Network Performance Analysis

Unix/IP Preparation Course

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Local analysis

- **As we know... Before we blame the network, let's verify whether the problem is ours.**
- **What can go wrong locally?**
  - Hardware problems
  - Excessive load (CPU, memory, I/O)
- **What's considered 'normal'?**
  - Use analysis tools frequently
    - Become familiar with the normal state and values for your machine.
  - **It is essential to maintain history**
    - SNMP agents and databases

Performance analysis in Unix

- Three main categories:
  - Processes
    - Processes that are executing (running)
    - Processes that are waiting (sleeping)
      - waiting their turn
      - blocked
  - Memory
    - Real
    - Virtual
  - I/O (Input/Output)
    - Storage
    - Network

Key indicators

- **Insufficent CPU**
  - Number of processes waiting to execute is always high
  - High CPU utilization (load avg.)
- **Insufficient memory**
  - Very little free memory
  - Lots of swap activity (swap in, swap out)
- **Slow I/O**
  - Lots of blocked processes
  - High number of block transfers

Local analysis

- Luckily, in Unix there are dozens of useful tools that give us lots of useful information about our machine
- Some of the more well-known include:
  - vmstat - tcpdump - iperf
  - top - wireshark (ethereal)
  - lsof - iptraf
  - netstat - ntop

vmstat

- Show periodic summary information about processes, memory, pagin, I/O, CPU state, etc

```
vmstat <-options> <delay> <count>
```

```
# vmstat 2
procs -----------memory---------- ---swap-- -----io---- --system-- ----cpu----
 r  b   swpd   free   buff  cache   si   so    bi    bo   in    cs us sy id wa
 2  0 209648  25552 571332 2804876    0    0     3     4    3     3 15 11 73  0
 2  0 209648  24680 571332 2804900    0    0     0   444  273 79356 16 16 68  0
 1  0 209648  25216 571336 2804904    0    0     6  1234  439 46735 16 10 74  0
 1  0 209648  25212 571336 2804904    0    0     0    22  159 100282 17 21 62  0
 2  0 209648  25196 571348 2804912    0    0     0   500  270 82455 14 18 68  0
 1  0 209648  25192 571348 2804912    0    0     0   272  243 77480 16 15 69  0
 2  0 209648  25880 571360 2804916    0    0     0   444  255 83619 16 14 69  0
 2  0 209648  25872 571360 2804920    0    0     0   178  220 90521 16 18 66  0
```

top

- Basic performance tool for Unix/Linux environments
- Periodically show a list of system performance statistics:
  - CPU use
  - RAM and SWAP memory usage
  - Load average (cpu utilization)
  - Information by process

Load Average

- Average number of active processes in the last 1, 5 and 15 minutes
  - A simple yet useful measurement
  - Depending on the machine the acceptable range considered to be normal can vary:
    - Multi-processor machines can handle more active processes per unit of time (than single processor machines)

top

- **Information by process (most relevant columns shown):**
  - PID: Process ID
  - USER: user running (owner) of the process
  - %CPU: Percentage of CPU utilization by the process since the last sample
  - %MEM: Percentage of physical memory (RAM) used by the process
  - TIME: Total CPU time used by the process since it was started

top

- **Some useful *interactive* commands**
  - **f** : Add or remove columns
  - **F** : Specify which column to order by
  - **<** , **>** : Move the column on which we order
  - **u** : Specify a specific user
  - **k** : Specify a process to kill (stop)
  - **d** , **s** : Change the display update interval

netstat

- **Show us information about:**
  - Network connections
  - Routing tables
  - Interface (NIC) statistics
  - Multicast group members

netstat

Some useful options

- **-n**: Show addresses, ports and userids in numeric form
- **-r**: Routing table
- **-s**: Statistics by protocol
- **-i**: Status of interfaces
- **-l**: Listening sockets
- **--tcp**, **--udp**: Specify the protocol
- **-A**: Address family [inet | inet6 | unix | etc.]
- **-p**: Show the name of each process for each port
- **-c**: Show output/results continuously

netstat

Examples:

```
# netstat -n --tcp -c
Active Internet connections (w/o servers)
Proto Recv-Q Send-Q Local Address               Foreign Address             State
tcp        0    272 ::ffff:192.188.51.40:22     ::ffff:128.223.60.27:60968  ESTABLISHED
tcp        0      0 ::ffff:192.188.51.40:22     ::ffff:128.223.60.27:53219  ESTABLISHED

# netstat -lnp --tcp
Active Internet connections (only servers)
Proto Recv-Q Send-Q Local Address               Foreign Address             State       PID/Program name
tcp        0      0 0.0.0.0:199                 0.0.0.0:*                   LISTEN      11645/snmpd
tcp        0      0 0.0.0.0:3306                0.0.0.0:*                   LISTEN      1997/mysqld
```

```
# netstat -ic
Kernel Interface table
Iface       MTU Met    RX-OK RX-ERR RX-DRP RX-OVR    TX-OK TX-ERR TX-DRP TX-OVR Flg
eth0       1500   0  2155901      0      0      0   339116      0      0      0 BMRU
lo        16436   0    18200      0      0      0    18200      0      0      0 LRU
eth0       1500   0  2155905      0      0      0   339117      0      0      0 BMRU
lo        16436   0    18200      0      0      0    18200      0      0      0 LRU
eth0       1500   0  2155907      0      0      0   339120      0      0      0 BMRU
lo        16436   0    18200      0      0      0    18200      0      0      0 LRU
eth0       1500   0  2155910      0      0      0   339122      0      0      0 BMRU
lo        16436   0    18200      0      0      0    18200      0      0      0 LRU
eth0       1500   0  2155913      0      0      0   339124      0      0      0 BMRU
```

netstat

Examples:

```
# netstat -tcp -listening --program
Active Internet connections (only servers)
Proto Recv-Q Send-Q Local Address           Foreign Address         State       PID/Program name
tcp        0      0 *:5001                  *:*                     LISTEN      13598/iperf
tcp        0      0 localhost:mysql         *:*                     LISTEN      5586/mysqld
tcp        0      0 *:www                   *:*                     LISTEN      7246/apache2
tcp        0      0 t60-2.local:domain      *:*                     LISTEN      5378/named
tcp        0      0 t60-2.local:domain      *:*                     LISTEN      5378/named
tcp        0      0 t60-2.local:domain      *:*                     LISTEN      5378/named
tcp        0      0 localhost:domain        *:*                     LISTEN      5378/named
tcp        0      0 localhost:ipp           *:*                     LISTEN      5522/cupsd
tcp        0      0 localhost:smtp          *:*                     LISTEN      6772/exim4
tcp        0      0 localhost:953           *:*                     LISTEN      5378/named
tcp        0      0 *:https                 *:*                     LISTEN      7246/apache2
tcp6       0      0 [::]:ftp                [::]:*                  LISTEN      7185/proftpd
tcp6       0      0 [::]:domain             [::]:*                  LISTEN      5378/named
tcp6       0      0 [::]:ssh                [::]:*                  LISTEN      5427/sshd
tcp6       0      0 [::]:3000               [::]:*                  LISTEN      17644/ntop
tcp6       0      0 ip6-localhost:953       [::]:*                  LISTEN      5378/named
tcp6       0      0 [::]:3005               [::]:*                  LISTEN      17644/ntop
```

lsof (List Open Files)

- lsof is particularly useful because in Unix everything is a file: unix sockets, ip sockets, directories, etc.
- Allows you to associate open files by:
  - **-p**: PID (Process ID)
  - **-i** : A network address (protocol:port)
  - **-u**: A user

lsof

- **Example:**
  - First, using *netstat -ln –tcp* determine that port 6010 is open and waiting for a connection (LISTEN)

```
# netstat -ln --tcp
Active Internet connections (only servers)
Proto Recv-Q Send-Q Local Address               Foreign Address             State

tcp        0      0 127.0.0.1:6010              0.0.0.0:*                   LISTEN
tcp        0      0 127.0.0.1:6011              0.0.0.0:*                   LISTEN
```

lsof

Determine what process has the port (6010) open and what other resources are being used:

```
# lsof -i tcp:6010
COMMAND   PID USER   FD   TYPE DEVICE SIZE NODE NAME
sshd    10301 root    6u  IPv4  53603       TCP localhost.localdomain:x11-ssh-offset (LISTEN)
sshd    10301 root    7u  IPv6  53604       TCP [::1]:x11-ssh-offset (LISTEN)
```

```
# lsof -p 10301
COMMAND   PID USER   FD   TYPE     DEVICE    SIZE    NODE NAME
sshd    10301 root  cwd    DIR        8,2    4096       2 /
sshd    10301 root  rtd    DIR        8,2    4096       2 /
sshd    10301 root  txt    REG        8,2  379720 1422643 /usr/sbin/sshd
sshd    10301 root  mem    REG        8,2   32724 1437533 /usr/lib/libwrap.so.0.7.6
sshd    10301 root  mem    REG        8,2   15088 3080329 /lib/libutil-2.4.so
sshd    10301 root  mem    REG        8,2   75632 1414093 /usr/lib/libz.so.1.2.3
sshd    10301 root  mem    REG        8,2   96040 3080209 /lib/libnsl-2.4.so
sshd    10301 root  mem    REG        8,2  100208 1414578 /usr/lib/libgssapi_krb5.so.2.2
sshd    10301 root  mem    REG        8,2   11684 1414405 /usr/lib/libkrb5support.so.0.0
sshd    10301 root  mem    REG        8,2   10368 3080358 /lib/libsetrans.so.0
sshd    10301 root  mem    REG        8,2    7972 3080231 /lib/libcom_err.so.2.1
sshd    10301 root  mem    REG        8,2   30140 1420233 /usr/lib/libcrack.so.2.8.0
sshd    10301 root  mem    REG        8,2   11168 3080399 /lib/security/pam_succeed_if.so
...
```

lsof

What network services am I running?

```
# lsof -i
COMMAND     PID        USER   FD   TYPE  DEVICE SIZE NODE NAME
firefox    4429      hervey   50u  IPv4 1875852       TCP 192.168.179.139:56890-
>128.223.60.21:www (ESTABLISHED)
named      5378        bind   20u  IPv6   13264       TCP *:domain (LISTEN)
named      5378        bind   21u  IPv4   13267       TCP localhost:domain (LISTEN)
sshd       5427        root    3u  IPv6   13302       TCP *:ssh (LISTEN)
cupsd      5522        root    3u  IPv4 1983466       TCP localhost:ipp (LISTEN)
mysqld     5586       mysql   10u  IPv4   13548       TCP localhost:mysql (LISTEN)
snmpd      6477        snmp    8u  IPv4   14633       UDP localhost:snmp
exim4      6772 Debian-exim    3u  IPv4   14675       TCP localhost:smtp (LISTEN)
ntpd       6859         ntp   16u  IPv4   14743       UDP *:ntp
ntpd       6859         ntp   17u  IPv6   14744       UDP *:ntp
ntpd       6859         ntp   18u  IPv6   14746       UDP [fe80::250:56ff:fec0:8]:ntp
ntpd       6859         ntp   19u  IPv6   14747       UDP ip6-localhost:ntp
proftpd    7185     proftpd    1u  IPv6   15718       TCP *:ftp (LISTEN)
apache2    7246    www-data    3u  IPv4   15915       TCP *:www (LISTEN)
apache2    7246    www-data    4u  IPv4   15917       TCP *:https (LISTEN)
...
iperf     13598        root    3u  IPv4 1996053       TCP *:5001 (LISTEN)
apache2   27088    www-data    3u  IPv4   15915       TCP *:www (LISTEN)
apache2   27088    www-data    4u  IPv4   15917       TCP *:https (LISTEN)
```

tcpdump

- Show received packet headers by a given interface. Optionally filter using boolean expressions.
- Allows you to write information to a file for later analysis.
- Requires administrator (root) privileges to use since you must configure network interfaces (NICs) to be in “promiscuous” mode.
  - Note: promiscuous mode is not very useful when you are connected by a switch.

tcpdump

Some useful options:

- **-i** : Specify the interface (ex: -i eth0)
- **-l** : Make stdout line buffered (view as you capture)
- **-v**, **-vv**, **-vvv**: Display more information
- **-n** : Don't convert addresses to names (avoid DNS)
- **-nn** : Don't translate port numbers
- **-w** : Write raw packets to a file
- **-r** : Read packets from a file created by '-w'

tcpdump

Boolean expressions

- Using the 'AND', 'OR', 'NOT' operators
- Expressions consist of one, or more, primtives, which consist of a qualifier and an ID (name or number)
  - Expression ::= [NOT] <primitive> [AND | OR | NOT <primitive> ...]
  - <primitive> ::= <qualifier> <name|number>
  - <qualifier> ::= <type> | <address> | <protocol>
  - <type> ::= host | net | port | port range
  - <address> ::= src | dst
  - <protocol> ::= ether | fddi | tr | wlan | ip | ip6 | arp | rarp | decnet | tcp | udp

tcpdump

Examples:

- Show all HTTP traffic that originates from 192.168.1.1

```
# tcpdump -lnXvvv port 80 and src host 192.168.1.1
```

- Show all traffic originating from 192.168.1.1 *except* SSH

```
# tcpdump -lnXvvv src host 192.168.1.1 and not port 22
```

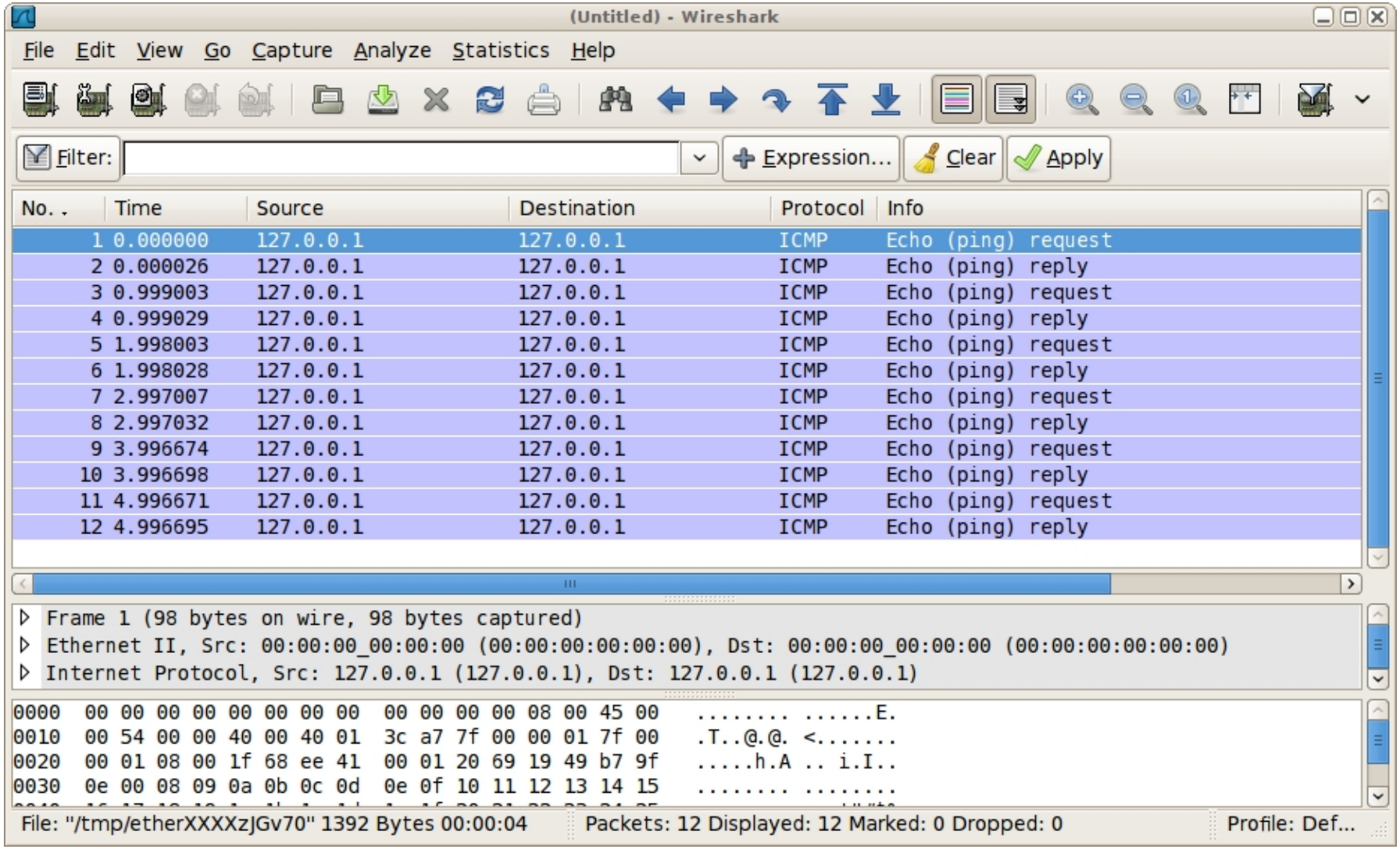
wireshark

- Wireshark is a graphical packet analyser based on *libpcap*, the same library that *tcpdump* utilizes for capturing and storing packets
- The graphical interface has some advantages, including:
  - Hierarchical visualization by protocol (drill-down)
  - Follow a TCP “conversation” (Follow TCP Stream)
  - Colors to distinguish traffic types
  - Lots of statistics, graphs, etc.

wireshark

- Wireshark is what came after *Ethereal*.
- The combination of *tcpdump* and *wireshark* can be quite powerful. For example:
  - `# tcpdump -i eth1 -A -s1500 -2 dump.log port 21`
  - `$ sudo wireshark -r dump.log`

wireshark


(Untitled) - Wireshark
File Edit View Go Capture Analyze Statistics Help
Filter:
Expression... Clear Apply
No. Time Source Destination Protocol Info
1 0.000000 127.0.0.1 127.0.0.1 ICMP Echo (ping) request
2 0.000026 127.0.0.1 127.0.0.1 ICMP Echo (ping) reply
3 0.999003 127.0.0.1 127.0.0.1 ICMP Echo (ping) request
4 0.999029 127.0.0.1 127.0.0.1 ICMP Echo (ping) reply
5 1.998003 127.0.0.1 127.0.0.1 ICMP Echo (ping) request
6 1.998028 127.0.0.1 127.0.0.1 ICMP Echo (ping) reply
7 2.997007 127.0.0.1 127.0.0.1 ICMP Echo (ping) request
8 2.997032 127.0.0.1 127.0.0.1 ICMP Echo (ping) reply
9 3.996674 127.0.0.1 127.0.0.1 ICMP Echo (ping) request
10 3.996698 127.0.0.1 127.0.0.1 ICMP Echo (ping) reply
11 4.996671 127.0.0.1 127.0.0.1 ICMP Echo (ping) request
12 4.996695 127.0.0.1 127.0.0.1 ICMP Echo (ping) reply
Frame 1 (98 bytes on wire, 98 bytes captured)
Ethernet II, Src: 00:00:00_00:00:00 (00:00:00:00:00:00), Dst: 00:00:00_00:00:00 (00:00:00:00:00:00)
Internet Protocol, Src: 127.0.0.1 (127.0.0.1), Dst: 127.0.0.1 (127.0.0.1)
0000 00 00 00 00 00 00 00 00 00 00 00 00 08 00 45 00 ....E.
0010 00 54 00 00 40 00 40 01 3c a7 7f 00 00 01 7f 00 .T..@.@. <.....
0020 00 01 08 00 1f 68 ee 41 00 01 20 69 19 49 b7 9f .....h.A .. i.I..
0030 0e 00 08 09 0a 0b 0c 0d 0e 0f 10 11 12 13 14 15 ....
File: "/tmp/etherXXXXzJGv70" 1392 Bytes 00:00:04
Packets: 12 Displayed: 12 Marked: 0 Dropped: 0
Profile: Def...

iptraf

- **Many measurable statistics and functions**
  - By protocol/port
  - By packet size
  - Generates logs
  - Utilizes DNS to translate addresses
- **Advantages**
  - Simplicity
  - Menu-based (uses “curses”)
  - Flexible configuration

iptraf

- You can run it periodically in the background (-B)
  - It allows you, for example, to run as a cron job to periodically analyze logs.
    - Generate alarms
    - Save in a data base
    - Has a great name... “Interactive Colorful IP LAN Monitor”
    - etc...

Example: `iptraf -i eth1`

ntop: Network Top

- **Equivalent to *top*, but for network information**
  - Information by node, network protocol, IP protocol, statistics, graphs, etc.
- **Web interface with an integrated web server**
  - Supports SSL
- **Multiple plug-ins are available to extend its functionality**
  - Creates RRD files
  - NetFlow analysis

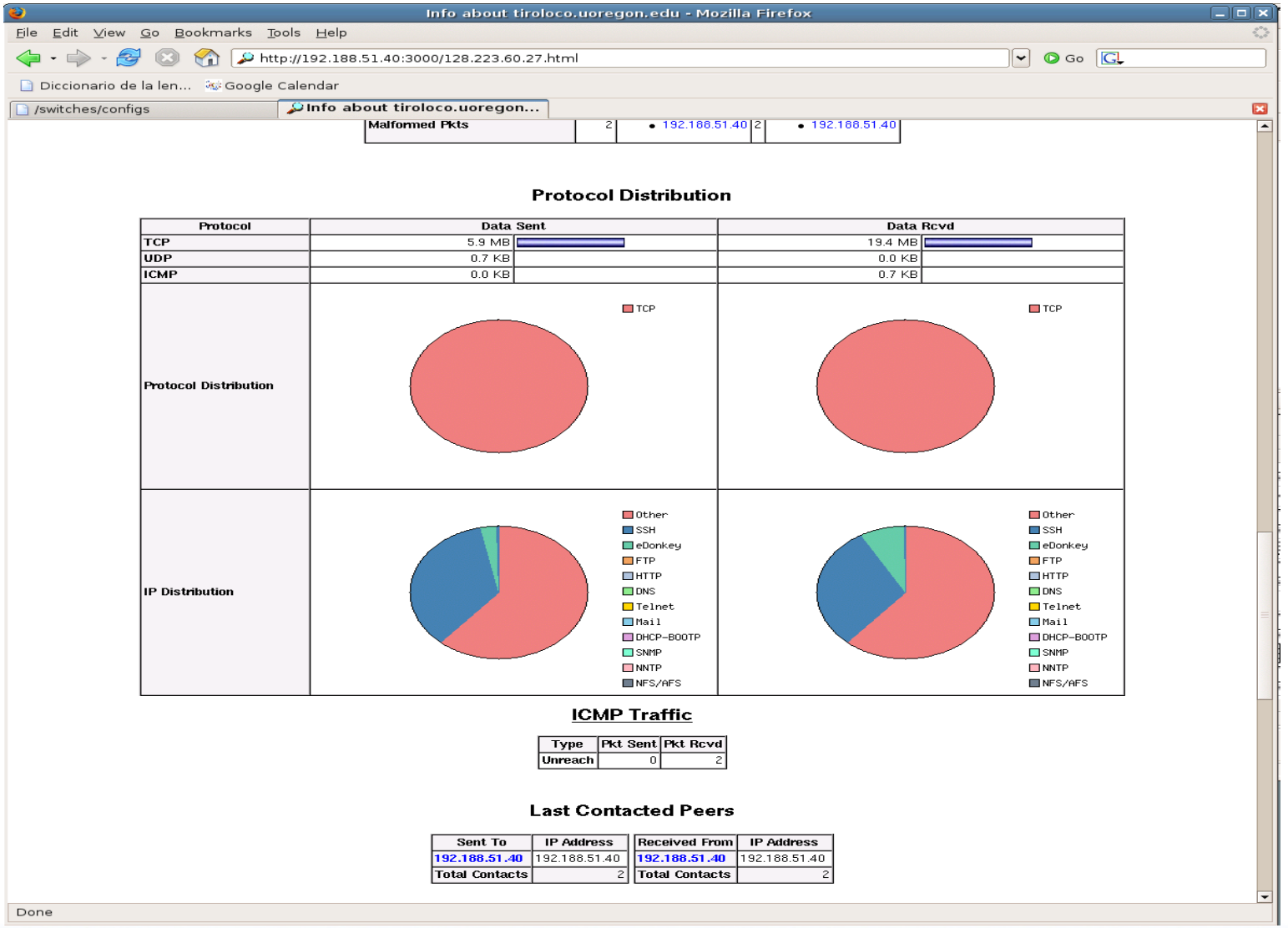
ntop

- It can run as a service (daemon), with SSL:
  - -d : daemon
  - -W <port> : Listen on port 3005, SSL mode

```
ntop -d -W 3005
```

- To see the web interface go to:
  - http://localhost:3000
  - https://localhost:3005

ntop


Info about tiroloco.uoregon.edu - Mozilla Firefox
File Edit View Go Bookmarks Tools Help
http://192.188.51.40:3000/128.223.60.27.html
Go
Diccionario de la len...
Google Calendar
/switches/configs
Info about tiroloco.uoregon...
Malformed Pkts 2 • 192.188.51.40 2 • 192.188.51.40
Protocol Distribution
Protocol | Data Sent | Data Rcvd
TCP | 5.9 MB | 19.4 MB
UDP | 0.7 KB | 0.0 KB
ICMP | 0.0 KB | 0.7 KB
Protocol Distribution
TCP
IP Distribution
Other
SSH
eDonkey
FTP
HTTP
DNS
Telnet
Mail
DHCP-BOOTP
SNMP
NNTP
NFS/AFS
ICMP Traffic
Type | Pkt Sent | Pkt Rcvd
Unreach | 0 | 2
Last Contacted Peers
Sent To | IP Address
192.188.51.40 | 192.188.51.40
Total Contacts | 2
Received From | IP Address
192.188.51.40 | 192.188.51.40
Total Contacts | 2
Done

ntop

Includes an option that creates a file with information about "suspicious packets":

```
       -q | --create-suspicious-packets
        This parameter tells ntop to create a dump file of suspicious packets.
There are many, many, things that cause a packet to be labeled as 'suspicious',
including:

          Detected ICMP fragment
          Detected Land Attack against host
          Detected overlapping/tiny packet fragment
          Detected traffic on a diagnostic port
          Host performed ACK/FIN/NULL scan
          Host rejected TCP session
          HTTP/FTP/SMTP/SSH detected at wrong port
          Malformed TCP/UDP/ICMP packet (packet too short)
          Packet # %u too long
          Received a ICMP protocol Unreachable from host
          Sent ICMP Administratively Prohibited packet to host
          Smurf packet detected for host
          TCP connection with no data exchanged
          TCP session reset without completing 3-way handshake
          Two MAC addresses found for the same IP address
          UDP data to a closed port
          Unknown protocol (no HTTP/FTP/SMTP/SSH) detected (on port 80/21/25/22)
          Unusual ICMP options
```

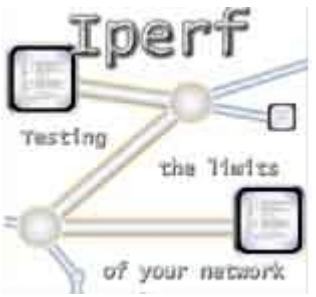
ntop

- After you've completed a capture of packets using the “-q” option, it's possible to analyze suspicious packets in more detail with *wireshark*:

```
# wireshark -r /usr/local/var/ntop/ntop-suspicious-pkts.deveth0.pcap
```

iperf

- To measure network throughput between two points
- *iperf* has two modes, *server* and *client*
- Easy to use
- Great to help determine optimal TCP parameters
  - TCP window size for optimal throughput



iperf

- Using UDP you can generate packet loss and *jitter* reports
- You can run multiple parallel sessions using *threads*
- Supports IPv6

Iperf parameters

```
Usage: iperf [-s|-c host] [options]
       iperf [-h|--help] [-v|--version]

Client/Server:
  -f, --format    [kmKM]   format to report: Kbits, Mbits, KBytes, MBytes
  -i, --interval  #        seconds between periodic bandwidth reports
  -l, --len       #[KM]    length of buffer to read or write (default 8 KB)
  -m, --print_mss          print TCP maximum segment size (MTU - TCP/IP header)
  -p, --port      #        server port to listen on/connect to
  -u, --udp                use UDP rather than TCP
  -w, --window    #[KM]    TCP window size (socket buffer size)
  -B, --bind      <host>   bind to <host>, an interface or multicast address
  -C, --compatibility      for use with older versions does not sent extra msgs
  -M, --mss       #        set TCP maximum segment size (MTU - 40 bytes)
  -N, --nodelay            set TCP no delay, disabling Nagle's Algorithm
  -V, --IPv6Version        Set the domain to IPv6

Server specific:
  -s, --server             run in server mode
  -U, --single_udp         run in single threaded UDP mode
  -D, --daemon             run the server as a daemon

Client specific:
  -b, --bandwidth #[KM]    for UDP, bandwidth to send at in bits/sec
                           (default 1 Mbit/sec, implies -u)
  -c, --client    <host>   run in client mode, connecting to <host>
  -d, --dualtest           Do a bidirectional test simultaneously
  -n, --num       #[KM]    number of bytes to transmit (instead of -t)
  -r, --tradeoff           Do a bidirectional test individually
  -t, --time      #        time in seconds to transmit for (default 10 secs)
  -F, --fileinput <name>   input the data to be transmitted from a file
  -I, --stdin              input the data to be transmitted from stdin
  -L, --listenport #       port to recieve bidirectional tests back on
  -P, --parallel  #        number of parallel client threads to run
  -T, --ttl       #        time-to-live, for multicast (default 1)
```

iperf - TCP

```
$ iperf -s
------------------------------------------------------------
Server listening on TCP port 5001
TCP window size: 85.3 KByte (default)
------------------------------------------------------------
[  4] local 128.223.157.19 port 5001 connected with 201.249.107.39
port 39601
[  4]  0.0-11.9 sec    608 KBytes    419 Kbits/sec
------------------------------------------------------------

# iperf -c nsrc.org
------------------------------------------------------------
Client connecting to nsrc.org, TCP port 5001
TCP window size: 16.0 KByte (default)
------------------------------------------------------------
[  3] local 192.168.1.170 port 39601 connected with 128.223.157.19
port 5001
[  3]  0.0-10.3 sec    608 KBytes    485 Kbits/sec
```

Iperf - UDP

```
# iperf -c host1 -u -b100M
------------------------------------------------------------
Client connecting to nsdb, UDP port 5001
Sending 1470 byte datagrams
UDP buffer size:   106 KByte (default)
------------------------------------------------------------
[  3] local 128.223.60.27 port 39606 connected with 128.223.250.135 port 5001
[  3]  0.0-10.0 sec    114 MBytes  95.7 Mbits/sec
[  3] Sent 81377 datagrams
[  3] Server Report:
[  3]  0.0-10.0 sec    114 MBytes  95.7 Mbits/sec  0.184 ms    1/81378 (0.0012%)

$ iperf -s -u -i 1
------------------------------------------------------------
Server listening on UDP port 5001
Receiving 1470 byte datagrams
UDP buffer size:   108 KByte (default)
------------------------------------------------------------
[  3] local 128.223.250.135 port 5001 connected with 128.223.60.27 port 39606
[  3]  0.0- 1.0 sec  11.4 MBytes  95.4 Mbits/sec  0.184 ms    0/ 8112 (0%)
[  3]  1.0- 2.0 sec  11.4 MBytes  95.7 Mbits/sec  0.177 ms    0/ 8141 (0%)
[  3]  2.0- 3.0 sec  11.4 MBytes  95.6 Mbits/sec  0.182 ms    0/ 8133 (0%)
...
[  3]  8.0- 9.0 sec  11.4 MBytes  95.7 Mbits/sec  0.177 ms    0/ 8139 (0%)
[  3]  9.0-10.0 sec  11.4 MBytes  95.7 Mbits/sec  0.180 ms    0/ 8137 (0%)
[  3]  0.0-10.0 sec    114 MBytes  95.7 Mbits/sec  0.184 ms    1/81378 (0.0012%)
```

Bibliography

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simple usage of tcpdump
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