August 10th 2010, OSG Site Admin Workshop - Network Performance

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BWCTL

Agenda

- Tutorial Agenda:
  - Network Performance Primer - Why Should We Care? (**15 Mins**)
  - Getting the Tools (**10 Mins**)
  - Use of the BWCTL Server and Client (**30 Mins**)
  - Use of the OWAMP Server and Client (**30 Mins**)
  - Use of the NDT Server and Client (**30 Mins**)
  - BREAK (**15 mins**)
  - Diagnostics vs Regular Monitoring (**30 Mins**)
  - Network Performance Exercises (**1 hr 30 Mins**)

BWCTL – What is it?

- BWCTL is:
  - A command line client application
  - A scheduling and policy daemon
  - Wraps the throughput testing tools **Iperf**, **Thrulay**, and **Nuttcp**.

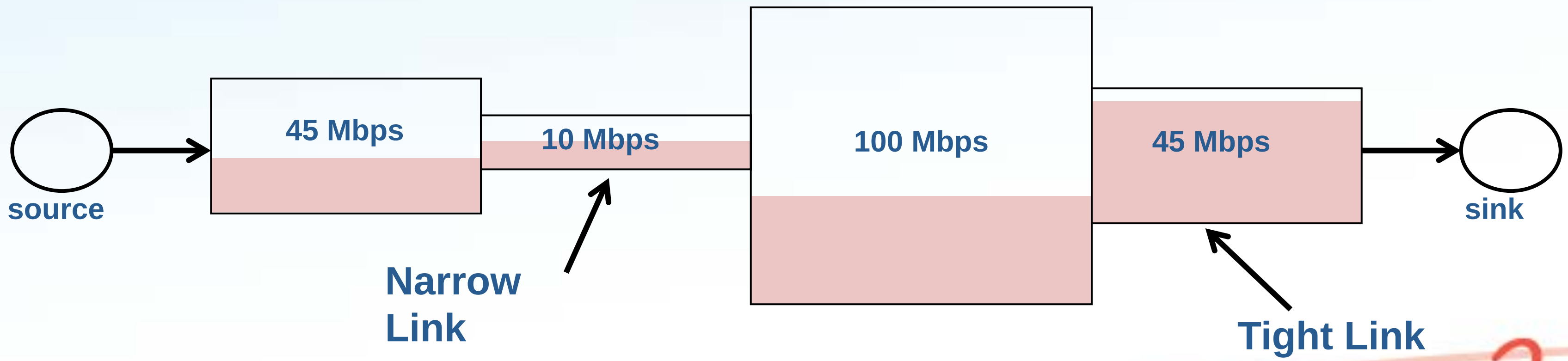
- These tests are able to measure:
  - Maximum TCP bandwidth (with various tuning options available)
  - The delay, jitter, and datagram loss of a network when doing a UDP test

Problem Statement

- Users want to verify available bandwidth/throughput:
  - Between their site and a remote resource
  - Between two remote resources
  - Validate/Verify an SLA
- Methodology:
  - Verify available bandwidth from each endpoint to points in the middle
  - Determine problem area(s)
  - Re-run tests over time – requires access to tool instead of doing a ‘one off’ test

Throughput? Bandwidth? What?

- The term "throughput" is vague
  - Capacity: link speed
    - Narrow Link: link with the lowest capacity along a path
    - Capacity of the end-to-end path = capacity of the narrow link
  - Utilized bandwidth: current traffic load
  - Available bandwidth: capacity – utilized bandwidth
    - Tight Link: link with the least available bandwidth in a path
  - Achievable bandwidth: includes protocol and host issues



(Shaded portion shows background traffic)

Typical Solution

- Run “iperf” or similar tool on two endpoints and hosts on intermediate paths
  - Roadblocks:
    - Need software on all test systems
    - Need permissions on all systems involved (usually full shell accounts*)
    - Need to coordinate testing with others *
    - Need to run software on both sides with specified test parameters *
- Desirable features for an alternate method
  - ‘Daemon’ to run in the background
  - Protocol to exchange results/errors
  - Works with firewalls
  - Protect resources

- (* BWCTL was designed to help with these)

Implementation

- Applications
  - bwctld daemon
  - bwctl client
- Open source license and development
- Built upon protocol abstraction library
  - Supports “one-off” applications, e.g. add in new testers
  - Allows authentication/policy hooks to be incorporated

Server Functionality (bwctld)

- bwctl client application makes requests to both endpoints of a test
  - Communication can be "open", "authenticated", or "encrypted" (encrypted reserved for future use)
  - Requests include a request for a ***time slot*** as well as a full parameterization of the test
  - "Third party" requests – run a test on two distributed hosts
  - If no server is available on the localhost, client handles test endpoint
  - *Mostly* the same command line options as testers (e.g. iperf, nuttcp – read the help or man pages to be sure…)

Server Functionality (bwctld)

- bwctld on each test host
  - Accepts requests for “iperf” tests including time slot and parameters for test
  - Responds with a tentative reservation or a denied message
  - Reservations by a client must be confirmed with a “start session” message
  - Acts as the “Resource Broker”
  - Runs the test
  - Both “sides” of test get results

TCP Measurements

- Measures TCP Achievable Bandwidth
  - Measurement includes the end system
  - Sometimes called “memory-to-memory” tests
  - Set expectations for well coded application
- Limits of what we can measure
  - TCP ***hides*** details
  - In hiding the details it can obscure what is causing errors
- Many things can limit TCP throughput
  - Loss
  - Congestion
  - Buffer Starvation
  - Out of order delivery

TCP Performance: Window Size

- Use TCP auto tuning if possible
  - Linux 2.6, Mac OS X 10.5, FreeBSD 7.x, and Windows Vista
- The –w option can be used to request a particular buffer size.
  - Use this if your OS doesn't have TCP auto tuning
  - This sets both send and receive buffer size.
  - The OS may need to be tweaked to allow buffers of sufficient size.
  - See http://fasterdata.es.net/tuning.html for more details
- Parallel transfers may help as well, the –P option can be used for this
- To get full TCP performance the TCP window needs to be large enough to accommodate the Bandwidth Delay Product

Bandwidth Delay Product Explained

- The amount of “in flight” data allowed for a TCP connection
- BDP = bandwidth * round trip time
- Example: 1Gb/s cross country, ~100ms
  - 1,000,000,000 b/s * .1 s = 100,000,000 bits
  - 100,000,000 / 8 = 12,500,000 bytes
  - 12,500,000 bytes / (1024*1024) ~ 12MB

TCP Performance: Read/Write Buffer Size

- TCP breaks the stream into pieces transparently
- Longer writes often improve performance
  - Let TCP "do it's thing"
  - Fewer system calls
- How?
  - -l <size> (lower case ell)
  - Example –l 128K
- UDP doesn't break up writes, don't exceed Path MTU

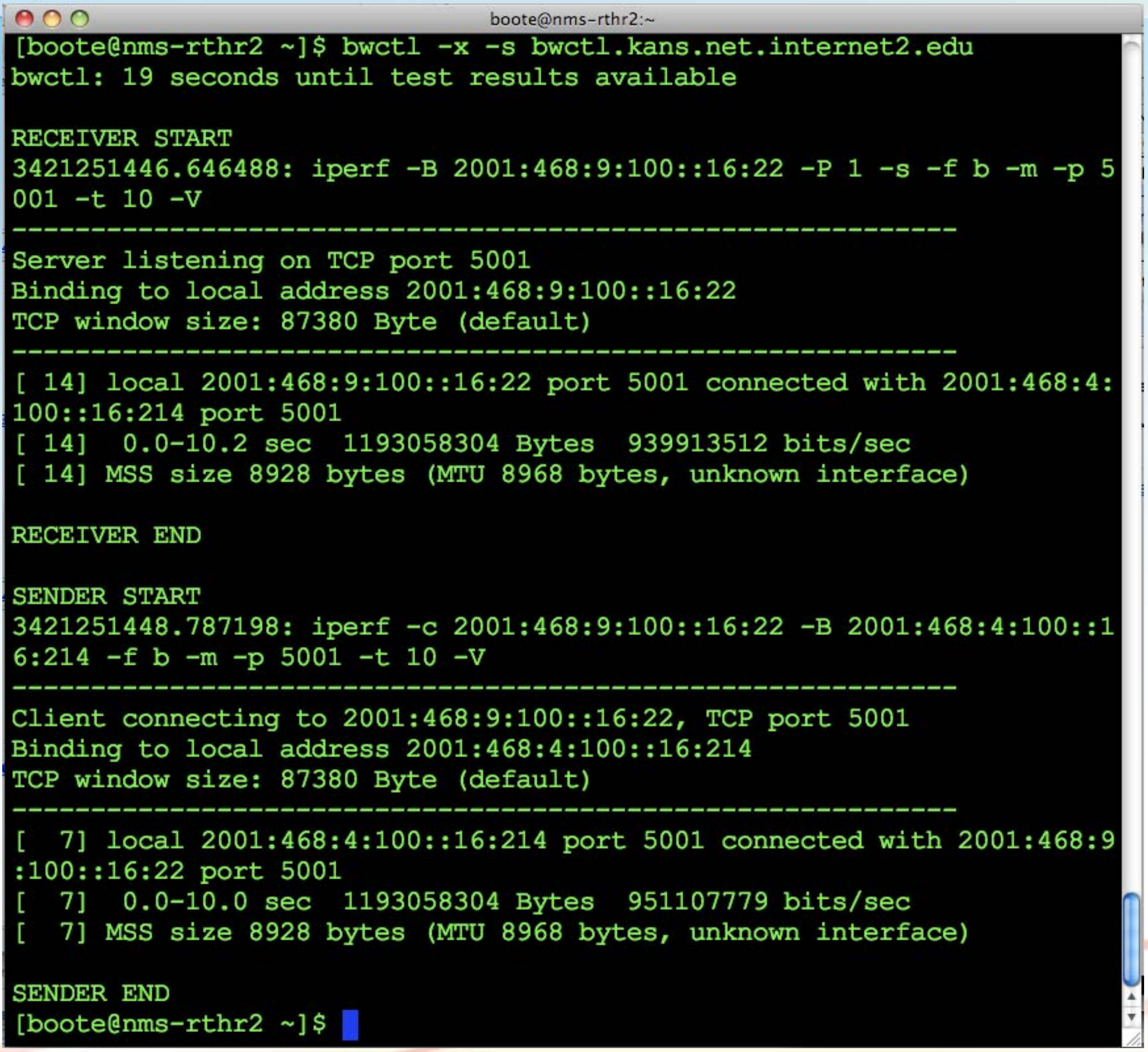
TCP Parallel Streams

- Parallel streams can help in some situations
- TCP attempts to be "fair" and conservative
  - Sensitive to loss, but more streams hedge bet
  - Circumventing fairness mechanism
    - 1 bwctl stream vs. n background: bwctl gets 1/(n+1)
    - X bwctl streams vs. n background: bwctl gets x/(n+x)
    - Example: 2 background, 1 bwctl stream: 1/3 = 33%
    - Example: 2 background, 8 bwctl streams: 8/10 = 80%
- How?
  - The –P option sets the number of streams/threads to use
  - There is a point of diminishing returns

UDP Measurements

- UDP provides greater transparency
- We can directly measure some things TCP hides
  - Loss
  - Jitter
  - Out of order delivery
- Use -b to specify target bandwidth
  - Default is 1M
  - Two sets of multipliers
    - K. m, g multipliers are 1000, 10002,10003
    - K, M, G multipliers are 1024, 10242,10243
  - Eg, -b 1m is 1,000,000 bits per second

Example



boote@nms-rthr2:~

```
[boote@nms-rthr2 ~]$ bwctl -x -s bwctl.kans.net.internet2.edu
bwctl: 19 seconds until test results available

RECEIVER START
3421251446.646488: iperf -B 2001:468:9:100::16:22 -P 1 -s -f b -m -p 5
001 -t 10 -V
------------------------------------------------------------
Server listening on TCP port 5001
Binding to local address 2001:468:9:100::16:22
TCP window size: 87380 Byte (default)
------------------------------------------------------------
[ 14] local 2001:468:9:100::16:22 port 5001 connected with 2001:468:4:
100::16:214 port 5001
[ 14]  0.0-10.2 sec  1193058304 Bytes  939913512 bits/sec
[ 14] MSS size 8928 bytes (MTU 8968 bytes, unknown interface)

RECEIVER END

SENDER START
3421251448.787198: iperf -c 2001:468:9:100::16:22 -B 2001:468:4:100::1
6:214 -f b -m -p 5001 -t 10 -V
------------------------------------------------------------
Client connecting to 2001:468:9:100::16:22, TCP port 5001
Binding to local address 2001:468:4:100::16:214
TCP window size: 87380 Byte (default)
------------------------------------------------------------
[  7] local 2001:468:4:100::16:214 port 5001 connected with 2001:468:9
:100::16:22 port 5001
[  7]  0.0-10.0 sec  1193058304 Bytes  951107779 bits/sec
[  7] MSS size 8928 bytes (MTU 8968 bytes, unknown interface)

SENDER END
[boote@nms-rthr2 ~]$ 
```

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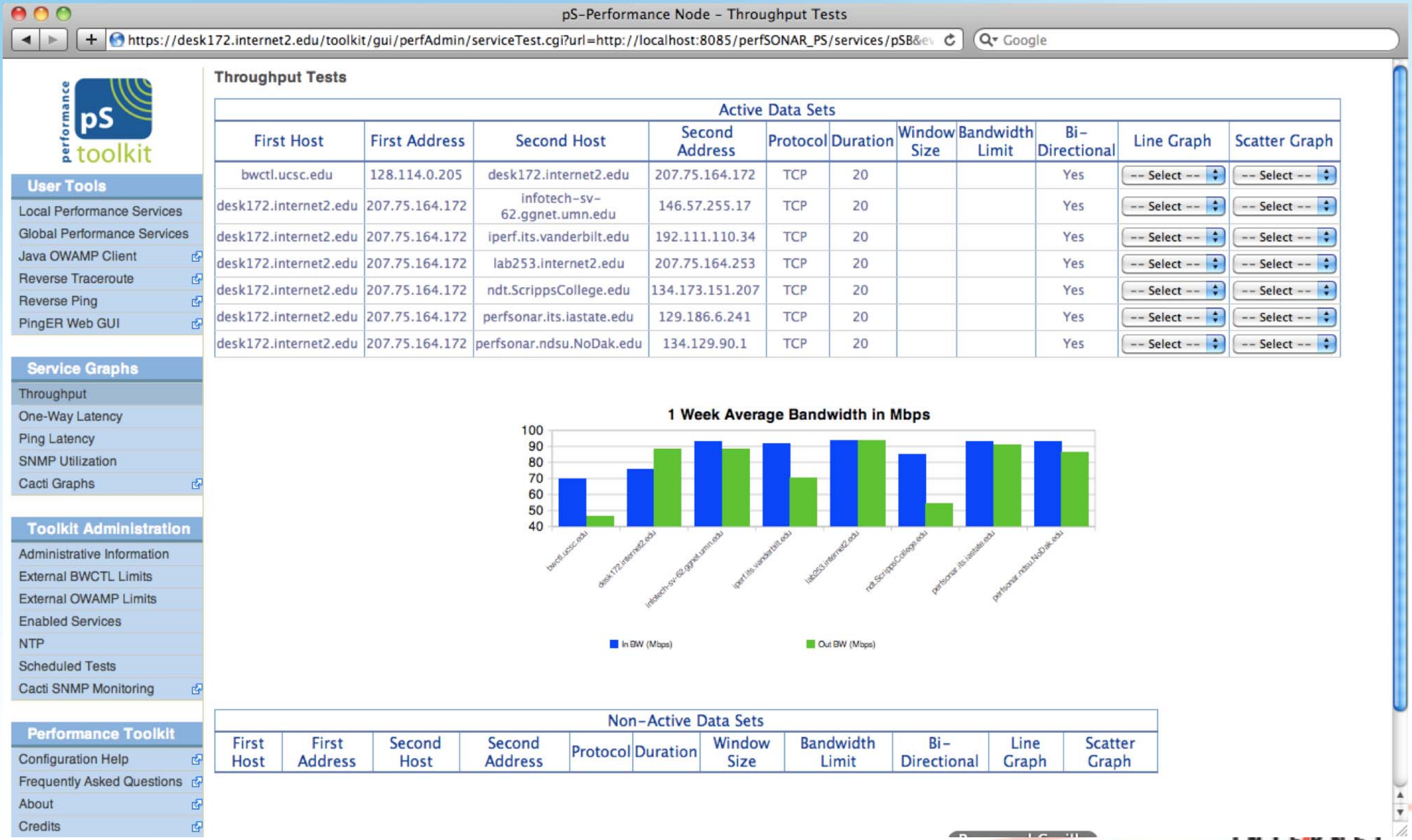
BWCTL GUIs



Throughput Tests

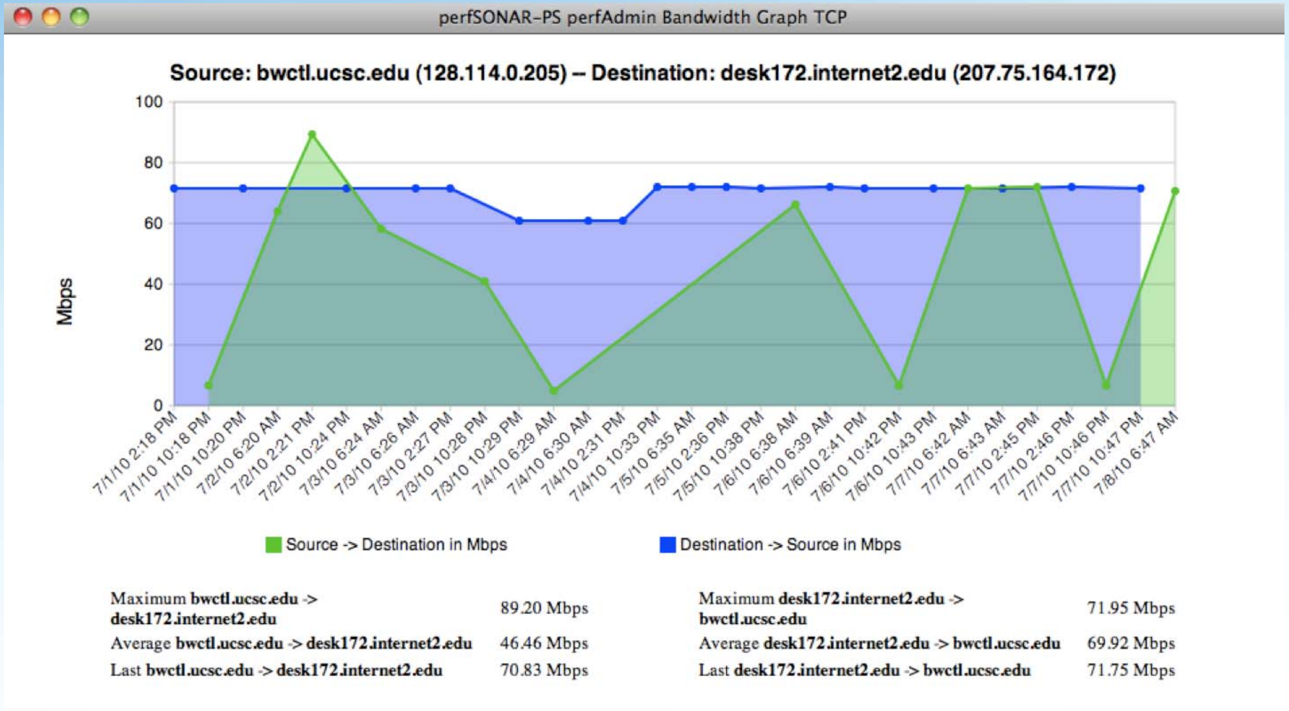
Active Data Sets

First Host	First Address	Second Host	Second Address	Protocol	Duration	Window Size	Bandwidth Limit	Bi-Directional	Line Graph	Scatter Graph
bwctl.ucsc.edu	128.114.0.205	desk172.internet2.edu	207.75.164.172	TCP	20			Yes	-- Select --	-- Select --
desk172.internet2.edu	207.75.164.172	infotech-sv-62.ggnet.umn.edu	146.57.255.17	TCP	20			Yes	-- Select --	-- Select --
desk172.internet2.edu	207.75.164.172	iperf.its.vanderbilt.edu	192.111.110.34	TCP	20			Yes	-- Select --	-- Select --
desk172.internet2.edu	207.75.164.172	lab253.internet2.edu	207.75.164.253	TCP	20			Yes	-- Select --	-- Select --
desk172.internet2.edu	207.75.164.172	ndt.ScrippsCollege.edu	134.173.151.207	TCP	20			Yes	-- Select --	-- Select --
desk172.internet2.edu	207.75.164.172	perfsonar.its.iastate.edu	129.186.6.241	TCP	20			Yes	-- Select --	-- Select --
desk172.internet2.edu	207.75.164.172	perfsonar.ndsu.NoDak.edu	134.129.90.1	TCP	20			Yes	-- Select --	-- Select --

Non-Active Data Sets

First Host	First Address	Second Host	Second Address	Protocol	Duration	Window Size	Bandwidth Limit	Bi-Directional	Line Graph	Scatter Graph

BWCTL GUIs

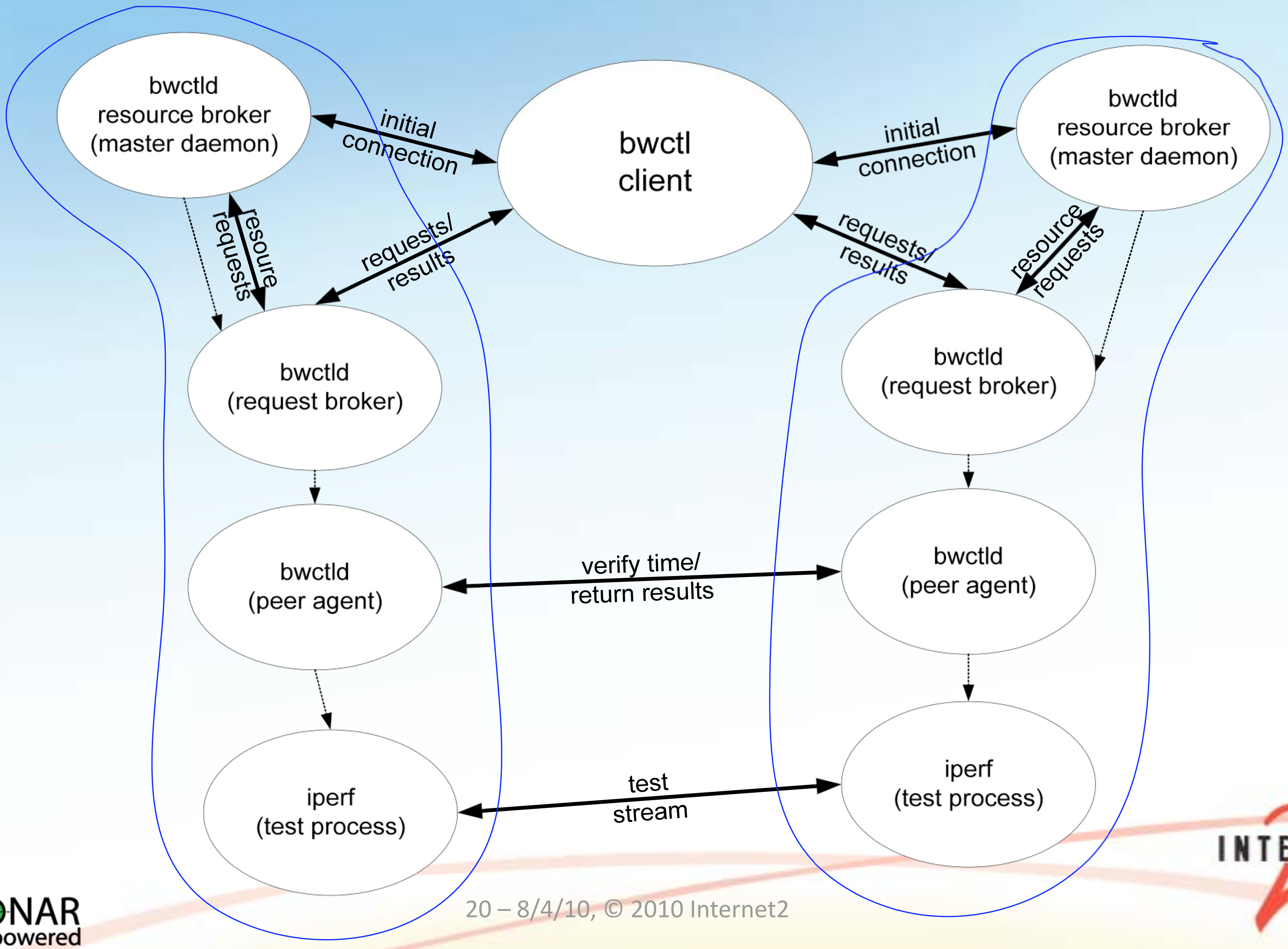


Maximum **bwctl.ucsc.edu -> desk172.internet2.edu**	89.20 Mbps	Maximum **desk172.internet2.edu -> bwctl.ucsc.edu**	71.95 Mbps
Average **bwctl.ucsc.edu -> desk172.internet2.edu**	46.46 Mbps	Average **desk172.internet2.edu -> bwctl.ucsc.edu**	69.92 Mbps
Last **bwctl.ucsc.edu -> desk172.internet2.edu**	70.83 Mbps	Last **desk172.internet2.edu -> bwctl.ucsc.edu**	71.75 Mbps

Resource Allocation

- Each connection is “classified” (authentication)
- Each classification is hierarchical and has an associated set of hierarchical limits:
  - Connection policy (allow_open_mode)
  - Bandwidth (allow_tcp,allow_udp,bandwidth)
  - Scheduling (duration,event_horizon,pending)
    - A time slot is simply a time-dependent resource that needs to be allocated just like any other resource. It therefore follows the resource allocation model.

3rd Party Testing



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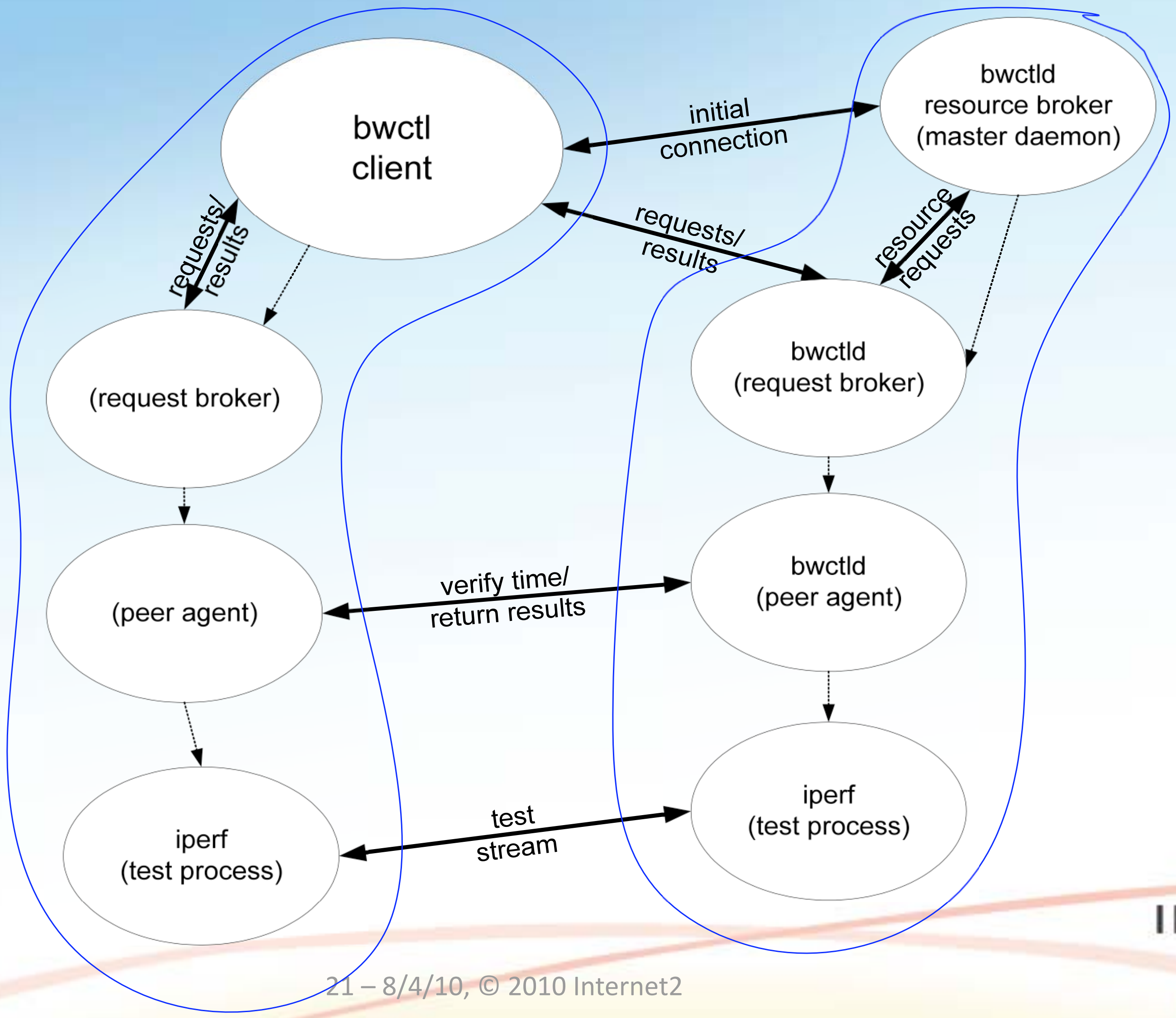
Testing with no "Local" Server



Tester Applications

- Iperf is primary "tester"
  - Well known – widely used
- Problems integrating exec'd tool
  - Server initialization (port number allocation)
  - error conditions
  - No indication of partial progress (How full was the send buffer when the session was killed?)
- thrulay/nuttcp are available also

General Requirements

- Iperf version 2.0 and 2.0.2
- NTP (ntpd) synchronized clock on the local system
  - Used for scheduling
  - More important that errors are accurate than the clock itself
- Firewalls:
  - Lots of ports for communication and testing
- End hosts must be tuned!
  - http://fasterdata.es.net

Supported Systems

- Source should compile for all modern *NIX
  - *BSD, Linux, OS X
- RPMs compiled specifically for CentOS 5.x
  - May work with other RPM based systems (Fedora, RHEL)

Security Considerations

- DoS source
  - Imagine a large number of compromised BWCTLD servers being used to direct traffic
- DoS target
  - Someone might attempt to affect statistics web pages to see how much impact they can have
- Resource consumption
  - Time slots
  - Network bandwidth

Policy Approaches

- Restrictive for UDP
- More liberal for TCP tests
- More liberal still for “peers”
- Protect AES keys! (if using)

Availability

- Main Page:
  - http://www.internet2.edu/performance/bwctl/
- Mailing lists:
  - bwctl-users@internet2.edu
  - bwctl-announce@internet2.edu

Hands On

- Testing BWCTL:
  - Log on to testbed
  - Test from one host to another:
    - bwctl –f m –t 10 –I 1 –c HOSTNAME
  - Test the other direction:
    - bwctl –f m –t 10 –I 1 –s HOSTNAME
  - Test UDP:
    - bwctl –f m –t 10 –I 1 –u –b 100M –c HOSTNAME
  - Try different hosts. Try longer tests. What happens when we use:
    - -w (Window size, try 128k and 4M)
    - -P (Parallel threads, try 2, try 4)

BWCTL

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