) | base-time |
| $2^{153}$ | (=0x0000.0000.0200.0000) | start-time-of-state |
| $2^{154}$ | (=0x0000.0000.0400.0000) | query-start-time |
| $2^{155}$ | (=0x0000.0000.0800.0000) | query-end-time |
| $2^{156}$ | (=0x0000.0000.1000.0000) | dhcp-state |
| $2^{157}$ | (=0x0000.0000.2000.0000) | data-source |
| $2^{158}$ | (=0x0000.0000.4000.0000) | — |
| $2^{159}$ | (=0x0000.0000.8000.0000) | — |
| $2^{160}$ | (=0x0000.0001.0000.0000) | — |
| $2^{161}$ | (=0x0000.0002.0000.0000) | — |
| $2^{162}$ | (=0x0000.0004.0000.0000) | — |
| $2^{163}$ | (=0x0000.0008.0000.0000) | — |
| $2^{164}$ | (=0x0000.0010.0000.0000) | — |
| $2^{165}$ | (=0x0000.0020.0000.0000) | — |
| $2^{166}$ | (=0x0000.0040.0000.0000) | — |
| $2^{167}$ | (=0x0000.0080.0000.0000) | — |
| $2^{168}$ | (=0x0000.0100.0000.0000) | — |
| $2^{169}$ | (=0x0000.0200.0000.0000) | — |
| $2^{170}$ | (=0x0000.0400.0000.0000) | — |
| $2^{171}$ | (=0x0000.0800.0000.0000) | — |
| $2^{172}$ | (=0x0000.1000.0000.0000) | — |
| $2^{173}$ | (=0x0000.2000.0000.0000) | — |
| $2^{174}$ | (=0x0000.4000.0000.0000) | — |
| $2^{175}$ | (=0x0000.8000.0000.0000) | Etherboot |
| $2^{176}$ | (=0x0001.0000.0000.0000) | IP Telephone |
| $2^{177}$ | (=0x0002.0000.0000.0000) | Etherboot, PacketCable and CableHome |
| $2^{178}$ | (=0x0004.0000.0000.0000) | — |
| $2^{179}$ | (=0x0008.0000.0000.0000) | — |
| $2^{180}$ | (=0x0010.0000.0000.0000) | — |
| $2^{181}$ | (=0x0020.0000.0000.0000) | — |
| $2^{182}$ | (=0x0040.0000.0000.0000) | — |
| $2^{183}$ | (=0x0080.0000.0000.0000) | — |
| $2^{184}$ | (=0x0100.0000.0000.0000) | — |
| $2^{185}$ | (=0x0200.0000.0000.0000) | — |
| $2^{186}$ | (=0x0400.0000.0000.0000) | — |
| $2^{187}$ | (=0x0800.0000.0000.0000) | — |
| $2^{188}$ | (=0x1000.0000.0000.0000) | — |
| $2^{189}$ | (=0x2000.0000.0000.0000) | — |
| $2^{190}$ | (=0x4000.0000.0000.0000) | — |
| $2^{191}$ | (=0x8000.0000.0000.0000) | — |

## 13.4 Packet File Output

In packet mode (`-s` option), the dhcpDecode plugin outputs the following columns:

| Column | Type | Description |
|---|---|---|
| dhcpMType | U8 | Message type |
| dhcpHops | U8 | Number of hops |
| dhcpTransID | U16 | Transaction Identifier |
| dhcpLFlow | U16 | Linked flow |

## 13.5 Plugin Report Output

The number of DHCP packets of each type (Section 13.3.2) is reported.

## 13.6 TODO

- DHCPv6

## 13.7 References

- RFC2131: Dynamic Host Configuration Protocol
- RFC2132: DHCP Options and BOOTP Vendor Extensions

# 14 dnsDecode

## 14.1 Description

The dnsDecode plugin analyzes DNS traffic.

## 14.2 Configuration Flags

The following flags can be used to control the output of the plugin:

| Name | Default | Description |
|---|---|---|
| DNS_MODE | 4 | 0: Only aggregated header count info<br>1: +REQ records<br>2: +ANS records<br>3: +AUX records<br>4: +ADD records |
| DNS_HEXON | 1 | 0: Hex output flags off<br>1: Hex output flags on |
| DNS_HDRMD | 0 | Header, OpCode, RetCode:<br>0: Bitfield<br>1: Numeric<br>2: String |
| DNS_AGGR | 0 | 0: Full vectors<br>1: Aggregate records |
| DNS_TYPE | 0 | Q/A type format:<br>0: Numeric<br>1: String |
| DNS_QRECMAX | 15 | Max # of query records / flow |
| DNS_ARECMAX | 20 | Max # of answer records / flow |
| DNS_WHO | 0 | 1: Output country and organization of DNS reply addresses |
| DNS_MAL_TEST | 0 | 0: No tests for malware<br>1: Mal test @ flow terminated<br>2: Mal test @ L4Callback, pcad ops |
| DNS_MAL_TYPE | 0 | Malware type format:<br>0: code<br>1: string |
| The following additional flag is available in malsite.h: | | |
| DNS_MAL_DOMAIN | 1 | 0: Malsite IP address labeling mode<br>1: Malsite domain labeling mode, not implemented yet |

DNS_MAL_TEST controls where the mal test is performed. Only in L4Callback enables a cooperation with pcaps, so that pcapd dumps all packets of a flow after the alarm was detected.

## 14.3 Flow File Output

The dnsDecode plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| dnsStat | H16 | Status, warnings and errors | |
| dnsHdrOPField | H16 | Header field of last packet in flow | |
| dnsHFlg_<br>OpC_<br>RetC | H8_<br>H16_<br>H16 | Aggregated header flags,<br>operational code and<br>return code | DNS_HDRMD=0 |
| dnsHFlg | H8 | Aggregated header flags | DNS_HDRMD>0 |
| dnsOpC | H16 | Operational code | DNS_HDRMD=1 |
| dnsOpN | S | Operational string | DNS_HDRMD=2 |
| dnsRetC | H16 | Return code | DNS_HDRMD=1 |
| dnsRetN | S | Return string | DNS_HDRMD=2 |
| dnsCntQu_<br>Asw_<br>Aux_<br>Add | R(U16_<br>U16_<br>U16_<br>U16) | # of question records,<br>answer records,<br>auxiliary records and<br>additional records | |
| dnsAAAqF | F | DDOS DNS AAA / query factor | |

If DNS_MODE>0, the following columns are displayed:

| | | | |
|---|---|---|---|
| dnsTypeBF3_BF2_BF1_BF0 | H8_H16_H16_H64 | Type bitfields | DNS_HEXON=1 |
| dnsQname | R(S) | Query name records | |
| dnsMalCnt | U32 | Domain malware count | DNS_MAL_TEST>0 &&<br>DNS_MAL_DOMAIN=1 |
| dnsMalType | R(S) | Domain malware type string | DNS_MAL_TEST>0 &&<br>DNS_MAL_DOMAIN=1&&<br>DNS_MAL_TYPE=1&& |
| dnsMalCode | R(U32) | Domain malware code | DNS_MAL_TEST>0 &&<br>DNS_MAL_DOMAIN=1&&<br>DNS_MAL_TYPE=0 |
| dnsAname | R(S) | Answer name records | |
| dnsAPname | R(S) | Name CNAME entries | |
| dns4Aaddress | R(IP4) | Address entries IPv4 | |
| dns4CC_Org | R(SC_S) | IPv4 country and organization | DNS_WHO=1 |
| dns6Aaddress | R(IP6) | Address entries IPv6 | |
| dns6CC_Org | R(SC_S) | IPv6 country and organization | DNS_WHO=1 |
| dnsIPMalCode | R(H32) | IP malware code | DNS_MAL_TEST>0&&<br>DNS_MAL_DOMAIN=0 |
| dnsQType | R(U16) | Query record type entries | DNS_TYPE=0 |
| dnsQTypeN | R(S) | Query record type names | DNS_TYPE=1 |
| dnsQClass | R(U16) | Query record class entries | |
| dnsAType | R(U16) | Answer record type entries | DNS_TYPE=0 |
| dnsATypeN | R(S) | Answer record type names | DNS_TYPE=1 |
| dnsAClass | R(U16) | Answer record class entries | |
| dnsATTL | R(U32) | Answer record TTL entries | |
| dnsMXpref | R(U16) | MX record preference entries | |

| Column | Type | Description | Flags |
|---|---|---|---|
| dnsSRVprio | R(U16) | SRV record priority entries | |
| dnsSRVwgt | R(U16) | SRV record weight entries | |
| dnsSRVprt | R(U16) | SRV record port entries | |
| dnsOptStat | R(H32) | Option status | |

### 14.3.1 dnsStat

The dnsStat column is to be interpreted as follows:

| dnsStat | Description |
|---|---|
| $2^0$ (=0x0001) | DNS ports detected |
| $2^1$ (=0x0002) | NetBIOS DNS |
| $2^2$ (=0x0004) | DNS TCP aggregated fragmented content |
| $2^3$ (=0x0008) | DNS TCP fragmented content state |
| $2^4$ (=0x0010) | — |
| $2^5$ (=0x0020) | Warning: ANY: Zone all from a domain or cached server |
| $2^6$ (=0x0040) | Warning: Incremental DNS zone transfer detected |
| $2^7$ (=0x0080) | Warning: DNS zone transfer detected |
| $2^8$ (=0x0100) | Warning: DNS UDP length exceeded |
| $2^9$ (=0x0200) | Warning: following records ignored |
| $2^{10}$ (=0x0400) | Warning: Max DNS query records exceeded... increase DNS_QRECMAX |
| $2^{11}$ (=0x0800) | Warning: Max DNS answer records exceeded... increase DNS_ARECMAX |
| $2^{12}$ (=0x1000) | Error: DNS record length error |
| $2^{13}$ (=0x2000) | Error: Wrong DNS PTR detected |
| $2^{14}$ (=0x4000) | Warning: DNS length undercut |
| $2^{15}$ (=0x8000) | Error: UDP/TCP DNS header corrupt or TCP packets missing |

### 14.3.2 dnsHdrOPField

From the 16 bit DNS header the QR bit and bit five to nine are extracted and mapped in their correct sequence into a byte as indicated below. It provides for a normal single packet exchange flow an accurate status of the DNS transfer. For a multiple packet exchange only the last packet is mapped into the variable. In that case the aggregated header state flags should be considered.

| QR | Opcode | AA | TC | RD | RA | Z | AD | CD | Rcode |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 0000 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0000 |

### 14.3.3 dnsHFlg_OpC_RetC

For multi-packet DNS flows e.g. via TCP the aggregated header state bit field describes the status of all packets in a flow. Thus, flows with certain client and server states can be easily identified and extracted during post-processing.

| | dnsHFlg | Short | Description |
|---|---|---|---|
| $2^7$ | (=0x01) | CD | Checking disabled |
| $2^6$ | (=0x02) | AD | Authenticated data |
| $2^5$ | (=0x04) | Z | Zone transfer |
| $2^4$ | (=0x08) | RA | Recursive query support available |
| $2^3$ | (=0x10) | RD | Recursion desired |
| $2^2$ | (=0x20) | TC | Message truncated |
| $2^1$ | (=0x40) | AA | Authoritative answer |
| $2^0$ | (=0x80) | QR | 0: Query / 1: Response |

The four bit opcode field of the DNS header is mapped via [$2^{\text{opcode}}$] and an OR into a 16 bit field. Thus, the client can be monitored or anomalies easily identified. E.g. appearance of reserved bits might be an indication for a covert channel or malware operation.

| | dnsOpC | Description |
|---|---|---|
| $2^0$ | (=0x0001) | Standard query |
| $2^1$ | (=0x0002) | Inverse query |
| $2^2$ | (=0x0004) | Server status request |
| $2^3$ | (=0x0008) | — |
| $2^4$ | (=0x0010) | Notify |
| $2^5$ | (=0x0020) | Update / Register (NetBIOS) |
| $2^6$ | (=0x0040) | Release (NetBIOS) |
| $2^7$ | (=0x0080) | Wait For Acknowledge (NetBIOS) |
| $2^8$ | (=0x0100) | Refresh (NetBIOS) |
| $2^9$ | (=0x0200) | reserved |
| $2^{10}$ | (=0x0400) | reserved |
| $2^{11}$ | (=0x0800) | reserved |
| $2^{12}$ | (=0x1000) | reserved |
| $2^{13}$ | (=0x2000) | reserved |
| $2^{14}$ | (=0x4000) | reserved |
| $2^{15}$ | (=0x8000) | reserved |

The four bit rcode field of the DNS header is mapped via [$2^{\text{rcode}}$] and an OR into a 16 bit field. It provides valuable information about success of DNS queries and therefore facilitates the detection of failures, misconfigurations and malicious operations.

| | dnsRetC | Short | Description |
|---|---|---|---|
| $2^0$ | (=0x0001) | No error | Request completed successfully |
| $2^1$ | (=0x0002) | Format error | Name server unable to interpret query |
| $2^2$ | (=0x0004) | Server failure | Name server unable to process query due to problem with name server |

| dnsRetC | Short | Description |
|---|---|---|
| $2^3$ (=0x0008) | Name error | Authoritative name server only: Domain name in query does not exist |
| $2^4$ (=0x0010) | Not implemented | Name server does not support requested kind of query |
| $2^4$ (=0x0020) | Refused | Name server refuses to perform the specified operation for policy reasons |
| $2^5$ (=0x0040) | YXDomain | Name exists when it should not |
| $2^6$ (=0x0080) | YXRRSet | Resource record set exists when it should not |
| $2^8$ (=0x0100) | NXRRSet | Resource record set that should exist does not |
| $2^9$ (=0x0200) | NotAuth | Server not authoritative for zone |
| $2^{10}$ (=0x0400) | NotZone | Name not contained in zone |
| $2^{11}$ (=0x0800) | — | — |
| $2^{12}$ (=0x1000) | — | — |
| $2^{13}$ (=0x2000) | — | — |
| $2^{14}$ (=0x4000) | — | — |
| $2^{15}$ (=0x8000) | — | — |

### 14.3.4 dnsTypeBF3_BF2_BF1_BF0

The 16 bit Type Code field is extracted from each DNS record and mapped via [$2^{\text{Typecode}}$] into a 64 bit fields. Gaps are avoided by additional higher bitfields defining higher codes.

| dnsTypeBF3 | Short | Description |
|---|---|---|
| $2^0$ (=0x01) | TA | DNSSEC Trust Authorities |
| $2^1$ (=0x02) | DLV | DNSSEC Lookaside Validation |
| $2^2$ (=0x04) | — | — |
| $2^3$ (=0x08) | — | — |
| $2^4$ (=0x10) | — | — |
| $2^5$ (=0x20) | — | — |
| $2^6$ (=0x40) | — | — |
| $2^7$ (=0x80) | — | — |

| dnsTypeBF2 | Short | Description |
|---|---|---|
| $2^0$ (=0x0001) | TKEY | Transaction Key |
| $2^1$ (=0x0002) | TSIG | Transaction Signature |
| $2^2$ (=0x0004) | IXFR | Incremental transfer |
| $2^3$ (=0x0008) | AXFR | Transfer of an entire zone |
| $2^4$ (=0x0010) | MAILB | Mailbox-related RRs (MB, MG or MR) |
| $2^5$ (=0x0020) | MAILA | Mail agent RRs (OBSOLETE - see MX) |
| $2^6$ (=0x0040) | ZONEALL | Request for all records the server/cache has available |
| $2^7$ (=0x0080) | URI | URI |

| dnsTypeBF2 | Short | Description |
|---|---|---|
| $2^8$ (=0x0100) | CAA | Certification Authority Restriction |
| $2^9$ (=0x0200) | — | — |
| $2^{10}$ (=0x0400) | — | — |
| $2^{11}$ (=0x0800) | — | — |
| $2^{12}$ (=0x1000) | — | — |
| $2^{13}$ (=0x2000) | — | — |
| $2^{14}$ (=0x4000) | — | — |
| $2^{15}$ (=0x8000) | — | — |

| dnsTypeBF1 | Short | Description |
|---|---|---|
| $2^0$ (=0x0001) | SPF | |
| $2^1$ (=0x0002) | UINFO | |
| $2^2$ (=0x0004) | UID | |
| $2^3$ (=0x0008) | GID | |
| $2^4$ (=0x0010) | UNSPEC | |
| $2^4$ (=0x0020) | NID | |
| $2^5$ (=0x0040) | L32 | |
| $2^6$ (=0x0080) | L64 | |
| $2^8$ (=0x0100) | LP | |
| $2^9$ (=0x0200) | EUI48 | EUI-48 address |
| $2^{10}$ (=0x0400) | EUI64 | EUI-48 address |
| $2^{11}$ (=0x0800) | — | — |
| $2^{12}$ (=0x1000) | — | — |
| $2^{13}$ (=0x2000) | — | — |
| $2^{14}$ (=0x4000) | — | — |
| $2^{15}$ (=0x8000) | — | — |

| dnsTypeBF0 | Short | Description |
|---|---|---|
| $2^0$ (=0x0000.0000.0000.0001) | — | — |
| $2^1$ (=0x0000.0000.0000.0002) | A | IPv4 address |
| $2^2$ (=0x0000.0000.0000.0004) | NS | Authoritative name server |
| $2^3$ (=0x0000.0000.0000.0008) | MD | Mail destination. Obsolete use MX instead |
| $2^4$ (=0x0000.0000.0000.0010) | MF | Mail forwarder. Obsolete use MX instead |
| $2^5$ (=0x0000.0000.0000.0020) | CNAME | Canonical name for an alias |
| $2^6$ (=0x0000.0000.0000.0040) | SOA | Marks the start of a zone of authority |
| $2^7$ (=0x0000.0000.0000.0080) | MB | Mailbox domain name |

| dnsTypeBF0 | Short | Description |
|---|---|---|
| $2^{8}$ (=0x0000.0000.0000.0100) | MG | Mail group member |
| $2^{9}$ (=0x0000.0000.0000.0200) | MR | Mail rename domain name |
| $2^{10}$ (=0x0000.0000.0000.0400) | NULL | Null resource record |
| $2^{11}$ (=0x0000.0000.0000.0800) | WKS | Well known service description |
| $2^{12}$ (=0x0000.0000.0000.1000) | PTR | Domain name pointer |
| $2^{13}$ (=0x0000.0000.0000.2000) | HINFO | Host information |
| $2^{14}$ (=0x0000.0000.0000.4000) | MINFO | Mailbox or mail list information |
| $2^{15}$ (=0x0000.0000.0000.8000) | MX | Mail exchange |
| $2^{16}$ (=0x0000.0000.0001.0000) | TXT | Text strings |
| $2^{17}$ (=0x0000.0000.0002.0000) | — | Responsible Person |
| $2^{18}$ (=0x0000.0000.0004.0000) | AFSDB | AFS Data Base location |
| $2^{19}$ (=0x0000.0000.0008.0000) | X25 | X.25 PSDN address |
| $2^{20}$ (=0x0000.0000.0010.0000) | ISDN | ISDN address |
| $2^{21}$ (=0x0000.0000.0020.0000) | RT | Route Through |
| $2^{22}$ (=0x0000.0000.0040.0000) | NSAP | NSAP address. NSAP style A record |
| $2^{23}$ (=0x0000.0000.0080.0000) | NSAP-PTR | — |
| $2^{24}$ (=0x0000.0000.0100.0000) | SIG | Security signature |
| $2^{25}$ (=0x0000.0000.0200.0000) | KEY | Security key |
| $2^{26}$ (=0x0000.0000.0400.0000) | PX | X.400 mail mapping information |
| $2^{27}$ (=0x0000.0000.0800.0000) | GPOS | Geographical Position |
| $2^{28}$ (=0x0000.0000.1000.0000) | AAAA | IPv6 Address |
| $2^{29}$ (=0x0000.0000.2000.0000) | LOC | Location Information |
| $2^{30}$ (=0x0000.0000.4000.0000) | NXT | Next Domain (obsolete) |
| $2^{31}$ (=0x0000.0000.8000.0000) | EID | Endpoint Identifier |
| $2^{32}$ (=0x0000.0001.0000.0000) | NIMLOC/NB | Nimrod Locator / NetBIOS general Name Service |
| $2^{33}$ (=0x0000.0002.0000.0000) | SRV/NBSTAT | Server Selection / NetBIOS NODE STATUS |
| $2^{34}$ (=0x0000.0004.0000.0000) | ATMA | ATM Address |
| $2^{35}$ (=0x0000.0008.0000.0000) | NAPTR | Naming Authority Pointer |
| $2^{36}$ (=0x0000.0010.0000.0000) | KX | Key Exchanger |
| $2^{37}$ (=0x0000.0020.0000.0000) | CERT | — |
| $2^{38}$ (=0x0000.0040.0000.0000) | A6 | A6 (OBSOLETE - use AAAA) |
| $2^{39}$ (=0x0000.0080.0000.0000) | DNAME | — |
| $2^{40}$ (=0x0000.0100.0000.0000) | SINK | — |
| $2^{41}$ (=0x0000.0200.0000.0000) | OPT | — |
| $2^{42}$ (=0x0000.0400.0000.0000) | APL | — |
| $2^{43}$ (=0x0000.0800.0000.0000) | DS | Delegation Signer |

| | dnsTypeBF0 | Short | Description |
|---|---|---|---|
| $2^{44}$ | (=0x0000.1000.0000.0000) | SSHFP | SSH Key Fingerprint |
| $2^{45}$ | (=0x0000.2000.0000.0000) | IPSECKEY | — |
| $2^{46}$ | (=0x0000.4000.0000.0000) | RRSIG | — |
| $2^{47}$ | (=0x0000.8000.0000.0000) | NSEC | NextSECure |
| $2^{48}$ | (=0x0001.0000.0000.0000) | DNSKEY | — |
| $2^{49}$ | (=0x0002.0000.0000.0000) | DHCID | DHCP identifier |
| $2^{50}$ | (=0x0004.0000.0000.0000) | NSEC3 | — |
| $2^{51}$ | (=0x0008.0000.0000.0000) | NSEC3PARAM | — |
| $2^{52}$ | (=0x0010.0000.0000.0000) | TLSA | — |
| $2^{53}$ | (=0x0020.0000.0000.0000) | SMIMEA | S/MIME cert association |
| $2^{54}$ | (=0x0040.0000.0000.0000) | — | |
| $2^{55}$ | (=0x0080.0000.0000.0000) | HIP | Host Identity Protocol |
| $2^{56}$ | (=0x0100.0000.0000.0000) | NINFO | — |
| $2^{57}$ | (=0x0200.0000.0000.0000) | RKEY | — |
| $2^{58}$ | (=0x0400.0000.0000.0000) | TALINK | Trust Anchor LINK |
| $2^{59}$ | (=0x0800.0000.0000.0000) | CDS | Child DS |
| $2^{60}$ | (=0x1000.0000.0000.0000) | CDNSKEY | DNSKEY(s) the Child wants reflected in DS |
| $2^{61}$ | (=0x2000.0000.0000.0000) | OPENPGPKEY | OpenPGP Key |
| $2^{62}$ | (=0x4000.0000.0000.0000) | CSYNC | Child-To-Parent Synchronization |
| $2^{63}$ | (=0x8000.0000.0000.0000) | — | |

## 14.4 Packet File Output

In packet mode (`-s` option), the dnsDecode plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| dnsIPs | R(IP) | IP addresses (A or AAAA records) | |
| dnsStat | H16 | Status, warnings and errors | |
| dnsHdr | H16 | Header field of packet | DNS_HDRMD=0 |
| dnsHFlg_OpC_RetC | H8_H16_H16 | Aggregated header flags, operational and return codes | DNS_HDRMD=1 |
| dnsHFlg_OpN_RetN | H8_S_S | Aggregated header flags, operational and return strings | DNS_HDRMD=2 |
| dnsCntQu_ | U16_ | # of question records, | |
| Asw_ | U16_ | answer records, | |
| Aux_ | U16_ | auxiliary records and | |
| Add | U16 | additional records | |

## 14.5 Monitoring Output

In monitoring mode, the dnsDecode plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| dnsPkts | U64 | Number of DNS packets | |
| dnsQPkts | U64 | Number of DNS Q packets | |
| dnsRPkts | U64 | Number of DNS R packets | |

## 14.6 Plugin Report Output

The following information is reported:

- Aggregated dnsStat
- Aggregated dnsHFlg, dnsOpC, dnsRetC
- Number of DNS packets
- Number of DNS Q packets
- Number of DNS R packets
- Number of alarms (DNS_MAL_TEST>0)

## 14.7 Example Output

The idea is that the string and integer array elements of question, answer, TTL and Type record entries match by column index so that easy script based mapping and post processing is possible. A sample output is shown below. Especially when large records are present the same name is printed several times which might degrade the readability. Therefore, a next version will have a multiple Aname suppressor switch, which should be off for script based post-processing.

| Query name | Answer name | Answer address | TTL | Type |
|---|---|---|---|---|
| www.macromedia.com; | www.macromedia.com;www-mm.wip4.adobe.com | 0.0.0.0;8.118.124.64 | 2787;4 | 5;1 |

## 14.8 TODO

- Compressed mode for DNS records

# 15 entropy

## 15.1 Description

The entropy plugin estimates the entropy of the snapped IP payload distribution. The number of bits of the alphabet can be 1,2,4,8. Default 8 bit, hence an alphabet of 256 symbols. The calculation of the entropy demands a certain minimum number of elements per flow. Two other key parameters, a binary and text based ratio, in combination with the entropy serve as input for AI for content and application classification. The character and binary ratio denote the degree of text or binary content respectively. All is experimental and described in detail in the Entropy et al tutorial on https://www.tranalyzer.com.

## 15.2 Configuration Flags

The following flags can be used to control the output of the plugin:

| Name | Default | Description |
|---|---|---|
| ENT_NORM | 1 | 0: # bits<br>1: Normalized entropy |
| ENT_NBITS | 8 | $N$ bit word, vocabulary: $2^N$ |
| ENT_HPKTIG | 0 | Ignore first $N$ packets |
| ENT_HEAD | 0 | Start word of entropy calc in payload |
| ENT_TAIL | 1500 | Position until entropy is calculated |
| ENT_THRESL | 8 | Threshold for minimal payload length |
| ENT_THRESH | 8192 | Threshold for maximal payload length |
| ENT_ALPHAD | 0 | Print alphabet distribution in flow file |

### 15.2.1 Environment Variable Configuration Flags

The following configuration flags can also be configured with environment variables (ENVCNTRL>0):

- ENT_HPKTIG
- ENT_HEAD
- ENT_TAIL
- ENT_THRESL
- ENT_THRESH

## 15.3 Flow File Output

The entropy plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| PyldEntropy | F | Payload entropy[10] | |
| PyldChRatio | F | Payload character ratio | |

[10] A value of -1 indicates that no entropy was calculated

| Column | Type | Description | Flags |
|---|---|---|---|
| PyldBinRatio | F | Payload binary ratio | |
| NumBin0 | U32 | Number of 0 count bins | ENT_ALPHAD=1 |
| Corr | F | entropy correction | ENT_ALPHAD=1 |
| PyldLen | U32 | Payload length | ENT_ALPHAD=1 |
| PyldHisto | R(U32) | Payload histogram | ENT_ALPHAD=1 |

## 15.4 Plugin Report Output

The following information is reported:

- NValFlows, Min, Average, Max entropy

# 16 findexer

## 16.1 Description

This plugin produces a binary index mapping each flow index to its packets positions in the input pcaps. The goal of this plugin is to be able to quickly extract flows from a big pcap without having to re-process it completely. The `fextractor` tool can be used to extract flows from the pcaps using the generated index.

## 16.2 Configuration Flags

The following flags can be used to control the output of the plugin:

| Name | Default | Description |
|---|---|---|
| FNDXR_SPLIT | 1 | Split the findexer file with t2 `-W` option |
| FNDXR_SUFFIX | `"_flows.xer"` | Suffix for flows output file |
| FNDXR_PKTSXER_SUFFIX | `"_packets.xer"` | Suffix for packets output file |

### 16.2.1 Environment Variable Configuration Flags

The following configuration flags can also be configured with environment variables (`ENVCNTRL>0`):

- FNDXR_SUFFIX
- FNDXR_PKTSXER_SUFFIX

## 16.3 fextractor

The `fextractor` tool can be used to extract flows using the generated `_flows.xer` index.

```
Usage: fextractor -r INPUT[:start][,end] (-w OUTPUT | -n) [OPTIONS]... \
            [[DIR@]FLOWINDEX[:start][,end]]... | [PKTNO]...

Extract the flows FLOWINDEX using the _flows.xer INTPUT generated by Tranalyzer2 findexer plugin.
Alternatively use a list of findexer files generated by Tranalyzer2 -W option from index start
to end. The extracted flows are written to the OUTPUT pcap.

An optional packet range can be provided on each command line FLOWINDEX to only extract packets
in the range [start, end] of this flow. If start or end are omitted, they are replaced by,
respectively, the first and the last available packets in the flow. The FLOWINDEX can also
optionally be prefixed with a direction A or B, by default both directions are extracted.

When using packet mode (-P), a optional list of packet numbers (PKTNO) can be provided instead of
the flow indexes (FLOWINDEX).

OPTIONS:
  -P        packet mode, extract specific packets (from "t2 -s" output) instead of whole flows.
  -r INPUT[:start][,end]
            either read packet indexes from a single _flows.xer file named INPUT
            or read packet indexes from multiple _flows.xer files prefixed by INPUT
            and with suffix in range [start, end]. If start or end are omitted,
```

```
          they are replaced by, respectively, first and last available XER files.
          When using packet mode (-P), INPUT must instead be in _packets.xer format.
-w OUTPUT write packets to pcap file OUTPUT
          OUTPUT "-" means that the PCAP is written to stdout.
-f        overwrite OUTPUT if it already exists
-i FILE   read flow indexes / packet numbers from FILE. FILE can either be in _flows.txt
          format (flow index in 2nd tab-separated column), have one flow index per line,
          or be in _packets.txt format (packet number in 1st tab-separated column) when
          using packet mode (-P).
          FILE "-" means that flows are read from stdin.
-b        by default when FILE is in _flows.txt format, only directions present in
          it are extracted, this option forces both directions to be extracted even if
          only the A or B direction is present in the flow file.
-s N      skip the first N PCAPs
-p DIR    search pcaps in DIR
          should only be set if pcaps were moved since Tranalyzer2 was run
-n        print oldest PCAP still available, its first packet timestamp and exit
-h        print this help message and exit
```

Example to extract flow 42, 123 and 1337 to the `output.pcap` file:

```
fextractor -r ~/t2_output/dmp1_flows.xer -w output.pcap 42 123 1337
```

Example to extract packet 100, 150 and 200 to the `output.pcap` file:

```
fextractor -P -r ~/t2_output/dmp1_packets.xer -w output.pcap 100 150 200
```

## 16.4 Example scenario

We want to extract all the flows whose source or destination are in China, to look at them in Wireshark.

First, we run tranalyzer with at least the findexer , basicFlow and txtSink plugins. The findexer plugin will generate a `_flows.xer` index file which keeps a list of packets positions in the original PCAP for each flow.

```
[user@machine]$ tranalyzer -r capture01.pcap -w t2_output/capture01
```

We now use the `srcIPCC` and `dstIPCC` columns to filter flows with IPs in China.

```
[user@machine]$ grep IPCC t2_output/capture01_headers.txt
9       SC:N    srcIPCC Source IP country code
12      SC:N    dstIPCC Destination IP country code
```

The country code are in the 9 and 12 columns. The flows to extract can directly be piped to the `fextractor` which then pipe the extracted PCAP to Wireshark.

```
[user@machine]$ awk -F"\t" '$9 == "cn" || $12 == "cn"' t2_output/capture01_flows.txt | \
        fextractor -i - -r t2_output/capture01_flows.xer -w - | wireshark -k -i -
```

By using tawk we don't even need to look at the column numbers in the header file, we can directly extract the flows of interest using the column names. tawk also provides a `-k` option which takes care of extracting the flows and opening them in Wireshark.

```
[user@machine]$ tawk -k '$srcIPCC == "cn" || $dstIPCC == "cn"' t2_output/capture01_flows.txt
```

### 16.4.1 Extract specific packets from packet forensic mode

We want to extract all packets containing the string "Apache" to an `apache.pcap` file.

```
[user@machine]$ t2 -s -r capture01.pcap -w t2_output/capture01
[user@machine]$ tawk '$l7Content ~ /Apache/' t2_output/capture01_packets.txt | \
        fextractor -P -i - -r t2_output/capture01_packets.xer -w apache.pcap
```

## 16.5 Additional Output (findexer v2)

### 16.5.1 Flows binary index

A binary index with suffix `_flows.xer` is generated. This file is composed of the following sections in any order, except the flows findexer header which is always at the beginning of the file. All numbers are written in little endian.

#### flows findexer header

```
struct findexer_header {
    uint64_t magic;          // 0x32455845444e4946 = FINDEXE2
    uint32_t pcapCount;      // number of input pcaps provided to tranalyzer
                             // 1 if -r or number of lines in -R file
    uin64_t firstPcapHeader; // offset of the fist pcap headers (see next section)
                             // in the _flows.xer file
};
```

#### flows pcap header

```
struct pcap_header {
    uint64_t nextPcapHeader;  // offset of the next pcap header
                              // in the _flows.xer file
    uint64_t flowCount;       // number of flows in this pcap
    uint64_t firstFlowHeader; // offset of the first flow header (see next section)
                              // of this pcap in the _flows.xer file
    uint16_t pathLength;      // length of the path string
    char* pcapPath;           // path string (NOT null terminated)
};
```

#### flow header

```
struct flow_header {
    uint64_t nextFlowHeader; // offset of the next flow header
                             // in the _flows.xer file
```

```
    uint64_t flowIndex;      // Tranalyzer flow index (2nd column in flow file)
    uint8_t flags;           // flow flags (see next section)
    uint64_t packetCount;    // number of packets in this flow
#FOREACH packet in the flow
    uin64t_t offset;         // offset in the pcap where to find the packet
#ENDFOREACH
};
```

**flow flags**

| | flags | Description |
|---|---|---|
| $2^0$ | (=0x01) | This is a B flow. |
| $2^1$ | (=0x02) | This is the first XER file in which this flow appears. |
| $2^2$ | (=0x04) | This is the last XER file in which this flow appears. |
| $2^3$ | (=0x08) | and all higher values: reserved for future use. |

### 16.5.2 Packets binary index

A binary index with suffix `_packets.xer` is generated when tranalyzer is run in packet forensics mode (`-s`). This file is composed of the following sections in any order, except the packets findexer header which is always at the beginning of the file. All numbers are written in little endian.

**packets findexer header**

```
struct pktsxer_header {
    uint64_t magic;          // 0x3252455853544b50 = PKTSXER2
    uint32_t pcapCount;      // number of input pcaps provided to tranalyzer
                             // 1 if -r or number of lines in -R file
    uin64_t firstPcapHeader; // offset of the fist pcap headers (see next section)
                             // in the _packets.xer file
};
```

**packets pcap header**

```
struct pkt_pcap_header {
    uint64_t nextPcapHeader;  // offset of the next pcap header
                              // in the _packets.xer file
    uint64_t first_pkt;       // fist PKTNO in this PCAP
    uint64_t last_pkt;        // last PKTNO in this PCAP
    uint16_t pathLength;      // length of the path string
    char* pcapPath;           // path string (NOT null terminated)
#FOREACH packet in the PCAP
    uin64t_t offset;          // offset in the pcap where to find the packet
#ENDFOREACH
};
```

## 16.6 Limitations

- PcapNg format is not supported (packet offsets in the pcap cannot be computed because of the additional block structures). PcapNg can however be converted in standard Pcap using the following command:

  ```
  editcap -F pcap input.pcapng output.pcap
  ```

- The findexer file cannot be generated when a BPF is used. With a BPF, not all packets are processed by Tranalyzer2 which makes it impossible to compute packets offsets in a PCAP.

## 16.7 Old format (findexer v1)

**findexer header**

```
struct findexer_header {
    uint64_t magic;           // 0x52455845444e4946 = FINDEXER
    uint32_t pcapCount;       // number of input pcaps provided to tranalyzer
                              // 1 if -r or number of lines in -R file
#FOREACH pcap
    uin64_t pcapHeaderOffset; // offset of the per pcap headers (see next section)
                              // in the _flows.xer file
#ENDFOREACH
};
```

**pcap header**

```
struct pcap_header {
    uint16_t pathLength;    // length of the path string
    char* pcapPath;         // path string (NOT null terminated)
    uint64_t flowCount;     // number of flows in this pcap
#FOREACH flow
    uint64_t flowIndex;     // Tranalyzer flow index (2nd column in flow file)
    uint64_t packetCount;   // number of packets in this flow
    uint64_t packetsOffset; // offset in the _flows.xer file where this flow packet
                            // offsets in the pcap (see next section) are located
#ENDFOREACH
};
```

**packet offsets**

```
#FOREACH packet in the flow
    uin64_t offset; // offset in the pcap where to find the packet
#ENDFOREACH
```

To extract flow `123`, the following steps are followed:

- open the `_flows.xer` file and check it has the right `magic` value
- for each pcap in `pcapCount`
  - read the pcap header located at `pcapHeaderOffset` in the `_find.xer` file.

- for each flow in `flowCount`
  - if `flowIndex == 123`: read `packetCount` offsets at position `packetsOffset` in the `_flows.xer` file and extract packets located at these offsets in the pcap at `pcapPath`

# 17 fnameLabel

## 17.1 Description

The fnameLabel plugin tags every flow with the name of the file or interface from which the flow originates. Moreover, it adds a hash value or a label which represents the number contained in a file or a specific letter. It is predominantly used to automatically separate flows or packets created by the `-R` or `-D` option. It can be used, e.g., for training classifiers.

## 17.2 Configuration Flags

The following flags can be used to control the output of the plugin:

| Name | Default | Description | Flags |
|---|---|---|---|
| `FNL_LBL` | 1 | 1: Output label derived from input<br>(Use `fileNum` for Tranalyzer `-D` option, otherwise, refer to `FNL_IDX`) | |
| `FNL_IDX` | 1 | Use the `FNL_IDX` letter of the filename as label<br>(Tranalyzer `-R`/`-i`/`-r` options) | `FBL_LBL=1` |
| `FNL_HASH` | 0 | 1: Output hash of filename | |
| `FNL_FLNM` | 1 | 1: Output filename | |
| `FNL_FREL` | 1 | Use absolute (0) or relative (1) filenames for `fnLabel`, `fnHash` and `fnName` | |
| `FNL_NAMELEN` | 1024 | Max length for filename | |

## 17.3 Flow File Output

The fnameLabel plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| `fnLabel` | U32 | `FNL_IDX` letter of the filename/interface | `FNL_LBL=1` |
| `fnHash` | U64 | Hash of the filename/interface | `FNL_HASH=1` |
| `fnName` | S | Filename | `FNL_FLNM=1` |

Note that the filename refers to the file in which the flow was created.

## 17.4 Packet File Output

In packet mode (`-s` option), the fnameLabel plugin outputs the same columns as in the flow file.

# 18 ftpDecode

## 18.1 Description

The ftpDecode plugin analyzes FTP traffic. The plugin identifies the client FTP flows automatically and links them via the ftpCDFindex, identifying the findex of the associated flows.

## 18.2 Configuration Flags

The following flags can be used to control the output of the plugin:

| Name | Default | Description | Flags |
|---|---|---|---|
| FTP_SAVE | 0 | Save content to FTP_F_PATH | |
| FTP_RMDIR | 1 | Empty FTP_F_PATH before starting | FTP_SAVE=1 |
| FTP_CMD_AGGR | 1 | Aggregate FTP commands/response codes | |
| FTP_BTFLD | 0 | Bitfield coding of FTP commands | |
| FTP_UXNMLN | 10 | maximal username length | |
| FTP_PXNMLN | 15 | maximal password length | |
| FTP_MXNMLN | 50 | maximal name length | |
| FTP_MAXCPFI | 10 | maximal number of parent findex | |
| FTP_MAXUNM | 5 | maximal number of users | |
| FTP_MAXPNM | 5 | maximal number of passwords | |
| FTP_MAXCNM | 20 | maximal number of parameters | |
| FTP_F_PATH | "/tmp/FTPFILES/" | Path for extracted content | |
| FTP_NONAME | "nudel" | Filename to use when none available | |

### 18.2.1 Environment Variable Configuration Flags

The following configuration flags can also be configured with environment variables (ENVCNTRL>0):

- FTP_F_PATH
- FTP_NONAME

## 18.3 Flow File Output

The ftpDecode plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| ftpStat | H8 | Status bit field | |
| ftpCDFindex | R(U64) | Command/data findex link | |
| ftpCBF | H64 | Command bitfield | FTP_BTFLD=1 |
| ftpCC | R(SC) | Command codes | |
| ftpRC | R(U16) | Response codes | |
| ftpNumUser | U8 | Number of users | |
| ftpUser | R(S) | Users | |
| ftpNumPass | U8 | Number of passwords | |

| Column | Type | Description | Flags |
|---|---|---|---|
| ftpPass | R(S) | Passwords | |
| ftpNumCP | U8 | Number of command parameters | |
| ftpCP | R(S) | Command parameters | |

### 18.3.1 ftpStat

The ftpStat column is to be interpreted as follows:

| | ftpStat | Description |
|---|---|---|
| $2^0$ | (=0x01) | FTP control port found |
| $2^1$ | (=0x02) | FTP passive parent flow |
| $2^2$ | (=0x04) | FTP passive parent flow length overrun, possibly by dupACK/retransmits |
| $2^3$ | (=0x08) | FTP active parent flow |
| $2^4$ | (=0x10) | FTP hash map full |
| $2^5$ | (=0x20) | File error (FTP_SAVE=1) |
| $2^6$ | (=0x40) | Data flow not detected |
| $2^7$ | (=0x80) | Array, string or filename overflow |

### 18.3.2 ftpCBF

The `ftpCBF` column is to be interpreted as follows:

| | ftpCBF | Description |
|---|---|---|
| $2^{0}$ | (=0x0000.0000.0000.0001) | ABOR |
| $2^{1}$ | (=0x0000.0000.0000.0002) | ACCT |
| $2^{2}$ | (=0x0000.0000.0000.0004) | ADAT |
| $2^{3}$ | (=0x0000.0000.0000.0008) | ALLO |
| $2^{4}$ | (=0x0000.0000.0000.0010) | APPE |
| $2^{5}$ | (=0x0000.0000.0000.0020) | AUTH |
| $2^{6}$ | (=0x0000.0000.0000.0040) | CCC |
| $2^{7}$ | (=0x0000.0000.0000.0080) | CDUP |
| $2^{8}$ | (=0x0000.0000.0000.0100) | CONF |
| $2^{9}$ | (=0x0000.0000.0000.0200) | CWD |
| $2^{10}$ | (=0x0000.0000.0000.0400) | DELE |
| $2^{11}$ | (=0x0000.0000.0000.0800) | ENC |
| $2^{12}$ | (=0x0000.0000.0000.1000) | EPRT |
| $2^{13}$ | (=0x0000.0000.0000.2000) | EPSV |
| $2^{14}$ | (=0x0000.0000.0000.4000) | FEAT |
| $2^{15}$ | (=0x0000.0000.0000.8000) | HELP |
| $2^{16}$ | (=0x0000.0000.0001.0000) | LANG |
| $2^{17}$ | (=0x0000.0000.0002.0000) | LIST |
| $2^{18}$ | (=0x0000.0000.0004.0000) | LPRT |
| $2^{19}$ | (=0x0000.0000.0008.0000) | LPSV |
| $2^{20}$ | (=0x0000.0000.0010.0000) | MDTM |
| $2^{21}$ | (=0x0000.0000.0020.0000) | MIC |
| $2^{22}$ | (=0x0000.0000.0040.0000) | MKD |
| $2^{23}$ | (=0x0000.0000.0080.0000) | MLSD |
| $2^{24}$ | (=0x0000.0000.0100.0000) | MLST |
| $2^{25}$ | (=0x0000.0000.0200.0000) | MODE |
| $2^{26}$ | (=0x0000.0000.0400.0000) | NLST |
| $2^{27}$ | (=0x0000.0000.0800.0000) | NOOP |
| $2^{28}$ | (=0x0000.0000.1000.0000) | OPTS |
| $2^{29}$ | (=0x0000.0000.2000.0000) | PASS |
| $2^{30}$ | (=0x0000.0000.4000.0000) | PASV |
| $2^{31}$ | (=0x0000.0000.8000.0000) | PBSZ |
| $2^{32}$ | (=0x0000.0001.0000.0000) | PORT |
| $2^{33}$ | (=0x0000.0002.0000.0000) | PROT |
| $2^{34}$ | (=0x0000.0004.0000.0000) | PWD |
| $2^{35}$ | (=0x0000.0008.0000.0000) | QUIT |
| $2^{36}$ | (=0x0000.0010.0000.0000) | REIN |
| $2^{37}$ | (=0x0000.0020.0000.0000) | REST |
| $2^{38}$ | (=0x0000.0040.0000.0000) | RETR |
| $2^{39}$ | (=0x0000.0080.0000.0000) | RMD |
| $2^{40}$ | (=0x0000.0100.0000.0000) | RNFR |
| $2^{41}$ | (=0x0000.0200.0000.0000) | RNTO |
| $2^{42}$ | (=0x0000.0400.0000.0000) | SITE |
| $2^{43}$ | (=0x0000.0800.0000.0000) | SIZE |
| $2^{44}$ | (=0x0000.1000.0000.0000) | SMNT |
| $2^{45}$ | (=0x0000.2000.0000.0000) | STAT |
| $2^{46}$ | (=0x0000.4000.0000.0000) | STOR |
| $2^{47}$ | (=0x0000.8000.0000.0000) | STOU |
| $2^{48}$ | (=0x0001.0000.0000.0000) | STRU |
| $2^{49}$ | (=0x0002.0000.0000.0000) | SYST |
| $2^{50}$ | (=0x0004.0000.0000.0000) | TYPE |
| $2^{51}$ | (=0x0008.0000.0000.0000) | USER |
| $2^{52}$ | (=0x0010.0000.0000.0000) | XCUP |
| $2^{53}$ | (=0x0020.0000.0000.0000) | XMKD |
| $2^{54}$ | (=0x0040.0000.0000.0000) | XPWD |
| $2^{55}$ | (=0x0080.0000.0000.0000) | XRCP |
| $2^{56}$ | (=0x0100.0000.0000.0000) | XRMD |
| $2^{57}$ | (=0x0200.0000.0000.0000) | XRSQ |
| $2^{58}$ | (=0x0400.0000.0000.0000) | XSEM |
| $2^{59}$ | (=0x0800.0000.0000.0000) | XSEN |
| $2^{60}$ | (=0x1000.0000.0000.0000) | CLNT |

## 18.4 Packet File Output

In packet mode (`-s` option), the ftpDecode plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| ftpStat | H8 | Status | |

## 18.5 Monitoring Output

In monitoring mode, the ftpDecode plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| ftpPkts | U64 | Number of FTP control packets | |
| ftpDataPkts | U64 | Number of FTP-DATA packets | |

## 18.6 Plugin Report Output

The following information is reported:

- Aggregated ftpStat
- Number of FTP control packets
- Number of FTP-DATA packets
- Number of files extracted (FTP_SAVE=1)

# 19 geoip

## 19.1 Description

This plugin outputs the geographic location of IP addresses.

## 19.2 Dependencies

This product includes GeoLite2 data created by MaxMind, available from http://www.maxmind.com.
The required dependencies depend on the value of GEOIP_LIB:

- GEOIP_LIB=0:
  Legacy databases (GeoLiteCity.data.gz and GeoLiteCityv6.dat.gz) require *libgeoip*.
- GEOIP_LIB=1:
  GeoLite2 requires *libmaxminddb*.

| | | GEOIP_LIB=1 | GEOIP_LIB=0 |
|---|---|---|---|
| **Ubuntu:** | sudo apt-get install | libmaxminddb-dev | libgeoip-dev |
| **Arch:** | sudo pacman -S | libmaxminddb | geoip |
| **Gentoo:** | sudo emerge | libmaxminddb | geoip |
| **openSUSE:** | sudo zypper install | libmaxminddb-devel | libGeoIP-devel |
| **Red Hat/Fedora**[11]**:** | sudo dnf install | libmaxminddb-devel | GeoIP-devel |
| **macOS**[12]**:** | brew install | libmaxminddb | geoip |

### 19.2.1 Databases Update

The geoIP databases can be updated with the updatedb.sh script as follows:

```
./scripts/updatedb.sh
```

Alternatively the latest version of the databases can be found at https://dev.maxmind.com/geoip/geoip2/geolite2/ (GeoLite2-City). Legacy databases, the latest version of which can be found at https://dev.maxmind.com/geoip/legacy/geolite (Geo Lite City and Geo Lite City IPv6), are also supported.

## 19.3 Configuration Flags

The following flags can be used to control the output of the plugin (Information in italic only applies to legacy databases):

| Name | Default | Description |
|---|---|---|
| GEOIP_LIB | 2 | Library to use:<br>2: GeoLite2 / Internal libmaxmind (faster)<br>1: GeoLite2 / libmaxmind<br>0: GeoLite / geoip (legacy) |

[11] If the dnf command could not be found, try with yum instead
[12] Brew is a packet manager for macOS that can be found here: https://brew.sh

| Name | Default | Description |
|---|---|---|
| GEOIP_SRC | 1 | Display geo info for the source IP |
| GEOIP_DST | 1 | Display geo info for the destination IP |
| GEOIP_CONTINENT | 2 | 0: no continent,<br>1: name (**GeoLite2**),<br>2: two letters code |
| GEOIP_COUNTRY | 2 | 0: no country,<br>1: name,<br>2: two letters code,<br>*3: three letters code* |
| GEOIP_CITY | 1 | Display the city of the IP |
| GEOIP_POSTCODE | 1 | Display the postal code of the IP |
| GEOIP_POSITION | 1 | Display the position (latitude, longitude) of the IP |
| GEOIP_METRO_CODE | 0 | Display the metro (dma) code of the IP (US only) |
| If GEOIP_LIB!=0, the following flags are available: | | |
| GEOIP_ACCURACY | 1 | Display the accuracy of the geolocation |
| GEOIP_TIMEZONE | 1 | Display the time zone |
| The six following flags are only available in GeoLite2 Enterprise databases: | | |
| GEOIP_ORG | 0 | Display the organization of the IP |
| GEOIP_ISP | 0 | Display the ISP name of the IP |
| GEOIP_ASN | 0 | Display the autonomous systems number of the IP |
| GEOIP_ASNAME | 0 | Display the autonomous systems name of the IP |
| GEOIP_CONNT | 0 | Display the connection type of the IP |
| GEOIP_USRT | 0 | Display the user type of the IP |
| GEOIP_DB_FILE | "GeoLite2-City.mmdb" | Name of the database to use for IPv4 and IPv6 (combined) |
| GEOIP_LANG | "en" | Language to use:<br>de: German,<br>en: English,<br>es: Spanish,<br>fr: French,<br>jp: Japanese,<br>pt-BR: Brazilian Portuguese,<br>ru: Russian,<br>zh-CN: Simplified Chinese |
| GEOIP_BUFSIZE | 64 | Buffer size |
| If GEOIP_LIB==0, the following flags are available: | | |
| GEOIP_REGION | *1* | *0: no region, 1: name, 2: code* |
| GEOIP_AREA_CODE | *0* | *Display the telephone area code of the IP* |

| Name | Default | Description |
|---|---|---|
| GEOIP_NETMASK | *1* | *0: no netmask,*<br>*1: netmask as int (cidr),*<br>*2: netmask as hex,*<br>*3: netmask as IP* |
| GEOIP_DB_CACHE | *2* | *0: read DB from file system (slower, least memory)*<br>*1: index cache (cache frequently used index only)*<br>*2: memory cache (faster, more memory)* |
| GEOIP_DB_FILE4 | *"GeoLiteCity.dat"* | *Name of the database to use for IPv4* |
| GEOIP_DB_FILE6 | *"GeoLiteCityv6.dat"* | *Name of the database to use for IPv6* |
| GEOIP_UNKNOWN | "--" | Representation of unknown locations (GeoIP's default) |

### 19.3.1 Environment Variable Configuration Flags

The following configuration flags can also be configured with environment variables (ENVCNTRL>0):

- GEOIP_DB_FILE (require GEOIP_LIB>0)
- GEOIP_DB_FILE4 (require GEOIP_LIB=0)
- GEOIP_DB_FILE6 (require GEOIP_LIB=0)
- GEOIP_UNKNOWN

## 19.4 Flow File Output

The geoip plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| The following columns prefixed with src are only output if GEOIP_SRC=1. | | | |
| srcIpContinent | S | Continent name | GEOIP_CONTINENT=1 |
| srcIpContinent | SC | Continent code | GEOIP_CONTINENT=2 |
| srcIpCountry | S | Country name | GEOIP_COUNTRY=1 |
| srcIpCountry | SC | Country code | GEOIP_COUNTRY=2\|3 |
| srcIpRegion | SC | Region | GEOIP_LIB=0&&GEOIP_REGION=1 |
| srcIpRegion | S | Region | GEOIP_LIB=0&&GEOIP_REGION=2 |
| srcIpCity | S | City | GEOIP_CITY>0 |
| srcIpPostcode | SC | Postal code | GEOIP_POSTCODE>0 |
| srcIpAccuracy | U16 | Accuracy of the geolocation (in km) | GEOIP_LIB>0&&GEOIP_ACCURACY=1 |
| srcIpLat | D | Latitude | GEOIP_LIB>0&&GEOIP_POSITION=1 |
| srcIpLong | D | Longitude | GEOIP_LIB>0&&GEOIP_POSITION=1 |
| srcIpLat | F | Latitude | GEOIP_LIB=0&&GEOIP_POSITION=1 |
| srcIpLong | F | Longitude | GEOIP_LIB=0&&GEOIP_POSITION=1 |
| srcIpMetroCode | U16 | Metro (DMA) code (US only) | GEOIP_LIB>0&&GEOIP_METRO_CODE=1 |
| srcIpMetroCode | I32 | Metro (DMA) code (US only) | GEOIP_LIB=0&&GEOIP_METRO_CODE=1 |

| Column | Type | Description | Flags |
|---|---|---|---|
| srcIpAreaCode | I32 | Area code | GEOIP_LIB=0&&GEOIP_AREA_CODE=1 |
| srcIpNetmask | U32 | Netmask (CIDR) | GEOIP_LIB=0&&GEOIP_NETMASK=1 |
| srcIpNetmask | H32 | Netmask | GEOIP_LIB=0&&GEOIP_NETMASK=2 |
| srcIpNetmask | IP4 | Netmask | GEOIP_LIB=0&&GEOIP_NETMASK=3 |
| srcIpTimeZone | S | Time zone | GEOIP_LIB=0&&GEOIP_TIMEZONE=1 |
| srcIpOrg | S | Organization | GEOIP_LIB>0&&GEOIP_ORG=1 |
| srcIpISP | S | ISP | GEOIP_LIB>0&&GEOIP_ISP=1 |
| srcIpASN | U32 | AS number | GEOIP_LIB>0&&GEOIP_ASN=1 |
| srcIpASName | S | AS name | GEOIP_LIB>0&&GEOIP_ASNAME=1 |
| srcIpConnT | S | Connection type | GEOIP_LIB>0&&GEOIP_CONNT=1 |
| srcIpUsrT | S | User type | GEOIP_LIB>0&&GEOIP_USRT=1 |

The same columns (with prefix dst instead of src) are output for the destination address if GEOIP_DST=1.

| | | |
|---|---|---|
| geoStat | H8 | Status |

### 19.4.1 srcIpContinent

Continent codes are as follows:

| Code | Description |
|---|---|
| AF | Africa |
| AS | Asia |
| EU | Europe |
| NA | North America |
| OC | Oceania |
| SA | South America |
| -- | Unknown (see GEOIP_UNKNOWN) |

### 19.4.2 geoStat

The geoStat column is to be interpreted as follows:

| geoStat | Description |
|---|---|
| $2^0$ (=0x01) | A string had to be truncated. . . increase GEOIP_BUFSIZE |
| $2^1$ (=0x02) | Source IP lookup failed |
| $2^2$ (=0x04) | Destination IP lookup failed |

## 19.5 Post-Processing

### 19.5.1 genkml.sh

The geoip plugin comes with the genkml.sh script which generates a KML (Keyhole Markup Language) file from a flow file. This KML file can then be loaded in Google Earth to display the location of the IP addresses involved in the dump file. Its usage is straightforward:

```
./scripts/genkml.sh FILE_flows.txt
```

### 19.5.2 t2mmdb

The t2mmdb program can be used to query the MaxMind DB. It is a faster and easier to use version of the mmdblookup utility.

### 19.5.3 t2mmdba

The t2mmdba script can be used to transform the MaxMind DB into Tranalyzer subnet format.

# 20 httpSniffer

## 20.1 Description

The httpSniffer plugin processes HTTP header and content information of a flow. The idea is to identify certain HTTP features using flow parameters and to extract certain content such as text or images for further investigation. The httpSniffer plugin requires no dependencies and produces only output to the flow file. User defined compiler switches in *httpSniffer.h* produce optimized code for the specific application.

## 20.2 Configuration Flags

The flow based output and the extracted information can be controlled by switches and constants listed in the table below. They control the output of host, URL and method counts, names and cookies and the function of content storage. **WARNING:** The amount of being stored on disk can be substantial, make sure that the number of concurrent file handles is large enough, use `ulimit -n`.

| Name | Default | Description | Flags |
|---|---|---|---|
| HTTP_MIME | 1 | Mime types | |
| HTTP_STAT | 1 | Status codes | |
| HTTP_MCNT | 1 | Mime count: GET, POST | |
| HTTP_HOST | 1 | Hosts | |
| HTTP_URL | 1 | URLs | |
| HTTP_COOKIE | 1 | Cookies | |
| HTTP_IMAGE | 1 | Image names | |
| HTTP_VIDEO | 1 | Video names | |
| HTTP_AUDIO | 1 | Audio names | |
| HTTP_MSG | 1 | Message names | |
| HTTP_APPL | 1 | Application names | |
| HTTP_TEXT | 1 | Text names | |
| HTTP_PUNK | 1 | POST/else/unknown names | |
| HTTP_BODY | 1 | Analyze body and print anomalies | |
| HTTP_BDURL | 1 | Refresh and set-cookie URLs | HTTP_BODY=1 |
| HTTP_USRAG | 1 | User-Agents | |
| HTTP_XFRWD | 1 | X-Forwarded-For | |
| HTTP_REFRR | 1 | Referer | |
| HTTP_VIA | 1 | Via | |
| HTTP_LOC | 1 | Location | |
| HTTP_SERV | 1 | Server | |
| HTTP_PWR | 1 | X-Powered-By | |
| | | | |
| HTTP_STATAGA | 1 | Aggregate status response | |
| HTTP_MIMEAGA | 1 | Aggregate mime response | |
| HTTP_HOSTAGA | 1 | Aggregate Hosts | |
| HTTP_URLAGA | 1 | Aggregate URLs | |
| HTTP_USRAGA | 1 | Aggregate User-Agents | |
| HTTP_XFRWDA | 1 | Aggregate X-Forwarded-For | |
| HTTP_REFRRA | 1 | Aggregate Referer | |
| HTTP_VIAA | 1 | Aggregate Via | |

| Name | Default | Description | Flags |
|---|---|---|---|
| HTTP_LOCA | 1 | Aggregate Location | |
| HTTP_SERVA | 1 | Aggregate Server | |
| HTTP_PWRA | 1 | Aggregate X-Powered-By | |
| HTTP_SAVE_IMAGE | 0 | Save all images | |
| HTTP_SAVE_VIDEO | 0 | Save all videos | |
| HTTP_SAVE_AUDIO | 0 | Save all audios | |
| HTTP_SAVE_MSG | 0 | Save all messages | |
| HTTP_SAVE_TEXT | 0 | Save all texts | |
| HTTP_SAVE_APPL | 0 | Save all applications | |
| HTTP_SAVE_PUNK | 0 | Save all else | |
| HTTP_RMDIR | 1 | Empty HTTP_*_PATH before starting | HTTP_SAVE=1 |

Note that HTTP_SAVE_* refers to the *Content-Type*, e.g., HTTP_SAVE_APPL, will save all payload whose *Content-Type* starts with application/ (including forms, such as application/x-www-form-urlencoded). The maximum memory allocation per item is defined by HTTP_DATA_C_MAX listed below. The path of each extracted HTTP content can be set by the HTTP_XXXX_PATH constants. HTTP content having no name is assigned a default name defined by HTTP_NONAME. Each name is prepended the findex, packet number and an index to facilitate the mapping between flows and its content. The latter constant has to be chosen carefully because for each item (mime, cookie, image, ...), HTTP_MXFILE_LEN * HTTP_DATA_C_MAX * HASHCHAINTABLE_SIZE * HASHFACTOR bytes are allocated.

The filenames are defined as follows:

```
Filename_findex_Flow-Dir(A/B)_#Packet-in-Flow_#Mimetype-in-Flow
```

So they can easily being matched with the flow or packet file.

| Name | Default | Description |
|---|---|---|
| HTTP_PATH | "/tmp" | Root path for extracted content |
| HTTP_IMAGE_PATH | "httpPicture" | Path for pictures |
| HTTP_VIDEO_PATH | "httpVideo" | Path for videos |
| HTTP_AUDIO_PATH | "httpAudio" | Path for audios |
| HTTP_MSG_PATH | "httpMSG" | Path for messages |
| HTTP_TEXT_PATH | "httpText" | Path for texts |
| HTTP_APPL_PATH | "httpAppl" | Path for applications |
| HTTP_PUNK_PATH | "httpPunk" | Path for PUT/else |
| HTTP_NONAME | "nudel" | File name for unnamed content |
| HTTP_DATA_C_MAX | 20 | Maximum dim of all storage array: # / flow |
| HTTP_CNT_LEN | 13 | Max # of cnt digits attached to file name |
| HTTP_FINDEX_LEN | 20 | String length of findex in decimal format |
| HTTP_MXFILE_LEN | 80 | Maximum image name length in bytes |
| HTTP_MXUA_LEN | 400 | Maximum User-Agent name length in bytes |
| HTTP_MXXF_LEN | 80 | Maximum X-Forward-For name length in bytes |

### 20.2.1 Environment Variable Configuration Flags

The following configuration flags can also be configured with environment variables (ENVCNTRL>0):

- HTTP_RMDIR
- HTTP_PATH
- HTTP_IMAGE_PATH
- HTTP_VIDEO_PATH
- HTTP_AUDIO_PATH
- HTTP_MSG_PATH
- HTTP_TEXT_PATH
- HTTP_APPL_PATH
- HTTP_PUNK_PATH

## 20.3 Flow File Output

The httpSniffer plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| httpStat | H16 | Status | |
| httpAFlags | H16 | Anomaly flags | |
| httpMethods | H8 | HTTP methods | |
| httpHeadMimes | H16 | HEADMIME-TYPES | |
| httpCFlags | H8 | HTTP content body info | HTTP_BODY=1 |
| httpGet_Post | 2U16 | Number of GET and POST requests | HTTP_MCNT=1 |
| httpRSCnt | U16 | Response status count | HTTP_STAT=1 |
| httpRSCode | RU16 | Response status code | HTTP_STAT=1 |
| httpURL_Via_Loc_Srv_ Pwr_UAg_XFr_ Ref_Cky_Mim | 10U16 | Number of URL, Via, Location, Server, X-Powered-By, User-Agent, X-Forwarded-For, Referer, Cookie and Mime-Type | |
| httpImg_Vid_Aud_Msg_ Txt_App_Unk | 7U16 | Number of images, videos, audios, messages, texts, applications and unknown | |
| httpHosts | RS | Host names | HTTP_HOST=1 |
| httpURL | RS | URLs (including parameters) | HTTP_URL=1 |
| httpMimes | RS | MIME-types | HTTP_MIME=1 |
| httpCookies | RS | Cookies | HTTP_COOKIE=1 |
| httpImages | RS | Images | HTTP_IMAGE=1 |
| httpVideos | RS | Videos | HTTP_VIDEO=1 |
| httpAudios | RS | Audios | HTTP_AUDIO=1 |
| httpMsgs | RS | Messages | HTTP_MSG=1 |
| httpAppl | RS | Applications | HTTP_APPL=1 |
| httpText | RS | Texts | HTTP_TEXT=1 |
| httpPunk | RS | Punk | HTTP_PUNK=1 |
| httpBdyURL | RS | Body: Refresh, set_cookie URL | HTTP_BODY=1&& HTTP_BDURL=1 |
| httpUsrAg | RS | User-Agent | HTTP_USRAG=1 |

| Column | Type | Description | Flags |
|---|---|---|---|
| httpXFor | RS | X-Forwarded-For | HTTP_XFRWD=1 |
| httpRefrr | RS | Referer | HTTP_REFRR=1 |
| httpVia | RS | Via (Proxy) | HTTP_VIA=1 |
| httpLoc | RS | Location (Redirection) | HTTP_LOC=1 |
| httpServ | RS | Server | HTTP_SERV=1 |
| httpPwr | RS | X-Powered-By / Application | HTTP_PWR=1 |

### 20.3.1 httpStat

The httpStat column is to be interpreted as follows:

| | httpStat | Description |
|---|---|---|
| $2^0$ | (=0x0001) | Warning: HTTP_DATA_C_MAX entries in flow name array reached |
| $2^1$ | (=0x0002) | Warning: Filename longer than HTTP_MXFILE_LEN |
| $2^2$ | (=0x0004) | Internal state: pending URL name |
| $2^3$ | (=0x0008) | HTTP flow |
| $2^4$ | (=0x0010) | Internal state: Chunked transfer |
| $2^5$ | (=0x0020) | Internal state: HTTP flow detected |
| $2^6$ | (=0x0040) | Internal state: HTTP header parsing in process |
| $2^7$ | (=0x0080) | Internal state: sequence number init |
| $2^8$ | (=0x0100) | Internal state: header shift |
| $2^9$ | (=0x0200) | Internal state: PUT payload sniffing |
| $2^{10}$ | (=0x0400) | Internal state: Image payload sniffing |
| $2^{11}$ | (=0x0800) | Internal state: video payload sniffing |
| $2^{12}$ | (=0x1000) | Internal state: audio payload sniffing |
| $2^{13}$ | (=0x2000) | Internal state: message payload sniffing |
| $2^{14}$ | (=0x4000) | Internal state: text payload sniffing |
| $2^{15}$ | (=0x8000) | Internal state: application payload sniffing |

### 20.3.2 httpAFlags

The httpAFlags column denotes HTTP anomalies regarding the protocol and the security. It is to be interpreted as follows:

| | httpAFlags | Description |
|---|---|---|
| $2^0$ | (=0x0001) | Warning: POST query with parameters, possible malware |
| $2^1$ | (=0x0002) | Warning: Host is IPv4 |
| $2^2$ | (=0x0004) | Warning: Possible DGA |
| $2^3$ | (=0x0008) | Warning: Mismatched content-type |
| $2^4$ | (=0x0010) | Warning: Sequence number mangled or error retry detected |

| | httpAFlags | Description |
|---|---|---|
| $2^5$ | (=0x0020) | Warning: Parse Error |
| $2^6$ | (=0x0040) | Warning: header without value, e.g., `Content-Type: [missing]` |
| $2^7$ | (=0x0080) | — |
| $2^8$ | (=0x0100) | Info: X-Site Scripting protection |
| $2^9$ | (=0x0200) | Info: Content Security Policy |
| $2^{10}$ | (=0x0400) | Info: Do not track |
| $2^{11}$ | (=0x0800) | — |
| $2^{12}$ | (=0x1000) | Warning: possible EXE download |
| $2^{13}$ | (=0x2000) | Warning: possible ELF download |
| $2^{14}$ | (=0x4000) | Warning: HTTP 1.0 legacy protocol, often used by malware |
| $2^{15}$ | (=0x8000) | — |

### 20.3.3 httpMethods

The `httpMethods` column is to be interpreted as follows:

| httpMethods | | Type | Description |
|---|---|---|---|
| $2^0$ | (=0x01) | OPTIONS | Return HTTP methods that server supports for specified URL |
| $2^1$ | (=0x02) | GET | Request of representation of specified resource |
| $2^2$ | (=0x04) | HEAD | Request of representation of specified resource without body |
| $2^3$ | (=0x08) | POST | Request to accept enclosed entity as new subordinate of resource identified by URI |
| $2^4$ | (=0x10) | PUT | Request to store enclosed entity under supplied URI |
| $2^5$ | (=0x20) | DELETE | Delete specified resource |
| $2^6$ | (=0x40) | TRACE | Echo back received request |
| $2^7$ | (=0x80) | CONNECT | Convert request connection to transparent TCP/IP tunnel |

### 20.3.4 httpHeadMimes

The `httpHeadMimes` column is to be interpreted as follows:

| httpHeadMimes | | Mime-Type | Description |
|---|---|---|---|
| $2^0$ | (=0x0001) | application | Multi-purpose files: java or postscript, ... |
| $2^1$ | (=0x0002) | audio | Audio file |
| $2^2$ | (=0x0004) | image | Image file |
| $2^3$ | (=0x0008) | message | Instant or email message type |
| $2^4$ | (=0x0010) | model | 3D computer graphics |
| $2^4$ | (=0x0020) | multipart | Archives and other objects made of more than one part |
| $2^5$ | (=0x0040) | text | Human-readable text and source code |
| $2^6$ | (=0x0080) | video | Video stream: Mpeg, Flash, Quicktime, ... |

| httpHeadMimes | Mime-Type | Description |
|---|---|---|
| $2^8$ (=0x0100) | vnd | Vendor-specific files: Word, OpenOffice, ... |
| $2^9$ (=0x0200) | x | Non-standard files: tar, SW packages, LaTeX, Shockwave Flash, ... |
| $2^{10}$ (=0x0400) | x-pkcs | public-key cryptography standard files |
| $2^{11}$ (=0x0800) | — | — |
| $2^{12}$ (=0x1000) | — | — |
| $2^{13}$ (=0x2000) | — | — |
| $2^{14}$ (=0x4000) | — | — |
| $2^{15}$ (=0x8000) | * | All else |

### 20.3.5 httpCFlags

The `httpCFlags` column is to be interpreted as follows:

| httpCFlags | Description |
|---|---|
| $2^0$ (=0x0001) | HTTP set cookie |
| $2^1$ (=0x0002) | HTTP refresh detected |
| $2^2$ (=0x0004) | Hostname detected |
| $2^3$ (=0x0008) | POST Boundary marker |
| $2^4$ (=0x0010) | Potential HTTP content |
| $2^5$ (=0x0020) | Stream |
| $2^6$ (=0x0040) | Quarantine virus upload |
| $2^7$ (=0x0080) | — |
| $2^8$ (=0x0100) | — |
| $2^9$ (=0x0200) | — |
| $2^{10}$ (=0x0400) | — |
| $2^{11}$ (=0x0800) | — |
| $2^{12}$ (=0x1000) | — |
| $2^{13}$ (=0x2000) | — |
| $2^{14}$ (=0x4000) | — |
| $2^{15}$ (=0x8000) | Stream1 |

## 20.4 Packet File Output

In packet mode (`-s` option), the httpSniffer plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| httpStat | H16 | Status | |
| httpAFlags | H16 | Anomaly flags | |
| httpMethods | H8 | HTTP methods | |
| httpHeadMimes | H16 | HEADMIME-TYPES | |

| Column | Type | Description | Flags |
|---|---|---|---|
| httpCFlags | H8 | HTTP content body info | HTTP_BODY=1 |

## 20.5 Monitoring Output

In monitoring mode, the httpSniffer plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| httpPkts | U64 | Number of HTTP packets | |

## 20.6 Plugin Report Output

The following information is reported:

- Max number of file handles (only if HTTP_SAVE=1)
- Number of HTTP packets
- Number of HTTP #GET, #POST, #GET/#POST ratio
- Aggregated httpStat
- Aggregated httpHeadMimes
- Aggregated httpAFlags
- Aggregated httpCFlags (HTTP_BODY=1)

The GET/POST ratio is very helpful in detecting malware operations, if you know the normal ratio of your machines in the network. The file descriptor gives you an indication of the maximum file handles the present pcap will produce. You can increase it by invoking uname -n mylimit, but it should not be necessary as we manage the number of handle being open to be always below the max limit.

# 21 icmpDecode

## 21.1 Description

The icmpDecode plugin analyzes ICMP and ICMPv6 traffic. It generates global and flow based statistics.

## 21.2 Configuration Flags

The following flags can be used to control the output of the plugin:

| Name | Default | Description | Flags |
|---|---|---|---|
| ICMP_TC_MD | 0 | Type/code representation:<br>0: bitfield,<br>1: explicit array of type code,<br>2: type code statistics [NOT IMPLEMENTED YET] | |
| ICMP_NUM | 10 | Number of type and code information | ICMP_TC_MD=1 |
| ICMP_FDCORR | 1 | Flow direction correction | |
| ICMP_PARENT | 0 | Resolve the parent flow | |
| ICMP_STATFILE | 0 | Print ICMP statistics in a separate file | |
| ICMP_NOCODE | "-" | Symbol to use to represent the absence of a code | |

### 21.2.1 Environment Variable Configuration Flags

The following configuration flags can also be configured with environment variables (ENVCNTRL>0):

- ICMP_NOCODE
- ICMP_SUFFIX

## 21.3 Flow File Output

The icmpDecode plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| icmpStat | H8 | Status | |
| icmpTCcnt | U8 | Type/Code count | |
| icmpBFType_Code | H32_H16 | Aggregated type (<32) and code bitfield | ICMP_TC_MD=0&&<br>IPV6_ACTIVATE=0 |
| icmpBFTypH_TypL_Code | H32_H32_H16 | Aggr. type H(>128), L(<32) and code bitfield | ICMP_TC_MD=0&&<br>IPV6_ACTIVATE=1 |
| icmpType_Code | R(U8_U8) | Type and code fields | ICMP_TC_MD=1 |
| icmpTmGtw | H32 | Time/gateway | |
| icmpEchoSuccRatio | F | Echo reply/request success ratio | |
| icmpPFindex | U64 | Parent flowIndex | ICMP_PARENT=1 |

### 21.3.1 icmpStat

The `icmpStat` column is to be interpreted as follows:

| | icmpStat | Description |
|---|---|---|
| $2^0$ | (=0x01) | Flow is ICMP |
| $2^1$ | (=0x02) | — |
| $2^2$ | (=0x04) | — |
| $2^3$ | (=0x08) | — |
| $2^4$ | (=0x10) | WANG2 Microsoft bandwidth test |
| $2^5$ | (=0x20) | ICMP ECHO Seq Num abnormal increment |
| $2^6$ | (=0x40) | Embedded LOKI covert channel |
| $2^7$ | (=0x80) | Embedded SSH covert channel |

### 21.3.2 icmpBFType_Code

For **ICMP (IPv4)**, the `icmpBFType_Code` column is to be interpreted as follows:

| | icmpBFType | Description |
|---|---|---|
| $2^0$ | (=0x00000001) | Echo Reply |
| $2^1$ | (=0x00000002) | — |
| $2^2$ | (=0x00000004) | — |
| $2^3$ | (=0x00000008) | Destination Unreachable |
| $2^4$ | (=0x00000010) | Source Quench |
| $2^5$ | (=0x00000020) | Redirect (change route) |
| $2^6$ | (=0x00000040) | Alternate Host Address (Deprecated) |
| $2^7$ | (=0x00000080) | — |
| $2^8$ | (=0x00000100) | Echo Request |
| $2^9$ | (=0x00000200) | Router Advisement |
| $2^{10}$ | (=0x00000400) | Router Selection |
| $2^{11}$ | (=0x00000800) | Time Exceeded |
| $2^{12}$ | (=0x00001000) | Parameter Problem |
| $2^{13}$ | (=0x00002000) | Timestamp Request |
| $2^{14}$ | (=0x00004000) | Timestamp Reply |
| $2^{15}$ | (=0x00008000) | Information Request |
| $2^{16}$ | (=0x00010000) | Information Reply |
| $2^{17}$ | (=0x00020000) | Address Mask Request |
| $2^{18}$ | (=0x00040000) | Address Mask Reply |
| $2^{19}$ | (=0x00080000) | Reserved (for Security) |
| $2^{20}$ | (=0x00100000) | Experimental |

| | icmpBFType | Description |
|---|---|---|
| $2^{21}$ | (=0x00200000) | Experimental |
| $2^{22}$ | (=0x00400000) | Experimental |
| $2^{23}$ | (=0x00800000) | Experimental |
| $2^{24}$ | (=0x01000000) | Experimental |
| $2^{25}$ | (=0x02000000) | Experimental |
| $2^{26}$ | (=0x04000000) | Experimental |
| $2^{27}$ | (=0x08000000) | Experimental |
| $2^{28}$ | (=0x10000000) | Experimental |
| $2^{29}$ | (=0x20000000) | Experimental |
| $2^{30}$ | (=0x40000000) | Traceroute |
| $2^{31}$ | (=0x80000000) | Datagram Conversion Error (Deprecated) |

The `icmpCode` for **Destination Unreachable** (`0x00000008`) is to be interpreted as follows:

| | icmpBFCode | Description |
|---|---|---|
| $2^{0}$ | (=0x0001) | Network Unreachable |
| $2^{1}$ | (=0x0002) | Host Unreachable |
| $2^{2}$ | (=0x0004) | Protocol Unreachable |
| $2^{3}$ | (=0x0008) | Port Unreachable |
| $2^{4}$ | (=0x0010) | Fragmentation Needed/DF set |
| $2^{5}$ | (=0x0020) | Source Route failed |
| $2^{6}$ | (=0x0040) | Destination Network unknown |
| $2^{7}$ | (=0x0080) | Destination Host unknown |
| $2^{8}$ | (=0x0100) | Src host isolated |
| $2^{9}$ | (=0x0200) | Dest net administratively prohibited |
| $2^{10}$ | (=0x0400) | Dest host administratively prohibited |
| $2^{11}$ | (=0x0800) | Dest net unreachable for type of service |
| $2^{12}$ | (=0x1000) | Dest host unreachable for type of service |
| $2^{13}$ | (=0x2000) | Communication administratively prohibited |
| $2^{14}$ | (=0x4000) | Precedence violation |
| $2^{15}$ | (=0x8000) | Precedence cut off |

For **ICMPv6 (IPv6)**, the `icmpBFType_Code` column is to be interpreted as follows:

| icmpType | Description |
|---|---|
| 0 | Reserved |
| 1 | Destination Unreachable |
| 2 | Packet Too Big |
| 3 | Time Exceeded |
| 4 | Parameter Problem |
| 100 | Private experimentation |
| 101 | Private experimentation |
| 102–126 | Unassigned |
| 127 | Reserved for expansion of ICMPv6 error messages |
| 128 | Echo Request |
| 129 | Echo Reply |
| 130 | Multicast Listener Query |
| 131 | Multicast Listener Report |
| 132 | Multicast Listener Done |
| 133 | Router Solicitation |
| 134 | Router Advertisement |
| 135 | Neighbor Solicitation |
| 136 | Neighbor Advertisement |
| 137 | Redirect Message |
| 138 | Router Renumbering |
| 139 | ICMP Node Information Query |
| 140 | ICMP Node Information Response |
| 141 | Inverse Neighbor Discovery Solicitation |
| 142 | Inverse Neighbor Discovery Advertisement |
| 143 | Version 2 Multicast Listener Report |
| 144 | Home Agent Address Discovery Request |
| 145 | Home Agent Address Discovery Reply |
| 146 | Mobile Prefix Solicitation |
| 147 | Mobile Prefix Advertisement |
| 148 | Certification Path Solicitation |
| 149 | Certification Path Advertisement |
| 150 | ICMP messages utilized by experimental mobility protocols such as Seamoby |
| 151 | Multicast Router Advertisement |
| 152 | Multicast Router Solicitation |
| 153 | Multicast Router Termination |
| 154 | FMIPv6 Messages |
| 155 | RPL Control Message |
| 156 | ILNPv6 Locator Update Message |
| 157 | Duplicate Address Request |
| 158 | Duplicate Address Confirmation |
| 159 | MPL Control Message |
| 160–199 | Unassigned |
| 200 | Private experimentation |
| 201 | Private experimentation |
| 255 | Reserved for expansion of ICMPv6 informational messages |

The `icmpCode` for **Destination Unreachable (1)** are:

| | icmpCode | Description |
|---|---|---|
| $2^0$ | (=0x0001) | No route to destination |
| $2^1$ | (=0x0002) | Communication with destination administratively prohibited |
| $2^2$ | (=0x0004) | Beyond scope of source address |
| $2^3$ | (=0x0008) | Address unreachable |
| $2^4$ | (=0x0010) | Port unreachable |
| $2^5$ | (=0x0020) | Source address failed ingress/egress policy |
| $2^6$ | (=0x0040) | Reject route to destination |
| $2^7$ | (=0x0080) | Error in Source Routing Header |

The `icmpCode` for **Time Exceeded (3)** are:

| | icmpCode | Description |
|---|---|---|
| $2^0$ | (=0x0001) | Hop limit exceeded in transit |
| $2^1$ | (=0x0002) | Fragment reassembly time exceeded |

The icmpCode for **Parameter Problem (4)** are:

| | icmpCode | Description |
|---|---|---|
| $2^0$ | (=0x0001) | Erroneous header field encountered |
| $2^1$ | (=0x0002) | Unrecognized Next Header type encountered |
| $2^2$ | (=0x0004) | Unrecognized IPv6 option encountered |
| $2^3$ | (=0x0008) | IPv6 First Fragment has incomplete IPv6 Header Chain |

The icmpCode for **Router Renumbering (138)** are:

| | icmpCode | Description |
|---|---|---|
| $2^0$ | (=0x0001) | Router Renumbering Command |
| $2^1$ | (=0x0002) | Router Renumbering Result |
| | 255 | Sequence Number Reset |

The icmpCode for **ICMP Node Information Query (139)** are:

| | icmpCode | Description |
|---|---|---|
| $2^0$ | (=0x0001) | The Data field contains an IPv6 address which is the Subject of this Query |
| $2^1$ | (=0x0002) | The Data field contains a name which is the Subject of this Query, or is empty, as in the case of a NOOP |
| $2^3$ | (=0x0004) | The Data field contains an IPv4 address which is the Subject of this Query |

The icmpCode for **ICMP Node Information Response (140)** are:

| | icmpCode | Description |
|---|---|---|
| $2^0$ | (=0x0001) | A successful reply. The Reply Data field may or may not be empty |
| $2^1$ | (=0x0002) | The Responder refuses to supply the answer. The Reply Data field will be empty |
| $2^2$ | (=0x0004) | The Qtype of the Query is unknown to the Responder. The Reply Data field will be empty |

## 21.4 Packet File Output

In packet mode (-s option), the icmpDecode plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| icmpStat | H8 | Status | |
| icmpType | U8 | Message type | |
| icmpCode | U8 | Message code | |
| icmpID | H16 | Identifier | |
| icmpSeq | H16 | Sequence number | |
| icmpPFindex | U64 | Parent flowIndex | ICMP_PARENT=1 |

## 21.5 Monitoring Output

In monitoring mode, the icmpDecode plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| icmpPkts | U64 | Number of ICMP/ICMPv6 packets | |
| icmpEchoReq | U64 | Number of ICMP/ICMPv6 echo request packets | |
| icmpEchoRep | U64 | Number of ICMP/ICMPv6 echo reply packets | |

## 21.6 Plugin Report Output

The following information is reported:

- Aggregated icmpStat
- Number of ICMP/ICMPv6 echo request packets
- Number of ICMP/ICMPv6 echo reply packets
- ICMP/ICMPv6 echo reply / request ratio

## 21.7 Additional Output

The icmpDecode plugin outputs absolute and relative statistics in the PREFIX_icmpStats.txt file. Note that the default suffix of "_icmpStats.txt" can be changed by editing the ICMP_SUFFIX flag.

The output is as follows (IPV6_ACTIVATE=0||IPV6_ACTIVATE=2):

| Type | Code | Description |
|---|---|---|
| ICMP_ECHOREQUEST | -- | Echo request |
| ICMP_ECHOREPLY | -- | Echo reply to an echo request |
| ICMP_SOURCE_QUENCH | -- | Source quenches |
| ICMP_TRACEROUTE | -- | Traceroute packets |
| ICMP_DEST_UNREACH | ICMP_NET_UNREACH | Network unreachable |
| ICMP_DEST_UNREACH | ICMP_HOST_UNREACH | Host unreachable |
| ICMP_DEST_UNREACH | ICMP_PROT_UNREACH | Protocol unreachable |
| ICMP_DEST_UNREACH | ICMP_PORT_UNREACH | Port unreachable |
| ICMP_DEST_UNREACH | ICMP_FRAG_NEEDED | Fragmentation needed |
| ICMP_DEST_UNREACH | ICMP_SR_FAILED | Source route failed |
| ICMP_DEST_UNREACH | ICMP_NET_UNKNOWN | Network unknown |
| ICMP_DEST_UNREACH | ICMP_HOST_UNKNOWN | Host unknown |
| ICMP_DEST_UNREACH | ICMP_HOST_ISOLATED | Host is isolated |
| ICMP_DEST_UNREACH | ICMP_NET_ANO | Network annotation |
| ICMP_DEST_UNREACH | ICMP_HOST_ANO | Host annotation |
| ICMP_DEST_UNREACH | ICMP_NET_UNR_TOS | Unreachable type of network service |
| ICMP_DEST_UNREACH | ICMP_HOST_UNR_TOS | Unreachable type of host service |
| ICMP_DEST_UNREACH | ICMP_PKT_FILTERED | Dropped by a filtering device |
| ICMP_DEST_UNREACH | ICMP_PREC_VIOLATION | Precedence violation |

| Type | Code | Description |
|---|---|---|
| ICMP_DEST_UNREACH | ICMP_PREC_CUTOFF | Precedence cut off |
| ICMP_REDIRECT | ICMP_REDIR_NET | Network redirection |
| ICMP_REDIRECT | ICMP_REDIR_HOST | Host redirection |
| ICMP_REDIRECT | ICMP_REDIR_NETTOS | Network type of service |
| ICMP_REDIRECT | ICMP_REDIR_HOSTTOS | Host type of service |
| ICMP_TIME_EXCEEDED | ICMP_EXC_TTL | TTL exceeded in Transit |
| ICMP_TIME_EXCEEDED | ICMP_EXC_FRAGTIME | Fragment Reassembly Time Exceeded |

If IPV6_ACTIVATE>0, then the output becomes:

| Type | Code | Description |
|---|---|---|
| ICMP6_ECHOREQUEST | -- | Echo request |
| ICMP6_ECHOREPLY | -- | Echo reply to an echo request |
| ICMP6_PKT_TOO_BIG | -- | Packet too big |
| ICMP6_DEST_UNREACH | ICMP6_NO_ROUTE | No route to destination |
| ICMP6_DEST_UNREACH | ICMP6_COMM_PROHIBIT | Communication with destination prohibited |
| ICMP6_DEST_UNREACH | ICMP6_BEYOND_SCOPE | Beyond scope of source address |
| ICMP6_DEST_UNREACH | ICMP6_ADDR_UNREACH | Address unreachable |
| ICMP6_DEST_UNREACH | ICMP6_PORT_UNREACH | Port unreachable |
| ICMP6_DEST_UNREACH | ICMP6_SR_FAILED | Source route failed |
| ICMP6_DEST_UNREACH | ICMP6_REJECT | Reject source to destination |
| ICMP6_DEST_UNREACH | ICMP6_ERROR_HDR | Error in Source Routing Header |
| ICMP6_TIME_EXCEEDED | ICMP6_EXC_HOPS | Hop limit exceeded in transit |
| ICMP6_TIME_EXCEEDED | ICMP6_EXC_FRAGTIME | Fragment reassembly time exceeded |
| ICMP6_PARAM_PROBLEM | ICMP6_ERR_HDR | Erroneous header field |
| ICMP6_PARAM_PROBLEM | ICMP6_UNRECO_NEXT_HDR | Unrecognized Next Header type |
| ICMP6_PARAM_PROBLEM | ICMP6_UNRECO_IP6_OPT | Unrecognized IPv6 option |
| ICMP6_MCAST_QUERY | -- | Multicast Listener Query |
| ICMP6_MCAST_REP | -- | Multicast Listener Report |
| ICMP6_MCAST_DONE | -- | Multicast Listener Done |
| ICMP6_RTER_SOLICIT | -- | Router Solicitation |
| ICMP6_RTER_ADVERT | -- | Router Advertisement |
| ICMP6_NBOR_SOLICIT | -- | Neighbor Solicitation |
| ICMP6_NBOR_ADVERT | -- | Neighbor Advertisement |
| ICMP6_REDIRECT_MSG | -- | Redirect Message |
| ICMP6_RTER_RENUM | ICMP6_RR_CMD (0) | Router Renumbering Command |
| ICMP6_RTER_RENUM | ICMP6_RR_RES (1) | Router Renumbering Result |
| ICMP6_RTER_RENUM | ICMP6_RR_RST (255) | Router Renum.: Sequence Number Reset |
| ICMP6_NODE_INFO_QUERY | ICMP6_NIQ_IP6 (0) | Node Info. Query: contains an IPv6 address |
| ICMP6_NODE_INFO_QUERY | ICMP6_NIQ_NAME (1) | Contains a name or is empty (NOOP) |
| ICMP6_NODE_INFO_QUERY | ICMP6_NIQ_IP4 (2) | Contains an IPv4 address |
| ICMP6_NODE_INFO_RESP | ICMP6_NIR_SUCC (0) | Node Info. Response: Successful reply |
| ICMP6_NODE_INFO_RESP | ICMP6_NIR_DENIED (1) | Responder refuses to answer |
| ICMP6_NODE_INFO_RESP | ICMP6_NIR_UNKN (2) | Qtype of the query unknown |
| ICMP6_INV_NBOR_DSM | -- | Inverse Neighbor Discovery Solicitation Msg |

| Type | Code | Description |
|---|---|---|
| ICMP6_INV_NBOR_DAM | -- | Inverse Neighbor Disc. Advertisement Msg |
| ICMP6_MLD2 | -- | Version 2 Multicast Listener Report |
| ICMP6_ADDR_DISC_REQ | -- | Home Agent Address Discovery Request Msg |
| ICMP6_ADDR_DISC_REP | -- | Home Agent Address Discovery Reply Msg |
| ICMP6_MOB_PREF_SOL | -- | Mobile Prefix Solicitation |
| ICMP6_MOB_PREF_ADV | -- | Mobile Prefix Advertisement |
| ICMP6_CERT_PATH_SOL | -- | Certification Path Solicitation Message |
| ICMP6_CERT_PATH_ADV | -- | Certification Path Advertisement Message |
| ICMP6_EXP_MOBI | -- | Experimental mobility protocols |
| ICMP6_MRD_ADV | -- | Multicast Router Advertisement |
| ICMP6_MRD_SOL | -- | Multicast Router Solicitation |
| ICMP6_MRD_TERM | -- | Multicast Router Termination |
| ICMP6_FMIPV6 | -- | FMIPv6 Messages |
| ICMP6_RPL_CTRL | -- | RPL Control Message |
| ICMP6_ILNP_LOC_UP | -- | ILNPv6 Locator Update Message |
| ICMP6_DUP_ADDR_REQ | -- | Duplicate Address Request |
| ICMP6_DUP_ADDR_CONF | -- | Duplicate Address Confirmation |

## 21.8 Post-Processing

### 21.8.1 icmpX

The `icmpX` script extracts all ICMP flows and their parents (flows which caused the ICMP message) from a flow file. Run `./icmpX --help` for more information.

### 21.8.2 protStat

The `protStat` script can be used to sort the `PREFIX_icmpStats.txt` file for the most or least occurring types and codes. It can output the top or bottom *N* protocols or only those with at least a given percentage:

- list all the options: `protStat --help`
- for better readability, use `protStat` with `tcol`: `protStat ... | tcol`
- sorted list of types (by packets):

```
protStat PREFIX_icmpStats.txt
```

- top 10 ICMP types and codes (by packets):

```
protStat PREFIX_icmpStats.txt -n 10 -icmp
```

- bottom 5 ICMPv6 types and codes (by packets):

```
protStat PREFIX_icmpStats.txt -n -5 -icmpv6
```

- ICMP and ICMPv6 types and codes with packets percentage greater than 20%:

```
protStat PREFIX_icmpStats.txt -p 20
```

- ICMP and ICMPv6 types and codes with packets percentage smaller than 5%:

```
protStat PREFIX_icmpStats.txt -p -5
```

# 22 igmpDecode

## 22.1 Description

This plugin analyzes IGMP traffic and provides absolute and relative statistics to the PREFIX_igmpStats.txt file.

## 22.2 Required Files

None

## 22.3 Configuration Flags

The following flags can be used to control the output of the plugin:

| Name | Default | Description |
|---|---|---|
| IGMP_STATFILE | 1 | Print IGMP statistics in a separate file |
| IGMP_NOCODE | "-" | Symbol to use to represent the absence of a code |
| IGMP_SUFFIX | "_igmpStats.txt" | Suffix for output file |

### 22.3.1 Environment Variable Configuration Flags

The following configuration flags can also be configured with environment variables (ENVCNTRL>0):

- IGMP_NOCODE
- IGMP_SUFFIX

## 22.4 Flow File Output

The igmpDecode plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| igmpStat | H8 | Status | |
| igmpVersion | RI8 | Version | |
| igmpAType | H32 | Aggregated type | |
| igmpMCastAddr | IP4 | Multicast address | |
| igmpNRec | U16 | Number of records | |

### 22.4.1 igmpStat

The igmpStat column is to be interpreted as follows:

| igmpStat | Description |
|---|---|
| $2^0$ (=0x01) | IGMP message had invalid length |
| $2^1$ (=0x02) | IGMP message had invalid checksum |
| $2^2$ (=0x04) | IGMP message had invalid TTL ($\neq 1$) |

| igmpStat | Description |
|---|---|
| $2^3$ (=0x08) | IGMP message was invalid for other reasons |

## 22.5 Plugin Report Output

The following information is reported:

- Aggregated igmpStat
- Number of IGMP packets
- Number of IGMP queries
- Number of IGMP reports
- IGMP query / report ratio

## 22.6 Additional Output

The plugin exports global statistics about IGMP traffic in the PREFIX_igmpStats.txt file. Note that the default suffix of "_igmpStats.txt" can be changed by editing the IGMP_SUFFIX flag.

## 22.7 Post-Processing

The protStat script can be used to sort the PREFIX_igmpStats.txt file for the most or least occurring types and codes. It can output the top or bottom *N* protocols or only those with at least a given percentage:

- list all the options: protStat --help
- for better readability, use protStat with tcol: protStat ... | tcol
- sorted list of types (by packets): protStat PREFIX_igmpStats.txt
- top 10 IGMP types and codes (by packets): protStat PREFIX_igmpStats.txt -n 10
- bottom 5 IGMP types and codes (by packets): protStat PREFIX_igmpStats.txt -n -5
- IGMP types and codes with packets percentage greater than 20%: protStat PREFIX_igmpStats.txt -p 20
- IGMP types and codes with packets percentage smaller than 5%: protStat PREFIX_igmpStats.txt -p -5

# 23 ircDecode

## 23.1 Description

The ircDecode plugin analyzes IRC traffic. User defined compiler switches are in *ircDecode.h*.

## 23.2 Configuration Flags

The following flags can be used to control the output of the plugin:

| Name | Default | Description | Flags |
|---|---|---|---|
| IRC_SAVE | 0 | Save content to IRC_F_PATH | |
| IRC_RMDIR | 1 | Empty IRC_F_PATH before starting | IRC_SAVE=1 |
| IRC_CMD_AGGR | 1 | Aggregate IRC commands/response codes | |
| IRC_BITFIELD | 0 | Bitfield coding of IRC commands | |
| IRC_UXNMLN | 10 | maximal username length | |
| IRC_PXNMLN | 10 | maximal password length | |
| IRC_NXNMLN | 10 | maximal nickname length | |
| IRC_MXNMLN | 50 | maximal name length | |
| IRC_MAXUNM | 5 | Maximal number of users | |
| IRC_MAXPNM | 5 | Maximal number of passwords | |
| IRC_MAXNNM | 5 | Maximal number of nicknames | |
| IRC_MAXCNM | 20 | Maximal number of parameters | |
| IRC_F_PATH | "/tmp/IRCFILES/" | Path for extracted content | |

### 23.2.1 Environment Variable Configuration Flags

The following configuration flags can also be configured with environment variables (ENVCNTRL>0):

- IRC_RMDIR
- IRC_F_PATH

## 23.3 Flow File Output

The ircDecode plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| ircStat | H8 | Status | |
| ircCBF | H64 | Commands | IRC_BITFIELD=1 |
| ircCC | RSC | Command codes | |
| ircRC | RU16 | Response codes | |
| ircNumUser | U8 | Number of users | |
| ircUser | RS | Users | |
| ircNumPass | U8 | Number of passwords | |
| ircPass | RS | Passwords | |
| ircNumNick | U8 | Number of nicknames | |

| Column | Type | Description | Flags |
|---|---|---|---|
| ircNick | RS | Nicknames | |
| ircNumC | U8 | Number of parameters | |
| ircC | RS | Content | |

### 23.3.1 ircStat

The `ircStat` column is to be interpreted as follows:

| | ircStat | Description |
|---|---|---|
| $2^0$ | (=0x01) | IRC port found |
| $2^1$ | (=0x02) | IRC registration successful |
| $2^2$ | (=0x04) | IRC password incorrect |
| $2^3$ | (=0x08) | — |
| $2^4$ | (=0x10) | Unrecognized IRC command |
| $2^5$ | (=0x20) | File error (`IRC_SAVE=1` |
| $2^6$ | (=0x40) | Array string or filename overflow |
| $2^7$ | (=0x80) | Invalid format or parsing error |

### 23.3.2 ircCBF

The `ircCBF` column is to be interpreted as follows:

| ircCBF | Description |
|---|---|
| $2^{0}$ (=0x0000.0000.0000.0001) | ADMIN |
| $2^{1}$ (=0x0000.0000.0000.0002) | AWAY |
| $2^{2}$ (=0x0000.0000.0000.0004) | CAP |
| $2^{3}$ (=0x0000.0000.0000.0008) | CNOTICE |
| $2^{4}$ (=0x0000.0000.0000.0010) | CONNECT |
| $2^{5}$ (=0x0000.0000.0000.0020) | CPRIVMSG |
| $2^{6}$ (=0x0000.0000.0000.0040) | DIE |
| $2^{7}$ (=0x0000.0000.0000.0080) | ENCAP |
| $2^{8}$ (=0x0000.0000.0000.0100) | ERROR |
| $2^{9}$ (=0x0000.0000.0000.0200) | HELP |
| $2^{10}$ (=0x0000.0000.0000.0400) | INFO |
| $2^{11}$ (=0x0000.0000.0000.0800) | INVITE |
| $2^{12}$ (=0x0000.0000.0000.1000) | ISON |
| $2^{13}$ (=0x0000.0000.0000.2000) | JOIN |
| $2^{14}$ (=0x0000.0000.0000.4000) | KICK |
| $2^{15}$ (=0x0000.0000.0000.8000) | KILL |
| $2^{16}$ (=0x0000.0000.0001.0000) | KNOCK |
| $2^{17}$ (=0x0000.0000.0002.0000) | LINKS |
| $2^{18}$ (=0x0000.0000.0004.0000) | LIST |
| $2^{19}$ (=0x0000.0000.0008.0000) | LUSERS |
| $2^{20}$ (=0x0000.0000.0010.0000) | MODE |
| $2^{21}$ (=0x0000.0000.0020.0000) | MOTD |
| $2^{22}$ (=0x0000.0000.0040.0000) | NAMES |
| $2^{23}$ (=0x0000.0000.0080.0000) | NAMESX |
| $2^{24}$ (=0x0000.0000.0100.0000) | NICK |
| $2^{25}$ (=0x0000.0000.0200.0000) | NJOIN |
| $2^{26}$ (=0x0000.0000.0400.0000) | NOTICE |
| $2^{27}$ (=0x0000.0000.0800.0000) | OPER |
| $2^{28}$ (=0x0000.0000.1000.0000) | PART |
| $2^{29}$ (=0x0000.0000.2000.0000) | PASS |
| $2^{30}$ (=0x0000.0000.4000.0000) | PING |
| $2^{31}$ (=0x0000.0000.8000.0000) | PONG |

| ircCBF | Description |
|---|---|
| $2^{32}$ (=0x0000.0001.0000.0000) | PRIVMSG |
| $2^{33}$ (=0x0000.0002.0000.0000) | QUIT |
| $2^{34}$ (=0x0000.0004.0000.0000) | REHASH |
| $2^{35}$ (=0x0000.0008.0000.0000) | RESTART |
| $2^{36}$ (=0x0000.0010.0000.0000) | RULES |
| $2^{37}$ (=0x0000.0020.0000.0000) | SERVER |
| $2^{38}$ (=0x0000.0040.0000.0000) | SERVICE |
| $2^{39}$ (=0x0000.0080.0000.0000) | SERVLIST |
| $2^{40}$ (=0x0000.0100.0000.0000) | SETNAME |
| $2^{41}$ (=0x0000.0200.0000.0000) | SILENCE |
| $2^{42}$ (=0x0000.0400.0000.0000) | SQUERY |
| $2^{43}$ (=0x0000.0800.0000.0000) | SQUIT |
| $2^{44}$ (=0x0000.1000.0000.0000) | STATS |
| $2^{45}$ (=0x0000.2000.0000.0000) | SUMMON |
| $2^{46}$ (=0x0000.4000.0000.0000) | TIME |
| $2^{47}$ (=0x0000.8000.0000.0000) | TOPIC |
| $2^{48}$ (=0x0001.0000.0000.0000) | TRACE |
| $2^{49}$ (=0x0002.0000.0000.0000) | UHNAMES |
| $2^{50}$ (=0x0004.0000.0000.0000) | USER |
| $2^{51}$ (=0x0008.0000.0000.0000) | USERHOST |
| $2^{52}$ (=0x0010.0000.0000.0000) | USERIP |
| $2^{53}$ (=0x0020.0000.0000.0000) | USERS |
| $2^{54}$ (=0x0040.0000.0000.0000) | VERSION |
| $2^{55}$ (=0x0080.0000.0000.0000) | WALLOPS |
| $2^{56}$ (=0x0100.0000.0000.0000) | WATCH |
| $2^{57}$ (=0x0200.0000.0000.0000) | WHO |
| $2^{58}$ (=0x0400.0000.0000.0000) | WHOIS |
| $2^{59}$ (=0x0800.0000.0000.0000) | WHOWAS |
| $2^{60}$ (=0x1000.0000.0000.0000) | - |
| $2^{61}$ (=0x2000.0000.0000.0000) | - |
| $2^{62}$ (=0x4000.0000.0000.0000) | - |
| $2^{63}$ (=0x8000.0000.0000.0000) | Not supported |

## 23.4 Plugin Report Output

The following information is reported:

- Aggregated `ircStat`

- Number of IRC packets

# 24 jsonSink

## 24.1 Description

The jsonSink plugin generates JSON output in a file `PREFIX_flows.json`, where `PREFIX` is provided via Tranalyzer `-w` or `-W` option.

## 24.2 Dependencies

### 24.2.1 External Libraries

If gzip compression is activated (`JSON_GZ_COMPRESS=1`), then **zlib** must be installed.

| | | JSON_GZ_COMPRESS=1 |
|---|---|---|
| **Ubuntu:** | `sudo apt-get install` | `zlib1g-dev` |
| **Arch:** | `sudo pacman -S` | `zlib` |
| **Gentoo:** | `sudo emerge` | `zlib` |
| **openSUSE:** | `sudo zypper install` | `zlib-devel` |
| **Red Hat/Fedora**[13]**:** | `sudo dnf install` | `zlib-devel` |
| **macOS**[14]**:** | `brew install` | `zlib` |

### 24.2.2 Core Configuration

This plugin requires the following core configuration:

- *$T2HOME/tranalyzer2/src/tranalyzer.h*:
  - `BLOCK_BUF=0`

## 24.3 Configuration Flags

The following flags can be used to control the output of the plugin:

| Name | Default | Description | Flags |
|---|---|---|---|
| `JSON_SOCKET_ON` | 0 | Output to a socket (1) or to a file (0) | |
| `JSON_SOCKET_ADDR` | `"127.0.0.1"` | Address of the socket | `JSON_SOCKET_ON=1` |
| `JSON_SOCKET_PORT` | 5000 | Port of the socket | `JSON_SOCKET_ON=1` |
| `JSON_GZ_COMPRESS` | 0 | Compress (gzip) the output | |
| `JSON_SPLIT` | 1 | Split the output file (Tranalyzer `-W` option) | `JSON_SOCKET_ON=0` |
| `JSON_ROOT_NODE` | 0 | Add a root node (array) | |
| `JSON_SUPPRESS_EMPTY_ARRAY` | 1 | Do not output empty fields | |
| `JSON_NO_SPACES` | 1 | Suppress unnecessary spaces | |

[13] If the `dnf` command could not be found, try with `yum` instead
[14] Brew is a packet manager for macOS that can be found here: https://brew.sh

| Name | Default | Description | Flags |
|---|---|---|---|
| JSON_BUFFER_SIZE | 1048576 | Size of output buffer | |
| JSON_SELECT | 0 | Only output specific fields | |
| JSON_SELECT_FILE | "json-columns.txt" | Filename of the field selector (one column name per line) | JSON_SELECT=1 |
| JSON_SUFFIX | "_flows.json" | Suffix for output file | JSON_SOCKET_ON=0 |

### 24.3.1 Environment Variable Configuration Flags

The following configuration flags can also be configured with environment variables (ENVCNTRL>0):

- JSON_BUFFER_SIZE
- JSON_SOCKET_ADDR (require JSON_SOCKET_ON=1)
- JSON_SOCKET_PORT (require JSON_SOCKET_ON=1)
- JSON_SUFFIX (require JSON_SOCKET_ON=0)
- JSON_SELECT_FILE

## 24.4 Plugin Report Output

The following information is reported:

- Number of flows discarded due to main buffer problems

## 24.5 Custom File Output

- PREFIX_flows.json: JSON representation of Tranalyzer output

## 24.6 Output Selected Fields Only

When JSON_SELECT=1, the columns to output can be customized with the help of JSON_SELECT_FILE. The filename defaults to json-columns.txt in the user plugin folder, e.g., *~/.tranalyzer/plugins*. The format of the file is simply one field name per line with lines starting with a '#' being ignored. For example, to only output source and destination addresses and ports, create the following file:

```
# Lines starting with a '#' are ignored and can be used to add comments
srcIP
srcPort
dstIP
dstPort
```

## 24.7 Example

To send compressed data over a socket (`JSON_SOCKET_ON=1` and `JSON_GZ_COMPRESS=1`):

1. `nc -l 127.0.0.1 5000 | gunzip`
2. `tranalyzer -r file.pcap`

# 25 kafkaSink

## 25.1 Description

The kafkaSink plugin outputs flows to an Apache Kafka event streaming platform.

## 25.2 Dependencies

### 25.2.1 External Libraries

This plugin depends on the **librdkafka** library.

| | | OPT2=1 |
|---|---|---|
| **Ubuntu:** | `sudo apt-get install` | `librdkafka-dev` |
| **Arch:** | `sudo pacman -S` | `librdkafka` |
| **Gentoo:** | `sudo emerge` | `librdkafka` |
| **openSUSE:** | `sudo zypper install` | `librdkafka-devel` |
| **Red Hat/Fedora**[15]**:** | `sudo dnf install` | `librdkafka-devel` |
| **macOS**[16]**:** | `brew install` | `librdkafka` |

### 25.2.2 Core Configuration

This plugin requires the following core configuration:

- *$T2HOME/tranalyzer2/src/tranalyzer.h*:
  - `BLOCK_BUF=0`

## 25.3 Services Initialization

The kafkaSink plugin requires a ZooKeeper and a Kafka broker service running on `KAFKA_BROKERS` (default address and port are `127.0.0.1:9092`).

```
# Start the ZooKeeper server and send it to the background
$ zookeeper-server-start.sh /etc/kafka/zookeeper.properties &

# Start the Kafka server and send it to the background
$ kafka-server-start.sh /etc/kafka/server.properties &
```

[15] If the `dnf` command could not be found, try with `yum` instead
[16] Brew is a packet manager for macOS that can be found here: `https://brew.sh`

## 25.4 Configuration Flags

The following flags can be used to control the output of the plugin:

| Name | Default | Description |
|---|---|---|
| KAFKA_BROKERS | "127.0.0.1:9092" | Broker address(es)<br>(comma separated list of host[:port]) |
| KAFKA_TOPIC | "tranalyzer.flows" | Topic to produce to |
| KAFKA_PARTITION | -1 | Target partition:<br>$\geq 0$: fixed partition<br>-1: automatic partitioning (unassigned) |
| KAFKA_RETRIES | 3 | Max. number of retries when message production failed [0 - 255] |
| KAFKA_DEBUG | 0 | Print debug messages |

### 25.4.1 Environment Variable Configuration Flags

The following configuration flags can also be configured with environment variables (ENVCNTRL>0):

- KAFKA_BROKERS
- KAFKA_TOPIC
- KAFKA_PARTITION

## 25.5 Plugin Report Output

The following information is reported:

- Number of flows discarded

## 25.6 Example

In this example, the flows will be sent to Kafka to the tranalyzer.flows topic. In addition, Tranalyzer information ([INF]) and warnings ([WRN]) will be sent to the tranalyzer.out, while errors ([ERR]) will use the tranalyzer.err topic.

First, we want to prevent Tranalyzer from coloring the output:

```
$ t2conf tranalyzer2 -D T2_LOG_COLOR=0
```

In this example, only the basicFlow and kafkaSink plugins will be used:

```
$ t2build tranalyzer2 basicFlow kafkaSink
```

Now, the fun part! Run Tranalyzer as per usual, but redirect stdout and stderr to a kcat[17] process, which will send the data to Kafka:

[17] kcat was formerly known as kafkacat

```
$ t2 -r file.pcap \
       1> >(grep -F -e "[INF]" -e "[WRN]" | kcat -P -b 127.0.0.1:9092 -t tranalyzer.out) \
       2> >(kcat -P -b 127.0.0.1:9092 -t tranalyzer.err)
```

The messages can now be consumed with the help of `kafka-console-consumer`.

```
# Consume messages for tranalyzer.flows topic
$ kafka-console-consumer \
       --bootstrap-server localhost:9092 \
       --from-beginning \
       --topic tranalyzer.flows

# Consume messages for tranalyzer.out topic
$ kafka-console-consumer \
       --bootstrap-server localhost:9092 \
       --from-beginning \
       --topic tranalyzer.out

# Consume messages for tranalyzer.err topic
$ kafka-console-consumer \
       --bootstrap-server localhost:9092 \
       --from-beginning \
       --topic tranalyzer.err
```

# 26 lldpDecode

## 26.1 Description

The lldpDecode plugin analyzes LLDP traffic.

## 26.2 Dependencies

### 26.2.1 Core Configuration

This plugin requires the following core configuration:

- *$T2HOME/tranalyzer2/src/networkHeaders.h*:
  - `ETH_ACTIVATE>0`

## 26.3 Configuration Flags

The following flags can be used to control the output of the plugin:

| Name | Default | Description |
|---|---|---|
| `LLDP_TTL_AGGR` | 1 | Aggregate TTL values |
| `LLDP_NUM_TTL` | 8 | Number of different TTL values to store |
| `LLDP_OPT_TLV` | 1 | Output optional TLVs info |
| `LLDP_STRLEN` | 20 | Maximum length of short strings to store |
| `LLDP_LSTRLEN` | 100 | Maximum length of long strings to store |

## 26.4 Flow File Output

The lldpDecode plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| `lldpStat` | H16 | Status | |
| `lldpTTL` | R(U16) | Time To Live (sec) | |
| `lldpTLVTypes` | H32 | TLV types | |
| `lldpChassis` | SC | Chassis ID | |
| `lldpPort` | S | Port ID | |
| `lldpPortDesc` | S | Port description | `LLDP_OPT_TLV=1` |
| `lldpSysName` | S | System name | `LLDP_OPT_TLV=1` |
| `lldpSysDesc` | S | System description | `LLDP_OPT_TLV=1` |
| `lldpCaps_enCaps` | H16_H16 | Supported and enabled capabilities | `LLDP_OPT_TLV=1` |
| `lldpMngmtAddr` | SC | Management address | `LLDP_OPT_TLV=1` |

### 26.4.1 lldpStat

The `lldpStat` column is to be interpreted as follows:

| lldpStat | Description |
|---|---|
| 0x0001 | Flow is LLDP |
| 0x0002 | Mandatory TLV missing |
| 0x0004 | Optional TLV present |
| 0x0008 | Reserved TLV type/subtype used |
| 0x0010 | Organization specific TLV used |
| 0x0020 | Unhandled TLV used |
| 0x0040 | Invalid TLV length |
| 0x0080 | — |
| 0x0100 | — |
| 0x0200 | — |
| 0x0400 | — |
| 0x0800 | — |
| 0x1000 | — |
| 0x2000 | String truncated... increase LLDP_STRLEN |
| 0x4000 | Too many TTL... increase LLDP_NUM_TTL |
| 0x8000 | Snapped payload |

### 26.4.2 lldpTLVTypes

The lldpTLVTypes column is to be interpreted as follows:

| lldpTLVTypes | Description |
|---|---|
| $2^0$ (=0x0000 0001) | End of LLDPDU |
| $2^1$ (=0x0000 0002) | Chassis ID |
| $2^2$ (=0x0000 0004) | Port ID |
| $2^3$ (=0x0000 0008) | Time To Live (sec) |
| $2^4$ (=0x0000 0010) | Port description |
| $2^5$ (=0x0000 0020) | System name |
| $2^6$ (=0x0000 0040) | System description |
| $2^7$ (=0x0000 0080) | System capabilities |
| $2^8$ (=0x0000 0100) | Management address |
| TLV types 9 to 126 are reserved | |
| $2^{31}$ (=0x8000 0000) | TLV type $\geq 31$ |

### 26.4.3 lldpCaps_enCaps

The lldpCaps_enCaps column is to be interpreted as follows:

| lldpCaps/lldpEnCaps | Description |
|---|---|
| 0x0001 | Other |
| 0x0002 | Repeater |
| 0x0004 | Bridge |
| 0x0008 | WLAN access point |
| 0x0010 | Router |
| 0x0020 | Telephone |
| 0x0040 | DOCSIS cable device |
| 0x0080 | Station only |
| 0x0100-0x8000 | Reserved |

## 26.5 Packet File Output

In packet mode (`-s` option), the lldpDecode plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| lldpStat | H16 | Status | |
| lldpTTL | U16 | Time To Live (sec) | |
| lldpTLVTypes | H32 | TLV types | |
| lldpChassis | SC | Chassis ID | |
| lldpPort | SC | Port ID | |
| lldpPortDesc | SC | Port description | LLDP_OPT_TLV=1 |
| lldpSysName | SC | System name | LLDP_OPT_TLV=1 |
| lldpCaps_enCaps | H16_H16 | Supported and enabled capabilities | LLDP_OPT_TLV=1 |
| lldpMngmtAddr | SC | Management address | LLDP_OPT_TLV=1 |

## 26.6 Monitoring Output

In monitoring mode, the lldpDecode plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| lldpPkts | U64 | Number of LLDP packets | |

## 26.7 Plugin Report Output

The following information is reported:

- Aggregated lldpStat
- Aggregated lldpTLVTypes
- Aggregated lldpCaps_enCaps
- Number of LLDP packets

# 27 macRecorder

## 27.1 Description

The macRecorder plugin provides the source- and destination MAC address as well as the number of packets detected in the flow separated by an underscore. If there is more than one combination of MAC addresses, e.g., due to load balancing or router misconfiguration, the plugin prints all recognized MAC addresses separated by semicolons. The number of distinct source- and destination MAC addresses can be output by activating the `MR_NPAIRS` flag. The `MR_MANUF` flags controls the output of the manufacturers for the source and destination addresses. The representation of MAC addresses can be altered using the `MR_MAC_FMT` flag.

## 27.2 Dependencies

### 27.2.1 Required Files

The file `manuf.txt` is required if `MR_MANUF > 0` and file `maclbl.txt` is required if `MR_MACLBL > 0`.

## 27.3 Configuration Flags

The following flags can be used to control the output of the plugin:

| Name | Default | Description | Flags |
|---|---|---|---|
| `MR_MAC_FMT` | 1 | Format for MAC addresses:<br>0: hex,<br>1: mac,<br>2: int | |
| `MR_NPAIRS` | 1 | Report number of distinct MAC/IP pairs | |
| `MR_MACLBL` | 2 | Format for MAC addresses labels<br>0: no labels,<br>1: numerical (int),<br>2: short Organization<br>3: full Organization | |
| `MR_MAX_MAC` | 16 | Max number of MAC addresses per flow | |
| `MR_NO_MANUF` | `"-"` | Representation of unknown manufacturers | |

In addition, the following flags can be found in *macLbl.h*:

| Name | Default | Description | Flags |
|---|---|---|---|
| `MAC_SORGLEN` | 12 | Maximum length for 'who' information (short version) | |
| `MAC_ORGLEN` | 44 | Maximum length for 'who' information (long version) | |

Note that the name of the MAC label file to load can be controlled with `MACLBLFILE` in *macLbl.h*.

## 27.4 Flow File Output

The macRecorder plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| macStat | H8 | Status | |
| macPairs | U32 | Number of distinct src/dst MAC addresses pairs | MR_NPAIRS=1 |
| srcMac_dstMac_numP | R(H64_H64_U64) | Src/Dst MAC addresses, number of packets | MR_MAC_FMT=0 |
| srcMac_dstMac_numP | R(MAC_MAC_U64) | Src/Dst MAC addresses, number of packets | MR_MAC_FMT=1 |
| srcMac_dstMac_numP | R(U64_U64_U64) | Src/Dst MAC addresses, number of packets | MR_MAC_FMT=2 |
| srcMacLbl_dstMacLbl | R(U32_U32) | Src/Dst MAC label (numerical) | MR_MACLBL=1 |
| srcMacLbl_dstMacLbl | R(SC_SC) | Src/Dst MAC label (string_class) | MR_MACLBL=2 |
| srcMacLbl_dstMacLbl | R(S_S) | Src/Dst MAC label (string) | MR_MACLBL=3 |

### 27.4.1 macStat

The macStat column is to be interpreted as follows:

| macStat | Description |
|---|---|
| 0x01 | MAC list overflow... increase MR_MAX_MAC |

## 27.5 Packet File Output

In packet mode (-s option), the macRecorder plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| srcMacLbl | S | Source MAC label | MR_MACLBL>0 |
| dstMacLbl | S | Destination MAC label | MR_MACLBL>0 |

## 27.6 Plugin Report Output

The following information is reported:

- Aggregated macStat
- MAC pairs per flow: min, max, average

## 27.7 Example Output

Consider a host with MAC address aa:aa:aa:aa:aa:aa in a local network requesting a website from a public server. Due to load balancing, the opposite flow can be split and transmitted via two routers with MAC addresses bb:bb:bb:bb:bb:bb and cc:cc:cc:cc:cc:cc. The macRecorder plugin then produces the following output in default configuration:

```
bb:bb:bb:bb:bb:bb_aa:aa:aa:aa:aa:aa_667;cc:cc:cc:cc:cc:cc_aa:aa:aa:aa:aa:aa_666
```

# 28 mndpDecode

## 28.1 Description

The mndpDecode plugin analyzes MNDP traffic.

## 28.2 Configuration Flags

The following flags can be used to control the output of the plugin:

| Name | Default | Description | Flags |
|---|---|---|---|
| MNDP_SAVE | 0 | Save MNDP messages in a separate file | |
| MNDP_DEBUG | 0 | Print debug messages | |
| MNDP_LSTLEN | 5 | Max number of elements for lists | |
| MNDP_STRLEN | 32 | Max length for strings | |
| MNDP_SUFFIX | "_mndp.txt" | Suffix for output file | |

### 28.2.1 Environment Variable Configuration Flags

The following configuration flags can also be configured with environment variables (ENVCNTRL>0):

- MNDP_SUFFIX

## 28.3 Flow File Output

The mndpDecode plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| mndpStat | H8 | Status | |
| mndpMAC | R(MAC) | MAC-Address | MNDP_LSTLEN>0 |
| mndpIdentity | R(STR) | Identity | MNDP_LSTLEN>0 |
| mndpVersion | R(STR) | Version | MNDP_LSTLEN>0 |
| mndpPlatform | R(STR) | Platform | MNDP_LSTLEN>0 |
| mndpSoftwareID | R(STR) | Software-ID | MNDP_LSTLEN>0 |
| mndpBoard | R(STR) | Board | MNDP_LSTLEN>0 |
| mndpUnpack | R(U8) | Packet compression type | MNDP_LSTLEN>0 |
| mndpIface | R(STR) | Interface name | MNDP_LSTLEN>0 |
| mndpIPv4 | R(IP4) | IPv4-Address | MNDP_LSTLEN>0 |
| mndpIPv6 | R(IP6) | IPv6-Address | MNDP_LSTLEN>0 |

### 28.3.1 mndpStat

The mndpStat column is to be interpreted as follows:

| mndpStat | Description |
|---|---|
| 0x01 | Flow is MNDP |

| mndpStat | Description |
|---|---|
| 0x02 | IPv4 address |
| 0x04 | IPv6 address |
| 0x08 | Unknown TLV type |
| 0x10 | Invalid TLV length, e.g., length of MAC address > 6 |
| 0x20 | List was truncated... increase MNDP_LSTLEN |
| 0x40 | String was truncated... increase MNDP_STRLEN |
| 0x80 | Packet was snapped |

## 28.4 Packet File Output

In packet mode (-s option), the mndpDecode plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| mndpStat | H8 | Status | |
| mndpSeqNo | U16 | Sequence Number | |
| mndpMAC | STR | MAC-Address | |
| mndpIdentity | STR | Identity | |
| mndpVersion | STR | Version | |
| mndpPlatform | STR | Platform | |
| mndpUptime | U32 | Uptime (seconds) | |
| mndpSoftwareID | STR | Software-ID | |
| mndpBoard | STR | Board | |
| mndpUnpack | U8 | Packet compression type | |
| mndpIface | STR | Interface name | |
| mndpIPv4 | IP4 | IPv4-Address | |
| mndpIPv6 | IP6 | IPv6-Address | |

## 28.5 Plugin Report Output

The following information is reported:

- Aggregated mndpStat
- Number of MNDP packets

## 28.6 Additional Output

Non-standard output:

- PREFIX_mndp.txt: MNDP messages

# 29 modbus

## 29.1 Description

The modbus plugin analyzes Modbus traffic.

## 29.2 Configuration Flags

The following flags can be used to control the output of the plugin:

| Name | Default | Description |
|---|---|---|
| MB_DEBUG | 0 | Activate debug output |
| MB_FE_FRMT | 0 | Function/Exception codes representation: 0: hex, 1: int |
| MB_NUM_FUNC | 0 | Number of function codes to store (0 to hide modbusFC) |
| MB_UNIQ_FUNC | 0 | Aggregate multiply defined function codes |
| MB_NUM_FEX | 0 | Number of function codes causing exceptions to store (0 to hide modbusFEx) |
| MB_UNIQ_FEX | 0 | Aggregate multiply defined function codes causing exceptions |
| MB_NUM_EX | 0 | Number of exception codes to store (0 to hide modbusExC) |
| MB_UNIQ_EX | 0 | Aggregate multiply defined exception codes |

## 29.3 Flow File Output

The modbus plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| modbusStat | H16 | Status | |
| modbusUID | U8 | Unit identifier | |
| modbusNPkts | U32 | Number of Modbus packets | |
| modbusNumEx | U16 | Number of exceptions | |
| modbusFCBF | H64 | Aggregated function codes | |
| modbusFC | RH8 | List of function codes | MB_NUM_FUNC>0 |
| modbusFExBF | H64 | Aggregated function codes which caused exceptions | |
| modbusFEx | RH8 | List of function codes which caused exceptions | MB_NUM_FEX>0 |
| modbusExCBF | H16 | Aggregated exception codes | |
| modbusExC | RH8 | List of exception codes | MB_NUM_EX>0 |

### 29.3.1 modbusStat

The `modbusStat` column is to be interpreted as follows:

| modbusStat | Description |
|---|---|
| 0x0001 | Flow is Modbus |
| 0x0002 | Non-modbus protocol identifier |
| 0x0004 | Unknown function code |
| 0x0008 | Unknown exception code |
| | |
| 0x0010 | Multiple unit identifiers |
| 0x0020 | — |
| 0x0040 | — |
| 0x0080 | — |
| | |
| 0x0100 | List of function codes truncated... increase `MB_NUM_FUNC` |
| 0x0200 | List of function codes which caused exceptions truncated... increase `MB_NUM_FEX` |
| 0x0400 | List of exception codes truncated... increase `MB_NUM_EX` |
| 0x0800 | — |
| | |
| 0x1000 | — |
| 0x2000 | — |
| 0x4000 | Snapped packet |
| 0x8000 | Malformed packet |

### 29.3.2 modbusFC and modbusFCBF

The `modbusFC` and `modbusFCBF` columns are to be interpreted as follows:

| modbusFC | modbusFCBF | Description |
|---|---|---|
| 1 = 0x01 | 0x0000 0000 0000 0002 | Read Coils |
| 2 = 0x02 | 0x0000 0000 0000 0004 | Read Discrete Inputs |
| 3 = 0x03 | 0x0000 0000 0000 0008 | Read Multiple Holding Registers |
| | | |
| 4 = 0x04 | 0x0000 0000 0000 0010 | Read Input Registers |
| 5 = 0x05 | 0x0000 0000 0000 0020 | Write Single Coil |
| 6 = 0x06 | 0x0000 0000 0000 0040 | Write Single Holding Register |
| 7 = 0x07 | 0x0000 0000 0000 0080 | Read Exception Status |
| | | |
| 8 = 0x08 | 0x0000 0000 0000 0100 | Diagnostic |
| 11 = 0x0b | 0x0000 0000 0000 0800 | Get Com Event Counter |
| | | |
| 12 = 0x0c | 0x0000 0000 0000 1000 | Get Com Event Log |
| 15 = 0x0f | 0x0000 0000 0000 8000 | Write Multiple Coils |
| | | |
| 16 = 0x10 | 0x0000 0000 0001 0000 | Write Multiple Holding Registers |
| 17 = 0x11 | 0x0000 0000 0002 0000 | Report Slave ID |

| modbusFC | modbusFCBF | Description |
|---|---|---|
| 20 = 0x14 | 0x0000 0000 0010 0000 | Read File Record |
| 21 = 0x15 | 0x0000 0000 0020 0000 | Write File Record |
| 22 = 0x16 | 0x0000 0000 0040 0000 | Mask Write Register |
| 23 = 0x17 | 0x0000 0000 0080 0000 | Read/Write Multiple Registers |
| 24 = 0x18 | 0x0000 0000 0100 0000 | Read FIFO Queue |
| 43 = 0x2b | 0x0000 0800 0000 0000 | Read Decide Identification |

### 29.3.3 modbusFEx and modbusFExBF

The modbusFEx and modbusFExBF columns are to be interpreted as modbusFC and modbusFCBF, respectively.

### 29.3.4 modbusExC and modbusExCBF

The modbusExC and modbusExCBF column are to be interpreted as follows:

| modbusExC | modbusExCBF | Description |
|---|---|---|
| 1 = 0x01 | 0x0002 | Illegal function code |
| 2 = 0x02 | 0x0004 | Illegal data address |
| 3 = 0x03 | 0x0008 | Illegal data value |
| 4 = 0x04 | 0x0010 | Slave device failure |
| 5 = 0x05 | 0x0020 | Acknowledge |
| 6 = 0x06 | 0x0040 | Slave device busy |
| 7 = 0x07 | 0x0080 | Negative acknowledge |
| 8 = 0x08 | 0x0100 | Memory parity error |
| 10 = 0x0a | 0x0400 | Gateway path unavailable |
| 11 = 0x0b | 0x0800 | Gateway target device failed to respond |

## 29.4 Packet File Output

In packet mode (-s option), the modbus plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| mbTranId | U16 | Transaction Identifier | |
| mbProtId | U16 | Protocol Identifier | |
| mbLen | U16 | Length | |
| mbUnitId | U8 | Unit identifier | |
| mbFuncCode | H8 | Function code | MB_FE_FRMT=0 |
| mbFuncCode | U8 | Function code | MB_FE_FRMT=1 |

### 29.4.1 mbFuncCode

If `mbFuncCode` column is to be interpreted as follows:

| mbFuncCode | Description |
|---|---|
| $< 128$ `(=0x80)` | refer to modbusFC and modbusFCBF |
| $\geq 128$ `(=0x80)` | subtract 128 (=`0x80`) and refer to modbusFEx and modbusFExBF |

## 29.5 Monitoring Output

In monitoring mode, the modbus plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| `modbusNPkts` | U64 | Number of Modbus packets | |
| `modbusStat` | H16 | Status | |

## 29.6 Plugin Report Output

The following information is reported:

- Aggregated `modbusStat`
- Number of Modbus packets

# 30 mongoSink

## 30.1 Description

The mongoSink plugin outputs flows to a MongoDB database.

## 30.2 Dependencies

### 30.2.1 External Libraries

This plugin depends on the **libmongoc** library.

| | | |
|---|---|---|
| **Ubuntu:** | `sudo apt-get install` | `libmongoc-dev` |
| **Arch:** | `sudo pacman -S` | `mongo-c-driver` |
| **Gentoo:** | `sudo emerge` | `mongo-c-driver` |
| **Red Hat/Fedora**[18]**:** | `sudo dnf install` | `mongo-c-driver-devel` |
| **macOS**[19]**:** | `brew install` | `mongo-c-driver` |

### 30.2.2 Core Configuration

This plugin requires the following core configuration:

- *$T2HOME/tranalyzer2/src/tranalyzer.h*:
  - `BLOCK_BUF=0`

## 30.3 Configuration Flags

The following flags can be used to control the output of the plugin:

| Name | Default | Description |
|---|---|---|
| `MONGO_HOST` | `"127.0.0.1"` | Address of the database |
| `MONGO_PORT` | `27017` | Port the database is listening to |
| `MONGO_DBNAME` | `"tranalyzer"` | Name of the database |
| `MONGO_TABLE_NAME` | `"flow"` | Name of the database flow table |
| `MONGO_NUM_DOCS` | 1 | Number of documents (flows) to write in bulk |
| `MONGO_QRY_LEN` | 2048 | Max length for query |
| `MONGO_SELECT` | 0 | Only insert specific fields into the DB |
| `MONGO_SELECT_FILE` | `"mongo-columns.txt"` | Filename of the field selector (one column name per line) |
| `BSON_SUPPRESS_EMPTY_ARRAY` | 1 | Output empty fields |
| `BSON_DEBUG` | 0 | Print debug messages |

[18] If the `dnf` command could not be found, try with `yum` instead
[19] Brew is a packet manager for macOS that can be found here: `https://brew.sh`

### 30.3.1 Environment Variable Configuration Flags

The following configuration flags can also be configured with environment variables (ENVCNTRL>0):

- MONGO_HOST
- MONGO_PORT
- MONGO_DBNAME
- MONGO_TABLE_NAME
- MONGO_SELECT_FILE (require MONGO_SELECT=1)

## 30.4 Insertion of Selected Fields Only

When MONGO_SELECT=1, the columns to insert into the DB can be customized with the help of MONGO_SELECT_FILE. The filename defaults to mongo-columns.txt in the user plugin folder, e.g., *~/.tranalyzer/plugins*. The format of the file is simply one field name per line with lines starting with a '#' being ignored. For example, to only insert source and destination addresses and ports, create the following file:

```
# Lines starting with a '#' are ignored and can be used to add comments
srcIP
srcPort
dstIP
dstPort
```

## 30.5 Working with Timestamps (ISODate)

MongoDB stores timestamps in UTC as ISODate. To convert them to localtime, you may use the following query:

```
> db.flow.aggregate([{
      $project: {
          localTime: {
              $dateToString: {
                  date: "$timeFirst",
                  format: "%Y-%m-%d %H:%M:%S",
                  timezone: "Europe/Berlin"
              }
          }
      }
  }])
```

## 30.6 Example

```
# Run Tranalyzer
$ t2 -r file.pcap

# Connect to the Mongo database
$ mongosh tranalyzer
```

```
# Number of flows
> db.flow.countDocuments()

# 10 first srcIP/dstIP pairs
> db.flow.find({}, { _id:  0, srcIP: 1, dstIP: 1 }).limit(10)

# All flows from 1.2.3.4 to 1.2.3.5
> db.flow.find({ srcIP: "1.2.3.4", dstIP: "1.2.3.5" })
```

For examples of more complex queries, have a look in `$T2HOME/scripts/t2fm/mongo/`.

### 30.6.1 Clean up an existing database

```
# Connect to the Mongo database
$ mongosh tranalyzer

# Drop the database
> db.flow.drop()
```

# 31 mqttDecode

## 31.1 Description

The mqttDecode plugin analyzes the MQ Telemetry Transport Protocol (MQTT).

## 31.2 Configuration Flags

The following flags can be used to control the output of the plugin:

| Name | Default | Description | Flags |
|---|---|---|---|
| MQTT_TOPIC_MSG | 1 | save topics and messages in a separate file | |
| MQTT_PROTO_LEN | 32 | Max length for protocol name | |
| MQTT_CLIENT_ID_LEN | 32 | Max length for client ID | |
| MQTT_TOPIC_LEN | 32 | Max length for topic | |
| MQTT_TOPIC_MSG_SUFFIX | "_mqtt_msg.txt" | suffix to use for topics and messages file | MQTT_TOPIC_MSG=1 |

### 31.2.1 Environment Variable Configuration Flags

The following configuration flags can also be configured with environment variables (ENVCNTRL>0):

- MQTT_TOPIC_MSG_SUFFIX (require MQTT_TOPIC_MSG=1)

## 31.3 Flow File Output

The mqttDecode plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| mqttStat | H8 | Status | |
| mqttCPT | H16 | Control Packet Types | |
| mqttProto | SC | Protocol Name | |
| mqttProtoLevel | U8 | Protocol Level | |
| mqttClientID | SC | Client ID | |
| mqttConAck | H8 | Connection status | |
| mqttTopic | S | Topics | |

### 31.3.1 mqttStat

The mqttStat column is to be interpreted as follows:

| mqttStat | Description |
|---|---|
| 0x01 | Flow is MQTT |
| 0x02 | — |
| 0x04 | — |
| 0x08 | — |

| mqttStat | Description |
|---|---|
| 0x10 | Reserved Control Packet Type (mqttCPT) (0 or 15) was used |
| 0x20 | — |
| 0x40 | — |
| 0x80 | Packet snapped |

### 31.3.2 mqttCPT

The mqttCPT column is to be interpreted as follows:

| | mqttCPT | Description |
|---|---|---|
| $2^0$ | (=0x0001) | Reserved |
| $2^1$ | (=0x0002) | Client request to connect to server |
| $2^2$ | (=0x0004) | Connect acknowledgment |
| $2^3$ | (=0x0008) | Publish message |
| $2^4$ | (=0x0010) | Publish acknowledgment |
| $2^5$ | (=0x0020) | Publish complete (assured delivery part 1) |
| $2^6$ | (=0x0040) | Publish complete (assured delivery part 2) |
| $2^7$ | (=0x0080) | Publish complete (assured delivery part 3) |
| $2^8$ | (=0x0100) | Subscribe request |
| $2^9$ | (=0x0200) | Subscribe acknowledgment |
| $2^{10}$ | (=0x0400) | Unsubscribe request |
| $2^{11}$ | (=0x0800) | Unsubscribe acknowledgment |
| $2^{12}$ | (=0x1000) | PING request |
| $2^{13}$ | (=0x2000) | PING response |
| $2^{14}$ | (=0x4000) | Client is disconnecting |
| $2^{15}$ | (=0x8000) | Reserved |

### 31.3.3 mqttConAck

The mqttConAck column is to be interpreted as follows:

| mqttConAck | | Description |
|---|---|---|
| $2^0$ | (=0x01) | Connection Accepted |
| $2^1$ | (=0x02) | Connection Refused, unacceptable protocol version |
| $2^2$ | (=0x04) | Connection Refused, identifier rejects |
| $2^3$ | (=0x08) | Connection Refused, Server unavailable |
| $2^4$ | (=0x10) | Connection Refused, bad user name or password |
| $2^5$ | (=0x20) | Connection Refused, not authorized |

| mqttConAck | Description |
|---|---|
| $2^6$ (=0x40) | — |
| $2^7$ (=0x80) | Return codes from 0x06 to 0xff are reserved for future use |

## 31.4 Packet File Output

In packet mode (-s option), the mqttDecode plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| mqttStat | H8 | Status | |

## 31.5 Monitoring Output

In monitoring mode, the mqttDecode plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| mqttPkts | U64 | Number of MQTT packets | |

## 31.6 Plugin Report Output

The following information is reported:

- Aggregated mqttStat
- Number of MQTT packets
- Aggregated mqttCPT
- Aggregated mqttConAck

## 31.7 Additional Output

Non-standard output:

- PREFIX_mqtt_msg.txt: list of topics and messages

# 32 mysqlSink

## 32.1 Description

The mysqlSink plugin outputs flows to a MariaDB / MySQL database.

## 32.2 Dependencies

### 32.2.1 External Libraries

This plugin depends on the **MariaDB** or **MySQL** library.

| | | **MariaDB** | **MySQL** |
|---|---|---|---|
| **Ubuntu:** | `sudo apt-get install` | `libmariadb-dev` | `libmysqlclient-dev` |
| **Arch:** | `sudo pacman -S` | `mariadb-libs` | |
| **Gentoo:** | `sudo emerge` | `mariadb-connector-c` | `mysql-connector-c` |
| **openSUSE:** | `sudo zypper install` | `libmariadb-devel` | |
| **Red Hat/Fedora**[20]**:** | `sudo dnf install` | `mariadb-connector-c-devel` | `community-mysql-devel` |
| **macOS**[21]**:** | `brew install` | `mariadb-connector-c` | |

### 32.2.2 Core Configuration

This plugin requires the following core configuration:

- *$T2HOME/tranalyzer2/src/tranalyzer.h*:
  - `BLOCK_BUF=0`

## 32.3 Database Setup

### 32.3.1 Create a User with Create and Write Permissions

```
$ sudo mysql -u root mysql
...
MariaDB [mysql]> create user 'mysql'@'localhost' identified by 'mysql';
MariaDB [mysql]> grant all privileges on *.* to 'mysql'@'localhost' with grant option;
```

## 32.4 Configuration Flags

The following flags can be used to control the output of the plugin:

| **Name** | **Default** | **Description** |
|---|---|---|
| `MYSQL_OVERWRITE_DB` | 2 | 0: abort if DB already exists<br>1: overwrite DB if it already exists<br>2: reuse DB if it already exists |

[20] If the `dnf` command could not be found, try with `yum` instead
[21] Brew is a packet manager for macOS that can be found here: https://brew.sh

| Name | Default | Description |
|---|---|---|
| MYSQL_OVERWRITE_TABLE | 2 | 0: abort if table already exists<br>1: overwrite table if it already exists<br>2: append to table if it already exists |
| MYSQL_TRANSACTION_NFLOWS | 40000 | 0: one transaction<br>> 0: one transaction every *n* flows |
| MYSQL_QRY_LEN | 32768 | Max length for query |
| MYSQL_HOST | "127.0.0.1" | Address of the database |
| MYSQL_DBPORT | 3306 | Port the DB is listening to |
| MYSQL_USER | "mysql" | Username to connect to DB |
| MYSQL_PASS | "mysql" | Password to connect to DB |
| MYSQL_DBNAME | "tranalyzer" | Name of the database |
| MYSQL_TABLE_NAME | "flow" | Name of the table |
| MYSQL_SELECT | 0 | Only insert specific fields into the DB |
| MYSQL_SELECT_FILE | "mysql-columns.txt" | Filename of the field selector (one column name per line) |

### 32.4.1 Environment Variable Configuration Flags

The following configuration flags can also be configured with environment variables (ENVCNTRL>0):

- MYSQL_HOST
- MYSQL_DBPORT
- MYSQL_USER
- MYSQL_PASS
- MYSQL_DBNAME
- MYSQL_TABLE_NAME
- MYSQL_SELECT_FILE (require MYSQL_SELECT=1)

## 32.5 Insertion of Selected Fields Only

When MYSQL_SELECT=1, the columns to insert into the DB can be customized with the help of MYSQL_SELECT_FILE. The filename defaults to mysql-columns.txt in the user plugin folder, e.g., *~/.tranalyzer/plugins*. The format of the file is simply one field name per line with lines starting with a '#' being ignored. For example, to only insert source and destination addresses and ports, create the following file:

```
# Lines starting with a '#' are ignored and can be used to add comments
srcIP
srcPort
dstIP
dstPort
```

## 32.6 Example

```
# Run Tranalyzer
$ t2 -r file.pcap
# Connect to the MySQL database
$ mysql tranalyzer
# Number of flows
MariaDB [tranalyzer]> select count(*) from flow;
# 10 first srcIP/dstIP pairs
MariaDB [tranalyzer]> select "srcIP", "dstIP" from flow limit 10;
# All flows from 1.2.3.4 to 1.2.3.5
MariaDB [tranalyzer]> select * from flow where "srcIP" = '1.2.3.4' and "dstIP" = '1.2.3.5';
```

# 33 nDPI

## 33.1 Description

This plugin is a simple wrapper around the nDPI library: https://github.com/ntop/nDPI. It classifies flows according to their protocol/application by analyzing the payload content instead of using the destination port. This plugin produces output to the flow file and to a protocol statistics file. Configuration is achieved by user defined compiler switches in `src/nDPI.h`.

## 33.2 Dependencies

### 33.2.1 External Libraries

This plugin depends on the **libgcrypt** library.

| | | |
|---|---|---|
| **Ubuntu:** | `sudo apt-get install` | `libgcrypt20-dev` |
| **Arch:** | `sudo pacman -S` | `libgcrypt` |
| **Gentoo:** | `sudo emerge` | `libgcrypt` |
| **openSUSE:** | `sudo zypper install` | `libgcrypt-devel` |
| **Red Hat/Fedora**[22]**:** | `sudo dnf install` | `libgcrypt-devel` |
| **macOS**[23]**:** | `brew install` | `libgcrypt` |

## 33.3 Configuration Flags

The following flags can be used to control the output of the plugin:

| Variable | Default | Description |
|---|---|---|
| `NDPI_OUTPUT_NUM` | 0 | Output a numerical classification |
| `NDPI_OUTPUT_STR` | 1 | Output a textual classification |
| `NDPI_OUTPUT_STATS` | 1 | Output nDPI protocol distribution in a separate file |
| `NDPI_GUESS_UNKNOWN` | 1 | Try guessing unknown protocols |

## 33.4 Flow File Output

The nDPI plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| `nDPIMstrProto` | U16 | nDPI numerical master protocol | `NDPI_OUTPUT_NUM=1` |
| `nDPISubProto` | U16 | nDPI numerical sub protocol | `NDPI_OUTPUT_NUM=1` |
| `nDPIclass` | S | nDPI based protocol classification | `NDPI_OUTPUT_STR=1` |

[22] If the `dnf` command could not be found, try with `yum` instead
[23] Brew is a packet manager for macOS that can be found here: https://brew.sh

## 33.5 Packet File Output

In packet mode (`-s` option), the nDPI plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| nDPIMstrProto | U16 | nDPI numerical master protocol | NDPI_OUTPUT_NUM=1 |
| nDPISubProto | U16 | nDPI numerical sub protocol | NDPI_OUTPUT_NUM=1 |
| nDPIclass | S | nDPI based protocol classification | NDPI_OUTPUT_STR=1 |

## 33.6 nDPIMstrProto

The `nDPIMstrProto` column is to be interpreted as follows:

**0** Unknown
**1** FTP_CONTROL
**2** POP3
**3** SMTP
**4** IMAP
**5** DNS
**6** IPP
**7** HTTP
**8** MDNS
**9** NTP
**10** NetBIOS
**11** NFS
**12** SSDP
**13** BGP
**14** SNMP
**15** XDMCP
**16** SMBv1
**17** Syslog
**18** DHCP
**19** PostgreSQL
**20** MySQL
**21** Outlook
**22** VK
**23** POPS
**24** Tailscale
**25** Yandex
**26** ntop
**27** COAP
**28** VMware
**29** SMTPS
**30** DTLS
**31** UBNTAC2
**32** Kontiki
**33** YandexMail
**34** YandexMusic
**35** Gnutella
**36** eDonkey
**37** BitTorrent
**38** Skype_TeamsCall
**39** Signal
**40** Memcached
**41** SMBv23
**42** Mining
**43** NestLogSink
**44** Modbus
**45** WhatsAppCall
**46** DataSaver
**47** Xbox
**48** QQ
**49** TikTok
**50** RTSP
**51** IMAPS
**52** IceCast
**53** CPHA
**54** PPStream
**55** Zattoo
**56** YandexMarket
**57** YandexDisk
**58** Discord
**59** TVUplayer
**60** MongoDB
**61** Pluralsight
**62** YandexCloud
**63** OCSP
**64** VXLAN

**65** IRC
**66** MerakiCloud
**67** Jabber
**68** Nats
**69** AmongUs
**70** Yahoo
**71** DisneyPlus
**72** GooglePlus
**73** VRRP
**74** Steam
**75** HalfLife2
**76** WorldOfWarcraft
**77** Telnet
**78** STUN
**79** IPSec
**80** GRE
**81** ICMP
**82** IGMP
**83** EGP
**84** SCTP
**85** OSPF
**86** IP_in_IP
**87** RTP
**88** RDP
**89** VNC
**90** Tumblr
**91** TLS
**92** SSH
**93** Usenet
**94** MGCP
**95** IAX
**96** TFTP
**97** AFP
**98** YandexMetrika
**99** YandexDirect
**100** SIP
**101** TruPhone
**102** ICMPV6
**103** DHCPV6
**104** Armagetron
**105** Crossfire
**106** Dofus
**107** ADS_Analytic_Track
**108** AdultContent
**109** Guildwars
**110** AmazonAlexa
**111** Kerberos
**112** LDAP
**113** MapleStory
**114** MsSQL-TDS
**115** PPTP
**116** Warcraft3
**117** WorldOfKungFu
**118** Slack
**119** Facebook
**120** Twitter
**121** Dropbox
**122** GMail
**123** GoogleMaps
**124** YouTube
**125** Skype_Teams
**126** Google
**127** RPC
**128** NetFlow
**129** sFlow
**130** HTTP_Connect
**131** HTTP_Proxy
**132** Citrix
**133** NetFlix
**134** LastFM
**135** Waze
**136** YouTubeUpload
**137** Hulu
**138** CHECKMK
**139** AJP
**140** Apple
**141** Webex
**142** WhatsApp
**143** AppleiCloud
**144** Viber
**145** AppleiTunes
**146** Radius
**147** WindowsUpdate
**148** TeamViewer
**149** Tuenti
**150** LotusNotes
**151** SAP
**152** GTP
**153** WSD
**154** LLMNR

**155** TocaBoca
**156** Spotify
**157** Messenger
**158** H323
**159** OpenVPN
**160** NOE
**161** CiscoVPN
**162** TeamSpeak
**163** Tor
**164** CiscoSkinny
**165** RTCP
**166** RSYNC
**167** Oracle
**168** Corba
**169** UbuntuONE
**170** Whois-DAS
**171** SD-RTN
**172** SOCKS
**173** Nintendo
**174** RTMP
**175** FTP_DATA
**176** Wikipedia
**177** ZeroMQ
**178** Amazon
**179** eBay
**180** CNN
**181** Megaco
**182** Redis
**183** Pinterest
**184** VHUA
**185** Telegram
**186** Vevo
**187** Pandora
**188** QUIC
**189** Zoom
**190** EAQ
**191** Ookla
**192** AMQP
**193** KakaoTalk
**194** KakaoTalk_Voice
**195** Twitch
**196** DoH_DoT
**197** WeChat
**198** MPEG_TS
**199** Snapchat
**200** Sina(Weibo)
**201** GoogleHangoutDuo
**202** IFLIX
**203** Github
**204** BJNP
**205** Reddit
**206** WireGuard
**207** SMPP
**208** DNScrypt
**209** TINC
**210** Deezer
**211** Instagram
**212** Microsoft
**213** Starcraft
**214** Teredo
**215** HotspotShield
**216** IMO
**217** GoogleDrive
**218** OCS
**219** Microsoft365
**220** Cloudflare
**221** MS_OneDrive
**222** MQTT
**223** RX
**224** AppleStore
**225** OpenDNS
**226** Git
**227** DRDA
**228** PlayStore
**229** SOMEIP
**230** FIX
**231** Playstation
**232** Pastebin
**233** LinkedIn
**234** SoundCloud
**235** CSGO
**236** LISP
**237** Diameter
**238** ApplePush
**239** GoogleServices
**240** AmazonVideo
**241** GoogleDocs
**242** WhatsAppFiles
**243** TargusDataspeed
**244** DNP3

**245** IEC60870
**246** Bloomberg
**247** CAPWAP
**248** Zabbix
**249** s7comm
**250** Teams
**251** WebSocket
**252** AnyDesk
**253** SOAP
**254** AppleSiri
**255** SnapchatCall
**256** HP_VIRTGRP
**257** GenshinImpact
**258** Activision
**259** FortiClient
**260** Z3950
**261** Likee
**262** GitLab
**263** AVASTSecureDNS
**264** Cassandra
**265** AmazonAWS
**266** Salesforce
**267** Vimeo
**268** FacebookVoip
**269** SignalVoip
**270** Fuze
**271** GTP_U
**272** GTP_C
**273** GTP_PRIME
**274** Alibaba
**275** Crashlytics
**276** Azure
**277** iCloudPrivateRelay
**278** EthernetIP
**279** Badoo
**280** AccuWeather
**281** GoogleClassroom
**282** HSRP
**283** Cybersec
**284** GoogleCloud
**285** Tencent
**286** RakNet
**287** Xiaomi
**288** Edgecast
**289** Cachefly
**290** Softether
**291** MpegDash
**292** Dazn
**293** GoTo
**294** RSH
**295** 1kxun
**296** PGM
**297** IP_PIM
**298** collectd
**299** TunnelBear
**300** CloudflareWarp
**301** i3D
**302** RiotGames
**303** Psiphon
**304** UltraSurf
**305** Threema
**306** AliCloud
**307** AVAST
**308** TiVoConnect
**309** Kismet
**310** FastCGI
**311** FTPS
**312** NAT-PMP
**313** Syncthing
**314** CryNetwork
**315** Line
**316** LineCall
**317** AppleTVPlus
**318** DirecTV
**319** HBO
**320** Vudu
**321** Showtime
**322** Dailymotion
**323** Livestream
**324** Tencentvideo
**325** IHeartRadio
**326** Tidal
**327** TuneIn
**328** SiriusXMRadio
**329** Munin
**330** Elasticsearch
**331** TuyaLP
**332** TPLINK_SHP
**333** Source_Engine
**334** BACnet

**335** OICQ
**336** Heroes_of_the_Storm
**337** FbookReelStory
**338** SRTP
**339** OperaVPN
**340** EpicGames
**341** GeForceNow
**342** Nvidia
**343** BITCOIN
**344** ProtonVPN
**345** Thrift
**346** Roblox
**347** Service_Location_Protocol
**348** Mullvad
**349** HTTP2
**350** HAProxy
**351** RMCP

## 33.7 Plugin Report Output

The following information is reported:

- Number of flows classified

## 33.8 Additional Output

If `NDPI_OUTPUT_STATS=1` then nDPI protocol distribution statistics are output in `PREFIX_nDPI.txt`.

## 33.9 Post-Processing

The `protStat` script can be used to sort the `PREFIX_nDPI.txt` file for the most or least occurring protocols (in terms of number of packets or bytes). It can output the top or bottom *N* protocols or only those with at least a given percentage:

- list all the options: `protStat --help`
- for better readability, use `protStat` with `tcol`: `protStat ... | tcol`
- sorted list of protocols (by packets): `protStat PREFIX_nDPI.txt`
- sorted list of protocols (by bytes): `protStat PREFIX_nDPI.txt -b`
- top 10 protocols (by packets): `protStat PREFIX_nDPI.txt -n 10`
- bottom 5 protocols (by bytes): `protStat PREFIX_nDPI.txt -n -5 -b`
- protocols with packets percentage greater than 20%: `protStat PREFIX_nDPI.txt -p 20`
- protocols with bytes percentage smaller than 5%: `protStat PREFIX_nDPI.txt -b -p -5`

## 33.10 How to Update nDPI to New Version

- download latest stable version (or git clone and checkout stable branch)
- delete `src/nDPI` and replace it with this new version
- run the `./new_ndpi_prepatch.sh` script
- build the nDPI plugin: `t2build -r nDPI`
- Replace the `proto.tex` file using the `prototex` utility and regenerate doc:

```
make -C prototex && ./prototex/prototex > doc/proto.tex
```

- Add the new files to SVN and delete removed files before commit.

# 34 netflowSink

## 34.1 Description

This plugin is an interface of Tranalyzer to a NetFlow collector.

## 34.2 Dependencies

### 34.2.1 Other Plugins

This plugin requires the basicFlow , basicStats and tcpFlags plugins.
In addition, the macRecorder plugin is recommended, but optional.

## 34.3 Configuration Flags

The following flags can be used to control the output of the plugin:

| Name | Default | Description |
|---|---|---|
| NF_SERVADD | "127.0.0.1" | Destination address |
| NF_DPORT | 9995 | Destination port |
| NF_SOCKTYPE | 0 | Socket type: 0: UDP; 1: TCP |
| NF_VER | 9 | NetFlow version 9 or 10 (IPFIX) |
| NF_NUM4FLWS | 200 | Max # of IPv4 flows in one message |
| NF_NUM6FLWS | 100 | Max # of IPv6 flows in one message |

### 34.3.1 Environment Variable Configuration Flags

The following configuration flags can also be configured with environment variables (ENVCNTRL>0):

- NF_NUM4FLWS
- NF_NUM6FLWS
- NF_SERVADD
- NF_DPORT

## 34.4 Example

To collect T2 flow data with **nfcapd**, use the following command:

```
nfcapd -T all -B 1000000 -n wurst,127.0.0.1,.
```

# 35 nFrstPkts

## 35.1 Description

The nFrstPkts plugin supplies the Packet Length (PL) and Inter-Arrival Times (IAT) of the *N* first packets per flow as a column. The default value for *N* is 20. It complements the packet mode (`-s` option) with flow based view for the *N* first packets signal. The plugin supplies several configuration options of how the resulting packet length signal should be represented. Using the `fpsGplt` script files are generated readily post processable by any command line tool (AWK, Perl), Excel or Data mining suit, such as SPSS. As outlined in the configuration below, Signals can be produced with IAT, or relative/absolute time. Also the aggregation of bursts into a single pulse can be configured via `NFRST_MINIAT`. `NFRST_MINPLAVE` controls the meaning of the PL value in pulse aggregation mode. If 0 it corresponds to the BPP measure currently used in research for categorizing media content.

## 35.2 Configuration Flags

The following flags can be used to control the output of the plugin:

| Name | Default | Description | Flags |
|---|---|---|---|
| `NFRST_IAT` | 1 | 0: Time relative to flow start<br>1: Inter-arrival time<br>2: Absolute time | |
| `NFRST_BCORR` | 0 | 0: A,B start at 0.0<br>1: B shift by flow start | <br>`NFRST_MINIATS=0` |
| `NFRST_PKTCNT` | 20 | Number of packets to record | |
| `NFRST_HDRINFO` | 0 | add L3,L4 header length | |
| `NFRST_MINIATS` | 0 | 0: Standard IAT sequence<br>> 0: minimal packet IAT us/ns defining a pulse signal | |
| `NFRST_MINIATU` | 0 | 0: Standard IAT sequence<br>> 0: minimal packet IAT us/ns defining a pulse signal | |
| `NFRST_MINPLENFRC` | 2 | Minimal pulse length fraction | |
| `NFRST_PLAVE` | 1 | 0: Sum PL (BPP)<br>1: Average PL | `NFRST_MINIATS>0\|\|`<br>`NFRST_MINIATU>0` |
| `NFRST_XMIN` | 0 | Min PL boundary | |
| `NFRST_XMAX` | `UINT16_MAX` | Max PL boundary | |

For the rest of this document, `NFRST_MINIAT` is used to represent `(NFRST_MINIATS>0||NFRST_MINIATU>0)`.

## 35.3 Flow File Output

The nFrstPkts plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| `nFpCnt` | U32 | Number of signal samples | |
| `L2L3L4Pl_Iat` | R(U16_UT) | L2/L3/L4 or payload length and inter-arrival times for the N first packets | `NFRST_HDRINFO=0&&`<br>`NFRST_MINIAT=0` |
| `L2L3L4Pl_Iat_nP` | R(U16_UT_UT) | L2/L3/L4 or payload length, inter-arrival times and pulse length for the N first packets | `NFRST_HDRINFO=0&&`<br>`NFRST_MINIAT>0` |

| Column | Type | Description | Flags |
|---|---|---|---|
| HD3l_HD4l_ L2L3L4Pl_Iat | R(U8_U8_ _U16_UT) | L3Hdr, L4Hdr, L2/L3/L4 or payload length and inter-arrival times for the N first packets | NFRST_HDRINFO=1&& NFRST_MINIAT=0 |
| HD3l_HD4l_ L2L3L4Pl_Iat_nP | R(U8_U8_U16_ UT_UT) | L3Hdr, L4Hdr, L2/L3/L4 or payload length and inter-arrival times for the N first packets | NFRST_HDRINFO=1&& NFRST_MINIAT>0 |

## 35.4 Post-Processing

The fpsGplt script can be used to transform the packet signal from nFrstPkts to gnuplot or t2plot format. It produces several signal variants which can also be used for signal processing and AI applications. For more details, refer to the traffic mining tutorial at https://tranalyzer.com/tutorial/trafficmining.

```
>fpsGplt -h
Usage:
    fpsGplt [OPTION...] <FILE>

Optional arguments:

    -f              Flow index to extract, default: all flows
    -d              Flow Direction: 0, 1; default both
    -t              noTime: counts on x axis; default time on x axis
    -i              invert B Flow PL
    -s              time sorted

    -h, --help      Show this help, then exit
```

# 36 ntlmsspDecode

## 36.1 Description

The ntlmsspDecode plugin analyzes the NT LAN Manager (NTLM) Security Support Provider (NTLMSSP) protocol.

## 36.2 Configuration Flags

The following flags can be used to control the output of the plugin:

| Name | Default | Description | Flags |
|---|---|---|---|
| NTLMSSP_CLI_CHALL | 0 | Output client challenge | |
| NTLMSSP_DNS | 1 | Output DNS computer/domain/tree name | |
| NTLMSSP_NETBIOS | 1 | Output NetBIOS computer/domain name | |
| NTLMSSP_VERSION | 2 | Output format for the version:<br>0: do not output the version<br>1: output the version as string<br>2: major_minor_build_revision | |
| NTLMSSP_NAME_LEN | 64 | Max length for string output | |
| NTLMSSP_SAVE_AUTH_V1 | 1 | Extract NetNTLMv1 hashes | |
| NTLMSSP_SAVE_AUTH_V2 | 1 | Extract NetNTLMv2 hashes | |
| NTLMSSP_SAVE_INFO | 0 | Add flow information in the hashes files | NTLMSSP_SAVE_AUTH_V1=1\|\|<br>NTLMSSP_SAVE_AUTH_V2=1 |

The suffix used for the NetNTLMv[12] hashes files is controlled by:

- NTLMSSP_AUTH_V1_FILE (default to "_NetNTLMv1.txt") for NetNTLMv1
- NTLMSSP_AUTH_V2_FILE (default to "_NetNTLMv2.txt") for NetNTLMv2

### 36.2.1 Environment Variable Configuration Flags

The following configuration flags can also be configured with environment variables (ENVCNTRL>0):

- NTLMSSP_AUTH_V1_FILE
- NTLMSSP_AUTH_V2_FILE

## 36.3 Flow File Output

The ntlmsspDecode plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| ntlmsspStat | H8 | Status | |
| ntlmsspTarget | STRC | Target name | |
| ntlmsspDomain | STRC | Domain name | |
| ntlmsspUser | STRC | Username | |
| ntlmsspHost | STRC | Host/workstation | |

| Column | Type | Description | Flags |
|---|---|---|---|
| ntlmsspNegotiateFlags | H32 | Negotiate Flags | |
| ntlmsspServChallenge | STRC | Server challenge | |
| ntlmsspNTProofStr | STRC | NT proof string | |
| ntlmsspCliChallenge | STRC | Client challenge | NTLMSSP_CLI_CHALL=1 |
| ntlmsspSessKey | STRC | Session key | |
| ntlmsspVersion | STR | Version | NTLMSSP_VERSION=1 |
| ntlmsspVersionMajor_ | U8_ | Major Version, | NTLMSSP_VERSION=2 |
| Minor_ | U8_ | Minor Version, | |
| Build_ | U16_ | Build Number and | |
| Rev | U8 | NTLM Current Revision) | |
| ntlmsspNbComputer | STRC | NetBIOS computer name | NTLMSSP_NETBIOS=1 |
| ntlmsspNbDomain | STRC | NetBIOS domain name | NTLMSSP_NETBIOS=1 |
| ntlmsspDnsComputer | STRC | DNS computer name | NTLMSSP_DNS=1 |
| ntlmsspDnsDomain | STRC | DNS domain name | NTLMSSP_DNS=1 |
| ntlmsspDnsTree | STRC | DNS tree name | NTLMSSP_DNS=1 |
| ntlmsspAttrTarget | STRC | Attribute Target Name | |
| ntlmsspTimestamp | U64.U32/S | Timestamp | |

### 36.3.1 ntlmsspStat

The ntlmsspStat column is to be interpreted as follows:

| ntlmsspStat | Description |
|---|---|
| 0x01 | Flow is NTLMSSP |
| 0x02 | Flow contains Negotiate messages |
| 0x04 | Flow contains Challenge messages |
| 0x08 | Flow contains Authenticate messages |
| 0x10 | NetNTLMv1 hash was extracted for this flow |
| 0x20 | NetNTLMv2 hash was extracted for this flow |
| 0x40 | String output was truncated... increase NTLMSSP_NAME_LEN |
| 0x80 | Decoding error, invalid message type, ... |

### 36.3.2 ntlmsspNegotiateFlags

The ntlmsspNegotiateFlags column is to be interpreted as follows:

| ntlmsspNegotiateFlags | Description |
|---|---|
| $2^0$ (=0x00000001) | NTLMSSP_NEGOTIATE_UNICODE |
| $2^1$ (=0x00000002) | NTLMSSP_NEGOTIATE_OEM |
| $2^2$ (=0x00000004) | NTLMSSP_REQUEST_TARGET |
| $2^3$ (=0x00000008) | NTLMSSP_NEGOTIATE_00000008 (Reserved, MUST be 0) |
| $2^4$ (=0x00000010) | NTLMSSP_NEGOTIATE_SIGN |

| ntlmsspNegotiateFlags | | Description |
|---|---|---|
| $2^5$ | (=0x00000020) | NTLMSSP_NEGOTIATE_SEAL |
| $2^6$ | (=0x00000040) | NTLMSSP_NEGOTIATE_DATAGRAM |
| $2^7$ | (=0x00000080) | NTLMSSP_NEGOTIATE_LM_KEY |
| $2^8$ | (=0x00000100) | NTLMSSP_NEGOTIATE_00000100 (Reserved, MUST be 0) |
| $2^9$ | (=0x00000200) | NTLMSSP_NEGOTIATE_NTLM |
| $2^{10}$ | (=0x00000400) | NTLMSSP_NEGOTIATE_NT_ONLY (Reserved, MUST be 0?) |
| $2^{11}$ | (=0x00000800) | NTLMSSP_NEGOTIATE_ANONYMOUS |
| $2^{12}$ | (=0x00001000) | NTLMSSP_NEGOTIATE_OEM_DOMAIN_SUPPLIED |
| $2^{13}$ | (=0x00002000) | NTLMSSP_NEGOTIATE_OEM_WORKSTATION_SUPPLIED |
| $2^{14}$ | (=0x00004000) | NTLMSSP_NEGOTIATE_00004000 (Reserved, MUST be 0) |
| $2^{15}$ | (=0x00008000) | NTLMSSP_NEGOTIATE_ALWAYS_SIGN |
| $2^{16}$ | (=0x00010000) | NTLMSSP_TARGET_TYPE_DOMAIN |
| $2^{17}$ | (=0x00020000) | NTLMSSP_TARGET_TYPE_SERVER |
| $2^{18}$ | (=0x00040000) | NTLMSSP_TARGET_TYPE_SHARE (Reserved, MUST be 0?) |
| $2^{19}$ | (=0x00080000) | NTLMSSP_NEGOTIATE_EXTENDED_SESSIONSECURITY |
| $2^{20}$ | (=0x00100000) | NTLMSSP_NEGOTIATE_IDENTIFY |
| $2^{21}$ | (=0x00200000) | NTLMSSP_NEGOTIATE_00200000 (Reserved, MUST be 0) |
| $2^{22}$ | (=0x00400000) | NTLMSSP_REQUEST_NON_NT_SESSION_KEY |
| $2^{23}$ | (=0x00800000) | NTLMSSP_NEGOTIATE_TARGET_INFO |
| $2^{24}$ | (=0x01000000) | NTLMSSP_NEGOTIATE_01000000 (Reserved, MUST be 0) |
| $2^{25}$ | (=0x02000000) | NTLMSSP_NEGOTIATE_VERSION |
| $2^{26}$ | (=0x04000000) | NTLMSSP_NEGOTIATE_04000000 (Reserved, MUST be 0) |
| $2^{27}$ | (=0x08000000) | NTLMSSP_NEGOTIATE_08000000 (Reserved, MUST be 0) |
| $2^{28}$ | (=0x10000000) | NTLMSSP_NEGOTIATE_10000000 (Reserved, MUST be 0) |
| $2^{29}$ | (=0x20000000) | NTLMSSP_NEGOTIATE_128 |
| $2^{30}$ | (=0x40000000) | NTLMSSP_NEGOTIATE_KEY_EXCH |
| $2^{31}$ | (=0x80000000) | NTLMSSP_NEGOTIATE_56 |

## 36.4 Plugin Report Output

The following information is reported:

- Aggregated ntlmsspStat
- Number of NTLMSSP packets
- Number of NetNTLMv1 hashes extracted (NTLMSSP_SAVE_AUTH_V1=1)
- Number of NetNTLMv2 hashes extracted (NTLMSSP_SAVE_AUTH_V2=1)

## 36.5 Additional Output

The following non-standard files are produced:

- `PREFIX_NetNTLMv1.txt`: NetNTLMv1 hashes (`NTLMSSP_SAVE_AUTH_V1=1`)
- `PREFIX_NetNTLMv2.txt`: NetNTLMv2 hashes (`NTLMSSP_SAVE_AUTH_V2=1`)

## 36.6 Post-Processing

### 36.6.1 NTLMSSP Authentications

When `NTLMSSP_SAVE_AUTH_V1=1` or `NTLMSSP_SAVE_AUTH_V1=1`, the plugin produces file(s) with suffix defined by `NTLMSSP_AUTH_V1_FILE` and `NTLMSSP_AUTH_V2_FILE` containing all the NetNTLMv1 and NetNTLMv2 hashes extracted from the traffic. The hashes can then be reversed using JohnTheRipper[24] or Hashcat[25] as follows:

- NetNTLMv1:
  - `john --wordlist=password.lst -format=netntlm FILE_NetNTLMv1.txt`
  - `hashcat -m 5500 FILE_NetNTLMv1.txt wordlist.txt --show`
- NetNTLMv2:
  - `john --wordlist=password.lst -format=netntlmv2 FILE_NetNTLMv2.txt`
  - `hashcat -m 5600 FILE_NetNTLMv2.txt wordlist.txt --show`

## 36.7 References

- [MS-NLMP]: NT LAN Manager (NTLM) Authentication Protocol

[24] https://github.com/magnumripper/JohnTheRipper
[25] https://hashcat.net

# 37 ntpDecode

## 37.1 Description

The ntpDecode plugin produces a flow based view of NTP operations between computers for anomaly detection and troubleshooting.

## 37.2 Configuration Flags

The following flags can be used to control the output of the plugin:

| Name | Default | Description | Flags |
|---|---|---|---|
| NTP_TS | 1 | 0: no time stamps,<br>1: print NTP time stamps | |
| NTP_LIVM_HEX | 0 | Leap indicator, version and mode:<br>0: split into three values,<br>1: aggregated hex number | |

## 37.3 Flow File Output

The ntpDecode plugin outputs the following columns:

| Name | Type | Description | Flags |
|---|---|---|---|
| ntpStat | H8 | NTP status, warnings and errors | |
| ntpLiVM | H8 | NTP leap indicator, version number and mode | NTP_LIVM_HEX=1 |
| ntpLi_V_M | U8_U8_U8 | NTP leap indicator, version number and mode | NTP_LIVM_HEX=0 |
| ntpStrat | H8 | NTP stratum | |
| ntpRefClkId | IP4 | NTP root reference clock ID (stratum $\geq$ 2) | |
| ntpRefStrId | SC | NTP root reference string (stratum $\leq$ 1) | |
| ntpPollInt | U32 | NTP poll interval | |
| ntpPrec | F | NTP precision | |
| ntpRtDelMin | F | NTP root delay minimum | |
| ntpRtDelMax | F | NTP root delay maximum | |
| ntpRtDispMin | F | NTP root dispersion minimum | |
| ntpRtDispMax | F | NTP root dispersion maximum | |
| ntpRefTS | TS | NTP reference timestamp | NTP_TS=1 |
| ntpOrigTS | TS | NTP originate timestamp | NTP_TS=1 |
| ntpRecTS | TS | NTP receive timestamp | NTP_TS=1 |
| ntpTranTS | TS | NTP transmit timestamp | NTP_TS=1 |

### 37.3.1 ntpStat

The `ntpStat` column is to be interpreted as follows:

| ntpStat | Description |
|---|---|
| $2^0$ (=0x01) | NTP port detected |
| $2^1$ (=0x02) | — |
| $2^2$ (=0x04) | — |
| $2^3$ (=0x08) | — |
| $2^4$ (=0x10) | — |
| $2^5$ (=0x20) | — |
| $2^6$ (=0x40) | — |
| $2^7$ (=0x80) | — |

### 37.3.2 ntpLiVM

The `ntpLiVM` column is to be interpreted as follows (refer to Section 37.6 for some examples):

| ntpLiVM | | Description |
|---|---|---|
| xx.. | .... | Leap indicator |
| ..xx | x... | Version number |
| .... | .xxx | Mode |

The `Leap Indicator` bits are to be interpreted as follows:

| Leap Indicator | Description |
|---|---|
| 0x0 | No warning |
| 0x1 | Last minute has 61 seconds |
| 0x2 | Last minute has 59 seconds |
| 0x3 | Alarm condition, clock not synchronized |

The `Mode` bits are to be interpreted as follows:

| Mode | Description |
|---|---|
| 0x0 | Reserved |
| 0x1 | Symmetric active |
| 0x2 | Symmetric passive |
| 0x3 | Client |
| 0x4 | Server |
| 0x5 | Broadcast |
| 0x6 | NTP control message |
| 0x7 | Private use |

### 37.3.3 ntpStrat

The `ntpStrat` column is to be interpreted as follows:

| ntpStrat | Description |
|---|---|
| 0x00 | Unspecified |
| 0x01 | Primary reference |
| 0x02-0xff | Secondary reference |

### 37.3.4 ntpRefStrId

The interpretation of the `ntpRefStrId` column depends on the value of ntpStrat. The following table lists some suggested identifiers:

| ntpStrat | ntpRefStrId | Description |
|---|---|---|
| 0x00 | DCN | DCN routing protocol |
| 0x00 | NIST | NIST public modem |
| 0x00 | TSP | TSP time protocol |
| 0x00 | DTS | Digital Time Service |
| 0x01 | ATOM | Atomic clock (calibrated) |
| 0x01 | VLF | VLF radio |
| 0x01 | callsign | Generic radio |
| 0x01 | LORC | LORAN-C |
| 0x01 | GOES | GOES UHF environment satellite |
| 0x01 | GPS | GPS UHF positioning satellite |

## 37.4 Monitoring Output

In monitoring mode, the ntpDecode plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| ntpPkts | U64 | Number of NTP packets | |

## 37.5 Plugin Report Output

The following information is reported:

- Aggregated ntpStat
- Number of NTP packets

## 37.6 Examples

- Extract the NTP leap indicator:
```
tawk 'NR > 1 { print rshift(and(strtonum($ntpLiVM), 0xc0), 6) }' out_flows.txt
```

- Extract the NTP version:
  ```
  tawk 'NR > 1 { print rshift(and(strtonum($ntpLiVM), 0x38), 3) }' out_flows.txt
  ```
- Extract the NTP mode:
  ```
  tawk 'NR > 1 { printf "%#x\n", and(strtonum($ntpLiVM), 0x7) }' out_flows.txt
  ```

# 38 ospfDecode

## 38.1 Description

This plugin analyzes OSPFv4/6 traffic and provides absolute and relative statistics to the PREFIX_ospfStats.txt file. In addition, the rospf script extracts the areas, networks and netmasks, along with the routers and their interfaces (Section 38.7).

## 38.2 Configuration Flags

The following flags can be used to control the output of the plugin:

| Name | Default | Description | Flags |
|---|---|---|---|
| OSPF_OUTPUT_HLO | 1 | Output hello messages | |
| OSPF_OUTPUT_DBD | 1 | Output database description messages (routing tables) | |
| OSPF_OUTPUT_MSG | 1 | Output all other messages | |
| OSPF_OUTPUT_STATS | 1 | Output statistics file | |
| OSPF_MASK_AS_IP | 1 | Netmasks representation: 0: hex, 1: IPv4 | |
| OSPF_AREA_AS_IP | 0 | Areas representation: 0: int, 1: IPv4, 2: hex | |
| OSPF_LSID_AS_IP | 0 | Link State ID representation:: 0: int, 1: IPv4 | |
| OSPF_TYP_STR | 1 | Message type representation: 0: hex, 1: string | |
| OSPF_LSTYP_STR | 1 | LS type representation: 0: int, 1: string | |
| OSPF_NEIGMAX | 10 | Maximum neighbors to store | |
| OSPF_NUMTYP | 10 | Maximum number of LS types to store | OSPF_TYP_STR=1 |

In addition, the suffix for the output files can be controlled with the following flags:

| Name | Default | Description |
|---|---|---|
| OSPF_SUFFIX | "_ospfStats.txt" | Statistics |
| OSPF_HELLO_SUFFIX | "_ospfHello.txt" | OSPFv2/3 hello messages |
| OSPF_DBD_SUFFIX | "_ospfDBD.txt" | OSPFv2/3 database description (routing tables) |
| OSPF2_MSG_SUFFIX | "_ospf2Msg.txt" | All other messages from OSPFv2 (Link State Request/Update/Ack) |
| OSPF3_MSG_SUFFIX | "_ospf3Msg.txt" | All other messages from OSPFv3 (Link State Request/Update/Ack) |

### 38.2.1 Environment Variable Configuration Flags

The following configuration flags can also be configured with environment variables (ENVCNTRL>0):

- OSPF_SUFFIX
- OSPF_HELLO_SUFFIX
- OSPF_DBD_SUFFIX
- OSPF2_MSG_SUFFIX
- OSPF3_MSG_SUFFIX

## 38.3 Flow File Output

The ospfDecode plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| ospfStat | H8 | Status | |
| ospfVersion | H8 | Version | |
| ospfType | H8/RS | Message Type | OSPF_TYP_STR=0/1 |
| ospfLSType | H64 | Update LS Type | |
| ospfAuType | H16 | Authentication type | |
| ospfAuPass | RS | Authentication password (if ospfAuType == 0x4) | |
| ospfArea | U32/IP4/H32 | Area ID | OSPF_AREA_AS_IP=0/1/2 |
| ospfSrcRtr | IP4 | Hello msg: Source Router | |
| ospfBkupRtr | IP4 | Hello msg: Backup Router | |
| ospfNeighbors | R(IP4) | Hello msg: Neighbor Router | |

### 38.3.1 ospfStat

The hex based status variable (ospfStat) is defined as follows:

| | ospfStat | Description |
|---|---|---|
| $2^0$ | (=0x01) | OSPF detected |
| $2^1$ | (=0x02) | OSPFv2 message had invalid TTL ($\neq 1$) |
| $2^2$ | (=0x04) | OSPFv2 message had invalid destination |
| $2^3$ | (=0x08) | OSPF message had invalid type |
| $2^4$ | (=0x10) | OSPF unknown version |
| $2^5$ | (=0x20) | — |
| $2^6$ | (=0x40) | — |
| $2^7$ | (=0x80) | OSPF message was malformed (snapped, covert channels?, ...) |

The invalid checksum status 0x08 is currently not implemented.
The malformed status 0x10 is currently used to report cases such as possible covert channels, e.g., authfield used when auType was NULL.

### 38.3.2 ospfType

The hex based message type variable ospfType is defined as follows:

| | ospfType | Description |
|---|---|---|
| $2^0$ | (=0x01) | Not valid |
| $2^1$ | (=0x02) | Hello |
| $2^2$ | (=0x04) | Database Description |
| $2^3$ | (=0x08) | Link State Request |

| | ospfType | Description |
|---|---|---|
| $2^4$ | (=0x10) | Link State Update |
| $2^5$ | (=0x20) | Link State Acknowledgement |
| $2^6$ | (=0x40) | — |
| $2^7$ | (=0x80) | — |

### 38.3.3 ospfLSType

The hex based message type variable ospfLSType is defined as follows:

| | ospfLSType | Description |
|---|---|---|
| $2^0$ | (=0x0000 0000 0000 0001) | Reserved |
| $2^1$ | (=0x0000 0000 0000 0002) | OSPFv2/3 Router-LSA |
| $2^2$ | (=0x0000 0000 0000 0004) | OSPFv2/3 Network-LSA |
| $2^3$ | (=0x0000 0000 0000 0008) | OSPFv2 Summary-LSA (IP network)<br>OSPFv3 Inter-Area-Prefix-LSA |
| $2^4$ | (=0x0000 0000 0000 0010) | OSPFv2 Summary-LSA (ASBR)<br>OSPFv3 Inter-Area-Router-LSA |
| $2^5$ | (=0x0000 0000 0000 0020) | OSPFv2/3 AS-External-LSA |
| $2^6$ | (=0x0000 0000 0000 0040) | OSPFv2 Multicast group LSA (not implemented by Cisco)<br>Deprecated in OSPFv3 |
| $2^7$ | (=0x0000 0000 0000 0080) | OSPFv2 Not-so-stubby area (NSSA) External LSA<br>OSPFv3 NSSA-LSA |
| $2^8$ | (=0x0000 0000 0000 0100) | OSPFv2 External attribute LSA for BGP<br>OSPFv3 Link-LSA |
| $2^9$ | (=0x0000 0000 0000 0200) | OSPFv2 Opaque LSA: Link-local scope<br>OSPFv3 Intra-Area-Prefix-LSA |
| $2^{10}$ | (=0x0000 0000 0000 0400) | OSPFv2 Opaque LSA: Area-local scope<br>OSPFv3 Intra-Area-TE-LSA |
| $2^{11}$ | (=0x0000 0000 0000 0800) | OSPFv2 Opaque LSA: autonomous system scope<br>OSPFv3 GRACE-LSA |
| $2^{12}$ | (=0x0000 0000 0000 1000) | OSPFv3 Router Information (RI) |
| $2^{13}$ | (=0x0000 0000 0000 2000) | OSPFv3 Inter-AS-TE-v3 LSA |
| $2^{14}$ | (=0x0000 0000 0000 4000) | OSPFv3 L1VPN LS |
| $2^{15}$ | (=0x0000 0000 0000 8000) | OSPFv3 Autoconfiguration (AC) LSA |
| $2^{16}$ | (=0x0000 0000 0001 0000) | OSPFv3 Dynamic Flooding LSA |
| $2^{17}$–$2^{32}$ | are unassigned | |
| $2^{33}$ | (=0x0000 0002 0000 0000) | OSPFv3 E-Router-LSA |
| $2^{34}$ | (=0x0000 0004 0000 0000) | OSPFv3 E-Network-LSA |
| $2^{35}$ | (=0x0000 0008 0000 0000) | OSPFv3 E-Inter-Area-Prefix-LSA |

| | ospfLSType | Description |
|---|---|---|
| $2^{36}$ | (=0x0000 0010 0000 0000) | OSPFv3 E-Inter-Area-Router-LSA |
| $2^{37}$ | (=0x0000 0020 0000 0000) | OSPFv3 E-AS-External-LSA |
| $2^{38}$ | (=0x0000 0040 0000 0000) | Unused (not to be allocated) |
| $2^{39}$ | (=0x0000 0080 0000 0000) | OSPFv3 E-Type-7-LSA |
| $2^{40}$ | (=0x0000 0100 0000 0000) | OSPFv3 E-Link-LSA |
| $2^{41}$ | (=0x0000 0200 0000 0000) | OSPFv3 E-Intra-Area-Prefix-LSA |

### 38.3.4 ospfAuType

The hex based authentication type variable ospfAuType is defined as follows:

| ospfAuType | Description |
|---|---|
| $2^1$ (=0x0002) | Null authentication |
| $2^2$ (=0x0004) | Simple password |
| $2^3$ (=0x0008) | Cryptographic authentication |

## 38.4 Packet File Output

In packet mode (-s option), the ospfDecode plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| ospfStat | H8 | Status | |
| ospfVersion | U8 | Version | |
| ospfArea | U32/IP4/H32 | Area ID | OSPF_AREA_AS_IP=0/1/2 |
| ospfType | S | Message Type | |
| ospfLSType | H64 | Update LS Type | |

## 38.5 Plugin Report Output

The following information is reported:

- Aggregated ospfStat
- Aggregated ospfType for OSPFv2 and OSPFv3
- Number of OSPFv2 packets
- Number of OSPFv3 packets

## 38.6 Additional Output

- PREFIX_ospfStats.txt: global statistics about OSPF traffic
- PREFIX_ospfHello.txt Hello messages (see Section 38.7)

- `PREFIX_ospfDBD.txt`: Routing tables (see `OSPF_OUTPUT_DBD` in Section 38.2)
- `PREFIX_ospf2Msg.txt`: All other messages from OSPFv2 (see `OSPF_OUTPUT_MSG` in Section 38.2)
- `PREFIX_ospf3Msg.txt`: All other messages from OSPFv3 (see `OSPF_OUTPUT_MSG` in Section 38.2)

## 38.7 Post-Processing

### 38.7.1 rospf

Hello messages can be used to discover the network topology and are stored in the `PREFIX_ospfHello.txt` file. The script `rospf` extracts the areas, networks, netmasks, routers and their interfaces:

```
./scripts/rospf PREFIX_ospfHello.txt
```

```
Name    Area    Network          Netmask
N1      0       192.168.21.0     0xffffff00
N2      1       192.168.16.0     0xffffff00
N3      1       192.168.22.0     0xfffffffc
...

Router    Interface_n      Network_n
R1        192.168.22.29    N11    192.168.21.4    N5    192.168.22.25    N10
R2        192.168.22.5     N12    192.168.16.1    N0    192.168.22.1     N6
R3        192.168.22.10    N13    192.168.21.2    N5    192.168.22.6     N12
...

Router    Connected Routers
R0        R2    R4    R6    R7    R8
R1        R2    R4
R2        R0    R1    R4    R8
...
```

### 38.7.2 dbd

If `OSPF_OUTPUT_DBD` is activated (Section 38.2), database description messages are stored in a file `PREFIX_ospfDBD.txt`. The `dbd` script formats this file to produce an output similar to that of standard routers:

```
./scripts/dbd PREFIX_ospfDBD.txt
```

```
OSPF Router with ID (192.168.22.10)

Router Link States (Area 1)

Link ID          ADV Router       Age    Seq#          Checksum
192.168.22.5     192.168.22.5     4      0x80000002    0x38ce
192.168.22.10    192.168.22.10    837    0x80000002    0x6b0f
192.168.22.9     192.168.22.9     837    0x80000002    0x156c

Net Link States (Area 1)

Link ID          ADV Router       Age    Seq#          Checksum
192.168.22.6     192.168.22.10    4      0x80000001    0x150b
192.168.22.9     192.168.22.9     838    0x80000001    0x39e0
```

```
Summary Net Link States (Area 1)

Link ID          ADV Router       Age     Seq#           Checksum
192.168.17.0     192.168.22.9     735     0x80000001     0x5dd9
192.168.17.0     192.168.22.10    736     0x80000001     0x57de
192.168.18.0     192.168.22.9     715     0x80000001     0x52e3
...
```

# 39 p0f

## 39.1 Description

The p0f plugin tries to fingerprint OS and applications.

## 39.2 Dependencies

### 39.2.1 Other Plugins

This plugin requires the **sslDecode** plugin with the following flags activated, i.e., set to 1:

- SSL_EXT_LIST
- SSL_CIPHER_LIST

### 39.2.2 Required Files

The file p0f-ssl.txt is required.

## 39.3 Configuration Flags

The following flags can be used to control the output of the plugin:

| Name | Default | Description | Flags |
|---|---|---|---|
| P0F_SSL_VER | 1 | Consider the version for fingerprint match | |
| P0F_SSL_NCIPHER | 1 | Consider the number of ciphers for fingerprint match | |
| P0F_SSL_NUMEXT | 1 | Consider the number of extensions for fingerprint match | |
| P0F_SSL_FLAGS | 1 | Consider flags for fingerprint match | |
| P0F_SSL_CIPHER | 1 | Consider ciphers for fingerprint match | |
| P0F_SSL_EXT | 1 | Consider extensions for fingerprint match | |
| P0F_SSL_ELEN | 6 | Maximum length of cipher or extension | |
| P0F_SSL_NSIG | 64 | Maximum number of signatures to read | |
| P0F_SSL_SLEN | 128 | Maximum length of a string (os, browser, comment) | |
| P0F_SSL_DB | "p0f-ssl.txt" | Name of the database to use | |

### 39.3.1 Environment Variable Configuration Flags

The following configuration flags can also be configured with environment variables (ENVCNTRL>0):

- P0F_SSL_DB

## 39.4 Flow File Output

The p0f plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| p0fSSLRule | U16 | p0f SSL fingerprint rule number | |
| p0fSSLOS | S | p0f SSL OS fingerprint | |
| p0fSSLOS2 | S | p0f SSL OS fingerprint (2) | |
| p0fSSLBrowser | S | p0f SSL browser fingerprint | |
| p0fSSLComment | S | p0f SSL fingerprint comment | |

## 39.5 References

- https://idea.popcount.org/2012-06-17-ssl-fingerprinting-for-p0f

# 40 payloadDumper

## 40.1 Description

The payloadDumper plugin dumps the payload of layer 2, TCP, UDP or SCTP flows to files. It provides features similar to tcpflow.

## 40.2 Configuration Flags

The following flags can be used to control the output of the plugin:

| Name | Default | Description | Flags |
|---|---|---|---|
| PLDUMP_L2 | 0 | Extract payload for layer 2 flows | ETH_ACTIVATE>0 |
| PLDUMP_ETHERTYPES | {} | Only extract L2 payloads for those ethertypes<br>e.g., {0x2000,0x2003} | PLDUMP_L2=1 |
| PLDUMP_TCP | 1 | Extract payload for TCP flows | |
| PLDUMP_TCP_PORTS | {} | Only extract TCP payloads on those ports,<br>e.g., {80,8080} | PLDUMP_TCP=1 |
| PLDUMP_UDP | 1 | Extract payload for UDP flows | |
| PLDUMP_UDP_PORTS | {} | Only extract UDP payloads on those ports,<br>e.g., {80,8080} | PLDUMP_UDP=1 |
| PLDUMP_SCTP | 0 | Extract payload for TCP flows | SCTP_ACTIVATE=1 |
| PLDUMP_SCTP_PORTS | {} | Only extract SCTP payloads on those ports,<br>e.g., {80,8080} | PLDUMP_SCTP=1&&<br>SCTP_ACTIVATE=1 |
| PLDUMP_MAX_BYTES | 0 | Max. number of bytes per flow to dump<br>(use 0 for no limits) | |
| PLDUMP_START_OFF | 0 | Start dumping bytes at a specific offset<br>(Layer 2 and UDP only) | PLDUMP_L2=1\|\|<br>PLDUMP_UDP=1 |
| PLDUMP_RMDIR | 1 | Empty PLDUMP_FOLDER before starting | |
| PLDUMP_NAMES | 0 | Format for filenames:<br>0: flowInd_[AB]<br>1: srcIP.srcPort-dstIP.dstPort-l4Proto<br>Extra suffix for SCTP: _sctpStream<br>For L2: srcMac-dstMac-etherType<br>2: Same as 1, but prefixed with timestampT | |
| PLDUMP_FOLDER | "/tmp/payloadDumper/" | Output folder for saved files | |
| PLDUMP_PREFIX | "" | Prefix for output files | |
| PLDUMP_SUFFIX | "" | Suffix for output files | |

### 40.2.1 Environment Variable Configuration Flags

The following configuration flags can also be configured with environment variables (ENVCNTRL>0):

- PLDUMP_RMDIR
- PLDUMP_FOLDER
- PLDUMP_PREFIX
- PLDUMP_SUFFIX

## 40.3 Flow File Output

The payloadDumper plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| pldStat | H8 | Status | |

### 40.3.1 pldStat

The pldStat column is to be interpreted as follows:

| | pldStat | Description |
|---|---|---|
| $2^0$ | (=0x01) | Match for this flow |
| $2^1$ | (=0x02) | Dump payload for this flow |
| $2^2$ | (=0x04) | SCTP init TSN diff engine |
| $2^3$ | (=0x08) | SCTP payload truncated |
| $2^4$ | (=0x10) | TCP sequence numbers out of order or roll-over or TCP keep-alive |
| $2^5$ | (=0x20) | SCTP TSN out of order or roll-over |
| $2^6$ | (=0x40) | Filename truncated |
| $2^7$ | (=0x80) | Failed to open file |

## 40.4 Packet File Output

In packet mode (-s option), the payloadDumper plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| pldStat | H8 | Status | |

## 40.5 Plugin Report Output

The following information is reported:

- Aggregated pldStat
- Number of non zero content dumped flows

## 40.6 Additional Output

The payload of the layer 2, TCP, UDP and/or SCTP flows is extracted in `PLDUMP_FOLDER`. Each file is named according to the value of `PLDUMP_NAMES`, `PLDUMP_SUFFIX` and `PLDUMP_SUFFIX`.

# 41 pcapd

## 41.1 Description

The pcapd plugin can be used to create PCAP files based on some criteria such as flow indexes (Section 41.3.2) or alarms raised by other plugins (Section Section 41.3.3).

## 41.2 Dependencies

If `PD_MODE=4`, the libpcap version must be at least 1.7.2. (In this mode, the plugin uses the `pcap_dump_open_append()` function which was introduced in the libpcap in February 12, 2015.)

## 41.3 Configuration Flags

The following flags can be used to configure the plugin:

| Variable | Default | Description | Flags |
|---|---|---|---|
| `PD_MODE_PKT` | 0 | 0: all packets, 1: activate packet range selection | |
| `PD_STRTPKT` | 1 | Packet at which processing starts | `PD_MODE_PKT=1` |
| `PD_ENDPKT` | 10 | 0: End of flow<br>> 0: Packet at which processing ends | `PD_MODE_PKT=1` |
| `PD_MODE_IN` | 0 | 0: if `-e` option was used, extract flows listed in `FILE`, otherwise, extract flows whose alarm bit is set<br>1: dump all packets | |
| `PD_EQ` | 1 | Save matching (1) or non-matching (0) flows | `PD_MODE_IN=0` |
| `PD_OPP` | 0 | 1: extract also the opposite flow, 0: don't | `PD_MODE_IN=0` |
| `PD_DIRSEL` | 0 | 2: extract A flow, 3: extract B flow, 0: off | `PD_MODE_IN=0` |
| `PD_MODE_OUT` | 0 | 0: one pcap<br>1: one pcap per flow | |
| `PD_SPLIT` | 1 | Split the output file (Tranalyzer `-W` option) | |
| `PD_LBSRCH` | 0 | Search algorithm (`-e` option):<br>0: linear search<br>1: binary search | |
| `PD_TSHFT` | 0 | Time stamp shift in packets | |
| `PD_TTSFTS` | 0 | Time stamp increment seconds | `PD_TSHFT=1` |
| `PD_TTSFTNMS` | 1 | Time stamp increment micro/nano seconds (depends on `TSTAMP_PREC` in *tranalyzer.h*) | `PD_TSHFT=1` |
| `PD_MACSHFT` | 0 | MAC shift in packets | |
| `PD_MACSSHFT` | 1 | Src MAC increment in packets last byte | `PD_MACSHFT=1` |
| `PD_MACDSHFT` | 1 | Src MAC increment in packets last byte | `PD_MACSHFT=1` |
| `PD_VLNSHFT` | 0 | VLAN shift in packets | |
| `PD_VLNISHFT` | 1 | VLAN increment in packets | `PD_VLNSHFT=1` |
| `PD_IPSHFT` | 0 | IPv4/6 increment in packets | |
| `PD_IP4SHFT` | 0x00000001 | IPv4 shift 32 bit network order | `PD_IPSHFT=1` |
| `PD_IP6SHFT` | 0x0000000000000001 | IPv6 shift last 64 bit network order | `PD_IPSHFT=1` |
| `PD_TTLSHFT` | 0 | 0: no TTL change, 1: TTL shift, 2: random shift | |

| Variable | Default | Description | Flags |
|---|---|---|---|
| PD_TTL | 8 | sub value from TTL | PD_TTLSHFT=1 |
| PD_TTLMOD | 128 | TTL modulo | PD_TTLSHFT>0 |
| PD_CHKSUML3 | 0 | Correct checksum in IPv4 header | |
| PD_MAX_FD | 128 | Max. number of simultaneously open file descriptors | PD_MODE_OUT=1 |
| PD_SUFFIX | "_pcapd.pcap" | Suffix for output pcap file | |

### 41.3.1 Environment Variable Configuration Flags

The following configuration flags can also be configured with environment variables (ENVCNTRL>0):

- PD_MAX_FD
- PD_SUFFIX

### 41.3.2 PD_MODE_IN=0, –e option used

The idea behind this mode (PD_MODE_IN=0 and Tranalyzer -e option used) is to use awk to extract flows of interest and then the pcapd plugin to create one or more PCAP with all those flows. The format of the file must be as follows:

| | |
|---|---|
| PD_FORMAT=0 | The first column must be the flow index (the rest (optional) is ignored):<br>1234 ... |
| PD_FORMAT=1 | The second column must be the flow index:<br>A 1234 ... |

Lines starting with '%', '#', a space or a tab are ignored, along with empty lines.

Flows whose index appears in the -e file will be dumped in a file named PREFIX_PD_SUFFIX, where PREFIX is the value given to Tranalyzer -e option. Note that if PD_EQ=0, then flows whose index does **not** appear in the file will be dumped.

### 41.3.3 PD_MODE_IN=0, –e option not used

In this mode (PD_MODE_IN=0 and Tranalyzer -e option **NOT** used), every flow whose status bit FL_ALARM=0x20000000 is set (PD_EQ=1) or not set (PD_EQ=0) will be dumped in a file named PREFIX_PD_SUFFIX, where PREFIX is the value given to Tranalyzer -w or -W option.

### 41.3.4 PD_MODE_IN=1

In this mode, all the packets are dumped into one or more PCAP files. If Tranalyzer -W option is used, then the pcap files will be split accordingly. For example, the following command will create PCAP files of 100MB each: tranalyzer -i eth0 -W out:100M

### 41.3.5 PD_MODE_OUT=1

In this mode, every flow will have its own PCAP file, whose name will end with the flow index.

## 41.4 Plugin Report Output

The following information is reported:

- Number of packets extracted

## 41.5 Additional Output

A PCAP file with suffix `PD_SUFFIX` will be created. The prefix and location of the file depends on the configuration of the plugin.

- If Tranalyzer `-e` option was used, the file is named according to the `-e` option.
- Otherwise the file is named according to the `-w` or `-W` option.

## 41.6 Examples

For the following examples, it is assumed that Tranalyzer was run as follows, with the basicFlow and txtSink plugins in their default configuration:

```
tranalyzer -r file.pcap -w out
```

The column numbers can be obtained by looking in the file `out_headers.txt` or by using tawk .

### 41.6.1 Extracting ICMP Flows

To create a PCAP file containing ICMP flows only, proceed as follows:

1. Identify the *"Layer 4 protocol"* column in `out_headers.txt` (column 14):
   `grep "Layer 4 protocol" out_headers.txt`
2. Extract all flow indexes whose protocol is ICMP (1):
   `awk -F'\t' '$14 == 1 { print $2 }' out_flows.txt > out_icmp.txt`
3. Configure pcapd.h as follows: `PD_MODE_IN=0, PD_EQ=1`
4. Build the pcapd plugin: `cd $T2HOME/pcapd/; ./autogen.sh`
5. Re-run Tranalyzer with the `-e` option:
   `tranalyzer -r file.pcap -w out -e out_icmp.txt`
6. The file `out_icmp.txt.pcap` now contains all the ICMP flows.

### 41.6.2 Extracting Non-ICMP Flows

To create a PCAP file containing non-ICMP flows only, use the same procedure as that of Section 41.6.1, but replace `PD_EQ=1` with `PD_EQ=0` in step 3. Alternatively, replace `$14==1` with `$14!=1` in step 2. Or if an entire flow file is preferred to the flow indexes only, set `PD_FORMAT=1` and replace `print $2` with `print $0` in step 2.

# 42 pktSIATHisto

## 42.1 Description

The pktSIATHisto plugin records the packet size (PS) and inter-arrival time (IAT) of a flow. While the PS reflects the bin, the IAT is divided by default into statistical bins to conserve memory / flow (see example below). Where the low precision is reserved for the most prominent IAT of all known codecs. Nevertheless, it can be configured by the user in any arbitrary way. If the memory is not sufficient then decrease `HASHCHAINTABLE_BASE_SIZE` in *tranalyzer.h*.

| Bin | Range of IAT (default) |
|---|---|
| 0 – 199 | 0 ms (incl.) – 200 ms (excl.), partitioned into bins of 1 ms |
| 200 – 239 | 200 ms (incl.) – 400 ms (excl.), partitioned into bins of 5 ms |
| 240 – 299 | 400 ms (incl.) – 1 sec. (excl.), partitioned into bins of 10 ms |
| 300 | for all IAT higher than 1 sec. |

## 42.2 Configuration Flags

Classifying tasks may require other IAT binning. Then the bin limit `IATBINBu` and the binsize `IATBINWu` constants in *pktSIATHisto.h* need to be adapted as being indicated below using 6 different classes of bins:

```
#define IATSECMAX 6 // max # of section in statistics;
                    // last section comprises all elements > IATBINBu6


#define IATBINBu1   50// bin boundary of section one: [0, 50)ms
#define IATBINBu2   200
#define IATBINBu3   1000
#define IATBINBu4   10000
#define IATBINBu5   100000
#define IATBINBu6 1000000

#define IATBINWu1   10// bin width 1ms
#define IATBINWu2   5
#define IATBINWu3   10
#define IATBINWu4   20
#define IATBINWu5   50
#define IATBINWu6   100

#define IATBINNu1   IATBINBu1 / IATBINWu1// # of bins in section one
#define IATBINNu2   (IATBINBu2 - IATBINBu1) / IATBINWu2 + IATBINNu1
#define IATBINNu3   (IATBINBu3 - IATBINBu2) / IATBINWu3 + IATBINNu2
#define IATBINNu4   (IATBINBu4 - IATBINBu3) / IATBINWu4 + IATBINNu3
#define IATBINNu5   (IATBINBu5 - IATBINBu4) / IATBINWu5 + IATBINNu4
#define IATBINNu6   (IATBINBu6 - IATBINBu5) / IATBINWu6 + IATBINNu5
```

The number of bin sections is defined by `IATSECMAX`, default is 3. The static fields `IATBinBu` and `IATBinWu` need to be adapted when `IATSECMAX` is changed. The static definition in curly brackets of the constant fields `IATBinBu[]`, `IATBinBu[]` and `IATBinBu[]` must adapted as well to the maximal bin size. The constant `IATBINUMAX` including his two dimensional packet length, IAT statistics is being used by the descriptive statistics plugin and can suit as a raw input for subsequent statistical classifiers, such as Bayesian networks or C5.0 trees.

The user is able to customize the output by changing several define statements in the header file *pktSIATHisto.h*. Every change requires a recompilation of the plugin using the *autogen.sh* script.

HISTO_PRINT_BIN == 0, the default case, selects the number of the IAT bin, while 1 supplies the lower bound of the IAT bin's range.
As being outlined in the Descriptive Statistics plugin the output of the plugin can be suppressed by defining PRINT_HISTO to zero.
For specific applications in the AI regime, the distribution can be directed into a separate file if the value PRINT_HISTO_IN_SEPARATE_FILE is different from zero. The suffix for the distribution file is defined by the HISTO_FILE_SUFFIX define.
All switches are listed below:

| Name | Default | Description | Flags |
|---|---|---|---|
| PSIAT_NDPLF | 17 | multiplication factor red-black tree nodepool | |
| PRINT_HISTO | 1 | print histo to flow file | |
| HISTO_PRINT_BIN | 0 | Bin number; 0: Minimum of assigned inter arrival time<br>Example: Bin = 10 ⇒ iat = [50:55) ⇒ min(iat) = 50ms | |
| HISTO_EARLY_CLEANUP | 0 | after t2OnFlowTerminate() tree information is destroyed<br>(**MUST** be 0 if dependent plugins are loaded) | |
| PSI_XCLD | 0 | 1: include (PSI_XMIN, UINT16_MAX] | |
| PSI_XMIN | 1 | minimal packet length starts at PSI_XMIN | PSI_XCLD=1 |
| PSI_MOD | 0 | > 1 : Modulo factor of packet length | |
| IATSECMAX | 3 | max # of sections in statistics,<br>last section comprises all elements > IATBINBuN | PSI_XCLD=1 |

### 42.2.1 Environment Variable Configuration Flags

The following configuration flags can also be configured with environment variables (ENVCNTRL>0):

- PSIAT_NDPLF

## 42.3 Flow File Output

The pktSIATHisto plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| tCnt | U32 | Number of tree entries for PS and IAT | |
| Ps_IatBin_Cnt_ PsCnt_IatCnt | R(U16_4xU32) | Packet size and inter-arrival time of bin histogram | HISTO_PRINT_BIN=0 |
| Ps_Iat_Cnt_ PsCnt_IatCnt | R(U16_4xU32) | Packet size and min inter-arrival time of bin histogram | HISTO_PRINT_BIN=1 |

All PS-IAT bins greater than zero are appended for each flow in the PREFIX_flows.txt file using the following format:

```
[PS]_[IAT]_[# packets]_[# of packets PS]_[# of packets IAT]
```

the PS-IAT bins are separated by semicolons. The IAT value is the lower bound of the IAT range of a bin.

## 42.4 Post-Processing

The `statGplt` script can be used to transform the packet length and IAT statistics from pktSIATHisto to gnuplot or t2plot format. The format is:

- For the 3D case: **PS** `<tab>` **IAT** `<tab>` **count**
- For the 2D case: **PS** `<tab>` **count**

## 42.5 Example Output

Consider a single flow with the following PS and IAT values:

| Packet number | PS (bytes) | IAT (ms) | IAT bin |
|---|---|---|---|
| 1 | 50 | 0 | 0 |
| 2 | 70 | 88.2 | 17 |
| 3 | 70 | 84.3 | 16 |
| 4 | 70 | 92.9 | 18 |
| 5 | 70 | 87.1 | 17 |
| 6 | 60 | 91.6 | 18 |

Packet number two and five have the same PS-IAT combination. Packets number two to five have the same PS and number two and five as well as the number four and six fall within the same IAT bin. Therefore the following sequence is generated:

```
50_0_1_1_1 ; 60_90_1_1_2 ; 70_80_1_4_1 ; 70_85_2_4_2 ; 70_90_1_4_2
```

Note that for better readability spaces are inserted around the semicolons which will not exist in the text based flow file!

# 43 popDecode

## 43.1 Description

The popDecode plugin processes MAIL header and content information of a flow. The idea is to identify certain POP mail features and save content.

## 43.2 Configuration Flags

The following flags can be used to control the output of the plugin:

| Name | Default | Description | Flags |
|---|---|---|---|
| POP_SAVE | 0 | Save content to POP_F_PATH | |
| POP_BTFLD | 1 | Enable bitfields output | |
| POP_MXNMLN | 65 | Maximal name length | |
| POP_MXUNM | 5 | Maximal number of users | |
| POP_MXPNM | 5 | Maximal number of passwords/parameters | |
| POP_MXCNM | 10 | Maximal number of content | |
| POP_RMDIR | 1 | Empty POP_F_PATH before starting | POP_SAVE=1 |
| POP_F_PATH | "/tmp/POPFILES/" | Path for extracted content | POP_SAVE=1 |
| POP_NONAME | "nudel" | No name file name | POP_SAVE=1 |

### 43.2.1 Environment Variable Configuration Flags

The following configuration flags can also be configured with environment variables (ENVCNTRL>0):

- POP_RMDIR
- POP_F_PATH
- POP_NONAME

## 43.3 Flow File Output

The popDecode plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| popStat | H16 | Status | |
| popCBF | H16 | POP command codes bitfield | POP_BTFLD=1 |
| popCC | RSC | POP command codes | |
| popRM | RU16 | POP response codes | |
| popUsrNum | U8 | POP Number of users | |
| popUsr | RS | POP users | |
| popPwNum | U8 | POP Number of passwords | |
| popPw | RS | POP passwords | |
| popCNum | U8 | POP Number of parameters | |
| popC | RS | POP content | |

### 43.3.1 popStat

The `popStat` column describes the errors encountered during the flow lifetime:

| | popStat | Description | Flags |
|---|---|---|---|
| $2^0$ | (=0x0001) | POP2 port found | |
| $2^1$ | (=0x0002) | POP3 port found | |
| $2^2$ | (=0x0004) | Response `+OK` | |
| $2^3$ | (=0x0008) | Response `-ERR` | |
| $2^4$ | (=0x0010) | Data storage exists | `POP_SAVE=1` |
| $2^5$ | (=0x0020) | Data storage in progress | `POP_SAVE=1` |
| $2^6$ | (=0x0040) | Response not valid or data | |
| $2^7$ | (=0x0080) | Array overflow | |
| $2^8$ | (=0x0100) | Authentication pending | |
| $2^9$ | (=0x0200) | Return path pending | |
| $2^{10}$ | (=0x0400) | — | |
| $2^{11}$ | (=0x0800) | — | |
| $2^{12}$ | (=0x1000) | — | |
| $2^{13}$ | (=0x2000) | — | |
| $2^{14}$ | (=0x4000) | — | |
| $2^{15}$ | (=0x8000) | — | |

### 43.3.2 popCBF

The `popCBF` column describes the commands encountered during the flow lifetime:

| | popCBF | Description |
|---|---|---|
| $2^0$ | (=0x0001) | Login with MD5 signature |
| $2^1$ | (=0x0002) | Authentication request |
| $2^2$ | (=0x0004) | Get a list of capabilities supported by the server |
| $2^3$ | (=0x0008) | Mark the message as deleted |
| $2^4$ | (=0x0010) | Get a scan listing of one or all messages |
| $2^5$ | (=0x0020) | Return a `+OK` reply |
| $2^6$ | (=0x0040) | Cleartext password entry |
| $2^7$ | (=0x0080) | Exit session. Remove all deleted messages from the server |
| $2^8$ | (=0x0100) | Retrieve the message |
| $2^9$ | (=0x0200) | Remove the deletion marking from all messages |
| $2^{10}$ | (=0x0400) | Get the drop listing |
| $2^{11}$ | (=0x0800) | Begin a TLS negotiation |
| $2^{12}$ | (=0x1000) | Get the top n lines of the message |

| | popCBF | Description |
|---|---|---|
| $2^{13}$ | (=0x2000) | Get a unique-id listing for one or all messages |
| $2^{14}$ | (=0x4000) | Mailbox login |
| $2^{15}$ | (=0x8000) | |

## 43.4 Packet File Output

In packet mode (-s option), the popDecode plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| popStat | H16 | Status | |

## 43.5 Plugin Report Output

The following information is reported:

- POP status
- Number of POP packets
- Number of files extracted (POP_SAVE=1)

## 43.6 TODO

- fragmentation

# 44 portClassifier

## 44.1 Description

The portClassifier plugin classifies the flow according to the destination port meaning. It accepts a default port list `portmap.txt`, automatically installed with the plugin.

## 44.2 Dependencies

### 44.2.1 Required Files

The file `portmap.txt` is required.

## 44.3 Configuration Flags

The following flags can be used to control the output of the plugin:

| Name | Default | Description |
|---|---|---|
| PBC_NUM | 1 | Print string representation of port classification |
| PBC_STR | 1 | Print numeric representation of port classification |
| PBC_CLASSFILE | "portmap.txt" | input file for the mapping between ports and applications |
| PBC_UNKNOWN | "unknown" | Label for unknown ports |

### 44.3.1 Environment Variable Configuration Flags

The following configuration flags can also be configured with environment variables (ENVCNTRL>0):

- PBC_CLASSFILE
- PBC_UNKNOWN

## 44.4 Flow File Output

The portClassifier plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| dstPortClassN | U16 | Port based classification of the destination port number | PBC_NUM=0 |
| dstPortClass | SC | Port based classification of the destination port name | PBC_STR=1 |

## 44.5 Packet File Output

In packet mode (`-s` option), the portClassifier plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| dstPortClassN | U16 | Port based classification of the destination port number | PBC_NUM=0 |
| dstPortClass | SC | Port based classification of the destination port name | PBC_STR=1 |

# 45 protoStats

## 45.1 Description

The protoStats plugin provides protocol/port sorted frequency statistics about the observed OSI layer 4 protocols and ports to the file named `PREFIX_protocols`. Protocols numbers are decoded via a `proto.txt` file, automatically installed with the plugin.

## 45.2 Dependencies

### 45.2.1 Required Files

The following files are required:

- `PST_L2ETHFILE` (`"ethertypes.txt"`)
- `PST_PORTFILE` (`"portmap.txt"`)
- `PST_PROTOFILE` (`"proto.txt"`)

## 45.3 Configuration Flags

The following flags can be used to control the output of the plugin:

| Name | Default | Description |
|---|---|---|
| `PST_ETH_STAT` | 1 | Output layer 2 statistics |
| `PST_SCTP_STAT` | 0 | Output SCTP statistics |
| `PST_UDPLITE_STAT` | 0 | Output UDP-Lite statistics |
| `PST_SUFFIX` | `"_protocols.txt"` | Suffix for output file |

### 45.3.1 Environment Variable Configuration Flags

The following configuration flags can also be configured with environment variables (`ENVCNTRL>0`):

- `PST_SUFFIX`
- `PST_L2ETHFILE`
- `PST_PORTFILE`
- `PST_PROTOFILE`

## 45.4 Flow File Output

None.

## 45.5 Additional Output

- `PREFIX_protocols.txt`: protocol statistics

## 45.6 Post-Processing

The `protStat` script can be used to sort the `PREFIX_protocols.txt` file for the most or least occurring protocols (in terms of number of packets or bytes). It can output the top or bottom *N* protocols or only those with at least a given percentage.

- list all the options: `protStat --help`
- for better readability, use `protStat` with `tcol`: `protStat ... | tcol`
- sorted list of protocols (by packets): `protStat PREFIX_protocols.txt`
- sorted list of protocols (by bytes): `protStat PREFIX_protocols.txt -b`
- top 10 protocols (by packets): `protStat PREFIX_protocols.txt -n 10`
- bottom 5 protocols (by bytes): `protStat PREFIX_protocols.txt -n -5 -b`
- protocols with packets percentage greater than 20%: `protStat PREFIX_protocols.txt -p 20`
- protocols with bytes percentage smaller than 5%: `protStat PREFIX_protocols.txt -b -p -5`
- TCP and UDP statistics only: `protStat PREFIX_protocols.txt -udp -tcp`

# 46 psqlSink

## 46.1 Description

The psqlSink plugin outputs flows to a PostgreSQL database.

## 46.2 Dependencies

### 46.2.1 External Libraries

This plugin depends on the **libpq** library.

| | | |
|---|---|---|
| **Ubuntu:** | `sudo apt-get install` | `libpq-dev` |
| **Arch:** | `sudo pacman -S` | `postgresql-libs` |
| **Gentoo:** | `sudo emerge` | `postgresql` |
| **openSUSE:** | `sudo zypper install` | `postgresql-devel` |
| **Red Hat/Fedora**[26]**:** | `sudo dnf install` | `libpq-devel` |
| **macOS**[27]**:** | `brew install` | `postgresql` |

### 46.2.2 Core Configuration

This plugin requires the following core configuration:

- *$T2HOME/tranalyzer2/src/tranalyzer.h*:
  - `BLOCK_BUF=0`

## 46.3 Database Initialization

The psqlSink plugin requires a PostgreSQL server running on `PSQL_HOST`, e.g., `127.0.0.1` on port `PSQL_PORT`, e.g., 5432. In addition, a user with name `PSQL_USER`, e.g., `postgres`, and password `PSQL_PASS`, e.g., `postgres` **MUST** exist and be allowed to create databases. This can be achieved with the following commands:

**Linux:** `$ sudo -u postgres psql` **macOS:** `$ psql postgres`

```
postgres=# CREATE ROLE postgres WITH LOGIN PASSWORD 'postgres';
CREATE ROLE
postgres=# ALTER ROLE postgres CREATEDB;
ALTER ROLE
```

## 46.4 Configuration Flags

The following flags can be used to control the output of the plugin:

| Name | Default | Description |
|---|---|---|
| `PSQL_OVERWRITE_DB` | 2 | 0: abort if DB already exists |

[26] If the `dnf` command could not be found, try with `yum` instead
[27] Brew is a packet manager for macOS that can be found here: `https://brew.sh`

| Name | Default | Description |
|---|---|---|
| PSQL_OVERWRITE_TABLE | 2 | 1: overwrite DB if it already exists<br>2: reuse DB if it already exists<br>0: abort if table already exists<br>1: overwrite table if it already exists<br>2: append to table if it already exists |
| PSQL_TRANSACTION_NFLOWS | 40000 | 0: one transaction<br>> 0: one transaction every *n* flows |
| PSQL_QRY_LEN | 32768 | Max length for query |
| PSQL_HOST | "127.0.0.1" | Address of the database |
| PSQL_PORT | 5432 | Port of the database |
| PSQL_USER | "postgres" | Username to connect to DB |
| PSQL_PASS | "postgres" | Password to connect to DB |
| PSQL_DBNAME | "tranalyzer" | Name of the database |
| PSQL_TABLE_NAME | "flow" | Name of the table |
| PSQL_SELECT | 0 | Only insert specific fields into the DB |
| PSQL_SELECT_FILE | "psql-columns.txt" | Filename of the field selector (one column name per line) |

### 46.4.1 Environment Variable Configuration Flags

The following configuration flags can also be configured with environment variables (ENVCNTRL>0):

- PSQL_HOST
- PSQL_PORT
- PSQL_USER
- PSQL_PASS
- PSQL_DBNAME
- PSQL_TABLE_NAME
- PSQL_SELECT_FILE (require PSQL_SELECT=1)

## 46.5 Insertion of Selected Fields Only

When PSQL_SELECT=1, the columns to insert into the DB can be customized with the help of PSQL_SELECT_FILE. The filename defaults to psql-columns.txt in the user plugin folder, e.g., *~/.tranalyzer/plugins*. The format of the file is simply one field name per line with lines starting with a '#' being ignored. For example, to only insert source and destination addresses and ports, create the following file:

```
# Lines starting with a '#' are ignored and can be used to add comments
srcIP
srcPort
dstIP
dstPort
```

## 46.6 Post-Processing

The following queries can be used to analyze bitfields in PostgreSQL:

- Select all A flows:
```
SELECT to_hex("flowStat"::bigint), *
FROM flow
WHERE ("flowStat"::bigint & 1) = 0::bigint
```
- Select all IPv4 flows:
```
SELECT *
FROM flow
WHERE ("flowStat"::bigint & x'4000'::bigint) != 0::bigint
```
- Select all IPv6 flows:
```
SELECT to_hex("flowStat"::bigint), *
FROM flow
WHERE ("flowStat"::bigint & x'8000'::bigint) != 0::bigint
```

## 46.7 Example

```
# Run Tranalyzer
$ t2 -r file.pcap

# Connect to the PostgreSQL database
$ psql -U postgres -d tranalyzer

# Number of flows
tranalyzer=# SELECT COUNT(*) FROM flow;

# 10 first srcIP/dstIP pairs
tranalyzer=# SELECT "srcIP", "dstIP" FROM flow LIMIT 10;

# All flows from 1.2.3.4 to 1.2.3.5
tranalyzer=# SELECT * FROM flow WHERE "srcIP" = '1.2.3.4' AND "dstIP" = '1.2.3.5';
```

For examples of more complex queries, have a look in `$T2HOME/scripts/t2fm/psql/`.

### 46.7.1 Clean up an existing database

```
# Connect to the PostgreSQL database
$ psql -U postgres

# Drop the database
tranalyzer=# DROP DATABASE tranalyzer;
```

# 47 pwX

## 47.1 Description

The pwX plugin extracts usernames and passwords from different plaintext protocols. This plugin produces only output to the flow file. Configuration is achieved by user defined compiler switches in `src/pwX.h`.

## 47.2 Configuration Flags

The following flags can be used to control the output of the plugin:

| Variable | Default | Description |
|---|---|---|
| PWX_USERNAME | 1 | Output the username |
| PWX_PASSWORD | 1 | Output the password |
| PWX_FTP | 1 | Extract FTP authentication |
| PWX_POP3 | 1 | Extract POP3 authentication |
| PWX_IMAP | 1 | Extract IMAP authentication |
| PWX_SMTP | 1 | Extract SMTP authentication |
| PWX_HTTP_BASIC | 1 | Extract HTTP Basic Authorization |
| PWX_HTTP_PROXY | 1 | Extract HTTP Proxy Authorization |
| PWX_HTTP_GET | 1 | Extract HTTP GET authentication |
| PWX_HTTP_POST | 1 | Extract HTTP POST authentication |
| PWX_IRC | 1 | Extract IRC authentication |
| PWX_TELNET | 1 | Extract Telnet authentication |
| PWX_LDAP | 1 | Extract LDAP bind request authentication |
| PWX_PAP | 1 | Extract PAP (Password Authentication Protocol) authentication |
| PWX_STATUS | 1 | Extract authentication status (success, error, ...). |
| PWX_DEBUG | 0 | Activate debug output. |

## 47.3 Flow File Output

The pwX plugin outputs the following columns:

| Name | Type | Description | Flags |
|---|---|---|---|
| pwxType | U8 | Authentication type | |
| pwxUser | S | Extracted username | PWX_USERNAME!=0 |
| pwxPass | S | Extracted password | PWX_PASSWORD!=0 |
| pwxStatus | U8 | Authentication status | PWX_STATUS!=0 |

### 47.3.1 pwxType

The `pwxType` column is to be interpreted as follows:

| pwxType | Description |
|---|---|
| 0 | No password or username extracted |
| 1 | FTP authentication |
| 2 | POP3 authentication |
| 3 | IMAP authentication |
| 4 | SMTP authentication |
| 5 | HTTP Basic Authorization |
| 6 | HTTP Proxy Authorization |
| 7 | HTTP GET authentication |
| 8 | HTTP POST authentication |
| 9 | IRC authentication |
| 10 | Telnet authentication |
| 11 | LDAP authentication |
| 12 | PAP authentication |

### 47.3.2 pwxStatus

The `pwxStatus` column is to be interpreted as follows:

| pwxStatus | Description |
|---|---|
| 0 | Authentication status is unknown |
| 1 | Authentication was successful |
| 2 | Authentication failed |

## 47.4 Plugin Report Output

The number of passwords extracted is reported.

# 48 radiusDecode

## 48.1 Description

The radiusDecode plugin analyzes RADIUS traffic.

## 48.2 Configuration Flags

The following flags can be used to control the output of the plugin:

| Name | Default | Description |
|---|---|---|
| RADIUS_CNTS | 1 | Output counts, necessary for FORCE_MODE |
| RADIUS_AVPTYPE | 1 | Output AVP Types |
| RADIUS_NAS | 1 | Output NAS info |
| RADIUS_FRAMED | 1 | Output framed info |
| RADIUS_TUNNEL | 1 | Output tunnel info |
| RADIUS_ACCT | 1 | Output accounting info |
| RADIUS_NMS | 0 | Codes and AVP types format:<br>0: No code/type output<br>1: Values,<br>2: Names |
| RAD_CNTMX | 20 | Maximum number of codes/AVP types |
| RADIUS_STRMAX | 128 | Maximum length for strings |

## 48.3 Flow File Output

The radiusDecode plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| radiusStat | H8 | Status | |
| radiusAxsReq_Acc_Rej_Chal | 4xU16 | Access-Request/Accept/Reject/Challenge | RADIUS_CNTS=1 |
| radiusAccReq_Resp | U16_U16 | Accounting-Request/Response | RADIUS_CNTS=1 |
| radiusAccStart_Stop | U16_U16 | Accounting Start/Stop | RADIUS_CNTS=1 |
| radiusCodes | R(U8) | Radius codes | RADIUS_NMS=1 |
| radiusCodeNms | R(S) | Radius code names | RADIUS_NMS=2 |
| radiusAVPTypes | R(U8) | AVP types | RADIUS_AVPTYPE=1&&<br>RADIUS_NMS=1 |
| radiusAVPTypeNms | R(S) | AVP type names | RADIUS_AVPTYPE=1&&<br>RADIUS_NMS=2 |
| radiusUser | S | Username | |
| radiusPW | S | Password | |
| radiusServiceType | U32 | Service type | |
| radiusLoginService | U32 | Login-Service | |
| radiusVendor | U32 | Vendor Id (SMI) | |

If RADIUS_NAS=1, the following columns are displayed:

| Column | Type | Description | Flags |
|---|---|---|---|
| radiusNasId | S | NAS Identifier | |
| radiusNasIp | IP4 | NAS IP address | |
| radiusNasPort | U32 | NAS IP port | |
| radiusNasPortType | U32 | NAS port type | |
| radiusNasPortId | S | NAS port Id | |
| If RADIUS_FRAMED=1, the following columns are displayed: | | | |
| radiusFramedIp | IP4 | Framed IP address | |
| radiusFramedMask | IP4 | Framed IP netmask | |
| radiusFramedProto | U32 | Framed protocol | |
| radiusFramedComp | U32 | Framed compression | |
| radiusFramedMtu | U32 | Framed MTU | |
| If RADIUS_TUNNEL=1, the following columns are displayed: | | | |
| radiusTunnel_Medium | U32_U32 | Tunnel type and medium type | |
| radiusTunnelCli | S | Tunnel client endpoint | |
| radiusTunnelSrv | S | Tunnel server endpoint | |
| radiusTunnelCliAId | S | Tunnel client authentication Id | |
| radiusTunnelSrvAId | S | Tunnel server authentication Id | |
| radiusTunnelPref | S | Tunnel preference | |
| If RADIUS_ACCT=1, the following columns are displayed: | | | |
| radiusAcctSessId | S | Accounting session Id | |
| radiusAcctSessTime | U32 | Accounting session time (seconds) | |
| radiusAcctStatType | U32 | Accounting status type | |
| radiusAcctTerm | U32 | Accounting terminate cause | |
| radiusAcctInOct_OutOct | U32_U32 | Accounting input/output octets | |
| radiusAcctInPkt_OutPkt | U32_U32 | Accounting input/output packets | |
| radiusAcctInGw_OutGw | U32_U32 | Accounting input/output gigawords | |
| radiusConnInfo | S | User connection info | |
| radiusFilterId | S | Filter Identifier | |
| radiusCalledId | S | Called Station Identifier | |
| radiusCallingId | S | Calling Station Identifier | |
| radiusReplyMsg | S | Reply message | |

### 48.3.1 radiusStat

The radiusStat column is to be interpreted as follows:

| radiusStat | Description |
|---|---|
| $2^0$ (=0x01) | Flow is RADIUS |

| radiusStat | Description |
|---|---|
| $2^1$ (=0x02) | Authentication and configuration traffic |
| $2^2$ (=0x04) | Accounting traffic |
| $2^3$ (=0x08) | — |
| $2^4$ (=0x10) | Connection successful |
| $2^5$ (=0x20) | Connection failed |
| $2^6$ (=0x40) | — |
| $2^7$ (=0x80) | Malformed packet |

### 48.3.2 radiusServiceType

The `radiusServiceType` column is to be interpreted as follows:

| radiusServiceType | Description |
|---|---|
| 1 | Login |
| 2 | Framed |
| 3 | Callback Login |
| 4 | Callback Framed |
| 5 | Outbound |
| 6 | Administrative |
| 7 | NAS Prompt |
| 8 | Authenticate Only |
| 9 | Callback NAS Prompt |
| 10 | Call Check |
| 11 | Callback Administrative |
| 12 | Voice |
| 13 | Fax |
| 14 | Modem Relay |
| 15 | IAPP-Register |
| 16 | IAPP-AP-Check |
| 17 | Authorize Only |
| 18 | Framed-Management |
| 19 | Additional-Authorization |

### 48.3.3 radiusLoginService

The `radiusLoginService` column is to be interpreted as follows:

| radiusLoginService | Description |
|---|---|
| 0 | Telnet |
| 1 | Rlogin |
| 2 | TCP Clear |
| 3 | PortMaster (proprietary) |
| 4 | LAT |

| radiusLoginService | Description |
|---|---|
| 5 | X25-PAD |
| 6 | X25-T3POS |
| 7 | Unassigned |
| 8 | TCP Clear Quiet (suppresses any NAS-generated connect string) |

### 48.3.4 radiusVendor

The `radiusVendor` column represents the SMI Network Management Private Enterprise Codes which can be found at https://www.iana.org/assignments/enterprise-numbers. Alternatively use `grep` on the file `vendor.txt` as follows: `grep id vendor.txt`, where `id` is the actual Id reported by Tranalyzer, e.g., 4874 for Juniper.

### 48.3.5 radiusNasPortType

The `radiusNasPortType` column is to be interpreted as follows:

| radiusNasPortType | Description |
|---|---|
| 0 | Async |
| 1 | Sync |
| 2 | ISDN Sync |
| 3 | ISDN Async V.120 |
| 4 | ISDN Async V.110 |
| 5 | Virtual |
| 6 | PIAFS |
| 7 | HDLC Clear Channel |
| 8 | X.25 |
| 9 | X.75 |
| 10 | G.3 Fax |
| 11 | SDSL - Symmetric DSL |
| 12 | ADSL-CAP - Asymmetric DSL, Carrierless Amplitude Phase Modulation |
| 13 | ADSL-DMT - Asymmetric DSL, Discrete Multi-Tone |
| 14 | IDSL - ISDN Digital Subscriber Line |
| 15 | Ethernet |
| 16 | xDSL - Digital Subscriber Line of unknown type |
| 17 | Cable |
| 18 | Wireless - Other |
| 19 | Wireless - IEEE 802.11 |
| 20 | Token-Ring |
| 21 | FDDI |
| 22 | Wireless - CDMA2000 |
| 23 | Wireless - UMTS |
| 24 | Wireless - 1X-EV |
| 25 | IAPP |
| 26 | FTTP - Fiber to the Premises |
| 27 | Wireless - IEEE 802.16 |
| 28 | Wireless - IEEE 802.20 |

| radiusNasPortType | Description |
|---|---|
| 29 | Wireless - IEEE 802.22 |
| 30 | PPPoA - PPP over ATM |
| 31 | PPPoEoA - PPP over Ethernet over ATM |
| 32 | PPPoEoE - PPP over Ethernet over Ethernet |
| 33 | PPPoEoVLAN - PPP over Ethernet over VLAN |
| 34 | PPPoEoQinQ - PPP over Ethernet over IEEE 802.1QinQ |
| 35 | xPON - Passive Optical Network |
| 36 | Wireless - XGP |
| 37 | WiMAX Pre-Release 8 IWK Function |
| 38 | WIMAX-WIFI-IWK: WiMAX WIFI Interworking |
| 39 | WIMAX-SFF: Signaling Forwarding Function for LTE/3GPP2 |
| 40 | WIMAX-HA-LMA: WiMAX HA and or LMA function |
| 41 | WIMAX-DHCP: WiMAX DCHP service |
| 42 | WIMAX-LBS: WiMAX location based service |
| 43 | WIMAX-WVS: WiMAX voice service |

#### 48.3.6 radiusFramedProto

The `radiusFramedProto` column is to be interpreted as follows:

| radiusFramedProto | Description |
|---|---|
| 1 | PPP |
| 2 | SLIP |
| 3 | AppleTalk Remote Access Protocol (ARAP) |
| 4 | Gandalf proprietary SingleLink/MultiLink protocol |
| 5 | Xylogics proprietary IPX/SLIP |
| 6 | X.75 Synchronous |
| 7 | GPRS PDP Context |

#### 48.3.7 radiusFramedComp

The `radiusFramedComp` column is to be interpreted as follows:

| radiusFramedComp | Description |
|---|---|
| 0 | None |
| 1 | VJ TCP/IP header compression |
| 2 | IPX header compression |
| 3 | Stac-LZS compression |

#### 48.3.8 radiusTunnel_Medium

The `radiusTunnel_Medium` column is to be interpreted as follows:

| radiusTunnel | Description |
|---|---|
| 1 | Point-to-Point Tunneling Protocol (PPTP) |
| 2 | Layer Two Forwarding (L2F) |
| 3 | Layer Two Tunneling Protocol (L2TP) |
| 4 | Ascend Tunnel Management Protocol (ATMP) |
| 5 | Virtual Tunneling Protocol (VTP) |
| 6 | IP Authentication Header in the Tunnel-mode (AH) |
| 7 | IP-in-IP Encapsulation (IP-IP) |
| 8 | Minimal IP-in-IP Encapsulation (MIN-IP-IP) |
| 9 | IP Encapsulating Security Payload in the Tunnel-mode (ESP) |
| 10 | Generic Route Encapsulation (GRE) |
| 11 | Bay Dial Virtual Services (DVS) |
| 12 | IP-in-IP Tunneling |
| 13 | Virtual LANs (VLAN) |

| radiusMedium | Description |
|---|---|
| 1 | IPv4 (IP version 4) |
| 2 | IPv6 (IP version 6) |
| 3 | NSAP |
| 4 | HDLC (8-bit multidrop) |
| 5 | BBN 1822 |
| 6 | 802 (includes all 802 media plus Ethernet “canonical format”) |
| 7 | E.163 (POTS) |
| 8 | E.164 (SMDS, Frame Relay, ATM) |
| 9 | F.69 (Telex) |
| 10 | X.121 (X.25, Frame Relay) |
| 11 | IPX |
| 12 | Appletalk |
| 13 | Decnet IV |
| 14 | Banyan Vines |
| 15 | E.164 with NSAP format subaddress |

### 48.3.9 radiusAcctStatType

The `radiusAcctStatType` column is to be interpreted as follows:

| radiusAcctStatType | Description |
|---|---|
| 1 | Start |
| 2 | Stop |
| 3 | Interim-Update |
| 7 | Accounting-On |
| 8 | Accounting-Off |
| 9 | Tunnel-Start |
| 10 | Tunnel-Stop |

| radiusAcctStatType | Description |
|---|---|
| 11 | Tunnel-Reject |
| 12 | Tunnel-Link-Start |
| 13 | Tunnel-Link-Stop |
| 14 | Tunnel-Link-Reject |
| 15 | Failed |

### 48.3.10 radiusAcctTerm

The `radiusAcctTerm` column is to be interpreted as follows:

| radiusAcctTerm | Description |
|---|---|
| 1 | User Request |
| 2 | Lost Carrier |
| 3 | Lost Service |
| 4 | Idle Timeout |
| 5 | Session Timeout |
| 6 | Admin Reset |
| 7 | Admin Reboot |
| 8 | Port Error |
| 9 | NAS Error |
| 10 | NAS Request |
| 11 | NAS Reboot |
| 12 | Port Unneeded |
| 13 | Port Preempted |
| 14 | Port Suspended |
| 15 | Service Unavailable |
| 16 | Callback |
| 17 | User Error |
| 18 | Host Request |
| 19 | Supplicant Restart |
| 20 | Reauthentication Failure |
| 21 | Port Reinitialized |
| 22 | Port Administratively Disabled |
| 23 | Lost Power |

## 48.4 Packet File Output

In packet mode (`-s` option), the radiusDecode plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| radiusStat | H8 | Status | |
| radiusCode | U8 | Code | RADIUS_NMS=1 |
| radiusCodeNm | S | Code name | RADIUS_NMS=2 |
| radiusAVPTypes | R(U8) | AVP types | RADIUS_AVPTYPE=1&&RADIUS_NMS=1 |

| Column | Type | Description | Flags |
|---|---|---|---|
| radiusAVPTypeNms | R(S) | AVP type names | RADIUS_AVPTYPE=1&&RADIUS_NMS=2 |

## 48.5 Monitoring Output

In monitoring mode, the radiusDecode plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| radiusPkts | U64 | Number of RADIUS packets | |
| radiusAxsPkts | U64 | Number of Access | |
| radiusAxsAccPkts | U64 | Number of Access-Accept | |
| radiusAxsRejPkts | U64 | Number of Access-Reject | |
| radiusAccPkts | U64 | Number of Accounting packets | |

## 48.6 Plugin Report Output

The following information is reported:

- Aggregated radiusStat
- Number of RADIUS packets
- Number of Access, Access-Accept, Access-Reject and Accounting packets

## 48.7 References

- RFC2865: Remote Authentication Dial In User Service (RADIUS)
- RFC2866: RADIUS Accounting
- RFC2867: RADIUS Accounting Modifications for Tunnel Protocol Support
- RFC2868: RADIUS Attributes for Tunnel Protocol Support
- RFC2869: RADIUS Extensions
- https://www.iana.org/assignments/radius-types/radius-types.xhtml

# 49 regex_pcre

## 49.1 Description

The regex_pcre plugin provides a full PCRE compatible regex engine.

## 49.2 Dependencies

### 49.2.1 External Libraries

This plugin depends on the **pcre** library.

| | | |
|---|---|---|
| **Ubuntu:** | `sudo apt-get install` | `libpcre3-dev` |
| **Arch:** | `sudo pacman -S` | `pcre pcre2` |
| **openSUSE:** | `sudo zypper install` | `pcre-devel` |
| **Red Hat/Fedora**[28]**:** | `sudo dnf install` | `pcre-devel` |
| **macOS**[29]**:** | `brew install` | `pcre` |

### 49.2.2 Required Files

The file `regexfile.txt` is required (automatically generated from `scripts/regfile.txt`). Refer to Section 49.3.4 for more details.

## 49.3 Configuration Flags

### 49.3.1 regfile_pcre.h

The compiler constants in *regfile_pcre.h* control the pre-processing and compilation of the rule sets supplied in the regex file during the initialization phase of Tranalyzer.

| Name | Default | Description | Flags |
|---|---|---|---|
| `RULE_OPTIMIZE` | 1 | 0: No opt rules allocated<br>1: Allocate opt rule structure and compile regex | |
| `REGEX_MODE` | `PCRE_DOTALL` | Regex compile time options | |
| `PREIDMX` | 4 | Max number of node predecessors | |

### 49.3.2 regex_pcre.h

The compiler constants in *regex_pcre.h* control the execution and the output the rule matches.

| Variable | Default | Description | Flags |
|---|---|---|---|
| `EXPERTMODE` | 0 | 0: Alarm with highest severity: class type and severity,<br>1: full info | |

[28] If the `dnf` command could not be found, try with `yum` instead
[29] Brew is a packet manager for macOS that can be found here: `https://brew.sh`

| Variable | Default | Description | Flags |
|---|---|---|---|
| PKTTIME | 0 | 0: no time, 1: timestamp when rule matched | |
| AGGR | 0 | 1: Aggregate alarms | |
| SALRMFLG | 0 | 1: enable sending FL_ALARM for pcapd | |
| MAXREGPOS | 30 | Maximal # of matches stored / flow | |
| RGX_POSIX_FILE | "regexfile.txt" | Name of regex file under *./tranalyzer/plugins* | |
| OVECCOUNT | 3 | Value % 3 | |

### 49.3.3 Environment Variable Configuration Flags

The following configuration flags can also be configured with environment variables (ENVCNTRL>0):

- RGX_POSIX_FILE

### 49.3.4 regexfile.txt

The *scripts/regexfile.txt* file has the following format:

```
#ID     PreID   Flags   ClassID Severity        Sel     Regexmode       FlwStat Proto   srcPort
    dstPort offset  Regex

# standalone rule: Alarm, start L7, Regexmode: default, select FlwStat: Req; Proto, dstPort
1       0       0x10    15      3       0x8000000d      0x0000000       0x00000000      6       0
          80      0       (OPTIONS|GET|HEAD|POST|PUT|DELETE|TRACE|CONNECT)[^\r\n]*\/u7avi*\.bin

# standalone rule: Alarm, disabled, start L7, select Regexmode: (PCRE_CASELESS|PCRE_DOTALL),
    FlwStat: Teredo, IPv6, Vlan, Repl; Proto, srcPort
3       0       0x10    15      3       0x0800000e      0x0000005       0x00088101      6       80
          0       0       \x31\xDB\x8D\x43\x0D\xCD\x80\x66.*\x31

# standalone rule: Alarm, start L7, Regexmode: default, FlwStat: IPv4, Rply
4       0       0x10    15      3       0x8000000c      0x0000000       0x00004001      6       80
          0       20      \x38\x55\x42\x66\xe2\xb5\x34.*\xb5\x95\xbb

# standalone rule, Alarm, start L7, select Regexmode: (PCRE_CASELESS|PCRE_DOTALL)
100     0       0x10    1       0       0x88000000      0x0000005       0x00000000      6       0
          80      0       ^http/1.0

# root rules to following tree, Reset if leaf fires
202     0       0x40    10      4       0x80000000      0x0000000       0x00000001      6       0
          80      0       (GET|PUT).*update/u7avi1777u1705ff.bin
203     202,4   0x41    20      4       0x88000000      0x0000005       0x00000001      6       0
          80      0       302 (?i)Found

# successors and predecessors, Reset if leaf fires
204     202,203 0x41    43      5       0x80000000      0x0000000       0x00000001      6       0
          21      0       (?i)\.exe

# successors 206 & 205 to 204 AND ruleset, don't reset tree if 205 fires
205     204     0x16    40      4       0x80000002      0x0000000       0x00000000      6       0
          20      0       ^get .*porno.*
206     204     0x56    35      6       0x8000000c      0x0000000       0x00000001      6       0
          21      0       igfxzoom\.exe
```

Lines starting with a '#' denote a comment line and will be ignored. All kind of rule trees can be formed using rules also acting on multiple packets using different ID's and Predecessor as outlined in the example above. Regex rules with the same ID denote combined predecessors to other rules. Default is an OR operation unless ANDPin bits are set. These bits denote the different inputs to a bitwise AND. The output is then provided to the successor rule which compares with the ANDMask bit field whether all necessary rules are matched. Then an evaluation of the successor rule can take place. Thus, arbitrary rule trees can be constructed and results of predecessors can be used for multiple successor rules. The variable Flags controls the basic PCRE rule interpretation and the flow alarm production (see the table below), e.g. only if bit eight is set and alarm flow output is produced. ClassID and Severity denote information being printed in the flow file if the rule fires.

| Flags | Description |
|---|---|
| $2^0$ (=0x01) | Predecessor OPS |
| $2^1$ (=0x02) | Predecessor OPS |
| $2^2$ (=0x04) | Leaf |
| $2^3$ (=0x08) | — |
| $2^4$ (=0x10) | Print alarm to flow file |
| $2^5$ (=0x20) | Rule active only in flow boundary |
| $2^6$ (=0x40) | Reset REG_F_MTCH tree if match |
| $2^7$ (=0x80) | Internal: Regex match |

| Predecessor OPS | OP | Description |
|---|---|---|
| 0x00 | NONE | None, solitary rule |
| 0x01 | AND | and(pred1, pred2, ...) |
| 0x02 | OR | or(pred1, pred2, ...) |
| 0x03 | XOR | xor(pred1, pred2, ...) |

The Sel column controls the header selection of a rule in the lower nibble and the start of regex evaluation in the higher nibble. The position of the bits in the control byte are outlined below:

| Sel | Description |
|---|---|
| $2^0$ (=0x00000001) | Activate srcPort field |
| $2^1$ (=0x00000002) | Activate dstPort field |
| $2^2$ (=0x00000004) | Activate L4Proto field |
| $2^3$ (=0x00000008) | Activate flowStat field |
| $2^{27}$ (=0x08000000) | PCRE mode active; otherwise default |
| $2^{28}$ (=0x10000000) | Header start: Layer 2 |
| $2^{29}$ (=0x20000000) | Header start: Layer 3 |
| $2^{30}$ (=0x40000000) | Header start: Layer 4 |
| $2^{31}$ (=0x80000000) | Header start: Layer 7 |

Bit 0 - 27 selects the first 32 bit of flowStat, the protocol, source and destination port will be evaluated per rule, all others will be ignored. The flowStat field might contain other bits meaning more selection options in future. The

`offset` column depicts the start of the regex evaluation from the selected header start, default value 0. The `Regex` column accepts a full PCRE regex term. If the regex is not correct, the rule will be discarded displaying an error message in the Tranalyzer report.

The `regexmode` column denotes the mode of regex compilation and execution, listed below. If **0x00000000** then the default defined by `REGEX_MODE` is used.

| | regexmode | Name | Description |
|---|---|---|---|
| $2^0$ | (=0x00000001) | PCRE_CASELESS | Compile |
| $2^1$ | (=0x00000002) | PCRE_MULTILINE | Compile |
| $2^2$ | (=0x00000004) | PCRE_DOTALL | Compile |
| $2^3$ | (=0x00000008) | PCRE_EXTENDED | Compile |
| $2^4$ | (=0x00000010) | PCRE_ANCHORED | Compile, DFA exec |
| $2^5$ | (=0x00000020) | PCRE_DOLLAR_ENDONLY | Compile |
| $2^6$ | (=0x00000040) | PCRE_EXTRA | Compile |
| $2^7$ | (=0x00000080) | PCRE_NOTBOL | Exec, DFA exec |
| $2^8$ | (=0x00000100) | PCRE_NOTEOL | Exec, DFA exec |
| $2^9$ | (=0x00000200) | PCRE_UNGREEDY | Compile |
| $2^{10}$ | (=0x00000400) | PCRE_NOTEMPTY | Exec, DFA exec |
| $2^{11}$ | (=0x00000800) | PCRE_UTF8 | Compile |
| $2^{12}$ | (=0x00001000) | PCRE_NO_AUTO_CAPTURE | Compile |
| $2^{13}$ | (=0x00002000) | PCRE_NO_UTF8_CHECK | Compile, DFA exec |
| $2^{14}$ | (=0x00004000) | PCRE_AUTO_CALLOUT | Compile |
| $2^{15}$ | (=0x00008000) | PCRE_PARTIAL_SOFT | Exec, DFA exec |
| $2^{16}$ | (=0x00010000) | PCRE_DFA_SHORTEST | DFA exec |
| $2^{17}$ | (=0x00020000) | PCRE_DFA_RESTART | DFA exec |
| $2^{18}$ | (=0x00040000) | PCRE_FIRSTLINE | Compile |
| $2^{19}$ | (=0x00080000) | PCRE_DUPNAMES | Compile |
| $2^{20}$ | (=0x00100000) | PCRE_NEWLINE_CR | Compile, DFA exec |
| $2^{21}$ | (=0x00200000) | PCRE_NEWLINE_LF | Compile, DFA exec |
| $2^{22}$ | (=0x00400000) | PCRE_NEWLINE_ANY | Compile, DFA exec |
| $2^{23}$ | (=0x00800000) | PCRE_BSR_ANYCRLF | Compile, DFA exec |
| $2^{24}$ | (=0x01000000) | PCRE_BSR_UNICODE | Compile, DFA exec |
| $2^{25}$ | (=0x02000000) | PCRE_JAVASCRIPT_COMPAT | Compile |
| $2^{26}$ | (=0x04000000) | PCRE_NO_START_OPTIMIZE | Compile, DFA exec |
| $2^{27}$ | (=0x08000000) | PCRE_PARTIAL_HARD | Exec, DFA exec |
| $2^{28}$ | (=0x10000000) | PCRE_NOTEMPTY_ATSTART | Exec, DFA exec |
| $2^{29}$ | (=0x20000000) | PCRE_UCP | Compile |

## 49.4 Flow File Output

The regex_pcre plugin outputs the following columns:

| Column name | Type | Description | Flags |
|---|---|---|---|
| rgxCnt | U16 | Number of regex alarms | |
| rgxRID_cType_sev | R(U16_U8_U8) | Regex ID, class type and severity | EXPERTMODE=0 |
| If EXPERTMODE=1, the following columns are displayed: | | | |
| rgxRID_cType_sev_pktN_bPos | R(U16_U8_U8_U32_U16) | Regex ID, class type, severity, packet number and byte position | PKTTIME=0 |
| rgxRID_cType_sev_pktN_bPos_time | R(U16_U8_U8_U32_U16_TS) | Regex ID, class type, severity, packet number, byte position and time) | PKTTIME=1 |

## 49.5 Packet File Output

In packet mode (-s option), the regex_pcre plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| rgxCnt | U16 | Number of regex alarms | |
| rgxRID_cType_sev | R(U16_U8_U8) | Regex ID, class type and severity | |

## 49.6 Plugin Report Output

The following information is reported:

- Number of alarms in number of flows with max severity

# 50 sctpDecode

## 50.1 Description

The sctpDecode plugin produces a flow based view of SCTP operations between computers for anomaly detection and troubleshooting purposes.

## 50.2 Configuration Flags

The following flags can be used to control the output of the plugin:

| Name | Default | Description | Flags |
|---|---|---|---|
| SCTP_CRCADL32CHK | 0 | Checksum computation:<br>0: No checksum computation<br>1: CRC32<br>2: ADLER32 | |
| SCTP_CHNKVAL | 0 | Chunk type representation:<br>0: chunk type bit field<br>1: chunk type value<br>2: chunk type as string | |
| SCTP_CHNKAGGR | 0 | Aggregate chunk types | SCTP_CHNKVAL>0 |
| SCTP_TSNREL | 0 | 1: Relative TSN, 0: Absolute TSN | |
| SCTP_MAXCTYPE | 15 | Maximum chunk types to store/flow | SCTP_CHNKVAL>0 |
| SCTP_ASMX | 10 | Maximum ASCONF IP | |
| SCTP_MXADDR | 5 | Maximum number of addresses to print in packet mode | |

## 50.3 Flow File Output

The sctpDecode plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| sctpStat | H8 | Status | |
| sctpDSNum | U16 | Data stream number | SCTP_ACTIVATE=1 |
| sctpMaxDSNum | U16 | Max. number of data streams | SCTP_ACTIVATE=0 |
| sctpPID | U32 | Payload ID | |
| sctpVTag | H32 | Verification tag | |
| sctpTypeBF | H16 | Aggregated type bit field | SCTP_CHNKVAL=0 |
| sctpType | R(U8) | Unique types values | SCTP_CHNKVAL=1 |
| sctpTypeN | R(SC) | Unique types names | SCTP_CHNKVAL=2 |
| sctpCntD_I_A | U16_U16_U16 | DATA, INIT and ABORT count | |
| sctpCFlags | H8 | Aggregated chunk flag | |
| sctpCCBF | H16 | Aggregated error cause code bit field | |
| sctpASIP4 | R(SC) | ASCONF IPv4 | |
| sctpASIP6 | R(SC) | ASCONF IPv6 | |
| sctpIS | U16 | Inbound streams | |
| sctpOS | U16 | Outbound streams | |
| sctpIARW | U32 | Initial Advertised Receiver Window | |

| Column | Type | Description Flags |
|---|---|---|
| sctpIARWMin | U32 | Initial Advertised Receiver Window Minimum |
| sctpIARWMax | U32 | Initial Advertised Receiver Window Maximum |
| sctpARW | F | Advertised Receiver Window |

### 50.3.1 sctpStat

The sctpStat column is to be interpreted as follows:

| | sctpStat | Description |
|---|---|---|
| $2^0$ | (=0x01) | Adler32 error |
| $2^1$ | (=0x02) | CRC32 error |
| $2^2$ | (=0x04) | Chunk padded |
| $2^3$ | (=0x08) | Chunk truncated |
| $2^6$ | (=0x10) | 3 ACK |
| $2^7$ | (=0x20) | Type Field overflow |
| $2^4$ | (=0x40) | Do not report |
| $2^5$ | (=0x80) | Stop processing of the packet |

### 50.3.2 sctpTypeN, sctpTypeBF and sctpType

The sctpTypeN, sctpTypeBF and sctpType columns are to be interpreted as follows:

| sctpTypeN | sctpTypeBF | sctpType | Description |
|---|---|---|---|
| 0 | 0x0001 | DATA | Payload data |
| 1 | 0x0002 | INIT | Initiation |
| 2 | 0x0004 | INIT_ACK | Initiation acknowledgement |
| 3 | 0x0008 | SACK | Selective acknowledgement |
| 4 | 0x0010 | HEARTBEAT | Heartbeat request |
| 5 | 0x0020 | HEARTBEAT_ACK | Heartbeat acknowledgement |
| 6 | 0x0040 | ABORT | Abort |
| 7 | 0x0080 | SHUTDOWN | Shutdown |
| 8 | 0x0100 | SHUTDOWN_ACK | Shutdown acknowledgement |
| 9 | 0x0200 | ERROR | Operation error |
| 10 | 0x0400 | COOKIE_ECHO | State cookie |
| 11 | 0x0800 | COOKIE_ACK | Cookie acknowledgement |
| 12 | 0x1000 | ECNE | Explicit congestion notification echo (reserved) |
| 13 | 0x2000 | CWR | Congestion window reduced (reserved) |
| 14 | 0x4000 | SHUTDOWN_COMPLETE | Shutdown complete |
| 15 | 0x8000 | AUTH | Authentication chunk |

### 50.3.3 sctpCFlags

The sctpCFlags column is to be interpreted as follows:

| sctpCFlags | Description |
|---|---|
| $2^0$ (=0x01) | Last segment |
| $2^1$ (=0x02) | First segment |
| $2^2$ (=0x04) | Ordered delivery |
| $2^3$ (=0x08) | Possibly delay SACK |
| $2^4$ (=0x10) | — |
| $2^5$ (=0x20) | — |
| $2^6$ (=0x40) | Transmission sequence number error |
| $2^7$ (=0x80) | Association sequence number error |

### 50.3.4 sctpCCBF

The sctpCCBF column is to be interpreted as follows:

| sctpCCBF | Description |
|---|---|
| $2^0$ (=0x0001) | — |
| $2^1$ (=0x0002) | Invalid Stream Identifier |
| $2^2$ (=0x0004) | Missing Mandatory Parameter |
| $2^3$ (=0x0008) | Stale Cookie Error |
| $2^4$ (=0x0010) | Out of Resource |
| $2^5$ (=0x0020) | Unresolvable Address |
| $2^6$ (=0x0040) | Unrecognized Chunk Type |
| $2^7$ (=0x0080) | Invalid Mandatory Parameter |
| $2^8$ (=0x0100) | Unrecognized Parameters |
| $2^9$ (=0x0200) | No User Data |
| $2^{10}$ (=0x0400) | Cookie Received While Shutting Down |
| $2^{11}$ (=0x0800) | Restart of an Association with New Addresses |
| $2^{12}$ (=0x1000) | User Initiated ABORT |
| $2^{13}$ (=0x2000) | Protocol Violation |
| $2^{14}$ (=0x4000) | — |
| $2^{15}$ (=0x8000) | Error code > 14 |

## 50.4 Packet File Output

In packet mode (-s option), the sctpDecode plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| sctpVTag | H32 | Verification tag | |
| sctpChkSum | H32 | Checksum | |
| sctpCalCRCChkSum | H32 | Computed CRC checksum | SCTP_CRCADL32CHK=1 |
| sctpCalADLChkSum | H32 | Checksum ADLER32 checksum | SCTP_CRCADL32CHK=2 |

| Column | Type | Description | Flags |
|---|---|---|---|
| sctpChunkType_ | U8_ | Chunk type, | |
| sid_ | U16_ | stream identifier, | |
| flags_ | H8_ | chunk flags, | |
| numDPkts_ | U16_ | DATA count, | |
| len_ | I32_ | chunk length, | |
| pid | U32 | Payload ID | |
| sctpNChunks | U8 | Number of chunks | |
| sctpCCBF | H16 | Aggregated error cause code bit field | |
| sctpARW | U32 | Advertised Receiver Window | |
| sctpPID | U32 | Payload ID | |
| sctpStat | U8 | Status | |
| sctpTSN | U32 | Transmission Sequence Number (TSN) | SCTP_TSNREL=0 |
| sctpTSNAck | U32 | TSN Acknowledgement | SCTP_TSNREL=0 |
| sctpRelTSN | U32 | Relative Transmission Sequence Number (TSN) | SCTP_TSNREL=1 |
| sctpRelTSNAck | U32 | Relative TSN Acknowledgement | SCTP_TSNREL=1 |
| sctpASIP4 | R(IP4) | ASCONF IPv4 | |
| sctpASIP6 | R(IP6) | ASCONF IPv6 | |

## 50.5 Plugin Report Output

The following information is reported:

- Aggregated sctpStat
- Aggregated sctpCFlags
- Aggregated sctpTypeBF

# 51 smbDecode

## 51.1 Description

The smbDecode plugin analyzes SMBv1 and SMBv2 traffic.

## 51.2 Configuration Flags

The following flags can be used to control the output of the plugin:

| Name | Default | Description | Flags |
|---|---|---|---|
| SMB1_DECODE | 0 | decode SMB1 (beta) | |
| SMB_SECBLOB | 0 | decode security blob (beta) | |
| SMB_NUM_FNAME | 5 | number of unique filenames to store | |
| SMB2_NUM_DIALECT | 3 | number of SMB2 dialects to store | |
| SMB1_NUM_DIALECT | 3 | number of SMB1 dialects to store | SMB1_DECODE=1 |
| SMB1_DIAL_MAXLEN | 32 | maximum length for SMB1 dialects | SMB1_DECODE=1 |
| SMB2_NUM_STAT | 18 | number of unique SMB2 header status to store | |
| SMB1_SAVE_DATA | 0 | save files (SMB1) | SMB1_DECODE=1 |
| SMB2_SAVE_DATA | 0 | save files (SMB2) | |
| SMB_SAVE_AUTH | 0 | save NTLM authentications | |
| SMB_NATIVE_NAME_LEN | 64 | Maximum length for names | |
| SMB_SAVE_DIR | "/tmp/TranSMB/" | Folder for saved data | SMB_SAVE_DATA=1 |
| SMB_FILE_ID | "File_Id_" | Prefix for output files | SMB_SAVE_DATA=1 |
| SMB_AUTH_FILE | "smb_auth.txt" | File where to store NTLM authentications | SMB_SAVE_AUTH=1 |
| SMB_RM_DATADIR | 1 | Remove SMB_SAVE_DIR before starting | SMB_SAVE_DATA=1 |
| SMB_FNAME_LEN | 512 | Maximum length for filenames | |
| SMB_STRCPY_BEHAVIOR | T2_STRCPY_TRUNC | If data to copy is bigger than buffer:<br>T2_STRCPY_EXIT: exit<br>T2_STRCPY_EMPTY: return an empty buffer ("abcdefg" → "")<br>T2_STRCPY_TRUNC: truncate destination ("abcdefg" → "abcdef")<br>T2_STRCPY_ELLIPSIS: truncate destination with an ellipsis ("abcdefg" → "abc...") | |

When saving files, the plugin uses a combination of the file ID and the flow index as name. The file ID can be replaced with the real filename by using the smbrename script and the SMB_GUID_MAP_FILE (*smb_filenames.txt*) file (See Section 51.5).

### 51.2.1 Environment Variable Configuration Flags

The following configuration flags can also be configured with environment variables (ENVCNTRL>0):

- SMB_RM_DATADIR
- SMB_AUTH_FILE
- SMB_SAVE_DIR
- SMB_MAP_FILE
- SMB_FILE_ID

## 51.3 Flow File Output

The smbDecode plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| smbStat | H16 | Status | |
| smb1NDialects | U32 | Number of requested dialects (SMB1) | |
| smb1Dialects | RS | SMB1 requested dialects (client: supported, server: chosen) | |
| smb2NDialects | U32 | Number of dialects (SMB2) | |
| smb2Dialects | RH16 | SMB2 dialect revision (client: supported, server: chosen) | |
| smbNHdrStat | U32 | Number of unique SMB2 header status values | |
| smbHdrStat | RH32 | SMB2 list of unique header status | |
| smbOpcodes | H32 | Opcodes | |
| smbNOpcodes | 19x(U32) | Number of records per opcode | |
| smbPrevSessId | H64 | SMB previous session ID | |
| smbNativeOS | S | SMB native OS | |
| smbNativeLanMan | S | SMB native LAN Manager | |
| smbPrimDom | S | SMB primary domain | |
| smbTargName | S | SMB target name | |
| smbDomName | S | SMB domain name | |
| smbUserName | S | SMB user name | |
| smbHostName | S | SMB host name | |
| smbNTLMServChallenge | S | SMB NTLM server challenge | |
| smbNTProofStr | S | SMB NT proof string | |
| smbSessionKey | S | SMB session key | |
| smbGUID | S | Client/Server GUID | |
| smbSessFlags_ | H16_ | Session flags, | |
| secM_ | H8_ | Security mode, | |
| caps | H32 | Capabilities | |
| smbBootT | TS | Server start time | |
| smbMaxSizeT_R_W | U32_U32_U32 | Max transaction/read/write size | |
| smbPath | S | Full share path name | |
| smbShareT | H8 | Type of share being accessed | |
| smbShareFlags | H32_ | Share flags, | |
| caps | H32_ | Capabilities, | |
| acc | H32 | Access mask | |
| smbNFiles | U32 | Number of accessed files | |

| Column | Type | Description | Flags |
|---|---|---|---|
| smbFiles | RS | Accessed files | |

### 51.3.1 smbStat

The smbStat column is to be interpreted as follows:

| smbStat | Description |
|---|---|
| 0x0001 | Flow is SMB |
| 0x0002 | SMB2 header status list truncated... increase SMB2_NUM_STAT |
| 0x0004 | Dialect name truncated... increase SMB1_DIAL_MAXLEN |
| 0x0008 | SMB1 dialect list truncated... increase SMB1_NUM_DIALECT |
| 0x0010 | SMB2 dialect list truncated... increase SMB_NUM_DIALECT |
| 0x0020 | List of accessed files truncated... increase SMB_NUM_FNAME |
| 0x0040 | Selected dialect index out of bound... increase SMB1_NUM_DIALECT |
| 0x0080 | Selected dialect index out of bound (error or reverse flow not found) |
| 0x0100 | Filename truncated... increase SMB_FNAME_LEN |
| 0x0200 | — |
| 0x0400 | — |
| 0x0800 | — |
| 0x1000 | Authentication information extracted |
| 0x2000 | — |
| 0x4000 | — |
| 0x8000 | Malformed packets |

### 51.3.2 smb2Dialects

The smb2Dialects column is to be interpreted as follows:

| smb2Dialects | Description |
|---|---|
| 0x0202 | SMB 2.0.2 |
| 0x0210 | SMB 2.1 |
| 0x02ff | Wildcard revision number ($\geq$ 2.1) |
| 0x0300 | SMB 3 |
| 0x0302 | SMB 3.0.2 |
| 0x0311 | SMB 3.1.1 |

### 51.3.3 smbHdrStat

The smbHdrStat column is to be interpreted as follows:

| smbHdrStat | Description |
|---|---|
| 0x00000000 | STATUS_SUCCESS |
| 0x00000103 | STATUS_PENDING |
| 0x0000010b | STATUS_NOTIFY_CLEANUP |
| 0x0000010c | STATUS_NOTIFY_ENUM_DIR |
| 0x80000005 | STATUS_BUFFER_OVERFLOW |
| 0x80000006 | STATUS_NO_MORE_FILES |
| 0xc0000003 | STATUS_INVALID_INFO_CLASS |
| 0xc000000d | STATUS_INVALID_PARAMETER |
| 0xc000000f | STATUS_NO_SUCH_FILE |
| 0xc0000010 | STATUS_INVALID_DEVICE_REQUEST |
| 0xc0000011 | STATUS_END_OF_FILE |
| 0xc0000016 | STATUS_MORE_PROCESSING_REQUIRED |
| 0xc0000022 | STATUS_ACCESS_DENIED |
| 0xc0000023 | STATUS_BUFFER_TOO_SMALL |
| 0xc0000034 | STATUS_OBJECT_NAME_NOT_FOUND |
| 0xc0000035 | STATUS_OBJECT_NAME_COLLISION |
| 0xc000003a | STATUS_OBJECT_PATH_SYNTAX_BAD |
| 0xc0000043 | STATUS_SHARING_VIOLATION |
| 0xc0000061 | STATUS_PRIVILEGE_NOT_HELD |
| 0xc000006a | STATUS_WRONG_PASSWORD |
| 0xc000006d | STATUS_LOGON_FAILURE |
| 0xc0000071 | STATUS_PASSWORD_EXPIRED |
| 0xc00000ac | STATUS_PIPE_NOT_AVAILABLE |
| 0xc00000ba | STATUS_FILE_IS_A_DIRECTORY |
| 0xc00000bb | STATUS_NOT_SUPPORTED |
| 0xc00000c9 | STATUS_NETWORK_NAME_DELETED |
| 0xc00000cc | STATUS_BAD_NETWORK_NAME |
| 0xc0000101 | STATUS_DIRECTORY_NOT_EMPTY |
| 0xc0000120 | STATUS_CANCELLED |
| 0xc0000128 | STATUS_FILE_CLOSED |
| 0xc000019c | STATUS_FS_DRIVER_REQUIRED |
| 0xc0000203 | STATUS_USER_SESSION_DELETED |
| 0xc0000225 | STATUS_NOT_FOUND |
| 0xc0000234 | STATUS_ACCOUNT_LOCKED_OUT |
| 0xc0000257 | STATUS_PATH_NOT_COVERED |
| 0xc0000275 | STATUS_NOT_A_REPARSE_POINT |

For a comprehensive list of the possible status and more extensive description, refer to [MS-ERREF], Section 2.3.1.

### 51.3.4 smbOpcodes

The `smbOpcodes` column is to be interpreted as follows:

| smbOpcodes | Description |
|---|---|
| $2^0$ (=0x00000001) | SMB2_NEGOTIATE |

| smbOpcodes | Description |
|---|---|
| $2^1$ (=0x00000002) | SMB2_SESSION_SETUP |
| $2^2$ (=0x00000004) | SMB2_LOGOFF |
| $2^3$ (=0x00000008) | SMB2_TREE_CONNECT |
| $2^4$ (=0x00000010) | SMB2_TREE_DISCONNECT |
| $2^5$ (=0x00000020) | SMB2_CREATE |
| $2^6$ (=0x00000040) | SMB2_CLOSE |
| $2^7$ (=0x00000080) | SMB2_FLUSH |
| $2^8$ (=0x00000100) | SMB2_READ |
| $2^9$ (=0x00000200) | SMB2_WRITE |
| $2^{10}$ (=0x00000400) | SMB2_LOCK |
| $2^{11}$ (=0x00000800) | SMB2_IOCTL |
| $2^{12}$ (=0x00001000) | SMB2_CANCEL |
| $2^{13}$ (=0x00002000) | SMB2_ECHO |
| $2^{14}$ (=0x00004000) | SMB2_QUERY_DIRECTORY |
| $2^{15}$ (=0x00008000) | SMB2_CHANGE_NOTIFY |
| $2^{16}$ (=0x00010000) | SMB2_QUERY_INFO |
| $2^{17}$ (=0x00020000) | SMB2_SET_INFO |
| $2^{18}$ (=0x00040000) | SMB2_OPLOCK_BREAK |

### 51.3.5 smbNOpcodes

The `smbNOpcodes` column reports the number of records of each type separated by underscores.

| smbNOpcodes | Description |
|---|---|
| 1 | Number of SMB2_NEGOTIATE records |
| 2 | Number of SMB2_SESSION_SETUP records |
| 3 | Number of SMB2_LOGOFF records |
| 4 | Number of SMB2_TREE_CONNECT records |
| 5 | Number of SMB2_TREE_DISCONNECT records |
| 6 | Number of SMB2_CREATE records |
| 7 | Number of SMB2_CLOSE records |
| 8 | Number of SMB2_FLUSH records |
| 9 | Number of SMB2_READ records |
| 10 | Number of SMB2_WRITE records |
| 11 | Number of SMB2_LOCK records |
| 12 | Number of SMB2_IOCTL records |
| 13 | Number of SMB2_CANCEL records |
| 14 | Number of SMB2_ECHO records |
| 15 | Number of SMB2_QUERY_DIRECTORY records |
| 16 | Number of SMB2_CHANGE_NOTIFY records |
| 17 | Number of SMB2_QUERY_INFO records |

| smbNOpcodes | Description |
|---|---|
| 18 | Number of SMB2_SET_INFO records |
| 19 | Number of SMB2_OPLOCK_BREAK records |

### 51.3.6 smbSessFlags_secM_caps

The smbSessFlags_secM_caps column is to be interpreted as follows:

| smbSessFlags | Description |
|---|---|
| 0x01 | Client authenticated as guest user |
| 0x02 | Client authenticated as anonymous user |
| 0x04 | Server requires encryption of messages on this session (SMB 3.x) |

| smbSecM | Description |
|---|---|
| 0x01 | Security signatures enabled on the server |
| 0x02 | Security signatures required by the server |

| smbCaps | Description |
|---|---|
| 0x01 | Server supports the Distributed File System (DFS) |
| 0x02 | Server supports leasing |
| 0x04 | Server supports multi-credit operation (Large MTU) |
| 0x08 | Server supports establishing multiple channels for a single session |
| 0x10 | Server supports persistent handles |
| 0x20 | Server supports directory leasing |
| 0x40 | Server supports encryption |

### 51.3.7 smbShareT

The smbShareT column is to be interpreted as follows:

| smbShareT | Description |
|---|---|
| 0x01 | Physical disk share |
| 0x02 | Named pipe share |
| 0x03 | Printer share |

### 51.3.8 smbShareFlags_caps_acc

The smbShareFlags_caps_acc column is to be interpreted as follows:

| smbShareFlags | Description |
|---|---|
| 0x00000001 | Specified share is present in a Distributed File System (DFS) tree structure |
| 0x00000002 | Specified share is present in a DFS tree structure (DFS root) |
| | If none of the following three bits is set, then the caching policy is "manual" |
| 0x00000010 | Auto caching |
| 0x00000020 | VDO Caching |
| 0x00000030 | Offline caching MUST NOT occur |
| 0x00000100 | Restrict exclusive opens |
| 0x00000200 | Force shared delete |
| 0x00000400 | Allow namespace caching |
| 0x00000800 | Server will filter directory entries based on access permissions of the client |
| 0x00001000 | Server will not issue exclusive caching rights on this share |
| 0x00002000 | Enable hash V1 |
| 0x00004000 | Enable hash V2 |
| 0x00008000 | Encrypt data required |

| smbShareCaps | Description |
|---|---|
| 0x00000008 | Specified share is present in a DFS tree structure |
| 0x00000010 | Continuous availability |
| 0x00000020 | Scaleout |
| 0x00000040 | Cluster |
| 0x00000080 | Asymmetric |

| smbShareAcc | Description |
|---|---|
| 0x00000001 | Read access |
| 0x00000002 | Write access |
| 0x00000004 | Append access |
| 0x00000008 | Read extended attributes access |
| 0x00000010 | Write extended attributes access |
| 0x00000020 | Execute access |
| 0x00000040 | Delete child access |
| 0x00000080 | Read attributes access |
| 0x00000100 | Write attributes access |
| 0x00010000 | Delete access |
| 0x00020000 | Read access to owner, group and ACL of the SID |

| smbShareAcc | Description |
|---|---|
| 0x00040000 | Owner may write the DAC |
| 0x00080000 | Can write owner (take ownership) |
| 0x00100000 | Can wait on handle to synchronize on completion of I/O |
| 0x01000000 | System security is NOT set |
| 0x02000000 | Maximum allowed is NOT set |
| 0x10000000 | Generic all is NOT set |
| 0x20000000 | Generic execute is NOT set |
| 0x40000000 | Generic write is NOT set |
| 0x80000000 | Generic read is NOT set |

## 51.4 Plugin Report Output

The following information is reported:

- Aggregated smbStat
- Number of SMBv1, SMBv2 and SMBv3 records
- Number of NetNTLMv2 hashes extracted (SMB_SAVE_AUTH=1)

## 51.5 Post-Processing

### 51.5.1 smbrename

The **smbrename** script can be used to rename and organize the files extracted by the plugin. It must be run from within the SMB_SAVE_DIR folder (where the file *smb_filenames.txt* is located). By default, it will replace the file ID with the real filename and organize the files into folders according to their mimetype. Either operation can be performed or not. Try 'smbrename -help' for more information.

### 51.5.2 SMB Authentications

When SMB1_DECODE=1, SMB_SECBLOB=1 and SMB_SAVE_AUTH=1, the plugin produces a file with suffix SMB_AUTH_FILE containing all the NetNTLMv2 hashes extracted from the traffic. The hashes can then be reversed using JohnTheRipper[30] or Hashcat[31] as follows:

```
john --wordlist=password.lst -format=netntlmv2 FILE_smb_auth.txt
        hashcat -m 5600 FILE_smb_auth.txt wordlist.txt
```

## 51.6 References

- [MS-CIFS]: Common Internet File System (CIFS) Protocol
- [MS-SMB]: Server Message Block (SMB) Protocol

[30] https://github.com/magnumripper/JohnTheRipper
[31] https://hashcat.net

- [MS-SMB2]: Server Message Block (SMB) Protocol Versions 2 and 3
- [MS-ERREF]: Windows Error Codes
- [MS-SPNG]: Simple and Protected GSS-API Negotiation Mechanism (SPNEGO) Extension
- [MS-AUTHSOD]: Authentication Services Protocols Overview
- [MS-DTYP]: Windows Data Types
- [RFC4178]: The Simple and Protected Generic Security Service Application Program Interface (GSS-API) Negotiation Mechanism

# 52 smtpDecode

## 52.1 Description

The smtpDecode plugin processes MAIL header and content information of a flow. The idea is to identify certain mail features and CNAMES.

## 52.2 Configuration Flags

The following flags can be used to control the output of the plugin:

| Name | Default | Description | Flags |
|---|---|---|---|
| SMTP_SAVE | 0 | 1: save content to SMTP_F_PATH | |
| SMTP_RMDIR | 1 | Empty SMTP_F_PATH before starting | SMTP_SAVE=1 |
| SMTP_BTFLD | 0 | 1: Bitfield coding of SMTP commands | |
| SMTP_RCTXT | 1 | 1: print response code text | |
| SMTP_MXNMLN | 70 | maximal name length | |
| SMTP_MXUNMLN | 25 | maximal user length | |
| SMTP_MXPNMLN | 15 | maximal PW length | |
| SMTP_MAXCNM | 8 | maximal number rec,trans codes | |
| SMTP_MAXUNM | 5 | maximal number server names | |
| SMTP_MAXPNM | 5 | maximal number server names | |
| SMTP_MAXSNM | 8 | maximal number of server addresses | |
| SMTP_MAXRNM | 8 | maximal number of rec EMail addresses | |
| SMTP_MAXTNM | 8 | maximal number of trans EMail addresses | |
| SMTP_F_PATH | "/tmp/SMTPFILES/" | Path for extracted content | |
| SMTP_NONAME | "nudel" | No name file name | |

### 52.2.1 Environment Variable Configuration Flags

The following configuration flags can also be configured with environment variables (ENVCNTRL>0):

- SMTP_RMDIR
- SMTP_F_PATH
- SMTP_NONAME

## 52.3 Flow File Output

The smtpDecode plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| smtpStat | H8 | Status | |
| smtpCBF | H16 | Command bit field | SMTP_BTFLD=1 |
| smtpCC | RSC | Command Codes | |
| smtpRC | RU16 | Response Codes | |
| smtpUsr | RS | SMTP Users | |

| Column | Type | Description | Flags |
|---|---|---|---|
| smtpPW | RS | SMTP Passwords | |
| smtpSANum | U8 | number of Server addresses | |
| smtpESANum | U8 | number of email sender addresses | |
| smtpERANum | U8 | number of email receiver addresses | |
| smtpSA | RS | Server send addresses | |
| smtpESA | RS | Email send addresses | |
| smtpERA | RS | Email receive addresses | |

### 52.3.1 smtpStat

The smtpStat column is to be interpreted as follows:

| smtpStat | Description | Flags |
|---|---|---|
| $2^0$ (=0x01) | SMTP ports found | |
| $2^1$ (=0x02) | Authentication pending | |
| $2^2$ (=0x04) | Data download pending | SMTP_SAVE=1 |
| $2^3$ (=0x08) | User password pending | |
| $2^4$ (=0x10) | flow write finished | SMTP_SAVE=1 |
| $2^5$ (=0x20) | — | |
| $2^6$ (=0x40) | File error | SMTP_SAVE=1 |
| $2^7$ (=0x80) | Array overflow | |

### 52.3.2 smtpCBF

The smtpCBF column is to be interpreted as follows:

| smtpCBF | Description |
|---|---|
| $2^0$ (=0x0001) | HELO |
| $2^1$ (=0x0002) | EHLO |
| $2^2$ (=0x0004) | MAIL |
| $2^3$ (=0x0008) | RCPT |
| $2^4$ (=0x0010) | DATA |
| $2^5$ (=0x0020) | RSET |
| $2^6$ (=0x0040) | SEND |
| $2^7$ (=0x0080) | SOML |

| smtpCBF | Description |
|---|---|
| $2^8$ (=0x0100) | SAML |
| $2^9$ (=0x0200) | VRFY |
| $2^{10}$ (=0x0400) | EXPN |
| $2^{11}$ (=0x0800) | HELP |
| $2^{12}$ (=0x1000) | NOOP |
| $2^{13}$ (=0x2000) | QUIT |
| $2^{14}$ (=0x4000) | TURN |
| $2^{15}$ (=0x8000) | AUTH |

## 52.4 Packet File Output

In packet mode (-s option), the smtpDecode plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| smtpStat | H8 | Status | |

## 52.5 Plugin Report Output

The following information is reported:

- Aggregated smtpStat
- Number of SMTP packets
- Number of SMTP files

## 52.6 TODO

- fragmentation

# 53 snmpDecode

## 53.1 Description

The snmpDecode plugin analyzes SNMP traffic.

## 53.2 Configuration Flags

The following flags can be used to control the output of the plugin:

| Name | Default | Description |
|---|---|---|
| SNMP_STRLEN | 64 | Maximum length for strings |

## 53.3 Flow File Output

The snmpDecode plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| snmpStat | H8 | Status | |
| snmpVersion | U8 | Version | |
| snmpCommunity | S | Community (SNMPv1-2) | |
| snmpUsername | S | Username (SNMPv3) | |
| snmpMsgT | H16 | Message types | |
| snmpNumReq_ | U64_ | Number of GetRequest, | |
| Next_ | U64_ | GetNextRequest, | |
| Resp_ | U64_ | GetResponse, | |
| Set_ | U64_ | SetRequest, | |
| Trap1_ | U64_ | Trapv1, | |
| Bulk_ | U64_ | GetBulkRequest, | |
| Info_ | U64_ | InformRequest, | |
| Trap2_ | U64_ | Trapv2, | |
| Rep | U64 | Report packets | |

### 53.3.1 snmpStat

The snmpStat column is to be interpreted as follows:

| snmpStat | Description |
|---|---|
| 0x01 | Flow is SNMP |
| 0x02 | — |
| 0x04 | — |
| 0x08 | — |
| 0x10 | — |
| 0x20 | — |
| 0x40 | String was truncated... increase SNMP_STRLEN |

| snmpStat | Description |
|---|---|
| 0x80 | Packet was malformed |

### 53.3.2 snmpVersion

The snmpVersion column is to be interpreted as follows:

| snmpVersion | Description |
|---|---|
| 0 | SNMPv1 |
| 1 | SNMPv2c |
| 3 | SNMPv3 |

### 53.3.3 snmpMsgT and snmpType

The snmpMsgT and snmpType columns are to be interpreted as follows:

| snmpMsgT | snmpType | Description |
|---|---|---|
| 0x0001 | 0xa0 | GetRequest |
| 0x0002 | 0xa1 | GetNextRequest |
| 0x0004 | 0xa2 | GetResponse |
| 0x0008 | 0xa3 | SetRequest |
| 0x0010 | 0xa4 | Trap (v1) |
| 0x0020 | 0xa5 | GetBulkRequest (v2c, v3) |
| 0x0040 | 0xa6 | InformRequest |
| 0x0080 | 0xa7 | Trap (v2c, v3) |
| 0x0100 | 0xa8 | Report |

## 53.4 Packet File Output

In packet mode (-s option), the snmpDecode plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| snmpVersion | U8 | Version | |
| snmpCommunity | S | Community | |
| snmpType | H8 | Message type | |

## 53.5 Plugin Report Output

The following information is reported:

- Number of SNMP packets
- Number of SNMP GetRequest packets

- Number of SNMP GetNextRequest packets
- Number of SNMP GetResponse packets
- Number of SNMP SetRequest packets
- Number of SNMP Trap v1 packets
- Number of SNMP GetBulkRequest packets
- Number of SNMP InformRequest packets
- Number of SNMP Trap v2 packets
- Number of SNMP Report packets

# 54 socketSink

## 54.1 Description

This plugin is a socket interface of Tranalyzer. The idea is to interface one or many distributed Tranalyzer instances with a central server post-processing and visualizing its data. The plugin also implements the Alarm Mode being activated by `ALARM_MODE=1` in the core *tranalyzer.h* file. Prepending information such as data length, checksum, or an id is controlled by the `BUF_DATA_SHFT` variable in the Tranalyzer core: *outputBuffer.h*. The user needs to configure the destination port, socket type and whether host info is transmitted in the first record. The socketSink plugin produces output directly into the Ethernet interface.

## 54.2 Dependencies

### 54.2.1 External Libraries

If gzip compression is activated (`SKS_GZ_COMPRESS=1`), then **zlib** must be installed.

| | | **SKS_GZ_COMPRESS=1** |
|---:|---|---|
| **Ubuntu:** | `sudo apt-get install` | `zlib1g-dev` |
| **Arch:** | `sudo pacman -S` | `zlib` |
| **Gentoo:** | `sudo emerge` | `zlib` |
| **openSUSE:** | `sudo zypper install` | `zlib-devel` |
| **Red Hat/Fedora**[32]**:** | `sudo dnf install` | `zlib-devel` |
| **macOS**[33]**:** | `brew install` | `zlib` |

### 54.2.2 Core Configuration

This plugin requires the following core configuration:

- *$T2HOME/tranalyzer2/src/tranalyzer.h*:
  - `BLOCK_BUF=0`

## 54.3 Configuration Flags

The following flags can be used to control the output of the plugin:

| Name | Default | Description | Flags |
|---|---|---|---|
| `SKS_SERVADD` | `"127.0.0.1"` | destination address | |
| `SKS_DPORT` | 6666 | destination port (host order) | |
| `SKS_SOCKTYPE` | 1 | Socket type: 0: UDP; 1: TCP | |
| `SKS_GZ_COMPRESS` | 0 | Compress (gzip) the output | `SKS_SOCKTYP=1` |
| `SKS_CONTENT_TYPE` | 1 | 0: binary; 1: text; 2: JSON | |
| `SKS_HOST_INFO` | 0 | 0: no info; 1: all info about host | `SKS_CONTENT_TYPE=0` |

[32] If the `dnf` command could not be found, try with `yum` instead
[33] Brew is a packet manager for macOS that can be found here: https://brew.sh

### 54.3.1 bin2txt.h

`bin2txt.h` controls the conversion from internal binary format to standard text output.

| Variable | Default | Description | Flags |
|---|---|---|---|
| `HEX_CAPITAL` | 0 | Hex number representation:<br>0: lower case,<br>1: upper case | |
| `IP4_NORMALIZE` | 0 | IPv4 addresses representation:<br>0: normal,<br>1: normalized (padded with 0) | |
| `IP6_COMPRESS` | 1 | IPv6 addresses representation:<br>0: full 128 bit length<br>1: compressed | |
| `TFS_EXTENDED_HEADER` | 0 | Print an extended header in the flow file<br>(number of rows, columns, columns type) | |
| `B2T_LOCALTIME` | 0 | Time representation:<br>0: UTC,<br>1: localtime | |
| `B2T_NANOSECS` | 0 | Time precision:<br>0: microsecs,<br>1: nanosecs | |
| `HDR_CHR` | `"%"` | start character of comments in flow file | |
| `SEP_CHR` | `"\t"` | character to use to separate the columns in the flow file | |

### 54.3.2 Environment Variable Configuration Flags

The following configuration flags can also be configured with environment variables (`ENVCNTRL>0`):

- `SKS_SERVADD`
- `SKS_DPORT`

## 54.4 Additional Output

The output buffer normally being written to the flow file will be directed to the socket.

If `SKS_HOST_INFO=1` then the following header is transmitted as a prelude.

| Parameter | Type | Description | Flags |
|---|---|---|---|
| 1 | U32 | Message length | `BUF_DATA_SHFT>0` |
| 2 | U32 | Checksum | `BUF_DATA_SHFT>1` |
| 3 | U32 | Sensor ID | |
| 4 | U64.U32 | Present Unix timestamp | |
| 5 | RS | OS;Machine Name;built;OS type;HW; | |
| 6 | RS | Ethername(address) or IPInterfacename(address/netmask) | |

After the prelude all flow based binary buffer will be directed to the socket interface according to the format shown in the following table:

| Column | Type | Description | Flags |
|---|---|---|---|
| 1 | U32 | Message length | BUF_DATA_SHFT>0 |
| 2 | U32 | Checksum | BUF_DATA_SHFT>1 |
| 3 | RU32 | Binary buffer output | |

## 54.5 Example

1. Open a socket, e.g., with netcat: `nc -l 127.0.0.1 6666`
2. Start T2 with the socketSink plugin, e.g., `t2 -r file.pcap`
3. You should now see the flows on your netcat terminal

To simulate a server collecting data from many T2 or save the transmitted flows into a file, use the following command: `nc -l 127.0.0.1 6666 > flowfile.txt`

## 54.6 Post-Processing

## 54.7 t2b2t

The program `t2b2t` can be used to transform binary Tranalyzer files generated by the binSink or socketSink plugin into text or JSON files. The converted files use the same format as the ones generated by the txtSink or jsonSink plugin.

The program can be found in `$T2HOME/utils/t2b2t` and can be compiled by typing `make`.

The use of the program is straightforward:

- bin→txt: `t2b2t -r FILE_flows.bin -w FILE_flows.txt`
- bin→JSON: `t2b2t -r FILE_flows.bin -j -w FILE_flows.json`
- bin→compressed txt: `t2b2t -r FILE_flows.bin -c -w FILE_flows.txt.gz`
- bin→compressed JSON: `t2b2t -r FILE_flows.bin -c -j -w FILE_flows.json.gz`

If the `-w` option is omitted, the destination is inferred from the input file, e.g., the examples above would produce the same output files with or without the `-w` option. Note that `-w -` can be used to output to stdout.
Additionally, the `-n` option can be used **not** to print the name of the columns as the first row.
Try `t2b2t -h` for more information.

# 55 sqliteSink

## 55.1 Description

The sqliteSink plugin outputs flows to a SQLite database.

## 55.2 Dependencies

### 55.2.1 External Libraries

This plugin depends on the **sqlite** library.

| | | |
|---|---|---|
| **Ubuntu:** | `sudo apt-get install` | `libsqlite3-dev` |
| **Arch:** | `sudo pacman -S` | `sqlite` |
| **openSUSE:** | `sudo zypper install` | `sqlite3-devel` |
| **Red Hat/Fedora**[34]**:** | `sudo dnf install` | `sqlite-devel` |
| **macOS**[35]**:** | `brew install` | `sqlite` |

### 55.2.2 Core Configuration

This plugin requires the following core configuration:

- *$T2HOME/tranalyzer2/src/tranalyzer.h*:
  - `BLOCK_BUF=0`

## 55.3 Configuration Flags

The following flags can be used to control the output of the plugin:

| Name | Default | Description |
|---|---|---|
| SQLITE_OVERWRITE | 2 | 0: abort if table already exists<br>1: overwrite table if it already exists<br>2: append to table if it already exists |
| SQLITE_HEX_AS_INT | 0 | 0: store hex numbers (bitfields) as text<br>1: store hex numbers (bitfields) as int |
| SQLITE_TRANSACTION_NFLOWS | 40000 | 0: one transaction<br>> 0: one transaction every *n* flows |
| SQLITE_QRY_LEN | 32768 | Initial length for query |
| SQLITE_QRY_MAXLEN | 4194304 | Maximal length for query |
| SQLITE_DB_SUFFIX | ".db" | Suffix for the database name |
| SQLITE_DBNAME | "/tmp/t2.db" | Name of the database |
| SQLITE_TABLE_NAME | "flow" | Name of the table |
| T2_SQLITE_SELECT | 0 | Only insert specific fields into the DB |
| SQLITE_SELECT_FILE | "sqlite-columns.txt" | Filename of the field selector |

[34] If the `dnf` command could not be found, try with `yum` instead
[35] Brew is a packet manager for macOS that can be found here: https://brew.sh

| Name | Default | Description |
|---|---|---|
| | | (one column name per line) |

### 55.3.1 Environment Variable Configuration Flags

The following configuration flags can also be configured with environment variables (ENVCNTRL>0):

- SQLITE_QRY_LEN
- SQLITE_QRY_MAXLEN
- SQLITE_DB_SUFFIX
- SQLITE_TABLE_NAME
- SQLITE_SELECT_FILE

### 55.3.2 Database Name

The database name is extracted from Tranalyzer input and/or -w/-W option. SQLITE_DB_SUFFIX is simply appended. Alternatively, an absolute path may be provided by uncommenting the SQLITE_DBNAME macro in *src/sqliteSink.h*.

## 55.4 Insertion of Selected Fields Only

When T2_SQLITE_SELECT=1, the columns to insert into the DB can be customized with the help of SQLITE_SELECT_FILE. The filename defaults to sqlite-columns.txt in the user plugin folder, e.g., *~/.tranalyzer/plugins*. The format of the file is simply one field name per line with lines starting with a '#' being ignored. For example, to only insert source and destination addresses and ports, create the following file:

```
# Lines starting with a '#' are ignored and can be used to add comments
srcIP
srcPort
dstIP
dstPort
```

## 55.5 Plugin Report Output

The following information is reported:

- Number of flows discarded due to main buffer problems

## 55.6 Example

```
# Run Tranalyzer
$ t2 -r file.pcap
# Connect to the SQLite database
$ sqlite3 file.db
# Number of flows
sqlite> select count(*) from flow;
# 10 first srcIP/dstIP pairs
```

```
sqlite> select "srcIP", "dstIP" from flow limit 10;
# All flows from 1.2.3.4 to 1.2.3.5
sqlite> select * from flow where "srcIP" = '1.2.3.4' and "dstIP" = '1.2.3.5';
```

# 56 sshDecode

## 56.1 Description

This plugin analyzes SSH traffic.

## 56.2 Dependencies

This plugin requires the **libssl**.

| | | |
|---|---|---|
| **Ubuntu:** | `sudo apt-get install` | `libssl-dev` |
| **Arch:** | `sudo pacman -S` | `openssl` |
| **openSUSE:** | `sudo zypper install` | `libopenssl-devel` |
| **Red Hat/Fedora**[36]**:** | `sudo dnf install` | `openssl-devel` |
| **macOS**[37]**:** | `brew install` | `openssl@1.1` |

## 56.3 Configuration Flags

The following flags can be used to control the output of the plugin:

| Name | Default | Description | Flags |
|---|---|---|---|
| `SSH_USE_PORT` | 0 | 1: Count all packets to/from `SSH_PORT` as SSH (useful if version exchange was not captured) | |
| `SSH_DECODE` | 2 | 0: Do not decode SSH handshake messages<br>1: Only decode SSH Key Exchange Init messages<br>2: Decode all SSH Exchange messages | |
| `SSH_FINGERPRINT` | 1 | Algorithm to use for the fingerprint:<br>0: No fingerprint, 1: MD5, 1: SHA256 | `SSH_DECODE=2` |
| `SSH_ALGO` | 1 | Output chosen algorithms | `SSH_DECODE>0` |
| `SSH_LISTS` | 0 | Output lists of supported algorithms | `SSH_DECODE>0` |
| `SSH_HASSH` | 1 | Output HASSH fingerprint (hash and description) | |
| `SSH_HASSH_STR` | 0 | Also output HASSH fingerprint before hashing | `SSH_HASSH=1` |
| `SSH_HASSH_DLEN` | 512 | Max length for HASSH descriptions | `SSH_HASSH=1` |
| `SSH_HASSH_STR_LEN` | 1024 | Max length for uncompressed HASSH signatures | `SSH_HASSH=1` |
| `SSH_BUF_SIZE` | 512 | Max length for strings | |
| `SSH_HKT_SIZE` | 48 | Max length for host key type and chosen algorithms | |
| `SSH_DEBUG` | 0 | Activate debug output | |

In addition, the name of the HASSH database is controlled by the `SSH_HASSH_NAME` flag and defaults to `"hassh_fingerprints.tsv"`.

[36] If the `dnf` command could not be found, try with `yum` instead
[37] Brew is a packet manager for macOS that can be found here: https://brew.sh

### 56.3.1 Environment Variable Configuration Flags

The following configuration flags can also be configured with environment variables (ENVCNTRL>0):

- SSH_HASSH_NAME

## 56.4 Flow File Output

The sshDecode plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| sshStat | H16 | Status | |
| sshVersion | R(S) | SSH version and software | |
| sshHostKeyType | R(SC) | SSH host key type | SSH_DECODE=2 |
| sshFingerprint | R(SC) | SSH public key fingerprint | SSH_DECODE=2&& SSH_FINGERPRINT>0 |
| sshCookie | R(SC) | SSH cookie | SSH_DECODE>0 |
| If SSH_DECODE>0&&SSH_ALGO=1, the following columns are displayed: | | | |
| sshKEX | R(S) | SSH chosen KEX algorithm | |
| sshSrvHKeyAlgo | R(S) | SSH chosen server host key algorithm | |
| sshEncCS | R(S) | SSH chosen encryption algorithm client to server | |
| sshEncSC | R(S) | SSH chosen encryption algorithm server to client | |
| sshMacCS | R(S) | SSH chosen MAC algorithm client to server | |
| sshMacSC | R(S) | SSH chosen MAC algorithm server to client | |
| sshCompCS | R(S) | SSH chosen compression algorithm client to server | |
| sshCompSC | R(S) | SSH chosen compression algorithm server to client | |
| sshLangCS | R(S) | SSH chosen language client to server | |
| sshLangSC | R(S) | SSH chosen language server to client | |
| If SSH_DECODE>0&&SSH_LISTS=1, the following columns are displayed: | | | |
| sshKEXList | R(S) | SSH KEX algorithms | |
| sshSrvHKeyAlgoList | R(S) | SSH server host key algorithms | |
| sshEncCSList | R(S) | SSH encryption algorithms client to server | |
| sshEncSCList | R(S) | SSH encryption algorithms server to client | |
| sshMacCSList | R(S) | SSH MAC algorithms client to server | |
| sshMacSCList | R(S) | SSH MAC algorithms server to client | |
| sshCompCSList | R(S) | SSH compression algorithms client to server | |
| sshCompSCList | R(S) | SSH compression algorithms server to client | |
| sshLangCSList | R(S) | SSH languages client to server | |
| sshLangSCList | R(S) | SSH languages server to client | |
| If SSH_HASSH=1, the following columns are displayed: | | | |
| sshHassh | R(SC) | SSH HASSH fingerprint | |
| sshHasshDesc | R(S) | SSH HASSH description | |

| Column | Type | Description | Flags |
|---|---|---|---|
| sshHasshStr | R(S) | SSH HASSH string | |

### 56.4.1 sshStat

The sshStat column is to be interpreted as follows:

| sshStat | Description |
|---|---|
| $2^0$ (=0x0001) | Flow contains SSH protocol |
| $2^1$ (=0x0002) | Keeps track of who sent the SSH banner first |
| $2^2$ (=0x0004) | Banner does not end with CRLF or contains NULL byte |
| $2^3$ (=0x0008) | Key Exchange Init message seen |
| $2^4$ (=0x0010) | Diffie-Hellman Key Exchange Init message seen |
| $2^5$ (=0x0020) | Diffie-Hellman Key Exchange Reply message seen |
| $2^6$ (=0x0040) | Elliptic Curve Diffie-Hellman Key Exchange Init message seen |
| $2^7$ (=0x0080) | Elliptic Curve Diffie-Hellman Key Exchange Reply message seen |
| $2^8$ (=0x0100) | Diffie-Hellman Group Exchange Group message seen |
| $2^9$ (=0x0200) | Diffie-Hellman Group Exchange Init message seen |
| $2^{10}$ (=0x0400) | Diffie-Hellman Group Exchange Request message seen |
| $2^{11}$ (=0x0800) | Diffie-Hellman Group Exchange Reply message seen |
| $2^{12}$ (=0x1000) | New Keys message seen |
| $2^{13}$ (=0x2000) | String truncated... increase SSH_BUF_SIZE |
| $2^{14}$ (=0x4000) | Host key type or chosen algorithm truncated... increase SSH_HKT_SIZE |
| $2^{15}$ (=0x8000) | Malformed (decoding error, encrypted, ...) |

### 56.4.2 sshFingerprint

The fingerprint of a public key can be computed as follows:

```
ssh-keygen -lf id_rsa.pub
```

To compute the fingerprint of each host listed in *~/.ssh/known_hosts*, use the following command:

```
ssh-keygen -lf ~/.ssh/known_hosts
```

Note that the default SHA256 algorithm can be changed with the -E md5 option.

## 56.5 Packet File Output

In packet mode (-s option), the sshDecode plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| sshStat | H16 | Status | |

## 56.6 Monitoring Output

In monitoring mode, the sshDecode plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| sshNFlows | U64 | Number of SSH flows | |
| sshStat | H16 | Status | |

## 56.7 Plugin Report Output

The following information is reported:

- Aggregated sshStat
- Number of SSH flows
- Number of HASSH signatures matched

# 57 sslDecode

## 57.1 Description

This plugin analyzes SSL/TLS and OpenVPN traffic.

## 57.2 Dependencies

If `SSL_ANALYZE_CERT` is activated, then **libssl** is required.

| | | **SSL_ANALYZE_CERT=1** |
|---|---|---|
| **Ubuntu:** | `sudo apt-get install` | `libssl-dev` |
| **Arch:** | `sudo pacman -S` | `openssl` |
| **openSUSE:** | `sudo zypper install` | `libopenssl-devel` |
| **Red Hat/Fedora**[38]**:** | `sudo dnf install` | `openssl-devel` |
| **macOS**[39]**:** | `brew install` | `openssl@1.1` |

## 57.3 Configuration Flags

The following flags can be used to control the output of the plugin:

| Name | Default | Description |
|---|---|---|
| `SSL_ANALYZE_OVPN` | 0 | Analyze OpenVPN (Experimental) |
| `SSL_REC_VER` | 1 | Output the list and number of record versions |
| `SSL_MAX_REC_VER` | 3 | Maximum number of record versions to store |
| `SSL_HAND_VER` | 1 | Output the list and number of handshake versions |
| `SSL_MAX_HAND_VER` | 2 | Maximum number of handshake versions to store |
| `SSL_EXT_LIST` | 1 | Output the list and number of extensions |
| `SSL_MAX_EXT` | 20 | Maximum number of extensions to store |
| `SSL_SUPP_VER` | 1 | Output the list and number of supported versions |
| `SSL_MAX_SUPP_VER` | 4 | Maximum number of supported versions to store |
| `SSL_SIG_ALG` | 1 | Output the list and number of signature hash algorithms |
| `SSL_MAX_SIG_ALG` | 15 | Maximum number of signature hash algorithms to store |
| `SSL_EC` | 1 | Output the list and number of elliptic curves |
| `SSL_MAX_EC` | 6 | Maximum number of elliptic curves to store |
| `SSL_EC_FORMATS` | 1 | Output the list and number of elliptic curve formats |
| `SSL_MAX_EC_FORMATS` | 6 | Maximum number of elliptic curve formats to store |

[38] If the `dnf` command could not be found, try with `yum` instead
[39] Brew is a packet manager for macOS that can be found here: https://brew.sh

| Name | Default | Description |
|---|---|---|
| SSL_ALPN_LIST | 1 | Output the list and number of protocols (ALPN) |
| SSL_ALPS_LIST | 1 | Output the list and number of protocols (ALPS) |
| SSL_NPN_LIST | 1 | Output the list and number of protocols (NPN) |
| SSL_MAX_PROTO | 6 | Maximum number of protocols (ALPN/ALPS/NPN) to store |
| SSL_PROTO_LEN | 16 | Maximum number of characters per protocol (ALPN) |
| SSL_CIPHER_LIST | 1 | Output the list and number of supported ciphers |
| SSL_MAX_CIPHER | 3 | Maximum number of ciphers to store |
| SSL_ANALYZE_CERT | 1 | Analyze certificates |
| If SSL_ANALYZE_CERT > 0, the following flags are available: | | |
| SSL_CERT_SERIAL | 1 | Print the certificate serial number |
| SSL_CERT_FINGPRINT | 1 | 0: no certificate fingerprint, 1: SHA1, 2: MD5 |
| SSL_CERT_VALIDITY | 1 | Print certificates validity (Valid from/to, lifetime) |
| SSL_CERT_SIG_ALG | 1 | Print the certificate signature algorithm |
| SSL_CERT_PUBKEY_ALG | 1 | Print the certificate public key algorithm |
| SSL_CERT_ALG_NAME_LONG | 0 | Use short (0) or long (1) names for algorithms |
| SSL_CERT_PUBKEY_TS | 1 | Print certificates public key type and size |
| SSL_CERT_SUBJECT | 2 | 0: no info about cert subject,<br>1: whole subject as one string,<br>2: selected fields (see below) |
| SSL_CERT_ISSUER | 2 | 0: no info about cert issuer,<br>1: whole issuer as one string,<br>2: selected fields (see below) |
| SSL_CERT_COMMON_NAME | 1 | Print the common name of the issuer/subject |
| SSL_CERT_ORGANIZATION | 1 | Print the organization name of the issuer/subject |
| SSL_CERT_ORG_UNIT | 1 | Print the organizational unit of the issuer/subject |
| SSL_CERT_LOCALITY | 1 | Print the locality name of the issuer/subject |
| SSL_CERT_STATE | 1 | Print the state/province name of the issuer/subject |
| SSL_CERT_COUNTRY | 1 | Print the country of the issuer/subject (iso3166) |
| SSL_RM_CERTDIR | 1 | Remove SSL_CERT_PATH before starting |
| SSL_SAVE_CERT | 0 | Save certificates |
| SSL_CERT_NAME_FINDEX | 0 | Prepend the flowIndex to the certificate name |
| SSL_DETECT_TOR | 0 | Detect likely Tor connections |
| SSL_BLIST | 0 | Flag blacklisted certificates |
| SSL_BLIST_LEN | 41 | Max length for blacklist descriptions |
| SSL_JA4 | 1 | Output JA4/JA4S fingerprints |
| SSL_JA4_O | 0 | Output JA4/JA4S_o fingerprints (original order) |

| Name | Default | Description |
|---|---|---|
| SSL_JA4_R | 0 | Output JA4/JA4S_r fingerprints (raw) |
| SSL_JA4_RO | 0 | Output JA4/JA4S_ro fingerprints (raw, original order) |
| SSL_JA4_STR_LEN | 254 | Max length for uncompressed JA4 signatures (JA4/JA4S_r, JA4/JA4S_ro) |
| SSL_JA4_DLEN | 64 | Max length for JA4/JA4S descriptions (sslJA4Desc) |
| SSL_JA3 | 1 | Output JA3 fingerprints (hash and description) |
| SSL_JA3_STR | 0 | Also output JA3 fingerprints before hashing |
| SSL_JA3_DLEN | 64 | Max length for JA3 descriptions |
| SSL_JA3_STR_LEN | 1024 | Max length for uncompressed JA3 signatures (ja3_str) |

If SSL_SAVE_CERT==1 then, certificates are saved under SSL_CERT_PATH (default: "/tmp/TranCerts/") with the extension SSL_CERT_EXT (default: ".pem") and the SHA1 or MD5 fingerprint as filename.

### 57.3.1 Environment Variable Configuration Flags

The following configuration flags can also be configured with environment variables (ENVCNTRL>0):

- SSL_RM_CERTDIR
- SSL_CERT_PATH
- SSL_CERT_EXT

## 57.4 Flow File Output

The sslDecode plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| sslStat | H32 | Status | |
| sslProto | H32 | Protocol | |
| ovpnType | H16 | OpenVPN message types | SSL_ANALYZE_OVPN=1 |
| ovpnSessionID | U64 | OpenVPN session ID | SSL_ANALYZE_OVPN=1 |
| sslFlags | H8 | SSL flags | |
| sslVersion | H16 | SSL/TLS Version | |
| sslNumRecVer | U16 | Number of record versions | SSL_REC_VER=1 |
| sslRecVer | R(H16) | List of record versions | SSL_REC_VER=1 |
| sslNumHandVer | U16 | Number of handshake versions | SSL_HAND_VER=1 |
| sslHandVer | R(H16) | List of handshake versions | SSL_HAND_VER=1 |
| sslVuln | H8 | Vulnerabilities | |
| sslAlert | H64 | Alert type | |
| sslCipher | H16 | Preferred (Client)/Negotiated (Server) cipher | |
| sslNumExt | U16 | Number of extensions | SSL_EXT_LIST=1 |
| sslExtList | R(H16) | List of extensions | SSL_EXT_LIST=1 |
| sslNumSuppVer | U16 | Number of supported versions | SSL_SUPP_VER=1 |

| Column | Type | Description | Flags |
|---|---|---|---|
| sslSuppVer | R(H16) | List of supported versions (client)<br>(Server: negotiated version) | SSL_SUPP_VER=1 |
| sslNumSigAlg | U16 | Number of signature hash algorithms | SSL_SIG_ALG=1 |
| sslSigAlg | R(H16) | List of signature hash algorithms | SSL_SIG_ALG=1 |
| sslNumECPt | U16 | Number of elliptic curve points | SSL_EC=1 |
| sslECPt | R(H16) | List of elliptic curve points | SSL_EC=1 |
| sslNumECFormats | U8 | Number of EC point formats | SSL_EC_FORMATS=1 |
| sslECFormats | R(H8) | List of EC point formats | SSL_EC_FORMATS=1 |
| sslNumALPN | U16 | Number of protocols (ALPN) | SSL_ALPN_LIST=1 |
| sslALPNList | R(S) | List of protocols (ALPN) | SSL_ALPN_LIST=1 |
| sslNumALPS | U16 | Number of protocols (ALPS) | SSL_ALPS_LIST=1 |
| sslALPSList | R(S) | List of protocols (ALPS) | SSL_ALPS_LIST=1 |
| sslNumNPN | U16 | Number of protocols (NPN) | SSL_NPN_LIST=1 |
| sslNPNList | R(S) | List of protocols (NPN) | SSL_NPN_LIST=1 |
| sslNumCipher | U16 | Number of supported ciphers | SSL_CIPHER_LIST=1 |
| sslCipherList | R(H16) | List of supported ciphers | SSL_CIPHER_LIST=1 |
| sslNumCC_ | U16_ | Number of change_cipher records, | |
| A_ | U16_ | Number of alert records, | |
| H_ | U16_ | Number of handshake records, | |
| AD_ | U64_ | Number of application data records, | |
| HB | U64 | Number of heartbeat records | |
| sslSessIdLen | U8 | Session ID length | |
| sslGMTTime | R(TS) | GMT Unix Time | |
| sslServerName | R(S) | server name | |

If SSL_ANALYZE_CERT == 1, the following columns are output:

| | | | |
|---|---|---|---|
| sslCertVersion | R(U8) | Certificate version | SSL_CERT_FINGPRINT=1 |
| sslCertSerial | R(SC) | Certificate serial number | SSL_CERT_SERIAL=1 |
| sslCertSha1FP | R(SC) | Certificate SHA1 fingerprint | SSL_CERT_FINGPRINT=1 |
| sslCertMd5FP | R(SC) | Certificate MD5 fingerprint | SSL_CERT_FINGPRINT=2 |
| sslCNotValidBefore_ | TS_ | Certificate validity: not valid before, | SSL_CERT_VALIDITY=1 |
| after_ | R( TS_ | not valid after, | |
| lifetime | U64) | lifetime | |
| sslCSigAlg | RS | Certificate signature algorithm | SSL_CERT_SIG_ALG=1 |
| sslCKeyAlg | RS | Certificate public key algorithm | SSL_CERT_PUBKEY_ALG=1 |
| sslCPKeyType_ | SC_ | Certificate public key type, | SSL_CERT_PUBKEY_TS=1 |
| Size | U16 | Certificate public key size (bits) | |

If SSL_CERT_SUBJECT > 0, the following columns are output:

| | | | |
|---|---|---|---|
| sslCSubject | R(S) | Certificate subject | SSL_CERT_SUBJECT=1 |
| sslCSubjectCommonName | R(S) | Certificate subject common name | SSL_CERT_SUBJECT=2 |
| sslCSubjectOrgName | R(S) | Certificate subject organization name | SSL_CERT_SUBJECT=2 |
| sslCSubjectOrgUnit | R(S) | Certificate subject organizational unit name | SSL_CERT_SUBJECT=2 |

| Column | Type | Description | Flags |
|---|---|---|---|
| sslCSubjectLocality | R(S) | Certificate subject locality name | SSL_CERT_SUBJECT=2 |
| sslCSubjectState | R(S) | Certificate subject state or province name | SSL_CERT_SUBJECT=2 |
| sslCSubjectCountry | R(S) | Certificate subject country name | SSL_CERT_SUBJECT=2 |
| If SSL_CERT_ISSUER > 0, the following columns are output: | | | |
| sslCIssuer | R(S) | Certificate issuer | SSL_CERT_ISSUER=1 |
| sslCIssuerCommonName | R(S) | Certificate issuer common name | SSL_CERT_ISSUER=2 |
| sslCIssuerOrgName | R(S) | Certificate issuer organization name | SSL_CERT_ISSUER=2 |
| sslCIssuerOrgUnit | R(S) | Certificate issuer organizational unit name | SSL_CERT_ISSUER=2 |
| sslCIssuerLocality | R(S) | Certificate issuer locality name | SSL_CERT_ISSUER=2 |
| sslCIssuerState | R(S) | Certificate issuer state or province name | SSL_CERT_ISSUER=2 |
| sslCIssuerCountry | R(S) | Certificate issuer country name | SSL_CERT_ISSUER=2 |
| sslBlistCat | R(S) | Blacklisted certificate category | SSL_BLIST=1&& (SSL_SAVE_CERT=1\|\| SSL_CERT_FINGPRINT=1) |
| sslJA3Hash | R(SC) | JA3 fingerprint | SSL_JA3=1 |
| sslJA3Desc | R(S) | JA3 description | SSL_JA3=1 |
| sslJA3Str | R(S) | JA3 string | SSL_JA3=1&& SSL_JA3_STR=1 |
| sslJA4 | R(SC) | JA4/JA4S fingerprint | SSL_JA4=1 |
| sslJA4Desc | R(S) | JA4/JA4S description | SSL_JA4=1 |
| sslJA4O | R(SC) | JA4/JA4S_o fingerprint (original order) | SSL_JA4_O=1 |
| sslJA4R | R(SC) | JA4/JA4S_r fingerprint (raw) | SSL_JA4_R=1 |
| sslJA4RO | R(SC) | JA4/JA4S_ro fingerprint (raw, original order) | SSL_JA4_RO=1 |
| sslTorFlow | U8 | Tor flow | SSL_DETECT_TOR=1 |

If SSL_CERT_SUBJECT=2 or SSL_CERT_ISSUER=2, then the columns displayed are controlled by the following self-explanatory flags:

- SSL_CERT_COMMON_NAME,
- SSL_CERT_ORGANIZATION,
- SSL_CERT_ORG_UNIT,
- SSL_CERT_LOCALITY,
- SSL_CERT_STATE,
- SSL_CERT_COUNTRY.

### 57.4.1 sslStat

The hex based status variable `sslStat` is defined as follows:

| sslStat | Description |
|---|---|
| 0x0000 0001 | Message had mismatched version |
| 0x0000 0002 | Record was too long (max 16384) |
| 0x0000 0004 | Record was malformed, eg, invalid value |
| 0x0000 0008 | Certificate had expired |
| 0x0000 0010 | Connection was closed due to fatal alert |
| 0x0000 0020 | Connection was renegotiated (existed before) |
| 0x0000 0040 | Peer not allowed to send heartbeat requests |
| 0x0000 0080 | Cipher list truncated... increase `SSL_MAX_CIPHER` |
| 0x0000 0100 | Extension list truncated... increase `SSL_MAX_EXT` |
| 0x0000 0200 | Protocol (ALPN/NPN/ALPS) list truncated... increase `SSL_MAX_PROTO` |
| 0x0000 0400 | Protocol (ALPN/NPN/ALPS) name truncated... increase `SSL_PROTO_LEN` |
| 0x0000 0800 | EC or EC formats list truncated... increase `SSL_MAX_EC` or `SSL_MAX_EC_FORMATS` |
| 0x0000 1000 | Certificate is blacklisted |
| 0x0000 2000 | Insecure or weak cipher detected (Null, DES, RC4 (RFC7465), ADH, 40/56 bits) |
| 0x0000 4000 | Weak protocol detected (SSL 2.0, SSL 3.0) |
| 0x0000 8000 | Weak key detected |
| 0x0001 0000 | Signature hash algorithms list truncated... increase `SSL_MAX_SIG_ALG` |
| 0x0002 0000 | Supported versions list truncated... increase `SSL_MAX_SUPP_VER` |
| 0x0004 0000 | Packet snapped, decoding failed |
| 0x0008 0000 | Failed to compute JA3 fingerprint... increase `SSL_JA3_STR_LEN` |
| 0x0010 0000 | Failed to compute JA4/JA4S fingerprint |
| 0x0020 0000 | JA4/JA4S_a successfully computed |
| 0x0040 0000 | JA4/JA4S_b successfully computed |
| 0x0080 0000 | JA4/JA4S_c successfully computed |
| 0x0100 0000 | Insecure cipher (should NEVER be used) |
| 0x0200 0000 | Weak cipher (should not be used) |
| 0x0400 0000 | Secure cipher |
| 0x0800 0000 | Perfect Forward Secrecy (PFS) ciphers |
| 0x1000 0000 | JA4/JA4S fingerprint truncated... increase `SSL_JA4_STR_LEN` |
| 0x2000 0000 | Record versions list truncated... increase `SSL_MAX_REC_VER` |
| 0x4000 0000 | Handshake versions list truncated... increase `SSL_MAX_HAND_VER` |
| 0x8000 0000 | — |

### 57.4.2 sslProto

The hex based protocol variable `sslProto` is defined as follows:

| sslProto | Description |
|---|---|
| 0x0000 0001 | HTTP/0.9, HTTP/1.0 or HTTP/1.1 (ALPN starts with `http`) |
| 0x0000 0002 | HTTP/2 (`h2` or `h2c`) |
| 0x0000 0004 | HTTP/3 (`h3` or HTTP/0.9/1.1 over QUIC (`hq`) |
| 0x0000 0008 | SPDY/1, SPDY/2 or SPDY/3 (ALPN starts with `spdy`) |
| 0x0000 0010 | IMAP |
| 0x0000 0020 | POP3 |
| 0x0000 0040 | FTP |
| 0x0000 0080 | XMPP jabber |
| 0x0000 0100 | STUN/TURN |
| 0x0000 0200 | Apple Push Notification Service (APNS)) |
| 0x0000 0400 | WebRTC Media and Data or Confidential WebRTC Media and Data |
| 0x0000 0800 | Constrained Application Protocol (CoAP) |
| 0x0000 1000 | ManageSieve |
| 0x0000 2000 | RTP or RTCP[40] |
| 0x0000 4000 | OpenVPN[41] |
| 0x0000 8000 | OASIS Message Queuing Telemetry Transport (MQTT) |
| 0x0001 0000 | acme-tls/1 |
| 0x0002 0000 | DICOM |
| 0x0004 0000 | NNTP (reading) or NNTP (transit) |
| 0x0008 0000 | SIP |
| 0x0010 0000 | Tabular Data Stream Protocol (TDS) |
| 0x0020 0000 | DNS over Dedicated QUIC Connections (DoQ) |
| 0x0040 0000 | DNS-over-TLS (DoT) |
| 0x0080 0000 | IRC |
| 0x0100 0000 | SMB |
| 0x0200 0000 | SUNRPC |
| 0x0400 0000 | Network Time Security Key Establishment |
| 0x0800 0000 | — |
| 0x1000 0000 | — |
| 0x2000 0000 | — |
| 0x4000 0000 | GREASE value |
| 0x8000 0000 | Unknown protocol (ALPN matched none of the above) |

### 57.4.3 ovpnType

The `ovpnType` column is to be interpreted as follows:

[40] Guessed by the presence of the `use-srtp` hello extension
[41] Guessed by being able to decode the protocol

| | ovpnType | Description |
|---|---|---|
| $2^1$ | (=0x0002) | P_CONTROL_HARD_RESET_CLIENT_V1 |
| $2^2$ | (=0x0004) | P_CONTROL_HARD_RESET_SERVER_V1 |
| $2^3$ | (=0x0008) | P_CONTROL_SOFT_RESET_V1 |
| $2^4$ | (=0x0010) | P_CONTROL_V1 |
| $2^5$ | (=0x0020) | P_ACK_V1 |
| $2^6$ | (=0x0040) | P_DATA_V1 |
| $2^7$ | (=0x0080) | P_CONTROL_HARD_RESET_CLIENT_V2 |
| $2^8$ | (=0x0100) | P_CONTROL_HARD_RESET_SERVER_V2 |
| $2^9$ | (=0x0200) | P_DATA_V2 |

### 57.4.4 sslFlags

The `sslFlags` is defined as follows:

| sslFlags | Description |
|---|---|
| 0x01 | request is SSLv2 |
| 0x02 | SSLv3 version on 'request' layer different than on 'record' layer |
| 0x04 | gmt_unix_time is small (less than 1 year since epoch, probably seconds since boot) |
| 0x08 | gmt_unix_time is more than 5 years in the future (probably random) |
| 0x10 | random data (28 bytes) is not random |
| 0x20 | compression (deflate) is enabled |

### 57.4.5 sslVersion, sslRecVer, sslHandVer and sslSuppVer

The hex based version variables `sslVersion`, `sslRecVer`, `sslHandVer` and `sslSuppVer` are defined as follows:

| sslVersion | Description |
|---|---|
| 0x0200 | SSL 2.0 |
| 0x0300 | SSL 3.0 |
| 0x0301 | TLS 1.0 |
| 0x0302 | TLS 1.1 |
| 0x0303 | TLS 1.2 |
| 0x0304 | TLS 1.3 |
| 0x0a0a | GREASE value |
| 0x1a1a | GREASE value |
| 0x2a2a | GREASE value |
| 0x3a3a | GREASE value |
| 0x4a4a | GREASE value |
| 0x5a5a | GREASE value |
| 0x6a6a | GREASE value |
| 0x7a7a | GREASE value |
| 0x7f0e | TLS 1.3 (draft 14) |
| 0x7f0f | TLS 1.3 (draft 15) |
| 0x7f10 | TLS 1.3 (draft 16) |
| 0x7f11 | TLS 1.3 (draft 17) |
| 0x7f12 | TLS 1.3 (draft 18) |
| 0x7f13 | TLS 1.3 (draft 19) |
| 0x7f14 | TLS 1.3 (draft 20) |

| sslVersion | Description |
|---|---|
| 0x7f15 | TLS 1.3 (draft 21) |
| 0x7f16 | TLS 1.3 (draft 22) |
| 0x7f17 | TLS 1.3 (draft 23) |
| 0x7f18 | TLS 1.3 (draft 24) |
| 0x7f19 | TLS 1.3 (draft 25) |
| 0x7f1a | TLS 1.3 (draft 26) |
| 0x7f1b | TLS 1.3 (draft 27) |
| 0x7f1c | TLS 1.3 (draft 28) |
| 0x8a8a | GREASE value |
| 0x9a9a | GREASE value |
| 0xaaaa | GREASE value |
| 0xbaba | GREASE value |
| 0xcaca | GREASE value |
| 0xdada | GREASE value |
| 0xeaea | GREASE value |
| 0xfafa | GREASE value |
| 0xfb17 | TLS 1.3 (Facebook draft 23) |
| 0xfb1a | TLS 1.3 (Facebook draft 26) |
| 0xfefc | DTLS 1.3 |
| 0xfefd | DTLS 1.2 |
| 0xfeff | DTLS 1.0 |

### 57.4.6 sslVuln

The hex based vulnerability variable `sslVuln` is defined as follows:

| sslVuln | Description |
|---|---|
| 0x01 | vulnerable to BEAST |
| 0x02 | vulnerable to BREACH |
| 0x04 | vulnerable to CRIME |
| 0x08 | vulnerable to FREAK |
| 0x10 | vulnerable to POODLE |
| 0x20 | HEARTBLEED attack attempted |
| 0x40 | HEARTBLEED attack successful (Not implemented) |
| 0x80 | — |

### 57.4.7 sslAlert

The hex based alert variable `sslAlert` is defined as follows (red is fatal):

| sslAlert | Description |
|---|---|
| 0x00000000 00000001 | close notify |
| 0x00000000 00000002 | unexpected message (fatal) |
| 0x00000000 00000004 | bad record MAC (fatal) |
| 0x00000000 00000008 | decryption failed |
| 0x00000000 00000010 | record overflow |
| 0x00000000 00000020 | decompression failed (fatal) |
| 0x00000000 00000040 | handshake failed (fatal) |
| 0x00000000 00000080 | no certificate |
| 0x00000000 00000100 | bad certificate |
| 0x00000000 00000200 | unsupported certificate |
| 0x00000000 00000400 | certificate revoked |
| 0x00000000 00000800 | certificate expired |
| 0x00000000 00001000 | certificate unknown |
| 0x00000000 00002000 | illegal parameter (fatal) |
| 0x00000000 00004000 | unknown CA (fatal) |
| 0x00000000 00008000 | access denied (fatal) |
| 0x00000000 00010000 | decode error (fatal) |
| 0x00000000 00020000 | decrypt error |
| 0x00000000 00040000 | export restriction (fatal) |
| 0x00000000 00080000 | protocol version (fatal) |
| 0x00000000 00100000 | insufficient security (fatal) |
| 0x00000000 00200000 | internal error (fatal) |
| 0x00000000 00400000 | user canceled |
| 0x00000000 00800000 | no renegotiation |
| 0x00000000 01000000 | unsupported extension |
| 0x00000000 02000000 | inappropriate fallback (fatal) |
| 0x00000000 04000000 | certificate unobtainable |
| 0x00000000 08000000 | unrecognized name |
| 0x00000000 10000000 | bad certificate status response |
| 0x00000000 20000000 | bad certificate hash value |
| 0x00000000 40000000 | unknown PSK identity (fatal) |
| 0x00000000 80000000 | no application protocol (fatal) |

| sslAlert | Description |
|---|---|
| 0x00000001 00000000 | unknown PSK identity (fatal) |
| 0x00000002 00000000 | no application protocol (fatal) |
| 0x00000004 00000000 | — |
| 0x00000008 00000000 | — |
| 0x00000010 00000000 | — |
| 0x00000020 00000000 | — |
| 0x00000040 00000000 | — |
| 0x00000080 00000000 | — |
| 0x00000100 00000000 | — |
| 0x00000200 00000000 | — |
| 0x00000400 00000000 | — |
| 0x00000800 00000000 | — |
| 0x00001000 00000000 | — |
| 0x00002000 00000000 | — |
| 0x00004000 00000000 | — |
| 0x00008000 00000000 | — |
| 0x00010000 00000000 | — |
| 0x00020000 00000000 | — |
| 0x00040000 00000000 | — |
| 0x00080000 00000000 | — |
| 0x00100000 00000000 | — |
| 0x00200000 00000000 | — |
| 0x00400000 00000000 | — |
| 0x00800000 00000000 | — |
| 0x01000000 00000000 | — |
| 0x02000000 00000000 | — |
| 0x04000000 00000000 | — |
| 0x08000000 00000000 | — |
| 0x10000000 00000000 | — |
| 0x20000000 00000000 | — |
| 0x40000000 00000000 | — |
| 0x80000000 00000000 | Fatal |

### 57.4.8 sslCipher

The `sslCipher` variable represents the preferred cipher for the client and the negotiated cipher for the server. The corresponding name can be found in the *src/sslCipher.h* file. All values following the `0x[0-9a-f]a[0-9a-f]a` pattern are GREASE values.

### 57.4.9 sslNumCC_A_H_AD_HB

The number of message variable `sslNumCC_A_H_AD_HB` decomposed as follows:

| sslNumCC_A_H_AD_HB | Description |
|---|---|
| `sslNumCC` | number of change cipher records |
| `sslNumA` | number of alerts records |
| `sslNumH` | number of handshake records |
| `sslNumAD` | number of application data records |
| `sslNumHB` | number of heartbeat records |

### 57.4.10 sslExtList

The list of extensions is to be interpreted as follows:

| sslExt | Description |
|---|---|
| 0x0000 | Server name |
| 0x0001 | Max fragment length |
| 0x0002 | Client certificate URL |
| 0x0003 | Trusted CA keys |
| 0x0004 | Truncated HMAC |
| 0x0005 | Status request |
| 0x0006 | User mapping |
| 0x0007 | Client authz |
| 0x0008 | Server authz |
| 0x0009 | Cert type |
| 0x000a | Supported groups (elliptic curves) |
| 0x000b | EC point formats |
| 0x000c | SRP |
| 0x000d | Signature hash algorithms |
| 0x000e | Use SRTP |
| 0x000f | Heartbeat |
| 0x0010 | ALPN |
| 0x0011 | Status request v2 |
| 0x0012 | Signed certificate timestamp |
| 0x0013 | Client certificate type |
| 0x0014 | Server certificate type |
| 0x0015 | Padding |
| 0x0016 | Encrypt then MAC |
| 0x0017 | Extended master secret |
| 0x0018 | Token binding |
| 0x0019 | Cached info |
| 0x001a | TLS LTS |
| 0x001b | Compress certificate |
| 0x001c | Record size limit |
| 0x001d | Pwd protect |
| 0x001e | Pwd clear |
| 0x001f | Password salt |
| 0x0020 | Ticket pinning |
| 0x0021 | TLS cert with extern PSK |
| 0x0022 | Delegated credential |
| 0x0023 | Session ticket |
| 0x0024 | TLMSP |
| 0x0025 | TLMSP proxying |
| 0x0026 | TLMSP delegate |
| 0x0027 | Supported EKT ciphers |
| 0x0028 | Extended random |
| 0x0029 | Pre-Shared Key (PSK) |
| 0x002a | Early data |

| sslExt | Description |
|---|---|
| 0x002b | Supported versions |
| 0x002c | Cookie |
| 0x002d | PSK key exchange modes |
| 0x002f | Certificate authorities |
| 0x0030 | OID filters |
| 0x0031 | Post handshake auth |
| 0x0032 | Signature algorithms cert |
| 0x0033 | Key Share |
| 0x0034 | Transparency info |
| 0x0035 | Connection ID (deprecated) |
| 0x0036 | Connection ID |
| 0x0037 | External ID hash |
| 0x0038 | External session ID |
| 0x0039 | QUIC transport parameters |
| 0x0040 | Ticket request |
| 0x0041 | DNSSEC chain |
| 0x0042 | Sequence number encryption algo. (DTLS) |
| 0x0043 | Return Routability Check (RRC) for DTLS |
| 0x0a0a | GREASE value |
| 0x1a1a | GREASE value |
| 0x2a2a | GREASE value |
| 0x3374 | NPN |
| 0x3377 | Origin bound cert |
| 0x337c | Encrypted client cert |
| 0x3a3a | GREASE value |
| 0x4469 | Application settings (ALPS) |
| 0x4a4a | GREASE value |
| 0x5a5a | GREASE value |
| 0x6a6a | GREASE value |
| 0x754f | Channel ID old |
| 0x7550 | Channel ID |
| 0x7a7a | GREASE value |
| 0x8a8a | GREASE value |
| 0x9a9a | GREASE value |
| 0xaaaa | GREASE value |
| 0xbaba | GREASE value |
| 0xcaca | GREASE value |
| 0xdada | GREASE value |
| 0xeaea | GREASE value |
| 0xfafa | GREASE value |
| 0xfd00 | Encrypted Client Hello outer extensions |
| 0xfe0d | Encrypted Client Hello |
| 0xff01 | Renegotiation info |

#### 57.4.11 sslSigAlg

The list of signature hash algorithms is to be interpreted as follows:

| sslSigAlg | Description |
|---|---|
| 0x0201 | rsa_pkcs1_sha1 |
| 0x0203 | ecdsa_sha1 |
| 0x0401 | rsa_pkcs1_sha256 |
| 0x0403 | ecdsa_secp256r1_sha256 |
| 0x0420 | rsa_pkcs1_sha256_legacy |
| 0x0501 | rsa_pkcs1_sha384 |
| 0x0503 | ecdsa_secp384r1_sha384 |
| 0x0520 | rsa_pkcs1_sha384_legacy |
| 0x0601 | rsa_pkcs1_sha512 |
| 0x0620 | rsa_pkcs1_sha512_legacy |
| 0x0603 | ecdsa_secp521r1_sha512 |
| 0x0708 | sm2sig_sm3 |
| 0x0709 | gostr34102012_256a |
| 0x070a | gostr34102012_256b |
| 0x070b | gostr34102012_256c |
| 0x070c | gostr34102012_256d |
| 0x070d | gostr34102012_512a |
| 0x070e | gostr34102012_512b |
| 0x070f | gostr34102012_512c |
| 0x0804 | rsa_pss_rsae_sha256 |
| 0x0805 | rsa_pss_rsae_sha384 |
| 0x0806 | rsa_pss_rsae_sha512 |
| 0x0807 | ed25519 |
| 0x0808 | ed448 |
| 0x0809 | rsa_pss_pss_sha256 |
| 0x080a | rsa_pss_pss_sha384 |
| 0x080b | rsa_pss_pss_sha512 |
| 0x081a | ecdsa_brainpoolP256r1tls13_sha256 |
| 0x081b | ecdsa_brainpoolP384r1tls13_sha384 |
| 0x081c | ecdsa_brainpoolP512r1tls13_sha512 |
| 0x0a0a | GREASE value |
| 0x1a1a | GREASE value |
| 0x2a2a | GREASE value |
| 0x3a3a | GREASE value |
| 0x4a4a | GREASE value |
| 0x5a5a | GREASE value |
| 0x6a6a | GREASE value |
| 0x7a7a | GREASE value |
| 0x8a8a | GREASE value |
| 0x9a9a | GREASE value |
| 0xaaaa | GREASE value |
| 0xbaba | GREASE value |
| 0xcaca | GREASE value |

| sslSigAlg | Description |
|---|---|
| 0xdada | GREASE value |
| 0xeaea | GREASE value |
| 0xfafa | GREASE value |
| 0xfea0 | dilithium2 |
| 0xfea1 | p256_dilithium2 |
| 0xfea2 | rsa3072_dilithium2 |
| 0xfea3 | dilithium3 |
| 0xfea4 | p384_dilithium3 |
| 0xfea5 | dilithium5 |
| 0xfea6 | p521_dilithium5 |
| 0xfea7 | dilithium2_aes |
| 0xfea8 | p256_dilithium2_aes |
| 0xfea9 | rsa3072_dilithium2_aes |
| 0xfeaa | dilithium3_aes |
| 0xfeab | p384_dilithium3_aes |
| 0xfeac | dilithium5_aes |
| 0xfead | p521_dilithium5_aes |
| 0xfe0b | falcon512 |
| 0xfe0c | p256_falcon512 |
| 0xfe0d | rsa3072_falcon512 |
| 0xfe0e | falcon1024 |
| 0xfe0f | p521_falcon1024 |
| 0xfe96 | picnicl1full |
| 0xfe97 | p256_picnicl1full |
| 0xfe98 | rsa3072_picnicl1full |
| 0xfe1b | picnic3l1 |
| 0xfe1c | p256_picnic3l1 |
| 0xfe1d | rsa3072_picnic3l1 |
| 0xfe27 | rainbowIclassic |
| 0xfe28 | p256_rainbowIclassic |
| 0xfe29 | rsa3072_rainbowIclassic |
| 0xfe3c | rainbowVclassic |
| 0xfe3d | p521_rainbowVclassic |
| 0xfe42 | sphincsharaka128frobust |
| 0xfe43 | p256_sphincsharaka128frobust |
| 0xfe44 | rsa3072_sphincsharaka128frobust |
| 0xfe5e | sphincssha256128frobust |
| 0xfe5f | p256_sphincssha256128frobust |
| 0xfe60 | rsa3072_sphincssha256128frobust |
| 0xfe7a | sphincsshake256128frobust |
| 0xfe7b | p256_sphincsshake256128frobust |
| 0xfe7c | rsa3072_sphincsshake256128frobust |

### 57.4.12 sslCNotValidBefore_after_lifetime

The `sslCNotValidBefore_after_lifetime` indicates the validity period of the certificate, i.e., not valid before / after, and the number of seconds between those two dates.

## 57.5 Plugin Report Output

The following information is reported:

- Aggregated `sslStat`
- Number of OpenVPN flows (`SSL_ANALYZE_OVPN=1`)
- Number of Tor flows (`SSL_DETECT_TOR=1`)
- Number of SSL 2.0, 3.0
- Number of TLS 1.0, 1.1, 1.2 and 1.3
- Number of DTLS 1.0 (OpenSSL pre 0.9.8f), 1.0 and 1.2 flows.
- Aggregated `sslProto`
- Number of certificates saved (`SSL_SAVE_CERT=1`)
- Number of blacklisted certificates (`SSL_BLIST=1`)
- Number of JA3 signatures matched (`SSL_JA3=1`)
- Number of JA4 signatures matched (`SSL_JA4=1`)
- Number of JA4S signatures matched (`SSL_JA4=1`)

# 58 stpDecode

## 58.1 Description

The stpDecode plugin analyzes STP traffic.

## 58.2 Dependencies

### 58.2.1 Core Configuration

This plugin requires the following core configuration:

- *$T2HOME/tranalyzer2/src/networkHeaders.h*:
  - `ETH_ACTIVATE>0`

## 58.3 Configuration Flags

The following flags can be used to control the output of the plugin:

| Name | Default | Description | Flags |
|---|---|---|---|
| `STP_RTPREXT` | 1 | 1: Priority Extension MAC, 0: BID hex | |

## 58.4 Flow File Output

The stpDecode plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| `stpStat` | H8 | Status | |
| `stpVer` | U8 | Protocol version identifier | |
| `stpType` | H8 | Aggregated BPDU types | |
| `stpFlags` | H8 | Aggregated BPDU flags | |
| `stpRtCst` | U32 | Root cost | |
| `stpRtBID` | H64 | Root BID | `STP_RTPREXT=0` |
| `stpRtPrio` | U16 | Root priority | `STP_RTPREXT=1` |
| `stpRtExt` | U16 | Root extension (VLAN) | `STP_RTPREXT=1` |
| `stpRtMAC` | MAC | Root MAC | `STP_RTPREXT=1` |
| `stpBrdgBID` | H64 | Bridge BID | `STP_RTPREXT=0` |
| `stpBrdgPrio` | U16 | Bridge priority | `STP_RTPREXT=1` |
| `stpBrdgExt` | U16 | Bridge extension (VLAN) | `STP_RTPREXT=1` |
| `stpBrdgMAC` | MAC | Bridge MAC | `STP_RTPREXT=1` |
| `stpFrwrd` | U16 | Forward delay | |

### 58.4.1 stpStat

The `stpStat` column is to be interpreted as follows:

| stpStat | Description |
|---|---|
| 0x01 | Flow is STP |

### 58.4.2 stpProto

The stpProto column is to be interpreted as follows:

| stpProto | Description |
|---|---|
| 0x0000 | Spanning Tree Protocol |

### 58.4.3 stpVer

The stpVer column is to be interpreted as follows:

| stpVer | Description |
|---|---|
| 0 | Spanning Tree |
| 2 | Rapid Spanning Tree |
| 3 | Multiple Spanning Tree |
| 4 | Shortest Path Tree |

### 58.4.4 stpType

The stpType column is to be interpreted as follows:

| stpType | Description |
|---|---|
| 0x00 | Configuration BPDU or TCN BPDU |
| 0x02 | Rapid/Multiple Spanning Tree |
| 0x80 | Topology Change Notification (TCN) BPDU |

### 58.4.5 stpFlags

The stpFlags column is to be interpreted as follows:

| stpFlags | Description |
|---|---|
| $2^0$ (=0x01) | Topology Change |
| $2^1$ (=0x02) | Proposal |
| $2^2$ (=0x04)<br>$2^3$ (=0x08) | Port Role: 0x00: Unknown, 0x10: Alternate or Backup, 0x20: Root, 0x30: Designated |
| $2^4$ (=0x10) | Learning |
| $2^5$ (=0x20) | Forwarding |
| $2^6$ (=0x40) | Agreement |
| $2^7$ (=0x80) | Topology Change Acknowledgment |

## 58.5 Packet File Output

In packet mode (-s option), the stpDecode plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| stpStat | H8 | Status | |
| stpProto | H16 | Protocol identifier | |
| stpVer | U8 | Protocol version identifier | |
| stpType | H8 | BPDU type | |
| stpFlags | H8 | BPDU flags | |
| stpRtCst | U32 | Root cost | |
| stpRtBID | H64 | Root BID | STP_RTPREXT=0 |
| stpRtPrio | U16 | Root priority | STP_RTPREXT=1 |
| stpRtExt | U16 | Root extension (VLAN) | STP_RTPREXT=1 |
| stpRtMAC | MAC | Root MAC | STP_RTPREXT=1 |
| stpBrdgBID | H64 | Bridge BID | STP_RTPREXT=0 |
| stpBrdgPrio | U16 | Bridge priority | STP_RTPREXT=1 |
| stpBrdgExt | U16 | Bridge extension (VLAN) | STP_RTPREXT=1 |
| stpBrdgMAC | MAC | Bridge MAC | STP_RTPREXT=1 |
| stpPort | H16 | Port identifier | |
| stpMsgAge | U16 | Message age | |
| stpMaxAge | U16 | Max age | |

| Column | Type | Description | Flags |
|---|---|---|---|
| stpHello | U16 | Hello time | |
| stpFrwrd | U16 | Forward delay | |
| stpPvstOrigVlan | U16 | Originating VLAN (PVSTP+) | |

## 58.6 Monitoring Output

In monitoring mode, the stpDecode plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| stpPkts | U64 | Number of STP packets | |

## 58.7 Plugin Report Output

The following information is reported:

- Aggregated stpStat
- Aggregated BPDU stpType
- Aggregated BPDU stpFlags
- Number of STP packets

# 59 stunDecode

This plugin analyzes the following protocols:

- Session Traversal Utilities for Nat (STUN)
- Traversal Using Relays around NAT (TURN)
- Interactive Connectivity Establishment (ICE)
- NAT Port Mapping Protocol (NAT-PMP)

## 59.1 Configuration Flags

The following flags can be used to control the output of the plugin:

| Name | Default | Description |
|---|---|---|
| NAT_PMP | 1 | Analyze NAT-PMP |

## 59.2 Flow File Output

The stunDecode plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| natStat | H32 | status | |
| natErr | H32 | error code | |
| natMCReq_Ind_Succ_Err | U16_U16_U16_U16 | number of messages (Req, Ind, Succ, Err) | |
| natAddr_Port | IP4_U16 | mapped address and port | |
| natXAddr_Port | IP4_U16 | (xor) mapped address and port | |
| natPeerAddr_Port | IP4_U16 | peer address and port | |
| natOrigAddr_Port | IP4_U16 | response origin address and port | |
| natRelayAddr_Port | IP4_U16 | relayed address and port | |
| natDstAddr_Port | IP4_U16 | destination address and port | |
| natOtherAddr_Port | IP4_U16 | other address and port | |
| natLifetime | U32 | binding lifetime (seconds) | |
| natUser | S | username | |
| natPass | S | password | |
| natRealm | S | realm | |
| natSoftware | S | software | |
| If NAT_PMP=1, the following columns are displayed: | | | |
| natPMPReqEA_MU_MT | U16_U16_U16 | NAT-PMP num. of requests (External Address, Map UDP, Map TCP) | |
| natPMPRespEA_MU_MT | U16_U16_U16 | NAT-PMP num. of responses (External Address, Map UDP, Map TCP) | |
| natPMPSSSOE | U32 | NAT-PMP seconds since start of epoch | |

### 59.2.1 natStat

The `natStat` column is to be interpreted as follows:

| natStat | Description |
|---|---|
| $2^0$ (=0x0000 0001) | STUN protocol |
| $2^1$ (=0x0000 0002) | TURN protocol |
| $2^2$ (=0x0000 0004) | ICE protocol |
| $2^3$ (=0x0000 0008) | SIP protocol |
| $2^4$ (=0x0000 0010) | Microsoft Extension |
| $2^5$ (=0x0000 0020) | Even Port |
| $2^6$ (=0x0000 0040) | Reserve next port |
| $2^7$ (=0x0000 0080) | Don't fragment |
| $2^8$ (=0x0000 0100) | Nonce |
| $2^{13}$ (=0x0000 2000) | Deprecated message attribute |
| $2^{14}$ (=0x0000 4000) | STUN over non-standard port |
| $2^{15}$ (=0x0000 8000) | malformed message |
| $2^{16}$ (=0x0001 0000) | Port Mapping Protocol (PMP) |
| $2^{31}$ (=0x8000 0000) | Packet snapped, analysis incomplete |

### 59.2.2 natErr

The hex based error variable `natErr` is defined as follows (STUN):

| natErr | Description |
|---|---|
| $2^0$ (=0x00000001) | Try alt |
| $2^1$ (=0x00000002) | Bad request |
| $2^2$ (=0x00000004) | Unauthorized |
| $2^3$ (=0x00000008) | Forbidden |
| $2^4$ (=0x00000010) | Unknown attribute |
| $2^5$ (=0x00000020) | Allocation mismatch |
| $2^6$ (=0x00000040) | Stale nonce |
| $2^7$ (=0x00000080) | Address family not supported |
| $2^8$ (=0x00000100) | Wrong credentials |
| $2^9$ (=0x00000200) | Unsupported transport protocol |
| $2^{10}$ (=0x00000400) | Peer address family mismatch |
| $2^{11}$ (=0x00000800) | Connection already exists |
| $2^{12}$ (=0x00001000) | Connection timeout or failure |

| natErr | | Description |
|---|---|---|
| $2^{13}$ | (=0x00002000) | Allocation quota reached |
| $2^{14}$ | (=0x00004000) | Role conflict |
| $2^{15}$ | (=0x00008000) | Server error |
| $2^{16}$ | (=0x00010000) | Insufficient capacity |
| $2^{31}$ | (=0x80000000) | Unhandled error |

The hex based error variable `natErr` is defined as follows (NAT-PMP):

| natErr | | Description |
|---|---|---|
| $2^{1}$ | (=0x00000002) | Unsupported version |
| $2^{2}$ | (=0x00000004) | Not authorized/refused |
| $2^{3}$ | (=0x00000008) | Network failure |
| $2^{4}$ | (=0x00000010) | Out of resources |
| $2^{5}$ | (=0x00000020) | Unsupported opcode |

### 59.2.3 natMCReq_Ind_Succ_Err

The number of messages variable `natMCReq_Ind_Succ_Err` decomposed as follows:

| natMCReq_Ind_Succ_Err | Description |
|---|---|
| natMCReq | number of requests |
| natMCInd | number of indications |
| natMCSucc | number of success response |
| natMCErr | number of error response |

## 59.3 Plugin Report Output

The following information is reported:

- Aggregated natStat
- Aggregated natErr
- Number of NAT-PMP packets
- Number of STUN packets

## 59.4 TODO

Port Control Protocol (PCP)

# 60 syslogDecode

## 60.1 Description

The syslogDecode plugin analyzes Syslog traffic.

## 60.2 Configuration Flags

The following flags can be used to control the output of the plugin:

| Name | Default | Description | Flags |
|---|---|---|---|
| SYSL_FSN | 0 | Format for Syslog severity/facility messages:<br>0: Numbers,<br>1: Names | |

## 60.3 Flow File Output

The syslogDecode plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| syslogStat | H8 | Status | |
| syslogMCnt | U32 | message count | |
| syslogSev_Fac_Cnt | RU8_U8_U32 | Number of severity/facility messages | |

### 60.3.1 syslogStat

The syslogStat column is to be interpreted as follows:

| syslogStat | Description |
|---|---|
| 0x01 | Syslog detected |
| 0x02 | — |
| 0x04 | — |
| 0x08 | — |
| 0x10 | — |
| 0x20 | — |
| 0x40 | — |
| 0x80 | Counter for facility/severity overflowed |

## 60.4 Packet File Output

In packet mode (-s option), the syslogDecode plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| syslogStat | H8 | Status | |
| syslogSev | U8/S | Severity | SYSL_FSN=0/1 |
| syslogFac | U8/S | Facility | SYSL_FSN=0/1 |

## 60.5 Plugin Report Output

The following information is reported:

- Aggregated syslogStat
- Number of Syslog packets
- Number of Syslog message types

## 60.6 TODO

- IPv6 tests

## 60.7 References

- https://tools.ietf.org/html/rfc5424

# 61 tcpFlags

## 61.1 Description

The tcpFlags plugin contains IP and TCP header information encountered during the lifetime of a flow.

## 61.2 Configuration Flags

The following flags can be used to control the output of the plugin:

| Name | Default | Description | Flags |
|---|---|---|---|
| IPTOS | 0 | IPv4 ToS / IPv6 Class representation:<br>0: IP ToS hex<br>1: DSCP_ECN decimal<br>2: Precedence(1-7)_ECN decimal | |
| RTT_ESTIMATE | 1 | Estimate Round trip time | |
| IPCHECKSUM | 2 | 0: No checksums calculation<br>1: Calculation of L3 (IP) header checksum<br>2: Calculation of L3 (IP) and L4 (TCP, UDP, . . . ) checksum | |
| WINDOWSIZE | 1 | Output TCP window size parameters | |
| WINMIN | 1 | Min. window size threshold defining a healthy communication<br>(only packets below the threshold are counted) | |
| SEQ_ACK_NUM | 1 | Output Sequence/Acknowledge number features | |
| FRAG_ANALYZE | 1 | Enable fragmentation analysis | |
| NAT_BT_EST | 1 | Estimate NAT boot time | |
| SCAN_DETECTOR | 1 | Enable scan flow detector | |
| MPTCP | 1 | Enable MPTCP dissection | |
| TCPJA4T | 1 | JA4 Output Syn/Syn-Ack | |
| JA4TOPTMX | 20 | Maximal options stored in flow | TCPJA4T=1 |
| SPKTMD_SEQACKREL | 0 | SEQ/ACK numbers representation (-s option):<br>0: absolute<br>1: relative | SEQ_ACK_NUM=1 |
| SPKTMD_SEQACKHEX | 0 | SEQ/ACK numbers representation (-s option):<br>0: uint32_t<br>1: hex32 | SEQ_ACK_NUM=1 |

### 61.2.1 WINMIN

WINMIN default 1 setting selects all packets/flow where communication came to a halt due to receiver buffer overflow. Literally the number of window size 0 packets to the sender are then counted. WINMIN can be set to any value defining a healthy communication, which depends on the network and application.

## 61.3 Flow File Output

The tcpFlags plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| tcpFStat | H16 | Status | |
| ipMindIPID | U16 | IP minimum delta IP ID | |
| ipMaxdIPID | U16 | IP maximum delta IP ID | |
| ipMinTTL | U8 | IP minimum TTL | |
| ipMaxTTL | U8 | IP maximum TTL | |
| ipTTLChg | U8 | IP TTL change count | |
| ipToS | H8 | IP Type of Service (ToS) | IPTOS=0 |
| ipToSDscp_ecn | U8_U8 | IP ToS: DSCP and ECN | IPTOS=1 |
| ipToSPrec_ecn | U8_U8 | IP ToS: Precedence and ECN | IPTOS=2 |
| ipFlags | H16 | IP aggregated flags | |
| ipOptCnt | U16 | IP options count | IPV6_ACTIVATE=0\|2 |
| ipOptCpCl_Num | H8_H32 | IP aggregated options, copy-class and number | IPV6_ACTIVATE=0\|2 |
| ip6OptCntHH_D | U16_U16 | IPv6 aggregated Hop-by-Hop dest. option counts | IPV6_ACTIVATE>0 |
| ip6OptHH_D | H32_H32 | IPv6 Hop-by-Hop destination options | IPV6_ACTIVATE>0 |
| tcpISeqN | U32 | TCP initial sequence number | SEQ_ACK_NUM=1 |
| tcpPSeqCnt | U16 | TCP packet sequence count | SEQ_ACK_NUM=1 |
| tcpSeqSntBytes | U64 | TCP sent seq diff bytes | SEQ_ACK_NUM=1 |
| tcpSeqFaultCnt | U16 | TCP sequence number fault count | SEQ_ACK_NUM=1 |
| tcpPAckCnt | U16 | TCP packet ACK count | SEQ_ACK_NUM=1 |
| tcpFlwLssAckRcvdBytes | U64 | TCP flawless ACK received bytes | SEQ_ACK_NUM=1 |
| tcpAckFaultCnt | U16 | TCP ACK number fault count | SEQ_ACK_NUM=1 |
| tcpBFlgtMx | U32 | TCP max bytes in flight | SEQ_ACK_NUM=1 |
| tcpInitWinSz | U32 | TCP initial effective window size | WINDOWSIZE=1 |
| tcpAveWinSz | F | TCP average effective window size | WINDOWSIZE=1 |
| tcpMinWinSz | U32 | TCP minimum effective window size | WINDOWSIZE=1 |
| tcpMaxWinSz | U32 | TCP maximum effective window size | WINDOWSIZE=1 |
| tcpWinSzDwnCnt | U16 | TCP effective window size change down count | WINDOWSIZE=1 |
| tcpWinSzUpCnt | U16 | TCP effective window size change up count | WINDOWSIZE=1 |
| tcpWinSzChgDirCnt | U16 | TCP effective window size direction change count | WINDOWSIZE=1 |
| tcpWinSzThRt | F | TCP packet count ratio below window size WINMIN | WINDOWSIZE=1 |
| tcpFlags | H16 | TCP aggregated protocol flags (FIN, SYN, RST, PSH, ACK, URG, ECE, CWR) | |
| tcpAnomaly | H16 | TCP aggregated header anomaly flags | |
| tcpInitWinSz_<br>tcpSSAOpts_<br>tcpMSS_<br>tcpWS | U32_<br>SC_<br>U16_<br>U16 | TCP JA4T client fingerprint | TCPJA4T=1 |
| tcpOptPktCnt | U16 | TCP options packet count | TCPJA4T=0 |
| tcpOptCnt | U16 | TCP options count | TCPJA4T=0 |

| Column | Type | Description | Flags |
|---|---|---|---|
| tcpOptions | H32 | TCP aggregated options | TCPJA4T=0 |
| tcpMSS | U16 | TCP maximum segment size | TCPJA4T=0 |
| tcpWS | U16 | TCP window scale factor | TCPJA4T=0 |
| tcpMPTBF | H16 | MPTCP type bitfield | MPTCP=1 |
| tcpMPF | H8 | MPTCP flags | MPTCP=1 |
| tcpMPAID | U8 | MPTCP address ID | MPTCP=1 |
| tcpMPDSSF | H8 | MPTCP DSS flags | MPTCP=1 |
| tcpTmS | U32 | TCP time stamp | NAT_BT_EST=1 |
| tcpTmER | U32 | TCP time echo reply | NAT_BT_EST=1 |
| tcpEcI | F | TCP estimated counter increment | NAT_BT_EST=1 |
| tcpUtm | D | TCP estimated up time | NAT_BT_EST=1 |
| tcpBtm | TS | TCP estimated boot time | NAT_BT_EST=1 |
| tcpSSASAATrip | F | (A) TCP trip time SYN, SYN-ACK,<br>(B) TCP trip time SYN-ACK, ACK | RTT_ESTIMATE=1 |
| tcpRTTAckTripMin | F | TCP ACK trip minimum | RTT_ESTIMATE=1 |
| tcpRTTAckTripMax | F | TCP ACK trip maximum | RTT_ESTIMATE=1 |
| tcpRTTAckTripAve | F | TCP ACK trip average | RTT_ESTIMATE=1 |
| tcpRTTAckTripJitAve | F | TCP ACK trip jitter average | RTT_ESTIMATE=1 |
| tcpRTTSseqAA | F | (A) TCP round trip time SYN, SYN-ACK, ACK<br>(B) TCP round trip time ACK-ACK | RTT_ESTIMATE=1<br>RTT_ESTIMATE=1 |
| tcpRTTAckJitAve | F | TCP ACK round trip average jitter | RTT_ESTIMATE=1 |

### 61.3.1 tcpFStat

The tcpFStat column is to be interpreted as follows:

| tcpFStat | Description |
|---|---|
| 0x0001 | Packet good for inter-distance assessment |
| 0x0002 | TCP option init |
| 0x0004 | Timestamp option decreasing |
| 0x0008 | L4 option field corrupt or not acquired |
| 0x0010 | Window state-machine initialized |
| 0x0020 | Window update |
| 0x0040 | Win 0 probe |
| 0x0080 | Win 0 probe ACK |
| 0x0100 | Min Window detected |
| 0x0200 | WS used |
| 0x0400 | Window Receiver full |
| 0x0800 | Window state-machine count up(1)/down(0) |

| tcpFStat | Description |
|---|---|
| 0x1000 | L4 Checksum calculation if present |
| 0x2000 | UDPLITE Checksum coverage error |
| 0x4000 | TCP Selective ACK Option |
| 0x8000 | MPTCP detected |

### 61.3.2 ipToS

The ipToS column is to be interpreted as follows:

| ipToS | Description |
|---|---|
| 0x01 | ECN0: enable ECN when requested by incoming connections, and also request ECN on outgoing connection attempts |
| 0x02 | ECN1: (default) enable ECN when requested by incoming connections, but do not request ECN on outgoing connections |
| 0x04 | Precedence 0 |
| 0x08 | Precedence 1 |
| 0x10 | Precedence 2 |
| 0x20 | Precedence 3: Class Sel 0 |
| 0x40 | Precedence 4: Class Sel 1 |
| 0x80 | Precedence 5: Class Sel 2 |

### 61.3.3 ipToS precedence description

The precedence in ipToS, Mode 0-2 is defined by the following table according to RFC 2474:

| DSCP | Hex Md 0 Values | Dec Md 1-2 Values | Precedence: Description |
|---|---|---|---|
| CS0 | 0x00 | 0 | Best Effort |
| LE | 0x01 | 1 | — |
| CS1 | 0x20,0x28,0x30,0x38 | 8, 10, 12, 14 | 1: Priority |
| CS2 | 0x40,0x48,0x50,0x58 | 16, 18, 20, 22 | 2: Immediate |
| CS3 | 0x60,0x68,0x70,0x78 | 24, 26, 28, 30 | 3: Flash - mainly used for voice signaling |
| CS4 | 0x80,0x88,0x90,0x98 | 32, 34, 36, 38 | 4: Flash Override |
| CS5 | 0xa0,0xb8 | 40, 46 | 5: Critical - mainly used for voice RTP |
| CS6 | 0xc0 | 48 | 6: Internetwork Control |
| CS7 | 0xe0 | 56 | 7: Network Control |

### 61.3.4 ipFlags

The `ipFlags` column is to be interpreted as follows:

| ipFlags | Description |
|---|---|
| 0x0001 | IP options corrupt |
| 0x0002 | IPv4 packets out of order |
| 0x0004 | IPv4 ID roll over |
| 0x0008 | IP fragment below minimum |
| 0x0010 | IP fragment out of range |
| 0x0020 | More Fragment bit |
| 0x0040 | IPv4: Don't Fragment bit<br>IPv6: reserve bit |
| 0x0080 | Reserve bit |

| ipFlags | Description |
|---|---|
| 0x0100 | Fragmentation position error |
| 0x0200 | Fragmentation sequence error |
| 0x0400 | L3 checksum error |
| 0x0800 | L4 checksum error |
| 0x1000 | Length in L3/4 header < actual L3/4 length |
| 0x2000 | Length in UDP/UDP-Lite header $\neq$ actual UDP/UDP-Lite length |
| 0x4000 | Packet inter-distance = 0 |
| 0x8000 | Packet inter-distance < 0 |

### 61.3.5 ipOptCpCl_Num

The aggregated IP options are coded as a bit field in hexadecimal notation where the bit position denotes the IP options type according to following format: [$2^{\text{Copy-Class}}$]_[$2^{\text{Number}}$]. If the field reads: `0x10_0x00100000` in an ICMP message it is a `0x94 = 148` router alert.
Refer to RFC for decoding the bitfield: http://www.iana.org/assignments/ip-parameters.

### 61.3.6 tcpFlags

The `tcpFlags` column is to be interpreted as follows:

| | tcpFlags | Description |
|---|---|---|
| $2^0$ | (=0x0001) | FIN: No more data, finish connection |
| $2^1$ | (=0x0002) | SYN: Synchronize sequence numbers |
| $2^2$ | (=0x0004) | RST: Reset connection |
| $2^3$ | (=0x0008) | PSH: Push data |
| $2^4$ | (=0x0010) | ACK: Acknowledgement field value valid |
| $2^5$ | (=0x0020) | URG: Urgent pointer valid |
| $2^6$ | (=0x0040) | ECE: ECN-Echo |
| $2^7$ | (=0x0080) | CWR: Congestion Window Reduced flag is set |
| $2^8$ | (=0x0100) | FIN_ACK: Acknowledgment of FIN |
| $2^9$ | (=0x0200) | SYN_ACK: Acknowledgment of SYN |
| $2^{10}$ | (=0x0400) | RST_ACK: Acknowledgment of RST |
| $2^{11}$ | (=0x0800) | Potential NULL scan packet or malicious channel |
| $2^{12}$ | (=0x1000) | SYN-FIN flag: potential scan packet or malicious packet |
| $2^{13}$ | (=0x2000) | SYN-FIN-RST flag: potential scan packet or malicious channel |
| $2^{14}$ | (=0x4000) | FIN-RST flag: abnormal flow termination |

| | tcpFlags | Description |
|---|---|---|
| $2^{15}$ | (=0x8000) | Potential Xmas scan packet or malicious channel |

### 61.3.7 tcpAnomaly

The `tcpAnomaly` column is to be interpreted as follows:

| tcpAnomaly | Description |
|---|---|
| 0x0001 | SYN retransmission |
| 0x0002 | SEQ retransmission |
| 0x0004 | SEQ fast retransmission |
| 0x0008 | Duplicate ACK |
| 0x0010 | TCP Keep-Alive |
| 0x0020 | TCP Keep-Alive ACK |
| 0x0040 | Sequence number out-of-order |
| 0x0080 | Sequence mess in flow order due to pcap packet loss |
| 0x0100 | ACK for unseen packet |
| 0x0200 | Previous packet not captured |
| 0x0100 | - |
| 0x0200 | - |
| 0x1000 | Scan detected in flow |
| 0x2000 | Successful Scan detected in flow |
| 0x4000 | SYN flag with L7 content |
| 0x8000 | - |

### 61.3.8 tcpOptions

The `tcpOptions` column is to be interpreted as follows:

| tcpOptions | | Description |
|---|---|---|
| $2^0$ | (=0x00000001) | End of Option List |
| $2^1$ | (=0x00000002) | No-Operation |
| $2^2$ | (=0x00000004) | Maximum Segment Size |
| $2^3$ | (=0x00000008) | Window Scale |
| $2^4$ | (=0x00000010) | SACK Permitted |
| $2^5$ | (=0x00000020) | SACK |
| $2^6$ | (=0x00000040) | Echo (obsoleted by option 8) |
| $2^7$ | (=0x00000080) | Echo Reply (obsoleted by option 8) |
| $2^8$ | (=0x00000100) | Timestamps |
| $2^9$ | (=0x00000200) | Partial Order Connection Permitted (obsolete) |
| $2^{10}$ | (=0x00000400) | Partial Order Service Profile (obsolete) |
| $2^{11}$ | (=0x00000800) | CC (obsolete) |
| $2^{12}$ | (=0x00001000) | CC.NEW (obsolete) |

| tcpOptions | | Description |
|---|---|---|
| $2^{13}$ | (=0x00002000) | CC.ECHO (obsolete) |
| $2^{14}$ | (=0x00004000) | TCP Alternate Checksum Request (obsolete) |
| $2^{15}$ | (=0x00008000) | TCP Alternate Checksum Data (obsolete) |
| $2^{16}$ | (=0x00010000) | Skeeter |
| $2^{17}$ | (=0x00020000) | Bubba |
| $2^{18}$ | (=0x00040000) | Trailer Checksum Option |
| $2^{19}$ | (=0x00080000) | MD5 Signature Option (obsoleted by option 29) |
| $2^{20}$ | (=0x00100000) | SCPS Capabilities |
| $2^{21}$ | (=0x00200000) | Selective Negative Acknowledgements |
| $2^{22}$ | (=0x00400000) | Record Boundaries |
| $2^{23}$ | (=0x00800000) | Corruption experienced |
| $2^{24}$ | (=0x01000000) | SNAP |
| $2^{25}$ | (=0x02000000) | Unassigned (released 2000-12-18) |
| $2^{26}$ | (=0x04000000) | TCP Compression Filter |
| $2^{27}$ | (=0x08000000) | Quick-Start Response |
| $2^{28}$ | (=0x10000000) | User Timeout Option (also, other known unauthorized use) |
| $2^{29}$ | (=0x20000000) | TCP Authentication Option (TCP-AO) |
| $2^{30}$ | (=0x40000000) | Multipath TCP (MPTCP) |
| $2^{31}$ | (=0x80000000) | all options > 31 |

### 61.3.9 tcpMPTBF

The `tcpMPTBF` column is to be interpreted as follows:

| tcpMPTBF | | Description |
|---|---|---|
| $2^0$ | (=0x0001) | TCP_MP_CAPABLE |
| $2^1$ | (=0x0002) | TCP_MP_JOIN |
| $2^2$ | (=0x0004) | TCP_MP_DSS |
| $2^3$ | (=0x0008) | TCP_MP_ADD_ADDR |
| $2^4$ | (=0x0010) | TCP_MP_REM_ADDR |
| $2^5$ | (=0x0020) | TCP_MP_PRIO |
| $2^6$ | (=0x0040) | TCP_MP_FAIL |
| $2^7$ | (=0x0080) | TCP_MP_FSTCLS |
| $2^{15}$ | (=0x8000) | TCP_MP_PRIV |

## 61.4 Packet File Output

In packet mode (`-s` option), the tcpFlags plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| ipToS | H8 | IP Type of Service (ToS) | IPTOS=0 |
| ipToSDcsp_ecn | U8_U8 | IP ToS: Precedence and ECN | IPTOS=1 |
| ipToSPrec_ecn | H8 | IP ToS: DSCP and ECN | IPTOS=2 |
| ipID | U16 | IP ID | |
| ipIDDiff | I32 | IP ID diff | |
| ipFrag | H16 | IP fragment | |
| ipTTL | U8 | IP TTL | |
| ipHdrChkSum | H16 | IP header checksum | |
| ipCalChkSum | H16 | IP header computed checksum | |
| l4HdrChkSum | H16 | Layer 4 header checksum | |
| l4CalChkSum | H16 | Layer 4 header computed checksum | |
| ipFlags | H16 | IP flags | |
| ip6HHOptLen | I16 | IPv6 Hop-by-Hop options length | IPV6_ACTIVATE>0 |
| ip6HHOpts | R(H8) | IPv6 Hop-by-Hop options | IPV6_ACTIVATE>0 |
| ip6DOptLen | I16 | IPv6 Destination options length | IPV6_ACTIVATE>0 |
| ip6DOpts | R(H8) | IPv6 Destination options | IPV6_ACTIVATE>0 |
| ipOptLen | I16 | IPv4 options length | IPV6_ACTIVATE=0\|2 |
| ipOpts | R(H8) | IPv4 options | IPV6_ACTIVATE=0\|2 |
| seq | U32/H32 | Sequence number | SEQ_ACK_NUM=1 |
| ack | U32/H32 | Acknowledgement number | SEQ_ACK_NUM=1 |
| seqMax | U32/H32 | Sequence number max | SEQ_ACK_NUM=1 |
| seqDiff | I32 | Sequence number diff | SEQ_ACK_NUM=1 |
| ackDiff | I32 | Acknowledgement number diff | SEQ_ACK_NUM=1 |
| seqLen | U32 | Sequence length | SEQ_ACK_NUM=1 |
| ackLen | U32 | Acknowledgement length | SEQ_ACK_NUM=1 |
| seqFlowLen | I64 | Sequence flow length | SEQ_ACK_NUM=1 |
| ackFlowLen | I64 | Acknowledgement flow length | SEQ_ACK_NUM=1 |
| tcpMLen | I64 | Aggregated valid bytes transmitted so far | SEQ_ACK_NUM=1 |
| tcpBFlgt | U32 | Number of bytes in flight (not acknowledge) | SEQ_ACK_NUM=1 |
| tcpFStat | H16 | TCP aggregated protocol flags + combinations (CWR, ACK, PSH, RST, SYN, FIN, ...) | |
| tcpFlags | H16 | Flags | |
| tcpAnomaly | H16 | TCP aggregated header anomaly flags | |
| tcpWin | U32 | TCP window size | |
| tcpWS | U16 | TCP window scale factor | |
| tcpMSS | U16 | TCP maximum segment size | |
| tcpTmS | U32 | TCP time stamp | NAT_BT_EST=1 |
| tcpTmER | U32 | TCP time echo reply | NAT_BT_EST=1 |
| tcpMPTyp | U16 | MPTCP type | MPTCP=1 |
| tcpMPF | H8 | MPTCP flags | MPTCP=1 |
| tcpMPAID | U8 | MPTCP address ID | MPTCP=1 |
| tcpMPdssF | H8 | MPTCP DSS flags | MPTCP=1 |
| tcpOptLen | I32 | TCP options length | |
| tcpOpts | R(H8) | TCP options | |

## 61.5 Monitoring Output

In monitoring mode, the tcpFlags plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| tcpScan | U64 | Number of TCP scans attempted | |
| tcpSuccScan | U64 | Number of TCP scans successful | |
| tcpSynRetries | U64 | Number of TCP SYN retries | |
| tcpSeqRetries | U64 | Number of TCP seq retries | |

## 61.6 Plugin Report Output

The following information is reported:

- Aggregated ipFlags
- Aggregated tcpFlags
- Aggregated tcpAnomaly
- Aggregated ipToS
- Number of TCP scans attempted, successful
- Number of TCP SYN retries, seq retries
- Number of WinSz below WINMIN

## 61.7 References

- http://www.iana.org/assignments/ip-parameters
- http://www.iana.org/assignments/tcp-parameters/tcp-parameters.xml

# 62 tcpStates

## 62.1 Description

The tcpStates plugin tracks the actual state of a TCP connection, by analyzing the flags set in the packet header. The plugin recognizes and reports non-compliant behavior.

## 62.2 Configuration Flags

None.

## 62.3 Flow File Output

The tcpStates plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| tcpStatesAFlags | H8 | TCP state machine anomalies | |

### 62.3.1 tcpStatesAFlags

The tcpStatesAFlags column is to be interpreted as follows:

| tcpStatesAFlags | Description |
|---|---|
| 0x01 | Malformed connection establishment |
| 0x02 | Malformed teardown |
| 0x04 | Malformed flags during established connection |
| 0x08 | Packets detected after teardown |
| 0x10 | Packets detected after reset |
| 0x20 | — |
| 0x40 | Reset from sender |
| 0x80 | Potential evil behavior (scan) |

### 62.3.2 Flow Timeouts

The tcpStates plugin also changes the timeout values of a flow according to its recognized state:

| State | Description | Timeout (seconds) |
|---|---|---|
| New | Three way handshake is encountered | 120 |
| Established | Connection established | 610 |
| Closing | Hosts are about to close the connection | 120 |
| Closed | Connection closed | 10 |
| Reset | Connection reset encountered by one of hosts | 0.1 |

### 62.3.3 Differences to the Host TCP State Machines

The plugin state machine (Figure 7) and the state machines usually implemented in hosts differ in some cases. Major differences are caused by the benevolence of the plugin. For example, if a connection has not been established in a correct way, the plugin treats the connection as established, but sets the *malformed connection establishment* flag. The reasons for this benevolence are the following:

- A flow might have been started before invocation of Tranalyzer2.
- A flow did not finish before Tranalyzer2 terminated.
- Tranalyzer2 did not detect every packet of a connection, for example due to a router misconfiguration.
- Flows from malicious programs may show suspicious behavior.
- Packets may be lost **after** being captured by Tranalyzer2 but **before** they reached the opposite host.

## 62.4 Packet File Output

In packet mode (`-s` option), the tcpStates plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| tcpStatesAFlags | H8 | TCP state machine anomalies | |

## 62.5 Plugin Report Output

The aggregated tcpStatesAFlags anomalies is reported.

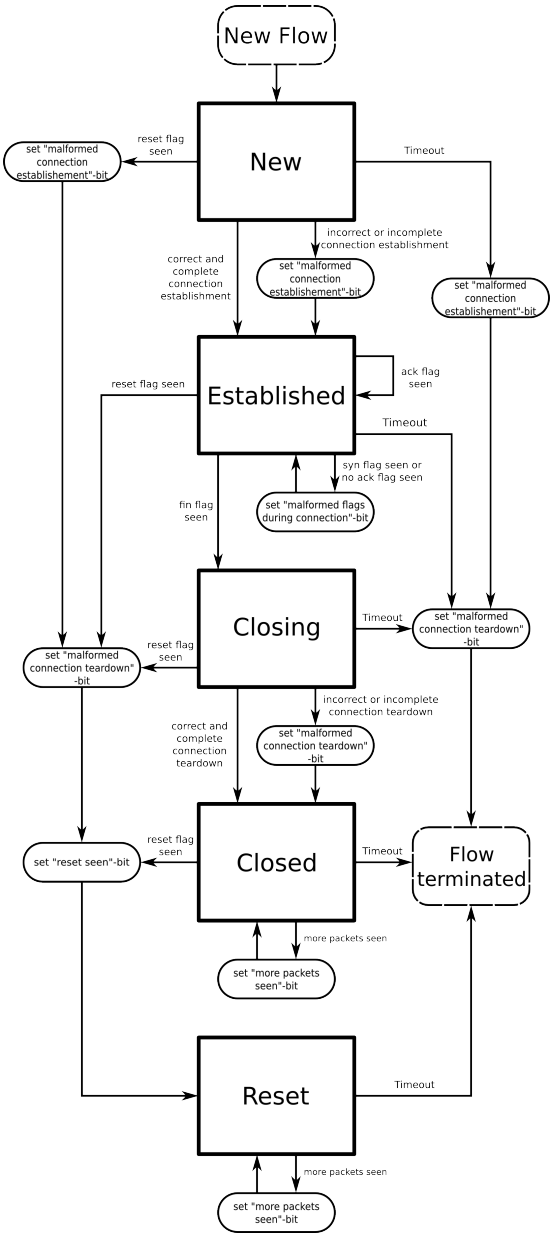



**Figure 7:** *State machine of the tcpState plugin*

# 63 telnetDecode

## 63.1 Description

The telnetDecode plugin analyzes TELNET traffic and is capable to extract L7 content.

## 63.2 Configuration Flags

The following flags can be used to control the output of the plugin:

| Name | Default | Description | Flags |
|---|---|---|---|
| TEL_SAVE | 0 | Save content to TEL_F_PATH | |
| TEL_RMDIR | 1 | Empty TEL_F_PATH before starting | TEL_SAVE=1 |
| TEL_SAVE_SPLIT | 1 | Save requests (A) and responses (B) | TEL_SAVE=1 |
| TEL_SEQPOS | 0 | 0: no file position control,<br>1: seq number file position control | TEL_SAVE=1 |
| TEL_CMDOPTS | 1 | 0: Output command/options,<br>1: Output command/options names | |
| TEL_CMD_AGGR | 1 | Aggregate commands | |
| TEL_OPT_AGGR | 1 | Aggregate options | |
| TELCMDN | 25 | Maximal command / flow | |
| TELUPLN | 25 | Maximal length user/password | |
| TELOPTN | 25 | Maximal options / flow | |
| TEL_F_PATH | "/tmp/TELFILES/" | Path for extracted content | |

### 63.2.1 Environment Variable Configuration Flags

The following configuration flags can also be configured with environment variables (ENVCNTRL>0):

- TEL_RMDIR
- TEL_F_PATH

## 63.3 Flow File Output

The telnetDecode plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| telStat | H8 | Status | |
| telCmdBF | H16 | Commands | TEL_BTFLD=1 |
| telOptBF | H32 | Options | TEL_BTFLD=1 |
| telUsr | SC | Username | |
| telPW | SC | Password | |
| telTCCnt | U16 | Total command count | |
| telTOCnt | U16 | Total option count | |
| telCCnt | U16 | Stored command count | |
| telCmdC | R(U8) | Command codes | TEL_CMDOPTS=0 |

| Column | Type | Description | Flags |
|---|---|---|---|
| telCmdS | R(S) | Command names | TEL_CMDOPTS=1 |
| telOCnt | U16 | Stored options count | |
| telOptC | R(U8) | Option codes | TEL_CMDOPTS=0 |
| telOptS | R(S) | Option names | TEL_CMDOPTS=1 |

### 63.3.1 telStat

The telStat column is to be interpreted as follows:

| | telStat | Description | Flags |
|---|---|---|---|
| $2^0$ | (=0x01) | TELNET port found | |
| $2^1$ | (=0x02) | — | |
| $2^2$ | (=0x04) | Successful username found | |
| $2^3$ | (=0x08) | Successful password found | |
| $2^4$ | (=0x10) | — | |
| $2^5$ | (=0x20) | File open error | TEL_SAVE=1 |
| $2^6$ | (=0x40) | Command array overflow... increase TELCMDN | |
| $2^7$ | (=0x80) | Options array overflow... increase TELOPTN | |

### 63.3.2 telCmdBF

The telCmdBF column is to be interpreted as follows:

| | telCmdBF | Description |
|---|---|---|
| $2^0$ | (=0x0001) | SE - End subNeg |
| $2^1$ | (=0x0002) | NOP - No operation |
| $2^2$ | (=0x0004) | Data Mark |
| $2^3$ | (=0x0008) | Break |
| $2^4$ | (=0x0010) | Int process |
| $2^5$ | (=0x0020) | Abort output |
| $2^6$ | (=0x0040) | Are You There? |
| $2^7$ | (=0x0080) | Erase char |

| | telCmdBF | Description |
|---|---|---|
| $2^8$ | (=0x0100) | Erase line |
| $2^9$ | (=0x0200) | Go ahead! |
| $2^{10}$ | (=0x0400) | SB - SubNeg |
| $2^{11}$ | (=0x0800) | WILL use |
| $2^{12}$ | (=0x1000) | WON'T use |
| $2^{13}$ | (=0x2000) | DO use |
| $2^{14}$ | (=0x4000) | DON'T use |
| $2^{15}$ | (=0x8000) | IAC |

### 63.3.3 telOptBF

The `telOptBF` column is to be interpreted as follows:

| telOptBF | | Description |
|---|---|---|
| $2^0$ | (=0x00000001) | Bin Xmit |
| $2^1$ | (=0x00000002) | Echo Data |
| $2^2$ | (=0x00000004) | Reconn |
| $2^3$ | (=0x00000008) | Suppr GA |
| $2^4$ | (=0x00000010) | Msg Sz |
| $2^5$ | (=0x00000020) | Opt Stat |
| $2^6$ | (=0x00000040) | Timing Mark |
| $2^7$ | (=0x00000080) | R/C XmtEcho |
| $2^8$ | (=0x00000100) | Line Width |
| $2^9$ | (=0x00000200) | Page Length |
| $2^{10}$ | (=0x00000400) | CR Use |
| $2^{11}$ | (=0x00000800) | Horiz Tabs |
| $2^{12}$ | (=0x00001000) | Hor Tab Use |
| $2^{13}$ | (=0x00002000) | FF Use |
| $2^{14}$ | (=0x00004000) | Vert Tabs |
| $2^{15}$ | (=0x00008000) | Ver Tab Use |

| telOptBF | | Description |
|---|---|---|
| $2^{16}$ | (=0x00010000) | Lf Use |
| $2^{17}$ | (=0x00020000) | Ext ASCII |
| $2^{18}$ | (=0x00040000) | Logout |
| $2^{19}$ | (=0x00080000) | Byte Macro |
| $2^{20}$ | (=0x00100000) | Data Term |
| $2^{21}$ | (=0x00200000) | SUPDUP |
| $2^{22}$ | (=0x00400000) | SUPDUP Outp |
| $2^{23}$ | (=0x00800000) | Send Locate |
| $2^{24}$ | (=0x01000000) | Term Type |
| $2^{25}$ | (=0x02000000) | End Record |
| $2^{26}$ | (=0x04000000) | TACACS ID |
| $2^{27}$ | (=0x08000000) | Output Mark |
| $2^{28}$ | (=0x10000000) | Term Loc |
| $2^{29}$ | (=0x20000000) | 3270 Regime |
| $2^{30}$ | (=0x40000000) | X.3 PAD |
| $2^{31}$ | (=0x80000000) | Window Size |

### 63.3.4 telCmdC and telCmdS

The `telCmdC` and `telCmdS` columns are to be interpreted as follows:

| telCmdC | telCmdS | Description |
|---|---|---|
| 0xf0 | SE | End of subnegotiation parameters |
| 0xf1 | NOP | No Operation |
| 0xf2 | DM | Data Mark |
| 0xf3 | BRK | Break |
| 0xf4 | IP | Interrupt Process |
| 0xf5 | AO | Abort Output |
| 0xf6 | AYT | Are You There |
| 0xf7 | EC | Erase Character |
| 0xf8 | EL | Erase Line |
| 0xf9 | GA | Go Ahead |
| 0xfa | SB | Subnegotiation |
| 0xfb | WILL | Will Perform |
| 0xfc | WONT | Won't Perform |
| 0xfd | DO | Do Perform |
| 0xfe | DONT | Don't Perform |

| telCmdC | telCmdS | Description |
|---|---|---|
| 0xff | IAC | Interpret As Command |

### 63.3.5 telOptC and telOptS

The telOptC and telOptS columns are to be interpreted as follows:

| telOptC | telOptS | Description |
|---|---|---|
| 0xf0 | SE | End of subnegotiation parameters |
| 0xf1 | NOP | No Operation |
| 0xf2 | DM | Data Mark |
| 0xf3 | BRK | Break |
| 0xf4 | IP | Interrupt Process |
| 0xf5 | AO | Abort Output |
| 0xf6 | AYT | Are You There |
| 0xf7 | EC | Erase Character |
| 0xf8 | EL | Erase Line |
| 0xf9 | GA | Go Ahead |
| 0xfa | SB | Subnegotiation |
| 0xfb | WILL | Will Perform |
| 0xfc | WONT | Won't Perform |
| 0xfd | DO | Do Perform |
| 0xfe | DONT | Don't Perform |
| 0xff | IAC | Interpret As Command |

## 63.4 Packet File Output

In packet mode (-s option), the telnetDecode plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| telStat | H8 | Status | |
| telCmdC | U8 | Last command code | TEL_CMDOPTS=0 |
| telCmdS | S | Last command name | TEL_CMDOPTS=1 |
| telOptC | U8 | Last option code | TEL_CMDOPTS=0 |
| telOptS | S | Last option name | TEL_CMDOPTS=1 |

## 63.5 Plugin Report Output

The following information is reported:

- Aggregated telStat
- Number of Telnet packets
- Number of files extracted (TEL_SAVE=1)

## 63.6 TODO

- fragmentation

# 64 tftpDecode

## 64.1 Description

The tftpDecode plugin analyzes TFTP traffic. User defined compiler switches are in *tftpDecode.h*.

## 64.2 Configuration Flags

The following flags can be used to control the output of the plugin:

| Name | Default | Description | Flags |
|---|---|---|---|
| TFTP_SAVE | 0 | Save content to TFTP_F_PATH | |
| TFTP_RMDIR | 1 | Empty TFTP_F_PATH before starting | TFTP_SAVE=1 |
| TFTP_CMD_AGGR | 1 | Aggregate TFTP commands/errors | |
| TFTP_BTFLD | 1 | Bitfield coding of TFTP commands | |
| TFTP_MXNMLN | 15 | Maximal name length | |
| TFTP_MAXCNM | 2 | Maximal length of command field | |
| TFTP_F_PATH | "/tmp/TFTPFILES/" | Path for extracted content | |

### 64.2.1 Environment Variable Configuration Flags

The following configuration flags can also be configured with environment variables (ENVCNTRL>0):

- TFTP_RMDIR
- TFTP_F_PATH

## 64.3 Flow File Output

The tftpDecode plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| tftpStat | H16 | Status | |
| tftpPFlow | U64 | Parent flow | |
| tftpOpCBF | H8 | Opcode bitfield | TFTP_BITFIELD=1 |
| tftpErrCBF | H8 | Error code bitfield | TFTP_BITFIELD=1 |
| tftpNumOpcode | U8 | Number of opcodes | |
| tftpOpcode | RSC | Opcodes | TFTP_MAXCNM>0 |
| tftpNumParam | U8 | Number of parameters | |
| tftpParam | RS | Parameters | TFTP_MAXCNM>0 |
| tftpNumError | U8 | Number of errors | |
| tftpErrC | RU16 | Error codes | TFTP_MAXCNM>0 |

### 64.3.1 tftpStat

The tftpStat column is to be interpreted as follows:

| | tftpStat | Description | Flags |
|---|---|---|---|
| $2^0$ | (=0x0001) | TFTP flow found | |
| $2^1$ | (=0x0002) | TFTP data read | |
| $2^2$ | (=0x0004) | TFTP data write | |
| $2^3$ | (=0x0008) | File open error | TFTP_SAVE=1 |
| $2^4$ | (=0x0010) | Error in block send sequence | |
| $2^5$ | (=0x0020) | Error in block ack sequence | |
| $2^6$ | (=0x0040) | Error or TFTP protocol error or not TFTP | |
| $2^7$ | (=0x0080) | Array overflow... increase TFTP_MAXCNM | |
| $2^8$ | (=0x0100) | String truncated... increase TFTP_MXNMLN | |
| $2^9$ | (=0x0200) | — | |
| $2^{10}$ | (=0x0400) | — | |
| $2^{11}$ | (=0x0800) | Crafted packet or TFTP read/write parameter length error | |
| $2^{12}$ | (=0x1000) | TFTP active | |
| $2^{13}$ | (=0x2000) | TFTP passive | |
| $2^{14}$ | (=0x4000) | — | |
| $2^{15}$ | (=0x8000) | — | |

### 64.3.2 tftpOpcode and tftpOpCBF

The tftpOpCBF column is to be interpreted as follows:

| tftpOpCBF | tftpOpcode | Description |
|---|---|---|
| $2^0$ (=0x01) | RRQ | Read request |
| $2^1$ (=0x02) | WRQ | Write request |
| $2^2$ (=0x04) | DTA | Read or write the next block of data |
| $2^3$ (=0x08) | ACK | Acknowledgment |
| $2^4$ (=0x10) | ERR | Error message |
| $2^5$ (=0x20) | OAK | Option acknowledgment |
| $2^6$ (=0x40) | --- | — |
| $2^7$ (=0x80) | --- | — |

### 64.3.3 tftpErrC and tftpErrCBF

The tftpErrCBF column is to be interpreted as follows:

| tftpErrC | tftpErrCBF | Description |
|---|---|---|
| | 0x00 | No Error |
| 0 | 0x01 | File not found |
| 1 | 0x02 | Access violation |
| 2 | 0x04 | Disk full or allocation exceeded |
| 3 | 0x08 | Illegal TFTP operation |

| tftpErrC | tftpErrCBF | Description |
|---|---|---|
| 4 | 0x10 | Unknown transfer ID |
| 5 | 0x20 | File already exists |
| 6 | 0x40 | No such user |
| 7 | 0x80 | Terminate transfer due to option negotiation |

## 64.4 Packet File Output

In packet mode (`-s` option), the tftpDecode plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| tftpOpcode | SC | TFTP opcode | |

## 64.5 Plugin Report Output

The following information is reported:

- Aggregated tftpStat
- Number of TFTP packets
- Number of files extracted (`TFTP_SAVE=1`)

# 65 torDetector

## 65.1 Description

This plugin detects Tor flows.

## 65.2 Dependencies

This plugin requires the **libssl**.

| | | |
|---|---|---|
| **Ubuntu:** | `sudo apt-get install` | `libssl-dev` |
| **Arch:** | `sudo pacman -S` | `openssl` |
| **openSUSE:** | `sudo zypper install` | `libopenssl-devel` |
| **Red Hat/Fedora**[42]**:** | `sudo dnf install` | `openssl-devel` |
| **macOS**[43]**:** | `brew install` | `openssl@1.1` |

## 65.3 Configuration Flags

| Name | Default | Description |
|---|---|---|
| `TOR_DETECT_OBFUSCATION` | 1 | Detect obfuscation protocols |
| `TOR_DEBUG_MESSAGES` | 0 | Activate debug output |
| `TOR_PKTL` | 1 | Activate packet length modulo 8 heuristic |

The obfuscation detection method has a pretty high rate of false positives when only one direction of the traffic is captured. It should therefore be disabled (or low confidence should be given to the resulting output) when analyzing Tor traffic which was only captured in one direction.

## 65.4 Flow File Output

The torDetector plugin outputs the following columns:

| Column | Type | Description |
|---|---|---|
| `torStat` | H8 | Tor status |

### 65.4.1 torStat

The `torStat` column is to be interpreted as follows:

[42] If the `dnf` command could not be found, try with `yum` instead
[43] Brew is a packet manager for macOS that can be found here: `https://brew.sh`

| torStat | Description |
|---|---|
| 0x01 | Tor flow |
| 0x02 | Obfuscated Tor flow (TOR_DETECT_OBFUSCATION=1) |
| 0x04 | Tor address detected |
| 0x08 | Tor pktlen modulo 8 detected |
| 0x10 | Internal state: SYN detected |
| 0x20 | Internal state: obfuscation checked |
| 0x40 | — |
| 0x80 | Packet snapped or decoding failed |

## 65.5 Packet File Output

In packet mode (-s option), the torDetector plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| torStat | H8 | Status | |

## 65.6 Plugin Report Output

The following information is reported:

- Aggregated torStat
- Number of Tor packets

## 65.7 Plugin Detection Method

This subsection briefly present the detection methods used by this plugin. Tor version 0.2.7.6 and 0.4.5.10 were used to test these detection methods, they might become invalid in the future.

### 65.7.1 TLS Certificate

On older versions of the Tor client (< 0.2.9.15) the TLS certificate can be extracted from the traffic. The following conditions are used to determine if it belongs to a Tor flow:

**Size of the certificate** Tor certificates are very minimalist and are always smaller than 500 bytes.

**Public key algorithm** Currently Tor uses RSA-1024 certificates. Proposal 220, https://gitweb.torproject.org/torspec.git/plain/proposals/220-ecc-id-keys.txt, defines how to support Ed25519 in addition to RSA-1024. This proposal was implemented in Tor 0.2.7.5 according to the changelog: https://gitweb.torproject.org/tor.git/tree/ReleaseNotes?h=release-0.2.8#n96. However tests with Tor 0.2.7.6 (client and entry node) showed that RSA-1024 was still used for the TLS link key.

**Validity period**

**before 0.2.4.11** Tor certificate are always valid for exactly one year (60*60*24*365 seconds).

**0.2.4.11 and after** In March 2013, Tor changed the way it generates the validity period in certificates. Certificates are valid for a random period of time but validity periods always start at exactly midnight.

**Certificate issuer** The certificate issuer is only defined by its common name (no organization, country, ...). This common name has the following format: `www.RAND.com` where `RAND` is between 8 and 20 (inclusive) base32 characters. If Tor is compiled with the `DISABLE_V3_LINKPROTO_SERVERSIDE` flag, the common name ends in `.net` instead of `.com`

**Certificate subject** The certificate subject is only defined by its common name (no organization, country, ...). This common name has the following format: `www.RAND.net` where `RAND` is between 8 and 20 (inclusive) base32 characters.

### 65.7.2 TLS Client Hello

Recent version of the Tor client (>= 0.2.9.15) use TLS 1.3 which encrypts the certificate. On these versions, only the TLS handshake Client Hello and Server Hello can be used.

**Cipher list** The `TLS_EMPTY_RENEGOTIATION_INFO_SCSV` is always the last element in the supported cipher list sent by Tor. Recent versions of Firefox and Chrome do not send this cipher.

**TLS extensions** The `renegotiation_info`, the `Application-Layer Protocol Negotiation (ALPN)` and the `Next Protocol Negotiation (NPN)` extensions are never present in Tor Client Hello messages. These extensions are almost always present in modern browsers.

**Server name extension** The `server_name` extension contains a hostname with the following format: `www.RAND.com` where `RAND` is between 4 and 25 (inclusive) base32 characters.

### 65.7.3 TLS Server Hello

The following fields are checked in the Server Hello to differentiate Tor from other TLS traffic:

**TLS extensions** The `Application-Layer Protocol Negotiation (ALPN)` and the `Next Protocol Negotiation (NPN)` extensions are never present in Tor Server Hello messages. These extensions are sometimes present in traffic sent by web servers.

### 65.7.4 Obfuscation detection

Different pluggable transport protocols can be used to obfuscate the Tor traffic between a client and a bridge. For more info: https://www.torproject.org/docs/pluggable-transports.html.en.

This plugin tries to detect the **obfs3** and **obfs4** obfuscation methods. The goal of these obfuscation methods is to make the traffic look completely random from the first byte (including the (EC) Diffie-Hellman key exchange). This characteristic is used to detect flows with high entropy in their first packets. Indeed, most encrypted protocols (TLS or SSH for instance) start with an unencrypted handshake phase.

## 65.8 Other Detection Methods

This subsection describes other possible detection methods not implemented in this plugin.

### 65.8.1 Relay blacklist

The list of all relays can be queried from the Tor directory. This list contain the relay IP address and OR port. Tor flows can easily be identified by comparing their IP addresses and ports against this list. A CSV list can be downloaded from https://torstatus.blutmagie.de/.

The disadvantages of this method are:

- It will not detect Bridge relays (https://www.torproject.org/docs/bridges) because it is not possible to query a list of Bridges from the Tor directory. Bridges addresses can only be retrieved three at a time from https://bridges.torproject.org/ unless the bridge was specifically configured to not publish its descriptor.
- As this list is constantly changing, we need to regularly fetch it and keep all possible versions to use the version with the date closest to the analyzed PCAP.

The advantage of this method is:

- The traffic payload is not necessary, this method only needs the flow ports and IP addresses.

### 65.8.2 Packet size distribution

Tor always pack data in cells of 512 bytes. This means that when a client or a relay only has a few bytes to transmit, a packet with a size a bit superior to 512 bytes (because of TLS overhead) will be sent. This results in a peak in the packet size distribution around 550 bytes (543 bytes in the tests done with Tor version 0.2.7.6) and very few packets with smaller sizes. Figures 8 and 9 show the difference in the packet size distribution between HTTPS traffic and Tor traffic.

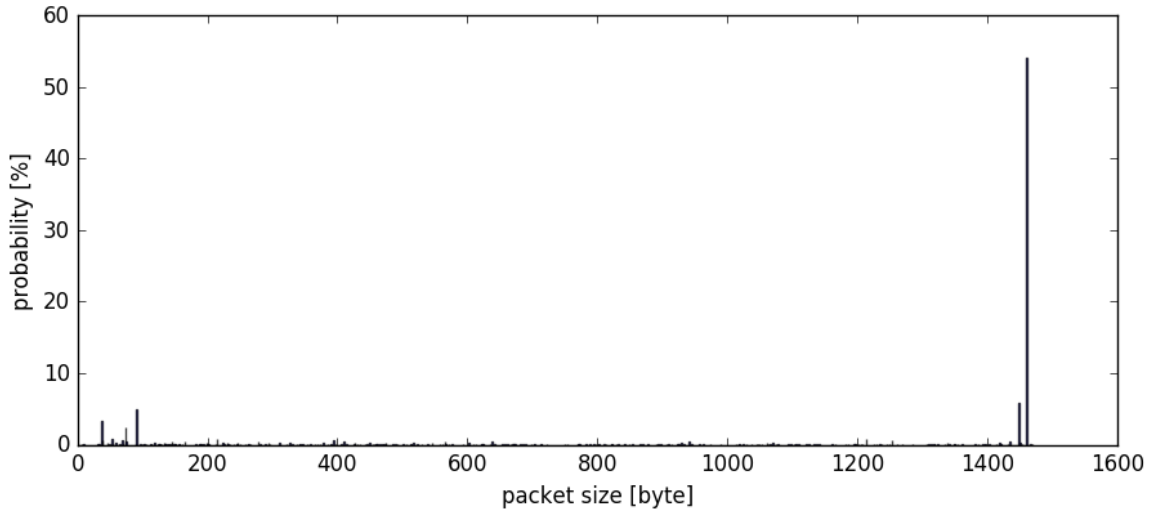



**Figure 8:** *Packet size distribution of HTTPS traffic.*

The disadvantage of this method is:

- False positives and negatives are way more frequent than with certificate analysis.

The advantage of this method is:

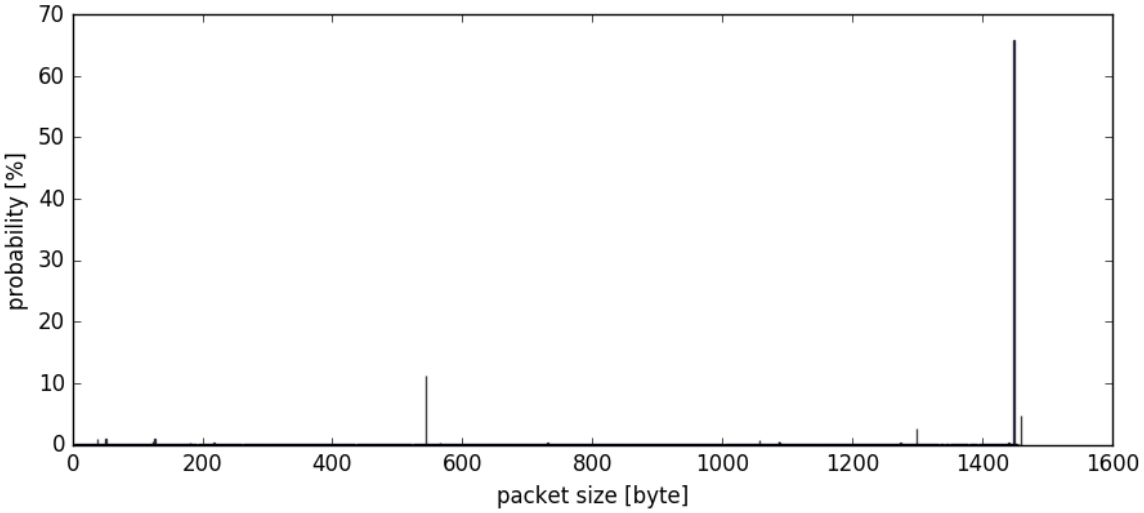



**Figure 9:** *Packet size distribution of Tor traffic.*

- The traffic payload is not necessary, this method only needs the packet size and the 5 (or 6 with VLAN) tuple necessary to aggregate packets in flows.

# 66 tp0f

## 66.1 Description

The tp0f plugin classifies IP addresses according to OS type and version. It uses initial TTL and window size and can also use the rules from p0f. In order to label non-TCP flows, the plugin can store a hash of already classified IP addresses.

### 66.1.1 Required Files

If `TP0FRULES=1`, then the file `tp0fL34.txt` is required.

## 66.2 Configuration Flags

The following flags can be used to control the output of the plugin:

| Name | Default | Description |
|---|---|---|
| `TP0FRULES` | 1 | 0: Standard OS guessing<br>1: OS guessing and p0f L3/4 rules |
| `TP0FHSH` | 1 | 0: No IP hash<br>1: IP hash to recognize IP already classified |
| `TP0FRC` | 0 | 0: Only human readable<br>1: p0f rule and classifier numbers |
| `TP0F_L34FILE` | `"tp0fL34.txt"` | File containing converted L3/4 rules |

In *tp0flist.h*:

| Name | Default | Description |
|---|---|---|
| `TCPOPTMAX` | 40 | Maximal TCP option codes to store and process |

### 66.2.1 Environment Variable Configuration Flags

The following configuration flags can also be configured with environment variables (`ENVCNTRL>0`):

- `TP0F_L34FILE`

## 66.3 Flow File Output

The p0f plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| `tp0fStat` | H8 | Status | |
| `tp0fDis` | U8 | Initial TTL distance | |
| `tp0fRN` | U16 | Rule number that triggered | `TP0FRC=1` |
| `tp0fClass` | U8 | OS class of rule file | `TP0FRC=1` |
| `tp0fProg` | U8 | Program category of rule file | `TP0FRC=1` |
| `tp0fVer` | U8 | Version category of rule file | `TP0FRC=1` |

| Column | Type | Description | Flags |
|---|---|---|---|
| tp0fClName | SC | OS class name | |
| tp0fPrName | SC | OS/program name | |
| tp0fVerName | SC | OS/program version name | |

### 66.3.1 tp0fStat

The tp0fStat column is to be interpreted as follows:

| tp0fStat | Description |
|---|---|
| 0x01 | SYN tp0f rule fired |
| 0x02 | SYN-ACK tp0f rule fired |
| 0x04 | — |
| 0x08 | — |
| 0x10 | — |
| 0x20 | — |
| 0x40 | IP already seen by tp0f |
| 0x80 | TCP option length or content corrupt |

## 66.4 Plugin Report Output

The number of packets which fired a tp0f rule is reported.

## 66.5 TODO

- Integrate TLS rules
- Integrate HTTP rules

## 66.6 References

- http://www.netresec.com/?page=Blog&month=2011-11&post=Passive-OS-Fingerprinting
- http://lcamtuf.coredump.cx/p0f3/

# 67 txtSink

## 67.1 Description

The txtSink plugin provides human readable text output which can be saved in a file `PREFIX_flows.txt`, where `PREFIX` is provided via the `-w` option. The generated output contains a textual representation of all plugins results. Each line in the file represents one flow. The different output statistics of the plugins are separated by a tab character to provide better post-processing with command line scripts or statistical toolsets.

## 67.2 Dependencies

### 67.2.1 External Libraries

If gzip compression is activated (`TFS_GZ_COMPRESS=1`), then **zlib** must be installed.

| | | **TFS_GZ_COMPRESS=1** |
|---:|---|---|
| **Ubuntu:** | `sudo apt-get install` | `zlib1g-dev` |
| **Arch:** | `sudo pacman -S` | `zlib` |
| **Gentoo:** | `sudo emerge` | `zlib` |
| **openSUSE:** | `sudo zypper install` | `zlib-devel` |
| **Red Hat/Fedora**[44]**:** | `sudo dnf install` | `zlib-devel` |
| **macOS**[45]**:** | `brew install` | `zlib` |

### 67.2.2 Core Configuration

This plugin requires the following core configuration:

- *$T2HOME/tranalyzer2/src/tranalyzer.h*:
  - `BLOCK_BUF=0`

## 67.3 Configuration Flags

The configuration flags for the txtSink plugins are separated in two files.

### 67.3.1 txtSink.h

| Name | Default | Description |
|---|---|---|
| `TFS_SPLIT` | 1 | Split the output file (Tranalyzer `-W` option) |
| `TFS_PRI_HDR` | 1 | Print a row with column names at the start of the flow file |
| `TFS_HDR_FILE` | 1 | Generate a separate header file (Section 67.4.1) |
| `TFS_PRI_HDR_FW` | 0 | Print header in every output fragment (Tranalyzer `-W` option) |
| `TFS_GZ_COMPRESS` | 0 | Compress the output (gzip) |
| `TFS_FLOWS_TXT_SUFFIX` | `"_flows.txt"` | Suffix for the flow file |

[44] If the `dnf` command could not be found, try with `yum` instead
[45] Brew is a packet manager for macOS that can be found here: https://brew.sh

| Name | Default | Description |
|---|---|---|
| TFS_HEADER_SUFFIX | "_headers.txt" | Suffix for the header file |

### 67.3.2 bin2txt.h

bin2txt.h controls the conversion from internal binary format to standard text output.

| Name | Default | Description |
|---|---|---|
| IP4_FORMAT | 0 | IPv4 addresses representation:<br>0: normal,<br>1: normalized (padded with zeros),<br>2: one 32-bits hex number<br>3: one 32-bits unsigned number |
| IP6_FORMAT | 0 | IPv6 addresses representation:<br>0: compressed,<br>1: uncompressed,<br>2: one 128-bits hex number,<br>3: two 64-bits hex numbers |
| MAC_FORMAT | 0 | MAC addresses representation:<br>0: normal (edit MAC_SEP to change the separator),<br>1: one 64-bits hex number, |
| MAC_SEP | ":" | Separator to use in MAC addresses: 11:22:33:44:55:66 |
| B2T_NON_IP_STR | "-" | Representation of non-IPv4/IPv6 addresses in IP columns |
| HEX_CAPITAL | 0 | Hex output: 0: lower case; 1: upper case |
| TFS_EXTENDED_HEADER | 0 | Extended header in flow file |
| B2T_NANOSECS | 0 | Time precision: 0: microsecs, 1: nanosecs |
| TFS_NC_TYPE | 2 | Types in header file: 0: none, 1: numbers, 2: C types |
| TFS_SAN_UTF8 | 1 | Activates the UTF-8 sanitizer for strings |
| B2T_TIMESTR | 0 | Print unix timestamps as human readable dates |
| HDR_CHR | "%" | start character(s) of comments |
| SEP_CHR | "\t" | column separator in the flow file<br>";", ".", "_" and "\"" should not be used |

### 67.3.3 Environment Variable Configuration Flags

The following configuration flags can also be configured with environment variables (ENVCNTRL>0):

- TFS_FLOWS_TXT_SUFFIX
- TFS_HEADER_SUFFIX

## 67.4 Additional Output

### 67.4.1 Header File

The header file PREFIX_headers.txt describes the columns of the flow file and provides some additional information, such as plugins loaded and PCAP file or interface used, as depicted below. The default suffix used for the header file is _headers.txt. This suffix can be configured using TFS_HEADER_SUFFIX.

```
# Date: 1566316839.259591 sec (Tue 5 Aug 2023 18:00:39 CEST)
# Tranalyzer 0.9.0 (Anteater), Cobra.
# Core configuration: L2, IPv4, IPv6
# SensorID: 666
# PID: 13221
# Command line: /home/user/tranalyzer2-0.9.0/tranalyzer2/src/tranalyzer -r file.pcap
# HW Info: hostname;sysname;release;version;machine
# SW info: libpcap version 1.9.1
#
# Plugins loaded:
#   01: protoStats, version 0.9.0
#   02: basicFlow, version 0.9.0
#   03: macRecorder, version 0.9.0
#   04: portClassifier, version 0.9.0
#   05: basicStats, version 0.9.0
#   06: tcpFlags, version 0.9.0
#   07: tcpStates, version 0.9.0
#   08: icmpDecode, version 0.9.0
#   09: connStat, version 0.9.0
#   10: txtSink, version 0.9.0
#
# Col No.   Type            Name              Description
1           C               dir               Flow direction
2           U64             flowInd           Flow index
3           H64             flowStat          Flow status and warnings
4           U64.U32         timeFirst         Date time of first packet
5           U64.U32         timeLast          Date time of last packet
6           U64.U32         duration          Flow duration
7           U8              numHdrDesc        Number of different headers descriptions
8           U16:R           numHdrs           Number of headers (depth) in hdrDesc
9           SC:R            hdrDesc           Headers description
10          MAC:R           srcMac            Mac source
11          MAC:R           dstMac            Mac destination
12          H16             ethType           Ethernet type
13          U16:R           vlanID            VLAN IDs
14          IPX             srcIP             Source IP address
15          SC              srcIPCC           Source IP country
16          S               srcIPOrg          Source IP organization
17          U16             srcPort           Source port
18          IPX             dstIP             Destination IP address
19          SC              dstIPCC           Destination IP country
20          S               dstIPOrg          Destination IP organization
21          U16             dstPort           Destination port
22          U8              l4Proto           Layer 4 protocol
23          H8              macStat           macRecorder status
...
```

The column number can be used, e.g., with `awk` or tawk to query a given column. For example, to extract all ICMP flows (layer 4 protocol equals 1) from a flow file:

```
awk -F'\t' '$22 == 1' PREFIX_flows.txt
```

The second column indicates the type of the column (see table below). If the value is repetitive, the type is postfixed with `:R`. Repetitive values can occur any number of times (from 0 to *N*). Each repetition is separated by a semicolon. The `'_'` indicates a compound, i.e., a value containing 2 or more subvalues.

| # | Name | Description |
|---|---|---|
| 1 | I8 | int8 |
| 2 | I16 | int16 |
| 3 | I32 | int32 |
| 4 | I64 | int64 |
| 5 | I128 | int128 |
| 6 | I256 | int256 |
| 7 | U8 | uint8 |
| 8 | U16 | uint16 |
| 9 | U32 | uint32 |
| 10 | U64 | uint64 |

| # | Name | Description |
|---|---|---|
| 11 | U128 | uint128 |
| 12 | U256 | uint256 |
| 13 | H8 | hex8 |
| 14 | H16 | hex16 |
| 15 | H32 | hex32 |
| 16 | H64 | hex64 |
| 17 | H128 | hex128 |
| 18 | H256 | hex256 |
| 19 | F | float |
| 20 | D | double |

| # | Name | Description |
|---|---|---|
| 21 | LD | long double |
| 22 | C | char |
| 23 | S | string |
| 24 | C | flow direction[46] |
| 25 | TS | timestamp[47] |
| 26 | U64.U32 | duration |
| 27 | MAC | mac address |
| 29 | IP4 | IPv4 address |
| 29 | IP6 | IPv6 address |
| 30 | IPX | IPv4 or 6 address |
| 31 | SC | string class[48] |

[46] `A`: client→server, `B`: server→client
[47] U64.U32/S (See `B2T_TIMESTR` in bin2txt.h )
[48] string without quotes

# 68 voipDetector

## 68.1 Description

The idea of this plugin is to identify SIP, RTP and RTCP flows independently of each other, so that also non standard traffic can be detected. Moreover certain QoS values are extracted.

## 68.2 Configuration Flags

The following flags can be used to control the output of the plugin:

| Name | Default | Description | Flags |
|---|---|---|---|
| VOIP_SIP | 1 | 0: do not decode SIP,<br>1: Enable SIP decoder,<br>2: Decode SIP and add RTP/SIP findex/ssrc flow correlation | |
| VOIP_SIP_PRV | 0 | 0: No RTP/SIP flow correlation enhancement,<br>1: add RTP srcIP,<br>2: add srcIP of SIP flow | VOIP_SIP=2<br>VOIP_SIP=2<br>VOIP_SIP=2 |
| VOIP_RTP | 1 | Enable RTP decoder | |
| VOIP_RTCP | 1 | Enable RTCP decoder | |
| VOIP_ANALEN | 0 | 0: only ssrc check,<br>1: additional check report len against payload length | |
| VOIP_SAVE | 0 | Save RTP content to VOIP_V_PATH | |
| VOIP_BUFMODE | 1 | Enable buffering of saved RTP content | VOIP_SAVE=1 |
| VOIP_SILREST | 1 | Restore back G.711 suppressed silences | VOIP_SAVE=1 |
| VOIP_PLDOFF | 0 | Offset for payload to save | VOIP_SAVE=1 |
| VOIP_SVFDX | 1 | Merge ops: 1: findex, 0: SSRC | VOIP_SAVE=1 |
| VOIP_MINPKT | 1 | Minimum packet length of a flow | VOIP_SAVE=1 |
| RTPFMAX | 10 | Maximal SSRC files | VOIP_SAVE=1&&<br>VOIP_SVFDX=0 |
| SIPNMMAX | 35 | Maximal SIP caller name length | |
| SIPSTATMAX | 8 | Maximal SIP state requests | |
| SIPCLMAX | 3 | Maximal SIP state requests name length | |
| SIPRFXMAX | 100 | Maximal SIP IP, m=audio / video ports | |
| RTPBUFSIZE | 4096 | Size of buffer for RTP content | VOIP_SAVE=1 |
| RTPMAXVERS | 1 | Maximal number of version violations | |
| VOIP_RMDIR | 1 | Empty VOIP_V_PATH before starting | VOIP_SAVE=1 |
| VOIP_PERM | S_IRWXU | File permissions | VOIP_SAVE=1 |
| VOIP_V_PATH | "/tmp/TranVoIP" | Path for extracted content | VOIP_SAVE=1 |
| VOIP_FNAME | "nudel" | Default content file name prefix | VOIP_SAVE=1 |

### 68.2.1 Environment Variable Configuration Flags

The following configuration flags can also be configured with environment variables (ENVCNTRL>0):

- VOIP_RMDIR
- VOIP_V_PATH

- VOIP_FNAME

## 68.3 Flow File Output

The voipDetector plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| voipStat | H16 | Status | |
| voipType | R(U8) | RTP/RTCP type | |
| voipSSRC | R(H32) | RTP/RTCP Synchronization Source Identifier | |
| voipCSRC | R(H32) | RTP/RTCP Contributing Sources | |
| voipSRCnt | U8 | RTP SID/RTCP record count | |
| voipPMCnt | U32 | RTP packet miss count | |
| voipPMr | F | RTP packet miss ratio | |
| voipSIPStatCnt | U8 | SIP stat count | VOIP_SIP>0 |
| voipSIPReqCnt | U8 | SIP request count | VOIP_SIP>0 |
| voipSIPUsrAgnt | S | SIP User-Agent | VOIP_SIP>0 |
| voipSIPRealIP | S | SIP X-Real-IP | VOIP_SIP>0 |
| voipSIPFrm | R(S) | SIP Caller | VOIP_SIP>0 |
| voipSIPTo | R(S) | SIP Callee | VOIP_SIP>0 |
| voipSIPCallID | R(S) | SIP Call-ID | VOIP_SIP>0 |
| voipSIPContact | R(S) | SIP Contact | VOIP_SIP>0 |
| voipSIPStat | R(U16) | SIP stat | VOIP_SIP>0 |
| voipSIPReq | R(SC) | SIP request | VOIP_SIP>0 |
| voipSDPSessID | R(S) | SDP session ID | VOIP_SIP>0 |
| voipSIPRFAdd | R(IP) | RTP audio/video flow address | VOIP_SIP>0 |
| voipSIPRAFPrt | R(U16) | SIP RTP audio flow port | VOIP_SIP>0 |
| voipSIPRVFPrt | R(U16) | SIP RTP video flow port | VOIP_SIP>0 |
| voipSIPRTPMap | R(SC) | SIP SDP rtpmap | VOIP_SIP>0 |
| voipFindex | R(U64) | SIP RTP findex | VOIP_SIP>1 |
| voipTPCnt | U32 | RTCP cumulated transmitter packet count | VOIP_RTCP=1 |
| voipTBCnt | U32 | RTCP cumulated transmitter byte count | VOIP_RTCP=1 |
| voipFracLst | U8 | RTCP cumulated fraction lost | VOIP_RTCP=1 |
| voipCPMCnt | U32 | RTCP cumulated packet miss count | VOIP_RTCP=1 |
| voipMaxIAT | U32 | RTCP max inter-arrival time | VOIP_RTCP=1 |
| voipFname | S | RTP content filename | VOIP_SAVE=1 |

### 68.3.1 voipStat

The voipStat column is to be interpreted as follows:

| voipStat | Description |
|---|---|
| $2^0$ (=0x0001) | RTP detected |

| | voipStat | Description |
|---|---|---|
| $2^1$ | (=0x0002) | RTCP detected |
| $2^2$ | (=0x0004) | SIP detected |
| $2^3$ | (=0x0008) | STUN detected |
| $2^4$ | (=0x0010) | RTP extension header |
| $2^5$ | (=0x0020) | RT(C)P padding bytes |
| $2^6$ | (=0x0040) | SDP detected |
| $2^7$ | (=0x0080) | RTP marker |
| $2^8$ | (=0x0100) | RTP content write operation |
| $2^9$ | (=0x0200) | SIP audio RTP flow announced |
| $2^{10}$ | (=0x0400) | SIP video RTP flow announced |
| $2^{11}$ | (=0x0800) | voipSIPRFAdd field truncated... increase SIPRFXMAX |
| $2^{12}$ | (=0x1000) | RTP packet loss detected |
| $2^{13}$ | (=0x2000) | RTP sequence number jump to past |
| $2^{14}$ | (=0x4000) | RTP new frame header flag |
| $2^{15}$ | (=0x8000) | RTP error in detection |

## 68.4 Packet File Output

In packet mode (-s option), the voipDetector plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| voipStat | H16 | Status | |
| voipType | R(U8) | RTP/RTCP type | |
| voipSeqN | U8 | RTP/RTCP sequence number | |
| voipTs | U32 | RTP/RTCP timestamp | |
| voipTsDiff | I32 | RTP/RTCP timestamp difference | |
| voipSSRC | H32 | RTP/RTCP ID | |

## 68.5 Plugin Report Output

The following information is reported:

- Aggregated voipStat
- Max number of file handles (VOIP_SAVE=1)
- Number of SIP packets (VOIP_SIP=1)
- Number of SDP packets (VOIP_SIP=1)
- Number of SIP INVITE packets (VOIP_SIP=1)
- Number of SIP ACK packets (VOIP_SIP=1)

- Number of SIP BYE packets (`VOIP_SIP=1`)
- Number of unique SDP audio address, port (`VOIP_SIP=1`)
- Number of unique SIP/RTP flow matches (`VOIP_SIP=1`)
- Number of RTP packets (`VOIP_RTP=1`)
- Number of RTCP packets (`VOIP_RTCP=1`)

## 68.6 TODO

- Skype
- Google Talk

# 69 vrrpDecode

## 69.1 Description

The vrrpDecode plugin analyzes Virtual Router Redundancy Protocol (VRRP) traffic.

## 69.2 Configuration Flags

The following flags can be used to control the output of the plugin:

| Name | Default | Description | Flags |
|---|---|---|---|
| VRRP_NUM_VRID | 5 | number of unique virtual router ID to store | |
| VRRP_NUM_IP | 25 | number of unique IPs to store | |
| VRRP_RT | 1 | output routing tables | |
| VRRP_SUFFIX | "_vrrp.txt" | Suffix for routing tables file | VRRP_RT=1 |

### 69.2.1 Environment Variable Configuration Flags

The following configuration flags can also be configured with environment variables (ENVCNTRL>0):

- VRRP_SUFFIX

## 69.3 Flow File Output

The vrrpDecode plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| vrrpStat | H16 | Status | |
| vrrpVer | H8 | Version | |
| vrrpType | H8 | Type | |
| vrrpVRIDCnt | U32 | Virtual router ID count | |
| vrrpVRID | R(U8) | Virtual router ID | |
| vrrpMinPri | U8 | Minimum priority | |
| vrrpMaxPri | U8 | Maximum priority | |
| vrrpMinAdvInt | U8 | Minimum advertisement interval [s] | |
| vrrpMaxAdvInt | U8 | Maximum advertisement interval [s] | |
| vrrpAuthType | H8 | Authentication type | |
| vrrpAuth | SC | Authentication string | |
| vrrpIPCnt | U32 | IP address count | |
| vrrpIP | R(IP) | IP addresses | |

### 69.3.1 vrrpStat

The vrrpStat column is to be interpreted as follows:

| vrrpStat | Description |
|---|---|
| 0x0001 | flow is VRRP |
| 0x0002 | invalid version |
| 0x0004 | invalid type |
| 0x0008 | invalid checksum |
| 0x0010 | invalid TTL (should be 255) |
| 0x0020 | invalid destination IP (should be 224.0.0.18) |
| 0x0040 | — |
| 0x0080 | — |
| 0x0100 | Virtual Router ID list truncated... increase VRRP_NUM_VRID |
| 0x0200 | IP list truncated... increase VRRP_NUM_IP |
| 0x0400 | — |
| 0x0800 | — |
| 0x1000 | — |
| 0x2000 | — |
| 0x4000 | Packet snapped |
| 0x8000 | Malformed packet... covert channel? |

### 69.3.2 vrrpVer

The vrrpVer column is to be interpreted as follows:

| vrrpVer | Description |
|---|---|
| 0x04 | VRRPv2 |
| 0x08 | VRRPv3 |

### 69.3.3 vrrpType

The vrrpType column is to be interpreted as follows:

| vrrpType | Description |
|---|---|
| 0x01 | Advertisement |

### 69.3.4 vrrpAuthType

The vrrpAuthType column is to be interpreted as follows:

| vrrpAuthType | Description |
|---|---|
| 0x01 | No authentication |
| 0x02 | Simple text password |
| 0x04 | IP Authentication Header |

## 69.4 Monitoring Output

In monitoring mode, the vrrpDecode plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| vrrp2NPkts | U64 | Number of VRRPv2 packets | |
| vrrp3NPkts | U64 | Number of VRRPv3 packets | |
| vrrpStat | H16 | Status | |

## 69.5 Plugin Report Output

The following information is reported:

- Aggregated vrrpStat
- Number of VRRPv2 packets
- Number of VRRPv3 packets

## 69.6 Additional Output

Non-standard output:

- PREFIX_vrrp.txt: VRRP routing tables

The routing tables contain the following columns:

| Name | Description |
|---|---|
| VirtualRtrID | Virtual router ID |
| Priority | Priority |
| SkewTime[s] | Skew time (seconds) |
| MasterDownInterval[s] | Master down interval (seconds) |
| AddrCount | Number of addresses |
| Addresses | List of addresses |
| Version | VRRP version |
| Type | Message type |
| AdverInt[s] | Advertisement interval |
| AuthType | Authentication type |
| AuthString | Authentication string |
| Checksum | Stored checksum |
| CalcChecksum | Calculated checksum |
| flowIndex | Flow index |

## 69.7 Post-Processing

The routing tables can be pruned by using the following command:

```
sort -u PREFIX_vrrp.txt > PREFIX_vrrp_pruned.txt
```

# 70 vtpDecode

## 70.1 Description

The vtpDecode plugin analyzes the VLAN Trunking Protocol (VTP) protocol.

## 70.2 Dependencies

### 70.2.1 Core Configuration

This plugin requires the following core configuration:

- *$T2HOME/tranalyzer2/src/networkHeaders.h*:
  - ETH_ACTIVATE>0

## 70.3 Configuration Flags

The following flags can be used to control the output of the plugin:

| Name | Default | Description | Flags |
|---|---|---|---|
| VTP_AGGR | 1 | Aggregate updater identity | |
| VTP_SAVE | 1 | Extract all VLANs info in a separate file | |
| VTP_DEBUG | 0 | Print debug messages | |
| VTP_TS_FRMT | 1 | Format for timestamps: 0: string, 1: timestamp | |
| VTP_NUM_UPDID | 16 | Max number of updater identity | |
| VTP_STR_MAX | 64 | Max length for strings | |
| VTP_SUFFIX | "_vtp.txt" | Suffix for separate file | VTP_SAVE=1 |
| VTP_VLANID_FRMT | 1 | Format for VLAN ID: 0: int, 1: hex | VTP_SAVE=1 |

### 70.3.1 Environment Variable Configuration Flags

The following configuration flags can also be configured with environment variables (ENVCNTRL>0):

- VTP_SUFFIX

## 70.4 Flow File Output

The vtpDecode plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| vtpStat | H8 | Status | |
| vtpVer | H8 | Version | |
| vtpCodeBF | H8 | Aggregated codes | |
| vtpVlanTypeBF | H8 | Aggregated VLAN types | |
| vtpDomain | S | Management Domain | |
| vtpNumUpdId | U32 | Number of Updater identity | VTP_NUM_UPDID>0 |
| vtpUpdId | R(IP4) | Updater identity | VTP_NUM_UPDID>0 |

| Column | Type | Description | Flags |
|---|---|---|---|
| vtpFirstUpdTS | S/TS | Timestamp of first update | VTP_TS_FRMT=0/1 |
| vtpLastUpdTS | S/TS | Timestamp of last update | VTP_TS_FRMT=0/1 |

### 70.4.1 vtpStat

The vtpStat column is to be interpreted as follows:

| vtpStat | Description |
|---|---|
| 0x0001 | Flow is VTP |
| 0x0002 | Different versions used |
| 0x0004 | Different Management Domains used |
| 0x0008 | - |
| 0x0010 | Invalid Management Domain Length (> 32) |
| 0x0020 | Invalid version |
| 0x0040 | Invalid code |
| 0x0080 | Invalid VLAN type |
| 0x0100 | — |
| 0x0200 | — |
| 0x0400 | — |
| 0x0800 | — |
| 0x1000 | — |
| 0x2000 | Array truncated... increase VTP_NUM_UPDID |
| 0x4000 | String truncated... increase VTP_STR_MAX |
| 0x8000 | Packet snapped, decoding failed |

### 70.4.2 vtpCode and vtpCodeBF

The vtpCode and vtpCodeBF columns are to be interpreted as follows:

| vtpCode | vtpCodeBF | Description |
|---|---|---|
| -- | 0x01 | — |
| 0x01 | 0x02 | Summary Advertisement |
| 0x02 | 0x04 | Subset Advertisement |
| 0x03 | 0x08 | Advertisement Request |
| 0x04 | 0x10 | Join/Prune Message |
| -- | 0x20 | — |
| -- | 0x40 | — |
| -- | 0x80 | Unknown VTP code |

### 70.4.3 vtpVlanType and vtpVlanTypeBF

The vtpVlanType and vtpVlanTypeBF columns are to be interpreted as follows:

| vtpVlanType | vtpVlanTypeBF | Description |
|---|---|---|
| -- | 0x01 | — |
| 0x01 | 0x02 | Ethernet |
| 0x02 | 0x04 | Fiber Distributed Data Interface (FDDI) |
| 0x03 | 0x08 | Token Ring Concentrator Relay Function (TrCRF) |
| 0x04 | 0x10 | Fiber Distributed Data Interface Network Entity Title (FFID-net) |
| 0x05 | 0x20 | Token Ring Bridge Relay Function (TrBRF) |
| -- | 0x40 | — |
| -- | 0x80 | Unknown VTP VLAN type |

## 70.5 Packet File Output

In packet mode (-s option), the vtpDecode plugin outputs the following columns:

| Column | Type | Description | Flags |
|---|---|---|---|
| vtpStat | H8 | Status | |
| vtpVer | H8 | Version | |
| vtpCode | H8 | Code | |
| vtpDomain | SC | Management Domain | |
| vtpVlanTypeBF | H8 | Aggregated VLAN type | |

## 70.6 Plugin Report Output

The following information is reported:

- Aggregated vtpStat
- Aggregated vtpCodeBF
- Aggregated vtpVlanTypeBF
- Number of VTP packets
- Number of VTPv1, VTPv2 and VTPv3 packets
- Number of VTP Summary Advertisement packets
- Number of VTP Subset Advertisement packets
- Number of VTP Advertisement Request packets
- Number of VTP Join/Prune Message packets
- Number of VTP packets with unknown type

## 70.7 Additional Output

Non-standard output:

- `PREFIX_vtp.txt`: List of VLANs extracted from Subset Advertisement messages

The `PREFIX_vtp.txt` file contains the following columns:

| Name | Description |
|---|---|
| `pktNo` | Packet number |
| `flowInd` | Flow index |
| `srcMac` | MAC address which issued this advertisement |
| `vtpVer` | VTP version |
| `vtpDomain` | VTP Management Domain |
| `vtpRevNum` | VTP Configuration Revision Number |
| `vtpVlanType` | Aggregated VLAN type |
| `vtpVlanID` | ISL VLAN ID |
| `vtpVlanName` | VLAN Name |
| `vtpVlanSAID` | 802.10 Index (IEEE 802.10 security association identifier for this VLAN) |
| `vtpVlanMTU` | MTU Size |
| `vtpVlanSuspended` | State of the VLAN (suspended or not) |

## 70.8 References

- Understanding VLAN Trunk Protocol (VTP)

# 71 wavelet

## 71.1 Description

The wavelet plugin calculates the Daubechies wavelet transformation of the IP packet length or the inter-arrival time of packets (IAT).

## 71.2 Configuration Flags

The following flags, defined in *define_global.h*, can be used to control the output of the plugin:

| Name | Default | Description |
|---|---|---|
| WAVELET_IAT | 0 | Values to analyze:<br>0: Packet length,<br>1: Inter-arrival times (IAT) |
| WAVELET_SIG | 0 | Print signal |
| WAVELET_PREC | 0 | Precision:<br>0: Float,<br>1: Double |
| WAVELET_THRES | 8 | Min. number of packets for analysis |
| WAVELET_MAX_PKT | 40 | Max. number of selected packets |
| WAVELET_LEVEL | 3 | Wavelet decomposition level |
| WAVELET_EXTMODE | ZPD | Extension Mode:<br>NON: No extension,<br>SYM: Symmetrization,<br>ZPD: Zero-padding |
| WAVELET_TYPE | DB3 | Mother Wavelet:<br>DB1: Daubechies 1 wavelet<br>DB2: Daubechies 2 wavelet<br>DB3: Daubechies 3 wavelet<br>DB4: Daubechies 4 wavelet |

## 71.3 Flow File Output

The wavelet plugin outputs the following columns:

| Name | Type | Description | Flags |
|---|---|---|---|
| waveNumPnts | U16 | Number of points | |
| waveSig | R(F/D) | Packet length / IAT signal | WAVELET_PREC=0/1 |
| waveNumLvl | U32 | Number of wavelet levels | |
| waveCoefDetail | R(R(F/D)) | Wavelet detail coefficients | WAVELET_PREC=0/1 |
| waveCoefApprox | R(R(F/D)) | Wavelet approximation coefficients | WAVELET_PREC=0/1 |

# 72 scripts

This section describes various scripts and utilities for Tranalyzer. For a complete list of options, use the scripts `-h` option.

## 72.1 b64ex

Extracts all HTTP, EMAIL, FTP, TFTP, etc base 64 encoded content extracted from T2. To produce a list of files containing base64 use `grep` as indicated below:

- `grep "base64" /tmp/SMTPFILE/*`
- `./b64ex /tmp/SMTPFILES/file@wurst.ch_0_1223`

## 72.2 fpsGplt

Transforms the output of the nFrstPkts plugin signal output to gnuplot or t2plot format for encrypted traffic mining purposes. It generates an output file: `flowfile_nps.txt` containing the processed PL signal according to nFrstPkts plugin configuration.

```
$ fpsGplt -h
Usage:
    fpsGplt [OPTION...] <FILE_flows.txt>

Optional arguments:
    -f findex        Flow index to extract [default: all flows]
    -d A|B           Flow direction: A or B only [default: A and B]
    -t               No time, but counts on x axis [default: time on x axis]
    -i               Invert B flow PL
    -s               Time sorted ascending
    -p s             Sample sorted signal with smplIAT in [s]; f = 1/smplIAT
    -e s             Time for each PL pulse edge in [s]
    -j               Calculate the jumps in IAT and report appropriate values
                     for MINIAT(S/U)
    -h, --help       Show this help, then exit
```

If `-f` is omitted all flows will be included. If `-d` is omitted both flow directions will be processed. `-t` removes the timestamp and replaces it with an integer count. `-i` inverts the `B` flow signal to produce a symmetrical signal. `-p` samples the sorted signal with the IAT in seconds resp. frequency you deem necessary and `-e` defines the pulse flank in seconds. `-j` calculates the jumps in IAT to allows the user to choose an appropriate `MINIAT(S/U)` in nFrstPkts plugin.

## 72.3 gpq3x

Use this script to create 3D waterfall plot. Was originally designed for the `centrality` plugin:

```
cat FILE_centrality | ./gpq3x
```

The script can be configured through the command line. For a full list of options, run `./gpq3x -help`

## 72.4 osStat

Counts the number of hosts of each operating system (OS) in a PCAP file. In addition, a file with suffix `_IP_OS.txt` mapping every IP to its OS is created. This script uses `p0f` which requires a fingerprints file (`p0f.fp`), the location of which can be specified using the `-f` option. Version 2 looks first in the current directory, then in `/etc/p0f`. Version 3 looks only in the current directory.

- list all the options: `osStat --help`
- top 10 OS: `osStat file.pcap -n 10`
- bottom 5 OS: `osStat file.pcap -n -5`

## 72.5 protStat

The `protStat` script can be used to sort the `PREFIX_protocols.txt` file (generated by the protoStats plugin) or the `PREFIX_nDPI.txt` file (generated by the nDPI plugin) for the most or least occurring protocols (in terms of number of packets or bytes). In addition, it can also sort the `PREFIX_icmpStats.txt` and `PREFIX_igmpStats.txt` files (generated by the icmpDecode and igmpDecode plugins respectively). It can output the top or bottom *N* protocols or only those with at least a given percentage:

- list all the options: `protStat --help`
- for better readability, use `protStat` with `tcol`: `protStat ... | tcol`
- sorted list of protocols (by packets): `protStat PREFIX_protocols.txt`
- sorted list of protocols (by bytes): `protStat PREFIX_protocols.txt -b`
- top 10 protocols (by packets): `protStat PREFIX_protocols.txt -n 10`
- bottom 5 protocols (by bytes): `protStat PREFIX_protocols.txt -n -5 -b`
- protocols with packets percentage greater than 20%: `protStat PREFIX_protocols.txt -p 20`
- protocols with bytes percentage smaller than 5%: `protStat PREFIX_protocols.txt -b -p -5`
- TCP and UDP statistics only: `protStat PREFIX_protocols.txt -udp -tcp`

## 72.6 statGplt

Transforms 2/3D statistics output from pktSIATHisto plugin to gnuplot or t2plot format for encrypted traffic mining purposes.

## 72.7 t2_aliases

Set of aliases for Tranalyzer.

### 72.7.1 Description

`t2_aliases` defines the following aliases, functions and variables:

**T2HOME**
Variable pointing to the root folder of Tranalyzer, e.g., `cd $T2HOME`.

**T2PLHOME**
Variable pointing to the root folder of Tranalyzer plugins, e.g., `cd $T2PLHOME`. In addition, every plugin can be accessed by typing its name instead of its full path. For example to access tcpFlags home folder, `tcpFlags` can be used instead of `cd $T2PLHOME/tcpFlags` or `cd $T2HOME/plugins/tcpFlags`.

**tran**
Shortcut to access `$T2HOME`, e.g., `tran`

**tranpl**
Shortcut to access `$T2PLHOME`, e.g., `tranpl`

**.tran**
Shortcut to access `$HOME/.tranalyzer/plugins`, e.g., `.tran`

**awkf**
Configures `awk` to use tabs, i.e., '`\t`' as input and output separator (prevents issue with repetitive values), e.g., `awkf '{ print $4 }' file_flows.txt`

**tawk**
Shortcut to run tawk from anywhere, e.g., `tawk`

**tcol**
Displays columns with minimum width, e.g., `tcol file_flows.txt`.

**lsx**
Displays columns with fixed width (default: 40), e.g., `lsx file_flows.txt` or `lsx 45 file_flows.txt`.
Note that ZSH already defines a `lsx` alias, therefore if using ZSH this command will **NOT** be installed. To have it installed, add the following line to your `~/.zshrc` file: `unalias lsx`

**sortu**
Sort rows and count the number of times a given row appears, then sort by the most occurring rows. (Alias for `sort | uniq -c | sort -rn`). Useful, e.g., to analyze the most occurring user-agents: `tawk '{ print $httpUsrAg }' FILE_flows.txt | sortu`

**sortup**
Same as `sortu`, but display the relative percentage instead of the absolute count. e.g., to analyze the most occurring user-agents: `tawk '{ print $httpUsrAg }' FILE_flows.txt | sortup`

**t2**
Shortcut to run Tranalyzer from anywhere, e.g., `t2 -r file.pcap -w out`

**gt2**
Shortcut to run Tranalyzer in `gdb` (Linux) or `lldb` (macOS) from anywhere, e.g., `gt2 -r file.pcap -w out`

**st2**
Shortcut to run Tranalyzer with sudo, e.g., `st2 -i eth0 -w out`

**tranalyzer**
Shortcut to run Tranalyzer from anywhere, e.g., `tranalyzer -r file.pcap -w out`

**fextractor**
Shortcut to run `fextractor` from anywhere, e.g., `fextractor -r file_flows.xer 1234`

**fpsGplt**
Shortcut to run `fpsGplt` from anywhere, e.g., `fpsGplt file_flows.txt`

**protStat**
Shortcut to run `protStat` from anywhere, e.g., `protStat file_protocols.txt`

**statGplt**
Shortcut to run `statGplt` from anywhere, e.g., `statGplt file_flows.txt`

**t2b2t**
Shortcut to run t2b2t from anywhere, e.g., `t2b2t -r file_flows.bin -w file_flows.txt`.

**t2build**
Function to build Tranalyzer and the plugins from anywhere, e.g., `t2build tcpFlags`. Use `<tab>` to list the available plugins and complete names. Use `t2build -h` for a full list of options.

**t2caplist**
Shortcut to run t2caplist from anywhere, e.g., `t2caplist`

**t2conf**
Shortcut to run t2conf from anywhere, e.g., `t2conf --gui`

**t2dmon**
Shortcut to run t2dmon from anywhere, e.g., `t2dmon dumps/`

**t2doc**
Shortcut to run t2doc from anywhere, e.g., `t2doc tranalyzer2`

**t2docker**
Shortcut to run t2docker from anywhere, e.g., `t2docker -r file.pcap`

**t2dpdk**
Shortcut to run t2dpdk from anywhere, e.g., `t2dpdk -N 4 -i 0000:04:00.0`.

**t2flowstat**
Shortcut to run t2flowstat from anywhere, e.g., `t2flowstat file_flows.txt -c numPktsSnt -s 1 -m 9000 -0`

**t2fm**
Shortcut to run t2fm from anywhere, e.g., `t2fm -r file.pcap`

**t2fuzz**
Shortcut to run t2fuzz from anywhere, e.g., `t2fuzz file.pcap`

**t2locate**
Shortcut to run t2locate from anywhere, e.g., `t2locate`

**t2mmdb**
Shortcut to run `t2mmdb` (see geoip plugin documentation for more information) from anywhere, e.g., `t2mmdb`

**t2netID**
Shortcut to run t2netID from anywhere, e.g., `t2netID 0x138020a5`

**t2plot**
Shortcut to run t2plot from anywhere, e.g., `t2plot file.txt`

**t2plugin**
Shortcut to run t2plugin from anywhere, e.g., `t2plugin -c pluginName`.

**t2rrd**
Shortcut to run t2rrd from anywhere, e.g., `t2 -i eth0 | t2rrd -m` or `t2rrd V4Pkts V6Pkts`

**t2stat**
Shortcut to run t2stat from anywhere, e.g., `t2stat -USR2`

**t2test**
Shortcut to run `tests/T2Tester.py` from anywhere, e.g., `t2test tranalyzer2`

**t2timeline**
Shortcut to run t2timeline from anywhere, e.g., `t2timeline file.txt`

**t2update**
Shortcut to run ./setup.sh –C from anywhere, e.g., `t2update`. This alias checks for the availability of a new version of Tranalyzer and proceed with the installation if requested.

**t2viz**
Shortcut to run t2viz from anywhere, e.g., `t2viz file.txt`

**t2whois**
Shortcut to run t2whois from anywhere, e.g., `t2whois 1.2.3.4`

### 72.7.2 Usage

Those aliases can be activated using either one of the following methods:

1. Append the content of this file to `~/.bash_aliases` or `~/.bashrc`
2. Append the following line to `~/.bashrc` (make sure to replace `$T2HOME` with the actual path, e.g., `$HOME/tranalyzer2-0.9.2`):

```
if [ -f "$T2HOME/scripts/t2_aliases" ]; then
    . $T2HOME/scripts/t2_aliases             # Note the leading `.'
fi
```

### 72.7.3 Known Bugs and Limitations

ZSH already defines a `lsx` alias, therefore if using ZSH this command will **NOT** be installed. To have it installed, add the following line to your `~/.zshrc` file: `unalias lsx`

## 72.8 t2alive

In order to monitor the status of T2, the t2alive script sends syslog messages to server defined by the user whenever the status of T2 changes. It acquires the PID of the T2 process and transmits every `REP` seconds a `kill -SYS $pid`. If T2 answers with a corresponding kill command defined in *tranalyzer.h*, s.b., then status is set to alive, otherwise to dead. Only if a status change is detected a syslog message is transmitted. The following constants residing in *tranalyzer.h* govern the functionality of the script:

| Name | Default | Description |
|---|---|---|
| SERVER | "127.0.0.1" | syslog server IP |
| PORT | 514 | syslog server port |
| FAC | "<25>" | facility code |
| STATFILE | "/tmp/t2alive.txt" | alive status file |
| REP | 10 | T2 test interval [s] |

**Table 425:** *t2alive script configuration*

T2 on the other hand has also to be configured. To preserve simplicity the unused SYS interrupt was abused to respond to the `t2alive` request, hence the monitoring mode depending on USR1 and USR2 can be still functional. Configuration is carried out in *tranalyzer.h* according to the table below:

| Name | Default | Description |
|---|---|---|
| REPSUP | 0 | 1: activate alive mode |
| ALVPROG | "t2alive" | name of control program |
| REPCMDAW | "a=`pgrep ALVPROG`; if [ $a ]; then kill -USR1 $a; fi" | alive and stall (no packets, looping?) |
| REPCMDAS | "a=`pgrep ALVPROG`; if [ $a ]; then kill -USR2 $a; fi" | alive and well (working) |

**Table 426:** *T2 configuration for t2alive mode*

`REPSUP=1` activates the alive mode. If more functionality is requested the `REPCMDAx` constant facilitates the necessary changes. On some Linux distributions the pcap read callback function is not thread safe, thus signals of any kind might

lead to crashes especially when capturing live traffic. Therefore **MONINTTHRD=1** in *main.h* is set by default.
Note that t2alive should be executed in a shell as a standalone script. If executed as a cron job, the while loop and the sleep command has to be removed, as described in the script itself.

## 72.9 t2b2t

The program `t2b2t` can be used to transform binary Tranalyzer files generated by the binSink or socketSink plugin into text or json files. The converted files use the same format as the ones generated by the txtSink or jsonSink plugin.

The program can be found in `$T2HOME/utils/t2b2t` and can be compiled by typing `make`.

The use of the program is straightforward:

- bin→txt: `t2b2t -r FILE_flows.bin -w FILE_flows.txt`
- bin→json: `t2b2t -r FILE_flows.bin -j -w FILE_flows.json`
- bin→compressed txt: `t2b2t -r FILE_flows.bin -c -w FILE_flows.txt.gz`
- bin→compressed json: `t2b2t -r FILE_flows.bin -c -j -w FILE_flows.json.gz`

If the `-w` option is omitted, the destination is inferred from the input file, e.g., the examples above would produce the same output files with or without the `-w` option. Note that `-w -` can be used to output to stdout.
Additionally, the `-n` option can be used **not** to print the name of the columns as the first row.
Try `t2b2t -h` for more information.

## 72.10 t2caplist

Generates a list of PCAP files with absolute path to use with Tranalyzer `-R` option. If no argument is provided, then lists all the PCAP files in the current directory. If a folder name is given, lists all capture files in the folder. If a list of files is given, list those files. Try `t2caplist -help` for more information.

- `t2caplist > pcap_list.txt`
- `t2caplist ~/dumps/ > pcap_list.txt`
- `t2caplist ~/dumps/testnet*.pcap > pcap_list.txt`

## 72.11 t2conf

Use `t2conf` to configure, activate and deactivate Tranalyzer plugins:

- To change the value of a configuration flag run:

```
t2conf pluginName -D FLAG_NAME=new_value
```

- To check the value of a configuration flag run:

```
t2conf pluginName -G FLAG_NAME
```

- To list the configuration flags available run:

```
t2conf pluginName -I
```

- To reset a plugin configuration to its default values run:

```
t2conf pluginName --reset
```

- To save a plugin configuration run:

```
t2conf pluginName -g
```

  - Note that the `-g` option accepts a filename:

```
t2conf pluginName -g /where/to/save/file.config
```

- To load plugin configuration run:

```
t2conf pluginName -C /path/to/file.config
```

  - Note that if the default filename is used, `-C auto` can be used instead:

```
t2conf pluginName -C auto
```

- For more details about `t2conf`, run:

```
t2conf --help
```

Alternatively, use `t2conf --gui` option or the `t2plconf` script provided with all the plugins to configure individual plugins as follows:

- `cd $T2PLHOME/pluginName`
- `./t2plconf`
  - Navigate through the different options with the up and down arrows
  - Use the left and right arrows to select an action:
    - `ok`: apply the changes
    - `configure`: edit the selected entry (use the space bar to select a different value)
    - `cancel`: discard the changes
    - `edit`: open the file containing the selected option in `EDITOR` (default: `vim`)
  - Use the space bar to select a different value

A more detailed description of the script can be found in Tranalyzer2 documentation.

### 72.11.1 Dependencies

The `t2conf` (if the `-gui` option is used) and `t2plconf` scripts require *dialog* (version 1.1-20120703 minimum) and the *vim* editor. The easiest way to install them is to use the `install.sh` script provided (Section 72.11.2). Note that the editor can be changed by exporting the environment variable `EDITOR` as follows: `export EDITOR=/path/to/editor`, e.g., `export EDITOR=/usr/bin/nano` or by setting the `EDITOR` variable at line 9 of the `t2conf` script and at line 90 of the `t2plconf` script.

### 72.11.2 Installation

The easiest way to install `t2conf` and its dependencies is to use tranalyzer2 `setup.sh` script. Alternatively, the provided `install.sh` script can be used to only install `t2conf`. Run `./install.sh --help` to see what can be installed.

Alternatively, use t2_aliases or add the following alias to `~/.bash_aliases`:

```
alias t2conf="$T2HOME/scripts/t2conf/t2conf"
```

Where `$T2HOME` is the root folder containing the source code of Tranalyzer2 and its plugins, i.e., where `README.md` is located.

### 72.11.3 Usage

For a complete list of options use the `-h` option, i.e., `t2conf -h`, or the man page (`man t2conf`).

### 72.11.4 Patch

`t2conf` can be used to patch Tranalyzer and the plugins (useful to save settings such as hash table size, IPv6, ...).

The format of the patch file is as follows:

- Empty lines and lines starting with `'%'` or `'#'` are ignored
- Filenames are relative to `$T2HOME`
- A line is composed of three or four tabs (not spaces) separated columns:
  - `NAME <tab> newvalue <tab> oldvalue <tab> file`
  - `NAME <tab> newvalue <tab> file`
- `--patch` uses newvalue
- `--rpatch` uses oldvalue[49]

As an example, let us take the value `T2PSKEL_IP` defined in *t2PSkel/src/t2PSkel.h*:

```
#define T2PSKEL_IP   1 // whether or not to output IP (var2)
```

A patch to set this value to 0 would look as follows (where the spaces between the columns are tabs, i.e., `'\t'`):

- `T2PSKEL_IP  0  1  t2PSkel/src/t2PSkel.h`
- `T2PSKEL_IP  0  t2PSkel/src/t2PSkel.h`

## 72.12 t2dmon

Monitors a folder for new files and creates symbolic links with incrementing indexes. This can be used with the `-D` option when the filenames have either multiple indexes, e.g., date and count, or when the filenames do not possess an index.

### 72.12.1 Dependencies

This script requires **inotify-tools**:

[49] This option is not valid if the patch has only three columns.

**Arch:** `sudo pacman -S inotify-tools`

**Fedora:** `sudo yum install inotify-tools`

**Gentoo:** `sudo emerge inotify-tools`

**Ubuntu:** `sudo apt-get install inotify-tools`

#### 72.12.2 Usage

t2dmon works as a daemon and as such, should either be run in the background (the ampersand `'&'` in step 1 below) or on a different terminal.

1. `t2dmon dumps/ -o nudel.pcap &`
2. `tranalyzer -D dumps/nudel.pcap0 -w out`
3. Finally, copy/move the pcap files into the `dumps/` folder.

### 72.13 t2doc

Access Tranalyzer documentation from anywhere, e.g., `t2doc tcpFlags`. Use `<tab>` to list the available plugins and complete names.

### 72.14 t2docker

Create and manage Tranalyzer Docker containers.

- Create a Docker container: `t2docker -B t2-latest.tar.gz`
- Download the latest version of T2 and create a Docker container: `t2docker -B latest`
- List existing Tranalyzer Docker containers: `t2docker -ls`
- Save a Docker image: `t2docker -S image-name-or-id`
- Load a Docker image: `t2docker -L t2docker-image.tar[.gz]`
- Get a Shell in a Docker image: `t2docker -X image-name-or-id`
- Run Tranalyzer inside a Docker container: `t2docker -r file.pcap`
- Run another T2 command inside a Docker container: `t2docker tawk -V flowStat`

Note that when running T2 inside a Docker container, the pcap file is copied to a temporary folder (automatically removed or shredded (`--shred` option) after the script has ended). This extra step make sure only the required files are accessible by the container.

## 72.15 t2dpdk

Run *N* instances of T2 in DPDK multi-process mode. T2 must be compiled with `DPDK_MP=1`:

```
$ t2conf tranalyzer2 -D DPDK_MP=1
$ t2build -R -r -f
$ t2dpdk -N 4 -i 0000:04:00.0
```

## 72.16 t2flowstat

Calculates statistical distributions of selected columns/flows from a flow file.

## 72.17 t2fm

Generates a PDF report out of:

- a flow file (`-F` option): `t2fm -F file_flows.txt`
- a live interface (`-i` option): `t2fm -i eth0`
- a PCAP file (`-r` option): `t2fm -r file.pcap`
- a list of PCAP files (`-R` option): `t2fm -R pcap_list.txt`

### 72.17.1 Required Plugins

- basicFlow
- basicStats
- txtSink

### 72.17.2 Optional Plugins

- arpDecode
- dnsDecode
- geoip
- httpSniffer
- nDPI
- portClassifier
- pwX
- sshDecode

## 72.18 t2fuzz

Randomly corrupt a PCAP file and run T2 against it: `t2fuzz file.pcap`.
Try `t2fuzz --help` for more information.

## 72.19 t2locate

Query location database to acquire information about a city near float point terrestrial coordinates. Build the DB first with the script: `$T2HOME/scripts/t2locate/update_db`, duration ca 30 min.

## 72.20 t2netID

Decode hexadecimal network IDs. An ID contain information about the country, the organization and whether or not the address is a Tor address. An ID can be decoded as follows: `t2netID 0x138020a5`.
Try `t2netID --help` for more information.

## 72.21 t2plot

2D/3D plot for Tranalyzer using gnuplot. First row of the input file must be the column names (may start with a '%'). The input file must contain one, two or more columns separated by tabs (\t). Columns to plot can be selected with -o option. Try t2plot --help for more information.

**Dependencies:** The t2plot script requires **gnuplot**.

**Arch:** sudo pacman -S gnuplot

**Ubuntu:** sudo apt-get install gnuplot-qt

**macOS:** brew install gnuplot --with-qt

**Examples:**

- tawk '{ print ip2num(shost()), ip2num(dhost()) }' f_flows.txt | t2plot -pt
- tawk '{ print ip2num($srcIP), $timeFirst, $connSip }' f_flows.txt | t2plot
- tawk '{ print $numPktsSnt }' f_flows.txt | t2plot -H 10 -sx "0:40"
- t2plot -o numPktsSnt f_flows.txt
- t2plot -D -o srcIPCC:numBytesSnt f_flows.txt
- tawk '{ print proto(), $numBytesSnt }' f_flows.txt | t2plot -D
- t2plot file_with_one_two_or_three_columns.txt
- t2plot -o "26:28" file_with_many_columns.txt
- t2plot -o "numBytesSnt:numBytesRcvd" file_with_many_columns.txt
- Try t2plot -e for more examples.

## 72.22 t2plugin

Use this script to create a new plugin or list existing plugins For a more comprehensive description of how to write a plugin, refer to Appendix A (Creating a custom plugin) of $T2HOME/doc/documentation.pdf.

## 72.23 t2rrd

Store Tranalyzer monitoring output into a RRD database (-m option) or use the RRD database generated with -m to monitor and plot various values, e.g., number of flows.

## 72.24 t2stat

Sends USR1 signal to Tranalyzer to produce intermediary report. The signal sent can be changed with the -SIGNAME option, e.g., t2stat -USR2 or t2stat -INT. If Tranalyzer was started as root, the -s option can be used to run the command with sudo. The -p option can be used to print the PID of running Tranalyzer instances and the -l option provides additional information about the running instances (command and running time). The -i option can be used to cycle through all the running instances and will prompt for confirmation before sending the signal to a specific process. If a numeric argument *N* is provided, sends the signal every *N* seconds, e.g., t2stat 10 to report every 10s. Use t2stat --help for more information.

## 72.25 t2timeline

Timeline plot of flows: `t2timeline FILE_flows.txt`

- To use relative time, i.e., starting at 0, use the `-r` option.
- The vertical space between A and B flows can be adapted with the `-v` option, e.g., `-v 50`.
- When hovering over a flow, the following information is displayed: `flowInd_flowStat_srcIP:srcPort_dstIP:dstPort_l4Proto_vlanID`.
- Additional information can be displayed with the `-e` option, e.g, `-e macS,macD,duration`
- Use `t2timeline --help` for more information.

An example graph is depicted in Figure 10.

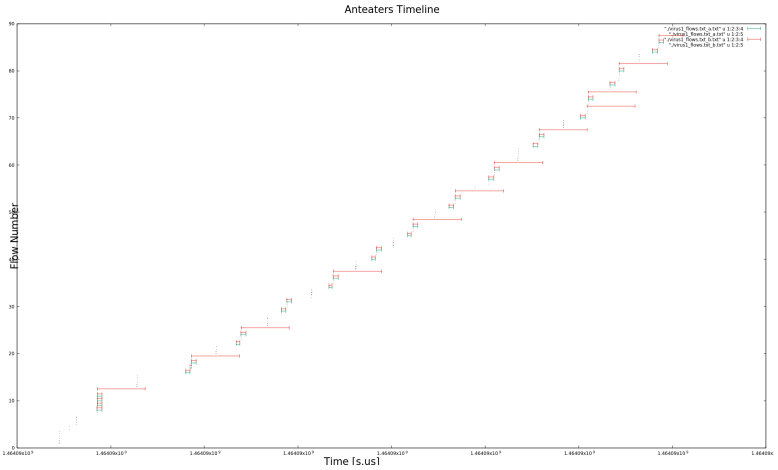



**Figure 10:** *T2 timeline flow plot*

## 72.26 t2utils.sh

Collection of bash functions and variables (`readonly`).

### 72.26.1 Usage

To access the functions and variables provided by this file, source it in your script as follows:

```
source "$(dirname "${0}")/t2utils.sh"
```

Note that if your script is not in the `scripts/` folder, you will need to adapt the path above to `t2utils.sh` accordingly.

**[ZSH]** If writing a script for ZSH, add the following line **BEFORE** sourcing the script:

```
unsetopt function_argzero
```

### 72.26.2 Colors

Alternatives to `printbold`, `printerr`, `printinf`, `printok` and `printwrn`:

| Variable | Description | Example |
|---|---|---|
| `${BLUE}` | Set the color to blue | `printf "${BLUE}%s${NOCOLOR}\n" "msg"` |
| `${GREEN}` | Set the color to green | `printf "${GREEN}%s${NOCOLOR}\n" "msg"` |
| `${ORANGE}` | Set the color to orange | `printf "${ORANGE}%s${NOCOLOR}\n" "msg"` |
| `${RED}` | Set the color to red | `printf "${RED}%s${NOCOLOR}\n" "msg"` |
| `${BLUE_BOLD}` | Set the color to blue bold | `printf "${BLUE_BOLD}msg${NOCOLOR}\n"` |
| `${GREEN_BOLD}` | Set the color to green bold | `printf "${GREEN_BOLD}msg${NOCOLOR}\n"` |
| `${ORANGE_BOLD}` | Set the color to orange bold | `printf "${ORANGE_BOLD}msg${NOCOLOR}\n"` |
| `${RED_BOLD}` | Set the color to red bold | `printf "${RED_BOLD}msg${NOCOLOR}\n"` |
| `${BLUE_ITALIC}` | Set the color to blue italic | `printf "${BLUE_BOLD}${msg}${NOCOLOR}\n"` |
| `${GREEN_ITALIC}` | Set the color to green italic | `printf "${GREEN_BOLD}${msg}${NOCOLOR}\n"` |
| `${ORANGE_ITALIC}` | Set the color to orange italic | `printf "${ORANGE_BOLD}${msg}${NOCOLOR}\n"` |
| `${RED_ITALIC}` | Set the color to red italic | `printf "${RED_BOLD}${msg}${NOCOLOR}\n"` |
| `${BLUE_UNDERLINE}` | Set the color to blue underline | `echo -e "${BLUE_ITALIC}msg${NOCOLOR}"` |
| `${GREEN_UNDERLINE}` | Set the color to green underline | `echo -e "${GREEN_ITALIC}msg${NOCOLOR}"` |
| `${ORANGE_UNDERLINE}` | Set the color to orange underline | `echo -e "${ORANGE_ITALIC}msg${NOCOLOR}"` |
| `${RED_UNDERLINE}` | Set the color to red underline | `echo -e "${RED_ITALIC}msg${NOCOLOR}"` |
| `${BOLD}` | Set the font to bold | `echo -e "${BOLD}${msg}${NOCOLOR}"` |
| `${ITALIC}` | Set the font to italic | `echo -e "${ITALIC}${msg}${NOCOLOR}"` |
| `${UNDERLINE}` | Set the font to underline | `echo -e "${UNDERLINE}${msg}${NOCOLOR}"` |
| `${STRIKETHROUGH}` | Set the font to strikethrough | `echo -e "${STRIKETHROUGH}${msg}${NOCOLOR}"` |
| `${NOCOLOR}` | Reset the color | `echo -e "${BOLD}${msg}${NOCOLOR}"` |

### 72.26.3 Folders

| Variable | Description | Example |
|---|---|---|
| `${SHOME}` | Points to the folder where the script resides | For `macRecorder/utils/mconv`, `${SHOME}` is `${T2PLHOME}/macRecorder/utils` |
| `${T2HOME}` | Points to the root folder of Tranalyzer | `cd "${T2HOME}/tranalyzer2"` |
| `${T2PLHOME}` | Points to the root folder of Tranalyzer plugins | `cd "${T2PLHOME}/t2PSkel"` |

### 72.26.4 Scripts and Programs

Functions and variables pointing to programs.

#### Functions

| Name | Program | Example |
|---|---|---|
| AWK | gawk | AWK '{ print }' file |
| AWKF | gawk -F'\t' -v OFS='\t' | AWKF '{ print }' file |
| T2 | Most recent tranalyzer executable in ${T2HOME}/tranalyzer2/ | T2 -r file.pcap |
| T2B2T | Most recent t2b2t executable in ${T2HOME}/utils/t2b2t/ | T2B2T -r file.bin -w file.txt |
| T2WHOIS | Most recent t2whois executable in ${T2HOME}/utils/t2whois/ | T2WHOIS 1.2.3.4 |

**Variables**

| Name | Program | Example |
|---|---|---|
| `${AWK_EXEC}` | `gawk` | `"${AWK_EXEC}" 'NR > 0 { print $2 }' file` |
| `${OPEN}` | `xdg-open` (Linux), `open` (macOS) | `"${OPEN}" file.pdf` |
| `${READLINK}` | `readlink` (Linux) / `greadlink` (macOS) | `"${READLINK}" file` |
| `${SED}` | `sed` (Linux) / `gsed` (macOS) | `"${SED}" 's/ /_/g' <<< "$str"` |
| `${T2BUILD}` | `"${T2HOME}/autogen.sh"` | `"${T2BUILD}" tranalyzer2` |
| `${T2CONF}` | `"${T2HOME}/scripts/t2conf/t2conf"` | `"${T2CONF}" basicFlow -D BFO_MAC=1` |
| `${T2PLOT}` | `"${T2HOME}/scripts/t2plot"` | `"${T2PLOT}" -o srcIPCC file` |
| `${TAWK}` | `"${T2HOME}/scripts/tawk/tawk"` | `"${TAWK}" '{ print tuple4() } file'` |

### 72.26.5 Functions

| Function | Description |
|---|---|
| `printbold "msg"` | print a message (bold) with a newline |
| `printerr "msg"` | print an error message (red) with a newline |
| `printinf "msg"` | print an info message (blue) with a newline |
| `printok "msg"` | print an ok message (green) with a newline |
| `printwrn "msg"` | print a warning message (orange) with a newline |
| `fatal "msg"` | print an error message (red) with a newline and exit with status 1 |
| `check_dependency "bin" "pkg"` | check whether a dependency exists (Linux/macOS) |
| `check_dependency_linux "bin" "pkg"` | check whether a dependency exists (Linux) |
| `check_dependency_macos "bin" "pkg"` | check whether a dependency exists (macOS) |
| `has_define "file" "name"` | return 0 if the macro `name` exists in `file`, 1 otherwise |
| `get_define "name" "file"` | return the value of the macro `name` in `file` |
| `set_define "name" "value" "file"` | set the value of the macro `name` in `file` to `value` |
| `replace_suffix "name" "old" "new"` | replace the `old` suffix in `name` by `new` |
| `join_by "sep" "values..."` | join `values...` with a separator `sep` |
| `ask_default_no "msg" ["answer"]` | ask the question `msg (y/N)?`, read the answer and assume `no` if answer is not `[yY]` or `[yY][eE][sS]`. Return 0 if answer is `yes`. `answer` can be set to `yes` or `no` to force the answer |
| `ask_default_yes "msg" ["answer"]` | ask the question `msg (Y/n)?`, read the answer and assume `yes` if answer is not `[nN]` or `[nN][oO]`. Return 0 if answer is `yes`. `answer` can be set to `yes` or `no` to force the answer |
| `find_most_recent_dir "dir" "dirname"` | recursively find the most recent `dirname` in a directory `dir` |
| `find_most_recent_file "dir" "filename"` | recursively find the most recent `filename` in a directory `dir` |
| `t2_build_exec "/path/to/exec" [force]` | ask whether to build the given executable if it does not exist |

| Function | Description |
|---|---|
| | (set `force` to 1 to rebuild `exec` regardless) |
| `get_t2_exec` | search for `tranalyzer` executable in `${T2HOME}/tranalyzer2` (return an empty string, if it could not be found) |
| `get_t2b2t_exec` | search for t2b2t executable in `${T2HOME}/utils/t2b2t` (return an empty string, if it could not be found) |
| `get_t2whois_exec` | search for t2whois executable in `${T2HOME}/utils/t2whois` (return an empty string, if it could not be found) |
| `abort_if_t2_exec_not_found` | search for `tranalyzer` executable in `${T2HOME}/tranalyzer2`. Abort with status 1 and an error and info message if it could not be found. |
| `abort_if_t2b2t_exec_not_found` | search for t2b2t executable in `${T2HOME}/utils/t2b2t`. Abort with status 1 and an error and info message if it could not be found. |
| `abort_if_t2whois_exec_not_found` | search for t2whois executable in `${T2HOME}/utils/t2whois`. Abort with status 1 and an error and info message if it could not be found. |
| `t2_wget "url" ["outfile"]` | download the data at `url` (set `outfile` (optional) to change the output path) |
| `t2_wget_n "url" ["outfile"]` | same as `t2_wget`, but turn on timestamping (see `wget -N` option) |
| `get_nproc` | return the number of processing units available |
| `validate_float "float"` | return 0 if `float` is a valid floating point value, 1 otherwise |
| `validate_int "int"` | return 0 if `int` is a valid integer, 1 otherwise |
| `validate_num "num"` | return 0 if `num` is a valid positive integer, 1 otherwise |
| `validate_ip "string"` | return 0 if `string` is a valid IPv4 address, 1 otherwise |
| `validate_pcap "file"` | return 0 if `file` is a valid PCAP file, 1 otherwise |
| `validate_next_arg "curr" "next"` | check whether `next` exists and is not an option (`curr` is used for error reporting) |
| `validate_next_arg_exists "curr" "next"` | check whether `next` exists |
| `validate_next_dir "curr" "next"` | check whether `next` exists and is a directory |
| `validate_next_file "curr" "next"` | check whether `next` exists and is a regular file |
| `validate_next_file_or_dir "curr" "next"` | check whether `next` exists and is a regular file or directory |
| `validate_next_pcap "curr" "next"` | check whether `next` exists and is a PCAP file |
| `validate_next_num "curr" "next"` | check whether `next` exists and is a positive integer |
| `validate_next_int "curr" "next"` | check whether `next` exists and is an integer |
| `validate_next_float "curr" "next"` | check whether `next` exists and is a float |
| `arg_is_option "arg"` | check whether `arg` exists and is an option (starts with `-`) |
| `abort_missing_arg "option"` | print an error about a missing argument and |

| Function | Description |
|---|---|
| | exit with status 1 |
| `abort_option_unknown "option"` | print an error about an unknown option and exit with status 1 |
| `abort_required_file` | print an error about a missing required file and exit with status 1 |
| `abort_required_dir` | print an error about a missing required directory and exit with status 1 |
| `abort_required_file_or_dir` | print an error about a missing required file or directory and exit with status 1 |
| `abort_with_help` | print a message explaining how to get help and exit with status 1 |

## 72.27 t2viz

Generates a graphviz script which can be loaded into xdot or dotty: `t2viz FILE_flows.txt`.
Accepts T2 flow or packet files with header description.
Try `t2viz --help` for more information.

## 72.28 t2voipconv

Convert raw audio files extracted with voipDetector to wav: `t2voipconv /tmp/TranVoIP`.
Try `t2voipconv --help` for more information.

## 72.29 t2whois

Query Tranalyzer subnet databases to get geolocation information about IP addresses:

- Get geo info for one IP address: `t2whois 1.2.3.4`
- Get geo info for multiple IPs: `t2whois 1.2.3.4 5.6.7.8`
- Get geo info for one or multiple IPs listed in a file (one IP per line): `t2whois -r file.txt`
- Get geo info for one or multiple IPs entered to stdin via a prompt: `t2whois` or `t2whois -r -`
- Get geo info for one or multiple IPs entered to stdin via a pipe: `cat file.txt | t2whois -q -l`
- Format the output (one line per IP, no header): `t2whois -l -H -r file.txt`
- Format the output (one line per IP, comma separated): `t2whois -l -s "," -r file.txt`
- Query information about the databases `t2whois -V`
- Try `t2whois -h` for more information

## 72.30 topNStat

Generates sorted lists of all the columns (names or numbers) provided. A list of examples can be displayed using the `-e` option.

# 73 PDF Report Generation from PCAP using t2fm

## 73.1 Introduction

This tutorial presents `t2fm`, a script which generates a PDF report out of a PCAP file. Information provided in the report includes top source and destination addresses and ports, protocols and applications, DNS and HTTP activity and potential warnings, such as executable downloads or SSH connections.

## 73.2 Prerequisites

For this tutorial, it is assumed the user has a basic knowledge of Tranalyzer and that the file `t2_aliases` has been sourced in `~/.bashrc` or `~/.bash_aliases` as follows[50] (make sure to replace `$T2HOME` with the actual path, e.g., `$HOME/tranalyzer2-0.9.2`):

```
# $HOME/.bashrc

if [ -f "$T2HOME/scripts/t2_aliases" ]; then
    . "$T2HOME/scripts/t2_aliases"            # Note the leading '.'
fi
```

### 73.2.1 Required plugins

The following plugins must be loaded for `t2fm` to produce a useful report:

- basicFlow
- basicStats
- txtSink

### 73.2.2 Optional plugins

The following plugins are optional:

- arpDecode
- dnsDecode
- geoip
- pwX
- sshDecode
- sslDecode
- httpSniffer , configured as follows[51]:
  - `HTTP_SAVE_IMAGE=1`
  - `HTTP_SAVE_VIDEO=1`
  - `HTTP_SAVE_AUDIO=1`
  - `HTTP_SAVE_MSG=1`
  - `HTTP_SAVE_TEXT=1`
  - `HTTP_SAVE_APPL=1`
- nDPI , configured as follows:
  - `NDPI_OUTPUT_STR=1`
- portClassifier , configured as follows:
  - `PBC_NUM=1`
  - `PBC_STR=1`

If one of those plugin is not loaded, messages like `N/A: dnsDecode plugin required` will be displayed in the PDF where the information could not be accessed.

[50] Refer to the file `README.md` or to the documentation for more details
[51] This is only required to report information about EXE downloaded

### 73.2.3 Packages

The following packages are required to build the PDF:

- texlive-latex-extra
- texlive-fonts-recommended

## 73.3 PCAP to PDF in One Command

For simplicity, this tutorial assumes the user wants a complete report, i.e., requires all of the optional plugins. The `-b` option builds and configures Tranalyzer and the plugins, the `-A` option opens the generated report.

1. Run `t2fm` directly on the PCAP file (the report will be named `file.pdf`):

```
t2fm -b -A -r file.pcap
```

## 73.4 Step-by-Step Instructions (PCAP to PDF)

Alternatively if you prefer to configure Tranalyzer, build the plugins and open the generated report yourself:

1. Make sure all the plugins are configured as described in Section 73.2
2. Build Tranalyzer and the plugins [52]:
   `t2build tranalyzer2 basicFlow basicStats txtSink arpDecode dnsDecode geoip \`
   `httpSniffer nDPI portClassifier pwX sshDecode sslDecode`
   (Note that those first two steps can be omitted if `t2fm -b` option is used)
3. Run `t2fm` directly on the PCAP file (the report will be named `file.pdf`):
   `t2fm -r file.pcap`
4. Open the generated PDF report `file.pdf` (Note that this step can be omitted if `t2fm -A` option is used):
   `evince file.pdf`

## 73.5 Step-by-Step Instructions (flow file to PDF)

Alternatively, if you prefer to run Tranalyzer yourself or already have access to a flow file, replace step 3 of Section 73.4 with the following steps:

1. Run Tranalyzer on a pcap file as follows:
   `t2 -r file.pcap -w out`
2. The previous command should have created the following files:
   `out_headers.txt`
   `out_flows.txt`
3. Run the `t2fm` script on the flow file generated previously:
   `t2fm -F out_flows.txt`

[52] Hint: use the tab completion to avoid typing the full name of all the plugins: `t2build tr<tab> ... ht<tab> ...`

## 73.6 Step-by-Step Instructions (ClickHouse / MongoDB / PostgreSQL to PDF)

If the clickhouseSink , mongoSink or psqlSink plugins were loaded, t2fm can use the created databases to generate the report (faster).

1. Follow point 1 and 2 from Section 73.4[53]
2. Build the clickhouseSink , mongoSink or psqlSink plugin:
   - **ClickHouse:** `t2build clickhouseSink`
   - **MongoDB:** `t2build mongoSink`
   - **postgreSQL:** `t2build psqlSink`
3. Run Tranalyzer on a pcap file as follows:
   `t2 -r file.pcap -w out`
4. Run the `t2fm` script on the database generated previously:
   - **ClickHouse:** `t2fm -C tranalyzer`
   - **MongoDB:** `t2fm -m tranalyzer`
   - **postgreSQL:** `t2fm -p tranalyzer`

When generating a report from a database a time range to query can be specified with the `-T` option. The complete format is as follows: `YYYY-MM-DD HH:MM:SS.USEC([+-]OFFSET|Z)`, e.g., `2022-08-23 12:34:56.912345+0100`. Note that only the required fields must be specified, e.g., `2022-08-23` is equivalent to `2022-08-23 00:00:00.000000`. For example, to generate a report from the 1st of July to the 11. of August 2022 at 14:59 from a PostgreSQL database, run the following command: `t2fm -p tranalyzer -T "2022-07-01" "2022-08-11 14:59"`

## 73.7 Conclusion

This tutorial has presented how `t2fm` can be used to create a PDF report summarizing the traffic contained in a PCAP file. Although not discussed in this tutorial, it is also possible to use `t2fm` on a live interface (`-i` option) or on a list of PCAP files (`-R` option). For more details, refer to `t2fm` man page or use `t2fm --help`.

[53] `HTTP_SAVE_*` do not need to be set as EXE downloads detection is currently not implemented in the DB backends

# 74 tawk

## 74.1 Description

This document describes tawk and its functionalities. tawk works just like awk, but provides access to the columns via their names. In addition, it provides access to helper functions, such as `host()` or `port()`. Custom functions can be added in the folder named `t2custom` where they will be automatically loaded.

## 74.2 Dependencies

gawk version 4.1 is required.

| | | |
|---|---|---|
| **Ubuntu:** | `sudo apt-get install` | `gawk` |
| **Arch:** | `sudo pacman -S` | `gawk` |
| **Gentoo:** | `sudo emerge` | `gawk` |
| **openSUSE:** | `sudo zypper install` | `gawk` |
| **Red Hat/Fedora**[54]**:** | `sudo dnf install` | `gawk` |
| **macOS**[55]**:** | `brew install` | `gawk` |

## 74.3 Installation

The recommended way to install `tawk` is to install `t2_aliases` as documented in `README.md`:

- Append the following line to `~/.bashrc` (make sure to replace `$T2HOME` with the actual path, e.g., `$HOME/tranalyzer2-0.9.2`):

```
if [ -f "$T2HOME/scripts/t2_aliases" ]; then
    . $T2HOME/scripts/t2_aliases            # Note the leading `.'
fi
```

### 74.3.1 Man Pages

The man pages for `tawk` and `t2nfdump` can be installed by running: `./install.sh man`. Once installed, they can be consulted by running `man tawk` and `man t2nfdump` respectively.

## 74.4 Usage

- To list the column numbers and names: `tawk -l file_flows.txt`
- To list the column numbers and names as 3 columns: `tawk -l=3 file_flows.txt`
- To list the available functions: `tawk -g file_flows.txt`
- To list the available functions as 3 columns: `tawk -g=3 file_flows.txt`
- To save the original filename and filter used: `tawk -c 'FILTER' file_flows.txt > file.txt`

[54] If the `dnf` command could not be found, try with `yum` instead
[55] Brew is a packet manager for macOS that can be found here: `https://brew.sh`

- To extract all ICMP flows and the header: `tawk 'hdr() || $l4Proto == 1' file_flows.txt > icmp.txt`
- To extract all ICMP flows without the header: `tawk -H 'icmp()' file_flows.txt > icmp.txt`
- To extract the flow with index 1234: `tawk '$flowInd == 1234' file_flows.txt`
- To extract all DNS flows and the header: `tawk 'hdr() || strtonum($dnsStat)' file_flows.txt`
- To consult the documentation for the function 'func': `tawk -d func`
- To consult the documentation for the functions 'min' and 'max': `tawk -d min,max`
- To consult the documentation for all the available functions: `tawk -d all`
- To consult the documentation for the variable 'var': `tawk -V var`
- To consult the documentation for the variable 'var' with value `0x8a`: `tawk -V var=0x8a`
- To decode all variables from Tranalyzer2 log file: `tawk -L out_log.txt`
- To decode all variables from Tranalyzer2 log file (stdout): `t2 -r file.pcap | tawk -L`
- To convert the output to JSON: `tawk 'json($flowStat "\t" tuple5())' file_flows.txt`
- To convert the output to JSON: `tawk 'aggr(tuple2())' file_flows.txt | tawk 'json()'`
- To create a PCAP with all packets from flow 5: `tawk -x flow5.pcap '$flowInd == 5' file_flows.txt`
- To create a PCAP with packets 4-9: `tawk -P -x pkts-4_to_9.pcap 'packet("4-9")' file_packets.txt`
- To see all ICMP packets in Wireshark: `tawk -k 'icmp()' file_flows.txt`
- To see packet 4, 10 and 42 in Wireshark: `tawk -P -k 'packet("4;10;42")' file_packets.txt`

For a complete list of options, use the `-h` option.

Note that an option not recognized by tawk is internally passed to awk/gawk. One of the most useful is the `-v` option to set the value of a variable:

- Changing the output field separator:
  `tawk -v OFS=',' '{ print $col1, $col2 }' file.txt`
- Passing a variable to tawk:
  `tawk -v myvar=myvalue '{ print $col1, myvar }' file.txt`

For a complete list of options, run `awk -h`.

## 74.5 -s and -N Options

The `-s` option can be used to specify the starting character(s) of the row containing the column names (default: `'%'`). If several rows start with the specified character(s), then the last one is used as column names. To change this behavior, the line number can be specified as well with the help of the `-N` option. For example, if rows 1 to 5 start with `'#'` and row 3 contains the column names, specify the separator as follows: `tawk -s '#' -N 3` If the row with column names does not start with a special character, use `-s ''`.

## 74.6 Related Utilities

### 74.6.1 awkf

Configure `awk` to use tabs, i.e., '`\t`' as input and output separator (prevent issue with repetitive values), e.g., `awkf '{ print $4 }' file_flows.txt`

### 74.6.2 lsx

Display columns with fixed width (default: 40), e.g., `lsx file_flows.txt` or `lsx 45 file_flows.txt`

### 74.6.3 sortu

Sort rows and count the number of times a given row appears, then sort by the most occurring rows. (Alias for `sort | uniq -c | sort -rn`). Useful, e.g., to analyze the most occurring user-agents: `tawk '{ print $httpUsrAg }' FILE_flows.txt | sortu`

**sortup**
Same as `sortu`, but display the relative percentage instead of the absolute count. e.g., to analyze the most occurring user-agents: `tawk '{ print $httpUsrAg }' FILE_flows.txt | sortup`

### 74.6.4 tcol

Display columns with minimum width, e.g., `tcol file_flows.txt`.

## 74.7 Functions

Collection of functions for `tawk`:

- Parameters between brackets are optional,
- IPs can be given as string (`"1.2.3.4"`), hexadecimal (`0xffffffff`) or int (`4294967295`),
- Network masks can be given as string (`"255.255.255.0"`), hexadecimal (`0xffffff00`) or CIDR notation (`24`),
- Networks can be given as string, hexadecimal or int, e.g., `"1.2.3.4/24"` or `"0x01020304/255.255.255.0"`,
- String functions can be made case insensitive by adding the suffix `i`, e.g., `streq` → `streqi`,
- Some examples are provided below,
- More details and examples can be found for every function by running `tawk -d funcname`.

| Function | Description |
|---|---|
| `hdr()` | Use this function in your tests to keep the header (column names). |
| `tuple2()` | Return the 2 tuple (source IP and destination IP). |
| `tuple3()` | Return the 3 tuple (source IP, destination IP and port). |
| `tuple4()` | Return the 4 tuple (source IP and port, destination IP and port). |
| `tuple5()` | Return the 5 tuple (source IP and port, destination IP and port, protocol). |

| Function | Description |
|---|---|
| `tuple6()` | Return the 6 tuple (source IP and port, dest. IP and port, proto, VLANID). |
| `host([ip\|net])` | Return true if the source or destination IP is equal to `ip` or belongs to `net`.<br>If `ip` is omitted, return the source and destination IP. |
| `shost([ip\|net])` | Return true if the source IP is equal to `ip` or belongs to `net`.<br>If `ip` is omitted, return the source IP. |
| `dhost([ip\|net])` | Return true if the destination IP is equal to `ip` or belongs to `net`.<br>If `ip` is omitted, return the destination IP. |
| `net([ip\|net])` | Alias for `host([ip\|net])`. |
| `snet([ip\|net])` | Alias for `shost([ip\|net])`. |
| `dnet([ip\|net])` | Alias for `dhost([ip\|net])`. |
| `loopback(ip)` | Return true if `ip` is a loopback address. |
| `mcast(ip)` | Return true if `ip` is a multicast address. |
| `privip(ip)` | Return true if `ip` is a private IP. |
| `port([p])` | Return true if the source or destination port appears in `p`<br>(comma or semicolon separated).<br>Ranges may also be specified using a dash, e.g., `port("1-3")`.<br>If `p` is omitted, return the source and destination port. |
| `dport([p])` | Return true if the destination port appears in `p` (comma or semicolon separated).<br>Ranges may also be specified using a dash, e.g., `dport("1-3")`.<br>If `p` is omitted, return the destination port. |
| `sport([p])` | Return true if the source port appears in `p` (comma or semicolon separated).<br>Ranges may also be specified using a dash, e.g., `sport("1-3")`.<br>If `p` is omitted, return the source port. |
| `ip()` | Return true if the flow contains IPv4 or IPv6 traffic. |
| `ipv4()` | Return true if the flow contains IPv4 traffic. |
| `ipv6()` | Return true if the flow contains IPv6 traffic. |
| `proto([p])` | Return true if the protocol number appears in `p` (comma or semicolon separated).<br>Ranges may also be specified using a dash, e.g., `proto("1-3")`.<br>If `p` is omitted, return the protocol number. |
| `proto2str([p])` | Return the string representation of the protocol number `p`.<br>If `p` is omitted, return the string representation of the protocol. |
| `icmp([p])` | Return true if the protocol is equal to 1 (ICMP). |
| `igmp([p])` | Return true if the protocol is equal to 2 (IGMP). |
| `tcp([p])` | Return true if the protocol is equal to 6 (TCP). |
| `udp([p])` | Return true if the protocol is equal to 17 (UDP). |
| `rsvp([p])` | Return true if the protocol is equal to 46 (RSVP). |
| `gre([p])` | Return true if the protocol is equal to 47 (GRE). |
| `esp([p])` | Return true if the protocol is equal to 50 (ESP). |
| `ah([p])` | Return true if the protocol is equal to 51 (AH). |
| `icmp6([p])` | Return true if the protocol is equal to 58 (ICMPv6). |

| Function | Description |
|---|---|
| sctp([p]) | Return true if the protocol is equal to 132 (SCTP). |
| dhcp() | Return true if the flow contains DHCP traffic. |
| dns() | Return true if the flow contains DNS traffic. |
| http() | Return true if the flow contains HTTP traffic. |
| tcpflags([val]) | If val is specified, return true if the specified flags are set.<br>If val is omitted, return a string representation of the TCP flags. |
| ip2num(ip) | Convert an IP address to a number. |
| ip2hex(ip) | Convert an IPv4 address to hex. |
| ip2str(ip) | Convert an IPv4 address to string. |
| ip62str(ip) | Convert an IPv6 address to string. |
| ip6compress(ip) | Compress an IPv6 address. |
| ip6expand(ip[,trim]) | Expand an IPv6 address.<br>If trim is different from 0, remove leading zeros. |
| ip2mask(ip) | Convert an IP address to a network mask (int). |
| mask2ip(m) | Convert a network mask (int) to an IPv4 address (int). |
| mask2ipstr(m) | Convert a network mask (int) to an IPv4 address (string). |
| mask2ip6(m) | Convert a network mask (int) to an IPv6 address (int). |
| mask2ip6str(m) | Convert a network mask (int) to an IPv6 address (string). |
| ipinnet(ip,net[,mask]) | Test whether an IP address belongs to a given network. |
| ipinrange(ip,low,high) | Test whether an IP address lies between two addresses. |
| localtime(t) | Convert UNIX timestamp to string (localtime). |
| utc(t) | Convert UNIX timestamp to string (UTC). |
| timestamp(t) | Convert date to UNIX timestamp. |
| t2split(val,sep<br>[,num[,osep]]) | Split values according to sep.<br>If num is omitted or 0, val is split into osep separated columns.<br>If num > 0, return the num repetition.<br>If num < 0, return the num repetition from the end, e.g., -1 for last element.<br>Multiple num can be specified, e.g., "1;-1;2".<br>Output separator osep, defaults to OFS. |
| splitc(val[,num[,osep]]) | Split compound values. Alias for t2split(val, "_", num, osep). |
| splitr(val[,num[,osep]]) | Split repetitive values. Alias for t2split(val, ";", num, osep). |
| valcontains(val,sep,item) | Return true if one item of val split by sep is equal to item. |
| cvalcontains(val,item) | Alias for valcontains(val, "_", item). |
| rvalcontains(val,item) | Alias for valcontains(val, ";", item). |
| strisempty(val) | Return true if val is an empty string. |
| streq(val1,val2) | Return true if val1 is equal to val2. |

| Function | Description |
|---|---|
| strneq(val1,val2) | Return true if val1 and val2 are not equal. |
| hasprefix(val,pre) | Return true if val begins with the prefix pre. |
| hassuffix(val,suf) | Return true if val finished with the suffix suf. |
| contains(val,txt) | Return true if val contains the substring txt. |
| not(q) | Return the logical negation of a query q.<br>This function must be used to keep the header when negating a query. |
| bfeq(val1,val2) | Return true if the hexadecimal numbers val1 and val2 are equal. |
| bitsallset(val,mask) | Return true if all the bits set in mask are also set in val. |
| bitsanyset(val,mask) | Return true if one of the bits set in mask is also set in val. |
| isset(v) | Return true if v is set, i.e., not empty, false otherwise. |
| isfloat(v) | Return true if v is a floating point number. |
| isint(v) | Return true if v is an integer. |
| isnum(v) | Return true if v is a number (signed, unsigned or floating point). |
| isuint(v) | Return true if v is an unsigned integer. |
| isip(v) | Return true if v is an IPv4 address in hexadecimal, numerical or dotted decimal notation. |
| isip6(v) | Return true if v is an IPv6 address. |
| isiphex(v) | Return true if v is an IPv4 address in hexadecimal notation. |
| isipnum(v) | Return true if v is an IPv4 address in numerical (int) notation. |
| isipstr(v) | Return true if v is an IPv4 address in dotted decimal notation. |
| join(a,s) | Convert an array to string, separating each value with s. |
| quote(s) | Add leading and trailing quotes to a string s and escape all quotes in s. |
| unquote(s) | Remove leading and trailing quotes from a string s and unespace all escaped quotes in s. |
| chomp(s) | Remove leading and trailing spaces from a string s. |
| strip(s) | Remove leading and trailing spaces from a string s. |
| lstrip(s) | Remove leading spaces from a string s. |
| rstrip(s) | Remove trailing spaces from a string s. |
| ientropy([num[,sc[,rev[,imin]]]]) | Compute the Shannon (information) entropy of each column.<br>Set imin to filter out columns with low entropy ($\leq$ *imin*). |
| mean(c) | Compute the mean value of a column c.<br>The result can be accessed with get_mean(c) or printed with print_mean([c]). |
| min(c) | Keep track of the min value of a column c.<br>The result can be accessed with get_min(c) or printed with print_min([c]). |
| max(c) | Keep track of the max value of a column c.<br>The result can be accessed with get_max(c) or |

| Function | Description |
|---|---|
| | printed with `print_max([c])`. |
| `abs(v)` | Return the absolute value of `v`. |
| `log2(n)` | Return the binary logarithm (log base 2) of `a`. |
| `max2(a,b)` | Return the maximum value between `a` and `b`. |
| `max3(a,b,c)` | Return the maximum value between `a`, `b` and `c`. |
| `min2(a,b)` | Return the minimum value between `a` and `b`. |
| `min3(a,b,c)` | Return the minimum value between `a`, `b` and `c`. |
| `aggr(fields[,val[,num]])` | Perform aggregation of `fields` and store the sum of `val`.<br>`fields` and `val` can be tab separated lists of fields, e.g., `$srcIP4"\t"$dstIP4`.<br>Results are sorted according to the first value of `val`.<br>If `val` is omitted, the empty string or equal to `"flows"` or `"packets"` (case insensitive), count the number of records (flows or packets).<br>If `num` is omitted or 0, return the full list.<br>If `num > 0` return the top `num` results.<br>If `num < 0` return the bottom `num` results. |
| `aggrrep(fields[,val[,num[,ign_e[,sep]]]])` | Perform aggregation of the repetitive `fields` and store the sum of `val`.<br>`val` can be a tab separated lists of fields, e.g., `$numBytesSnt"\t"$numPktsSnt`.<br>Results are sorted according to the first value of `val`.<br>If `val` is omitted, the empty string or equal to `"flows"` or `"packets"` (case insensitive), count the number of records (flows or packets).<br>If `num` is omitted or 0, return the full list.<br>If `num > 0` return the top `num` results.<br>If `num < 0` return the bottom `num` results.<br>If `ign_e` is omitted or 0, consider all values, otherwise ignore empty values.<br>`sep` can be used to change the separator character (default: `";"`). |
| `t2rsort(col[,num[,type]])` | Sort the file in reverse order according to `col`.<br>(Multiple column numbers can be specified by using `";"` as separator, e.g., `1 ";" 2`)<br>If `num` is omitted or 0, return the full list.<br>If `num > 0` return the top `num` results.<br>If `num < 0` return the bottom `num` results.<br>`type` can be used to specify the type of data to sort: `"ip"`, `"num"` or `"str"` (default is based on the first matching record). |
| `t2sort(col[,num[,type[,rev]]])` | Sort the file according to `col`.<br>(Multiple column numbers can be specified by using `";"` as separator, e.g., `1 ";" 2`)<br>If `num` is omitted or 0, return the full list.<br>If `num > 0` return the top `num` results.<br>If `num < 0` return the bottom `num` results.<br>`type` can be used to specify the type of data to sort: |

| Function | Description |
|---|---|
| | "ip", "num" or "str" (default is based on the first matching record).<br>If rev > 0, sort in reverse order (alternatively, use the t2rsort() function). |
| t2whois(ip[,o_opt]) | Wrapper to call t2whois from tawk.<br>ip must be a valid IPv4/6 address.<br>o_opt is passed verbatim to t2whois -o option<br>(run t2whois -L for more details). |
| wildcard(expr) | Print all columns whose name matches the regular expression expr.<br>If expr is preceded by an exclamation mark, return all columns whose name does **NOT** match expr. |
| hrnum(num[,mode[,suffix]]) | Convert the number num to its human readable form. |
| json([s]) | Convert the string s to JSON. The first record is used as column names.<br>If s is omitted, convert the entire row. |
| texscape(s) | Escape the string s to make it LaTeX compatible. |
| bitshift(n,t[,d[,b]]) | Shift a byte or of a list of bytes n to the left or right by a given number of bits t.<br>To shift to the left, set d to 0 (default), to shift to the right set d $\neq$ 0.<br>Set b to 16 to force interpretation as hexadecimal,<br>e.g., interpret 45 as 69 (0x45) instead of 45. |
| nibble_swap(n[,b]) | Swap the nibbles of a byte or of a list of bytes n.<br>Set b to 16 to force interpretation as hexadecimal,<br>e.g., interpret 45 as 69 (0x45) instead of 45. |
| tobits(u,[b]) | Convert the unsigned integer u to its binary representation.<br>Set b to 16 to force interpretation as hexadecimal,<br>e.g., interpret 45 as 69 (0x45) instead of 45. |
| base64(s) | Encode a string s as base64. |
| base64d(s) | Decode a base64 encoded string s. |
| urldecode(url) | Decode the encoded URL url. |
| printerr(s) | Print the string s in red with an added newline to stderr. |
| printinf(s) | Print the string s in blue with an added newline. |
| printok(s) | Print the string s in green with an added newline. |
| printwrn(s) | Print the string s in orange with an added newline. |
| diff(file[,mode]) | Compare two files (file and the input), and print the name and number of the columns which differ. The mode parameter can be used to control the format of the output. |
| ffsplit([s[,k[,h]]]) | Split the input file into smaller more manageable files.<br>The files to create can be specified as argument to the function (one comma separated string). If no argument is specified, create one file per column whose name ends with Stat, e.g., dnsStat, and one for pwxType (pw). |

| Function | Description |
|---|---|
| | If k > 0, then only print relevant fields and those controlled by h, a comma separated list of fields to keep in each file, e.g., "srcIP,dstIP". |
| flow([f]) | Return all flows whose index appears in f (comma or semicolon separated). Ranges may also be specified using a dash, e.g., flow("1-3"). If f is omitted, return the flow index. |
| packet([p]) | Return all packets whose number appears in p (comma or semicolon separated). Ranges may also be specified using a dash, e.g., packet("1-3"). If p is omitted, return the packet number. |
| follow_stream(f[,of[,d[,pf[,r[,nc]]]]]) | Return the payload of the flow with index f.<br>of can be used to change the output format [default: 0]:<br>0: Payload only,<br>1: prefix each payload with packet/flow info,<br>2: JSON,<br>3: Reconstruct (pipe the output to xxd -p -r to reproduce the binary file).<br>d can be used to only extract a specific direction ("A" or "B") [default: "" (A and B)].<br>pf can be used to change the payload format [default: 0]:<br>0: ASCII,<br>1: Hexdump,<br>2: Raw/Binary,<br>3: Base64.<br>r can be used to prevent the analysis of TCP sequence numbers (no TCP reassembly and reordering).<br>nc can be used to print the data without colors. |
| shark(q) | Query flow files according to Wireshark's syntax. |

## 74.8 Examples

Collection of examples using tawk functions:

| Function | Description |
|---|---|
| dnsZT() | Return all flows where a DNS zone transfer was performed. |
| exeDL([n]) | Return the top N EXE downloads. |
| httpHostsURL([f]) | Return all HTTP hosts and a list of the files hosted (sorted alphabetically). If f > 0, print the number of times a URL was requested. |
| nonstdports() | Return all flows running protocols over non-standard ports. |
| passivedns() | Extract all DNS server replies from a flow file. |

| Function | Description |
|---|---|
| | The following information is reported for each reply:<br>FirstSeen, LastSeen, Type (A or AAAA), TTL, Query, Answer,<br>Organization, Country, AS number |
| `passwords([val[,num]])` | Return information about hosts sending authentication in cleartext.<br>If `val` is omitted or equal to `"flows"`, count the number of flows.<br>Otherwise, sum up the values of `val`.<br>If `num` is omitted or 0, returns the full list.<br>If `num > 0` return the top `num` results.<br>If `num < 0` return the bottom `num` results. |
| `postQryStr([n])` | Return the top N POST requests with query strings. |
| `ssh()` | Return the SSH connections. |
| `topDnsA([n])` | Return the top N DNS answers. |
| `topDnsIp4([n])` | Return the top N DNS answers IPv4 addresses. |
| `topDnsIp6([n])` | Return the top N DNS answers IPv6 addresses. |
| `topDnsQ([n])` | Return the top N DNS queries. |
| `topHttpMimesST([n])` | Return the top HTTP content-type (type/subtype). |
| `topHttpMimesT([n])` | Return the top HTTP content-type (type only). |
| `topSLD([n])` | Return the top N second-level domains queried (google.com, yahoo.com, ...). |
| `topTLD([n])` | Return the top N top-level domains (TLD) queried (.com, .net, ...). |

## 74.9 t2nfdump

Collection of functions for `tawk` allowing access to specific fields using a syntax similar as `nfdump`.

| Function | Description |
|---|---|
| `ts()` | Start Time — first seen |
| `te()` | End Time — last seen |
| `td()` | Duration |
| `pr()` | Protocol |
| `sa()` | Source Address |
| `da()` | Destination Address |
| `sap()` | Source Address:Port |
| `dap()` | Destination Address:Port |
| `sp()` | Source Port |
| `dp()` | Destination Port |
| `pkt()` | Packets — default input |
| `ipkt()` | Input Packets |
| `opkt()` | Output Packets |
| `byt()` | Bytes — default input |

| Function | Description |
|---|---|
| ibyt() | Input Bytes |
| obyt() | Output Bytes |
| flg() | TCP Flags |
| mpls1() | MPLS label 1 |
| mpls2() | MPLS label 2 |
| mpls3() | MPLS label 3 |
| mpls4() | MPLS label 4 |
| mpls5() | MPLS label 5 |
| mpls6() | MPLS label 6 |
| mpls7() | MPLS label 7 |
| mpls8() | MPLS label 8 |
| mpls9() | MPLS label 9 |
| mpls10() | MPLS label 10 |
| mpls() | MPLS labels 1–10 |
| bps() | Bits per second |
| pps() | Packets per second |
| bpp() | Bytes per packet |
| | |
| oline() | nfdump line output format (-o line) |
| olong() | nfdump long output format (-o long) |
| oextended() | nfdump extended output format (-o extended) |

## 74.10 t2custom

Copy your own functions in this folder. Refer to Section 74.11 for more details on how to write a tawk function. To have your functions automatically loaded, include them in the file t2custom/t2custom.load.

## 74.11 Writing a tawk Function

- Ideally one function per file (where the filename is the name of the function)
- Private functions are prefixed with an underscore
- Always declare local variables 8 spaces after the function arguments
- Local variables are prefixed with an underscore
- Use uppercase letters and two leading and two trailing underscores for global variables
- Include all referenced functions
- Files should be structured as follows:

```
#!/usr/bin/env awk
#
# Function description
#
# Parameters:
```

```
#   - arg1: description
#   - arg2: description (optional)
#
# Dependencies:
#   - plugin1
#   - plugin2 (optional)
#
# Examples:
#   - tawk 'funcname()' file.txt
#   - tawk '{ print funcname() }' file.txt

@include "hdr"
@include "_validate_col"

function funcname(arg1, arg2, [8 spaces] _locvar1, _locvar2) {
    _locvar1 = _validate_col("colname1;altcolname1", _my_colname1)
    _validate_col("colname2")

    if (hdr()) {
        if (__PRIHDR__) print "header"
    } else {
        print "something", $_locvar1, $colname2
    }
}
```

## 74.12 Using tawk Within Scripts

To use `tawk` from within a script:

1. Create a `TAWK` variable pointing to the script: `TAWK="$T2HOME/scripts/tawk/tawk"`
2. Call `tawk` as follows: `$TAWK 'dport(80)' file.txt`

## 74.13 Using tawk With Non-Tranalyzer Files

`tawk` can also be used with files which were not produced by Tranalyzer.

- The input field separator can be specified with the `-F` option, e.g., `tawk -F ',' 'program' file.csv`
- The row listing the column names, can start with any character specified with the `-s` option, e.g., `tawk -s '#' 'program' file.txt`
- All the column names must not be equal to a function or builtin name
- Valid column names must start with a letter (`a-z`, `A-Z`) and can be followed by any number of alphanumeric characters or underscores
- If the column names are different from those used by Tranalyzer, refer to Section 74.13.1.

### 74.13.1 Mapping External Column Names to Tranalyzer Column Names

If the column names are different from those used by Tranalyzer, a mapping between the different names can be made in the file `my_vars`. The format of the file is as follows:

```
BEGIN {
    _my_srcIP = non_t2_name_for_srcIP
    _my_dstIP = non_t2_name_for_dstIP
    ...
}
```

Once edited, run tawk with the `-i $T2HOME/scripts/tawk/my_vars` option and the external column names will be automatically used by tawk functions, such as `tuple2()`. For more details, refer to the `my_vars` file.

### 74.13.2 Using tawk with Bro/Zeek Files

To use tawk with Bro/Zeek log files, use one of `--bro` or `--zeek` option:

```
tawk -bro '{ program }' file.log tawk -zeek '{ program }' file.log
```

## 74.14 Awk Cheat Sheet

- Tranalyzer flow files default field separator is '`\t`':
  - **Always** use `awk -F'\t'` (or `awkf`/`tawk`) when working with flow files.
- Load libraries, e.g., tawk functions, with `-i`: `awk -i file.awk 'program' file.txt`
- Always use `strtonum` with hex numbers (bitfields)
- Awk indices start at 1
- Using tawk is recommended.

### 74.14.1 Useful Variables

- `$0`: entire line
- `$1`, `$2`, ..., `$NF`: column 1, 2, ...
- `FS`: field separator
- `OFS`: output field separator
- `ORS`: output record separator
- `NF`: number of fields (columns)
- `NR`: record (line) number
- `FNR`: record (line) number relative to the current file
- `FILENAME`: name of current file
- To use external variables, use the `-v` option, e.g., `awk -v name="value" '{ print name }' file.txt`.

### 74.14.2 Awk Program Structure

```
awk -F'\t' -i min -v OFS='\t' -v h="$(hostname)" '
    BEGIN { a = 0; b = 0; }         # Called once at the beginning
    /^A/  { a++ }                   # Called for every row starting with char A
    /^B/  { b++ }                   # Called for every row starting with char B
          { c++ }                   # Called for every row
    END   { print h, min(a, b), c } # Called once at the end
' file.txt
```

## 74.15 Awk Templates

- Print the whole line:
  - `tawk '{ print }' file.txt`
  - `tawk '{ print $0 }' file.txt`
  - `tawk 'FILTER' file.txt`
  - `tawk 'FILTER { print }' file.txt`
  - `tawk 'FILTER { print $0 }' file.txt`
- Print selected columns only:
  - `tawk '{ print $srcIP4, $dstIP4 }' file.txt`
  - `tawk '{ print $1, $2 }' file.txt`
  - `tawk '{ print $4 "\t" $6 }' file.txt`
  - ```
    tawk '{
          for (i = 6; i < NF; i++) {
              printf "%s\t", $i
          }
          printf "%s\n", $NF
      }' file.txt
    ```
- Keep the column names:
  - `tawk 'hdr() || FILTER' file.txt`
  - `awkf 'NR == 1 || FILTER' file.txt`
  - `awkf '/^%/ || FILTER' file.txt`
  - `awkf '/^%[[:space:]]*[[:alpha:]][[:alnum:]_]*$/ || FILTER' file.txt`
- Skip the column names:
  - `tawk '!hdr() && FILTER' file.txt`
  - `awkf 'NR > 1 && FILTER' file.txt`
  - `awkf '!/^%/ && FILTER' file.txt`
  - `awkf '!/^%[[:space:]]*[[:alpha:]][[:alnum:]_]*$/ && FILTER' file.txt`
- Bitfields and hexadecimal numbers:
    ```

  - `tawk 'bfeq($3,0)' file.txt`
  - `awkf 'strtonum($3) == 0' file.txt`
  - `tawk 'bitsanyset($3,1)' file.txt`
  - `tawk 'bitsallset($3,0x81)' file.txt`
  - `awkf 'and(strtonum($3), 0x1)' file.txt`

- Split compound values:
  - `tawk '{ print splitc($16, 1) }' file.txt # first element`
  - `tawk '{ print splitc($16, -1) }' file.txt # last element`
  - `awkf '{ split($16, A, "_"); print A[1] }' file.txt`
  - `awkf '{ n = split($16, A, "_"); print A[n] }' file.txt # last element`
  - `tawk '{ print splitc($16) }' file.txt`
  - `awkf '{ split($16, A, "_"); for (i=1;i<=length(A);i++) print A[i] }' file.txt`

- Split repetitive values:
  - `tawk '{ print splitr($16, 3) }' file.txt # third repetition`
  - `tawk '{ print splitr($16, -2) }' file.txt # second to last repetition`
  - `awkf '{ split($16, A, ";"); print A[3] }' file.txt`
  - `awkf '{ n = split($16, A, ";"); print A[n] }' file.txt # last repetition`
  - `tawk '{ print splitr($16) }' file.txt`
  - `awkf '{ split($16, A, ";"); for (i=1;i<=length(A);i++) print A[i] }' file.txt`

- Filter out empty strings:
  - `tawk '!strisempty($4)' file.txt`
  - `awkf '!(length($4) == 0 || $4 == "\"\"")' file.txt`

- Compare strings (case sensitive):
  - `tawk 'streq($3,$4)' file.txt`
  - `awkf '$3 == $4' file.txt`
  - `awkf '$3 == \"text\"' file.txt`

- Compare strings (case insensitive):
  - `tawk 'streqi($3,$4)' file.txt`
  - `awkf 'tolower($3) == tolower($4)' file.txt`

- Use regular expressions on specific columns:
  - `awkf '$8 ~ /^192.168.1.[0-9]{1,3}$/' file.txt # print matching rows`
  - `awkf '$8 !~ /^192.168.1.[0-9]{1,3}$/' file.txt # print non-matching rows`

- Use column names in awk:

```
– tawk '{ print $srcIP4, $dstIP4 }' file.txt
– awkf '
      NR == 1 {
          for (i = 1; i <= NF; i++) {
              if ($i == "srcIP4") srcIP4 = i
              else if ($i == "dstIP4") dstIP4 = i
          }
          if (srcIP4 == 0 || dstIP4 == 0) {
              print "No column with name srcIP4 and/or dstIP4"
              exit
          }
      }
      NR > 1 {
          print $srcIP4, $dstIP4
      }
  ' file.txt
– awkf '
      NR == 1 {
          for (i = 1; i <= NF; i++) {
              col[$i] = i
          }
      }
      NR > 1 {
          print $col["srcIP4"], $col["dstIP4"];
      }

  ' file.txt
```

## 74.16 Examples

1. Pivoting (variant 1):

   (a) First extract an attribute of interest, e.g., an unresolved IP address in the `Host:` field of the HTTP header:

   ```
   tawk 'aggr($httpHosts)' FILE_flows.txt | tawk '{ print unquote($1); exit }'
   ```

   (b) Then, put the result of the last command in the `badguy` variable and use it to extract flows involving this IP:

   ```
   tawk -v badguy="$(!!)" 'host(badguy)' FILE_flows.txt
   ```

2. Pivoting (variant 2):

   (a) First extract an attribute of interest, e.g., an unresolved IP address in the `Host:` field of the HTTP header, and store it into a `badip` variable:

   ```
   badip="$(tawk 'aggr($httpHosts)' FILE_flows.txt | tawk '{ print unquote($1);exit }')"
   ```

   (b) Then, use the `badip` variable to extract flows involving this IP:

   ```
   tawk -v badguy="$badip" 'host(badguy)' FILE_flows.txt
   ```

3. Aggregate the number of bytes sent between source and destination addresses (independent of the protocol and port) and output the top 10 results:

```
tawk 'aggr($srcIP4 "\t" $dstIP4, $numBytesSnt, 10)' FILE_flows.txt

tawk 'aggr(tuple2(), $numBytesSnt "\t" "Flows", 10)' FILE_flows.txt
```

4. Sort the flow file according to the duration (longest flows first) and output the top 5 results:

```
tawk 't2sort(duration, 5)' FILE_flows.txt
```

5. Extract all TCP flows while keeping the header (column names):

```
tawk 'hdr() || tcp()' FILE_flows.txt
```

6. Extract all flows whose destination port is between 6000 and 6008 (included):

```
tawk 'dport("6000-6008")' FILE_flows.txt
```

7. Extract all flows whose destination port is 53, 80 or 8080:

```
tawk 'dport("53;80;8080")' FILE_flows.txt
```

8. Extract all flows whose source IP is in subnet 192.168.1.0/24 (using `host` or `net`):

```
tawk 'shost("192.168.1.0/24")' FILE_flows.txt

tawk 'snet("192.168.1.0/24")' FILE_flows.txt
```

9. Extract all flows whose source IP is in subnet 192.168.1.0/24 (using `ipinrange`):

```
tawk 'ipinrange($srcIP4, "192.168.1.0", "192.168.1.255")' FILE_flows.txt
```

10. Extract all flows whose source IP is in subnet 192.168.1.0/24 (using `ipinnet`):

```
tawk 'ipinnet($srcIP4, "192.168.1.0", "255.255.255.0")' FILE_flows.txt
```

11. Extract all flows whose source IP is in subnet 192.168.1.0/24 (using `ipinnet` and a hex mask):

```
tawk 'ipinnet($srcIP4, "192.168.1.0", 0xffffff00)' FILE_flows.txt
```

12. Extract all flows whose source IP is in subnet 192.168.1.0/24 (using `ipinnet` and the CIDR notation):

```
tawk 'ipinnet($srcIP4, "192.168.1.0/24")' FILE_flows.txt
```

13. Extract all flows whose source IP is in subnet 192.168.1.0/24 (using `ipinnet` and a CIDR mask):

```
tawk 'ipinnet($srcIP4, "192.168.1.0", 24)' FILE_flows.txt
```

For more examples, refer to tawk `-d` option, e.g., `tawk -d aggr`, where every function is documented and comes with a set of examples. The complete documentation can be consulted by running `tawk -d all`.

## 74.17 FAQ

### 74.17.1 Can I use tawk with non Tranalyzer files?

Yes, refer to Section 74.13.

### 74.17.2 Can I use tawk functions with non Tranalyzer column names?

Yes, edit the `my_vars` file and load it using `-i $T2HOME/scripts/tawk/my_vars` option. Refer to Section 74.13.1 for more details.

### 74.17.3 Can I use tawk with files without column names?

Yes, but you won't be able to use the functions which require a specific column, e.g., `host()`.

### 74.17.4 The row listing the column names start with a `'#'` instead of a `'%'`... Can I still use tawk?

Yes, use the `-s` option to specify the first character, e.g., `tawk -s '#' 'program'`

### 74.17.5 Can I process Bro/Zeek log files with tawk?

Yes, use the `--zeek` option.

### 74.17.6 Can I process a CSV (Comma Separated Value) file with tawk?

The simplest way to process CSV files is to use the `--csv` option. This sets the input and output separators to a comma and considers the first row to be the column names.

```
tawk --csv 'program' file.csv
```

Alternatively, the input field separator can be changed with the `-F` option and the output separator with `-O ','` or `-v OFS=','`. Note that tawk expects the column names to be the last row starting with a `'%'`. This can be changed with the `-s` and `-N` options (Section 74.5).

```
tawk -F ',' -v OFS=',' -s "" -N 1 'program' file.csv
```

### 74.17.7 Can I produce a CSV (Comma Separated Value) file from tawk?

The output field separator (`OFS`) can be changed with the `-O 'fs'` or `-v OFS='fs'` option. To produce a CSV file, run tawk as follows: `tawk -O ',' 'program' file.txt` or `tawk -v OFS=',' 'program' file.txt`

### 74.17.8 Can I write my tawk programs in a file instead of the command line?

Yes, copy the program (without the single quotes) in a file, e.g., `prog.txt` and run it as follows:
`tawk -f prog.txt file.txt`

### 74.17.9 Can I still use column names if I pipe data into tawk?

Yes, you can specify a file containing the column names with the `-I` option as follows:
`cat file.txt | tawk -I colnames.txt 'program'`

### 74.17.10 Can I use tawk if the row with the column names does not start with a special character?

Yes, you can specify the empty character with `-s ""`. Refer to Section 74.5 for more details.

### 74.17.11 I get a list of syntax errors from gawk... What is the problem?

The name of the columns is used to create variable names. If it contains forbidden characters, then an error similar to the following is reported.

```
gawk: /tmp/fileBndhdf:3: col-name = 3
gawk: /tmp/fileBndhdf:3:          ^ syntax error
```

Although tawk will try to replace forbidden characters with underscore, the best practice is to use only alphanumeric characters (`A-Z`, `a-z`, `0-9`) and underscore as column names. Note that a column name **MUST NOT** start with a number.

### 74.17.12 I get a function name previously defined error from gawk... What is the problem?

The name of the columns is used to create variable names. If a column is named after a tawk function or a builtin, then an error similar to the following is reported.

```
gawk: In file included from ah:21,
gawk:                  from /home/user/tranalyzer2/scripts/tawk/funcs/funcs.load:8,
gawk: proto:36: error: function name 'proto' previously defined
```

In this case, you have two options. Either rename the column(s) in your file, e.g., `proto` → `l4Proto` or use `tawk -t` option. With the `-t` option, Tawk tries to validate the column names by ensuring that no column names is equal to a function name and that all column names used in the program exist. Note that this verification process can be slow.

### 74.17.13 Tawk cannot find the column names... What is the problem?

First, make sure the comment char (`-s` option) is correctly set for your file (the default is `'%'`). Second, make sure the column names do not contain forbidden characters, i.e., use only alphanumeric and underscore and do not start with a number. If the row with column names is not the last one to start with the separator character, then specify the line number with the `-N` option as follows: `tawk -N 3'` or `tawk -s '#' -N 2`. Refer to Section 74.5 for more details.

### 74.17.14 Wireshark refuses to open PCAP files generated with tawk `-k` option...

If Wireshark displays the message `Couldn't run /usr/bin/dumpcap in child process: Permission Denied.`, then this means that your user does not belong to the `wireshark` group. To fix this issue, simply run the following command `sudo gpasswd -a YOUR_USERNAME wireshark` (you will then need to log off and on again).

### 74.17.15 Tawk reports errors similar to `free(): double free detected in tcache 2`

Tawk uses `gawk -M` option to handle IPv6 addresses. For some reasons, this option is regularly affected by bugs... If you do not need IPv6 support, you can simply comment out line 653 in `tawk`:

```
OPTS=(
    #-M -v PREC=256         # <-- Add the leading sharp ('#') here
    -v __PRIHDR__=$PRIHDR
    -v __UNAME__="$(uname)"
)
```

#### 74.17.16 Tawk `-k` reports errors similar to `Couldn't run dumpcap in child process: Permission denied`

On some Linux distributions, capturing packets is only allowed as `root` or as a member of the `wireshark` group.

Run the following command to add yourself to the `wireshark` group.

```
$ sudo usermod -a -G wireshark $USER
```

Then, log out and log in again (or reboot) and the problem should be fixed!

More information on the Wireshark wiki.

# A Creating a Custom Plugin

A plugin is a shared library file comprising of special functionality. Tranalyzer2 dynamically loads these shared libraries at runtime from the *~/.tranalyzer/plugins* directory in the user's home folder. Therefore Tranalyzer2 is available for users if being installed in the */usr/local/bin* directory while the plugins are user dependent. To develop a plugin it is strongly recommended that the user utilizes our special "t2plugin" script. This script uses the plugin skeleton "t2PSkel" to create a new custom named plugin. It is available in the *scripts/* folder. The script copies only the required files. Therefore it is recommended to upload the newly created folder to a SVN/GIT repository before running `./autogen.sh` (alternatively, `./autogen.sh -c` can be used to clean up automatically generated files that should not be committed). The skeleton contains a header and a source file comprising of all mandatory and optional functions as well as a small `HOWTO` file and a script to build and move a shared library to the plugins folder.

## A.1 Plugin Name

Plugin names should be kept short, start with a lowercase letter and only contain characters in the following ranges: a–z, A–Z, 0–9, _. In addition, each "word" should start with an uppercase letter, e.g., `pluginName`.

## A.2 Plugin Number

The plugin number (or order) influences when a plugin is to be loaded (useful if a plugin depends on another one). This number should consist of three digits and be unique. The plugin orders used in your Tranalyzer installation can be listed with `$T2HOME/doc/list_plugin_numbers.sh` or `t2plugin -l`. As a rule of thumb, numbers greater than 900 should be kept for sink (output) plugins and numbers smaller than 10 for global plugins.

| plugin range | description |
|---|---|
| 000 - 099 | Global |
| 100 - 199 | Basic L2/3/4 plugins |
| 200 - 299 | Service and routing |
| 300 - 699 | L7 protocols |
| 700 - 799 | Math and statistics |
| 800 - 899 | Classifier and AI |
| 900 - 999 | Output (sink) |

## A.3 Plugin Creation

To create a new plugin named *pluginName* with plugin order 123, run the following command from Tranalyzer's root folder:

```
./scripts/t2plugin -c pluginName -n 123
```

If no plugin number is provided, then the script will choose a random one that is not used by any other plugin.
A C++ plugin can be created by passing the additional '–cpp' option:

```
./scripts/t2plugin -c pluginName -n 123 -cpp
```

### A.3.1 autogen.sh

The `autogen.sh` script provides the `EXTRAFILES` variable, which is used to list extra files, such as lists of subnets, protocols, services, databases or blacklists, that the plugin needs in order to run. The files listed in this variable are automatically copied into the Tranalyzer plugin folder.

```
EXTRAFILES=(dependency1 dependency2)
```

The `CFLAGS` variable in `autogen.sh` can be used if a plugin requires specific libraries, compilation or linking flags, e.g., `CFLAGS="-lzip"`. In such a case, the `DEPS` variable can be used to list the dependencies, e.g., `DEPS="libzip"`.

## A.4 Compilation

The plugin can then be compiled by typing `./autogen.sh`. For a complete list of options, run `./autogen.sh -h`

## A.5 Plugin Structure

All plugins have the same global structures, namely, a comment describing the license of the plugin, e.g., GPLv2+, some includes, followed by the declaration of variables and functions. This section discusses the Tranalyzer callbacks which follows the elements already mentioned. Note that all the callbacks are optional, but a plugin **MUST** call one of the initialization macros.

**First, a plugin MUST have one the following declarations:**

- `T2_PLUGIN_INIT(name, version, t2_v_major, t2_v_minor)`
- `T2_PLUGIN_INIT_WITH_DEPS(name, version, t2_v_major, t2_v_minor, deps)`

For example, to initialize `myPlugin`:

```
T2_PLUGIN_INIT_WITH_DEPS("myPlugin", "0.9.2", 0, 9, "tcpFlags,basicStats")
```

**The available callbacks are:**

- `void t2Init()`
- `binary_value_t *t2PrintHeader()`
- `void t2OnNewFlow(packet_t *packet, unsigned long flowIndex)`
- `void t2OnLayer2(packet_t *packet, unsigned long flowIndex)`
- `void t2OnLayer4(packet_t *packet, unsigned long flowIndex)`
- `void t2OnFlowTerminate(unsigned long flowIndex, outputBuffer_t *buf)`
- `void t2PluginReport(FILE *stream)`
- `void t2Finalize()`
- `void t2BufferToSink(outputBuffer_t *buffer, binary_value_t *bv)` [Sink (output) plugins only]

**The following callbacks offer more advanced capabilities:**

- `void t2BusCallback(uint32_t status)` [Not implemented]
- `void t2Monitoring(FILE *stream, uint8_t state)`
- `void t2SaveState(FILE *stream)`
- `void t2RestoreState(char *str)`

### A.5.1 `void t2Init()`

This function is called before processing any packet.

### A.5.2 `binary_value_t *t2PrintHeader()`

This function is used to describe the columns output by the plugin. Refer to Section A.8 and the `BV_APPEND` macros.

### A.5.3 `void t2OnNewFlow(packet_t *packet, unsigned long flowIndex)`

This function is called every time a new flow is created.

### A.5.4 `void t2OnLayer2(packet_t *packet, unsigned long flowIndex)`

This function is called for every packet with a layer 2. If `flowIndex` is `HASHTABLE_ENTRY_NOT_FOUND`, this means the packet also has a layer 4 and thus a call to `t2OnLayer4()` will follow.

### A.5.5 `void t2OnLayer4(packet_t *packet, unsigned long flowIndex)`

This function is called for every packet with a layer 4.

### A.5.6 `void t2OnFlowTerminate(unsigned long flowIndex, outputBuffer_t *buf)`

This function is called once a flow is terminated. Output all the statistics for the flow here. Refer to Section A.8 and the `OUTBUF_APPEND` macros.

### A.5.7 `void t2BusCallback(uint32_t status)`

Currently not implemented.

### A.5.8 `void t2Monitoring(FILE *stream, uint8_t state)`

This function is used to report information regarding the plugin at regular interval or when a `USR1` signal is received. `state` can be one of the following:

- `T2_MON_PRI_HDR`: a header (value names) must be printed
- `T2_MON_PRI_VAL`: the actual data must be printed
- `T2_MON_PRI_REPORT`: a report (similar to the plugin report) must be printed

#### A.5.9 `void t2PluginReport(FILE *stream)`

This function is used to report information regarding the plugin. This will appear in the final report.

#### A.5.10 `void t2Finalize()`

This function is called once all the packets have been processed. Cleanup all used memory here.

#### A.5.11 `void t2SaveState(FILE *stream)`

This function is used to save the state of the plugin. Tranalyzer can then restore the state in a future execution.

#### A.5.12 `void t2RestoreState(char *str)`

This function is used to restore the state of the plugin. `str` represents the line written in t2SaveState().

#### A.5.13 `void t2BufferToSink(outputBuffer_t *buffer, binary_value_t *bv)`

This callback is only required for sink (output) plugins.

## A.6 Error, warning, and informational messages

Tranalyzer2 provides several macros to report errors, warnings, information or simple messages:

| | | |
|---|---|---|
| `T2_PLOG()` | print a normal message (standard terminal colors) | `pluginName: message` |
| `T2_PINF()` | print an information message (blue) | `[INF] pluginName: message` |
| `T2_POK()` | print an okay message (green) | `[OK] pluginName: message` |
| `T2_PWRN()` | print a warning message (yellow) | `[WRN] pluginName: message` |
| `T2_PERR()` | print an error message (red) | `[ERR] pluginName: message` |

Note that `T2_PERR` always prints to `stderr`, while the other macros print to `stdout` or `PREFIX_log.txt` if Tranalyzer `-l` option was used.

Their usage is straightforward:

```
T2_PLOG("pluginName", "message %d", 42);
```

Note that a trailing newline is automatically added.

## A.7 Naming Conventions

In order to avoid conflicts with other plugins, prefix all your macros and publicly available functions and variables with the plugin name or a few letters uniquely identifying the plugin.

## A.8 Generating Output

The following macros can be used to declare and append new columns to the output buffer. The `BV_APPEND_*` macros are used to declare a new column with a given `name`, description `desc` and type. The `OUTBUF_APPEND_*` macros are used to append a value `val` of the given type to the buffer `buf`.

| `BV` **Macro** | **Type** | **Corresponding** `OUBUF` **Macro** |
|---|---|---|
| **Unsigned values** | | |
| `BV_APPEND_U8(bv, name, desc)` | `bt_uint_8` | `OUTBUF_APPEND_U8(buf, val)` |
| `BV_APPEND_U16(bv, name, desc)` | `bt_uint_16` | `OUTBUF_APPEND_U16(buf, val)` |
| `BV_APPEND_U32(bv, name, desc)` | `bt_uint_32` | `OUTBUF_APPEND_U32(buf, val)` |
| `BV_APPEND_U64(bv, name, desc)` | `bt_uint_64` | `OUTBUF_APPEND_U64(buf, val)` |
| `BV_APPEND_H8(bv, name, desc)` | `bt_hex_8` | `OUTBUF_APPEND_H8(buf, val)` |
| `BV_APPEND_H16(bv, name, desc)` | `bt_hex_16` | `OUTBUF_APPEND_H16(buf, val)` |
| `BV_APPEND_H32(bv, name, desc)` | `bt_hex_32` | `OUTBUF_APPEND_H32(buf, val)` |
| `BV_APPEND_H64(bv, name, desc)` | `bt_hex_64` | `OUTBUF_APPEND_H64(buf, val)` |
| **Signed values** | | |
| `BV_APPEND_I8(bv, name, desc)` | `bt_int_8` | `OUTBUF_APPEND_I8(buf, val)` |
| `BV_APPEND_I16(bv, name, desc)` | `bt_int_16` | `OUTBUF_APPEND_I16(buf, val)` |
| `BV_APPEND_I32(bv, name, desc)` | `bt_int_32` | `OUTBUF_APPEND_I32(buf, val)` |
| `BV_APPEND_I64(bv, name, desc)` | `bt_int_64` | `OUTBUF_APPEND_I64(buf, val)` |
| **Floating points values** | | |
| `BV_APPEND_FLT(bv, name, desc)` | `bt_float` | `OUTBUF_APPEND_FLT(buf, val)` |
| `BV_APPEND_DBL(bv, name, desc)` | `bt_double` | `OUTBUF_APPEND_DBL(buf, val)` |
| **String values** | | |
| `BV_APPEND_STR(bv, name, desc)` | `bt_string` | `OUTBUF_APPEND_STR(buf, val)` |
| `BV_APPEND_STRC(bv, name, desc)` | `bt_string_class` | `OUTBUF_APPEND_STR(buf, val)` |
| **Time values (timestamp and duration)**[56] | | |
| `BV_APPEND_TIMESTAMP(bv, name, desc)` | `bt_timestamp` | `OUTBUF_APPEND_TIME(buf, sec, usec)` |
| `BV_APPEND_DURATION(bv, name, desc)` | `bt_duration` | `OUTBUF_APPEND_TIME(buf, sec, usec)` |
| **IP values (network order)** | | |
| `BV_APPEND_IP4(bv, name, desc)` | `bt_ip4_addr` | `OUTBUF_APPEND_IP4(buf, val)` |
| `BV_APPEND_IP6(bv, name, desc)` | `bt_ip6_addr` | `OUTBUF_APPEND_IP6(buf, val)` |

[56] Time values use an `uint64` for the seconds and an `uint32` for the micro-seconds

| | | |
|---|---|---|
| `BV_APPEND_IPX(bv, name, desc)` | `bt_ipx_addr` | `OUTBUF_APPEND_IPX(buf, version, val)`[57] |

If more flexibility is required the following macros can be used:

- `BV_APPEND(bv, name, desc, num_val, type1, type2, ...)`
- `OUTBUF_APPEND(buf, val, size)`

### A.8.1 Repetitive Values

A repetitive value consists of a `uint32` representing the number of repetitions, followed by the actual repetitions.

All the `BV_APPEND` macros introduced in the previous section can be suffixed with `_R` to represent a repetitive value:

`BV_APPEND_U8(bv, name, desc)` (non-repetitive) ⇒ `BV_APPEND_U8_R(bv, name, desc)` (repetitive).

In addition, the following `OUTBUF` macros are available for repetitive values:

| `OUTBUF` **Macro** | **Description** | **Type** |
|---|---|---|
| `OUTBUF_APPEND_OPTSTR(buf, val)` | If `val` is `NULL` or empty, appends 0 (`uint32`) else appends 1 (`uint32`) and the string | `bt_string`, `bt_string_class` |
| `OUTBUF_APPEND_NUMREP(buf, reps)` | Appends the number of repetitions (`uint32`)[58] | |

### A.8.2 Column Names

Column names should be kept short and only contain characters in the following ranges: `_, a-z, A-Z, 0-9`. In addition, each "word" should start with an uppercase letter, e.g., `myCol2`. The `'_'` character should be used to name compound values, e.g., `field1_field2`. A good practice is to prefix each column name with the short name of the plugin, e.g., `ftpDecode` → `ftpStat, ftpCNum`.

### A.8.3 More Complex Output

Refer to Section A.8.

## A.9 Accessible structures

Due to practical reasons all plugins are able to access every structure of the main program and the other plugins. This is indeed a security risk, but since Tranalyzer2 is a tool for practitioners and scientists in access limited environments the maximum possible freedom of the programmer is more important for us.

[57] Appends the IP `version` (`uint8`), followed by the IP. If `version` is 6, then calls `OUTBUF_APPEND_IP6(buf, val.IPv6.s6_addr[0]` else calls `OUTBUF_APPEND_IP4(buf, val.IPv4.s_addr`

[58] The correct number of values **MUST** then be appended.

## A.10 Important structures

A predominant structure in the main program is the flow table *flow* where the six tuple for the flow lookup timing information is stored as well as a pointer to a possible opposite flow. A plugin can access this structure by including the `packetCapture.h` header. For more information please refer to the header file.
Another important structure is the main output buffer `mainOutputBuffer`. This structure holds all standard output of activated plugins whenever a flow is terminated. The main output buffer is accessible if the plugin includes the header file `main.h`.

## A.11 Generating output (advanced)

As mentioned in Section A.8 there are two ways to generate output. The first is the case where a plugin just writes its arbitrary output into its own file, the second is writing flow-based information to a standard output file. We are now discussing the later case.

The standard output file generated by the txtSink plugin consists of a header, a delimiter and values. The header is generated using header information provided by each plugin, that writes output into the standard output file. During the initialization phase of the sniffing process, the core calls the `t2PrintHeader()` functions of these plugins. These functions return a single structure or a list of structures of type `binary_value_t`. Each structure represents a statistic. To provide a mechanism for hierarchical ordering, the statistic itself may contain one ore more values and one or more substructures.

The structure contains the following fields:

| Name | Type | Description |
|---|---|---|
| `num_values` | `uint32_t` | Amount of values in the statistic |
| `subval` | `binary_subvalue_t*` | Type definition of the values |
| `name` | `char[128]` | Name of the statistic |
| `desc` | `char[1024]` | Description of the statistic |
| `is_repeating` | `uint32_t` | One, if the statistic is repeating, zero otherwise |
| `next` | `binary_value_t*` | Used if the plugin provides more than one statistics |

The substructure `binary_subvalue_t` is used to describe the values of the statistic. For each value, one substructure is required. For example, if `num_values` is two, two substructures have to be allocated. The substructures must be implemented as a continuous array consisting of the following fields:

| Name | Type | Description |
|---|---|---|
| `value_type` | `uint32_t` | Type of the value |
| `num_values` | `uint32_t` | Amount of values in the statistic |
| `subval` | `binary_subvalue_t*` | Definition of the values |
| `is_repeating` | `uint32_t` | one, statistic is repeating, zero otherwise |

Compared to the `binary_value_t` representation two strings are omitted in the statistic's short and long description and the `*next` pointer but it contains a new field, the value type. Possible values for this new field are described in the enumeration `binary_types` defined in the header file *binaryValue.h*. If the field contains a value greater than zero the fields `num_values` and `subval` are ignored. They are needed if a subval contains itself subvalues. To indicate additional

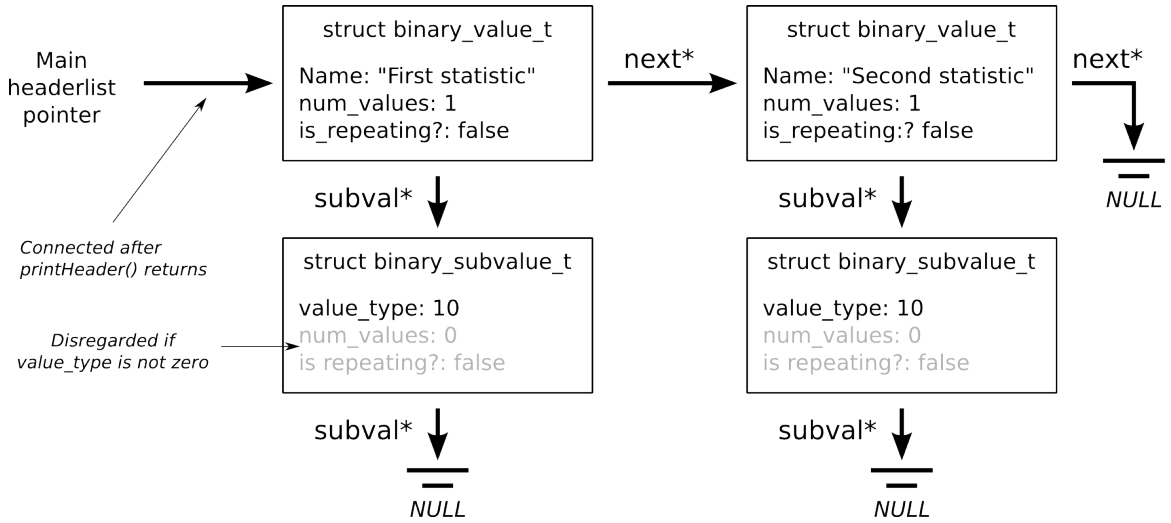
subvalues, the field `value_type` need to be set to zero. The mechanism is the same as for the `binary_value_t`.

The field `is_repeating` should be used if the number of values inside a statistic is variable; e.g. a statistic of a vector with variable length.

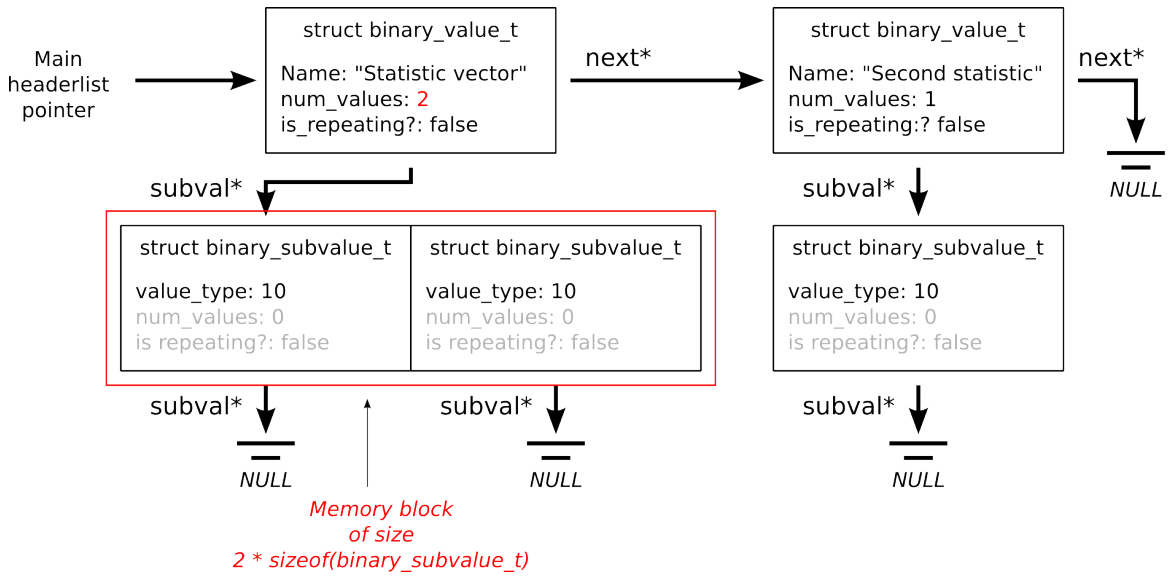
### A.11.1 Examples

The following examples illustrate the usage of the said two structures:

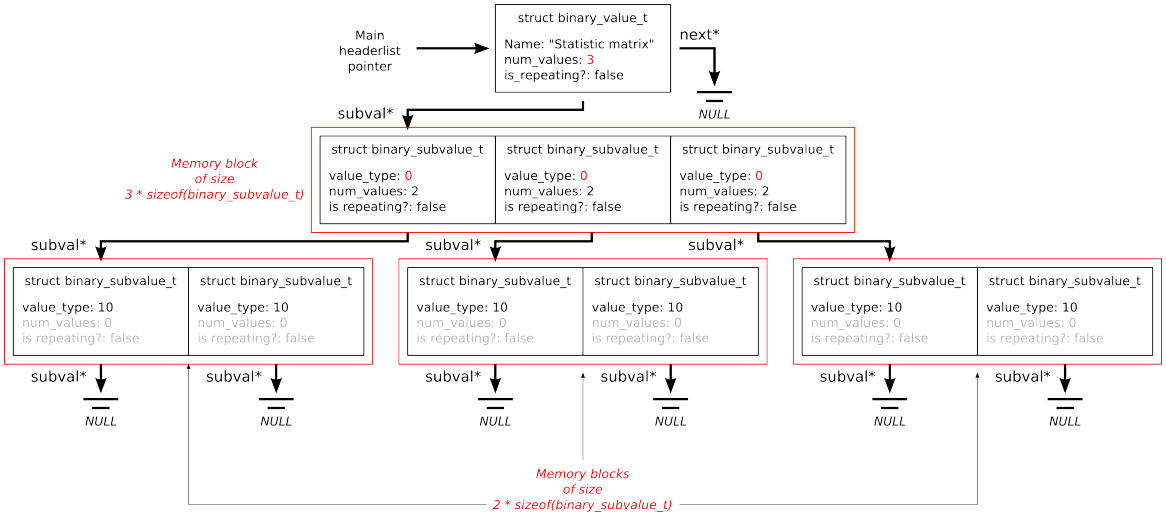
**Example 1: Two Statistics each containing a single value** If a plugin's output is consisting of two statistics each having a single value it needs to pass a list containing two structures of type `binary_value_t`. Both structures contain a substructure with the type of the single values. The following diagram shows the relationships between all four structures:




**Example 2: A statistic composed of two values** Now the output of the plugin is again two statistics, but the first statistic consists of two values; e.g. to describe a position on a grid. Therefore `num_values` is two and `subval*` points to a memory field of size two-times struct `binary_subvalue_t`. The subvalues themselves contain again the type of the statistic's values. Note: These values do not need to be identical.




**Example 3: A statistic containing a complete matrix** With the ability to define subvalues in subvalues it is possible to store multidimensional structures such as matrices. The following example illustrates the definition of a matrix of size three times two:




### A.11.2 Helper functions

In order to avoid filling the structures by hand a small API is located in the header file *binaryValue.h* doing all the nitty-gritty work for the programmer. The most important functions are described below.

`binary_value_t* bv_append_bv(binary_value_t* dest, binary_value_t* new)`

Append a `binary_value_t` struct at the end of a list of `binary_value_t` structures.

Return a pointer to the start of the list.

Arguments:

| Type | Name | Description |
|---|---|---|
| `binary_value_t*` | `dest` | pointer to the start of the list |
| `binary_value_t*` | `new` | pointer to the new `binary_value_t` structure |

```
binary_value_t* bv_new_bv (const char *name, const char *desc, uint32_t is_repeating,
                           uint32_t num_values...)
```

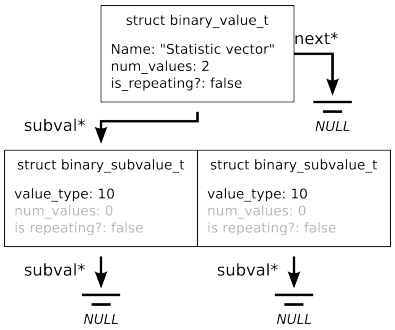
Generate a new structure of type `binary_value_t` and returns a pointer to it.

Arguments:

| Type | Name | Description |
|---|---|---|
| `char*` | `name` | name for the statistic |
| `char*` | `desc` | description for the statistic |
| `uint32_t` | `is_repeating` | one, if the statistic is repeating, zero otherwise |
| `uint32_t` | `num_values` | number of values for the statistic |
| `int` | `...` | types of the statistical values, repeated `num_values`-times |

The function creates a `binary_value_t` structure and sets the values. In addition, it creates an array field with `num_values binary_subvalue_t` structures and fills the value types provided in the variable argument list.

**Example:** The call `bv_new_bv("stat_vec", "Statistic vector", 2, 0, bt_uint_64, bt_uint_64)` creates the following structures:




```
binary_value_t* bv_add_sv_to_bv (binary_value_t* dest, uint32_t pos,
                                 uint32_t is_repeating, uint32_t num_values, ...)
```

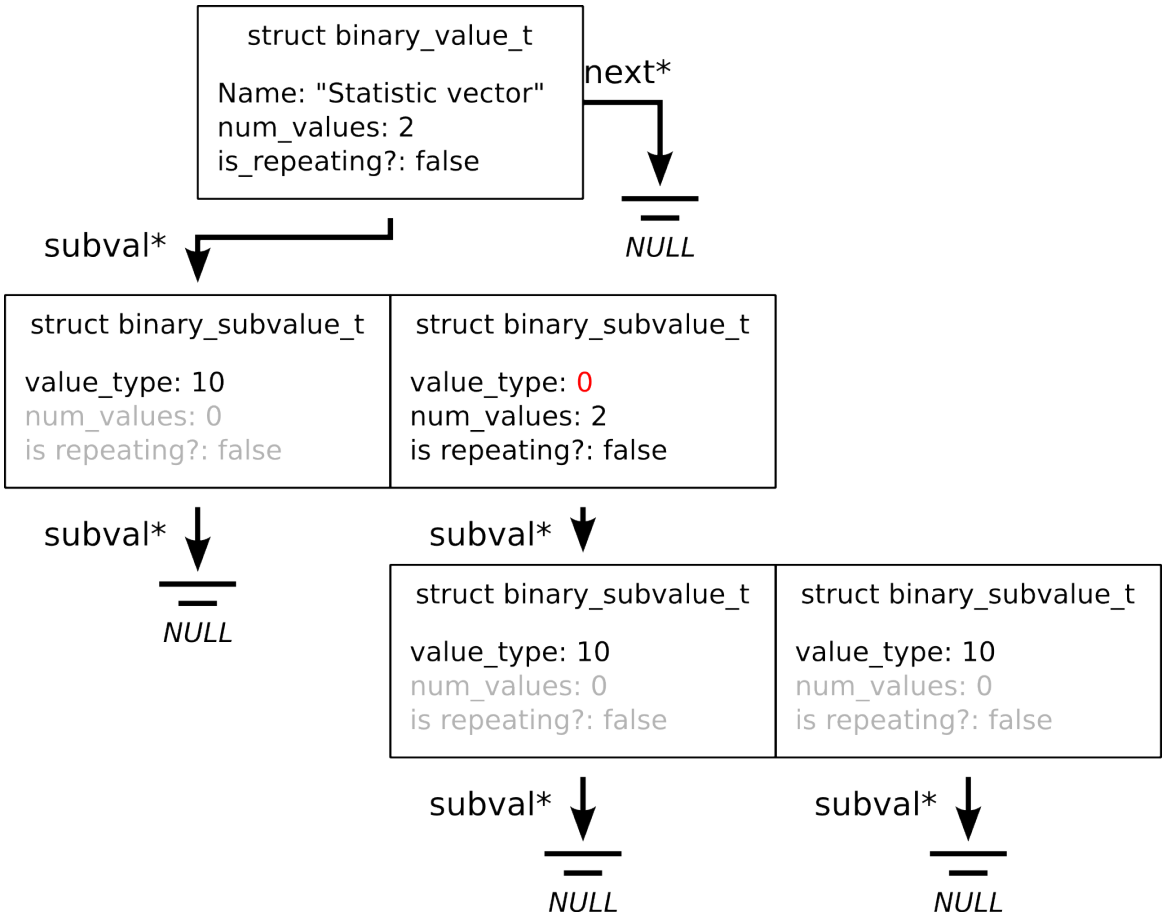
Replace a subvalue in a `binary_value_t` structure with a new substructure that contains additional substructures and returns a pointer to the parent binary value.

Arguments:

| Type | Name | Description |
|---|---|---|
| `binary_value_t*` | `dest` | pointer to the parent binary value |
| `uint32_t` | `pos` | position of the substructure to be replaced, starting at 0 |
| `uint32_t` | `is_repeating` | one, if the subvalue is repeating, zero otherwise |
| `uint32_t` | `num_values` | number of values in the subvalue |
| `int` | `...` | types of the statistical values, repeated `num_values`-times |

This function is only valid if `dest` is already a complete statistic containing all necessary structures.

**Example:** Let *dest* be a pointer to the `binary_value_t` structure from the example above. A call to the function `bv_add_sv_to_bv(dest, 1, 0, 2, bt_uint_64, bt_uint_64)` replaces the second substructure with a new substructure containing two more substructures:



```
binary_value_t* bv_add_sv_to_sv (binary_subvalue_t* dest, uint32_t pos,
                                 uint32_t is_repeating, uint32_t num_values, ...)
```

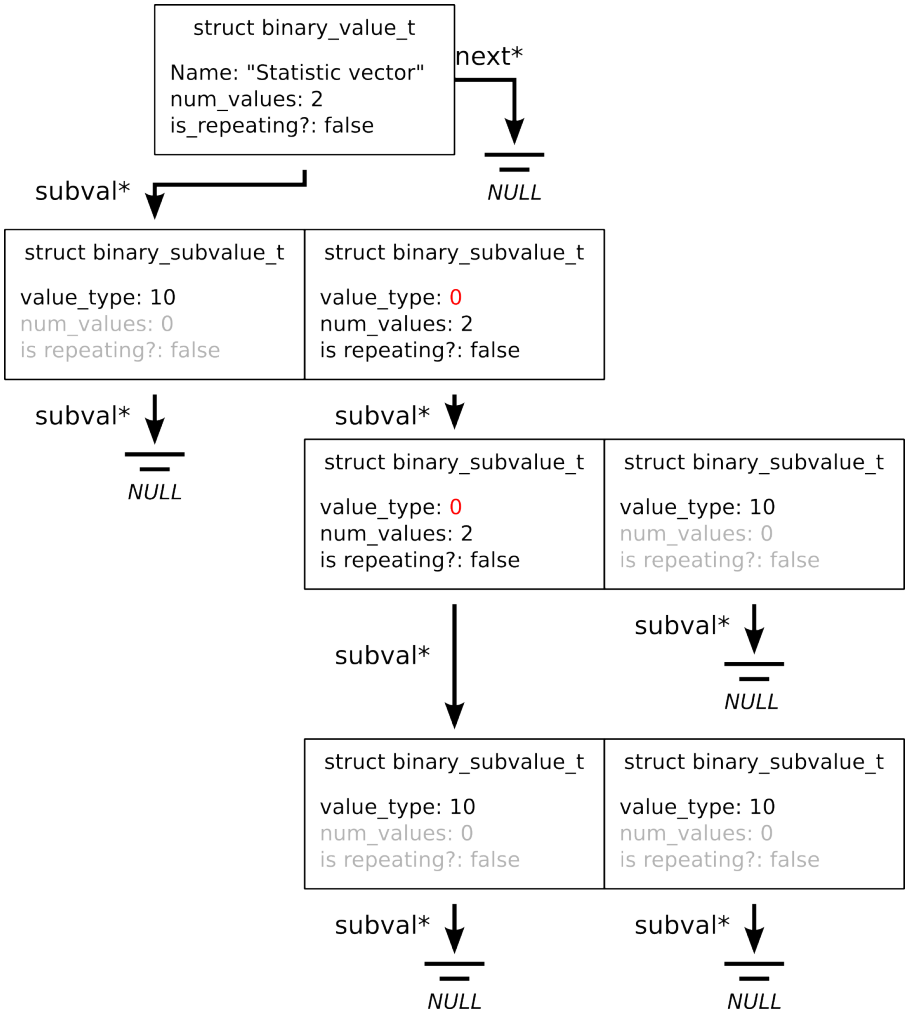
Replace a subvalue in a `binary_subvalue_t` structure with a new substructure that contains additional substructures and returns a pointer to the parent binary subvalue.

Arguments:

| Type | Name | Description |
|---|---|---|
| `binary_subvalue_t*` | `dest` | Pointer to the parent binary subvalue |
| `uint32_t` | `pos` | Position of the substructure to be replaced, starting at 0 |
| `uint32_t` | `is_repeating` | one, if the subvalue is repeating, zero otherwise |
| `uint32_t` | `num_values` | Number of values in the subvalue |
| `int` | `...` | Types of the statistical values, repeated `num_values`-times |

For all hierarchical deeper located structures than above the function described above is required.

**Example:** Let *dest* be a pointer to the subvalue structure being replaced in the example above. A call to the function `bv_add_sv_to_sv(dest, 0, 0, 2, bt_uint_64, bt_uint_64)` replaces *dest's* first the substructure with a new substructure containing two more substructures:




### A.11.3 Writing into the standard output

Standard output is generated using a buffer structure. Upon the event `t2OnFlowTerminate` (see A.15.6) Plugins write all output into this buffer. It is strongly recommended using the function `outputBuffer_append(outputBuffer_t* buffer, char* output, size_t size_of_output)`.
Arguments:

| Type | Name | Description |
|---|---|---|
| `outputBuffer_t*` | `buffer` | pointer to the standard output buffer structure, for standard output, this is `main_output_buffer` |
| `char*` | `output` | pointer to the output, currently of type `char` |
| `size_t` | `size_of_output` | the length of field `output` in single bytes |

The output buffer is send to the *output sinks* after all plugins have stored their information.

**Example:** If a plugin wants to write two statistics each with a single value of type `uint64_t` it first has to commit its `binary_value_t` structure(s) (see section above). During the call of its `t2OnFlowTerminate()` function the plugin writes both statistical values using the append function:

```
outputBuffer_append(main_output_buffer, (char*) &value1, 4);
outputBuffer_append(main_output_buffer, (char*) &value2, 4);
```

Where `value1` and `value2` are two pointers to the statistical values.

## A.12 Writing repeated output

If a statistic could be repeated (field `is_repeating` is one) the plugin has first to store the number of values as `uint32_t` value into the buffer. Afterwards, it appends the values.

**Example:** A plugin's output is a vector of variable length, the values are of type `uint16_t`. For the current flow, that is terminated in the function `t2OnFlowTerminate()`, there are three values to write. The plugin first writes a field of type `uint32_t` with value three into the buffer, using the append function:

```
outputbuffer_append(main_output_buffer, (char*) &numOfValues, sizeof(uint32_t));
```

Afterwards, it writes the tree values.

## A.13 Important notes

- IP addresses (`bt_ip4_addr`, `bt_ip6_addr` and `bt_ipx_addr`) or MAC addresses (`bt_mac_addr`) are stored in network order.
- Strings are of variable length and need to be stored with a trailing zero byte (`'\0'`).

## A.14 Administrative functions

Every plugin has to provide five administrative functions. The first four are mandatory while the last one is optional. For convenience, the following two macros can be used instead:

- `T2_PLUGIN_INIT(name, version, t2_v_major, t2_v_minor)`
- `T2_PLUGIN_INIT_WITH_DEPS(name, version, t2_v_major, t2_v_minor, deps)`

For example, to initialize `myPlugin`:

```
T2_PLUGIN_INIT_WITH_DEPS("myPlugin", "0.9.2", 0, 9, "tcpFlags,basicStats")
```

| Function | Description |
|---|---|
| `const char *t2PluginName()` | Name of the plugin, e.g., `"myPlugin"`. |
| `const char *t2PluginVersion()` | Version of the plugin, e.g., `"0.9.0"` |
| `unsigned int t2SupportedT2Major()` | Minimum major version of the core supported by the plugin, e.g., 0 |
| `unsigned int t2SupportedT2Minor()` | Minimum minor version of the core supported by the plugin, e.g., 9 |
| `const char *t2Dependencies()` | Comma separated list of plugin names required by the plugin, e.g., |

| Function | Description |
|---|---|
| | `"tcpFlags,tcpStates"` |

The existence of these functions is checked during the plugin initialization phase one and two, as highlighted in Figure 11.

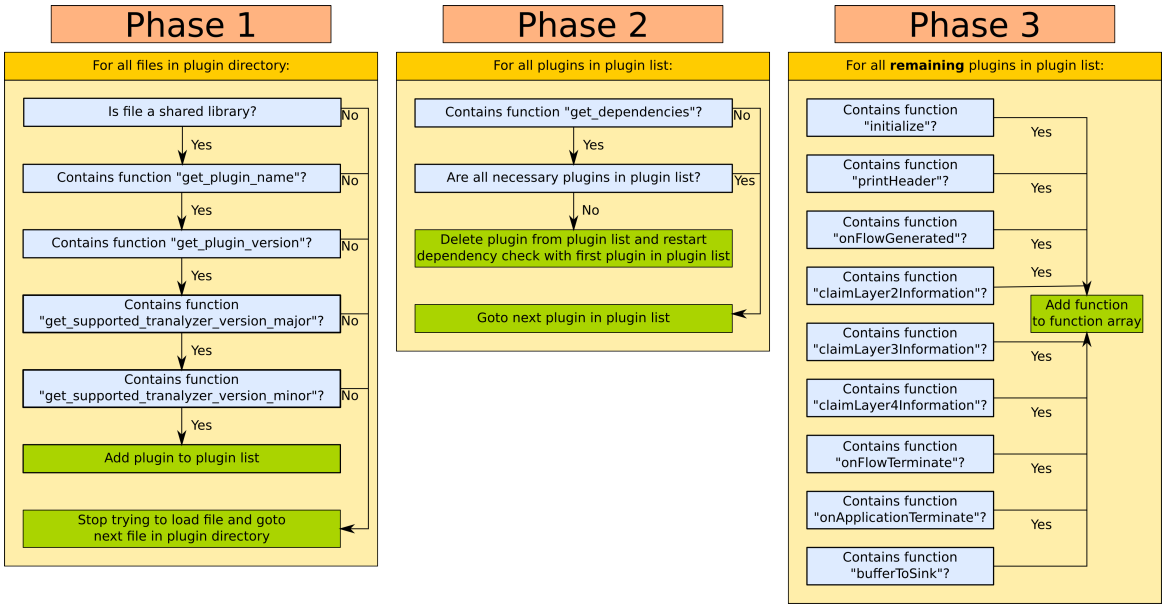



**Figure 11:** *Processing of the plugin loading mechanism*

## A.15 Processing functions

During flow analysis Tranalyzer2 generates several *events* based on the status of the program, the inspected OSI layer of the current packet or the status of the current flow. These events consist of specific function calls provided by the plugins. The implementation of the event functions is dependent on the required action of a plugin to be carried out upon a certain event.

### A.15.1 void t2Init()

The `t2Init` event is generated before the program activates the packet capturing phase. After Tranalyzer2 has initialized its internal structures it grants the same phase to the plugins. Therefore temporary values should be allocated during that event by using a C `malloc`.

### A.15.2 binary_value_t *t2PrintHeader()

This event is also generated during the initialization phase. With this event the plugin providing data to the standard output file signals the core what type of output they want to write (see A.8). The function returns a pointer to the generated `binary_value_t` structure or to the start pointer of a list of generated `binary_value_t` structures.

### A.15.3 void t2OnNewFlow(packet_t *packet, unsigned long flowIndex)

This event is generated every time Tranalyzer2 recognizes a new flow not present in the flow table. The first parameter is the currently processed packet, the second denotes the new generated flow index. As long as the flow is not terminated the flow index is valid. After flow termination the flow number is reintegrated into a list for later reuse.

### A.15.4 void t2OnLayer2(packet_t *packet, unsigned long flowIndex)

This event is generated for every new packet comprising of a valid and supported layer two header, e.g. Ethernet as default. This is the first event generated after libpcap dispatches a packet and before a lookup in the flow table happened. At this very point in time no tests are conducted for higher layer headers. If a plugin tries to access higher layer structures it has to test itself if they are present or not. Otherwise, at non-presence of higher layers an unchecked access can result in a `NULL` pointer access and therefore in a possible segmentation fault! We recommend using the subsequent two events to access higher layers.

### A.15.5 void t2OnLayer4(packet_t *packet, unsigned long flowIndex)

This event is generated for every new packet containing a valid and supported layer four header. The current supported layer four headers are TCP, UDP and ICMP. This event is called after Tranalyzer2 performs a lookup in its flow table and eventually generates an `t2OnNewFlow` event. Implementation of other protocols such as IPsec or OSPF are planned.

### A.15.6 void t2OnFlowTerminate(unsigned long flowIndex, outputBuffer_t *buf)

This event is generated every time Tranalyzer2 removes a flow from its active status either due to timeout or protocol normal or abnormal termination. Only during this event, the plugins write output to the standard output.

### A.15.7 void t2Finalize()

This event is generated shortly before the program is terminated. At this time no more packets or flows are processed. This event enables the plugins to do memory housekeeping, stream buffer flushing or printing of final statistics.

### A.15.8 void t2BufferToSink(outputBuffer_t *buffer, binary_value_t *bv)

The Tranalyzer core generates this event immediately after the `t2OnFlowTerminate` event with the main output buffer as parameter. A plugin listening to this event is able to write this buffer to a data sink. For example the binSink plugin pushes the output into the `PREFIX_flows.bin` file.

## A.16 Timeout handlers

A flow is terminated after a certain timeout being defined by so called *timeout handlers*. The default timeout value for a flow is 182 seconds. The plugins are able to access and change this value. For example, the tcpStates plugin changes the value according to different connection states of a TCP flow.

### A.16.1 Registering a new timeout handler

To register a new timeout handler, a plugin has to call the `timeout_handler_add(float timeout_in_sec)` function. The argument is the new timeout value in seconds. Now the plugin is authorized by the core to change the timeout of a flow to the registered timeout value. Without registering a timeout handler the test is unreliable.

### A.16.2 Programming convention and hints

- A call to `timeout_handler_add` should only happen during the initialization function of the plugin.
- Registering the same timeout value twice is no factor.
- Registering timeout values in fractions of seconds is possible, see tcpStates plugin.

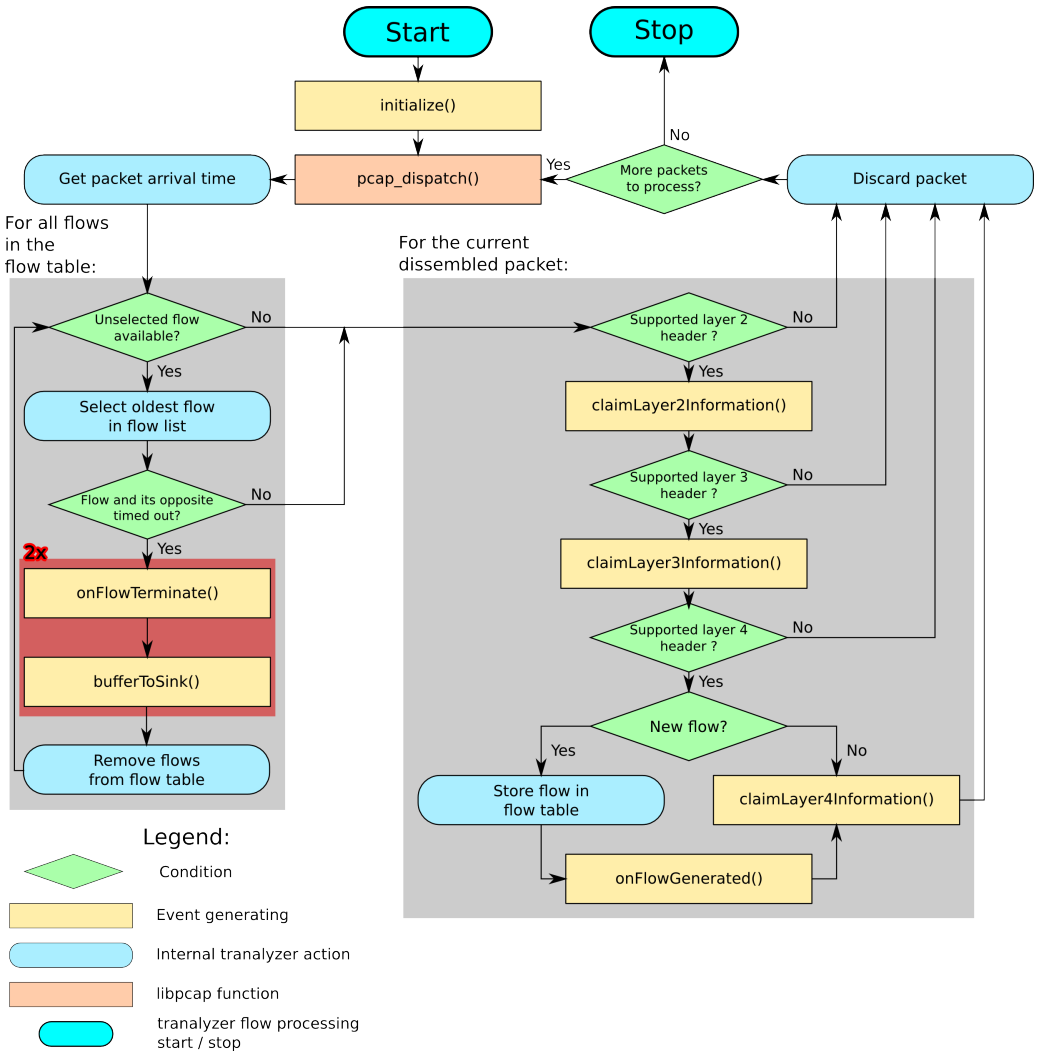



**Figure 12:** *Tranalyzer packet processing and event generation.*

# B Importing Tranalyzer Flows in Splunk

## B.1 Prerequisites

- tranalyzer2-0.9.2 is installed with standard/default plugins,
- Splunk 6.5.x is installed, Splunk account exists,
- At least one network interface (Ethernet or WLAN) has network traffic.

## B.2 Select Network Interface

Determine the network interface name by entering the following command:

```
ifconfig
```

at the terminal command line. In the output look for the interface name which has the IP address where the network traffic should be collected from:

```
en0: flags=8863<UP,BROADCAST,SMART,RUNNING,SIMPLEX,MULTICAST>
mtu 1500 inet 10.20.6.79 netmask 0xfffffc00 broadcast 10.20.7.255
```

## B.3 Configure Tranalyzer jsonSink Plugin

Go to *tranalyzer2-0.9.2/plugins/jsonSink/src/jsonSink.h* and set the configuration parameters as needed:

```
#define SOCKET_ON             1 // Whether to output to a socket (1) or file (0)
#define SOCKET_ADDR "127.0.0.1" // address of the socket
#define SOCKET_PORT        5000 // port of the socket
```

Set `SOCKET_ON` to `1` to configure the output to a socket. Set the IP address of the destination server which should receive the data stream. If the localhost will be the destination, leave the default setting `"127.0.0.1"`. Set the socket server port of the destination.

## B.4 Recompile the jsonSink Plugin

Enter the following command:

```
tranalyzer2-0.9.2/plugins/jsonSink/autogen.sh
```

Make sure that the plugin is compiled successfully. In this case the following message will be shown at the command line:

```
Plugin jsonSink copied into USER_DIRECTORY/.tranalyzer/plugins
```

## B.5 Start Tranalyzer2

Start generating flow records by launching Tranalyzer2 with the interface name determined on the previous step and setting a file name as the command line arguments by entering the command:

```
tranalyzer -i en0 -w test1 &
```

Note that the file name is optional for JSON stream import, if file name is not indicated the records will be shown in the standard output (besides being streamed over the configured TCP socket).

### B.5.1 Check File Output

Check that the flow records are written to the file by entering the command:

```
tail -f test1_flows.txt
```

Flow records should be shown in the terminal.

### B.5.2 Collect Traffic

Let Tranalyzer2 run and collect network traffic.

## B.6 Start Splunk

Start Splunk by entering the following command:

```
splunk start
```

in the directory where Splunk is installed. Wait for the confirmation message that Splunk is up and running:

```
The Splunk web interface is at http://splunk_hostname:8000
```

## B.7 Login to Splunk, Import and Search Data

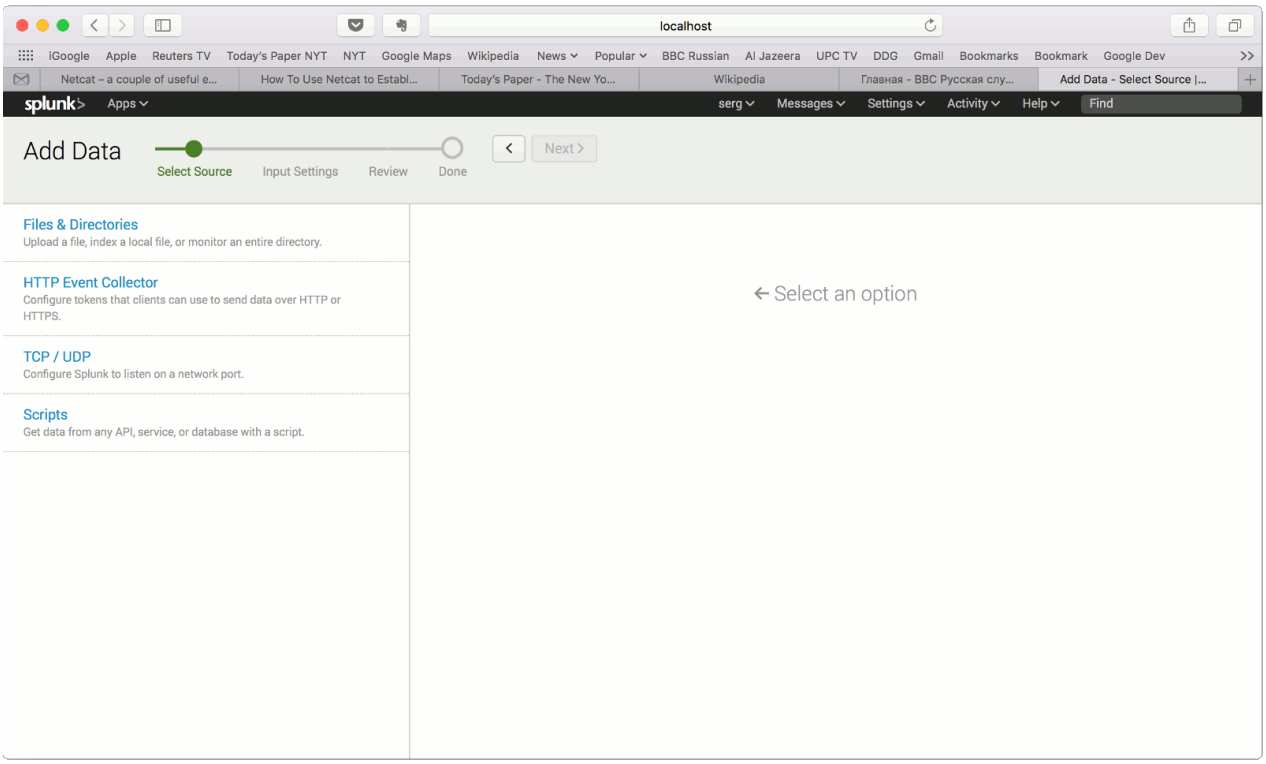



**Figure 13:** *Select "Add Data".*

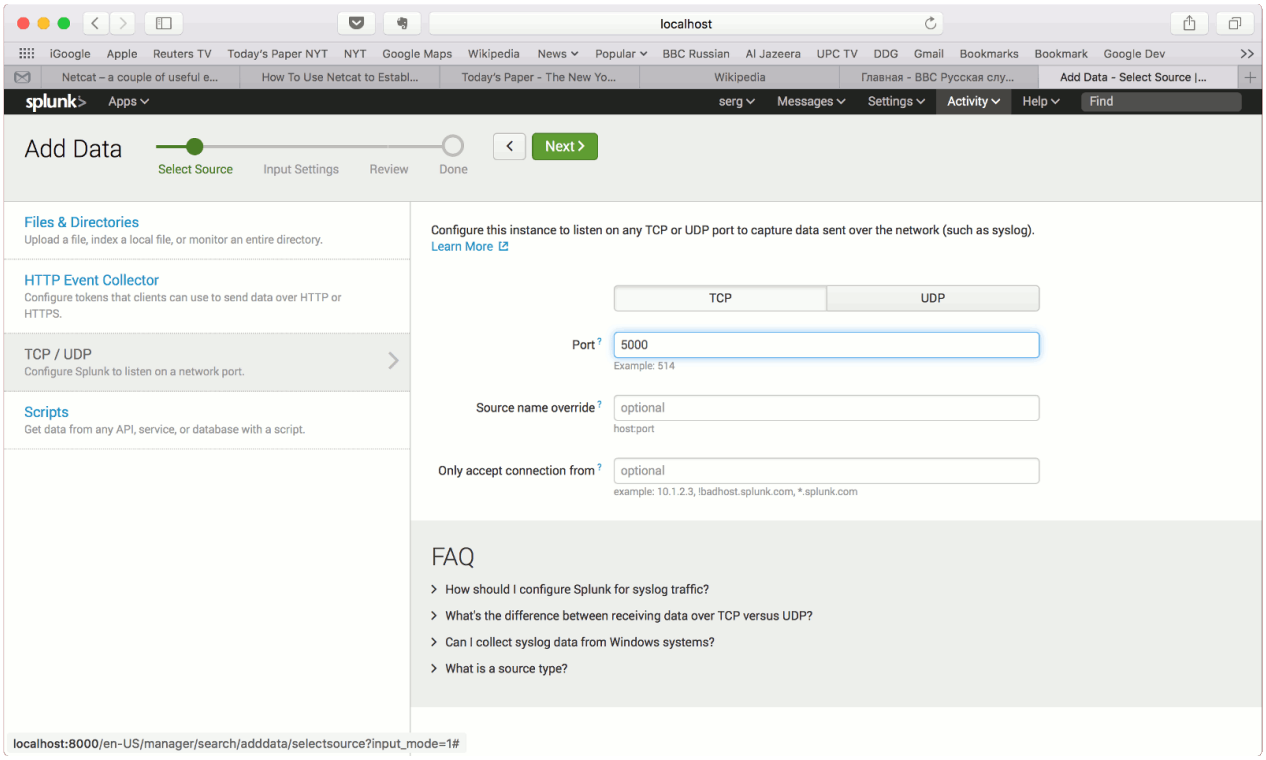



**Figure 14:** *Select "TCP/UDP" and set protocol to "TCP" and set the correct port number (same as in the Tranalyzer2 plugin configuration file, in this example — 5000).*

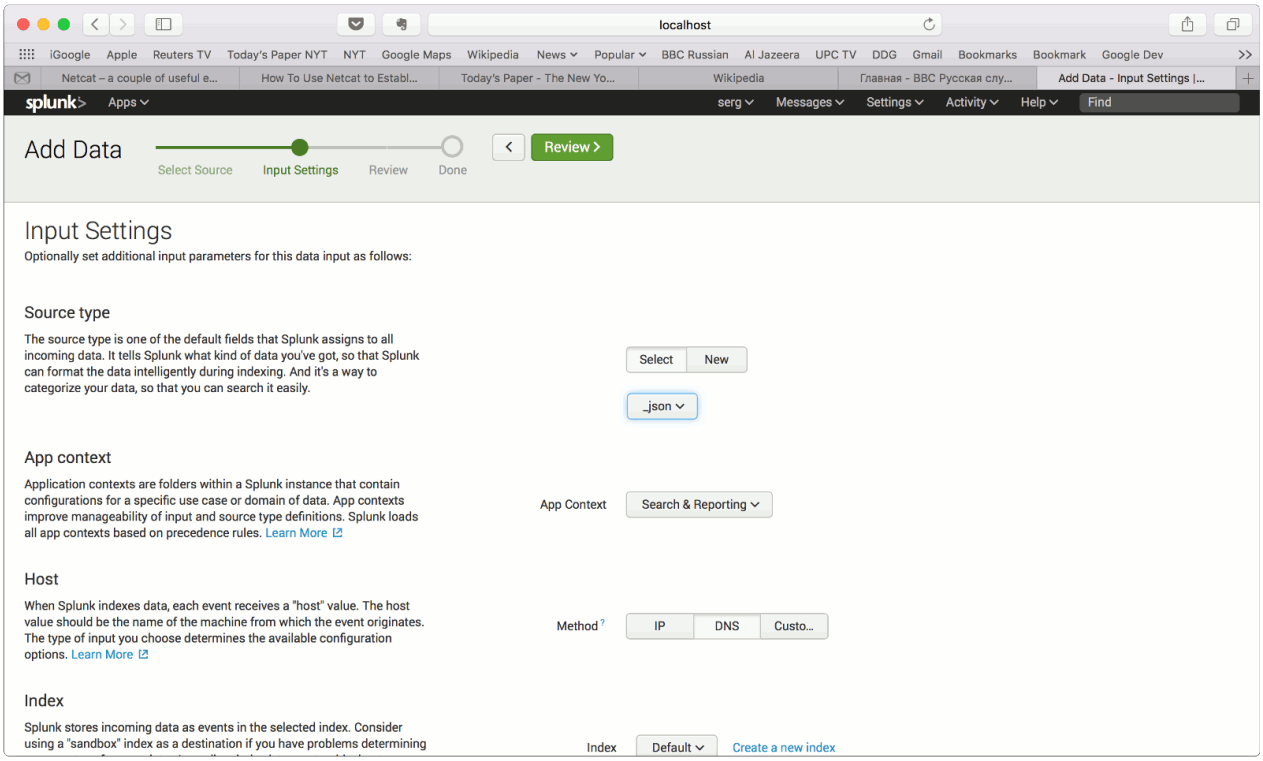



**Figure 15:** *Select "_json" as Source Type and proceed to "Review".*

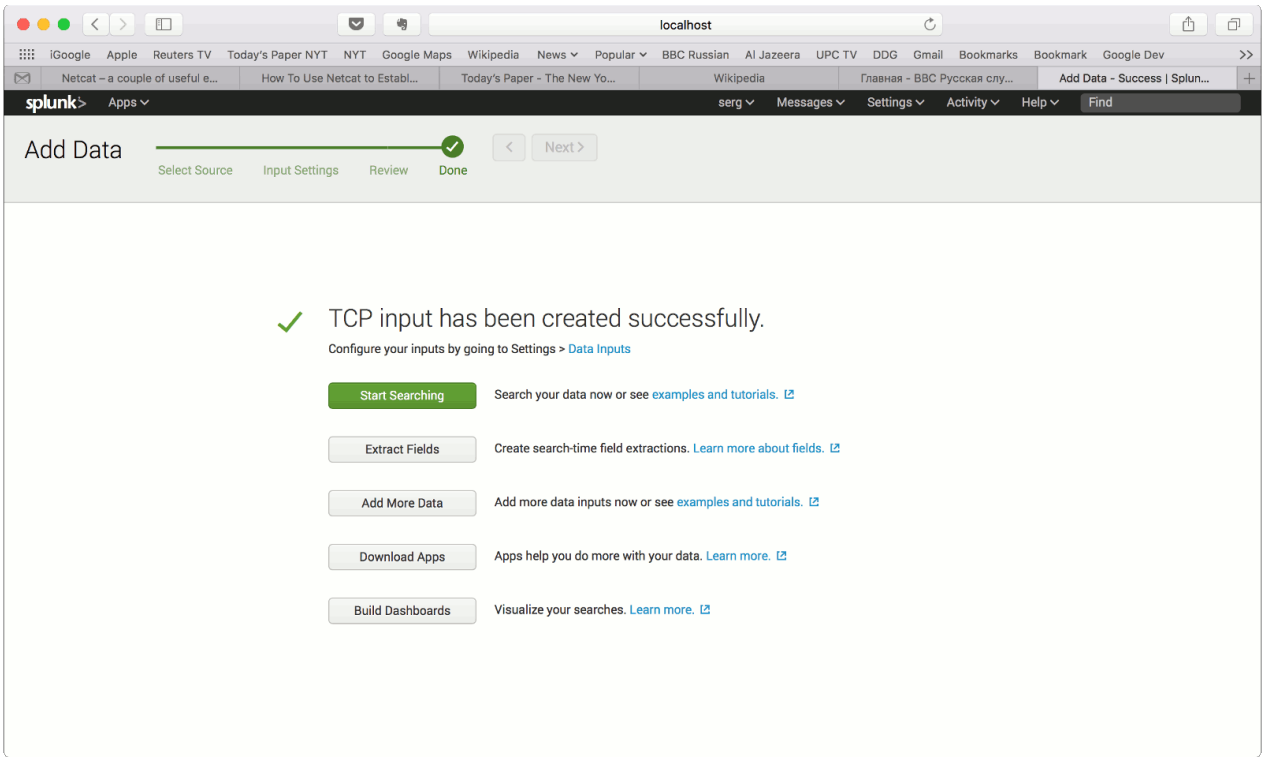



**Figure 16:** *Select "Start Searching" to make sure that the data is being received by Splunk.*

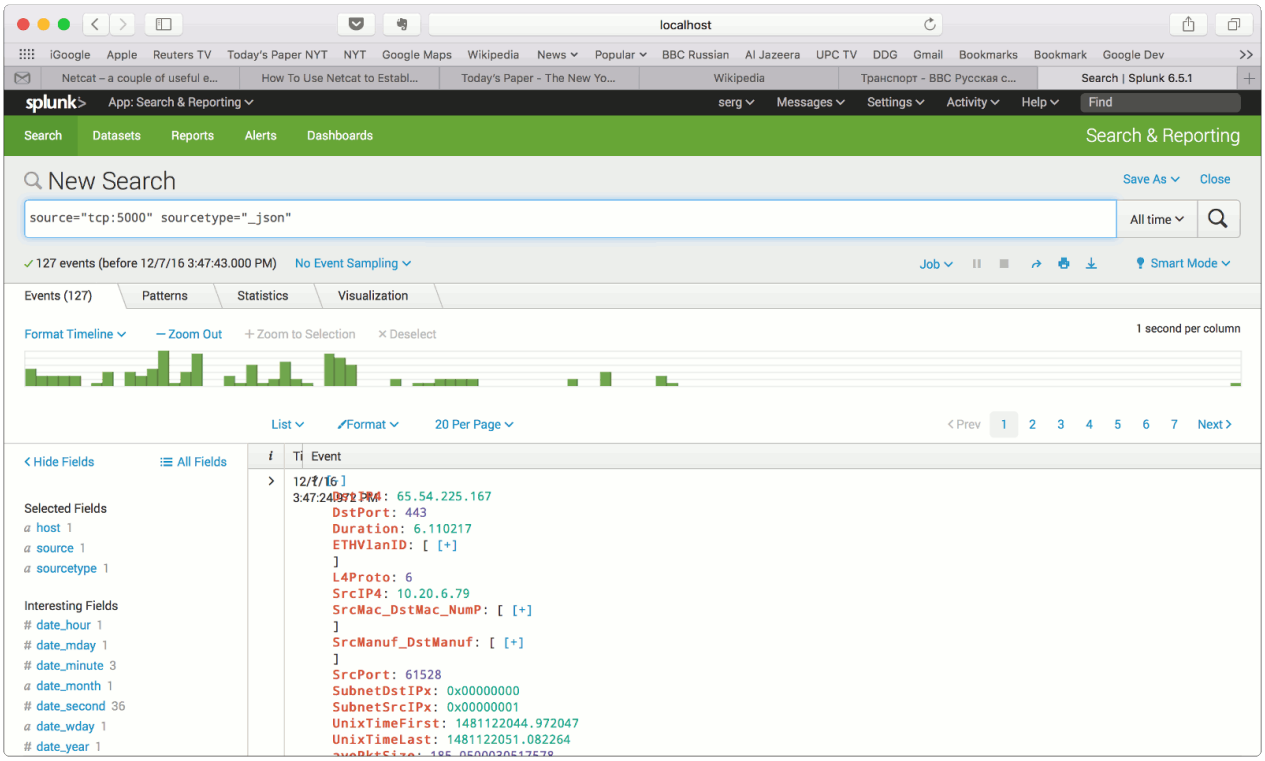



**Figure 17:** *Note that the data is being received, but the Tranalyzer2 specific data record field are not shown yet.*

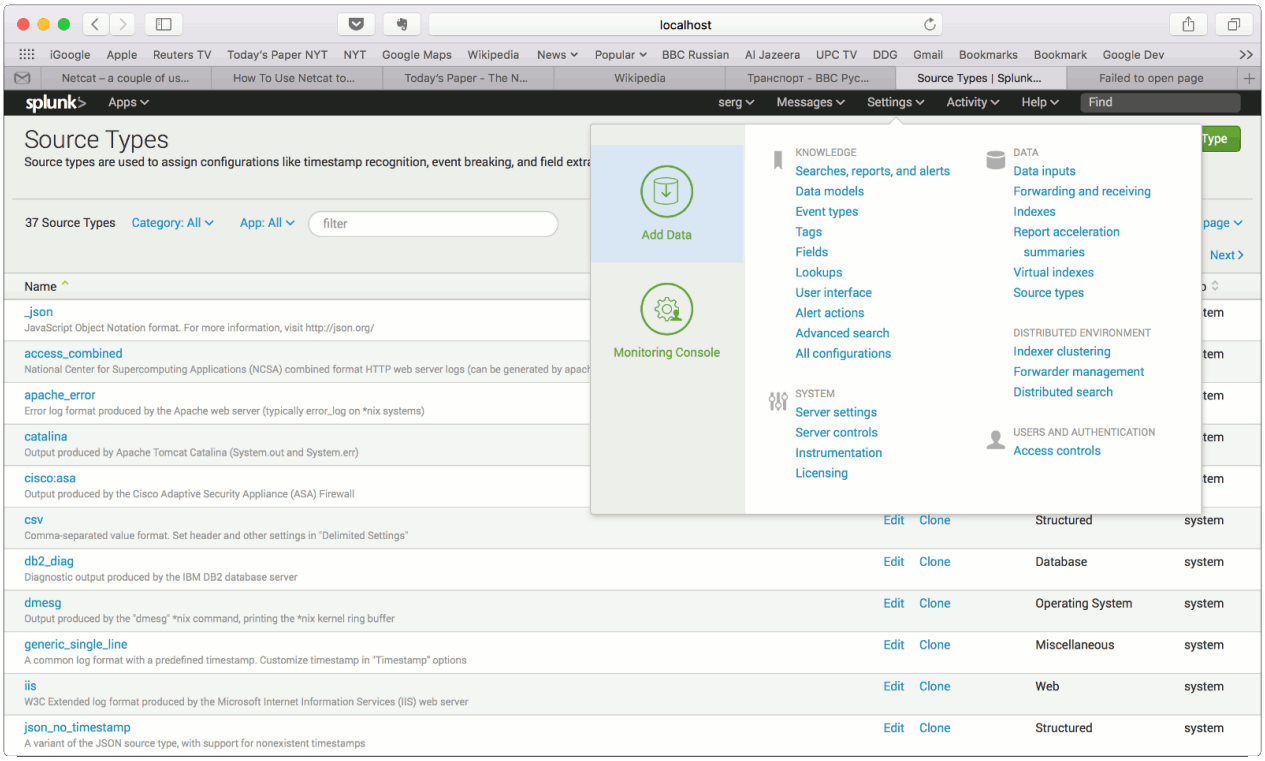



**Figure 18:** *Go to "Settings"->"DATA"->"Source Types" and click on "_json" data source type to edit it.*

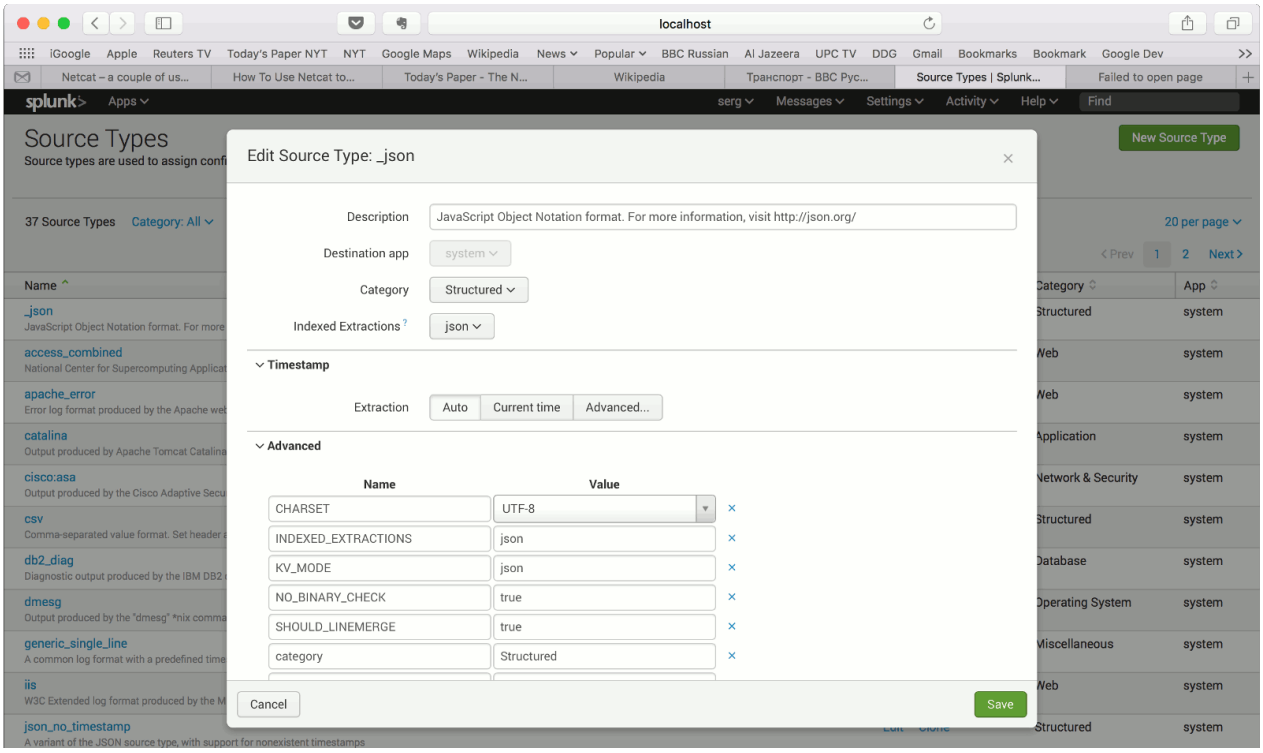



**Figure 19:** *Change option "KV_MODE" from "none" to "json" and save the changes.*

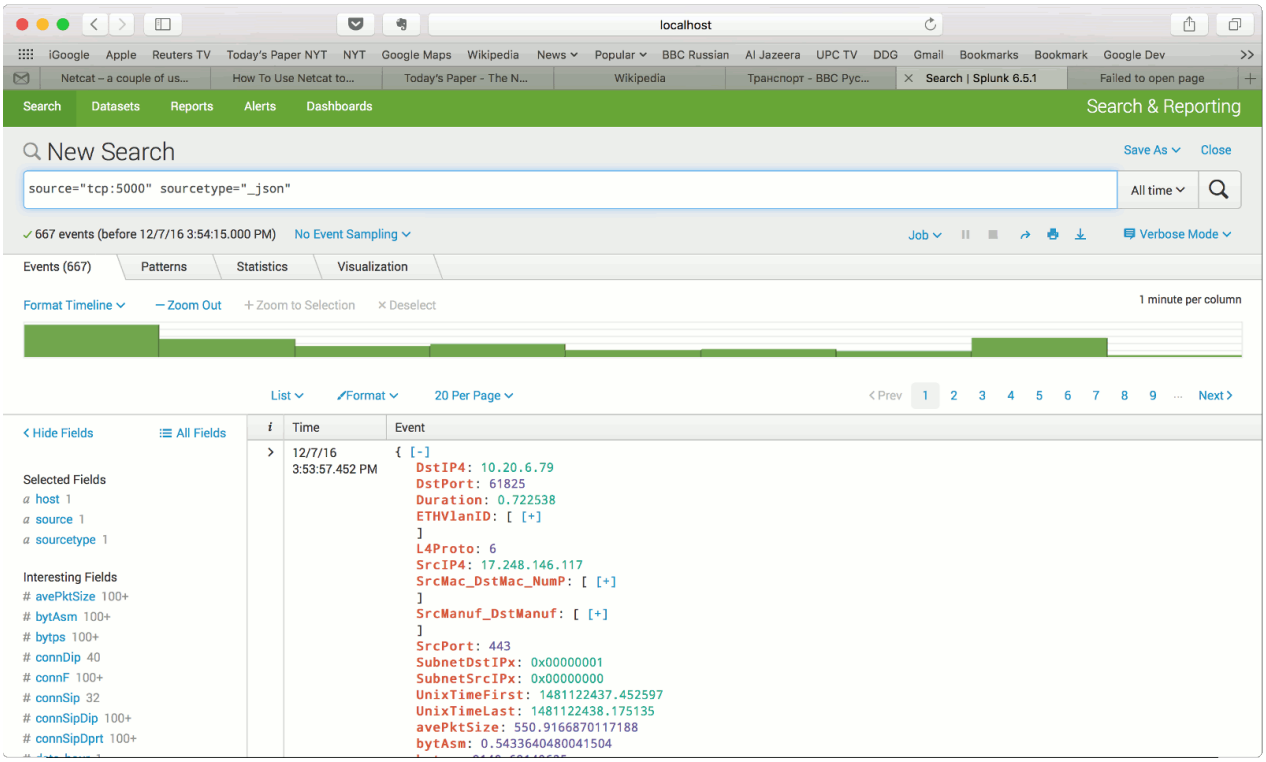



**Figure 20:** *Return to the Search window and make sure that the Tranalyzer2 specific fields are recognized by Splunk.*

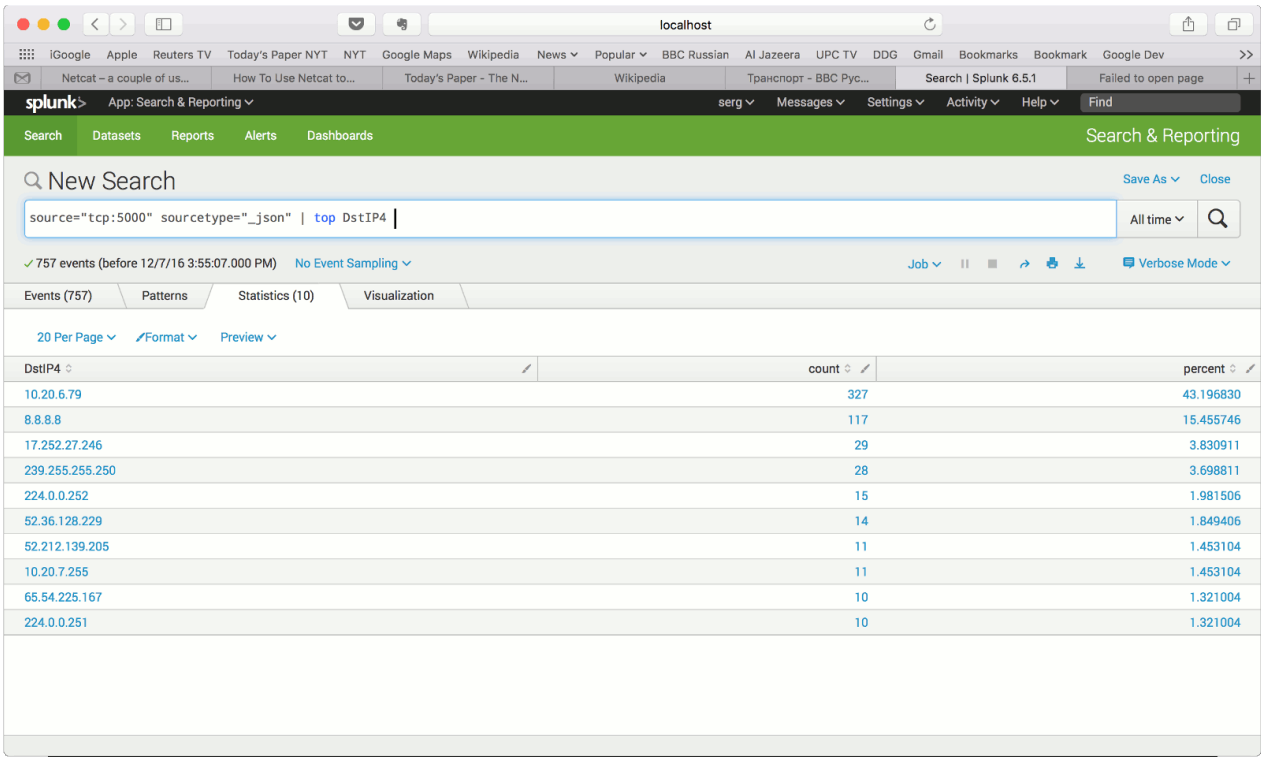



**Figure 21:** *Query data, e.g. show top destination IP addresses by number of the records.*

# C Advanced Performance Enhancements with PF_RING

Under certain circumstances, e.g., large quantities of small packets, the kernel might drop packets. This happens due to the normal kernel dispatching which is known to be inefficient for packet capture operations. The capturing process can be devised more efficiently by changing the kernel as in packet_mmap, but then a patched libpcap is required which is not available yet.[59] Another option is pf_ring. Its kernel module passes the incoming packets in a different way to the user process.[60]

## Requirements

- Kernel version prior to 3.10. [61]
- All packages needed for building a kernel module, names are distribution-dependent
- A network interface which supports NAPI polling by its driver.
- optional: A network card which supports Direct Network Interface Card (NIC) access (DNA).[62]

## Quick setup

Download PF_RING from a stable tar ball or development source at http://www.ntop.org/get-started/download/. In order to build the code the following commands have to executed in a bash window:

```
cd PF_RING/kernel
make && sudo make install
modprobe pf_ring
```

**Figure 22:** *building kernel module*

Tranalyzer2 requires at least libpfring and libpcap-ring which can be installed the following way:

```
cd PF_RING/userland
cd lib
make && sudo make install
cd ..
cd libpcap
make && sudo make install
```

**Figure 23:** *basic userland*

You may like to install other tools such as tcpdump. Just install it the same way as described above.
NOTE: The *pf_ring.ko* is loaded having the `transparent_mode=0` by default which enables NAPI polling. If you use a card with special driver support for DNA you may want to compile the driver and load *pf_ring.ko* in a different mode.[63]

[59] See https://www.kernel.org/doc/Documentation/networking/packet_mmap.txt for more information
[60] See http://www.ntop.org/products/pf_ring/
[61] Presently when composing this document there is no patch for the depreciation of `create_proc_read_entry()` function. See: https://lkml.org/lkml/2013/4/11/215
[62] documentation: http://www.ntop.org/products/pf_ring/DNA/
[63] See: `man modprobe.d`

## Load on boot

Since this seems to be difficult for many users the load procedure is described in the following.
Depending on your distribution or to be more specific, the init system your distribution uses at boot time may be somewhere different. In systemd [64] create a file with a '.conf' ending at */etc/modules-load.d/* which contains just the text `pf_ring`, the module name without the '.ko' ending.[65]
Ubuntu uses */etc/modules* as a single file where you can add a line with the module name.[66]

```
systemd
echo pf_ring > /etc/modules-load.d/pfring.conf
OR
ubuntu
echo pf_ring >> /etc/modules
```

**Figure 24:** *on-boot kernel module load examples*

## New kernel

Once in a while there is indeed a new kernel available. If you want to use pf_ring afterwards do not forget to recompile the kernel module, or set up `dkms`.

[64] More info: http://www.freedesktop.org/wiki/Software/systemd/
[65] For more info: `man modules-load.d`
[66] See: `man modules`

# D Status

This section summarizes the available plugins. For each plugin, a brief description is provided, along with the development status (pre-alpha, alpha, beta, release-candidate, release or deprecated).

## D.1 Global Plugins

| Plugin Name | Number | Description | Status |
|---|---|---|---|
| protoStats | 001 | Overall statistics about protocols | release |

## D.2 Basic Plugins

| Plugin Name | Number | Description | Status |
|---|---|---|---|
| basicFlow | 100 | Overall flow information | release |
| basicStats | 120 | Basic statistics | release |
| connStat | 500 | Connection statistics | release |
| macRecorder | 110 | MAC addresses and manufacturers | release |
| portClassifier | 111 | Classification based on port numbers | release |

## D.3 Layer 2 Protocol Plugins

| Plugin Name | Number | Description | Status |
|---|---|---|---|
| arpDecode | 179 | Address Resolution Protocol (ARP) | beta |
| cdpDecode | 207 | Cisco Discovery Protocol (CDP) | beta |
| lldpDecode | 206 | Link Layer Discovery Protocol (LLDP) | beta |
| stpDecode | 203 | Spanning Tree Protocol (STP) | beta |
| vtpDecode | 208 | VLAN Trunking Protocol (VTP) | beta |

## D.4 Layer 3/4 Protocol Plugins

| Plugin Name | Number | Description | Status |
|---|---|---|---|
| icmpDecode | 140 | Internet Control Message Protocol (ICMP) | release |
| igmpDecode | 204 | Internet Group Management Protocol (IGMP) | alpha |
| ospfDecode | 202 | Open Shortest Path First (OSPF) | release |
| sctpDecode | 135 | Stream Control Transmission Protocol (SCTP) | beta |
| tcpFlags | 130 | IP and TCP flags | release |
| tcpStates | 132 | TCP connection tracker | release |
| vrrpDecode | 220 | Virtual Router Redundancy Protocol (VRRP) | beta |

## D.5 Layer 7 Protocol Plugins

| Plugin Name | Number | Description | Status |
|---|---|---|---|
| bgpDecode | 201 | Border Gateway Protocol (BGP) | beta |
| dhcpDecode | 250 | Dynamic Host Configuration Protocol (DHCP) | release |
| dnsDecode | 251 | Domain Name System (DNS) | beta |
| ftpDecode | 301 | File Transfer Protocol (FTP) | release |
| gtpDecode | 302 | GPRS Tunneling Protocol (GTP) | alpha |
| httpSniffer | 310 | HyperText Transfer Protocol (HTTP) | release |
| ircDecode | 401 | Internet Relay Chat (IRC) | beta |
| ldapDecode | 230 | Lightweight Directory Access Protocol (LDAP) | alpha |
| mndpDecode | 252 | MikroTik Neighbor Discovery Protocol (MNDP) | beta |
| modbus | 450 | Modbus | beta |
| mqttDecode | 452 | MQ Telemetry Transport Protocol (MQTT) | alpha |
| ntlmsspDecode | 342 | NT LAN Manager (NTLM) Security Support Provider (NTLMSSP) | beta |
| ntpDecode | 205 | Network Time Protocol (NTP) | release |
| popDecode | 304 | Post Office Protocol (POP) | release |
| radiusDecode | 255 | Remote Authentication Dial-In User Service (RADIUS) | beta |
| smbDecode | 335 | Server Message Block (SMB) | beta |
| smtpDecode | 303 | Simple Mail Transfer Protocol (SMTP) | release |
| snmpDecode | 386 | Simple Network Management Protocol (SNMP) | beta |
| sshDecode | 309 | Secure Shell (SSH) | beta |
| sslDecode | 315 | SSL/TLS, OpenVPN | release |
| stunDecode | 257 | STUN, TURN, ICE and NAT-PMP | beta |
| syslogDecode | 260 | Syslog | release |
| telnetDecode | 305 | Telnet | release |
| tftpDecode | 300 | Trivial File Transfer Protocol (TFTP) | release |

## D.6 Application Plugins

| Plugin Name | Number | Description | Status |
|---|---|---|---|
| pwX | 602 | Password extractor | release |
| regex_pcre | 603 | Perl Compatible Regular Expressions (PCRE) | release |
| torDetector | 609 | Tor Detector | release |
| voipDetector | 410 | Voice over IP (VoIP) | release |

## D.7 Math Plugins

| Plugin Name | Number | Description | Status |
|---|---|---|---|
| descriptiveStats | 702 | Descriptive statistics | release |
| entropy | 710 | Entropy | beta |
| nFrstPkts | 700 | Statistics over the first *N* packets | release |

| Plugin Name | Number | Description | Status |
|---|---|---|---|
| pktSIATHisto | 701 | Histograms of packet size and inter-arrival times | release |
| wavelet | 720 | Wavelet | beta |

## D.8 Classifier Plugins

| Plugin Name | Number | Description | Status |
|---|---|---|---|
| bayesClassifier | 866 | Classification using Naive Bayes | beta |
| fnameLabel | 899 | Classification based on filename | beta |
| geoip | 116 | Classification based on IP address location | release |
| nDPI | 112 | Classification based on content analysis | release |
| p0f | 779 | OS classification based on content analysis (SSL) | release |
| tp0f | 117 | OS classification based on layer 3/4 (IP/TCP) analysis | release |

## D.9 Output Plugins

| Plugin Name | Number | Description | Status |
|---|---|---|---|
| binSink | 900 | Binary output into a flow file | release |
| clickhouseSink | 927 | Output into a ClickHouse database | release |
| findexer | 961 | Produce a binary index mapping flow index and packets | release |
| jsonSink | 903 | Produce a JSON file | release |
| kafkaSink | 928 | Output into an Apache Kafka event streaming platform | beta |
| mongoSink | 926 | Output into a MongoDB database | beta |
| mysqlSink | 925 | Output into a MariaDB/MySQL database | beta |
| netflowSink | 904 | NetFlow output format for existing Cisco tools | beta |
| payloadDumper | 862 | Dump the payload of TCP/UDP flows to files | beta |
| pcapd | 960 | Store packets from specific flows in pcap files | release |
| psqlSink | 923 | Output into a PostgreSQL database | beta |
| socketSink | 910 | Binary output into a TCP/UDP socket | release |
| sqliteSink | 924 | Output into a SQLite database | beta |
| txtSink | 901 | Text output into a flow file | release |

# E TODO

This section lists some features, capabilities and plugins which Tranalyzer is currently missing. Feel free to pick a task or two and contribute code, plugins or ideas.

## E.1 Features

- Anonymization
- Endianness independence
- Support for NetMon dump files
- Stream reassembly and reordering
- Parallelization

## E.2 Plugins

### E.2.1 Layer 2 Protocol Plugins

- Extreme Discovery Protocol (EDP)
- Dynamic Trunk Protocol (DTP)
- Port Aggregation Protocol (PAgP)

### E.2.2 Layer 3/4 Protocol Plugins

- Datagram Congestion Control Protocol (DCCP)
- Reliable Datagram Sockets (RDS)
- Reliable UDP (RUDP)
- Resource Reservation Protocol (RSVP)
- Signalling Connection Control Part (SCCP)

### E.2.3 Layer 7 Protocol Plugins

- Distributed Computing Environment / Remote Procedure Calls (DCE/RPC)
- Dropbox
- Extensible Messaging and Presence Protocol (XMPP)
- Financial Information eXchange Protocol (FIX)
- Internet Message Access Protocol (IMAP)
- Internet Small Computer Systems Interface (iSCSI)
- Microsoft Tabular Data Stream (TDS)

- Network File System (NFS)
- OCSP, PKIX-CRL (include in sslDecode ?)
- Routing Protocols:
  - Enhanced Interior Gateway Routing Protocol (EIGRP)
  - Routing Information Protocol (RIP)
  - Cisco Hot Standby Router Protocol (HSRP)
  - ...
- Signaling System No. 7 (SS7) protocols
- Torrent, Gnutella
- X11

# F FAQ

This section answers some frequently asked questions.

## F.1 After `./setup.sh`, I receive the following error: `-bash: t2: command not found`

After running the `setup.sh` script, you need to open a new bash window or source your `.bashrc` (or `.zshrc`, ...) file in order for the new aliases and functions to be available:

```
$ t2
-bash: t2: command not found
$ source ~/.bashrc
$ t2
Tranalyzer 0.9.0 - High performance flow based network traffic analyzer

Usage
    tranalyzer [OPTION...] <INPUT>

...
```

## F.2 If the hashtable is full, how much memory do I need to add?

When T2 warns you that the hashtable is full, it also tells you how to correct the problem:

```
[WRN] Hash Autopilot: main HashMap full: flushing 1 oldest flow(s)
[INF] Hash Autopilot: Fix: Invoke T2 with '-f 5'
```

T2 calculates an estimate of the multiplication factor `HASHFACTOR` which you can set with the `-f` command-line option. By default the main hash autopilot is enabled which maintains the sanity of T2 even if it runs out of flow memory. Nevertheless, T2 will be faster if you feed him the recommended `-f` factor.

## F.3 Can I change the timeout of a specific flow in my plugin?

That is possible because each flow owns a timeout value which can be altered even on packet basis. It enables the user to program stateful protocol plugins. Check out the tcpStates plugin as an inspiration.

## F.4 Can I reduce the maximal flow length?

In *tranalyzer2/src/tranalyzer.h* you will find a constant called `FDURLIMIT`. Set it to the amount of seconds you like and T2 will terminate every flow with max `FDURLIMIT+1` seconds. And create a new flow for the next packet to come.

## F.5 How can I change the separation character in the flow file?

The separation character is defined as `SEP_CHAR` in *utils/bin2txt.h*. It can be set to any character(s), e.g., `","` or `"||"`. In addition, the character(s) used for comments, e.g., column names, is controlled by `HDR_CHR` in the same file. Note that Tranalyzer default values are `"\t"` and `"%"`, respectively. Be advised that if you changed either of those values, some scripts may not work as expected.

## F.6 How can I build all the plugins?

If you invoked the script setup.sh then you may use
`t2build -a`
otherwise, old school:

```
   cd  /tranalyzer2-0.9.2
./autogen.sh -a
```

## F.7 T2 failed to compile: What can I do?

If a dependency is missing, you should see an appropriate message, e.g., *Missing dependency libname*. If no such message is displayed, it could be that the Makefiles are outdated. Then use `autogen.sh -r` to force the rebuild of the Makefiles. A typical error requiring the use of `autogen.sh -r` is:

```
...
/bin/bash: line 10: automake-: command not found
Makefile:333: recipe for target 'Makefile.in' failed
make[1]: *** [Makefile.in] Error 127
...
```

If you see the following message, then the autotools are not installed.

```
make: Entering directory '/home/user/tranalyzer2-0.9.2/tranalyzer2/doc'
make: Nothing to be done for 'clean'.
make: Leaving directory '/home/user/tranalyzer2-0.9.2/tranalyzer2/doc'
../autogen.sh: line 116: autoreconf: command not found
../autogen.sh: line 118: ./configure: No such file or directory

Failed to configure tranalyzer2
```

In this case, please refer to the *doc/tutorials/install.pdf*.

## F.8 T2 segfaults: What can I do?

T2 never segfaults! Unless he deviates from his cosmic plan and indeed segfaults. The prominent reason are memory inconsistencies with old plugins being resident under `~/.tranalyzer/plugins/`.

1. Remove all the plugins: `rm ~/.tranalyzer/plugins/*.so`
2. Recompile the plugins, e.g., `cd ~/tranalyzer2-0.9.2/ && ./autogen.sh`
3. T2 should behave again.

For the developer:
If that does not fix the problem, recompile T2 in debug mode with `./autogen.sh -d` and try to run tranalyzer in *gdb*: `gdb -args ./tranalyzer -r file.pcap -w outpref`. If the error happens while writing flows, try to remove plugins until the error disappears. Finally, run the `segvtrack` script as follows: `segvtrack yourpcap`. This will automatically reduce the PCAP to the smallest set of packets which causes a segfault. If this does not help, send us a bug report at andy@tranalyzer.com with this pcap, T2 configuration (the values that differ from the default) and the plugins you are using. Then we will get a fix for you in no time.

## F.9 socketSink plugin aborts with "could not connect to socket: Connection refused"

The socketSink plugins acts as a client in a socket communication. Therefore, a server listening to `SERVADD`, `DPORT` and `SOCKTYPE` is required. As described in the **Example** Section of the socketSink plugin documentation, a simple server can be set up with netcat as follows: `nc -l 127.0.0.1 6666`. Make sure the address and port match the values listed in *socketSink.h*.

## F.10 T2 stalls after USR1 interrupt: What can I do?

It is a bug in the libpcap, which somehow is not thread-safe under certain conditions. Check whether T2 is set to default signal threading mode in (`main.h`):

- Set `MONINTTHRD` to 1
- Set `MONINTPSYNC` to 1

Do not forget to recompile T2 with `./autogen.sh` if you had to change the configuration.

Now the process of printing is detached from the packet capture and the output is synchronized to the packet processing main loop. Thus, pcap is never interrupted.

## F.11 Can I reuse my configuration between different machines or Tranalyzer versions?

You can write a patch for t2conf and use it as follows: `t2conf --patch file.patch`. Revert the patch with the `--rpatch` option. The patch is a simple text file listing the defines to change, e.g., `IPV6_ACTIVATE <tab> 1 <tab> 0 <tab> tranalyzer2/src/networkHeaders.h`. For more details, refer to the documentation of t2conf .

## F.12 How to contribute code, submit a bug or request a feature?

Contact the Anteater via email at andy@tranalyzer.com, and he will answer you.