Simplemux Readme file

About Simplemux

There are some situations in which multiplexing a number of small packets into a bigger one is desirable. For example, a number of small packets can be sent together between a pair of machines if they share a common network path. Thus, the traffic profile can be shifted from small to larger packets, reducing the network overhead and the number of packets per second to be managed by intermediate routers.

Simplemux is a generic multiplexing protocol, described in draft-saldana-tsvwg-simplemux. It is able to encapsulate a number of packets belonging to different protocols into a single packet. It includes the "Protocol" field on each multiplexing header, thus allowing the inclusion of a number of packets belonging to different protocols in a packet of another protocol (Fig. 1). The size of the multiplexing headers is kept very low (it may be a single byte when multiplexing small packets) in order to reduce the overhead.

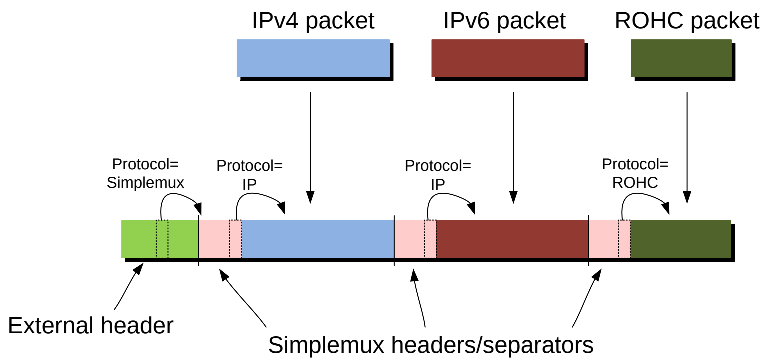

Fig. 1. Example of a Simplemux packet including packets of different protocols

Simplemux is designed to optimize together a number of flows sharing a common network path or segment (Fig. 2). Optimization in the end host is (in principle) not useful, since a number of small-packet flows departing from the same host are unusual. The multiplexing is performed between a pair of machines called ingress-optimizer and egress-optimizer.

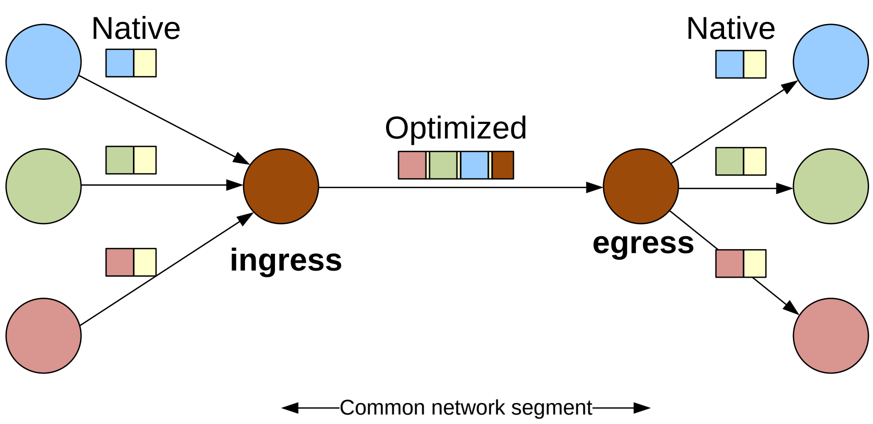

Fig. 2. Scheme of the optimization

The present code is an implementation of **Simplemux**, using IP/UDP or IP as the *tunneling protocol*, and IP or ROHC (RFC 5795) as the *multiplexed protocol*, as illustrated in Fig. 3. Thus, it is able to perform traffic optimization, combining multiplexing with header compression. This may result on significant bandwidth savings and pps reductions for small-packet flows (e.g. VoIP, online games).

Simplemux can run in two modes:

- **Network mode**: the multiplexed packet is sent in an IP datagram using Protocol Number 253 (according to IANA, this number can be used for experimentation and testing[1]).

- **Transport mode**: the multiplexed packet is sent in an IP/UDP datagram. In this case, the protocol number in the IP header is that of UDP (17) and both ends have to agree on a UDP port.

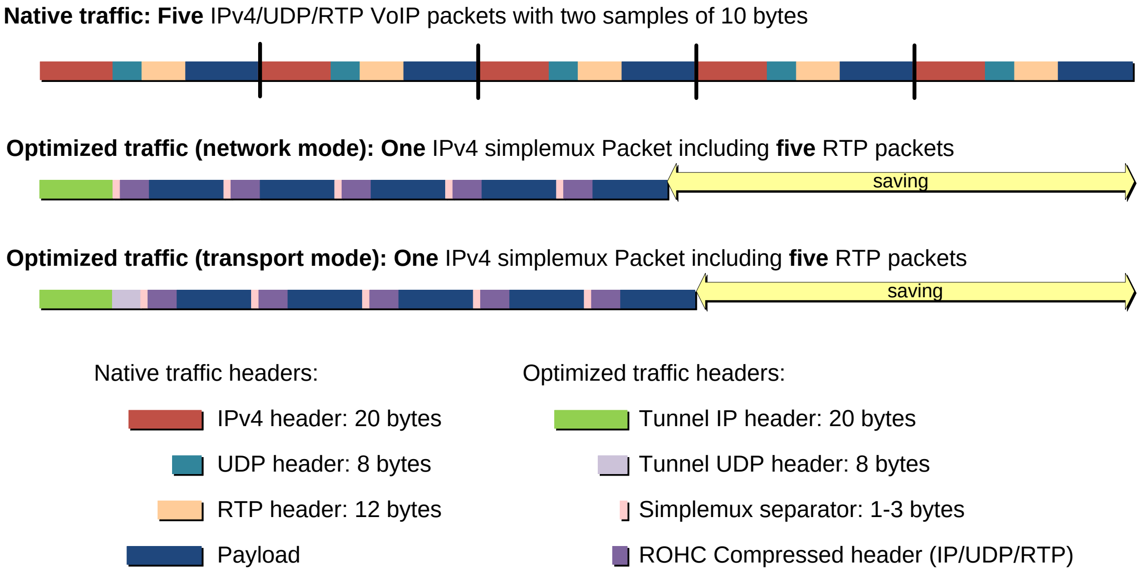

Fig. 3. Optimization of five RTP packets of VoIP

Simplemux can be used as an option at the multiplexing layer of TCM[2], a combination of protocols for **T**unneling, **C**ompressing and **M**ultiplexing, allowing the optimization of small-packet flows. TCM may use of a number of different standard algorithms for header compression, multiplexing and tunneling, combined in a similar way to RFC 4170, as proposed in draft-saldana-tsvwg-tcmtf.

The implementation is written in C for Linux. It compresses headers using an implementation of ROHC by Didier Barvaux (https://rohc-lib.org/).

Simplemux uses Linux TUN virtual interface.

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[1] Protocol numbers, http://www.iana.org/assignments/protocol-numbers/protocol-numbers.xhtml

[2] Jose Saldana *et al*, "*Emerging Real-time Services: Optimizing Traffic by Smart Cooperation in the Network*," IEEE Communications Magazine, Vol. 51, n. 11, pp 127-136, Nov. 2013. doi 10.1109/MCOM.2013.6658664

Header compression

This **Simplemux** implementation includes these ROHC modes:

- ROHC unidirectional.

- ROHC bidirectional optimistic

- ROHC bidirectional reliable is not yet implemented.

ROHC cannot be enabled in one of the peers and disabled in the other peer.

ROHC is able to compress this traffic flows:

- IP/UDP/RTP: If the UDP packets have the destination ports 1234, 36780, 33238, 5020, 5002, the compressor assumes that they are RTP.
- IP/UDP
- IP/TCP
- IP/ESP
- IP/UDP-Lite

Tunneling

In this implementation, tunneling is performed in a very simple way:

- In **network mode**, the external IP header is the tunneling header. It uses Protocol number 253.

- In **transport mode**, an IP/UDP header is added before the first **Mux separator.** By default, the destination UDP port is 55555.

ROHC feedback information (when using ROHC Bidirectional modes) is sent in UDP packets using port 55556 by default.

Multiplexing

The **Simplemux separator** (see Fig. 4) has two different formats: one for the *First header* (the separator before the first packet included in the multiplexed bundle), and another one for *Non-first headers* (the rest of the separators).

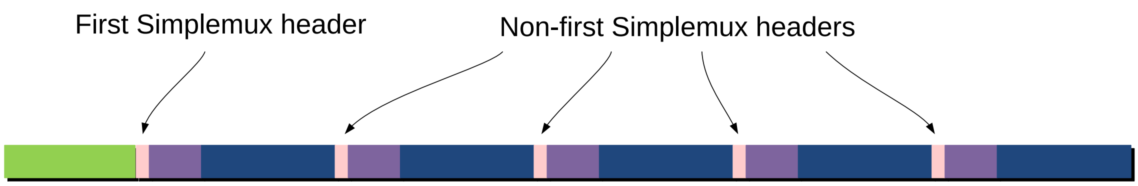


Fig. 4. First and Non-first Simplemux headers (also known as separators)

Format of the First Simplemux header/separator

In order to allow the multiplexing of packets of any length, the number of bytes expressing the length is variable, and the field Length Extension (LXT, one bit) is set to 0 if the current byte is the last one including length information.

These are the fields of the header:

- **Single Protocol Bit (SPB, one bit)** only appears in the first Simplemux header. It is set to 1 if all the multiplexed packets belong to the same protocol (in this case, the “protocol” field will only appear in the first Simplemux header). It is set to 0 when each packet MAY belong to a different protocol.

- **Length Extension (LXT, one bit)** is 0 if the current byte is the last byte where the length of the first packet is included, and 1 in other case.

- **Length (LEN, 6, 13, 20, etc. bits).** This is the length of the multiplexed packet (in bytes), not including the length field. If the length of the multiplexed packet is less than 64 bytes (less than or equal to 63 bytes), the first LXT is set to 0 and the 6 bits of the length field are the length of the multiplexed packet. If the length of the multiplexed packet is equal or greater than 64 bytes, additional bytes are added. The first bit of each of the added bytes is the LXT. If LXT is set to 1, it means that there is an additional byte for expressing the length. This allows to multiplex packets of any length (see Figure 5).

- **Protocol (8 bits)** is the Protocol field of the multiplexed packet, according to IANA "Assigned Internet Protocol Numbers".

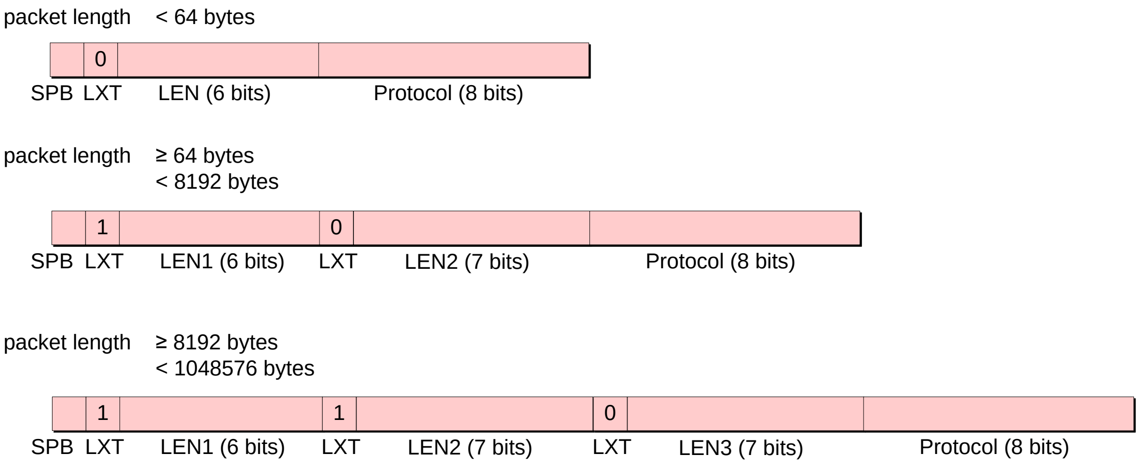


Fig. 5. Fields of the First Simplemux header/separator

For example, in the case of a packet of 65 bytes, the Simplemux separator will be three bytes long. In this case, the length of the packet will be the number expressed by the concatenation of the bits of Length 1 - Length 2 (total 13 bits). Length 1 includes the 6 most significant bits and Length 2 the 7 less significant bits.

More bytes can be added to the length if required, using the same scheme: 1 LXT byte plus 7 bits for expressing the length.

Format of the Non-first Simplemux header/separator

The Non-first Simplemux headers also employ a format allowing the multiplexing of packets of any length, so the number of bytes expressing the length is variable, and the field Length Extension (LXT, one bit) is set to 0 if the current byte is the last one including length information.

If the SPB (Single Protocol Bit) of the First Simplemux header is set to 1, it means that all the multiplexed packets belong to the same protocol. In this case, the format is the one presented in Fig. 6:

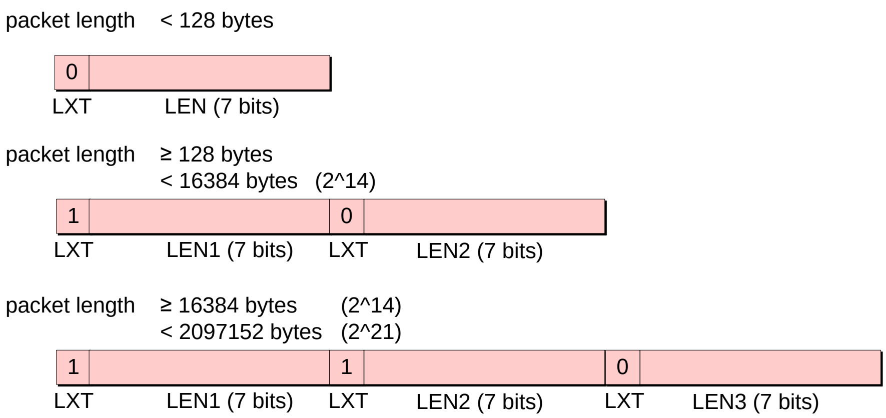


Fig. 6. Fields of the Non-first Simplemux header/separator, when the SPB bit of the First header is 1

If the SPB of the First Simplemux header is set to 0, then each packet may belong to a different protocol, so the “Protocol” field is also included, as shown in Fig. 7:

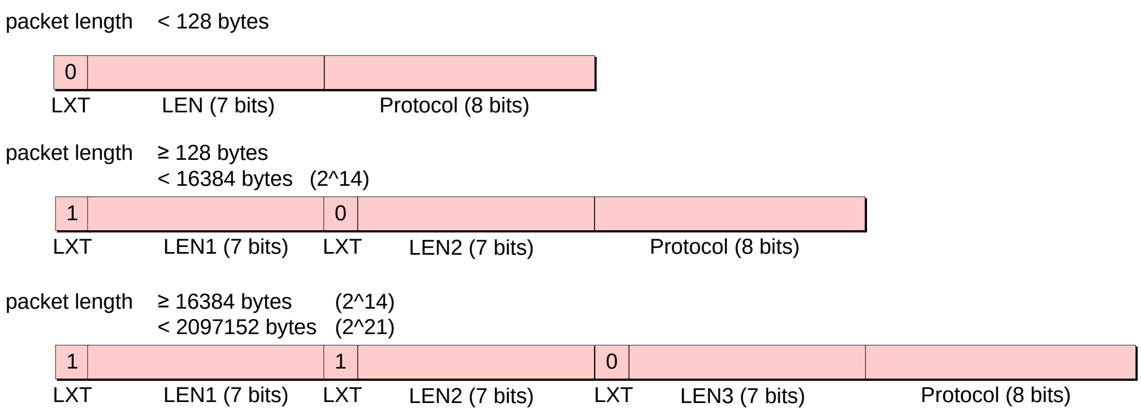


Fig. 7. Fields of the Non-first Simplemux header/separator, when the SPB bit of the First header is 0

These are the fields:

- **Length Extension (LXT, one bit)** is 0 if the current byte is the last byte where the length of the first packet is included, and 1 in other case.

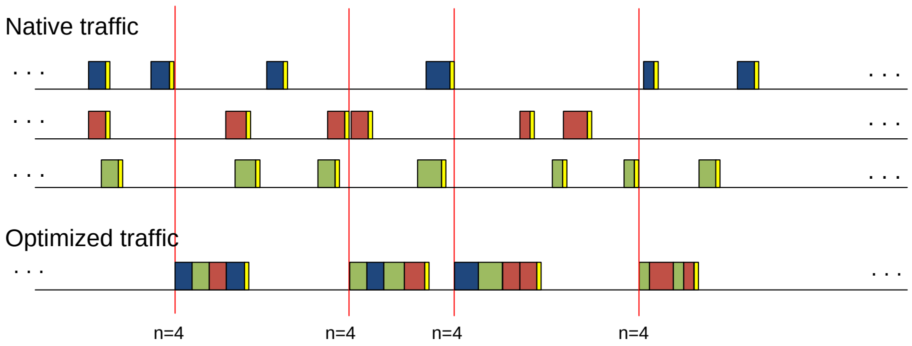
- **Length (LEN, 7, 14, 21, etc. bits).** This is the length of the multiplexed packet (in bytes), not including the length field. If the length of the multiplexed packet is less than 128 bytes (less than or equal to 127 bytes), the first LXT is set to 0 and the 7 bits of the length field are the length of the multiplexed packet. If the length of the multiplexed packet is equal or greater than 128 bytes, additional bytes are added. The first bit of each of the added bytes is the LXT. If LXT is set to 1, it means that there is an additional byte for expressing the length. This allows to multiplex packets of any length.

- **Protocol (8 bits)** is the Protocol field of the multiplexed packet, according to IANA "Assigned Internet Protocol Numbers". It is only included when the SPB of the First Multiplexing header is 0.

Multiplexing policies

Four different conditions can be used and combined for triggering the sending of a multiplexed packet (in the figures, the triggering moment is expressed by red lines):

- **number of packets**: a number of packets have arrived to the multiplexer.



- **size**: two different options apply:

  - the size of the multiplexed packet has exceeded the size threshold specified by the user, but not the MTU. In this case, a packet is sent and a new period is started with the buffer empty.
  - the size of the multiplexed packet has exceeded the MTU (and the size threshold consequently). In this case, a packet is sent without the last one. A new period is started, and the last arrived packet is stored for the next period.

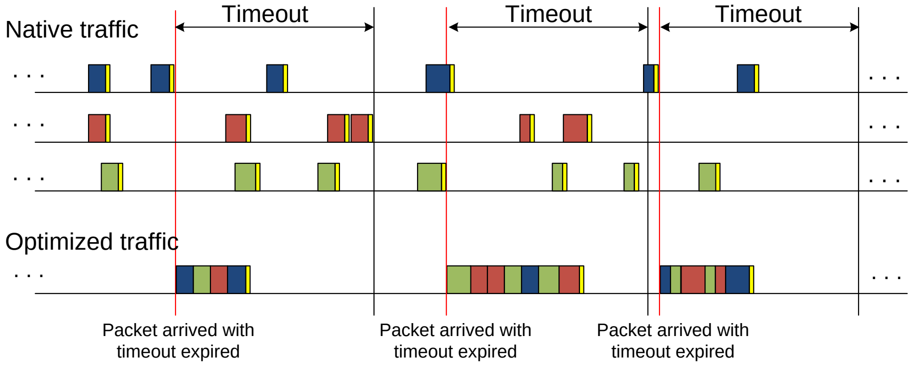
  If you want to specify an MTU different from the one of the local interface, you can use the '-m' option. You may use other tools for getting the MTU of a network path. For example with the command[3]:

```
# tracepath 192.168.137.3 | grep Resume | cut -c 19-22
```

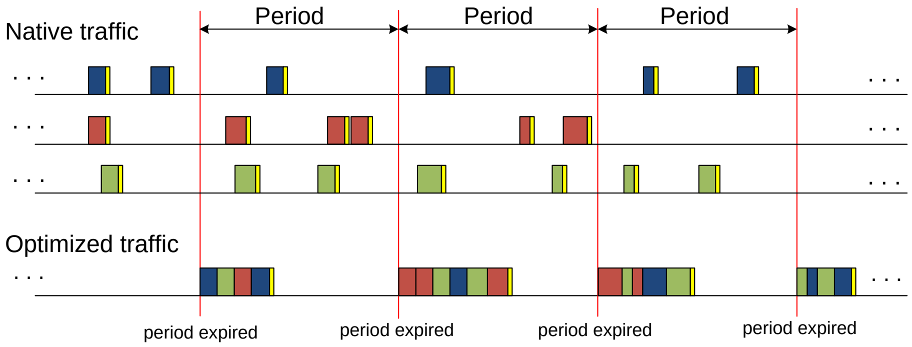
  you will obtain the MTU of the path to 192.168.137.3

[3] http://packetlife.net/blog/2008/aug/18/path-mtu-discovery/

- **timeout**: a packet arrives, and a timeout since the last sending has expired.



- **period**: an active waiting is performed, and a multiplexed packet including all the packets arrived during a period is sent.



More than one condition can be set at the same time. Please note that if (timeout > period), then the timeout has no effect. Note that **only period policy guarantees an upper bound for the multiplexing delay.**

Simplemux is symmetric, i.e. both machines may act as ingress and egress simultaneously. However, different policies can be established at each of the optimizers, e.g. in one side you can send a multiplexed packet every two native ones, and in the other side you can set a timeout.

What will you find in this package

You will find two different source files:

`simplemux.c`	The complete version of **Simplemux**
`simplemux_multiplexing_delay.pl`	A perl script for reading the traces
`simplemux_throughput_pps.pl`	A perl script for reading the traces
`driveGnuPlotStreams.pl`	A perl script for creating real-time graphs

Required tools

ROHC (not required for simplemux-no-compress.c)

First, you have to install rohc 1.7.0 from https://rohc-lib.org/. Download and uncompress the ROHC package.

```
cd rohc-1.7.0
./configure --prefix=/usr
make all
make check
make install
```

Compiling simplemux

```
gcc -o simplemux -g -Wall $(pkg-config rohc --cflags) simplemux_vX.Y.c $(pkg-
config rohc --libs )
```

Usage of simplemux

```
./simplemux -i <ifacename> -e <ifacename> -c <peerIP> -M <N or T> [-p <port>]
[-d <debug_level>] [-r <ROHC_option>] [-n <num_mux_tun>] [-m <MTU>] [-b
<num_bytes_threshold>] [-t <timeout (microsec)>] [-P <period (microsec)>] [-l
<log file name>] [-L]

./simplemux -h

-i <ifacename>: Name of tun interface to use for capturing native packets
(mandatory)
-e <ifacename>: Name of local interface which IP will be used for reception
of muxed packets, i.e., the tunnel local end (mandatory)
-c <peerIP>: specify peer destination IP address, i.e. the tunnel remote end
(mandatory)
-M <mode>: Network(N) or Transport (T) mode (mandatory)
-p <port>: port to listen on, and to connect to (default 55555)
-d: outputs debug information while running. 0:no debug; 1:minimum debug;
2:medium debug; 3:maximum debug (incl. ROHC)
-r: 0:no ROHC; 1:Unidirectional; 2: Bidirectional Optimistic; 3:
Bidirectional Reliable (not available yet)
-n: number of packets received, to be sent to the network at the same time,
default 1, max 100
-m: Maximum Transmission Unit of the network path (by default the one of the
local interface is taken)
-b: size threshold (bytes) to trigger the departure of packets (default MTU-
28 in transport mode and MTU-20 in network mode)
-t: timeout (in usec) to trigger the departure of packets
-P: period (in usec) to trigger the departure of packets. If ( timeout <
period ) then the timeout has no effect
```

```
-l: log file name. Use 'stdout' if you want the log data in standard output
-L: use default log file name (day and hour Y-m-d_H.M.S)
-h: prints this help text
```

If you have to use the same local interface more than once

It may happen that you have to create more than one tunnel using the same local interface. In that case, you may obtain a message `Is already in use`.

For example, if you run these two commands in the same machine, you may obtain this error message:

```
./simplemux -i tun0 -e wlan0 -M N -c 10.1.10.4
```

```
./simplemux -i tun1 -e wlan0 -M N -c 10.1.10.6
```

To avoid the problem, you can use an alias (see e.g. https://www.cyberciti.biz/faq/linux-creating-or-adding-new-network-alias-to-a-network-card-nic/). So you can do `ifconfig wlan0:0 x.y.z.t. up`, and then you can use `wlan0` in one case, and `wlan0:0` in the other.

Format of the Simplemux traces

Using the options `-l log file name` or `-L` you can obtain a text file with traces. This is the format of these traces:

<table>
<tr><th>timestamp</th><th>event</th><th>type</th><th>size</th><th>sequence number</th><th>from/to</th><th>IP</th><th>port</th><th>number of packets</th><th>triggering event(s)</th></tr>
<tr><td>%"PRIu64"</td><td>text</td><td>text</td><td>%i</td><td>%lu</td><td>text</td><td>%s</td><td>%d</td><td>%i</td><td>text</td></tr>
<tr><td rowspan="10">microseconds</td><td rowspan="3">rec</td><td>native</td><td rowspan="10">packet size in bytes</td><td rowspan="10">sequence number</td><td>-</td><td>-</td><td>-</td><td rowspan="3">-</td><td rowspan="3">-</td></tr>
<tr><td>muxed</td><td rowspan="2">from</td><td rowspan="2">ingress IP address</td><td rowspan="2">port
(only in transport mode)</td></tr>
<tr><td>ROHC_feedback</td></tr>
<tr><td rowspan="2">sent</td><td>muxed</td><td>to</td><td>egress IP address</td><td>port
(only in transport mode)</td><td>number</td><td>numpacket_limit
size_limit
timeout
period
MTU</td></tr>
<tr><td>demuxed</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>forward</td><td>native</td><td>from</td><td>ingress IP address</td><td>port</td><td>-</td><td>-</td></tr>
<tr><td rowspan="4">error</td><td>bad_separator</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>demux_bad_length</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>decomp_failed</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>comp_failed</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
</table>

	drop	too_long			to	egress IP address	port	number	-
	drop	no_ROHC_mode			-	-	-	-	-

- `timestamp`: it is in microseconds. It is obtained with the function `GetTimeStamp()`.

- `event` and `type`:

  - `rec`: a packet has been received:

    - `native`: a native packet has arrived to the ingress optimizer.

    - `muxed`: a multiplexed packet has arrived to the egress optimizer.

    - `ROHC_feedback`: a ROHC feedback-only packet has been received from the decompressor. It only contains ROHC feedback information, so there is nothing to decompress

  - `sent`: a packet has been sent

    - `muxed`: the ingress optimizer has sent a multiplexed packet.

    - `demuxed`: the egress optimizer has demuxed a native packet and sent it to its destination.

  - `forward`: when a packet arrives to the egress with a port different to the one where the optimization is being deployed, it is just forwarded to the network.

  - `error`:

    - `bad_separator`: the Simplemux header before the packet is not well constructed.

    - `demux_bad_length`: the length of the packet expressed in the Simplemux header is excessive (the multiplexed packet would finish after the end of the global packet).

    - `decomp_failed`: ROHC decompression failed.

    - `comp_failed`: ROHC compression failed.

  - `drop`:

    - `no_ROHC_mode`: a ROHC packet has been received, but the decompressor is not in ROHC mode.

- `size`: it expresses (in bytes) the size of the packet. If it is a muxed one, it is the global size of the packet (including IP header). If it is a `native` or `demuxed` one, it is the size of the original (native) packet.

- `sequence number`: it is a sequence number generated internally by the program. Two different sequences are generated: one for received packets and other one for sent packets.

- `IP`: it is the IP address of the peer Simplemux optimizer.

- `port`: it is the destination port of the packet.

- `number of packets`: it is the number of packets included in a multiplexed bundle.

- `triggering event(s)`: it is the cause (more than one may appear) of the triggering of the multiplexed bundle:

  - `numpacket_limit`: the limit of the number of packets has been reached.

  - `size_limit`: the maximum size has been reached.

  - `timeout`: a packet has arrived once the timeout had expired.

  - `period`: the period has expired.

  - `MTU`: the MTU has been reached.

Trace examples

In the ingress optimizer you may obtain:

```
1417693720928101    rec     native      63    1505
1417693720931540    rec     native      65    1506
1417693720931643    rec     native      52    1507
1417693720936101    rec     native      48    1508
1417693720936210    rec     native      53    1509
1417693720936286    rec     native      67    1510
1417693720937162    rec     native      57    1511
1417693720938081    sent    muxed       237   1511   to     192.168.137.4    55555  7   period
```

This means that 7 native packets (length 63, 65, … 57, and sequence numbers 1505 to 1511) have been received, and finally the period has expired, so they have been sent together to the egress Simplemux optimizer at 192.168.137.4, port 55555.

In the egress optimizer you may obtain:

```
1417693720922848    rec     muxed       237   210    from   192.168.0.5    55555
1417693720922983    sent    demuxed     63    210
1417693720923108    sent    demuxed     65    210
1417693720923186    sent    demuxed     52    210
1417693720923254    sent    demuxed     48    210
1417693720923330    sent    demuxed     53    210
1417693720923425    sent    demuxed     67    210
1417693720923545    sent    demuxed     57    210
```

This means that a multiplexed packet (sequence number 210) has been received from the ingress optimizer 192.168.0.5 with port 55555, and it has been demuxed, resulting into 7 different packets of lengths 63, 65, … 57.

Scripts for calculating some statistics

This package includes the next Perl scripts:

Calculate throughput and packets per second

`simplemux_throughput_pps.pl`

It is able to calculate the throughput and the packet-per-second rate, from a Simplemux output trace. The result is in three columns:

```
tick_end_time(us)   throughput(bps)     packets_per_second
1000000             488144              763
2000000             490504 7            59
3000000             475576              749
4000000             483672              760
5000000             481784              758
6000000             487112              762
7000000             486824              760
8000000             488792              765
9000000             483528              761
10000000            486360              760
```

Usage:

```
$perl simplemux_throughput_pps.pl <trace file> <tick(us)> <event> <type>
<peer IP> <port>
```

Examples:

```
# $ perl simplemux_throughput_pps.pl tracefile.txt 1000000 rec native all all
# $ perl simplemux_throughput_pps.pl log_simplemux 1000000 rec muxed all all
```

```
# $ perl simplemux_throughput_pps.pl log_simplemux 1000000 rec muxed
192.168.0.5 55555
# $ perl simplemux_throughput_pps.pl log_simplemux 1000000 sent demuxed
```

Calculate the multiplexing delay of each packet

Multiplexing delay is the time each packet is stopped in the multiplexer, i.e. the interval between its arrival as native packet and its departure inside a multiplexed packet.

`simplemux_multiplexing_delay.pl`

It is able to calculate the multiplexing delay of each packet, from a Simplemux output trace. The result is an output file in two columns:

```
packet_id    multiplexing_delay(us)
1      5279
2      1693
3      1202
4      507
5      10036
6      8471
7      6974
8      5588
9      1143
10     10435
11     8935
12     7522
13     5981
14     4520
15     3011
...
```

And other results are shown in stdout:

```
total native packets:     6661
Average multiplexing delay:     5222.47680528449 us
stdev of the multiplexing delay:3425.575192789 us
```

Usage:
```
$ perl simplemux_multiplexing_delay.pl <trace file> <output file>
```

Scripts for drawing the instantaneous throughput and pps

You can make Simplemux generate real-time graphs of the throughput and the amount of packets per second. For that aim, you have to use pipes in order to combine two perl scripts.

You will need to install the `gnuplot-x11` Linux package.

- Send the log of simplemux to `stdout`, using `-l stdout` option.

- Use the script `simplemux_throughput_pps_live.pl` to generate a summary every e.g. 10 ms of packets coming from (or going to) 192.168.0.5 using port 55555.

The output is something like this:

```
0:492800
1:532000
2:700
```

```
3:700
0:492800
1:532000
2:700
3:700
```

Where each row represents a value of

0: native throughput

1: multiplexed throughput

2: native pps

3: multiplexed pps

- Use the script `driveGnuPlotStreams.pl`, by Andreas Bernauer[4] to represent different graphs.

Some examples:

The next command presents two windows, each one with two graphs of 300 samples width, titled “native”, “muxed”, “ppsnat” and “ppsmux”

```
$ ./simplemux -i tun0 -e eth0 -c 192.168.0.5 -M T -d 0 -r 2 -l stdout |
perl simplemux_throughput_pps_live.pl 10000 192.168.0.5 55555 |
perl ./driveGnuPlotStreams.pl 4 2 300 300 0 1000000 0 200 500x300+0+0
500x300+0+0 'native' 'muxed' 'ppsnat' 'ppsmux' 0 0 1 1
```

The next command presents one window with two graphs of 300 samples width, titled “native” and “muxed”

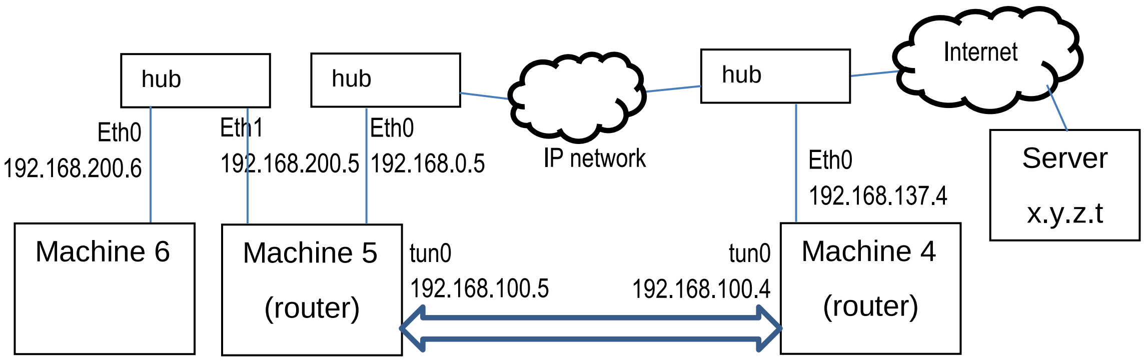
```
./simplemux_1.6.21 -i tun0 -e eth0 -c 192.168.0.5 -M T -d 0 -r 2 -l stdout |
perl simplemux_throughput_pps_live.pl 10000 192.168.0.5  |
perl ./driveGnuPlotStreams.pl 2 1 300 0 1000000 500x300+0+0 'native' 'muxed'
0 0
```

[4] http://www.lysium.de/blog/index.php?/archives/234-Plotting-data-with-gnuplot-in-real-time.html

Usage example with three machines

This is the setup:

Machine 6 is the source. Machine 5 and Machine 4 are the two optimizers. Server x.y.z.t is the destination.



Create a tun interface in machine 4

`#ip tuntap add dev tun0 mode tun user root`[5]

(`#openvpn --mktun --dev tun0 --user root` will work in OpenWrt and also in other Linux distributions[6]).

`#ip link set tun0 up` (or `ifconfig tun0 up` for e.g. OpenWRT)

If you want to add an IP address to the tun0 interface, use:

`#ip addr add 192.168.100.4/24 dev tun0`

If you do not need an IP address, you can omit the previous command.

Create a tun interface in machine 5

`#ip tuntap add dev tun0 mode tun user root`
(`#openvpn --mktun --dev tun0 --user root` will also work)

```
#ip link set tun0 up
#ip addr add 192.168.100.5/24 dev tun0
```

Establish the simplemux tunnel between machine 4 and machine 5

In machine4:

```
# ./simplemux -i tun0 -e eth0 -M N-c 192.168.0.5
```

In machine5:

```
# ./simplemux -i tun0 -e eth0 –M N -c 192.168.137.4
```

Now you can ping from machine 5 or machine6 to machine 4:

[5] For removing the interface use `ip tuntap del dev tun0 mode tun`
[6] Openvpn is used to create and destroy tun/tap devices. In Debian you can install it this way: `#apt-get install openvpn`
In OpenWRT you will not be able to run `ip tuntap`, so you should install `openvpn` with: `#opkg install openvpn-nossl`. (do `opkg update` before)

```
$ ping 192.168.100.4
```

The ping arrives to the `tun0` interface of machine 5, goes to machine 4 through the tunnel and is returned to machine 6 through the tunnel.

How to steer traffic from Machine 6 to server x.y.z.t through the tunnel

The idea of **simplemux** is that it does not run on endpoints, but on some "optimizing" machines in the network. So you have to define policies to steer the flows of interest, in order to make them go through the TUN interface of the ingress (machine 5). This can be done with `iprules` and `iptables`.

Following with the example:

In Machine 5, add a rule that makes the kernel route packets marked with "2" through `table 3`:

```
# ip rule add fwmark 2 table 3
```

In Machine 5, add a new route for `table 3`:

```
# ip route add default dev tun0 table 3 [7]
# ip route flush cache
```

If you show the routes of table 3

```
# ip route show table 3
```

Then you should obtain this:

```
      default via 192.168.100.5 dev tun0
```

And now you can use `iptables` in order to mark certain packets as "2" if they have a certain destination IP, or a port number.

Examples:

All packets with destination IP address x.y.z.t

```
iptables -t mangle -A PREROUTING -p udp -d x.y.z.t -j MARK --set-mark 2
```

All packets with destination UDP port 8999

```
iptables -t mangle -A PREROUTING -p udp --dport 8999 -j MARK --set-mark 2
```

All packets with destination TCP port 44172

```
iptables -t mangle -A PREROUTING -p tcp --dport 44172 -j MARK --set-mark 2
```

Remove the table rule

```
iptables -t mangle -D PREROUTING -p tcp --dport 44172 -j MARK --set-mark 2
```

Show the table

```
iptables -t mangle –L
```

[7] If you have set an IP address in the tun0 interface, this command should also work:

```
# ip route add default via 192.168.100.5 table 3
```

Other examples implementing different policies

Set a period of 50 ms

```
./simplemux -i tun0 -e eth0 –M N -c 192.168.0.5 –P 50000
```

Send a multiplexed packet every 2 packets, use ROHC Bidirectional Optimistic

```
./simplemux -i tun0 -e eth0 –M N -c 192.168.0.5–n 2 –r 2
```

Send a multiplexed packet if the size of the multiplexed bundle is 400 bytes

```
./simplemux -i tun0 -e eth0 –M N -c 192.168.0.5 –b 400
```

Send a timeout of 50ms, and a period of 100 ms (to set an upper bound on the added delay), use ROHC Unidirectional

```
./simplemux -i tun0 -e eth0 –M N -c 192.168.0.5 –t 50000 –P 100000 –r 1
```

Credits

The author of **simplemux** is Jose Saldana (jsaldana at unizar.es). **Simplemux** has been written for research purposes, so if you find it useful, I would appreciate that you send a message sharing your experiences, and your improvement suggestions.

The software is released under the **GNU General Public License**, Version 3, 29 June 2007.

Thanks to Didier Barvaux for his ROHC implementation.

Thanks to Davide Brini for his simpletun program.

If you have some improvement suggestions, do not hesitate to contact me.

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