



August 9<sup>th</sup> 2011, OSG Site Admin Workshop  
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# Performance Measurement Tools

# Agenda

- Tutorial Agenda:
  - Network Performance Primer - Why Should We Care? **(30 Mins)**
  - **Introduction to Measurement Tools (20 Mins)**
  - Use of NTP for network measurements **(15 Mins)**
  - Use of the BWCTL Server and Client **(25 Mins)**
  - Use of the OWAMP Server and Client **(25 Mins)**
  - Use of the NDT Server and Client **(25 Mins)**
  - perfSONAR Topics **(30 Mins)**
  - Diagnostics vs Regular Monitoring **(20 Mins)**
  - Use Cases **(30 Mins)**
  - Exercises

# Basic Premise

- Use of the network should meet user expectations.
  - See Examples from earlier
  - When things don't look right, time to explore 'why'
- If they don't, user has the right to complain!
  - Will you listen? ☺
  - Learn how to complain effectively
    - Produce results
    - Isolate problem
  - 'The network is slow' is not how to complain effectively

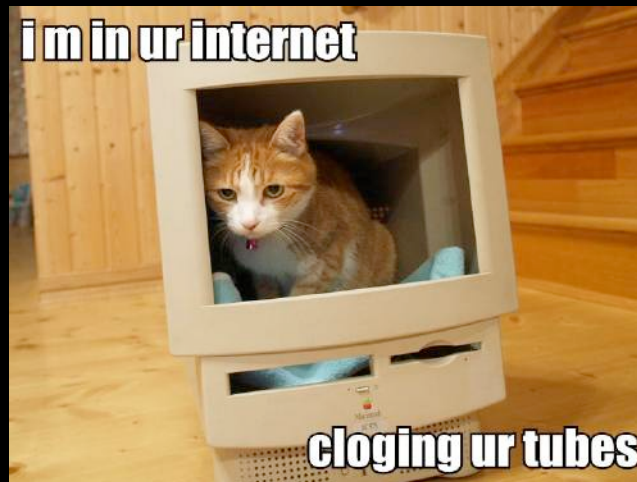
# Underlying Assumption

- When problems exist, it's the networks fault!
  - Easy to blame a resource, but where else could a problem be when transferring large data sets?
    - Host (Disk, CPU, Kernel, NIC Drivers)
    - Network Interface Cards
    - Routers/Switches, Routing and Configuration
    - Physical Infrastructure
    - Protocols
- The network is viewed as a single resource in many cases
  - Reality – complex series of components
  - Multiple vendors/technologies
  - Multiple configuration options
  - Crossing administrative domains

# Network View (Layman's Terms)

Bob's  
Host

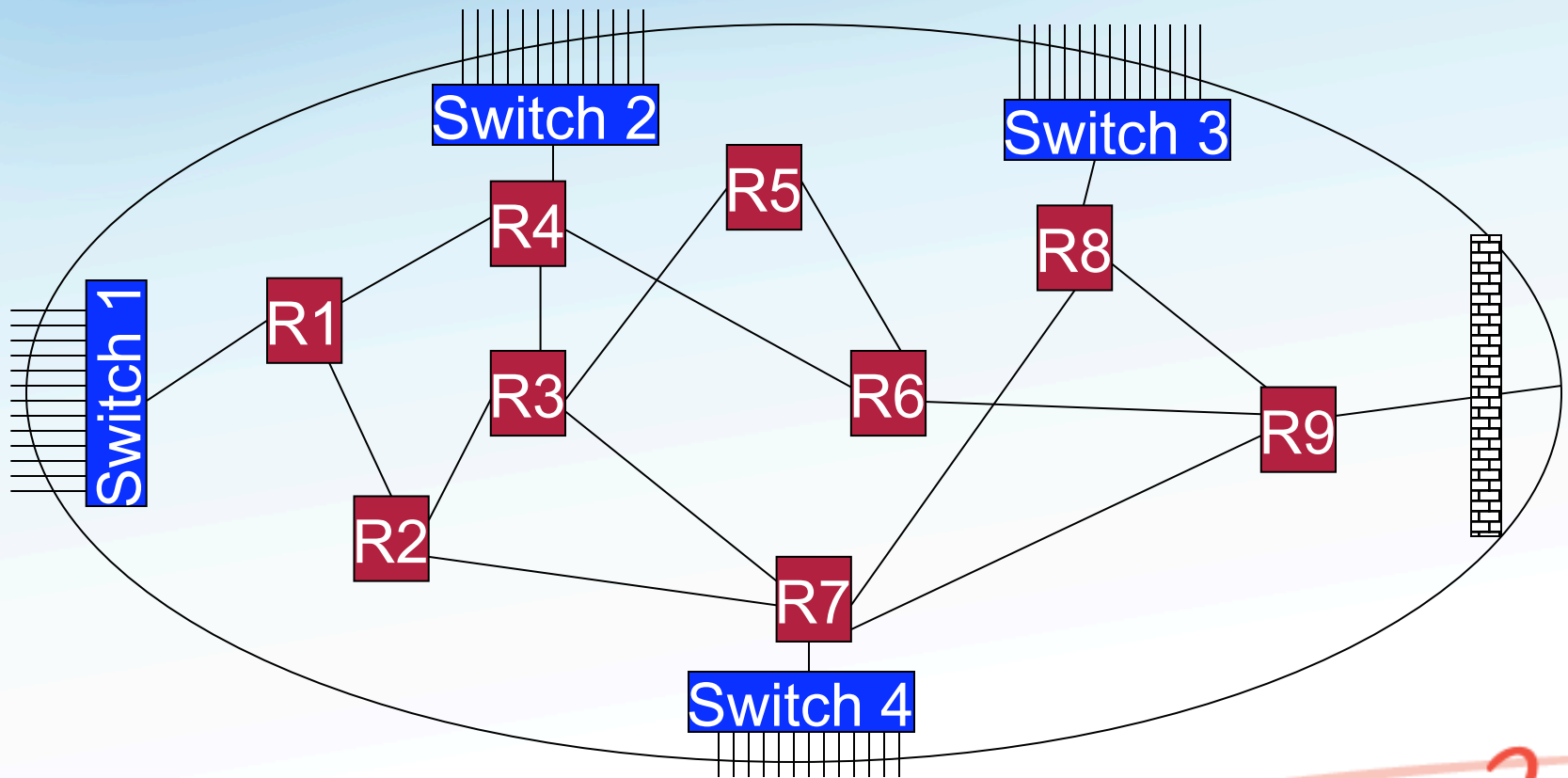
"The Internets"



Carol's  
Host

INTERNET  
2

# Network View (Actual)



# Addressing a Performance Discrepancy

- What are the first steps to address problems related to network performance?
  - Try a Tool
- What tools are out there
  - Numerous
  - Different metrics (measurements) available
  - How to interpret the results?

# Tools, Tools, Tools

- Ping
- Traceroute
- Iperf
- Tcpdump
- Tcptrace
- BWCTL
- NDT
- OWAMP
- AMP
- Advisor
- Thrulay
- Web100
- MonaLisa
- pathchar
- NPAD
- Pathdiag
- Surveyor
- Ethereal
- CoralReef
- MRTG
- Skitter
- Cflowd
- Cricket
- Net100
- Pathload
- Pathchrip
- MRTG
- Cacti
- Smokeping
- PingER
- FDT
- perfSONAR
- Nagios
- Ganglia
- Thurlay
- Etc. etc. etc.



# Highlighting some Interesting Tools

- Focus on 3 Types of tools (for now)
  - Basic Diagnostics
    - Ping, Traceroute
  - Advanced User Tools
    - NDT
  - Network Admin Focused
    - OWAMP, BWCTL
- What about the others?
  - Try them out, learn how they work.
  - Most tools are designed to solve a specific problem and they may add value to your organization
- Integration of multiple solutions
  - Measurement frameworks integrate use of tools (operation, collecting results) along with analysis and presentation
  - perfSONAR

# Basic Diagnostic Tools

- Ping
  - Round Trip (e.g. source to destination, and back)
  - Confirms that remote host is ‘up’
  - Some network operators block these packets
    - Play w/ command options to see if that will change anything
- Traceroute
  - Identifies the routers along the path
  - Same blocking problem as above
  - Routers treat TR packets with lower priority
    - See presentation from prior JTs:
    - <http://www.internet2.edu/presentations/jt2009jul/20090722-litvanyi.pdf>

# Ping Output

```
zurawski@latrobe:~ — ssh — ttys001 — 85x25
[zurawski@latrobe ~]$ ping -c 4 packrat.internet2.edu
PING packrat.internet2.edu (207.75.164.10) 56(84) bytes of data:
64 bytes from packrat.internet2.edu (207.75.164.10): icmp_seq=1 ttl=57 time=16.2 ms
64 bytes from packrat.internet2.edu (207.75.164.10): icmp_seq=2 ttl=57 time=16.4 ms
64 bytes from packrat.internet2.edu (207.75.164.10): icmp_seq=3 ttl=57 time=16.5 ms
64 bytes from packrat.internet2.edu (207.75.164.10): icmp_seq=4 ttl=57 time=16.4 ms

--- packrat.internet2.edu ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 3000ms
rtt min/avg/max/mdev = 16.225/16.423/16.594/0.204 ms
[zurawski@latrobe ~]$
```

# Ping Output

- Intro message
  - Identifies remote host name and IP address
  - States size of packets being sent
    - Setting larger sizes may reveal hidden problems
- Output lines
  - Who responded, and the RTT, maybe other details
- Summary lines
  - Number of packets sent/received/lost
  - RTT statistics min/average/max

N.B. 1 msec RTT = ~50 miles of between hosts

# Traceroute Output

```
zurawski@latrobe:~ — ssh — ttys001 — 88x24

[zurawski@latrobe ~]$ traceroute packrat.internet2.edu
traceroute to packrat.internet2.edu (207.75.164.10), 30 hops max, 40 byte packets
 1  192.52.179.1 (192.52.179.1)  0.445 ms  0.427 ms  0.388 ms
 2  clpk-ucaid-gige.maxgigapop.net (206.196.177.29)  1.772 ms  1.737 ms  1.737 ms
 3  xe-7-2-0-0.lvl3-t640.maxgigapop.net (206.196.178.90)  2.954 ms  2.969 ms  2.936 ms
 4  i2-lvl3.maxgigapop.net (206.196.178.46)  2.841 ms  2.812 ms  2.918 ms
 5  xe-0-1-0x1004.wsu5.mich.net (192.122.183.9)  14.723 ms  14.567 ms  14.623 ms
 6  tenge0-0-0-0x22.aa2.mich.net (198.108.23.49)  16.617 ms tenge0-0-0-0x76.aa2.mich.net
   (198.108.23.10)  16.617 ms tenge0-0-0-0x22.aa2.mich.net (198.108.23.49)  16.724 ms
 7  mam-77.merit.edu (192.122.200.77)  16.492 ms  16.497 ms  16.603 ms
 8  packrat.internet2.edu (207.75.164.10)  16.324 ms  16.292 ms  16.282 ms
[zurawski@latrobe ~]$ _
```

# Traceroute Output

- Intro messages
  - Name and address of remote host
  - Maximum number of link before giving up
- Status messages
  - One line per router in path
  - ‘\*’ indicates router didn’t respond
  - Routers usually rate limit replies
  - No name indicates DNS entry is missing
  - Hops required to reach remote host or max number from above

# Advanced User Tool - NDT

- NDT = Network Diagnostics Tool
- Measure performance to users desktop
- Identify real problems for real users
  - Network infrastructure could be the problem
  - Host tuning issues could be the problem
- Make tool simple to use and understand
  - Presentation in a method almost all users can access: web browser
- Make tool useful for users and network administrators
  - Variables for many aspects of host, protocol, and network performance

# NDT User Interface

- Web-based JAVA applet allows testing from any browser
  - One Click testing
  - Option to dig deep into available results
  - Send report of results to network administrators
- Command-line client allows testing from remote login shell
  - Same options available
  - Client software can be build independent of server software



# NDT Results

The screenshot shows a web browser window with the address bar displaying `http://207.75.164.80:7123/`. The page content includes a "Getting Started" section with a "Latest Headlines" link. The main text describes the NDT tool's purpose and lists the tests it performs:

- The slowest link in the end-to-end path (Dial-up modem to 10 Gbps Ethernet/OC-192)
- The Ethernet duplex setting (full or half);
- If congestion is limiting end-to-end throughput.

It also identifies two serious error conditions:

- Duplex Mismatch
- Excessive packet loss due to faulty cables.

A test takes about 20 seconds. Click on "start" to begin.

The test results are displayed in a text box:

```
TCP/Web100 Network Diagnostic Tool v5.3.4e
click START to begin
Checking for Middleboxes ..... Done
running 10s outbound test (client to server) ..... 360.76Kb/s
running 10s inbound test (server to client) ..... 20.53Mb/s
Warning! Client time-out while reading data, possible duplex mismatch exists
The slowest link in the end-to-end path is a 100 Mbps Full duplex Fast Ethernet subnet
Alarm: Duplex Mismatch condition detected Switch=Full and Host=half

click START to re-test
```

Below the text box are four buttons: "START", "Statistics", "More Details...", and "Report Problem".

The status bar at the bottom of the browser window shows "Tcpbw100 done".

# Finding Results of Interest

- Duplex Mismatch
  - This is a serious error and nothing will work right. Reported on *main* page, on *Statistics* page, and **mismatch:** on *More Details* page
- Packet Arrival Order
  - Inferred value based on TCP operation. Reported on *Statistics* page, (with loss statistics) and **order:** value on *More Details* page
- Packet Loss Rates
  - Calculated value based on TCP operation. Reported on *Statistics* page, (with out-of-order statistics) and **loss:** value on *More Details* page
- Path Bottleneck Capacity
  - Measured value based on TCP operation. Reported on *main* page

# Network Administration Tools

- BWCTL – Bandwidth Control
  - Allows single person operation over wide area testing environment
  - Runs NLANR ‘iperf’ program
    - Support for Thrulay, nuttcp
- OWAMP – One way Delay Measurement
  - Advanced ‘ping’ command
    - One way vs round trip
  - Allows single person operation over wide area testing environment

# BWCTL Sample Results

```
nmsx.internet2 - SecureCRT
File Edit View Options Transfer Script Tools Window Help
[rcarlson@nmsx-aami rcarlson]$ bwctl -L90 -i2 -t20 -w8388608 -A AE AESKEY rcarlson .aeskey
-s nms1-sttl.abilene.ucaid.edu -c nms1-ipls.abilene.ucaid.edu
bwctl: 107 seconds until test results available
RECEIVER START
3349536592.521172: /ami/bin/iperf -B 198.32.8.174 -P 1 -s -f b -m -p 5002 -w 8388608 -t 20
-i 2
-----
Server listening on TCP port 5002
Binding to local address 198.32.8.174
TCP window size: 16777216 Byte (WARNING: requested 8388608 Byte)
-----
[ 14] local 198.32.8.174 port 5002 connected with 198.32.8.190 port 5002
[ 14] 0.0- 2.0 sec 203240632 Bytes 812962528 bits/sec
[ 14] 2.0- 4.0 sec 247453364 Bytes 989813456 bits/sec
[ 14] 4.0- 6.0 sec 247453276 Bytes 989813104 bits/sec
[ 14] 6.0- 8.0 sec 247392040 Bytes 989568160 bits/sec
[ 14] 8.0-10.0 sec 247454640 Bytes 989818560 bits/sec
[ 14] 10.0-12.0 sec 247451404 Bytes 989805616 bits/sec
[ 14] 12.0-14.0 sec 247447240 Bytes 989788960 bits/sec
[ 14] 14.0-16.0 sec 247459968 Bytes 989839872 bits/sec
[ 14] 16.0-18.0 sec 247445468 Bytes 989781872 bits/sec
[ 14] 18.0-20.0 sec 247453536 Bytes 989814144 bits/sec
[ 14] 0.0-20.0 sec 2435407872 Bytes 972137651 bits/sec
[ 14] MSS size 8948 bytes (MTU 8988 bytes, unknown interface)
RECEIVER END
[rcarlson@nmsx-aami rcarlson]$
```

Ready ssh2: AES-128 26, 32 28 Rows, 90 Cols VT100

# BWCTL Highlights

- You must pre-install BWCTL software package
  - Server/Client required for ends of a test
- Internet2 default permission: TCP test from any member
  - UDP available on request
- Sites can restrict access to ‘known’ remote users
  - Rich set of permissions and limitations

# BWCTL Commands

```
bwctl -L90 -i2 -t20 -c bwctl.losa.net.internet2.edu
```

```
bwctl -L90 -i2 -t20 -s bwctl.newy.net.internet2.edu
```

- Bwctl = name of program
- L90 = wait up to 90 seconds for a test
- i2 = report intermediate results every 2 seconds
- t20 – run test for 20 seconds
- s name = remote end will send data to you
- c name = you will send data to the remote host

# BWCTL 3<sup>rd</sup> Party Testing

```
bwctl -L90 -i2 -t20
```

```
-c bwctl.salt.net.internet2.edu
```

```
-s bwctl.atla.net.internet2.edu
```

- User can run a test between 2 remote hosts



# OWPing Results

```
nmsy.internet2 - SecureCRT
File Edit View Options Transfer Script Tools Window Help

rcarlson@nmsy-aami$ ./owping -F /tmp/from.owamp -T /tmp/to.owamp nms4-ipls.abilene.ucaid.edu
Approximately 12.8 seconds until results available

--- owping statistics from [207.75.164.84]:61960 to [nms4-ipls.abilene.ucaid.edu]:57501 ---
SID: c6200ae4c7a5e3dc5ffc50773bbed85a
100 sent, 0 lost (0.0%), 0 duplicates
one-way delay min/median/max = 5.04/5.1/5.2 ms, (err=5.2 ms)
one-way jitter = 0.1 ms (P95-P50)
Hops = 5 (consistently)
no reordering

--- owping statistics from [nms4-ipls.abilene.ucaid.edu]:63467 to [207.75.164.84]:61887 ---
SID: cf4ba454c7a5e3dc67124c14947f2e5d
100 sent, 0 lost (0.0%), 0 duplicates
one-way delay min/median/max = 5.14/5.2/5.35 ms, (err=5.35 ms)
one-way jitter = 0.1 ms (P95-P50)
Hops = 5 (consistently)
no reordering

rcarlson@nmsy-aami$ ./owstats -a99 /tmp/to.owamp

--- owping statistics from [nmsy-aami-abilene.internet2.edu]:61960 to [nms4-ipls.abilene.ucaid.edu]:57501 ---
SID: c6200ae4c7a5e3dc5ffc50773bbed85a
100 sent, 0 lost (0.0%), 0 duplicates
one-way delay min/median/max = 5.04/5.1/5.2 ms, (err=5.2 ms)
one-way jitter = 0.1 ms (P95-P50)
Percentiles:
    99.0: 5.2 ms
Hops = 5 (consistently)
```



# OWAMP Results

- You must pre-install OWAMP software package
- User program is called ‘owping’
- Internet2 default permissions: basic test from any member
  - Other options (e.g. longer test, more data sent) available on request
- Sites can restrict access to ‘known’ remote users
  - Similar rich set of permissions to BWCTL

# Using OWPing

- `owping owamp.salt.net.internet2.edu`
  - `owping` = program name
  - `owamp...` = name of server
- Output results
  - Separate statistics for both directions
  - Number of packets sent and lost
  - One-way delay statistics min/median/max
  - Number of IP hops in path
  - Number of packets that arrives out-of-order

# Software Availability

- Source Packages (Client and Server)
  - <http://software.internet2.edu/sources/>
  - Typical 'configure/make/make install'
- RPM Installation (CentOS 5.5 Supported):
  - Install our RPM package to enable the Internet2 Repository
  - See instructions here: <http://software.internet2.edu/>
  - Support for YUM and APT-RPM
- pS Performance Toolkit ISO
  - All tools, pre-installed and configured
  - More info: <http://psps.perfsonar.net/toolkit/>
- Others Notes:
  - Other RPM based distros (Fedora/RHEL) may work with packaged RPMs ... YMMV
  - To install on Debian, consider source. Alien conversions of RPMs may be problematic

# Conclusions

- Primary tools still useful
  - Know the tool
- Advanced tools are being developed all the time
- Installation using simple methods (e.g. RPM based package managers)



## **Performance Measurement Tools**

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For more information, visit <http://www.internet2.edu/workshops/npw>