nProbe™

An Extensible NetFlow v5/v9/IPFIX Probe for IPv4/v6

User Guide

Version 7.3

June 2016

Introduction

Traffic measurements are necessary to operate all types of IP networks. Networks admin need a detailed view of network traffic for security, accounting and management reasons. The compositions of the traffic have to be analyzed accurately when estimating traffic metrics or when finding network problems. All of these measurements have to be made by analyzing all the packets flowing to the central points in the network (such as router and/or switches). The analysis could be done on the fly or by logging all the packets and than post-processing them. But with the increasing network capacities and traffic volumes this kind of approach is not very efficient. Instead similar packets (packets with a set of common properties) can be grouped together composing flows. As an example, a flow can be composed of all flowing packets that share the same source and destination address so a flow can be derived using only some fields of a network packet. This way, similar types of traffic can be stored in a more compact format without loosing the information we are interested in. This information can be aggregated in a flow datagram and exported to a collector able to report network metrics in a user-friendly format.
When collected this information provides a detailed view of the network traffic.

Precise network metric measurements is a challenging task so a lot of work has been done in this filed. In commercial environments, NetFlow is probably the de-facto standard for network traffic accounting and billing. NetFlow is a technology originally created by Cisco in 1996 and is now standardized as Internet Protocol Flow Information eXport (IPFIX -- RFC 3917). NetFlow is based on the probe/collector paradigm. The probe, usually part of network appliance such as a router or a switch, is deployed on the measured network segment, it sends traffic information in NetFlow format towards a central collector.

nProbe is a software NetFlow v5/v9/IPFIX probe able to collect, analyze and export network traffic reports using the standard Cisco NetFlow v5/v9/IPFIX format. It is available for most of the OSs on the market (Windows, BSD, Linux, MacOSX). When installed on a PC, nProbe turn it into a Network-aware monitoring appliance.

This manual aims at describing how to use nProbe, deploy it in networks, and how to develop plugins for extending it functionalities.

Main Features

Some of the nProbe features include:

- Limited memory footprint (regardless of the network size and speed) and CPU savvy.
- Designed for running on environments with limited resources.
- Fully user configurable.
- Fully NetFlow v4/v5/v9 IPFIX compliant.
- High-performance probe: commercial probes included those embedded on routers and switches are often not able to keep up with high-speeds or, when able, their performance decreases dramatically handling small size packets.
- Ability to work as a NetFlow proxy.
- Support for disk-dump flow, either text files or SQLite files, and MySQL database server dump flow.
- Scriptable nProbe actions and behaviors using Lua

What's New

Releases up to 7.4 (June 2016)

- Full IPFIX support: PEN (Private Enterprise Numbers) and Variable length encoding.
- Ability to natively dump flows in FastBit format that allows to outperform relational and raw flow-based collectors.
- Ability to collect sFlow flows and turn them into flows (v5/v9/IPFIX).
- Collection of Cisco ASA flows and conversion in 'standard' flows.
- New design for better performance and exploitation of multicore architectures.
- Support of tunneled (including GRE, PPP and GTP) traffic and ability to export in flows inner/outer envelope/packet information.
- HTTP and MySQL protocol analysis: ability to generate logs of web and mysql activities in addition to flow export.
- BGP Plugin for establishing a BGP session with a router and generate flows with AS and AS path information.
- ElasticSearch flow export
- Kafka brokers flow export

Release 6.15 (January 2014)

- Updated nProbe with 6.15 features.

Release 5.0 (February 2008)

- Updated nBox firmware
- Updated nProbe with latest features.
- Updated ntop with latest 3.3.X version.

Release 4.0 (July 2007)

- Updated nBox with latest 2.6 kernel series image
- Updated nProbe with 4.9 version coverage.

Release 3.9 (April 2005)

- Updated nBox section

Release 3.0.1 (February 2004)

- Updated nBox section

Release 3.0 (January 2004)

- Added nProbe 3.0 coverage

Release 2.2 (October 2003)

- Added nBox coverage

Release 2.1 (June 2003)

- Added nFlow support

Release 2.0.1 (February 2003)

- Added the ability to save flows on disk (-P flag)

Release 2.0 (January 2003)

- Added the ability to select multiple NetFlow collectors.
- Added --p flag for ignoring TCP/UDP ports.
- Added --e flag for slowing down flow export speed.
- Added --u flag for identifying input NetFlow devices into emitted flows.
- Added --z flag for preventing nProbe from emitting tiny flows.
- Added --a flag for selecting the way flows are exported to several collectors (if defined).
- Added the ability to control an LCD display where the probe can report traffic statistics.
- Enhanced TCP flags support in exported flows.

Release 1.3 (July 2002)

- First public release.

Installing nProbe

The nProbe probe has to be activated on a PC from which it is possible to see/capture all the traffic you are interested in. For this reason, in case of switched networks, it is necessary to either mirror traffic (VLAN or port mirror) or place the probe on a location (e.g. by the border gateway) where most of the traffic flows.

When activated, nProbe will collect traffic data and emit NetFlow v4/v5/v9/IPFIX flows towards the specified collector. A set of packets with the same (src ip & port, dst ip & port, protocol #) is called flow (note that some protocols such as ICMP have no concept of ports). Every flow, even a very long-standing ISO CD image download, has a limited lifetime; this is because the flow collector should periodically receive flow chunks for accounting traffic precisely.

The windows version of nProbe comes in a standard installer package that can be installed using the wizard. On Linux, we pre-build packages for the most popular distributions. Packages and installation instructions are available at http://packages.ntop.org/ for every distribution supported.

Once the installation is completed it is necessary to create the nProbe license otherwise the probe will operate in demo mode.

Licensing

Binary nProbe instances require a per-server license that is released according to the EULA (End User License Agreement) as specified in the appendix. Each license is perpetual (i.e. it does not expire) and it allows to install updates for one year since purchase/license issue. This means that a license generated on 1/1/2016 will be able to activate new versions of the software until 1/1/2017. If you want to install new versions of the software release after that date, you need to purchase a new license or avoid further updating the software. For source-based nProbes you still have to obey to the nProbe license listed in appendix.

nProbe licenses are generated using the orderId and email you provided when the license has been purchased on https://shop.ntop.org/. The licenses are generated at https://shop.ntop.org/mklicense.

nProbe Command Line Options

nProbe allows network administrators to precisely tune the flow generation policy. In particular, it is possible to specify a lot of command line options.
Below are listed the available options and a detailed explanation of each option:

```
# /.nprobe --help

Welcome to nProbe

Copyright 2002-16 ntop.org

nProbe is subject to the terms and conditions defined in
the LICENSE and EULA files that are part of this package.

nProbe also contains third party code:
Radix tree code - (C) The Regents of the University of Michigan
                      ("The Regents") and Merit Network, Inc.
sFlow collector - (C) InMon Inc.

Usage:
nprobe -n <host:port|none> [-i <interface|dump file>] [-t <lifetime timeout>]
              [-d <idle timeout>] [-l <queue timeout>] [-s <snaplen>]
              [-p <aggregation>] [-f <filter>] [-a] [-b <level>] [-G] [-O <# threads>]
              [-P <path>] [-F <dump timeout>] [-D <format>]
              [-u <in dev idx>] [-Q <out dev idx>]
              [-I <probe name>] [-v] [-w <hash size>] [-e <flow delay>] [-B <packet count>]
              [-z <min flow size>] [-M <max num flows>]
              [-x <payload policy>] [-E <engine>] [-C <flow lock file>]
              [-m <min # flows>] [-R <cmd>]
              [-S <sample rate>] [-A <AS list>] [-g <PID file>]
              [-T <flow template>] [-U <flow template id>]
              [-o <v9 templ. export policy>] [-L <local nets>] [-c] [-r]
              [-1 <interface nets>] [-2 <number>] [-3 <port>] [-4] [-5 <port>] [-6]
              [-9 <path>] [--black-list <networks>] [--pcap-file-list <filename>]
              [-N <biflows export policy>] [--dont-drop-privileges]


[--collector|-n] <host:port|none>   | Address of the NetFlow collector(s).
                                    | Multiple collectors can be defined using
                                    | multiple -n flags. In this case flows
                                    | will be sent in round robin mode to
                                    | all defined collectors if the -a flag
                                    | is used. Note that you can specify
                                    | both IPv4 and IPv6 addresses.
                                    | If you specify none as value,
                                    | no flow will be export; in this case
                                    | the -P parameter is mandatory.
                                    | Note that you can specify the protocol
                                    | used to send packets. Example:
                                    | udp://192.168.0.1:2055,tcp://10.1.2.3:2055
[--interface|-i] <iface|pcap>       | Interface name from which packets are
                                    | captured, or .pcap file (debug only).
[--lifetime-timeout|-t] <timeout>   | It specifies the maximum (seconds) flow
                                    | lifetime [default=120]
[--idle-timeout|-d] <timeout>       | It specifies the maximum (seconds) flow
                                    | idle lifetime [default=30]
[--queue-timeout|-l] <timeout>      | It specifies how long expired flows
                                    | (queued before delivery) are emitted
                                    | [default=30]
[--snaplen|-s] <snaplen>            | Packet capture snaplen [default 128 bytes]
[--aggregation|-p] <aggregation>    | It specifies the flow aggregation level:
                                    | <VLAN Id>/<proto>/<IP>/<port>/<TOS>/<SCTP StreamId>
                                    | where each element can be set to 0=ignore
                                    | or 1=take care. Example '-p 1/0/1/1/1/1'
                                    | ignores the protocol, whereas
                                    | '-p 0/0/1/0/0/0' ignores everything
                                    | but the IP
[--bpf-filter|-f] <BPF filter>      | BPF filter for captured packets
                                    | [default=no filter]
[--all-collectors|-a]               | If several collectors are defined, this
                                    | option gives the ability to send all
                                    | collectors all the flows. If the flag is
                                    | omitted collectors are selected in
                                    | round robin.
[--verbose|-b] <level>              | Verbose output:
                                    | 0 - No verbose logging
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                                  | 1 - Limited logging (traffic statistics)
                                  | 2 - Full verbose logging
[--daemon-mode|-G]                | Start as daemon.
[--num-threads|-O] <# threads>    | Number of packet fetcher threads
                                  | [default=1]. Use 1 unless you know
                                  | what you're doing.
[--dump-path|-P] <path>           | Directory where dump files will
                                  | be stored.
[--exec-cmd-dump|-R] <cmd>        | Execute the specified command for each
                                  | file dump on disk (including plugins).
[--dump-frequency|-F] <dump timeout>| Dump files dump frequencey (sec).
                                  | Default: 60
[--dump-format|-D] <format>       | <format>: flows are saved as:
                                  | b       : raw/uncompressed flows
                                  | B       : raw core flow fields (152 bytes)
                                  | t       : text flows
                                  | Example: -D b. Note: this flag has no
                                  | effect without -P.
[--in-iface-idx|-u] <in dev idx>  | Index of the input device used in the
                                  | emitted flows (incoming traffic). Default
                                  | value is 0. Use -1 as value to dynamically
                                  | set to the last two bytes of
                                  | the MAC address of the flow sender.
[--out-iface-idx|-Q] <out dev idx>| Index of the output device used in the
                                  | emitted flows (outgoing traffic). Default
                                  | value is 0. Use -1 as value to dynamically
                                  | set to the last two bytes of
                                  | the MAC address of the flow receiver.
[--vlanid-as-iface-idx] <mode>    | Use vlanId (0 for untagged traffic)
                                  | as interface index. Mode specifies with
                                  | stacked VLANs which vlanId to choose. Values
                                  | are 'inner', 'outer', 'single', or 'dual':
                                  | inner  = use the most inner VLAN tag
                                  | outer  = use the first (the one close to ether) VLAN tag
                                  | single = for even outer VLAN tags 'E',
                                  |          where E={2,4,6...4094},
                                  |          ifIdx is set to IN='0',OUT='E'.
                                  |          For odd outer VLAN tags 'O',
                                  |          where O={3,5,7...4095},
                                  |          ifIdx is set to IN='O-1',OUT='0'
                                  | double = for even outer VLAN tags 'E',
                                  |          where E={2,4,6...4094}, ifIdx
                                  |          is set to IN='E+1',OUT='E'.
                                  |          For odd outer VLAN tags 'O',
                                  |          where O={3,5,7...4095},
                                  |          ifIdx are set to IN='O-1',OUT='O'
                                  | Note that this option
                                  | superseedes the --in/out-iface-idx options
[--discard-unknown-flows] <mode>  | In case you enable L7 proto detection
                                  | (e.g. add %L7_PROTO to the template)
                                  | this options enables you not to export
                                  | flows for which nDPI has not been able
                                  | to detect the proto. Mode values:
                                  | 0 - Export known/unknown flows (default)
                                  | 1 - Export only known flows (discard
                                  |     flows with unknown protos)
                                  | 2 - Export only unknown flows (discard
                                  |     flows with known protos)
[--nprobe-version|-v]             | Prints the program version.
[--flow-lock|-C] <flow lock>      | If the flow lock file is present no flows
                                  | are emitted. This facility is useful to
                                  | implement high availability by means of
                                  | a daemon that can create a lock file
                                  | when this instance is in standby.
[--help|-h]                       | Prints this help.
--interpret-flow-packets          | Interpret received packets to see
                                  | if they contain flows (development only).
--debug                           | Enable debugging (development only).
--json-to-syslog                  | Export flows in JSON format to syslog
--json-labels                     | In case JSON label is used (e.g. with ZMQ)
                                  | labels instead of numbers are used as keys.
--fake-capture                    | Fake packet capture (development only).
--drop-flow-no-plugin             | Drop flows that have not processed by a plugin.
--l7-aggregation <mode>           | Enable data aggregation in redis (--redis required)
                                  | 1 - Aggregate hourly (redis key nprobe.l7_xxx.epoch)
                                  | 2 - Aggregate daily (redis key nprobe.l7_xxx.epoch)
                                  | 3 - Aggregate totals (redis key nprobe.l7_totals)
                                  | Where epoch is the current epoch modulus 3600 (hourly)
                                  | and 86400 (daily) and xxx is bytes/pkts.
--dont-nest-dump-dirs             | Dump files won't be saved on nested dirs.
--performance                     | Enable performance tracing (debug only).
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--capture-direction <direction>     | Specify packet capture direction
                                    | 0=RX+TX (default), 1=RX only, 2=TX only
--plugin-notify                     | In case plugin(s) are enabled and --zmq is used
                                    | it is possible to send immediately to remote collectors
                                    | a JSON message with the decoded plugin flow info without
                                    | having to wait the flow to expire
--lua <lua path>                    | Run the specified lua file before flow export (nProbe Pro).
--add-pid-to-logfile                | Append the nprobe PID to dump files to avoid file
                                    | overwrite in case multiple probes dump onto the
                                    | same directory
--add-engineid-to-logfile           | Append the defined NetFlow engineId to dump files
--enable-ipv4-deduplication         | By default IPv4 frames hw-duplicated are not detected
                                    | and discarded. Use this option to enable
                                    | IPv4 hw-deduplication
[--syslog|-I] <probe name>          | Log to syslog as <probe name>
                                    | [default=stdout]
[--hash-size|-w] <hash size>        | Flows hash size [default=131072]
[--no-ipv6|-W]                      | IPv6 packets will not be accounted.
[--flow-delay|-e] <flow delay>      | Delay (in ms) between two flow
                                    | exports [default=1]
[--count-delay|-B] <packet count>   | Send this many packets before
                                    | the -e delay [default=1]
[--min-flow-size|-z] <min flow size>| Minimum TCP flow size (in bytes).
                                    | If a TCP flow is shorter than the
                                    | specified size the flow is not
                                    | emitted [default=unlimited]
[--max-num-flows|-M] <max num flows>| Limit the number of active flows. This is
                                    | useful if you want to limit the memory
                                    | or CPU allocated to nProbe in case of non
                                    | well-behaved applications such as
                                    | worms or DoS. [default=524288]
[--netflow-engine|-E] <type:id>     | Specify the engine type and id.
                                    | The format is engineType:engineId.
                                    | [default=0:18] where engineId is a
                                    | random number.
[--min-num-flows|-m] <min # flows>  | Minimum number of flows per packet
                                    | unless an expired flow is queued
                                    | for too long (see -l) [default=30
                                    | for v5, dynamic for v9]
[--sender-address|-q] <host:port>   | Specifies the address:port of the flow
                                    | sender. This option is useful for hosts
                                    | with multiple interfaces or if flows
                                    | must be emitted from a static port/IP.
[--sample-rate|-S] <pkt rate>:<flow rate>
                                    | Packet capture sampling rate and flow
                                    | sampling rate. If <pkt rate> starts with
                                    | '@' it means that nprobe will report
                                    | the specified sampling rate but will
                                    | not sample itself as incoming packets
                                    | are already sampled on the specified
                                    | capture device at the specified rate.
                                    | Default: 1:1 [no sampling]
[--as-list|-A] <AS list>            | GeoIP file containing with known ASs.
                                    | Example: GeoIPASNum.dat
--city-list <city list>             | GeoIP file containing the city/IP mapping.
                                    | Note that nProbe will load the IPv6 file
                                    | equivalent if present. Example:
                                    | --city-list GeoLiteCity.dat will also
                                    | attempt to load GeoLiteCityv6.dat
[--pid-file|-g] <PID file>          | Put the PID in the specified file
[--flow-templ|-T] <flow template>   | Specify the NFv9/IPFIX template (see below).
[--flow-templ-id|-U] <templ. id>    | Specify the NFv9/IPFIX template identifier
                                    | [default: 257]
[--flow-version|-V] <version>       | NetFlow Version: 5=NFv5, 9=NFv9, 10=IPFIX
[--flows-intra-templ|-o] <num>      | Specify how many flow pkts are exported
                                    | between template exports [default: 10]
[--aggregate-gtp-tunnels]           | Aggregate GTP traffic on tunnel id.
[--collector-sample-rate] <value>   | Specify the bytes/pkts collection sample rate.
[--keep-probes-unmerged]            | Don't merge flows rcvd from different probe IPs.
[--skip-packet-header-bytes] <num>  | Skip <num> bytes from ingress packet header.
[--local-networks|-L] <nets>        | Specify the list of local networks whose
                                    | format is <net>/<mask> (if multiple use comma).
[--local-hosts-only|-c]             | All the IPv4 hosts outside the local
                                    | network lists will be set to 0.0.0.0
                                    | (-L must be specified before -c).
                                    | This reduces the load on the probe
                                    | instead of discarding flows on the
                                    | collector side.
[--local-traffic-direction|-r]      | All the traffic going towards
                                    | the local networks (-L must also be
                                    | specified before -r) is assumed incoming
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                                  | traffic all the rest is assumed outgoing
                                  | (see also -u and -Q).
[--max-flow-size|-0] <size>       | Specify the maximum flow size. NOTE:
                                  | This parameter has influence on -m.
[--if-networks|-1] <nets>         | Specify the binding between interfaceId
                                  | and a network (see below).
[--count|-2] <number>             | Capture a specified number of packets
                                  | and quit (debug only)
[--collector-port|-3] <port>      | NetFlow/IPFIX/sFlow collector flows port
[--tunnel|-5]                     | Compute flows on tunneled traffic rather than
                                  | on the external envelope
[--no-promisc|-6]                 | Capture packets in non-promiscuous mode
[--smart-udp-frags|-7]            | Ignore UDP fragmented packets with fragment offset
                                  | greater than zero, and compute the fragmented
                                  | packet length on the initial fragment header.
[--ipsec-auth-data-len|-8] <len>  | Length of the authentication data of IPSec
                                  | in tunnel mode. If not set, IPSec will not be decoded
[--dump-stats|-9] <path>          | Periodically dump traffic stats into the
                                  | specified file
--black-list <networks>           | All the IPv4 hosts inside the networks
                                  | black-list will be discarded.
                                  | This reduces the load on the probe
                                  | instead of discarding flows on the
                                  | collector side.
--pcap-file-list <filename>       | Specify a filename containing a list
                                  | of pcap files.
                                  | If you use this flag the -i option will be
                                  | ignored.
[--biflows-export-policy|-N] <pol>| Bi-directional flows export policy:
                                  | 0 - export all flows
                                  | 1 - export bi-directional flows only
                                  | 2 - export mono-directional flows only
--csv-separator <separator>       | Specify the text files separator (see -P)
                                  | Default is '|' (pipe)
--dont-drop-privileges            | Do not drop privileges changing to user nobody
--bi-directional                  | Force flows to be bi-directional. This option
                                  | is not supported by NetFlow V5 that by nature
                                  | supports only mono-directional flows
--account-l2                      | NetFlow accounts IP traffic only, not counting
                                  | L2 headers. Using this option the L2 headers
                                  | are also accounted
--dump-metadata <file>            | Dump flow metadata into the specified file
                                  | and quit. Useful for knowking the IE handled.
--dump-pkts <.pcap file>          | Dump incoming packets on the specified dump
--max-log-lines <num>             | Maximum number of lines on a dump file. Default: 10000.
--timestamp-format <mode>         | Specify the timestamp format on dump files. Values:
                                  | 0 - Unix Epoch
                                  | 1 - Unix Epoch with microseconds
                                  | 2 - Human readable timestamp
--ndpi-proto <proto>              | Comma separated list of nDPI protocols to enable. If
                                  | not specified, all known protocols are detected.
--account-imsi-traffic            | When used with GTP traffic and --redis, the user traffic
                                  | is accounted per IMSI/NSAPI (mobile traffic only)
--event-log <file>                | Dump relevant activities into the specified log file
--online-license-check            | Check license online instead of using a license file
--host                            | The probe is used for capturing packet from a host interface
                                  | rather that from a mirror/tap. This way the RX direction
                                  | identifies ingress traffic, and TX egress traffic
--cli <port>:<user>:<pwd>         | Enable command-line on the specified port
--collection-filter <filter>      | Filter applied to collected filters only (-3). Filter format:
                                  | [!]<asX | network/mask> (! means discard flows matching filter)
                                  | Example: !as12345, 192.168.0.0/24, !10.0.0.0/8
--imsi-aggregation                | Aggregate IMSI traffic (GTP traffic only)
--simulate-storage                | Simulate storage to disk (debug only)
--zmq <socket>                    | Deliver flows to subscribers connected to the specified endpoint.
                                  | Example tcp://*:5556 or ipc://flows.ipc
--zmq-encrypt-pwd <pwd>           | Encrypt the ZMQ data using the specified password
--zmq-probe-mode                  | By default nProbe in ZMQ mode acts as a server with subscribers
                                  | (e.g. ntopng) attaching to it. When this option is used, roles
are
                                  | reverted (i.e. use ntopng --zmq-collector-mode).
--tcp <server:port>               | Deliver flows in JSON format to the specified server via TCP.
--dump-bad-packets <file>         | Dump bad/undecodeable packets into the specified pcap file
--lru-cache-size <size>           | Users and protocol cache size. Default 16384
--enable-throughput-stats         | Compute throughput stats that can be dumped when -P is used
--ndpi-proto-ports <file>         | Read custom ports definitions for nDPI (see nDPI/example/
protos.txt)
--disable-l7-protocol-guess       | When nDPI is enabled, in case a protocol is not recognized,
                                  | nProbe guesses the protocol based on ports. This option disables
                                  | this feature and uses only strict payload dissection
--original-speed                  | When using -i with a pcap file, instead of reading packets
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                                    | as fast as possible, the original speed is preserved (debug only)
--dont-reforge-timestamps           | Disable nProbe to reforge timestamps with -i <pcap file> and
                                    | prevent flows from expire until the whole pcap is read (debug
only)
--db-engine <database engine>       | Define the DB engine type (example MyISAM, InfiniDB).
                                    | This information is used by the database plugin.
                                    | Default MyISAM.
--unprivileged-user <name>          | Use <name> instead of nobody when dropping privileges
--disable-cache                     | Disable flow cache for avoid merging flows. This option
                                    | is available only in collector/proxy mode
                                    | (i.e. use -i none)
--redis <host>[:<port>]             | Connected to the specified redis server
                                    | Example --redis localhost
--use-redis-proxy                   | Use a redis proxy (e.g.
                                    | https://github.com/twitter/twemproxy)
--ucloud                            | Enable the nProbe micro-cloud
--bind-export-interface <name>      | Bind the flow export socket to the IP of specified
                                    | network interface
--disable-startup-checks            | Disable startup activities such as computation of public
                                    | IP address
--dump-plugin-families              | Dump all available plugin families
--kentik-host                       | Enable kentik.com host mode
--kentik-sensor                     | Enable kentik.com sensor mode
```

-n: collector addresses

This specifies the NetFlow collectors addresses to which nProbe will send the flows. If more than one is specified, they need to be separated with a comma or the --n flag can be repeated several times (e.g. -n 172.22.3.4:33,172.22.3.4:34 and -n 172.22.3.4:33 --n 172.22.3.4:34 are equivalent). When multiple collectors are defined, you can control the way flows are exported using the --a option (see below); if on a collector address the destination port is omitted, flows are sent to 2055 port and whereas if all the option is not specified, by default, flows are sent to the loop back interface (127.0.0.1) on port 2055. If this parameter is used, nProbe exports flows towards collector running at 127.0.0.1:2055. By default the UDP protocol is used but also TCP and SCTP (Linux only when nProbe is compiled with SCTP support and the kernel supports it). In this case you can specify the collector address as udp://<host>:<port>, tcp://<host>:<port>, and sctp://<host>:<port>,

-i: interface name

It specifies the interface from which packets are captured. If -i is not used, nProbe will use the default interface (if any). In case a user needs to activate nProbe on two different interfaces, then he/she needs to activate multiple nProbe instances once per interface. For debugging purposes it is possible to pass nProbe a .pcap file from which packets will be read. If nProbe is compiled and activated with PF_RING support, you can specify multiple interfaces from which packets are captured. Example "-i eth0,eth1"

-t: maximum flow lifetime

Regardless of the flow duration, a flow that has been active for more that the specified maximum lifetime is considered expired and it will be emitted. Further packets belonging to the same flow will be accounted on a new flow.

-d: maximum flow idle lifetime

A flow is over when the last packet received is older that the maximum flow idle lifetime. This means that whenever applicable, (e.g. SNMP walk) UDP flows will not be accounted on 1 packet/1 flow basis, but on one global flow that accounts all the traffic. This has a benefit on the total number of generated flows and on the overall collector performance.

-l: maximum queue timeout

It specifies the maximum amount of time that a flow can be queued waiting to be exported. Use this option in order to try to pack several flows into fewer packets, but at the same time have an upper bound timeout for queuing flows into the probe.

-s: snaplen

This flag specifies the portion of the packet (also called snaplen) that will be captured by nProbe. By default nprobe sets the snaplen automatically according to its configuration, but you can override its value using thia flag.

-p: flow aggregation

Flows can be aggregated both at collector and probe side. However probe allocation is much more effective as it reduces significantly the number of emitted flows hence the work that the collector has to carry on. nProbe supports various aggregation levels that can be selected specifying with the --p flag. The aggregation format is <vlanid>/<proto>/<IP>/<port>/<TOS>/<AS> where each option can be set to 0 (ignore) or 1 (take care). Ignored fields are set to a null value. For instance the value 0/0/1/0/0/0 is useful for creating a map of who's talking to who (network conversation matrix).

-f: packet capture filter

This BPF filter (see the appendix for further information about BPF filters) allows nProbe to take into account only those packets that match the filter (if specified).

-a: select flow export policy

When multiple collectors are defined (see --n option), nProbe sends them flows in round robin. However it is possible to send the same flow to all collectors as a flow redirector does if the --a option is used.

-b: enable verbose logging

Using this flag, nProbe generates verbose output that can be used to tune its performance (see chapter 2.4). Zero is the lowest level (little information is printed), 1 displays traffic statistics, 2 is really verbose. Example of traffic statistics:

```
04/Jul/2007 18:16:00 [nprobe.c:1129] Average traffic: [1.7 pkt/sec][1 Kb/sec]
04/Jul/2007 18:16:00 [nprobe.c:1134] Current traffic: [1.9 pkt/sec][1 Kb/sec]
04/Jul/2007 18:16:00 [nprobe.c:1140] Current flow export rate: [0.9 flows/sec]
04/Jul/2007 18:16:00 [nprobe.c:1144] Buckets:
[active=13][allocated=21][free=8][toBeExported=0][frags=0]
04/Jul/2007 18:16:00 [nprobe.c:1149] Fragment queue: [len=0]
04/Jul/2007 18:16:00 [nprobe.c:1153] Num Packets: 111 (max bucket search: 0)
04/Jul/2007 18:16:00 [nprobe.c:1170] 115 pkts rcvd/0 pkts dropped
```

-G: start nprobe as a daemon.

Useful when starting nprobe as daemon.

-O: set the number of threads that fetch packets out of the network interface.

In general: the more threads are available, the better is the performance. However it is not suggested to have too many threads as in some platforms this can slow down the probe. Start with 1 and increase it if necessary. We suggest to run nprobe as single threaded application and distribute the traffic across multiple probes using PF_RING (e.g. PF_RING cluster or libzero). In fact adding threads you will end up spending a lot of time on synchronization without improving the performance. Please refer to this post http://www.ntop.org/nprobe/10-gbit-line-rate-netflow-traffic-analysis-using-nprobe-and-dna/ for more information.

-P: dump flows

This path specifies the directory where flows will be dumped. The dump format is text and it depends on the nProbe template specified with -T.

-F:

It specifies the frequency at which files are dumped on disk

-D: dump flows format

Flows stored on disks can be stored in two formats: text with user-specified format or SQLite format (availability depends on the platform and if nProbe has been compiled with it). Using flow SQLite format (-D d) can significantly reduce the size of stored files, although all the collectors might not support this

format. Text flows (-D t) are the safest setting if you want to use a standard collector able to read flows dump on disk. You can also export core flow fields (-D B) in binary format for post-processing by binary applications. Note that this flag has no effect unless --P is used.

-u: input device index

The NetFlow specification contains a numeric index in order to identify flows coming from different interfaces of the same probe. As multiple nProbe instances can be started on the same host but on different devices, the collector can use this flag to divide flows according to the interface number. If --u is not used, then nprobe will use 0 as interface index. Alternatively, if -1 is used then the last two bytes of the mac address of the flow sender are used as index.

-Q: output device index

Similar to --u but for the output interface.

--vlanid-as-iface-idx <mode: inner | outer | single | double>

nProbe can use the VLAN tag as interface identifier. Using this flag you enable this feature. As VLAN tags can be stacked you need to specify if the inner or outer tag will be used for the interface identifier.

--discard-unknown-flows <mode:0 | 1 | 2>

nProbe includes nDPI support for analyzing packet contents in order to detect application protocol. The mode value can be used to:

- 0: Export all know (i.e. those whose application protocol has been detected) and unknown (i.e. the application protocol is unknown)
- 1: Export only know flows, discarding unknown flows.
- 2:Export only unknown flows, discarding known flows.

-v: print version

This flag is used to print the nProbe version number and date.

-C: flow export lock

This is a simple way to implement high-availability. Start two probes capturing the same data. The master probe emit flows, the slave probe is started with --C <path>. As long as <path> exists, the slave works but no flow is emitted. If the <path> file is deleted (e.g. using an external program for controlling the master/slave such as heartbeat) the slave starts emitting flows. If the file is restored, the slave is silent again.

-h: print help

Prints the nProbe help.

--quick-mode

nProbe is computing many statistics, but if you care just about basic netflow (i.e. V5 or V9/IPFIX flows with standard fields) you can use this flag to expedite operations telling nProbe to avoid doing many unnecessary things (e.g. handle L2 traffic). Use this option if you care about speed.

--dont-nest-dump-dirs

nProbe dumps data on disk (e.g. with -P) using a nested directory. In essence the base directory will be partitioned in sub-directories with <year>/<month>/<day>/<hour>/<min> structure. use this option is you want nProbe to dump all data in the base directory without creating this nested directory tree.

-l: log to syslog <probe name>

nProbe logs on stdout unless the --g flag (see above) is used. If the syslog needs to be used instead of a file, this flag instruments nProbe to log on it using the specified name (this is useful when multiple nProbe instances are active on the same host). Please note that --g is ignored if --l is used, and this option is not available on nProbe for Win32.

-w: size of the hash that stores the flows

The default size is 131072 and it should be enough for most of networks. In case flows are not emitted often and with strong traffic conditions it would be necessary to increase the hash. See later in this manual for knowing more about nProbe tuning.

-W: Discard IPv6 traffic

Use this flag if you want nProbe not to account IPv6 traffic.

-e: flow export delay

Some collectors cannot keep up with nProbe export speed. This flag allows flows to be slow down by adding a short delay (specified in ms) between two consecutive exports. The maximum allowed delay is 1000 ms.

-B: packet count delay

It specified how many flow packets need to be sent before --e is applied,

-z: minimum TCP flow size

Peer-to-peer applications, attacks or misconfigured applications often generate a lot of tiny TCP flows that can cause significant load on the collector side. As most collector setups often discarded those flows, it is possible to instrument nProbe via the --z flag not to emit such flows. Note that the --z flag affects only the TCP protocol (i.e. UDP, ICMP and other protocols are not affected).

-M: maximum number of active flows

It is used to limit the maximum number of concurrent flows that the probe can sustain. This is useful for preventing the probe from creating as many flows as needed and hence to take over all the available resources.

-E: netflow engine

Specify the netflow engineType:engineId into the generated flows.

-m: minimum number of flows per packet

In order to minimize the number of emitted packets containing flows, it is possible to specify the minimum number of flows that necessarily need to be contained in a packet. This means that the packet is not emitted until the specified number of flows is reached.

-q: flow sender address

This option is used to specify the address and port from which the packets containing flows are coming from. Usually the operating systems prevents people from sending packets from addresses different from those assigned to the network interfaces.

-S: sample rate <packet rate>:<flow rate>

nProbe uses all the captured packets for calculating flows. In some situations (e.g. strong traffic conditions) it is necessary to reduce the number of packets that need to be handled by nProbe. This option specifies the sampling rate, i.e. the number of packets that are discarded between two packets used to produce flows. You can also specify the flow sample rate that reduce the egress flow rate thus lowering the load on collectors. The default value is 1:1 (no packet sample, no flow sample).

-A: AS file

Network probes are usually installed on systems where the routing information is available (e.g. via BGP) in order to specify the AS (Autonomous System) id of the flow peer. As nProbe has no access to BGP information unless you enable the BGP plugin, users need to provide this information by means of a static file whose format is <AS>:<network>. The file can be stored in both plain text and gzip format.

--city-list: City List

With this option you can enable geolocation of IP addresses at city/country detail level. Here you need to specify the GeoIP city database (e.g. GeoLiteCity.dat)

-g:

It specifies the path where nProbe will save the process PID.

-T: flow template definition

Contrary to NetFlow v5 where the flow format is fixed, NetFlow V9 and IPFIX flows have a custom format that can be specified at runtime using this option as specified in appendix.

-U: flow template id

NetFlow v9 and IPFIX flows format is specified in a template whose definition is sent by nProbe before to start sending flows. The flow format is defined by --T, where --U is used to set the template identifier. This option should not be used unless the default template value (257) needs to be changed. As based on -T nProbe can define several templates, this value is the one used for the first defined template.

-V: flow export version

It is used to specify the flow version for exported flows. Supported versions are 5 (v5), 9 (v9) and 10 (IPFIX).

-o: intra templates packet export.

It specifies the number of flow packets that are exported between two templates export.

--aggregate-gtp-tunnels

Aggregates traffic flowing in each GTP tunnel based in tunnel id.

[--collector-sample-rate] <value>

Specifies the sample rate of the collector (either in bytes of packets).

-L: local networks

Use this flag to specify (format network/mask, e.g. 192.168.0.10/24) the list of networks that are considered local (see --c).

-c: track local hosts only

It allows nProbe to set to 0.0.0.0 all those hosts that are considered non-local (see --L). This is useful when it is necessary to restrict the traffic analysis only to local hosts.

-r: set traffic direction

When this option is used (-L must be specified before --r), all the traffic that goes towards the local networks is considered incoming, all the rest is outgoing. This has effect on the --u/-Q that are then forced with --r.

--if-networks: specify a mapping between MAC address/Interface index

Flags -u and -Q are used to specify the SNMP interface identifiers for emitted flows. In mirrored environments, it is possible to simulate a switched environment by playing with MAC addresses. This option allows users to bind a MAC or IP address to a specified interfaceId.. The syntax of --if-networks is <MAC|IP/mask>@<interfaceId> where multiple entries can be separated by a comma (,). Example: --if-networks "AA:BB:CC:DD:EE:FF@3,192.168.0.0/24@2" or --if-networks @<filename> where <filename> is a file path containing the networks specified using the above format.

--count: debug only

Let the probe capture only up to the specified number of packets.

--collector-port: specifies the NetFlow collector port

It is now possible to use the nProbe as NetFlow proxy. With --collector-port we can se the incoming NetFlow port on which flows are received instead of sniffing packets. nProbe is able to convert flows from various versions. For instance "nprobe --collector-port 2055 --i 192.168.0.1:2056 --V 10" converts each flow received on port 2055 to IPFIX and sends them to 192.168.0.1:2056.

--tunnel:

Let the probe decode tunneled traffic (e.g. GTP or GRE traffic) and thus extract traffic information from such traffic rather than from the external envelope.

--no-promisc:

With this option nProbe does not use promiscuous mode to capture packets.

--smart-udp-frags:

Ignore UDP fragmented packets with fragment offset greater than zero, and compute the fragmented packet length on the initial fragment header. This flag might lead to inaccuracy in measurement but it speeds us operations with fragmented traffic.

--ipsec-auth-data-len

Length of the authentication data of IPSec in tunnel mode. If not set, IPSec will not be decoded but just accounted.

--dump-stats: dump some flow statistics on file

Periodically dump NetFlow statistics on the specified file. Note that when using nProbe over PF_RING, nProbe dumps statistics on /proc/net/pf_ring/stats/<nprobe stats file>.

--black-list

With this option you can specify a list of networks or hosts from which all the incoming packets will be discarded by the probe. The accepted notation can be CIDR format or the classical network/netmask format.

--pcap-file-list <file>

The specified file path contains a list of pcap files to be read in sequence by nProbe. Use this option when you want nProbe to read a list of pcap files (e.g. when generated using tcpdump).

--biflows-export-policy <policy>

Bi-directional flows are such when there is traffic in both direction of the flow (i.e. source->dest and dest->source). As mono-directional flows might indicate suspicious activities, this flag is used to determine the export policy:

- 0: Export all know (i.e. mono and bi-directional flows)
- 1: Export only bi-directional flows, discarding mono-directional flows.
- 2: Export only mono-directional flows, discarding bi-directional flows.

--csv-separator <separator>

Override the default 'l' separator in dumps with the specified one.

--dont-drop-privileges

Do not drop root privileges to user 'nobody' when this option is specified. See al --unprivileged-user later int this manual.

--bi-directional

Force flows to be bi-directional. This option is not supported by NetFlow V5 that by nature supports only mono-directional flows

--account-l2

NetFlow accounts IP traffic only, not counting layer 2 headers. Using this option the layer 2 headers are also accounted in flow traffic statistics.

--dump-metadata <file>

Dump metadata information into the specified file and quit. This option is useful when users want to know the type of each information element exported by nProbe so that (for instance) they can properly import into a database.

--zmq <socket>

Specify a socket (e.g., tcp://*:5556) that will be used to deliver flows to subscribers polling the socket.

--zmq-probe-mode

By default, nProbe act as a ZMQ server that delivers flows to subscribers. Using this switch, its role is reverted. This is typically used in conjunction with ntopng run in collector mode. For a thorough description refer to the section "Using nProbe with ntopng".

--tcp <server:port>

Delivers flows in JSON format via TCP to the specified pair server:port.

--event-log <file>

Dump relevant activities (e.g. nProbe start/stop or packet drop) onto the specified file.

--enable-throughput-stats

When -P is used, with this option is also possible to generate throughput information. The file has the following format: <epoch> <bytes> <packets>. Each line is printed every second and it contains the number of bytes and packets observed within minute.

--ndpi-proto-ports <file>

Read the nDPI custom protocol and ports configuration from the specified file. Please refer to the nDPI manual for further information about the format of this file.

--disable-l7-protocol-guess

When nDPI is unable to detect a protocol, nProbe uses the port information to guess the protocol. This flag prevents nProbe from doing that, so protocols are detected only by nDPI without relying on default ports.

--db-engine <database engine>

In case flows are dumped on a MySQL database (see later on this manual) the default database engine used by nProbe is MyISAM. With this option you can use another engine (e.g. InnoDB).

--unprivileged-user <name>

When nprobe drops privileges (unless --dont-drop-privileges is used) the user nobody is used. It is possible to use another user by using this option.

--disable-cache

nProbe implements a flow cache for merging packets belonging to the same flow. In proxy/collector mode, nProbe can disable this feature so that incoming flows are not put in cache but immediately exported.

--redis <host>[:<port>]

The redis database (when nProbe is compiled with it) is used to implement a data cache and for aggregating flow information. This option specifies the host (and optionally the port) where redis is listening. nProbe opens several connections to redis (not just one) in order to maximize performance.

--ucloud

This option enables the micro-cloud concept. Please refer to http://www.ntop.org/nprobe/monitoring-on-the-microcloud/ for more information.

--show-system-id

Shown the systemId where nProbe is running (for binary nProbe's only).

--check-license

Checks if the configured license is valid (for binary nProbe's only).

--disable-startup-checks

During startup nProbe obtains both the management interface IP address and its public IP address. The management interface IP address is the address of the physically-attached interface that carries nProbe network traffic. The public IP address is the address of the management interface as it is seen from the internet. Obtaining the public IP address triggers a request to http://checkip.dyndns.org

nProbe is designed to obtain these two addresses with the aim of reporting them to ntopng. This information is important for ntopng to correctly report statistical information without using more complicated mechanisms such as SNMP.

Using this option causes nProbe to refrain from obtaining the IP addresses described above.

--dump-plugin-families

Dump installed plugin family names.

As some people prefer to have a configuration file containing the options that otherwise would be specified on the command line, it is also possible to start nProbe as follows:

```
nprobe <configuration file path>
```

where the configuration file contains the same options otherwise specified on the command line. The only difference between the command line and the configuration file is that different options need to be specified on different lines. For instance:

```
nprobe --n 127.0.0.1:2055 --i en0 --a -p
```

is the same as:

```
nprobe /etc/nprobe.conf
```

where /etc/nprobe.conf contains the following lines:

```
# cat /etc/nprobe.conf

-n=127.0.0.1:2055
-i=en0
-a=
-p=
```

Note that flags with no parameter associated (e.g. --a) also need to have '=' specified.
Any standard NetFlow collector (e.g. ntop) can be used to analyze the flows generated by nProbe. When used with ntop, the nProbe can act as a remote and light traffic collector and ntop as a central network monitoring console. See chapter 3 for further information about this topic.

Running nProbe as a Daemon

nProbe can be run in daemon mode on unix systems and one or more of its instances can be optionally run automatically on system startup. Daemon execution and status are controlled using the script

```
/etc/init.d/nprobe
```

The script is installed automatically on unix systems as it is part of any standard nProbe installation procedure.

Configuration Files

Multiple nProbe instances can be simultaneously executed on the same machine. Typically, each instance is bound to an interface. To allow different nProbes to be run with independent configurations, multiple configuration files co-exist under the directory

```
/etc/nprobe/
```

Each configuration file starts with nprobe- and ends with a suffix corresponding to the interface name it is associated to. For example, assuming three different nProbe daemons have to be run independently for eth0, eth4, and myri0, the following configuration files must be created

```
deri@devel 210> ls -lha /etc/nprobe/
total 28K
4.0K -rw-r--r--   1 root root  211 Mar 15 17:54 nprobe-eth0.conf
4.0K -rw-r--r--   1 root root  195 Jan  8 17:17 nprobe-eth4.conf
4.0K -rw-r--r--   1 root root  215 Jan  8 17:22 nprobe-myri0.conf
```

When nProbe is used in probe mode it is not bound to any interface as its job is to collect NetFlow from some other device. In this case the configuration file to be created is

```
nprobe-none.conf
```

Automatic Startup

In order to launch nProbe daemons automatically on system startup, empty files ending with ".start" must be created in the same directory of the configuration files. For example, if the eth0 nProbe daemon has to be launched on startup, the file nprobe-eth0.start must be created, e.g.,

```
root@devel:/etc/nprobe# ls -lha
total 28K
drwxr-xr-x   2 root root 4.0K Mar 17 15:44 .
drwxr-xr-x 117 root root  12K Mar 11 12:16 ..
-rw-r--r--   1 root root  211 Mar 15 17:54 nprobe-eth0.conf
-rw-r--r--   1 root root    0 Mar 17 15:44 nprobe-eth0.start
-rw-r--r--   1 root root  195 Jan  8 17:17 nprobe-eth4.conf
-rw-r--r--   1 root root  215 Jan  8 17:22 nprobe-myri0.conf
```

Daemon Control

nProbes daemons are controlled with the script /etc/init.d/nprobe. The script accept different options and one or more interface names as input. Calling the script without options yields the following brief help

```
deri@devel 204> sudo /etc/init.d/nprobe
Usage: /etc/init.d/nprobe {start|force-start|stop|restart|status} [interface(s)]
```

The options and the usage of the daemon control script is discusse below.

start
This option is used to start daemon nProbes for interfaces that have a ".start" file. Calling start on interfaces with missing ".start" files yield and error. For example

```
root@devel:/etc/nprobe# ls -lha
-rw-r--r--   1 root root  211 Mar 15 17:54 nprobe-eth0.conf
-rw-r--r--   1 root root    0 Mar 17 15:44 nprobe-eth0.start
-rw-r--r--   1 root root  195 Jan  8 17:17 nprobe-eth4.conf
-rw-r--r--   1 root root  215 Jan  8 17:22 nprobe-myri0.conf
root@devel:/etc/nprobe# /etc/init.d/nprobe start eth0
Starting nProbe eth0
root@devel:/etc/nprobe# /etc/init.d/nprobe start eth4
nProbe eth4 not started: missing /etc/nprobe/nprobe-eth4.start
```

force-start
This option is used to start daemon nProbes for instances that do not have a ".start" file. Calling force-start on interface eth4 shown in the example above doesn't raise any error and the daemon is properly started

```
root@devel:/etc/nprobe# /etc/init.d/nprobe force-start eth4
Starting nProbe eth4
```

stop
This option is used to stop an nProbe daemon instance. For example

```
root@devel:/etc/nprobe# /etc/init.d/nprobe stop eth4
Stopping nProbe eth4
```

restart
This option causes the restart of a daemon associated to a given interface, e.g.,

```
root@devel:/etc/nprobe# /etc/init.d/nprobe restart eth0
Stopping nProbe eth0
Starting nProbe eth0
```

status
This options prints the status of a daemon associated to a given interface, e.g.,

```
root@devel:/etc/nprobe# /etc/init.d/nprobe status eth0
nprobe running
```

Running nProbe on Windows

nProbe can be activated either as service or as application (i.e. you can start it from cmd.exe). The nProbe installer registers the service and creates an entry on the Start menu. In order to display nProbe inline help, the executable must be run with /h

```
C:\Program Files\nProbe>nprobe /h
Available options:
/i <service name> [nprobe options] - Install nprobe as service
/c [nprobe options]                - Run nprobe on a console
/r <service name>                  - Deinstall the service

Example:
Install nprobe as a service: 'nprobe /i my_nProbe -i 0 -n 192.168.0.1:2055'
Remove the nprobe service:   'nprobe /r my_nProbe'

Notes:
1. Type 'nprobe /c -h' to see all options
1. In order to reinstall a service with new options
   it is necessary to first remove the service, then add it
   again with the new options.
2. Services are started/stopped using the Services
   control panel item.
3. You can install the nProbe service multiple times
   as long as you use different service names.
```

The full list of options is available with nprobe /c -h. If nProbe is started on the console, the /c flag needs to be used (e.g. nprobe /c --n 127.0.0.1:2055).

Specify Monitored Interfaces

As network interfaces on Windows can have long names, a numeric index is associated to the interface in order to ease the nProbe configuration. The association interface name and index is shows typing the 'nprobe /c --h'

C:\ntop\nprobe\Debug>nprobe.exe/c -h

[…]
Available interfaces:
    [index=0] 'Adapter for generic dialup and VPN capture'
    [index=1] 'Realtek 8139-series PCI NIC'

[…]

For instance, in the above example the index 1 is associated to the interface Realtek 8139-series PCI NIC, hence in order to select this interface nprobe needs to be started with --i 1 option.

Execution as a Windows Service

Windows services are started and stopped using the Services application part of the Windows administrative tools. When nProbe is used as service, command line options need to be specified at service registration and can be modified only by removing and adding the service. The nProbe installer registers nProbe as a service with the default options. If you need to change the nProbe setup, you need to do as follows:

nprobe /r	Remove the service
nprobe /i <put your options here>	Install the service with the specified options.

Tuning nProbe Performance

As nProbe can be deployed on very different environments, it is necessary to tune it according to the network where is active. In order to achieve a good probe setup, it is necessary to understand how nProbe is working internally. Each captured packet is analyzed, associated to a flow, and stored onto a hash. Periodically, the hash is analyzed and expired flows are emitted[1]. The hash size is static (-w flag)[2] as this allows nProbe to:

- Allocate all the needed memory at startup (this is compulsory on embedded systems where memory is limited and it is necessary to know at startup whether a certain application can operate with the available resources).
- Avoid exhausting all the available memory in case of attacks that can produce several flows.

Selecting the hash size is a matter of trade-off between efficiency (an efficient hash is at least 1/3 empty) and memory usage. This statement does not mean that a huge hash is always the solution as the flow export process can be slower (and more CPU cycles are needed) as a large hash needs to be explored.

On the other hand, the hash size is just a part of the problem. In fact, the hash fill percentage can be also controlled by other factors such as:

- Reducing the flow lifetime (-t)
- Reducing the maximum flow idle time (-d)
- Increasing how often the hash is walked searching expired flows (-s)

nProbe allows users to ease the tuning process by printing the status of internal hashes using the --b flag. Users who experience severe nProbe performance problems, packet loss or high CPU usage, should start nProbe with --b in order to find out whether their probe setup is optimal.

1 It is worth to remark that packets are captured while nProbe performs flow export (i.e. packet capture is not stopped during flow export).

2 Note that the basic hash has a static size specified by --w that can grow as needed according to traffic conditions.

Using nProbe with ntopng

On the Internet there are several NetFlow collectors that can be used to consume flows generated by nProbe. Among them ntopng is included. This section explains how to configure ntopng to take advantage of nProbe. nProbe can be used as pure probe (i.e. it convert raw packets into flows) or as proxy (i.e. it acts as an sFlow/NetFlow collector with respect to ntopng. The following picture illustrated the two different modes of operation.

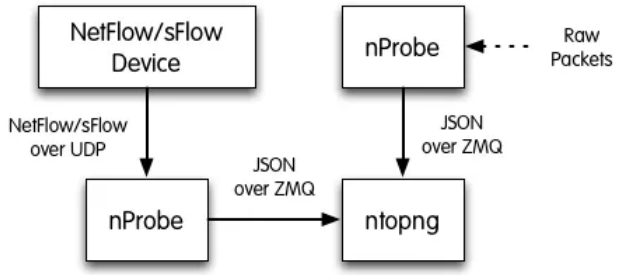

Fig. 1-- Using ntop with nProbe

In the picture above, the arrow from nProbe to ntopng depicts the flow of information. Actually (and physically) is ntopng that connects (as client) to nProbe that instead acts as data source. Following is an example configuration of nProbe and ntopng. It is assumed they are running on the same (local) host. In case they are run on separate machines, the IP address 127.0.0.1 has to be changed with the address of the machine hosting nProbe. For the sake of completeness, two nProbe instances are started, namely, a pure probe and a proxy as described above.

ntop Configuration

ntopng -i tcp://127.0.0.1:5556

nProbe Configuration

nprobe --zmq "tcp://*:5556" -i eth1 -n none *(probe mode)*
nprobe --zmq "tcp://*:5556" -i none -n none --collector-port 2055 *(sFlow/NetFlow collector mode)*

Please refer to this blog post for a detailed explanation: http://www.ntop.org/nprobe/why-nprobejsonzmq-instead-of-native-sflownetflow-support-in-ntopng/

Usage Behind a Firewall

In the remainder of this section it is shown how to swap the client and data source roles between ntopng and nProbe. This is particularly useful in network configurations with NAT or firewalls. Indeed, the communication paradigm described in the section above might not work in case there is a firewall between nProbe and ntopng. Following is an exhaustive list of all the possible scenarios that may involve nProbe and ntopng.

Scenario A

- Both nProbe and ntopng are on the same private network (firewall protected).

In this case the firewall does not create any trouble to ZMQ communications and the normal configurations described above can be used.

Scenario B

- nProbe is on a public network/IP
- ntopng is on a private network/IP protected by a firewall

In this case the ZMQ paradigm works well as ntopng connects to nProbe and the normal configurations highlighted above can be used.

Scenario C

- nProbe is on a private network/IP
- ntopng is on a public network/IP protected by a firewall

In this case the ZMQ paradigm does not work as the firewall prevents ntopng (connection initiator) to connect to nProbe. In this case you need to revert the ZMQ paradigm by swapping the roles of nProbe and ntopng. This can be done as follows. Suppose nProbe runs n host IP 192.168.1.100 and ntopng on host IP 46.101.x.y. In this case it is necessary to start the applications as follows

```
nprobe --zmq-probe-mode --zmq "tcp://46.101.x.y:5556" -i eth1 -n none
ntopng --zmq-collector-mode -i "tcp://*:5556"
```

In essence the roles of nProbe and ntopng have been reverted. In this setup they behave as NetFlow/IPFIX probes do.

Exporting to Apache Kafka

nProbe, if configured with the export plugin, can send flows to one or more Kafka brokers in a cluster. Initially, the nProbe tries to contact one or more user-specified brokers to retrieve Kafka cluster metadata. Metadata include the list of brokers available in the cluster that are responsible for a given user-specified topic. Once the nProbe has the list of brokers available, it starts sending flows to them. The user can also decide to compress data and specify if he/she:

- Doesn't want to wait for ACKs
- Wants to receive an ACK only from the Kafka leader
- Wants to receive an ACK from every replica

Example

Assuming there is a Zookeeper on localhost port 2181 that manages the Kafka cluster, it is possible to ask for the creation of a new Kafka topic. Let's say the topic is called "topicFlows" and we want it to be split across three partitions with replication factor two. The command that has to be issued is the following

```
bin/kafka-topics.sh --zookeeper localhost:2181 --create --topic topicFlows \
--partitions 3 --replication-factor 2
```

Now that the Kafka topic has been created, it is possible to execute nProbe and tell the instance to export to Kafka topic "topicFlows". We also tell the instance a list of three brokers running on localhost (on ports 9092, 9093 and 9094 respectively) that will be queried at the beginning to obtain kafka cluster/topic metadata.

```
./nprobe --kafka "127.0.0.1:9092,127.0.0.1:9093,127.0.0.1:9094;topicFlows"
```

At this point the nProbe instance is actively exporting flows to the Kafka cluster. To verify that everything is running properly, we can take messages out of the Kafka topic with the following command

```
bin/kafka-console-consumer.sh --zookeeper localhost:2181 --topic topicFlows\
--from-beginning
```

Scripting nProbe Actions Using Lua

nProbe Professional allows the user to script custom actions and behaviors right before a flow is exported out. Scripted actions and behaviors are executed on a per-protocol basis and require the corresponding plugin. For example, scripting actions and behaviors for HTTP flows requires the HTTP plugin installed and available. Similarly, scripting actions and behaviors for DNS flows requires the DNS plugin to be enabled and available.

Scripts have to be written in Lua language (https://www.lua.org/about.html). Lua is a lightweight scripting language that is dynamically typed, runs by interpreting byte-code with a register-based virtual machine, and has automatic memory management with incremental garbage collection, making it ideal for configuration, scripting, and rapid prototyping.

Lua scripts are specified using nProbe option `--lua`. For example, to tell nProbe to execute script `dnsSearch.lua` located in folder `lua/` one can run the following command

```
./nprobe -i eth1 --lua lua/dnsSearch.lua
```

But how does nProbe know which function to call? The answer is pretty straightforward: it looks for Lua functions with specific name patterns inside the Lua script received as input.

Lua Functions Naming Convention

nProbe looks for Lua functions that are structured as

```
check<Protocol>Flow
```

Every nProbe plugin will inspect the input Lua file and try to find its corresponding function. Plugins must be correctly enabled and set up in order to properly call Lua functions. Plugins that support Lua scripts are outlined in the following table

Protocol	Lua Function Name	Lua Global Table Name
DHCP	`checkDHCPFlow`	`dhcp`
DNS	`checkDNSFlow`	`dns`
FTP	`checkFTPFlow`	`ftp`
GTPV1	`checkGTPV1Flow`	`gtpv1`
HTTP	`checkHTTPFlow`	`http`
IMAP	`checkIMAPFlow`	`imap`
POP	`checkPOPFlow`	`pop`
RADIUS	`checkRADIUSFlow`	`radius`
SIP	`checkSIPFlow`	`sip`
SMTP	`checkSMTPFlow`	`smtp`

Every plugin, for every flow -- before calling, if available, its corresponding Lua function -- pushes into the Lua stack a global table that contains:

- Flow elements that are common to any flow
- Additional elements that are peculiar to flows captured with the plugin

Elements are pushed in the global Lua table as pairs Key - Value.

Common Lua Flow Elements

Every flow has some basic elements that are made available, in a global lua table, my plugin. Common information include source and destination ports, for example. The list of common information fields are outlined in the following table

Common Element Name	Description
`nprobe.pid`	The process id of the nProbe instance
`flow.id`	A unique integer identification to uniquely represent the flow
`flow.from`	The flow source IP address
`flow.to`	The flow destination IP address
`flow.sport`	The flow source Layer-3 port
`flow.dport`	The flow destination Layer-3 port
`flow.duration`	The duration of the flow in seconds
`flow.beginTime`	The epoch of the flow start time
`flow.endTime`	The epoch of the flow end time
`flow.l7_proto`	A unique integer number to represent the Layer-7 protocol
`flow.protocol`	A unique, standard, integer number to represent the Layer-4 protocol as approved by IANA (http://www.iana.org/assignments/protocol-numbers/protocol-numbers.xhtml)

Plugin-Specific Lua Flow Elements

These additional fields vary depending on the plugin that called the Lua function. Every plugin prefixes its additional fields with a name that resembles the plugin.

For example, the DNS plugin adds the following fields

Additional DNS Plugin Element Name	Description
`dns.dns_client`	The IP address of the client that made the DNS request
`dns.as`	The Autonomous System of the client that made the DNS request
`dns.clientcountry`	The country of the client that made the DNS request

Additional DNS Plugin Element Name	Description
dns.clientcity	The city of the client that made the DNS request
dns.query	The DNS query performed
dns.answers	The DNS answers received

Examples

In the remainder of this section are shown examples of nProbe Lua scripting.

Intercepting DNS Flows

Let's say a custom action has to be performed right before the export of any DNS flow. Let's also assume, in the interest of pedagogical clarity, that the custom action consists in printing to the console the global flow Lua table `dns` that has been pushed in by nProbe. To accomplish the action outlined above it suffices to create a Lua script with the following contents

```
function checkDNSFlow()
   for k, v in pairs(dns) do
      print('k: '..k..' v: '..v..'\n')
   end
end
```

The script above iterates over the global dns table and prints all the key-value pairs to the console, one per line. The execution occurs one time for every DNS flow detected, right before exporting the flow. Assuming the script is saved to file `dnsSearch.lua` under the `lua/` directory, then nProbe can be started as follow

```
./nprobe -i en4 --lua lua/dnsSearch.lua  --dns-dump-dir /tmp
```

Console logs will confirm the DNS plugin is enabled and that the Lua interpreter correctly parsed `dnsSearch.lua`:

```
[...]
[LUA] Successfully interpreted lua/dnsSearch.lua
DNS log files will be saved in /tmp
1 plugin(s) enabled
[...]
```

At this point it is possible fire a query to a DNS server

```
$ dig google.it @8.8.8.8
```

nProbe, right after dig termination, will output to the console the following information

```
[...]
k: flow.duration v: 1
k: dns.dns_client v: 192.168.2.130
k: flow.sport v: 54209
k: flow.protocol v: 17
k: dns.query v: google.it
k: flow.endTime v: 1466425499
k: flow.beginTime v: 1466425499
k: flow.dport v: 53
k: dns.answers v:
k: dns.as v: 0
k: flow.to v: 8.8.8.8
k: nprobe.pid v: 3278
k: flow.id v: 42
k: flow.from v: 192.168.2.130
[...]
```

Frequently Asked Questions

(1) Q: I'm sending 60 bytes ping packets using 'ping --s 60' but nProbe reports 92 bytes packets.
A: nProbe counts the packet size at IP level. An ICMP Echo Request packet with 60 bytes payload is 92 bytes long.

(2) Q: I need to capture traffic from several interfaces but nProbe allows just one interface to be used. What can I do?
A: You can start several instances of nProbe, each on a different network interface.

(3) Q: nProbe is exporting flows too fast and my collector cannot keep up with it. How can I slow down nProbe export rate?
A: nProbe has been for high-speed networks (1Gb and above) so its export rate can be high due to traffic conditions. There are several solutions available:

a. Specify a minimum intra-flow delay (-e flag)
b. Use several collectors and send them flows in round robin (-n flag) in order to balance load among the collectors.

nProbe Plugins

nProbe has been designed as an engine that processes packets and compute basic statistics, and plugins that extend the core with additional capabilities. Each plugin dissects a specific traffic (e.g. SMTP email traffic), but you can enable the use of multiple plugins simultaneously. nProbe based on the template configuration (-T) will selectively enable plugins and define as many templates as necessary. Their number depends on the plugins enabled and on the fact that you might enable IPv4 and/or IPv6 traffic support.

The following sections cover the configuration and information elements provided by each individual plugin. Most plugins are available also in source format, but sometimes due to license restrictions (e.g. the plugin has been sponsored by a company that does not want others to access the source code) we are unable to release all plugins in source format.

BGP Plugin

This plugin is used in combination with the bgp_probe_client.pl script for receiving BGP information and updates from a router. In order to use it you need to:

- Edit the bgp_probe_client.pl file and configure the IP address of the machine where the script is listening (`$local_ip`) and its AS (`$local_as`), the IP address of the router (`$remote_ip`) and its AS (`$remote_as`). Of course you better define a private AS for doing all this.

```
# BGP
my $local_ip = '192.168.48.2';
my $local_as = 65498;
my $remote_ip = '192.168.48.1';
my $remote_as = 2597;

# nProbe
my $nprobe_ip   = '127.0.0.1';
my $nprobe_port = 4096;
```

- Start the script and configure the router to connect to the script (that acts as a server). The router will initially send its BGP table, and then periodically send BGP updates.
- Start nProbe on the same machine where the script is active with the option `--bgp-port <port>` where <port> is set to the value of `$nprobe_port`.

With this plugin nProbe will emit AS information with exported flows using the information exported by the router via BGP. If the plugin is not active, nProbe will use information from GeoIP if configured.

This plugin defines the following information elements used to export not just the AS to which flows belong to, but also the whole AS path.

```
%SRC_AS_PATH_1                  Src AS path position 1
%SRC_AS_PATH_2                  Src AS path position 2
%SRC_AS_PATH_3                  Src AS path position 3
%SRC_AS_PATH_4                  Src AS path position 4
%SRC_AS_PATH_5                  Src AS path position 5
%SRC_AS_PATH_6                  Src AS path position 6
%SRC_AS_PATH_7                  Src AS path position 7
%SRC_AS_PATH_8                  Src AS path position 8
%SRC_AS_PATH_9                  Src AS path position 9
%SRC_AS_PATH_10                 Src AS path position 10
%DST_AS_PATH_1                  Dest AS path position 1
%DST_AS_PATH_2                  Dest AS path position 2
%DST_AS_PATH_3                  Dest AS path position 3
%DST_AS_PATH_4                  Dest AS path position 4
%DST_AS_PATH_5                  Dest AS path position 5
```

```
%DST_AS_PATH_6                  Dest AS path position 6
%DST_AS_PATH_7                  Dest AS path position 7
%DST_AS_PATH_8                  Dest AS path position 8
%DST_AS_PATH_9                  Dest AS path position 9
%DST_AS_PATH_10                 Dest AS path position 10
```

DNS Plugin

This plugin dissects DNS traffic and saves it in dump files as well export the information via NetFlow/IPFIX using the following information elements.

```
%DNS_QUERY                      DNS query
%DNS_QUERY_ID                   DNS query transaction Id
%DNS_QUERY_TYPE                 DNS query type (e.g. 1=A, 2=NS..)
%DNS_RET_CODE                   DNS return code (e.g. 0=no error)
%DNS_NUM_ANSWERS                DNS # of returned answers
```

Using --dns-dump-dir <dump dir> it is possible to specify where the DNS dump files will be saved. Each file is up to 1000 lines long and when is completed a new file will be created.

Export Plugin

nProbe allows you to export data do external sources. This plugin allows to export flows to ElasticSearch and kafka. Following are the configuration options required:

```
  --elastic <format>          | Enable export to ElasticSearch
                              | Format: <index type>;<index name>;<es URL>;<es user>:<es pwd>
                              | Example:
                              | --elastic "flows;nprobe-%Y.%m.%d;http://localhost:9200/_bulk;user:pwd"
                              | Note: the <index name> accepts the format supported by strftime().

--kafka <brokers>;<topic>[;<ack>;<compr>]
                             | Send flows to Apache Kafka brokers obtained by metadata information
                             | <host1>[:<port1>],<host2>[:<port2>]... Initial brokers list used to
                             | receive metadata information
                             | <topic>       Message topic
                             | <0|1|-1>      0=Don't wait for ack
                             |               1=Leader ack is enough
                             |               -1=All replica must ack
                             | <compression> Compression type: none, gzip, snappy
                             | Example --kafka localhost;test;0;gzip
```

GTPv0 Plugin

This plugin dissects GTPv0 signaling information (GTP-C) and saves it in dump files as well export the information via NetFlow/IPFIX using the following information elements.

```
%GTPV0_REQ_MSG_TYPE             GTPv0 Request Msg Type
%GTPV0_RSP_MSG_TYPE             GTPv0 Response Msg Type
%GTPV0_TID                      GTPv0 Tunnel Identifier
%GTPV0_APN_NAME                 GTPv0 APN Name
%GTPV0_END_USER_IP              GTPv0 End User IP Address
%GTPV0_END_USER_MSISDN          GTPv0 End User MSISDN
%GTPV0_RAI_MCC                  GTPv0 Mobile Country Code
%GTPV0_RAI_MNC                  GTPv0 Mobile Network Code
%GTPV0_RAI_CELL_LAC             GTPv0 Cell Location Area Code
```

```
%GTPV0_RAI_CELL_RAC              GTPv0 Cell Routing Area Code
%GTPV0_RESPONSE_CAUSE            GTPv0 Cause of Operation
```

The plugin supports the following command line options that are used to specify where the (optional) GTP log file is saved. As previously described for -P, dumps are nested in directories. It is possible to instruct nProbe to execute a command when a directory (not a log file) if fully dumped (i.e. nProbe has moved to the next directory in time order).

--gtpv0-dump-dir <dump dir> Directory where GTP logs will be dumped
--gtpv0-exec-cmd <cmd> Command executed whenever a directory has been dumped

Please note that GTP-U is not handled by this plugin but rather by the nProbe core when the --tunnel option is used.

GTPv1 Plugin

This plugin dissects GTPv1 signaling information (GTP-C) and saves it in dump files as well export the information via NetFlow/IPFIX using the following information elements.

```
%GTPV1_REQ_MSG_TYPE              GTPv1 Request Msg Type
%GTPV1_RSP_MSG_TYPE              GTPv1 Response Msg Type
%GTPV1_C2S_TEID_DATA             GTPv1 Client->Server TunnelId Data
%GTPV1_C2S_TEID_CTRL             GTPv1 Client->Server TunnelId Control
%GTPV1_S2C_TEID_DATA             GTPv1 Server->Client TunnelId Data
%GTPV1_S2C_TEID_CTRL             GTPv1 Server->Client TunnelId Control
%GTPV1_END_USER_IP               GTPv1 End User IP Address
%GTPV1_END_USER_IMSI             GTPv1 End User IMSI
%GTPV1_END_USER_MSISDN           GTPv1 End User MSISDN
%GTPV1_END_USER_IMEI             GTPv1 End User IMEI
%GTPV1_APN_NAME                  GTPv1 APN Name
%GTPV1_RAI_MCC                   GTPv1 RAI Mobile Country Code
%GTPV1_RAI_MNC                   GTPv1 RAI Mobile Network Code
%GTPV1_RAI_LAC                   GTPv1 RAI Location Area Code
%GTPV1_RAI_RAC                   GTPv1 RAI Routing Area Code
%GTPV1_ULI_MCC                   GTPv1 ULI Mobile Country Code
%GTPV1_ULI_MNC                   GTPv1 ULI Mobile Network Code
%GTPV1_ULI_CELL_LAC              GTPv1 ULI Cell Location Area Code
%GTPV1_ULI_CELL_CI               GTPv1 ULI Cell CI
%GTPV1_ULI_SAC                   GTPv1 ULI SAC
%GTPV1_RESPONSE_CAUSE            GTPv1 Cause of Operation
```

The plugin supports the following command line options that are used to specify where the (optional) GTP log file is saved. As previously described for -P, dumps are nested in directories. It is possible to instruct nProbe to execute a command when a directory (not a log file) if fully dumped (i.e. nProbe has moved to the next directory in time order).

--gtpv1-dump-dir <dump dir> Directory where GTP logs will be dumped
--gtpv1-exec-cmd <cmd> Command executed whenever a directory has been dumped

Please note that GTP-U is not handled by this plugin but rather by the nProbe core when the --tunnel option is used.

GTPv2 Plugin

This plugin dissects GTPv2 signaling information (GTP-C) and saves it in dump files as well export the information via NetFlow/IPFIX using the following information elements.

```
%GTPV2_REQ_MSG_TYPE              GTPv2 Request Msg Type
%GTPV2_RSP_MSG_TYPE              GTPv2 Response Msg Type
%GTPV2_C2S_S1U_GTPU_TEID         GTPv2 Client->Svr S1U GTPU TEID
%GTPV2_C2S_S1U_GTPU_IP           GTPv2 Client->Svr S1U GTPU IP
%GTPV2_S2C_S1U_GTPU_TEID         GTPv2 Srv->Client S1U GTPU TEID
%GTPV2_S2C_S1U_GTPU_IP           GTPv2 Srv->Client S1U GTPU IP
%GTPV2_END_USER_IMSI             GTPv2 End User IMSI
%GTPV2_END_USER_MSISDN           GTPv2 End User MSISDN
%GTPV2_APN_NAME                  GTPv2 APN Name
%GTPV2_ULI_MCC                   GTPv2 Mobile Country Code
%GTPV2_ULI_MNC                   GTPv2 Mobile Network Code
%GTPV2_ULI_CELL_TAC              GTPv2 Tracking Area Code
%GTPV2_ULI_CELL_ID               GTPv2 Cell Identifier
%GTPV2_RESPONSE_CAUSE            GTPv2 Cause of Operation
```

The plugin supports the following command line options that are used to specify where the (optional) GTP log file is saved. As previously described for -P, dumps are nested in directories. It is possible to instruct nProbe to execute a command when a directory (not a log file) if fully dumped (i.e. nProbe has moved to the next directory in time order).

--gtpv2-dump-dir <dump dir> Directory where GTP logs will be dumped
--gtpv2-exec-cmd <cmd> Command executed whenever a directory has been dumped

Please note that GTP-U is not handled by this plugin but rather by the nProbe core when the --tunnel option is used.

HTTP Plugin

This plugin dissects HTTP traffic information (https can be decoded if the plugin is compiled with CyaSLL and the private SSL key is available and configured in the plugin) and saves it in dump files as well export the information via NetFlow/IPFIX using the following information elements.

```
%HTTP_URL                        HTTP URL
%HTTP_RET_CODE                   HTTP return code (e.g. 200, 304...)
%HTTP_REFERER                    HTTP Referer
%HTTP_UA                         HTTP User Agent
%HTTP_MIME                       HTTP Mime Type
%HTTP_HOST                       HTTP Host Name
%HTTP_FBOOK_CHAT                 HTTP Facebook Chat
```

The plugin supports the following command line options that are used to specify where the (optional) HTTP log file is saved. As previously described for -P, dumps are nested in directories. It is possible to instruct nProbe to execute a command when a directory (not a log file) if fully dumped (i.e. nProbe has moved to the next directory in time order).

```
--http-dump-dir <dump dir>    Directory where HTTP logs will be dumped
--ssl-config-file <path>      Configuration file for SSL certificate decoding
--ssl-debug                   Enables ssl tracing (highly verbose)
--http-exec-cmd <cmd>         Command executed whenever a directory has been dumped
--dont-hash-cookies           Dump cookie string instead of cookie hash
--max-http-log-lines          Max number of lines per log file (default 10000)
--http-dump-timeout           After that timeout (in sec) the log file will be closed
--http-ports                  List of ports used for http protocol (default: 80)
--https-ports                 List of ports used for https protocol (default: 443)
--proxy-ports                 List of ports used for proxy protocol (default: 3128, 8080)
```

IMAP Plugin

This plugin dissects IMAP traffic information and saves it in dump files as well export the information via NetFlow/IPFIX using the following information element.

```
%IMAP_LOGIN                         Mail sender
```

The plugin supports the following command line options that are used to specify where the (optional) log file is saved. As previously described for -P, dumps are nested in directories. It is possible to instruct nProbe to execute a command when a directory (not a log file) if fully dumped (i.e. nProbe has moved to the next directory in time order).

--imap-dump-dir <dump dir> Directory where IMAP logs will be dumped
--imap-exec-cmd <cmd> Command executed whenever a directory has been dumped
--imap-peek-headers Dump both emails body and headers (default: body only)

MySQL Plugin

This plugin dissects MySQL (unencrypted) traffic information and saves the queries log in dump files as well export the information via NetFlow/IPFIX using the following information elements.

```
%MYSQL_SERVER_VERSION               MySQL server version
%MYSQL_USERNAME                     MySQL username
%MYSQL_DB                           MySQL database in use
%MYSQL_QUERY                        MySQL Query
%MYSQL_RESPONSE                     MySQL server response
%MYSQL_APPL_LATENCY_USEC            MySQL request->response latecy (usec)
```

The plugin supports the following command line options that are used to specify where the (optional) log file is saved. As previously described for -P, dumps are nested in directories. It is possible to instruct nProbe to execute a command when a directory (not a log file) if fully dumped (i.e. nProbe has moved to the next directory in time order).

--mysql-dump-dir <dump dir> Directory where MySQL logs will be dumped
--mysql-exec-cmd <cmd> Command executed whenever a directory has been dumped
--max-mysql-log-lines Max number of lines per log file (default 10000)

Oracle Plugin

This plugin dissects Oracle (unencrypted) traffic information and saves the queries log in dump files as well export the information via NetFlow/IPFIX using the following information elements.

```
%ORACLE_USERNAME                    Oracle Username
%ORACLE_QUERY                       Oracle Query
%ORACLE_RSP_CODE                    Oracle Response Code
%ORACLE_RSP_STRING                  Oracle Response String
%ORACLE_QUERY_DURATION              Oracle Query Duration (msec)
```

The plugin supports the following command line options that are used to specify where the (optional) log file is saved. As previously described for -P, dumps are nested in directories. It is possible to instruct nProbe to

execute a command when a directory (not a log file) if fully dumped (i.e. nProbe has moved to the next directory in time order).
--oracle-dump-dir <dump dir> Directory where Oracle logs will be dumped
--oracle-exec-cmd <cmd> Command executed whenever a directory has been dumped
--max-oracle-log-lines Max number of lines per log file (default 10000)

Note that not all Oracle DB version might be supported by this plugin.

POP3 Plugin

This plugin dissects POP3 traffic information and saves it in dump files as well export the information via NetFlow/IPFIX using the following information element.

```
%POP_USER                       POP3 user login
```

The plugin supports the following command line options that are used to specify where the (optional) log file is saved. As previously described for -P, dumps are nested in directories. It is possible to instruct nProbe to execute a command when a directory (not a log file) if fully dumped (i.e. nProbe has moved to the next directory in time order).
--pop-dump-dir <dump dir> Directory where POP3 logs will be dumped
--pop-exec-cmd <cmd> Command executed whenever a directory has been dumped

Radius Plugin

This plugin dissects Radius (unencrypted) traffic information and saves it in dump files as well export the information via NetFlow/IPFIX using the following information elements.

```
%RADIUS_REQ_MSG_TYPE            RADIUS Request Msg Type
%RADIUS_RSP_MSG_TYPE            RADIUS Response Msg Type
%RADIUS_USER_NAME               RADIUS User Name (Access Only)
%RADIUS_CALLING_STATION_ID      RADIUS Calling Station Id
%RADIUS_CALLED_STATION_ID       RADIUS Called Station Id
%RADIUS_NAS_IP_ADDR             RADIUS NAS IP Address
%RADIUS_NAS_IDENTIFIER          RADIUS NAS Identifier
%RADIUS_USER_IMSI               RADIUS User IMSI (Extension)
%RADIUS_USER_IMEI               RADIUS User MSISDN (Extension)
%RADIUS_FRAMED_IP_ADDR          RADIUS Framed IP
%RADIUS_ACCT_SESSION_ID         RADIUS Accounting Session Name
%RADIUS_ACCT_STATUS_TYPE        RADIUS Accounting Status Type
%RADIUS_ACCT_IN_OCTETS          RADIUS Accounting Input Octets
%RADIUS_ACCT_OUT_OCTETS         RADIUS Accounting Output Octets
%RADIUS_ACCT_IN_PKTS            RADIUS Accounting Input Packets
%RADIUS_ACCT_OUT_PKTS           RADIUS Accounting Output Packets
```

The plugin supports the following command line options that are used to specify where the (optional) log file is saved. As previously described for -P, dumps are nested in directories. It is possible to instruct nProbe to execute a command when a directory (not a log file) if fully dumped (i.e. nProbe has moved to the next directory in time order).
--radius-dump-dir <dump dir> Directory where Radius logs will be dumped
--radius-exec-cmd <cmd> Command executed whenever a directory has been dumped

Note that 3GPP radius extensions are supported by the plugin.

RTP Plugin

This plugin dissects RTP traffic information and saves it in dump files as well export the information via NetFlow/IPFIX using the following information elements.

```
%RTP_FIRST_SSRC                 First flow RTP Sync Source ID
%RTP_FIRST_TS                   First flow RTP timestamp
%RTP_LAST_SSRC                  Last flow RTP Sync Source ID
%RTP_LAST_TS                    Last flow RTP timestamp
%RTP_IN_JITTER                  RTP Jitter (ms * 1000)
%RTP_OUT_JITTER                 RTP Jitter (ms * 1000)
%RTP_IN_PKT_LOST                Packet lost in stream
%RTP_OUT_PKT_LOST               Packet lost in stream
%RTP_IN_PAYLOAD_TYPE            RTP payload type
%RTP_OUT_PAYLOAD_TYPE           RTP payload type
%RTP_IN_MAX_DELTA              Max delta (ms*100) between consecutive pkts
%RTP_OUT_MAX_DELTA             Max delta (ms*100) between consecutive pkts
%RTP_SIP_CALL_ID               SIP call-id corresponding to this RTP stream
```

SIP Plugin

This plugin dissects SIP traffic information and saves it in dump files as well export the information via NetFlow/IPFIX using the following information elements.

```
%SIP_CALL_ID                    SIP call-id
%SIP_CALLING_PARTY              SIP Call initiator
%SIP_CALLED_PARTY               SIP Called party
%SIP_RTP_CODECS                 SIP RTP codecs
%SIP_INVITE_TIME                SIP SysUptime (msec) of INVITE
%SIP_TRYING_TIME                SIP SysUptime (msec) of Trying
%SIP_RINGING_TIME               SIP SysUptime (msec) of RINGING
%SIP_INVITE_OK_TIME             SIP SysUptime (msec) of INVITE OK
%SIP_INVITE_FAILURE_TIME        SIP SysUptime (msec) of INVITE FAILURE
%SIP_BYE_TIME                   SIP SysUptime (msec) of BYE
%SIP_BYE_OK_TIME                SIP SysUptime (msec) of BYE OK
%SIP_CANCEL_TIME                SIP SysUptime (msec) of CANCEL
%SIP_CANCEL_OK_TIME             SIP SysUptime (msec) of CANCEL OK
%SIP_RTP_IPV4_SRC_ADDR          SIP RTP stream source IP
%SIP_RTP_L4_SRC_PORT            SIP RTP stream source port
%SIP_RTP_IPV4_DST_ADDR          SIP RTP stream dest IP
%SIP_RTP_L4_DST_PORT            SIP RTP stream dest port
%SIP_FAILURE_CODE               SIP failure response code
%SIP_REASON_CAUSE               SIP Cancel/Bye/Failure reason cause
```

SMTP Plugin

This plugin dissects IMAP traffic information and saves it in dump files as well export the information via NetFlow/IPFIX using the following information elements.

```
%SMTP_MAIL_FROM                 Mail sender
%SMTP_RCPT_TO                   Mail recipient
```

The plugin supports the following command line options that are used to specify where the (optional) log file is saved. As previously described for -P, dumps are nested in directories. It is possible to instruct nProbe to

execute a command when a directory (not a log file) if fully dumped (i.e. nProbe has moved to the next directory in time order).
--smtp-dump-dir <dump dir> Directory where SMTP logs will be dumped
--smtp-exec-cmd <cmd> Command executed whenever a directory has been dumped

NetFlow-Lite Plugin

This plugin collects NetFlow-Lite flows and uses them as (simulated) packets as if they where received from a captured device. As the plugin acts as a collector for flows sent in NF-Lite format, you need to specify the listening port and an optional number of sequential ports to which flows will be sent. The more ports the more performance can be achieved.

--nflite <flow listen port low>[:<num ports>]> | Specify NetFlow-Lite listen port(s) (max 32)

Developing nProbe Plugins

Each nProbe plugin is implemented as shared library to be loaded at runtime by nProbe. The probe comes with several plugins that can be used as example for this activity. Below we list the main concepts you need to know if you plan to develop nProbe plugins.

Each plugin has to defined a plugin entry point as follows

```
static PluginEntryPoint dbPlugin = {
  NPROBE_REVISION,
  "My Plugin Name",
  "shortName", NULL,
  "version",
  "Plugin string description",
  "author email",
  0 /* always enabled */, 1, /* enabled */
  PLUGIN_DONT_NEED_LICENSE,
  myPlugin_init,
  NULL, /* Term */
  myPlugin_conf,
  myPlugin_delete,
  1, /* call packetFlowFctn for each packet */
  NULL /* myPlugin_packet */,
  myPlugin_get_template,
  myPlugin_export,
  myPlugin_print,
  NULL,
  NULL,
  myPlugin_help,
  NULL, 0, 0
};
```

and a function with the following format

```
#ifdef MAKE_STATIC_PLUGINS
PluginEntryPoint* myPluginEntryFctn(void)
#else
PluginEntryPoint* PluginEntryFctn(void)
#endif
{
  return(&myPlugin);
}
```

The fields of the PluginEntryPoint function have the following meaning:

- char *nprobe_revision;
  String to be defined as `NPROBE_REVISION`.
- char *name;
  Extended plugin name.
- char *short_name;
  Short plugin name.
- char *family;
  Plugin family name (if any) or NULL to use the short plugin name.
- char *version;
  Plugin version (e.g. 1.0)
- char *descr;
  Plugin description in plain English.
- char*author;
  Plugin author name and email.

- u_int8_t always_enabled;
  Set it to 1 to enable the plugin permanently regardless of its use in the template (-T command line option).
- u_int8_t enabled;
  Do not touch it and set it to 0 (used by nProbe).
- u_int8_t need_license;
  Set it to 1 if a license for this plugin is needed, or 0 if is not needed.
- PluginInitFctn initFctn;
  Plugin initialization function called when the plugin is loaded in memory. This function is called regardless of the fact that the plugin will later be used or not.
- PluginTermFctn termFctn;
  Plugin termination function called when the plugin is terminated during nProbe shutdown.
- PluginConf pluginFlowConf;
  Function that returns the flow configuration (see below).
- PluginFctn deleteFlowFctn;
  Flow callback that is called for flows handled by this plugin whenever a flow has been exported. This function is used to free memory of resources associated to the flow. Set it to NULL if no function will be defined,
- u_int8_t call_packetFlowFctn_for_each_packet;
  Set it to 1 to ask nProbe to call the packetFlowFctn callback for every packet belonging to this flow, or 0 for calling it only for the first flow packet.
- PluginPacketFctn packetFlowFctn;
  Callback called whenever nProbe has a packet belonging to the flow to be processed by the plugin.
- PluginGetTemplateFctn getTemplateFctn;
  Function used to return the template Element for the specified information element passed as parameter.
- PluginExportFctn pluginExportFctn;
  Callback called whenever the flow handled by this plugin is going to be exported.
- PluginPrintFctn pluginPrintFctn;
  Function that is called when nprobe -P is used, and that is supposed to print flow information into text files.
- PluginStatsFctn pluginStatsFctn;
  Function that is called (when not set to NULL) whenever nProbe prints periodic information (-b 1 or -b 2).
- PluginSetupFctn setupFctn;
  Function called after plugin initialization (when not set to NULL), if according to the specified template, this plugin will be used.
- PluginHelpFctn helpFctn;
  Function that is called when nprobe -h is executed, and that is supposed to print plugin information.
- PluginIdleTaskFctn idleFctn;
  If not set to NULL, this function will be periodically called by the nProbe core to execute (if any) housekeeping activities.
- u_int8_t v4TemplateIdx, v6TemplateIdx;
  Used by nProbe. Set them to 0.

Each plugin must define a template with the following format

```
static V9V10TemplateElementId myPlugin_template[] = {
.....
    { 0, BOTH_IPV4_IPV6, FLOW_TEMPLATE, LONG_SNAPLEN, NTOP_ENTERPRISE_ID, 0,
STATIC_FIELD_LEN, 0, 0, 0, NULL, NULL, NULL }
};
```

what will be then used by the following functions

```
static V9V10TemplateElementId* myPlugin_get_template(char* template_name) {
  int i;

  for(i=0; myPlugin_template[i].templateElementId != 0; i++) {
    if(!strcmp(template_name, myPlugin_template[i].netflowElementName)) {
      return(&myPlugin_template[i]);
    }
  }

  return(NULL); /* Unknown */
}

static V9V10TemplateElementId* myPlugin_conf(void) {
  return(myPlugin_template);
}
```

In the file template.h are specified the flow identifiers to be used in `V9V10TemplateElementId` that is defined as follows:

- u_ int8_t isInUse;
  Always set it to 1, or 0 if it is the last template element to indicate that no further element will be defined.
- u_int8_t protoMode;
  Set it to BOTH_IPV4_IPV6 or ONLY_IPV4, ONLY_IPV6 if this element is for both IPv4 and IPv46 flows, just for IPv4 flows, or just for IPv6 flows.
- const u_int8_t isOptionTemplate;
  Set it to 0 if this is a flow template (default), or 1 if it used as option template.
- const u_int8_t useLongSnaplen;
  Set it to 1 if this plugin requires nProbe to capture packets with long snaplen that are needed when the plugin has to perform payload analysis.
- const u_int32_t templateElementEnterpriseId;
  Specify the IANA defined enterprise Id for this custom field. ntop uses `NTOP_ENTERPRISE_ID` for the proprietary ones.
- const u_int16_t templateElementId;
  Used by nProbe, leave it to 0.
- u_int8_t variableFieldLength;
  Set it to 1 to indicate that if nProbe exports flows in IPFIX format (-V 10) this field will have a variable field size.
- u_int16_t templateElementLen;
  Specify the static field size (-V 9) or max field size (-V 10)
- const ElementFormat elementFormat;
  Specify the format of the element. This information will be used when this data is printed into MySQL. The supported format types are: ascii_format, hex_format, numeric_format, ipv6_address_format.
- const ElementDumpFormat fileDumpFormat;
  Specify the field format when the nProbe metadata information is printed (--metadata). The supported format types are: dump_as_uint , dump_as_formatted_uint, dump_as_ip_port, dump_as_ip_proto, dump_as_ipv4_address, dump_as_ipv6_address, dump_as_mac_address, dump_as_epoch, dump_as_bool, dump_as_tcp_flags, dump_as_hex, dump_as_ascii
- const char *netflowElementName;
  String with the symbolic network element name used in NetFlow (-V 9).
- const char *ipfixElementName;
  String with the symbolic network element name used in IPFIX (-V 10).

- const char *templateElementDescr;
  String that describes the element information type used by nProbe when the help (-h) is printed.

Most plugin callbacks are straightforward and its logic can be understood simply having a look at examples of existing plugins. The only function worth to describe is the one that processes packets as it is the most complex one.

```
static void myPlugin_packet(u_char new_bucket,
                    int packet_if_idx /* -1 = unknown */,
                    void *pluginData,
                    FlowHashBucket* bkt,
                    FlowDirection flow_direction,
                    u_int16_t ip_offset, u_short proto,
                    u_char isFragment,
                    u_short numPkts, u_char tos,
                    u_short vlanId, struct eth_header *ehdr,
                    IpAddress *src, u_short sport,
                    IpAddress *dst, u_short dport,
                    u_int len, u_int8_t flags,
                    u_int32_t tcpSeqNum,  u_int8_t icmpType,
                    u_short numMplsLabels,
                    u_char mplsLabels[MAX_NUM_MPLS_LABELS [MPLS_LABEL_LEN],
                    const struct pcap_pkthdr *h, const u_char *p,
                    u_char *payload, int payloadLen) {
   ...
}
```

This function processes a packet belonging to a flow handled by this plugin. nProbe has no clue what plugins are doing, this whenever a new flow is created (new_bucket is set to 1 for the first packet of the flow, or 0 for the following packets), it calls all active plugins to tell that a new flow is active in cache. The plugin will then decide if the packet can be handled by the plugin or not. This is done by looking at the packet header fields passed to the function, or inspecting the packet payload (payload point whose length is specified by payloadLen). If a plugin decides that the packet cannot be handled by the plugin (for instance because the packet protocol is not managed by the plugin) no action is needed and the function must simply return. Instead if the plugin can handle the packet, at the beginning of the function the following code-like must be specified in order to add the plugin to the list of plugins (it should usually be 1 or 0 element long) handling this flow.

```
 if(new_bucket /* This bucket has been created recently */) {

      info->pluginPtr  = (void*)&myPlugin;
pluginData = info->pluginData = (struct my_plugin_info*)malloc(sizeof(struct
my_plugin_info));

      if(info->pluginData == NULL) {
        traceEvent(TRACE_ERROR, "Not enough memory?");
        free(info);
        return; /* Not enough memory */
      } else {
        struct my_plugin_info *myinfo = (struct my_plugin_info*)pluginData;

        /* Reset fields */
        memset(myinfo, 0, sizeof(struct my_plugin_info));

        info->next = bkt->ext->plugin;
        info->plugin_used = 0;
        bkt->ext->plugin = info;
      }
    }
  }
```

Once a plugin is defined, it must be placed into the nProbe/plugins directory so that the nProbe build process will detect and compile it.

References

1. Introduction to Cisco NetFlow, http://www.cisco.com/warp/public/cc/pd/iosw/ioft/neflct/tech/napps_wp.htm
2. ntop, http://www.ntop.org/
3. nProbe, http://www.ntop.org/nprobe.html
4. nBox, http://www.ntop.org/products/netflow/nbox/
5. Linux Debian, http://www.debian.org/
6. tcpdump, http://www.tcpdump.org/
7. Extreme Happy Netflow Tool, http://ehnt.sourceforge.net/
8. Libpcap, http://www.tcpdump.org/
9. Winpcap, http://winpcap.polito.it/
10. PC Engines, http://www.pcengines.ch/
11. SQLite, http://www.sqlite.org
12. IPerf, http://dast.nlanr.net/Projects/Iperf

Credits:

- NetFlow is a trademark of Cisco Systems.
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Appendix A: BPF Packet Filtering Expressions

This section has been extracted from the tcpdump man page and it describes the syntax of BPF filters you can specify using the --f flag.

The expression consists of one or more primitives. Primitives usually consist of an id (name or number) preceded by one or more qualifiers. There are three different kinds of qualifier:

type
qualifiers say what kind of thing the id name or number refers to. Possible types are host, net and port. E.g., `host foo', `net 128.3', `port 20'. If there is no type qualifier, host is assumed.

dir
qualifiers specify a particular transfer direction to and/or from id. Possible directions are src, dst, src or dst and src and dst. E.g., `src foo', `dst net 128.3', `src or dst port ftp-data'. If there is no dir qualifier, src or dst is assumed.

proto
qualifiers restrict the match to a particular protocol. Possible protos are: ether, fddi, ip, arp, rarp, decnet, lat, moprc, mopdl, tcp and udp. E.g., `ether src foo', `arp net 128.3', `tcp port 21'. If there is no proto qualifier, all protocols consistent with the type are assumed. E.g., `src foo' means `(ip or arp or rarp) src foo' (except the latter is not legal syntax), `net bar' means `(ip or arp or rarp) net bar' and `port 53' means `(tcp or udp) port 53'.
[`fddi' is actually an alias for `ether'; the parser treats them identically as meaning `the data link level used on the specified network interface." FDDI headers contain Ethernet-like source and destination addresses, and often contain Ethernet-like packet types, so you can filter on these FDDI fields just as with the analogous Ethernet fields. FDDI headers also contain other fields, but you cannot name them explicitly in a filter expression.]

In addition to the above, there are some special `primitive' keywords that don't follow the pattern: gateway, broadcast, less, greater and arithmetic expressions. All of these are described below.
More complex filter expressions are built up by using the words and, or and not to combine primitives. E.g., `host foo and not port ftp and not port ftp-data'. To save typing, identical qualifier lists can be omitted. E.g., `tcp dst port ftp or ftp-data or domain' is exactly the same as `tcp dst port ftp or tcp dst port ftp-data or tcp dst port domain'.

Allowable primitives are:

dst host host
True if the IP destination field of the packet is host, which may be either an address or a name.

src host host
True if the IP source field of the packet is host.

host host
True if either the IP source or destination of the packet is host. Any of the above host expressions can be prepended with the keywords, ip, arp, or rarp as in: ip host host
which is equivalent to: ether proto \ip and host host
If host is a name with multiple IP addresses, each address will be checked for a match.

ether dst ehost
True if the ethernet destination address is ehost. Ehost may be either a name from /etc/ethers or a

number.

ether src ehost
True if the ethernet source address is ehost.

ether host ehost
True if either the ethernet source or destination address is ehost.

gateway host
True if the packet used host as a gateway. I.e., the ethernet source or destination address was host but neither the IP source nor the IP destination was host. Host must be a name and must be found in both /etc/hosts and /etc/ethers. (An equivalent expression is ether host ehost and not host host which can be used with either names or numbers for host / ehost.)

dst net net
True if the IP destination address of the packet has a network number of net, which may be either an address or a name.

src net net
True if the IP source address of the packet has a network number of net.

net net
True if either the IP source or destination address of the packet has a network number of net.

dst port port
True if the packet is ip/tcp or ip/udp and has a destination port value of port. The port can be a number or a name used in /etc/services. If a name is used, both the port number and protocol are checked. If a number or ambiguous name is used, only the port number is checked (e.g., dst port 513 will print both tcp/login traffic and udp/who traffic, and port domain will print both tcp/domain and udp/domain traffic).

src port port
True if the packet has a source port value of port.

port port
True if either the source or destination port of the packet is port. Any of the above port expressions can be prepended with the keywords, tcp or udp, as in: tcp src port port which matches only tcp packets.

less length
True if the packet has a length less than or equal to length. This is equivalent to: len <= length.

greater length
True if the packet has a length greater than or equal to length. This is equivalent to: len >= length.

ip proto protocol
True if the packet is an ip packet of protocol type protocol. Protocol can be a number or one of the names icmp, udp, nd, or tcp. Note that the identifiers tcp, udp, and icmp are also keywords and must be escaped via backslash (\), which is \\ in the C-shell.

ether broadcast
True if the packet is an ethernet broadcast packet. The ether keyword is optional.

ip broadcast
True if the packet is an IP broadcast packet. It checks for both the all-zeroes and all-ones broadcast conventions, and looks up the local subnet mask.

ether multicast
True if the packet is an ethernet multicast packet. The ether keyword is optional. This is shorthand for `ether[0] & 1 != 0'.

ip multicast
True if the packet is an IP multicast packet.

ether proto protocol
True if the packet is of ether type protocol. Protocol can be a number or a name like ip, arp, or rarp. Note these identifiers are also keywords and must be escaped via backslash (\). [In the case of FDDI (e.g., `fddi protocol arp'), the protocol identification comes from the 802.2 Logical Link Control (LLC) header, which is usually layered on top of the FDDI header. ntop assumes, when filtering on the protocol identifier, that all FDDI packets include an LLC header, and that the LLC header is in so-called SNAP format.]

decnet src host
True if the DECNET source address is host, which may be an address of the form "10.123", or a DECNET host name. [DECNET host name support is only available on Ultrix systems that are configured to run DECNET.]

decnet dst host
True if the DECNET destination address is host.

decnet host host
True if either the DECNET source or destination address is host.

ip, arp, rarp, decnet
Abbreviations for: ether proto p where p is one of the above protocols.

lat, moprc, mopdl
Abbreviations for: ether proto p where p is one of the above protocols. Note that ntop does not currently know how to parse these protocols.

tcp, udp, icmp
Abbreviations for: ip proto p where p is one of the above protocols.

expr relop expr

True if the relation holds, where relop is one of >, <, >=, <=, =, !=, and expr is an arithmetic expression composed of integer constants (expressed in standard C syntax), the normal binary operators [+, -, *, /, &, |], a length operator, and special packet data accessors. To access data inside the packet, use the following syntax: proto [expr : size] Proto is one of ether, fddi, ip, arp, rarp, tcp, udp, or icmp, and indicates the protocol layer for the index operation. The byte offset, relative to the indicated protocol layer, is given by expr. Size is optional and indicates the number of bytes in the field of interest; it can be either one, two, or four, and defaults to one. The length operator, indicated by the keyword len, gives the length of the packet.

For example, `ether[0] & 1 != 0' catches all multicast traffic. The expression `ip[0] & 0xf != 5' catches all IP packets with options. The expression `ip[6:2] & 0x1fff = 0' catches only unfragmented datagrams

and frag zero of fragmented datagrams. This check is implicitly applied to the tcp and udp index operations. For instance, tcp[0] always means the first byte of the TCP header, and never means the first byte of an intervening fragment.
Primitives may be combined using:

- A parenthesized group of primitives and operators
- (parentheses are special to the Shell and must be escaped).
- Negation (`!' or `not').
- Concatenation (`&&' or `and').
- Alternation (`||' or `or').

Negation has highest precedence. Alternation and concatenation have equal precedence and associate left to right. Note that explicit and tokens, not juxtaposition, are now required for concatenation. If an identifier is given without a keyword, the most recent keyword is assumed. For example, not host vs and ace is short for not host vs and host ace which should not be confused with not (host vs or ace). Expression arguments can be passed to nProbe as either a single argument or as multiple arguments, whichever is more convenient. Generally, if the expression contains Shell metacharacters, it is easier to pass it as a single, quoted argument. Multiple arguments are concatenated with spaces before being parsed.

Examples

To select all packets arriving at or departing from sundown:

nprobe -f "host sundown"

To select traffic between helios and either hot or ace:

nprobe -f "host helios and (hot or ace)"

To select all IP packets between ace and any host except helios:

nprobe -f "ip host ace and not helios"

To select all traffic between local hosts and hosts at Berkeley:

nprobe -f "net ucb-ether"

To select all ftp traffic through internet gateway snup: (note that the expression is quoted to prevent the shell from (mis-)interpreting the parentheses):

nprobe -f "gateway snup and (port ftp or ftp-data)"

To select traffic neither sourced from nor destined for local hosts (if you gateway to one other net, this stuff should never make it onto your local net).

nprobe -f " ip and not net localnet"

To select the start and end packets (the SYN and FIN packets) of each TCP conversation that involves a non-local host.

nprobe -f "tcp[13] & 3 != 0 and not src and dst net localnet"

To select IP packets longer than 576 bytes sent through gateway snup:

nprobe -f "gateway snup and ip[2:2] > 576"

To select IP broadcast or multicast packets that were not sent via ethernet broadcast or multicast:

nprobe -f "ether[0] & 1 = 0 and ip[16] >= 224"

To select all ICMP packets that are not echo requests/replies (i.e., not ping packets):

nprobe -f "icmp[0] != 8 and icmp[0] != 0"

Appendix B: Flow Information Elements

The --T flag enabled users to specify the format of NetFlow v9/IPFIX flows. The format options currently supported by nProbe are those specified in the NetFlow v9 RFC, namely (in square brackets it is specified the field Id as defined in the RFC). As nProbe can be extended by means of plugins, further information elements can be defined based on plugin presence. Following is the exhaustive list of all options available.

ID	NetFlow Label	IPFIX Label	Description
[1]	%IN_BYTES	%octetDeltaCount	Incoming flow bytes (src->dst)
[2]	%IN_PKTS	%packetDeltaCount	Incoming flow packets (src->dst)
[4]	%PROTOCOL	%protocolIdentifier	IP protocol byte
[58500]	%PROTOCOL_MAP		IP protocol name
[5]	%SRC_TOS	%ipClassOfService	TOS/DSCP (src->dst)
[6]	%TCP_FLAGS	%tcpControlBits	Cumulative of all flow TCP flags
[7]	%L4_SRC_PORT	%sourceTransportPort	IPv4 source port
[58503]	%L4_SRC_PORT_MAP		Layer 4 source port symbolic name
[8]	%IPV4_SRC_ADDR	%sourceIPv4Address	IPv4 source address
[9]	%IPV4_SRC_MASK	%sourceIPv4PrefixLength	IPv4 source subnet mask (/<bits>)
[10]	%INPUT_SNMP	%ingressInterface	Input interface SNMP idx
[11]	%L4_DST_PORT	%destinationTransportPort	IPv4 destination port
[58507]	%L4_DST_PORT_MAP		Layer 4 destination port symbolic name
[58508]	%L4_SRV_PORT		Layer 4 server port
[58509]	%L4_SRV_PORT_MAP		Layer 4 server port symbolic name
[12]	%IPV4_DST_ADDR	%destinationIPv4Address	IPv4 destination address
[13]	%IPV4_DST_MASK	%destinationIPv4PrefixLength	IPv4 dest subnet mask (/<bits>)
[14]	%OUTPUT_SNMP	%egressInterface	Output interface SNMP idx
[15]	%IPV4_NEXT_HOP	%ipNextHopIPv4Address	IPv4 next hop address
[16]	%SRC_AS	%bgpSourceAsNumber	Source BGP AS
[17]	%DST_AS	%bgpDestinationAsNumber	Destination BGP AS
[21]	%LAST_SWITCHED	%flowEndSysUpTime	SysUptime (msec) of the last flow pkt
[22]	%FIRST_SWITCHED	%flowStartSysUpTime	SysUptime (msec) of the first flow pkt
[23]	%OUT_BYTES	%postOctetDeltaCount	Outgoing flow bytes (dst->src)
[24]	%OUT_PKTS	%postPacketDeltaCount	Outgoing flow packets (dst->src)
[27]	%IPV6_SRC_ADDR	%sourceIPv6Address	IPv6 source address
[28]	%IPV6_DST_ADDR	%destinationIPv6Address	IPv6 destination address
[29]	%IPV6_SRC_MASK	%sourceIPv6PrefixLength	IPv6 source mask
[30]	%IPV6_DST_MASK	%destinationIPv6PrefixLength	IPv6 destination mask
[32]	%ICMP_TYPE	%icmpTypeCodeIPv4	ICMP Type * 256 + ICMP code
[34]	%SAMPLING_INTERVAL		Sampling rate
[35]	%SAMPLING_ALGORITHM		Sampling type (deterministic/random)
[36]	%FLOW_ACTIVE_TIMEOUT	%flowActiveTimeout	Activity timeout of flow cache entries
[37]	%FLOW_INACTIVE_TIMEOUT	%flowIdleTimeout	Inactivity timeout of flow cache entries
[38]	%ENGINE_TYPE		Flow switching engine
[39]	%ENGINE_ID		Id of the flow switching engine
[40]	%TOTAL_BYTES_EXP	%exportedOctetTotalCount	Total bytes exported
[41]	%TOTAL_PKTS_EXP	%exportedMessageTotalCount	Total flow packets exported
[42]	%TOTAL_FLOWS_EXP	%exportedFlowRecordTotalCount	Total number of exported flows
[52]	%MIN_TTL	%minimumTTL	Min flow TTL
[53]	%MAX_TTL	%maximumTTL	Max flow TTL
[55]	%DST_TOS	%ipClassOfService	TOS/DSCP (dst->src)
[56]	%IN_SRC_MAC	%sourceMacAddress	Source MAC Address
[58]	%SRC_VLAN	%vlanId	Source VLAN (inner VLAN in QinQ)
[59]	%DST_VLAN	%postVlanId	Destination VLAN (inner VLAN in QinQ)

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[243] %DOT1Q_SRC_VLAN            %dot1qVlanId                 Source VLAN (outer VLAN in QinQ)
[254] %DOT1Q_DST_VLAN            %postdot1qVlanId             Destination VLAN (outer VLAN in QinQ)
[ 60] %IP_PROTOCOL_VERSION       %ipVersion                   [4=IPv4][6=IPv6]
[ 61] %DIRECTION                 %flowDirection               It indicates where a sample has been taken
(always 0)
[ 62] %IPV6_NEXT_HOP             %ipNextHopIPv6Address        IPv6 next hop address
[ 70] %MPLS_LABEL_1              %mplsTopLabelStackSection    MPLS label at position 1
[ 71] %MPLS_LABEL_2              %mplsLabelStackSection2      MPLS label at position 2
[ 72] %MPLS_LABEL_3              %mplsLabelStackSection3      MPLS label at position 3
[ 73] %MPLS_LABEL_4              %mplsLabelStackSection4      MPLS label at position 4
[ 74] %MPLS_LABEL_5              %mplsLabelStackSection5      MPLS label at position 5
[ 75] %MPLS_LABEL_6              %mplsLabelStackSection6      MPLS label at position 6
[ 76] %MPLS_LABEL_7              %mplsLabelStackSection7      MPLS label at position 7
[ 77] %MPLS_LABEL_8              %mplsLabelStackSection8      MPLS label at position 8
[ 78] %MPLS_LABEL_9              %mplsLabelStackSection9      MPLS label at position 9
[ 79] %MPLS_LABEL_10             %mplsLabelStackSection10     MPLS label at position 10
[ 80] %OUT_DST_MAC               %destinationMacAddress       Destination MAC Address
[ 95] %APPLICATION_ID            %application_id              Collected Application Id (Cisco or IXIA)
[102] %PACKET_SECTION_OFFSET                                  Packet section offset
[103] %SAMPLED_PACKET_SIZE                                    Sampled packet size
[104] %SAMPLED_PACKET_ID                                      Sampled packet id
[130] %EXPORTER_IPV4_ADDRESS     %exporterIPv4Address         Exporter IPv4 Address
[131] %EXPORTER_IPV6_ADDRESS     %exporterIPv6Address         Exporter IPv6 Address
[148] %FLOW_ID                   %flowId                      Serial Flow Identifier
[150] %FLOW_START_SEC            %flowStartSeconds            Seconds (epoch) of the first flow packet
[151] %FLOW_END_SEC              %flowEndSeconds              Seconds (epoch) of the last flow packet
[152] %FLOW_START_MILLISECONDS   %flowStartMilliseconds       Msec (epoch) of the first flow packet
[153] %FLOW_END_MILLISECONDS     %flowEndMilliseconds         Msec (epoch) of the last flow packet
[239] %BIFLOW_DIRECTION          %biflow_direction            1=initiator, 2=reverseInitiator
[277] %OBSERVATION_POINT_TYPE                                 Observation point type
[300] %OBSERVATION_POINT_ID                                   Observation point id
[302] %SELECTOR_ID                                            Selector id
[304] %IPFIX_SAMPLING_ALGORITHM                               Sampling algorithm
[309] %SAMPLING_SIZE                                          Number of packets to sample
[310] %SAMPLING_POPULATION                                    Sampling population
[312] %FRAME_LENGTH                                           Original L2 frame length
[318] %PACKETS_OBSERVED                                       Tot number of packets seen
[319] %PACKETS_SELECTED                                       Number of pkts selected for sampling
[335] %SELECTOR_NAME                                          Sampler name
[57899] %APPLICATION_NAME                                     Palo Alto App-Id
[57900] %USER_NAME                                            Palo Alto User-Id
[NFv9 57552][IPFIX 35632.80] %FRAGMENTS                 Number of fragmented flow packets
[NFv9 57595][IPFIX 35632.123] %CLIENT_NW_LATENCY_MS           Network RTT/2 client <-> nprobe (msec)
[NFv9 57596][IPFIX 35632.124] %SERVER_NW_LATENCY_MS           Network RTT/2 nprobe <-> server (msec)
[NFv9 57597][IPFIX 35632.125] %APPL_LATENCY_MS                Application latency (msec)
[NFv9 57560][IPFIX 35632.88] %NUM_PKTS_UP_TO_128_BYTES   # packets whose IP size <= 128
[NFv9 57561][IPFIX 35632.89] %NUM_PKTS_128_TO_256_BYTES  # packets whose IP size > 128 and <= 256
[NFv9 57562][IPFIX 35632.90] %NUM_PKTS_256_TO_512_BYTES  # packets whose IP size > 256 and < 512
[NFv9 57563][IPFIX 35632.91] %NUM_PKTS_512_TO_1024_BYTES # packets whose IP size > 512 and < 1024
[NFv9 57564][IPFIX 35632.92] %NUM_PKTS_1024_TO_1514_BYTES        # packets whose IP size > 1024 and <= 1514
[NFv9 57565][IPFIX 35632.93] %NUM_PKTS_OVER_1514_BYTES   # packets whose IP size > 1514
[NFv9 57570][IPFIX 35632.98] %CUMULATIVE_ICMP_TYPE       Cumulative OR of ICMP type packets
[NFv9 57573][IPFIX 35632.101] %SRC_IP_COUNTRY                    Country where the src IP is located
[NFv9 57574][IPFIX 35632.102] %SRC_IP_CITY                       City where the src IP is located
[NFv9 57575][IPFIX 35632.103] %DST_IP_COUNTRY                    Country where the dst IP is located
[NFv9 57576][IPFIX 35632.104] %DST_IP_CITY                       City where the dst IP is located
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[NFv9 57577][IPFIX 35632.105] %FLOW_PROTO_PORT	L7 port that identifies the flow protocol or 0 if unknown
[NFv9 57578][IPFIX 35632.106] %UPSTREAM_TUNNEL_ID	Upstream tunnel identifier (e.g. GTP TEID) or 0 if unknown
[NFv9 57918][IPFIX 35632.446] %UPSTREAM_SESSION_ID	Upstream session identifier (e.g. L2TP) or 0 if unknown
[NFv9 57579][IPFIX 35632.107] %LONGEST_FLOW_PKT	Longest packet (bytes) of the flow
[NFv9 57580][IPFIX 35632.108] %SHORTEST_FLOW_PKT	Shortest packet (bytes) of the flow
[NFv9 57599][IPFIX 35632.127] %RETRANSMITTED_IN_BYTES	Number of retransmitted TCP flow bytes (src->dst)
[NFv9 57581][IPFIX 35632.109] %RETRANSMITTED_IN_PKTS	Number of retransmitted TCP flow packets (src->dst)
[NFv9 57600][IPFIX 35632.128] %RETRANSMITTED_OUT_BYTES	Number of retransmitted TCP flow bytes (dst->src)
[NFv9 57582][IPFIX 35632.110] %RETRANSMITTED_OUT_PKTS	Number of retransmitted TCP flow packets (dst->src)
[NFv9 57583][IPFIX 35632.111] %OOORDER_IN_PKTS	Number of out of order TCP flow packets (dst->src)
[NFv9 57584][IPFIX 35632.112] %OOORDER_OUT_PKTS	Number of out of order TCP flow packets (src->dst)
[NFv9 57585][IPFIX 35632.113] %UNTUNNELED_PROTOCOL	Untunneled IP protocol byte
[NFv9 57586][IPFIX 35632.114] %UNTUNNELED_IPV4_SRC_ADDR	Untunneled IPv4 source address
[NFv9 57587][IPFIX 35632.115] %UNTUNNELED_L4_SRC_PORT	Untunneled IPv4 source port
[NFv9 57588][IPFIX 35632.116] %UNTUNNELED_IPV4_DST_ADDR	Untunneled IPv4 destination address
[NFv9 57589][IPFIX 35632.117] %UNTUNNELED_L4_DST_PORT	Untunneled IPv4 destination port
[NFv9 57590][IPFIX 35632.118] %L7_PROTO	Layer 7 protocol (numeric)
[NFv9 57591][IPFIX 35632.119] %L7_PROTO_NAME	Layer 7 protocol name
[NFv9 57592][IPFIX 35632.120] %DOWNSTREAM_TUNNEL_ID	Downstream tunnel identifier (e.g. GTP TEID) or 0 if unknown
[NFv9 57919][IPFIX 35632.447] %DOWNSTREAM_SESSION_ID	Downstream session identifier (e.g. L2TP) or 0 if unknown
[NFv9 57593][IPFIX 35632.121] %FLOW_USER_NAME	Flow username of the tunnel (if known)
[NFv9 57594][IPFIX 35632.122] %FLOW_SERVER_NAME	Flow server name (if known)
[NFv9 57598][IPFIX 35632.126] %PLUGIN_NAME	Plugin name used by this flow (if any)
[NFv9 57868][IPFIX 35632.396] %UNTUNNELED_IPV6_SRC_ADDR	Untunneled IPv6 source address
[NFv9 57869][IPFIX 35632.397] %UNTUNNELED_IPV6_DST_ADDR	Untunneled IPv6 destination address
[NFv9 57819][IPFIX 35632.347] %NUM_PKTS_TTL_EQ_1	# packets with TTL = 1
[NFv9 57818][IPFIX 35632.346] %NUM_PKTS_TTL_2_5	# packets with TTL > 1 and TTL <= 5
[NFv9 57806][IPFIX 35632.334] %NUM_PKTS_TTL_5_32	# packets with TTL > 5 and TTL <= 32
[NFv9 57807][IPFIX 35632.335] %NUM_PKTS_TTL_32_64	# packets with TTL > 32 and <= 64
[NFv9 57808][IPFIX 35632.336] %NUM_PKTS_TTL_64_96	# packets with TTL > 64 and <= 96
[NFv9 57809][IPFIX 35632.337] %NUM_PKTS_TTL_96_128	# packets with TTL > 96 and <= 128
[NFv9 57810][IPFIX 35632.338] %NUM_PKTS_TTL_128_160	# packets with TTL > 128 and <= 160
[NFv9 57811][IPFIX 35632.339] %NUM_PKTS_TTL_160_192	# packets with TTL > 160 and <= 192
[NFv9 57812][IPFIX 35632.340] %NUM_PKTS_TTL_192_224	# packets with TTL > 192 and <= 224
[NFv9 57813][IPFIX 35632.341] %NUM_PKTS_TTL_224_255	# packets with TTL > 224 and <= 255
[NFv9 57821][IPFIX 35632.349] %IN_SRC_OSI_SAP	OSI Source SAP (OSI Traffic Only)
[NFv9 57822][IPFIX 35632.350] %OUT_DST_OSI_SAP	OSI Destination SAP (OSI Traffic Only)
[NFv9 57863][IPFIX 35632.391] %DURATION_IN	Client to Server stream duration (msec)
[NFv9 57864][IPFIX 35632.392] %DURATION_OUT	Client to Server stream duration (msec)
[NFv9 57887][IPFIX 35632.415] %TCP_WIN_MIN_IN	Min TCP Window (src->dst)
[NFv9 57888][IPFIX 35632.416] %TCP_WIN_MAX_IN	Max TCP Window (src->dst)
[NFv9 57889][IPFIX 35632.417] %TCP_WIN_MSS_IN	TCP Max Segment Size (src->dst)
[NFv9 57890][IPFIX 35632.418] %TCP_WIN_SCALE_IN	TCP Window Scale (src->dst)
[NFv9 57891][IPFIX 35632.419] %TCP_WIN_MIN_OUT	Min TCP Window (dst->src)
[NFv9 57892][IPFIX 35632.420] %TCP_WIN_MAX_OUT	Max TCP Window (dst->src)
[NFv9 57893][IPFIX 35632.421] %TCP_WIN_MSS_OUT	TCP Max Segment Size (dst->src)
[NFv9 57894][IPFIX 35632.422] %TCP_WIN_SCALE_OUT	TCP Window Scale (dst->src)
[NFv9 57910][IPFIX 35632.438] %PAYLOAD_HASH	Initial flow payload hash
[NFv9 57915][IPFIX 35632.443] %SRC_AS_MAP	Organization name for SRC_AS
[NFv9 57916][IPFIX 35632.444] %DST_AS_MAP	Organization name for SRC_AS

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Plugin BGP Update Listener templates:
[NFv9 57762][IPFIX 35632.290] %SRC_AS_PATH_1                    Src AS path position 1
[NFv9 57763][IPFIX 35632.291] %SRC_AS_PATH_2                    Src AS path position 2
[NFv9 57764][IPFIX 35632.292] %SRC_AS_PATH_3                    Src AS path position 3
[NFv9 57765][IPFIX 35632.293] %SRC_AS_PATH_4                    Src AS path position 4
[NFv9 57766][IPFIX 35632.294] %SRC_AS_PATH_5                    Src AS path position 5
[NFv9 57767][IPFIX 35632.295] %SRC_AS_PATH_6                    Src AS path position 6
[NFv9 57768][IPFIX 35632.296] %SRC_AS_PATH_7                    Src AS path position 7
[NFv9 57769][IPFIX 35632.297] %SRC_AS_PATH_8                    Src AS path position 8
[NFv9 57770][IPFIX 35632.298] %SRC_AS_PATH_9                    Src AS path position 9
[NFv9 57771][IPFIX 35632.299] %SRC_AS_PATH_10                   Src AS path position 10
[NFv9 57772][IPFIX 35632.300] %DST_AS_PATH_1                    Dest AS path position 1
[NFv9 57773][IPFIX 35632.301] %DST_AS_PATH_2                    Dest AS path position 2
[NFv9 57774][IPFIX 35632.302] %DST_AS_PATH_3                    Dest AS path position 3
[NFv9 57775][IPFIX 35632.303] %DST_AS_PATH_4                    Dest AS path position 4
[NFv9 57776][IPFIX 35632.304] %DST_AS_PATH_5                    Dest AS path position 5
[NFv9 57777][IPFIX 35632.305] %DST_AS_PATH_6                    Dest AS path position 6
[NFv9 57778][IPFIX 35632.306] %DST_AS_PATH_7                    Dest AS path position 7
[NFv9 57779][IPFIX 35632.307] %DST_AS_PATH_8                    Dest AS path position 8
[NFv9 57780][IPFIX 35632.308] %DST_AS_PATH_9                    Dest AS path position 9
[NFv9 57781][IPFIX 35632.309] %DST_AS_PATH_10                   Dest AS path position 10

Plugin DHCP Protocol templates:
[NFv9 57825][IPFIX 35632.353] %DHCP_CLIENT_MAC                  MAC of the DHCP client
[NFv9 57826][IPFIX 35632.354] %DHCP_CLIENT_IP                   DHCP assigned client IPv4 address
[NFv9 57827][IPFIX 35632.355] %DHCP_CLIENT_NAME                 DHCP client name
[NFv9 57895][IPFIX 35632.423] %DHCP_REMOTE_ID                   DHCP agent remote Id
[NFv9 57896][IPFIX 35632.424] %DHCP_SUBSCRIBER_ID               DHCP subscribed Id
[NFv9 57901][IPFIX 35632.429] %DHCP_MESSAGE_TYPE                DHCP message type

Plugin Diameter Protocol templates:
[NFv9 57871][IPFIX 35632.399] %DIAMETER_REQ_MSG_TYPE            DIAMETER Request Msg Type
[NFv9 57872][IPFIX 35632.400] %DIAMETER_RSP_MSG_TYPE            DIAMETER Response Msg Type
[NFv9 57873][IPFIX 35632.401] %DIAMETER_REQ_ORIGIN_HOST         DIAMETER Origin Host Request
[NFv9 57874][IPFIX 35632.402] %DIAMETER_RSP_ORIGIN_HOST         DIAMETER Origin Host Response
[NFv9 57875][IPFIX 35632.403] %DIAMETER_REQ_USER_NAME           DIAMETER Request User Name
[NFv9 57876][IPFIX 35632.404] %DIAMETER_RSP_RESULT_CODE         DIAMETER Response Result Code
[NFv9 57877][IPFIX 35632.405] %DIAMETER_EXP_RES_VENDOR_ID       DIAMETER Response Experimental Result Vendor Id
[NFv9 57878][IPFIX 35632.406] %DIAMETER_EXP_RES_RESULT_CODE     DIAMETER Response Experimental Result Code
[NFv9 57917][IPFIX 35632.445] %DIAMETER_HOP_BY_HOP_ID           DIAMETER Hop by Hop Identifier

Plugin DNS/LLMNR Protocol templates:
[NFv9 57677][IPFIX 35632.205] %DNS_QUERY                        DNS query
[NFv9 57678][IPFIX 35632.206] %DNS_QUERY_ID                     DNS query transaction Id
[NFv9 57679][IPFIX 35632.207] %DNS_QUERY_TYPE                   DNS query type (e.g. 1=A, 2=NS..)
[NFv9 57680][IPFIX 35632.208] %DNS_RET_CODE                     DNS return code (e.g. 0=no error)
[NFv9 57681][IPFIX 35632.209] %DNS_NUM_ANSWERS                  DNS # of returned answers
[NFv9 57824][IPFIX 35632.352] %DNS_TTL_ANSWER                   TTL of the first A record (if any)
[NFv9 57870][IPFIX 35632.398] %DNS_RESPONSE                     DNS response(s)

Plugin FTP Protocol templates:
[NFv9 57828][IPFIX 35632.356] %FTP_LOGIN                        FTP client login
[NFv9 57829][IPFIX 35632.357] %FTP_PASSWORD                     FTP client password
[NFv9 57830][IPFIX 35632.358] %FTP_COMMAND                      FTP client command
[NFv9 57831][IPFIX 35632.359] %FTP_COMMAND_RET_CODE             FTP client command return code
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Plugin GTPv0 Signaling Protocol templates:
[NFv9 57793][IPFIX 35632.321] %GTPV0_REQ_MSG_TYPE              GTPv0 Request Msg Type
[NFv9 57794][IPFIX 35632.322] %GTPV0_RSP_MSG_TYPE              GTPv0 Response Msg Type
[NFv9 57795][IPFIX 35632.323] %GTPV0_TID                       GTPv0 Tunnel Identifier
[NFv9 57798][IPFIX 35632.326] %GTPV0_APN_NAME                  GTPv0 APN Name
[NFv9 57796][IPFIX 35632.324] %GTPV0_END_USER_IP               GTPv0 End User IP Address
[NFv9 57797][IPFIX 35632.325] %GTPV0_END_USER_MSISDN           GTPv0 End User MSISDN
[NFv9 57799][IPFIX 35632.327] %GTPV0_RAI_MCC                   GTPv0 Mobile Country Code
[NFv9 57800][IPFIX 35632.328] %GTPV0_RAI_MNC                   GTPv0 Mobile Network Code
[NFv9 57801][IPFIX 35632.329] %GTPV0_RAI_CELL_LAC              GTPv0 Cell Location Area Code
[NFv9 57802][IPFIX 35632.330] %GTPV0_RAI_CELL_RAC              GTPv0 Cell Routing Area Code
[NFv9 57803][IPFIX 35632.331] %GTPV0_RESPONSE_CAUSE            GTPv0 Cause of Operation

Plugin GTPv1 Signaling Protocol templates:
[NFv9 57692][IPFIX 35632.220] %GTPV1_REQ_MSG_TYPE              GTPv1 Request Msg Type
[NFv9 57693][IPFIX 35632.221] %GTPV1_RSP_MSG_TYPE              GTPv1 Response Msg Type
[NFv9 57694][IPFIX 35632.222] %GTPV1_C2S_TEID_DATA             GTPv1 Client->Server TunnelId Data
[NFv9 57695][IPFIX 35632.223] %GTPV1_C2S_TEID_CTRL             GTPv1 Client->Server TunnelId Control
[NFv9 57696][IPFIX 35632.224] %GTPV1_S2C_TEID_DATA             GTPv1 Server->Client TunnelId Data
[NFv9 57697][IPFIX 35632.225] %GTPV1_S2C_TEID_CTRL             GTPv1 Server->Client TunnelId Control
[NFv9 57698][IPFIX 35632.226] %GTPV1_END_USER_IP               GTPv1 End User IP Address
[NFv9 57699][IPFIX 35632.227] %GTPV1_END_USER_IMSI             GTPv1 End User IMSI
[NFv9 57700][IPFIX 35632.228] %GTPV1_END_USER_MSISDN           GTPv1 End User MSISDN
[NFv9 57701][IPFIX 35632.229] %GTPV1_END_USER_IMEI             GTPv1 End User IMEI
[NFv9 57702][IPFIX 35632.230] %GTPV1_APN_NAME                  GTPv1 APN Name
[NFv9 57708][IPFIX 35632.236] %GTPV1_RAT_TYPE                  GTPv1 RAT Type
[NFv9 57703][IPFIX 35632.231] %GTPV1_RAI_MCC                   GTPv1 RAI Mobile Country Code
[NFv9 57704][IPFIX 35632.232] %GTPV1_RAI_MNC                   GTPv1 RAI Mobile Network Code
[NFv9 57814][IPFIX 35632.342] %GTPV1_RAI_LAC                   GTPv1 RAI Location Area Code
[NFv9 57815][IPFIX 35632.343] %GTPV1_RAI_RAC                   GTPv1 RAI Routing Area Code
[NFv9 57816][IPFIX 35632.344] %GTPV1_ULI_MCC                   GTPv1 ULI Mobile Country Code
[NFv9 57817][IPFIX 35632.345] %GTPV1_ULI_MNC                   GTPv1 ULI Mobile Network Code
[NFv9 57705][IPFIX 35632.233] %GTPV1_ULI_CELL_LAC              GTPv1 ULI Cell Location Area Code
[NFv9 57706][IPFIX 35632.234] %GTPV1_ULI_CELL_CI               GTPv1 ULI Cell CI
[NFv9 57707][IPFIX 35632.235] %GTPV1_ULI_SAC                   GTPv1 ULI SAC
[NFv9 57804][IPFIX 35632.332] %GTPV1_RESPONSE_CAUSE            GTPv1 Cause of Operation

Plugin GTPv2 Signaling Protocol templates:
[NFv9 57742][IPFIX 35632.270] %GTPV2_REQ_MSG_TYPE              GTPv2 Request Msg Type
[NFv9 57743][IPFIX 35632.271] %GTPV2_RSP_MSG_TYPE              GTPv2 Response Msg Type
[NFv9 57744][IPFIX 35632.272] %GTPV2_C2S_S1U_GTPU_TEID         GTPv2 Client->Svr S1U GTPU TEID
[NFv9 57745][IPFIX 35632.273] %GTPV2_C2S_S1U_GTPU_IP           GTPv2 Client->Svr S1U GTPU IP
[NFv9 57746][IPFIX 35632.274] %GTPV2_S2C_S1U_GTPU_TEID         GTPv2 Srv->Client S1U GTPU TEID
[NFv9 57907][IPFIX 35632.435] %GTPV2_S5_S8_GTPC_TEID           GTPv2 S5/S8 SGW GTPC TEIDs
[NFv9 57747][IPFIX 35632.275] %GTPV2_S2C_S1U_GTPU_IP           GTPv2 Srv->Client S1U GTPU IP
[NFv9 57911][IPFIX 35632.439] %GTPV2_C2S_S5_S8_GTPU_TEID       GTPv2 Client->Srv S5/S8 PGW GTPU TEID
[NFv9 57912][IPFIX 35632.440] %GTPV2_S2C_S5_S8_GTPU_TEID       GTPv2 Srv->Client S5/S8 PGW GTPU TEID
[NFv9 57913][IPFIX 35632.441] %GTPV2_C2S_S5_S8_GTPU_IP         GTPv2 Client->Srv S5/S8 PGW GTPU IP
[NFv9 57914][IPFIX 35632.442] %GTPV2_S2C_S5_S8_GTPU_IP         GTPv2 Srv->Client S5/S8 PGW GTPU IP
[NFv9 57748][IPFIX 35632.276] %GTPV2_END_USER_IMSI             GTPv2 End User IMSI
[NFv9 57749][IPFIX 35632.277] %GTPV2_END_USER_MSISDN           GTPv2 End User MSISDN
[NFv9 57750][IPFIX 35632.278] %GTPV2_APN_NAME                  GTPv2 APN Name
[NFv9 57751][IPFIX 35632.279] %GTPV2_ULI_MCC                   GTPv2 Mobile Country Code
[NFv9 57752][IPFIX 35632.280] %GTPV2_ULI_MNC                   GTPv2 Mobile Network Code
[NFv9 57753][IPFIX 35632.281] %GTPV2_ULI_CELL_TAC              GTPv2 Tracking Area Code
[NFv9 57754][IPFIX 35632.282] %GTPV2_ULI_CELL_ID               GTPv2 Cell Identifier
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[NFv9 57805][IPFIX 35632.333] %GTPV2_RESPONSE_CAUSE             GTPv2 Cause of Operation
[NFv9 57755][IPFIX 35632.283] %GTPV2_RAT_TYPE                   GTPv2 RAT Type
[NFv9 57756][IPFIX 35632.284] %GTPV2_PDN_IP                     GTPV2 PDN IP Address
[NFv9 57757][IPFIX 35632.285] %GTPV2_END_USER_IMEI              GTPv2 End User IMEI

Plugin HTTP Protocol templates:
[NFv9 57652][IPFIX 35632.180] %HTTP_URL                         HTTP URL
[NFv9 57832][IPFIX 35632.360] %HTTP_METHOD                      HTTP METHOD
[NFv9 57653][IPFIX 35632.181] %HTTP_RET_CODE                    HTTP return code (e.g. 200, 304...)
[NFv9 57654][IPFIX 35632.182] %HTTP_REFERER                     HTTP Referer
[NFv9 57655][IPFIX 35632.183] %HTTP_UA                          HTTP User Agent
[NFv9 57656][IPFIX 35632.184] %HTTP_MIME                        HTTP Mime Type
[NFv9 57659][IPFIX 35632.187] %HTTP_HOST                        HTTP Host Name
[NFv9 57833][IPFIX 35632.361] %HTTP_SITE                        HTTP server without host name

Plugin IMAP Protocol templates:
[NFv9 57732][IPFIX 35632.260] %IMAP_LOGIN                       Mail sender

Plugin MySQL Plugin templates:
[NFv9 57667][IPFIX 35632.195] %MYSQL_SERVER_VERSION             MySQL server version
[NFv9 57668][IPFIX 35632.196] %MYSQL_USERNAME                   MySQL username
[NFv9 57669][IPFIX 35632.197] %MYSQL_DB                         MySQL database in use
[NFv9 57670][IPFIX 35632.198] %MYSQL_QUERY                      MySQL Query
[NFv9 57671][IPFIX 35632.199] %MYSQL_RESPONSE                   MySQL server response
[NFv9 57792][IPFIX 35632.320] %MYSQL_APPL_LATENCY_USEC          MySQL request->response latecy (usec)

Plugin NETBIOS Protocol templates:
[NFv9 57982][IPFIX 35632.510] %NETBIOS_QUERY_NAME               NETBIOS Query Name
[NFv9 57983][IPFIX 35632.511] %NETBIOS_QUERY_TYPE               NETBIOS Query Type
[NFv9 57983][IPFIX 35632.511] %NETBIOS_QUERY_RSP                NETBIOS Query Response

Plugin Oracle Protocol templates:
[NFv9 57672][IPFIX 35632.200] %ORACLE_USERNAME                  Oracle Username
[NFv9 57673][IPFIX 35632.201] %ORACLE_QUERY                     Oracle Query
[NFv9 57674][IPFIX 35632.202] %ORACLE_RSP_CODE                  Oracle Response Code
[NFv9 57675][IPFIX 35632.203] %ORACLE_RSP_STRING                Oracle Response String
[NFv9 57676][IPFIX 35632.204] %ORACLE_QUERY_DURATION            Oracle Query Duration (msec)

Plugin POP3 Protocol templates:
[NFv9 57682][IPFIX 35632.210] %POP_USER                         POP3 user login

Plugin System process information templates:
[NFv9 57640][IPFIX 35632.168] %SRC_PROC_PID                     Src process PID
[NFv9 57641][IPFIX 35632.169] %SRC_PROC_NAME                    Src process name
[NFv9 57897][IPFIX 35632.425] %SRC_PROC_UID                     Src process UID
[NFv9 57844][IPFIX 35632.372] %SRC_PROC_USER_NAME               Src process user name
[NFv9 57845][IPFIX 35632.373] %SRC_FATHER_PROC_PID              Src father process PID
[NFv9 57846][IPFIX 35632.374] %SRC_FATHER_PROC_NAME             Src father process name
[NFv9 57855][IPFIX 35632.383] %SRC_PROC_ACTUAL_MEMORY           Src process actual memory (bytes)
[NFv9 57856][IPFIX 35632.384] %SRC_PROC_PEAK_MEMORY             Src process peak memory (bytes)
[NFv9 57857][IPFIX 35632.385] %SRC_PROC_AVERAGE_CPU_LOAD        Src process avg load (% * 100)
[NFv9 57858][IPFIX 35632.386] %SRC_PROC_NUM_PAGE_FAULTS         Src process num pagefaults
[NFv9 57865][IPFIX 35632.393] %SRC_PROC_PCTG_IOWAIT             Src process iowait time % (% * 100)
[NFv9 57847][IPFIX 35632.375] %DST_PROC_PID                     Dst process PID
[NFv9 57848][IPFIX 35632.376] %DST_PROC_NAME                    Dst process name
[NFv9 57898][IPFIX 35632.426] %DST_PROC_UID                     Dst process UID
```

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[NFv9 57849][IPFIX 35632.377] %DST_PROC_USER_NAME              Dst process user name
[NFv9 57850][IPFIX 35632.378] %DST_FATHER_PROC_PID             Dst father process PID
[NFv9 57851][IPFIX 35632.379] %DST_FATHER_PROC_NAME            Dst father process name
[NFv9 57859][IPFIX 35632.387] %DST_PROC_ACTUAL_MEMORY          Dst process actual memory (bytes)
[NFv9 57860][IPFIX 35632.388] %DST_PROC_PEAK_MEMORY            Dst process peak memory (bytes)
[NFv9 57861][IPFIX 35632.389] %DST_PROC_AVERAGE_CPU_LOAD       Dst process avg load (% * 100)
[NFv9 57862][IPFIX 35632.390] %DST_PROC_NUM_PAGE_FAULTS        Dst process num pagefaults
[NFv9 57866][IPFIX 35632.394] %DST_PROC_PCTG_IOWAIT            Src process iowait time % (% * 100)

Plugin Radius Protocol templates:
[NFv9 57712][IPFIX 35632.240] %RADIUS_REQ_MSG_TYPE             RADIUS Request Msg Type
[NFv9 57713][IPFIX 35632.241] %RADIUS_RSP_MSG_TYPE             RADIUS Response Msg Type
[NFv9 57714][IPFIX 35632.242] %RADIUS_USER_NAME                RADIUS User Name (Access Only)
[NFv9 57715][IPFIX 35632.243] %RADIUS_CALLING_STATION_ID       RADIUS Calling Station Id
[NFv9 57716][IPFIX 35632.244] %RADIUS_CALLED_STATION_ID        RADIUS Called Station Id
[NFv9 57717][IPFIX 35632.245] %RADIUS_NAS_IP_ADDR              RADIUS NAS IP Address
[NFv9 57718][IPFIX 35632.246] %RADIUS_NAS_IDENTIFIER           RADIUS NAS Identifier
[NFv9 57719][IPFIX 35632.247] %RADIUS_USER_IMSI                RADIUS User IMSI (Extension)
[NFv9 57720][IPFIX 35632.248] %RADIUS_USER_IMEI                RADIUS User MSISDN (Extension)
[NFv9 57721][IPFIX 35632.249] %RADIUS_FRAMED_IP_ADDR           RADIUS Framed IP
[NFv9 57722][IPFIX 35632.250] %RADIUS_ACCT_SESSION_ID          RADIUS Accounting Session Name
[NFv9 57723][IPFIX 35632.251] %RADIUS_ACCT_STATUS_TYPE         RADIUS Accounting Status Type
[NFv9 57724][IPFIX 35632.252] %RADIUS_ACCT_IN_OCTETS           RADIUS Accounting Input Octets
[NFv9 57725][IPFIX 35632.253] %RADIUS_ACCT_OUT_OCTETS          RADIUS Accounting Output Octets
[NFv9 57726][IPFIX 35632.254] %RADIUS_ACCT_IN_PKTS             RADIUS Accounting Input Packets
[NFv9 57727][IPFIX 35632.255] %RADIUS_ACCT_OUT_PKTS            RADIUS Accounting Output Packets

Plugin RTP Plugin templates:
[NFv9 57909][IPFIX 35632.437] %RTP_SSRC                        RTP Sync Source ID
[NFv9 57622][IPFIX 35632.150] %RTP_FIRST_SEQ                   First flow RTP Seq Number
[NFv9 57623][IPFIX 35632.151] %RTP_FIRST_TS                    First flow RTP timestamp
[NFv9 57624][IPFIX 35632.152] %RTP_LAST_SEQ                    Last flow RTP Seq Number
[NFv9 57625][IPFIX 35632.153] %RTP_LAST_TS                     Last flow RTP timestamp
[NFv9 57626][IPFIX 35632.154] %RTP_IN_JITTER                   RTP jitter (ms * 1000)
[NFv9 57627][IPFIX 35632.155] %RTP_OUT_JITTER                  RTP jitter (ms * 1000)
[NFv9 57628][IPFIX 35632.156] %RTP_IN_PKT_LOST                 Packet lost in stream (src->dst)
[NFv9 57629][IPFIX 35632.157] %RTP_OUT_PKT_LOST                Packet lost in stream (dst->src)
[NFv9 57902][IPFIX 35632.430] %RTP_IN_PKT_DROP                 Packet discarded by Jitter Buffer (src->dst)
[NFv9 57903][IPFIX 35632.431] %RTP_OUT_PKT_DROP                Packet discarded by Jitter Buffer (dst->src)
[NFv9 57633][IPFIX 35632.161] %RTP_IN_PAYLOAD_TYPE             RTP payload type
[NFv9 57630][IPFIX 35632.158] %RTP_OUT_PAYLOAD_TYPE            RTP payload type
[NFv9 57631][IPFIX 35632.159] %RTP_IN_MAX_DELTA                Max delta (ms*100) between consecutive pkts (src-
>dst)
[NFv9 57632][IPFIX 35632.160] %RTP_OUT_MAX_DELTA               Max delta (ms*100) between consecutive pkts (dst-
>src)
[NFv9 57820][IPFIX 35632.348] %RTP_SIP_CALL_ID                 SIP call-id corresponding to this RTP stream
[NFv9 57906][IPFIX 35632.434] %RTP_MOS                         RTP pseudo-MOS (value * 100) (average both
directions)
[NFv9 57842][IPFIX 35632.370] %RTP_IN_MOS                      RTP pseudo-MOS (value * 100) (src->dst)
[NFv9 57904][IPFIX 35632.432] %RTP_OUT_MOS                     RTP pseudo-MOS (value * 100) (dst->src)
[NFv9 57908][IPFIX 35632.436] %RTP_R_FACTOR                    RTP pseudo-R_FACTOR (value * 100) (average both
directions)
[NFv9 57843][IPFIX 35632.371] %RTP_IN_R_FACTOR                 RTP pseudo-R_FACTOR (value * 100) (src->dst)
[NFv9 57905][IPFIX 35632.433] %RTP_OUT_R_FACTOR                RTP pseudo-R_FACTOR (value * 100) (dst->src)
[NFv9 57853][IPFIX 35632.381] %RTP_IN_TRANSIT                  RTP Transit (value * 100) (src->dst)
[NFv9 57854][IPFIX 35632.382] %RTP_OUT_TRANSIT                 RTP Transit (value * 100) (dst->src)
[NFv9 57852][IPFIX 35632.380] %RTP_RTT                         RTP Round Trip Time (ms)
[NFv9 57867][IPFIX 35632.395] %RTP_DTMF_TONES                  DTMF tones sent (if any) during the call
```

```
Plugin S1AP Protocol templates:
[NFv9 57879][IPFIX 35632.407] %S1AP_ENB_UE_S1AP_ID              S1AP ENB Identifier
[NFv9 57880][IPFIX 35632.408] %S1AP_MME_UE_S1AP_ID              S1AP MME Identifier
[NFv9 57881][IPFIX 35632.409] %S1AP_MSG_EMM_TYPE_MME_TO_ENB     S1AP EMM Message Type from MME to ENB
[NFv9 57882][IPFIX 35632.410] %S1AP_MSG_ESM_TYPE_MME_TO_ENB     S1AP ESM Message Type from MME to ENB
[NFv9 57883][IPFIX 35632.411] %S1AP_MSG_EMM_TYPE_ENB_TO_MME     S1AP EMM Message Type from ENB to MME
[NFv9 57884][IPFIX 35632.412] %S1AP_MSG_ESM_TYPE_ENB_TO_MME     S1AP ESM Message Type from ENB to MME
[NFv9 57885][IPFIX 35632.413] %S1AP_CAUSE_ENB_TO_MME            S1AP Cause from ENB to MME
[NFv9 57886][IPFIX 35632.414] %S1AP_DETAILED_CAUSE_ENB_TO_MME   S1AP Detailed Cause from ENB to MME

Plugin SIP Plugin templates:
[NFv9 57602][IPFIX 35632.130] %SIP_CALL_ID                      SIP call-id
[NFv9 57603][IPFIX 35632.131] %SIP_CALLING_PARTY                SIP Call initiator
[NFv9 57604][IPFIX 35632.132] %SIP_CALLED_PARTY                 SIP Called party
[NFv9 57605][IPFIX 35632.133] %SIP_RTP_CODECS                   SIP RTP codecs
[NFv9 57606][IPFIX 35632.134] %SIP_INVITE_TIME                  SIP time (epoch) of INVITE
[NFv9 57607][IPFIX 35632.135] %SIP_TRYING_TIME                  SIP time (epoch) of Trying
[NFv9 57608][IPFIX 35632.136] %SIP_RINGING_TIME                 SIP time (epoch) of RINGING
[NFv9 57609][IPFIX 35632.137] %SIP_INVITE_OK_TIME               SIP time (epoch) of INVITE OK
[NFv9 57610][IPFIX 35632.138] %SIP_INVITE_FAILURE_TIME          SIP time (epoch) of INVITE FAILURE
[NFv9 57611][IPFIX 35632.139] %SIP_BYE_TIME                     SIP time (epoch) of BYE
[NFv9 57612][IPFIX 35632.140] %SIP_BYE_OK_TIME                  SIP time (epoch) of BYE OK
[NFv9 57613][IPFIX 35632.141] %SIP_CANCEL_TIME                  SIP time (epoch) of CANCEL
[NFv9 57614][IPFIX 35632.142] %SIP_CANCEL_OK_TIME               SIP time (epoch) of CANCEL OK
[NFv9 57615][IPFIX 35632.143] %SIP_RTP_IPV4_SRC_ADDR            SIP RTP stream source IP
[NFv9 57616][IPFIX 35632.144] %SIP_RTP_L4_SRC_PORT              SIP RTP stream source port
[NFv9 57617][IPFIX 35632.145] %SIP_RTP_IPV4_DST_ADDR            SIP RTP stream dest IP
[NFv9 57618][IPFIX 35632.146] %SIP_RTP_L4_DST_PORT              SIP RTP stream dest port
[NFv9 57619][IPFIX 35632.147] %SIP_RESPONSE_CODE                SIP failure response code
[NFv9 57620][IPFIX 35632.148] %SIP_REASON_CAUSE                 SIP Cancel/Bye/Failure reason cause
[NFv9 57834][IPFIX 35632.362] %SIP_C_IP                         SIP C IP adresses
[NFv9 57835][IPFIX 35632.363] %SIP_CALL_STATE                   SIP Call State

Plugin SMTP Protocol templates:
[NFv9 57657][IPFIX 35632.185] %SMTP_MAIL_FROM                   Mail sender
[NFv9 57658][IPFIX 35632.186] %SMTP_RCPT_TO                     Mail recipient

Plugin SSDP Protocol templates:
[NFv9 57972][IPFIX 35632.500] %SSDP_HOST                        SSDP Host
[NFv9 57973][IPFIX 35632.501] %SSDP_USN                         SSDP USN
```

If you want to specify NetFlow v9 flows in a format similar to v5 flows you can do as follows:

nprobe -T "%IPV4_SRC_ADDR %IPV4_DST_ADDR %IPV4_NEXT_HOP %INPUT_SNMP %OUTPUT_SNMP %IN_PKTS %IN_BYTES %FIRST_SWITCHED %LAST_SWITCHED %L4_SRC_PORT %L4_DST_PORT %TCP_FLAGS %PROTOCOL %SRC_TOS %SRC_AS %DST_AS %SRC_MASK %DST_MASK"

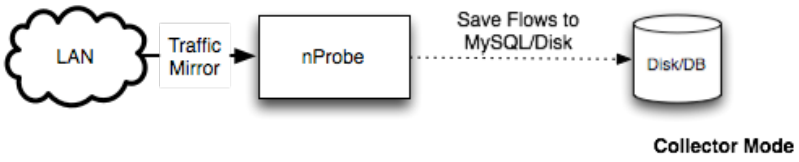
Note that the fields start with a % and are separated by a space.

Appendix C: nProbe Usage Modes

nProbe can be used in three modes, namely:

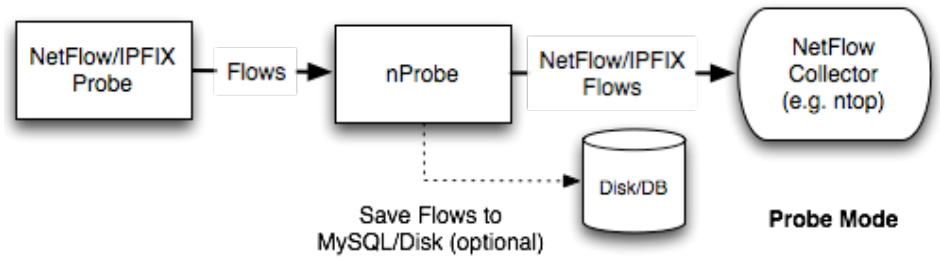
- Probe (default);
- Collector (flow collection only, no Probe)
- Proxy: Receive flows via NetFlow and emit them (optionally combining with captured traffic) to a remote collector.

1. Probe mode (default)



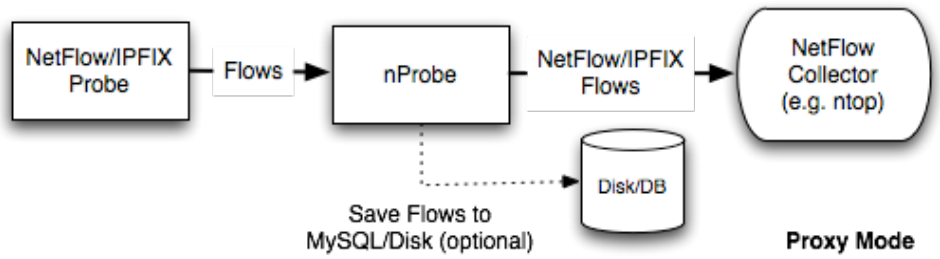
Command: "nprobe -i eth0 -n collector_ip:2055"

2. Collector mode



Command: "nprobe nf-collector-port 2055"

3. Proxy mode



Command: "nprobe --nf-collector-port 2055 -n collector_ip:2055 -V 9"

In proxy mode you can convert from/to IPFIX/NetFlow v5/v9 in order to smoothly upgrade to newer netflow protocol versions while capitalizing on previous protocol versions. So you can for instance convert flows coming from your v5 router into IPFIX and vice-versa. Note that with some combinations (e.g. from v9 to v5) you might loose some flow information.

Appendix D: EULA

Licensee's use of this software is conditioned upon acceptance of the terms specified in https://svn.ntop.org/svn/ntop/trunk/legal/LicenseAgreement