- In chapter 9: do not consider slides from 37 to 96, so do not consider
  - MIB Engineering
  - NMS design

Chapter 9

Network Management Tools, Systems, and Engineering

Basic Network Software Tools

- Status monitoring tools
- Traffic monitoring tools
- Route monitoring tools

Notes

- Basic tools are available as
  - Part of the Operating System
  - Add-on applications

Status Monitoring Tools

Table 9.1 Status-Monitoring Tools

NAME	OS	DESCRIPTION
Ifconfig	UNIX	Obtains and configures networking interface parameters and status
ping	UNIX Windows	Checks the status of node / host
nslook-up	UNIX Windows	Looks up DNS for name-IP address translation
dig	UNIX	Queries DNS server
host	UNIX	Displays information on Internet hosts / domains

ifConfig

- Used to assign/read an address to/of an interface
- Option -a is to display all interfaces
- Notice two interface loop-back (lo0) and Ethernet (hme0)

Notes

netman: ifconfig –a

Example:

```
lo0: flags=849<UP,LOOPBACK,RUNNING,MULTICAST> mtu 8232
        inet 127.0.0.1 netmask ff000000

hme0: flags=863<UP,BROADCAST,NOTRAILERS,RUNNING,
      MULTICAST> mtu 1500 inet 192.207.8.31 netmask ffffff00
      broadcast 192.207.8.255
```

Ping

- Most basic tool for internet management
- Based on ICMP ECHO_REQUEST message
- Available on all TCP/IP stacks
- Useful for measuring connectivity
- Useful for measuring packet loss
- Can do autodiscovery of TCP/IP equipped stations on single segment

Notes

Example:

```
% ping 205.152.8.138
PING 205.152.8.138 (205.152.8.138): 56 data bytes
64 bytes from 205.152.8.138: icmp_seq=0 ttl=17 time=14.8 ms
64 bytes from 205.152.8.138: icmp_seq=1 ttl=17 time=20.2 ms
64 bytes from 205.152.8.138: icmp_seq=2 ttl=17 time=15.7 ms
64 bytes from 205.152.8.138: icmp_seq=3 ttl=17 time=21.6 ms
64 bytes from 205.152.8.138: icmp_seq=4 ttl=17 time=20.0 ms

--- 205.152.8.138 ping statistics ---
5 packets transmitted, 5 packets received, 0% packet loss
round-trip min/avg/max = 14.8/18.4/21.6 ms
```

nslookup

- An interactive program for querying Internet Domain Name System servers
- Converts a hostname into an IP address and vice versa querying DNS
- Useful to identify the subnet a host or node belongs to
- Lists contents of a domain, displaying DNS record
- Available with BSD UNIX; FTP from uunet.uu.net
- Available in Windows NT

Notes

Example:

noc2% nslookup 172.152.8.138
Server: ada.btc.gatech.edu
Address: 192.77.147.28

Name: mani.bellsouth.net
Address: 172.152.8.138

Domain Name Groper: dig

Used to gather lots of information on hosts from DNS

Notes

Example:

```
[beluga]~> dig +nocomments nimbus.tenet.res.in
nimbus.tenet.res.in. 604800    IN          A      203.199.255.4
tenet.res.in.        604800    IN          NS     volcano.tenet.res.in.
tenet.res.in.        604800    IN          NS     lantana.tenet.res.in.
volcano.tenet.res.in.604800    IN          A      203.199.255.3
;; Query time: 2 msec
;; SERVER: 203.199.255.3#53(203.199.255.3)
;; WHEN: Fri Mar  6 14:12:43 2009
;; MSG SIZE  rcvd: 149
[beluga]~>
```

Host

- Command: host
- Displays host names using DNS
- Available from ftp.nikhef.nl:/pub/network/host.tar.Z

Notes

Example:

```
% host -a sun4-gw.cc.gatech.edu
Trying null domain
rcode = 0 (Success), ancount=1
The following answer is not authoritative:
sun4-gw.cc.gatech.edu   85851 IN  A  130.207.111.100
```

Traffic Monitoring Tools

Table 9.2 Traffic-Monitoring Tools

Name	Operating System	Description
ping	UNIX / Windows	Used for measuring roundtrip packet loss
bing	UNIX	Measures point-to-point bandwidth of a link
tcpdump	UNIX	Dumps traffic on a network
getethers	UNIX	Acquires all host addresses of an Ethernet LAN segment
iptrace	UNIX	Measures performance of gateways
ethereal, wireshark	Linux / Windows	Graphical tool to capture, inspect , and to save Ethernet packets

Notes

- *ping* and *bing* used to measure the propagation characteristics of the transmission path
- *ethereal* (a.k.a. *wireshark*), and *tcpdump* (also *snoop)* puts the network interface in promiscuous mode and logs the data
- *iptrace* uses NETMON program in UNIX and produces 3 types of outputs:
  - IP traffic
  - Host traffic
  - Abbreviated sampling of pre-defined number of packets

Packet Loss Measurement

- Command: ping
- Many options available
- Implementation varies from system to system

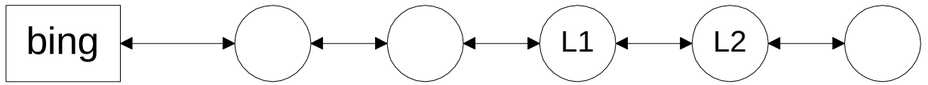
Notes

Example:

```
netman: ping -s mit.edu
PING mit.edu: 56 data bytes
64 bytes from MIT.MIT.EDU (18.72.0.100): icmp_seq=0. time=42. ms
64 bytes from MIT.MIT.EDU (18.72.0.100): icmp_seq=1. time=41. ms
64 bytes from MIT.MIT.EDU (18.72.0.100): icmp_seq=2. time=41. ms
64 bytes from MIT.MIT.EDU (18.72.0.100): icmp_seq=3. time=40. ms
64 bytes from MIT.MIT.EDU (18.72.0.100): icmp_seq=4. time=40. ms

----mit.edu PING Statistics----
5 packets transmitted, 5 packets received, 0% packet loss
round-trip (ms)  min/avg/max = 40/40/42
```

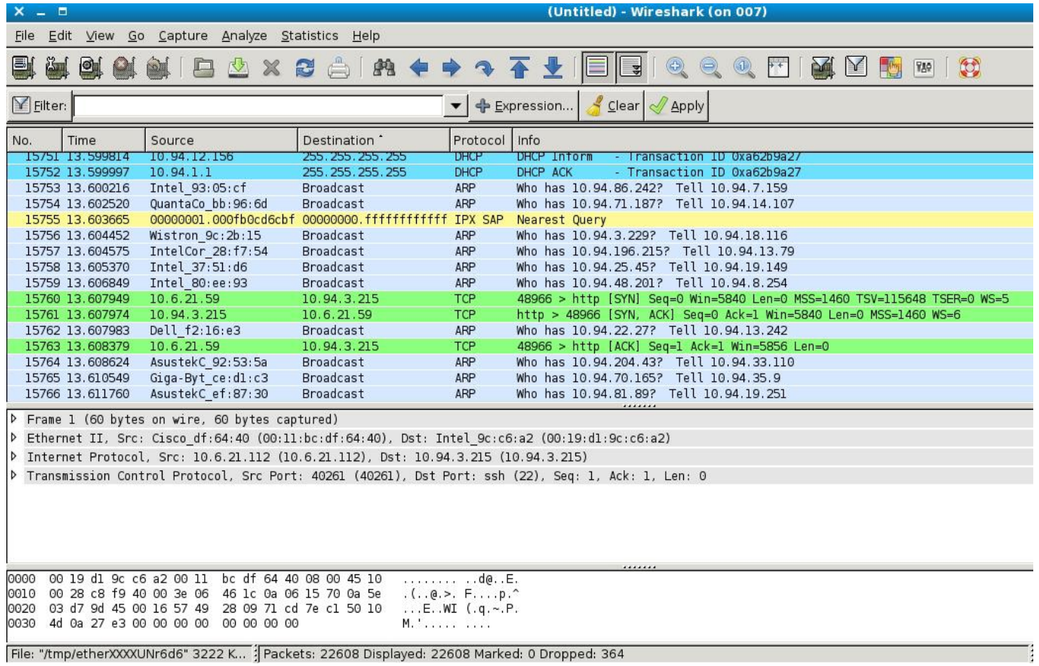
bing



- Used to determine throughput of a link
- Uses icmp_echo utility
- Knowing packet size and delay, calculates bandwidth
- bing L1 and L2 and the difference yields the bandwidth of link L1-L2
- Bandwidth of link L1-L2 could be higher than the intermediate links.

Notes

Ethereal (Wireshark)



Notes

snoop

- Puts a network interface in promiscuous mode
- Logs data on
  - Protocol type
  - Length
  - Source address
  - Destination address
  - Reading of user data limited to superuser

Notes

Example: Options: -d for device interface and -c for counts

```
root@noc2:~# snoop -d hme0 -c 5
Using device /dev/hme (promiscuous mode)
noc2.btc.gatech.edu -> noc4.btc.gatech.edu TCP D=22 S=1221
Ack=2845521735 Seq=24552727 Len=0 Win=7368
        ? -> (multicast)  ETHER Type=809B (EtherTalk (AppleTalk over
Ethernet)), size = 80 bytes
        ? -> (multicast)  ETHER Type=809B (EtherTalk (AppleTalk over
Ethernet)), size = 86 bytes
noc2.btc.gatech.edu -> 199.77.147.255 UDP D=137 S=137 LEN=108
noc2.btc.gatech.edu -> 199.77.147.255 UDP D=137 S=137 LEN=108
noc2.btc.gatech.edu -> 199.77.147.255 UDP D=137 S=137 LEN=108
noc2.btc.gatech.edu -> 199.77.147.255 UDP D=137 S=137 LEN=108
        ? -> (broadcast)  ETHER Type=8137 (Novell (old) NetWare IPX), size =
88 noc4.btc.gatech.edu -> noc2.btc.gatech.edu TCP D=1221 S=22
Ack=24552727 Seq=2845521735 Len=64 Win=8760
noc2.btc.gatech.edu -> noc4.btc.gatech.edu TCP D=22 S=1221
Ack=2845521799 Seq=24552727 Len=0 Win=7304
noc4.btc.gatech.edu -> noc2.btc.gatech.edu TCP D=1221 S=22
Ack=24552727 Seq=2845521799 Len=56 Win=8760
snoop: 5 packets captured
```

tcpdump

- Command: tcpdump
- Interprets and prints headers for:

Ethernet	IP	ICMP
TCP	UDP	NFS
ND	ARP	Appletalk

- Useful for examining and evaluating the TCP based traffic
- Available in UNIX system; FTP from ftp.ee.lbl.gov

Notes

Example: SNMP message

```
14:03:36.798269 noc1.btc.gatech.edu.snmp > noc3.btc.gatech.edu.164:
Community = public
GetResponse(196)
Request ID = 4
system.sysDescr.0 = "SunOS noc1 5.5.1 Generic_103640-08 sun4u"
system.sysObjectID.0 = E:hp.2.3.10.1.2
system.sysUpTime.0 = 247396453
system.sysContact.0 = "Brandon Rhodes"
system.sysName.0 = "noc1"
system.sysLocation.0 = "BTC NM Lab"
system.sysServices.0 = 72
```

Figure 5.17(b) Get-Response Message from Agent-to-Manager (After)

Network Routing *Tools*

Table 9.3 Route-Monitoring Tools

Name	Operating System	Description
netstat	UNIX	Displays the contents of various network-related data structures
arp rarp	UNIX, Windows 9x/00/NT	Displays and modifies the Internet-to-Ethernet address translation tables
traceroute tracert	UNIX Windows	Traces route to a destination with routing delays

Notes

Network Status

netstat -r
Routing tables

Internet:

Destination	Gateway	Flags	Refs	Use	Netif	Expire
Default	gw.litech.net	UGC	44	541550	de0	
172.16.15.1	gw.litech.net	UGH	0	0	de0	
ah.litech.net	0:80:48:ee:74:b4	UHLW	9	2653683	de0	202
uucp.litech.net	uucp.litech.net	UH	0	0	lo0	
sip-17.litech.net	big	UH	0	5551	ppp3	
dip-244.litech.net	gw.litech.net	UGH	0	2472	de0	
univers-litech-gw	gw.litech.net	UGH	0	47	de0	
194.44.232	gw.isr.lviv.ua	Ugc	0	171831	ppp9	
OSPF-ALL.MCAST.NET	localhost	UH	1	86491	lo0	
OSPF-DSIG.MCAST.NE	localhost	UH	1	25127	lo0	

Figure 9.5 Routing Table using netstat -r

Notes

Route Tracing

- Command: traceroute (UNIX) / tracert (MS TIME-EXCEED error report
- Available in most UNIX OS
- Windows)
- ICMP Also available from uc.msc.unm.edu
- Discovers route taken by packets from source to destination
- Useful for diagnosing route failures
- Useful for detecting bottleneck nodes

Notes

Trace Route Sample 1

```
Tracing route to mani.btc.gatech.edu [199.77.147.96]
over a maximum of 30 hops:

 1    2 ms    3 ms    3 ms  bims008001.bims.bellsouth.net [205.152.8.1]
 2    4 ms    2 ms    3 ms  172.16.11.2
 3    5 ms    4 ms    3 ms  172.16.4.2
 4    5 ms    3 ms    3 ms  bims011033.bims.bellsouth.net [205.152.11.33]
 5    4 ms    4 ms    4 ms  205.152.13.98
 6    *       *       *     Request timed out
 7    5 ms    9 ms  12 ms  205.152.2.249
 8   33 ms  31 ms  31 ms  Hssi0-0-0.GW2.ATL1.ALTER.NET [157.130.65.229]
 9   68 ms  10 ms  11 ms  105.ATM3-0-0.XR1.ATL1.ALTER.NET [146.188.232.66]
10  11 ms  14 ms  12 ms  195.ATM12-0-0.BR1.ATL1.ALTER.NET [146.188.232.49]
11  16 ms  14 ms  14 ms  atlanta1-br1.bbnplanet.net [4.0.2.141]
12  19 ms  15 ms  17 ms  atlanta2-br2.bbnplanet.net [4.0.2.158]
13  21 ms  56 ms  328 ms  atlanta2-cr99.bbnplanet.net [4.0.2.91]
14  17 ms  18 ms   17 ms  192.221.26.3
15  32 ms  20 ms   18 ms  130.207.251.3
16  20 ms  17 ms   17 ms  mani.btc.gatech.edu [199.77.147.96]

Trace complete
```

Notes

Trace Route Sample 2

Tracing route to mani.btc.gatech.edu [199.77.147.96]
over a maximum of 30 hops:

1	3 ms	3 ms	4 ms	bims008001.bims.bellsouth.net [205.152.8.1]
2	3 ms	3 ms	2 ms	172.16.11.2
3	5 ms	4 ms	4 ms	172.16.4.2
4	5 ms	3 ms	4 ms	bims011033.bims.bellsouth.net [205.152.11.33]
5	7 ms	4 ms	4 ms	205.152.13.98
6	*	*	*	Request timed out
7	9 ms	8 ms	9 ms	205.152.2.249
8	228 ms	214 ms	191 ms	206.80.168.9
9	230 ms	246 ms	234 ms	maeeast.bbnplanet.net [192.41.177.2]
10	243 ms	222 ms	212 ms	vienna1-nbr2.bbnplanet.net [4.0.1.93]
11	230 ms	213 ms	202 ms	vienna1-nbr3.bbnplanet.net [4.0.5.46]
12	247 ms	227 ms	236 ms	vienna1-br2.bbnplanet.net [4.0.3.149]
13	228 ms	235 ms	238 ms	atlanta1-br1.bbnplanet.net [4.0.2.58]
14	*	257 ms	238 ms	atlanta2-br2.bbnplanet.net [4.0.2.158]
15	225 ms	234 ms	233 ms	atlanta2-cr99.bbnplanet.net [4.0.2.91]
16	240 ms	229 ms	251 ms	192.221.26.3
17	235 ms	245 ms	225 ms	130.207.251.3
18	*	268 ms	243 ms	mani.btc.gatech.edu [199.77.147.96]

Trace complete

Notes

SNMP Tools

- SNMP command-line tools
- SNMP MIB Browser with graphical interface
- snmpsniff: Linux/Free BSD based tool. Reads PDUs

Notes

- Many tools available on public domain.

SNMP Command Tools

- snmptest
- snmpget
- snmpgetnext
- snmpset
- snmptrap
- snmpwalk
- snmpnetstat

Notes

- Test tool is an interactive tool to get values of several managed objects, one at a time.
- Get, Get-next and Set are the SNMP commands that we learned under SNMP architecture / messages. Execution of these will return an SNMP Response message.
- SNMPWalk uses snmpgetnext to trace the entire MIB.
- Network status command is used to test the status of network connections of a host.

SNMP Get Command

```
% snmpget noc5.btc.gatech.edu public system.sysDescr.0

system.sysDescr.0 = OCTET STRING: "SunOS noc5 5.6 Generic_105181-03 sun4u"
```

Notes

- Note that the value 0 at the end of the object id indicates that it is a single-valued scalar.

SNMP Get Next Command

```
% snmpgetnext noc5.btc.gatech.edu public interfaces.ifTable.ifEntry.ifIndex.1

interfaces.ifTable.ifEntry.ifIndex. 2 = INTEGER: 2
```

Notes
Snmpget host community OID

SNMP Set Command

- Command: snmpset host community

Notes

Network Status

- Command: snmpnetstat host community
- Useful for finding status of network connections

% snmpnetstat noc5 public

Active Internet Connections

Proto	Recv-Q	Send-Q	Local Address	Foreign Address	(state)
tcp	0	0	*.*	*.*	CLOSED
tcp	0	0	localhost.46626	localhost.3456	ESTABLISHED
tcp	0	0	localhost.46626	localhost.3712	ESTABLISHED
tcp	0	0	localhost.46626	localhost.3968	ESTABLISHED
tcp	0	0	localhost.46626	localhost.4224	ESTABLISHED
tcp	0	0	localhost.3456	localhost.46626	ESTABLISHED
tcp	0	0	localhost.3712	localhost.46626	ESTABLISHED
tcp	0	0	localhost.3968	localhost.46626	ESTABLISHED
tcp	0	0	localhost.4224	localhost.46626	ESTABLISHED
tcp	0	0	noc5.41472	noc5.4480	ESTABLISHED
tcp	0	0	noc5.41472	noc5.4736	ESTABLISHED
tcp	0	0	noc5.4480	noc5.41472	ESTABLISHED
tcp	0	0	noc5.4736	noc5.41472	ESTABLISHED

Notes

SNMP Browser

- Command: snmpwalk host community [variable name]
- Uses Get Next Command
- Presents MIB Tree

Notes

199.77.147.182:

sysDescr.0 : SunOS noc5 5.6 Generic_105181-03 sun4u
sysObjectID.0 : 1.3.6.1.4.1.11.2.3.10.1.2
sysUpTime.0 : 8d 22:21:53.74
sysContact.0 :
sysName.0 : noc5
sysLocation.0 :
sysServices.0 : 72
sysORLastChange.0 : 0d 0:00:00.00

Figure 9.8 MIB Browser Example (text based) for System Group

SNMP Sniff

- *snmpsniff -I interface*
- A tool in Linux / FreeBSD environment
- Puts the interface in **promiscuous mode** and captures snmp PDUs.
- Similar to *tcpdump*

Protocol Analyzer

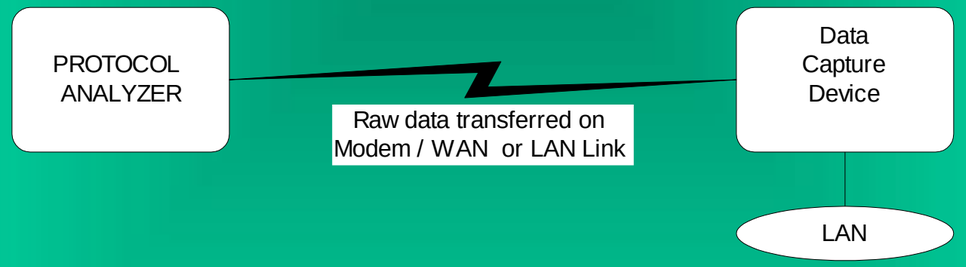


Figure 9.9 Basic Configuration of a Protocol Analyzer

Notes

- Analyzes data packets on any transmission line including LAN
- Measurements made locally or remotely
- Probe (data capture device) captures data and transfers to the protocol analyzer (no storage)
- Data link between probe and protocol analyzer either dial-up or dedicated link or LAN
- Protocol analyzer analyzes data at all protocol levels

RMON Probe

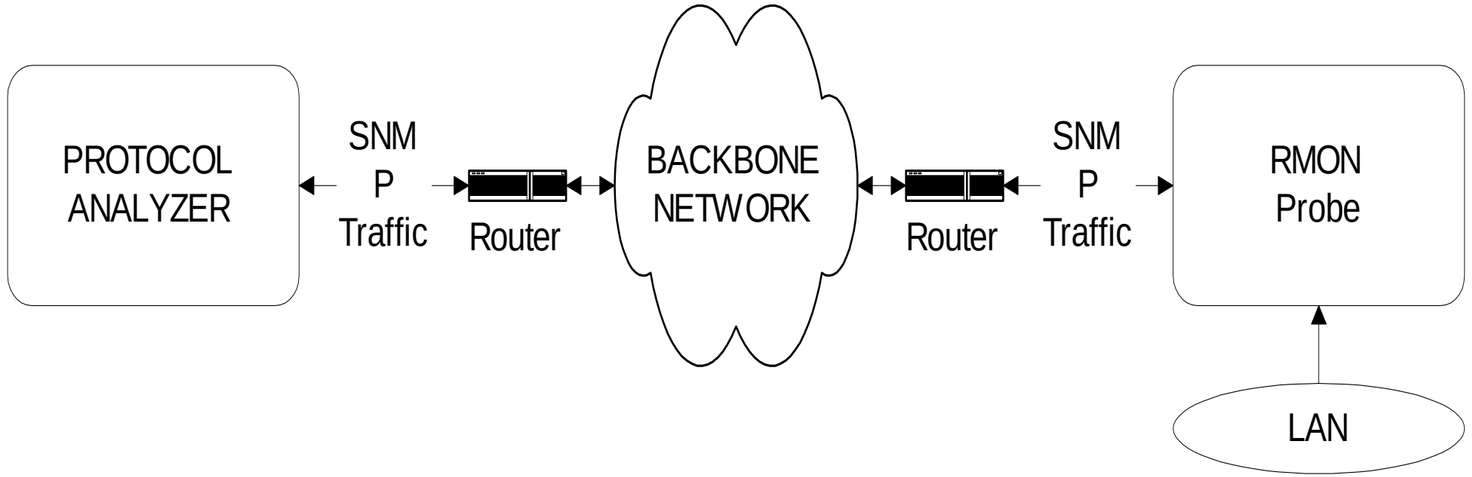


Figure 9.10 Protocol Analyzer with RMON Probe

Notes

- Network Associates Sniffer
  - Stand-alone and Networked
- HP NetMetrix / HP OpenView
  - Communication between probe and analyzer is using SNMP
- Data gathered and stored for an extended period of time and analyzed later

- Used for gathering traffic statistics and used for configuration management for performance tuning

Network Monitoring with RMON Probe

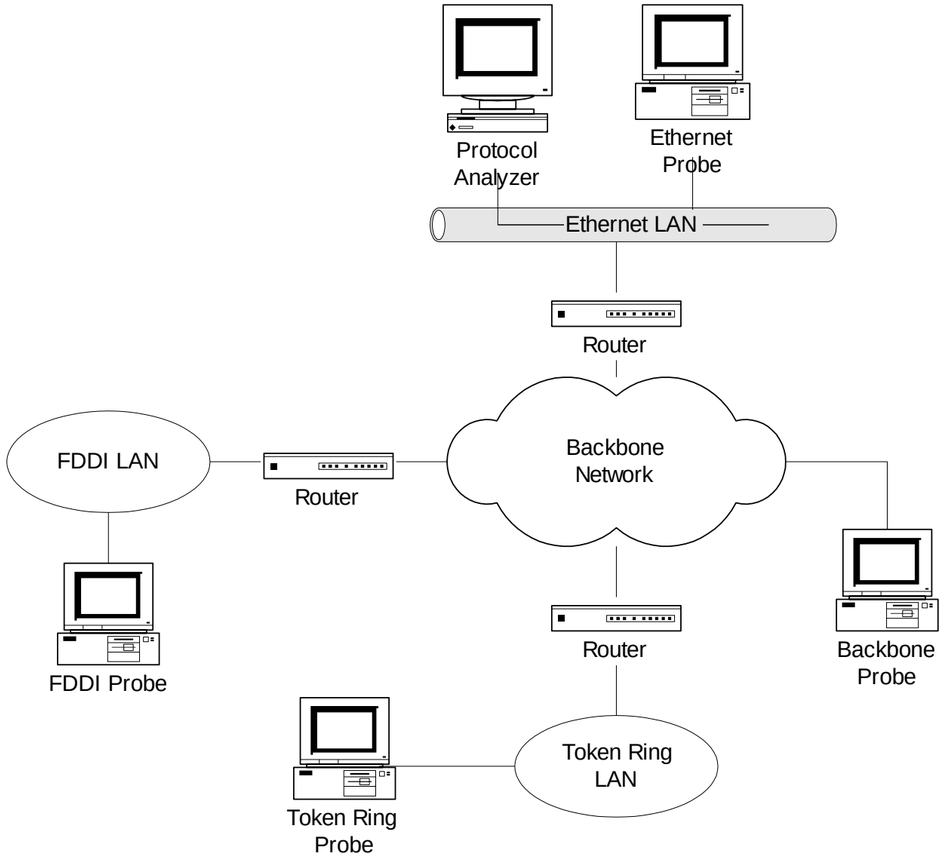


Figure 9.11 Monitoring of Total Network with Individual RMON Probes

Network Statistics

- Protocol Analyzers
- RMON Probe / Protocol analyzer
- MRTG (Multi router traffic grouper)
- Home-grown program using *tcpdump*

Notes

Traffic Load: Source

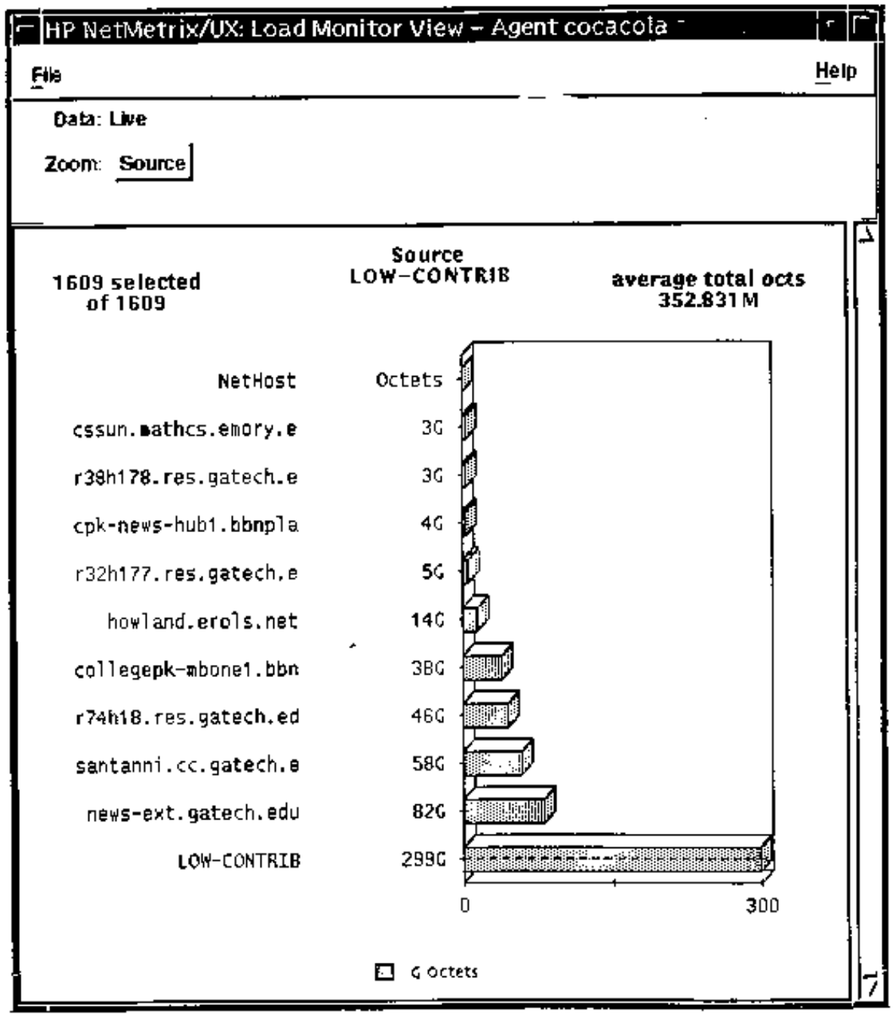


Figure 9.12 Load Statistics: Monitoring of Sources

Traffic Load: Destination

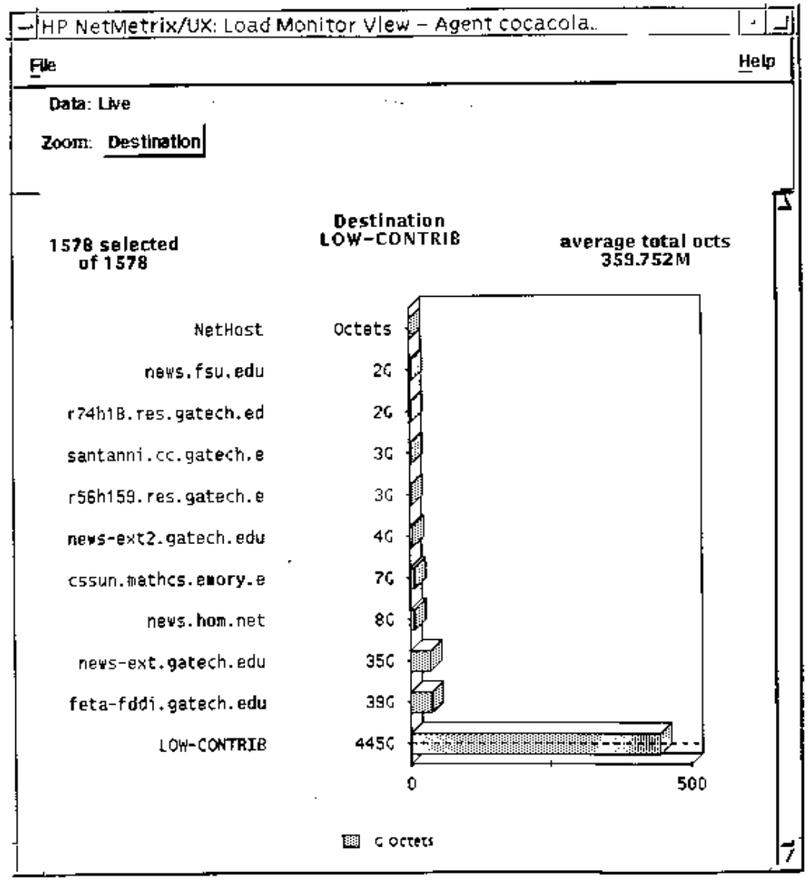


Figure 9.13 Load Statistics: Monitoring of Destinations

Traffic Load: Conversation

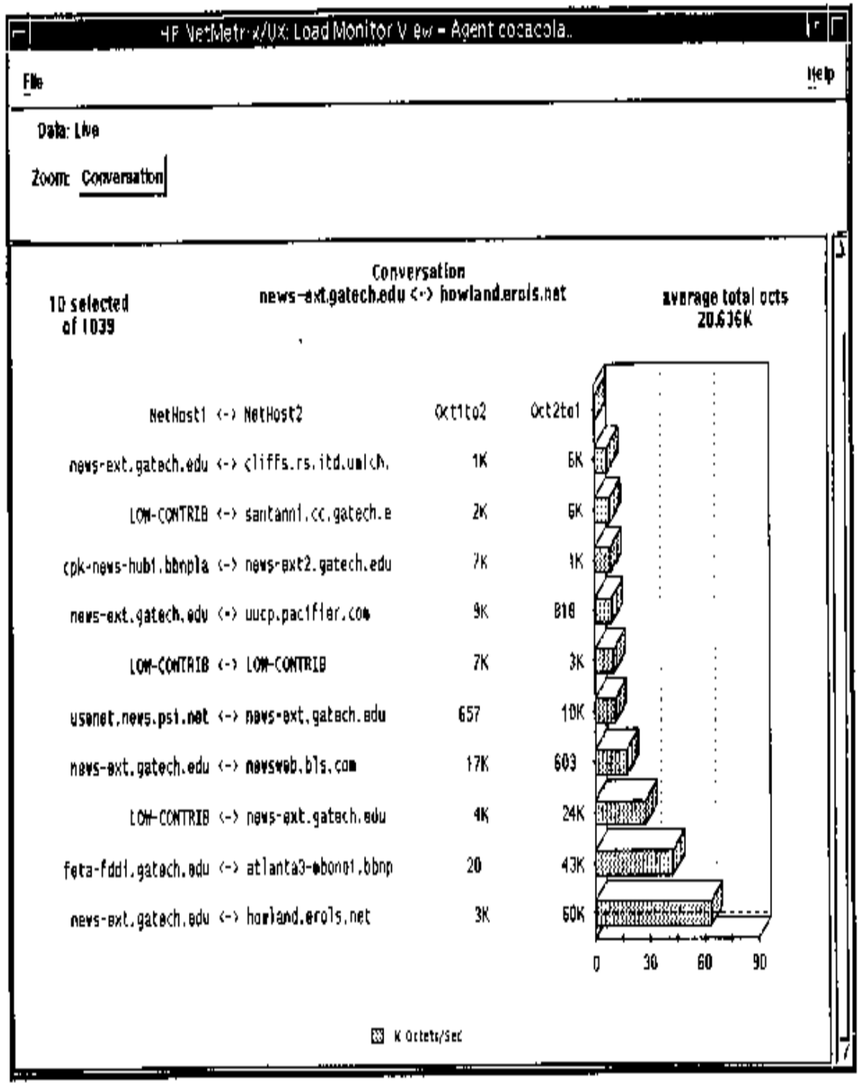


Figure 9.14 Load Statistics: Monitoring of Conversation Pairs

Protocol Distribution

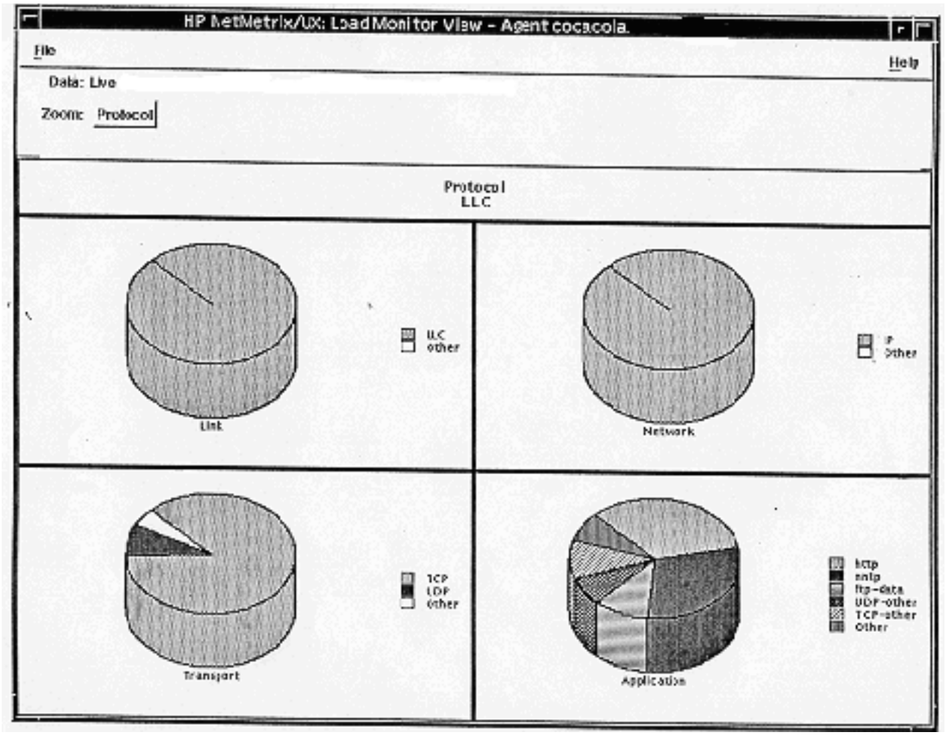


Figure 9.15 Protocol Distribution (NetMetrix)

MRTG

- Multi Router Traffic Grouper (Oeticker and Rand)
- www.ee.ethz.ch/stats/mrtg/
- Generates graphic presentation of traffic on Web
  - Daily view
  - Weekly view
  - Monthly view
  - Yearly view

Notes

MIB Engineering

- In chapter 9: do not consider slides from 37 to 96, so do not consider
  - MIB Engineering
  - NMS design