OSG CAMPUS INFRASTRUCTURES SERIES

Methods for Network Troubleshooting in Distributed High Throughput Environments --- Webinar

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Open Science Grid

Presentation Abstract

ABSTRACT: Often in grid and distributed campus environments, users will notice problems with "the network". This takes many forms including an inability to reach remote sites, very poor application performance and/or very slow data transfer rates. There are a number of challenges with "network" problems, not the least of which is verifying it is really a network problem. Debugging network problems and isolating the location of the problem can be very difficult and time-consuming. The perfSONAR project was designed to help aid in the diagnosis and location of network problems. OSG is working on providing a robust installation of the perfSONAR-PS toolkit and services to configure and gather network metrics from OSG sites with perfSONAR-PS. In this talk we address the details of perfSONAR-PS: how to install, configure and use it to help better understand issues in the network. The presentation will include practical information about using the perfSONAR-PS toolkit installation along with relevant URLs for further information.

Webinar Overview

- Overview: OSG, Campus grids and "network problems"
  - Understanding the overall system
  - Categorizing problems and localizing them
- perfSONAR-PS is your friend: What it is and why it can help
- Details about perfSONAR-PS
  - Installation and configuration
  - Using perfSONAR-PS when there are problems
- Walkthru of a documenting a problem
- Summary and Resources for Going Further

OSG Network Monitoring

- Distributed collaborations rely upon the network as a critical part of their infrastructure, yet finding and debugging network problems can be difficult and, in some cases, take months.
- There is typically no differentiation of how the network is used amongst the OSG users. (Quantity may vary)
- **We need a standardized way to monitor the network and locate problems quickly if they arise**
- We don't want to have a network monitoring system per VO!

Data Movement for Science

This should not be news to anyone here …

Flows getting larger (e.g. *Science datasets* in the R&E world)

- Special requirements (e.g. *Streaming media* is sensitive to jitter, *bulk data transfer* is sensitive to loss)
- Number of users/devices is increasing
- Locations are spread out
- ***Everything*** is cross domain

(for Spinal Tap fans…)

Slide from Jason Zurawski

OSG, Campus grids and "network problems"

- The Open Science Grid (OSG) advances science through open distributed computing.
  - Underlying OSG is a robust network, tying together distributed compute and storage resources
- Grids in general also assume and require a ubiquitous and high-performing network interconnecting all relevant resources.
- What happens when things don't work as planned?
  - In many cases users and local administrators face a daunting and potentially LONG period of diagnosing, debugging and waiting….
  - The "network" is often blamed…but is it the issue?
  - If it IS the network…which part? Where? What?

Network Realities

- Where are the problems?

  Network Core? Everything is well connected, well provisioned, and flawlessly configured, ***RIGHT***?

End Systems? Properly tuned for optimal TCP performance (no matter the operating system), proper drivers installed and functioning optimally, ***RIGHT***?

LAN? Regional Net?

Better to ask "Where aren't there problems?"

Slide from Jason Zurawski

Understanding Distributed Infrastructures

- As noted, when problems involving distributed resources occur the first thing to get the blame is "the Network"…sometimes that is even correct!
- Problems span a wide range of symptoms:
  - Loss of connectivity
  - Poor utilization of the network
  - Intermittent connectivity or widely varying performance
  - Application errors or misbehavior
- Grid systems and campus infrastructures are complex and involve many "moving pieces"
- Network diagnosis is non-trivial for many reasons, not the least of which is that networks span multiple administrative domains and no single entity usually has visibility into more than their part of the path.
- **The critical issue is to understand, even approximately, where the problem lies.**

The Possible "Where"

- When problems arise in a distributed system there are many possible sources since they can be **anywhere, end-to-end**
- First step is to understand if it is the network or the end-systems.
  - This can be *subtle*. Local network issues may not have a significant impact on local network flows but can cripple Wide Area Network (WAN) flows.
  - Likewise poorly tuned hosts or ones with faulty hardware may perform OK for local network transfers but very badly on WAN connections

What to do?

- Users, local administrators and network engineers are faced with the daunting issue of trying to track down a problem where they have limited information and access to the full end-to-end path.
- In general we need to divide-and-conquer
  - Examine end-hosts for problems and misconfigurations
  - Measure network path behavior

End-Hosts and Applications

- Many end-to-end problems are actually issues at the ends.
- The good news is users and admins usually have access-to, and experience-with, end-systems.
  - Important to understand network host tuning
  - Application may not be designed properly for WAN network use (poor buffering, many small, latency-sensitive transactions, etc.)

End-Host / Application Checklist

- This could be a whole other Webinar ☺
- Check for errors and faulty hardware
- Document/understand how the host connects to the Local Area Network(LAN)
- Use 'ifconfig' and 'ethtool' to gather network and network interface info
  - ethtool –S eth0 (or ethN) displays NIC stats
- Has the application in question worked before? Differences in use?
- See 'ESnet page http://fasterdata.es.net/host-tuning/

Need for a "Finger Pointing" Tool

- Once we have checked the end-host setup and tuned appropriately, what if the problem persists?
- How can we quickly identify when problems are network problems and help isolate their locations?
- The perfSONAR project was designed to help do this

Network Monitoring Motivation

perfSONAR powered

- Finding a solution to network performance problems can be broken into two distinct steps:
  - Use of *Diagnostic Tools* to locate problems
    - Tools that actively measure performance (e.g. Latency, Available Bandwidth)
    - Tools that passively observe performance (e.g. error counters)
  - *Regular Monitoring* to establish performance baselines and alert when expectation drops.
    - Using diagnostic tools in a structured manner
    - Visualizations and alarms to analyze the collected data
- Incorporation of either of these techniques must be:
  - *ubiquitous*, e.g. the solution works best when it is available everywhere
  - seamless (e.g. *federated*) in presenting information from different resources and domains

Slide from Jason Zurawski

History of perfSONAR

- perfSONAR: a joint effort of ESnet, Internet2, GEANT and RNP (and others) to standardize network monitoring protocols, schema and tools
- perfSONAR as a project provides a common way to define network metrics the makes implementations able to share data and inter-operate
  - Many Research and Education networks worldwide have adopted perfSONAR as the standard way to gather network metrics
- One example implementation from Internet2 and ESnet is the perfSONAR-PS Toolkit and that is what I will discuss in this Webinar

Example perfSONAR Use Case

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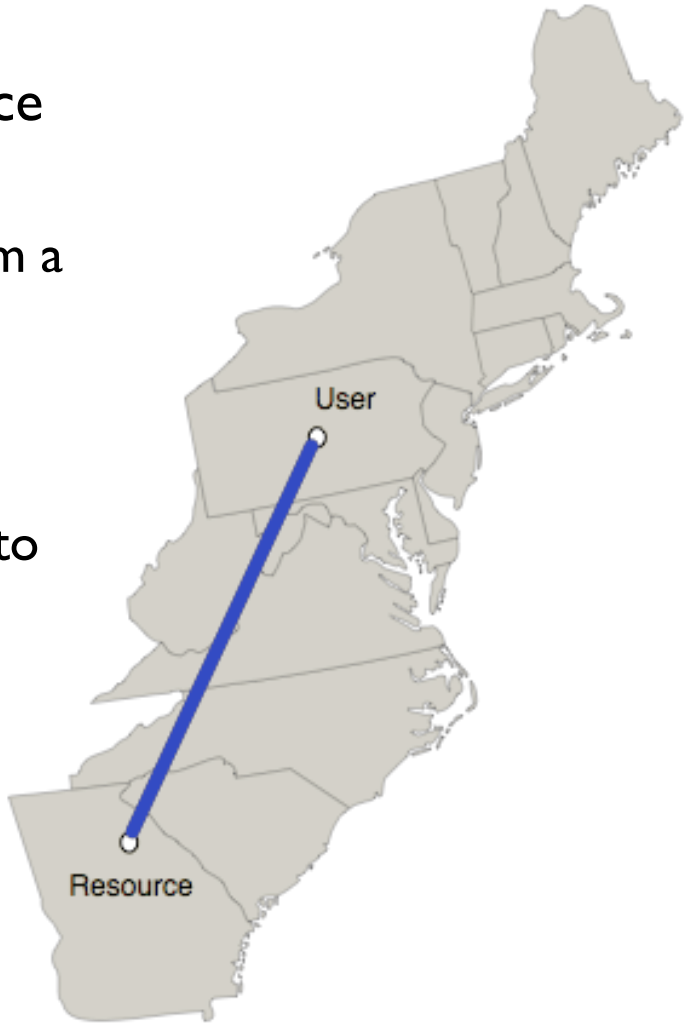
- perfSONAR should be used to diagnose an end-to-end performance problem
  - User is attempting to download from a remote resource
  - Resource and user are separated by distance
  - Both are assumed to be connected to high speed networks
- Operation does not go as planned, where to start?



Slides from Jason Zurawski

Example perfSONAR Use Case

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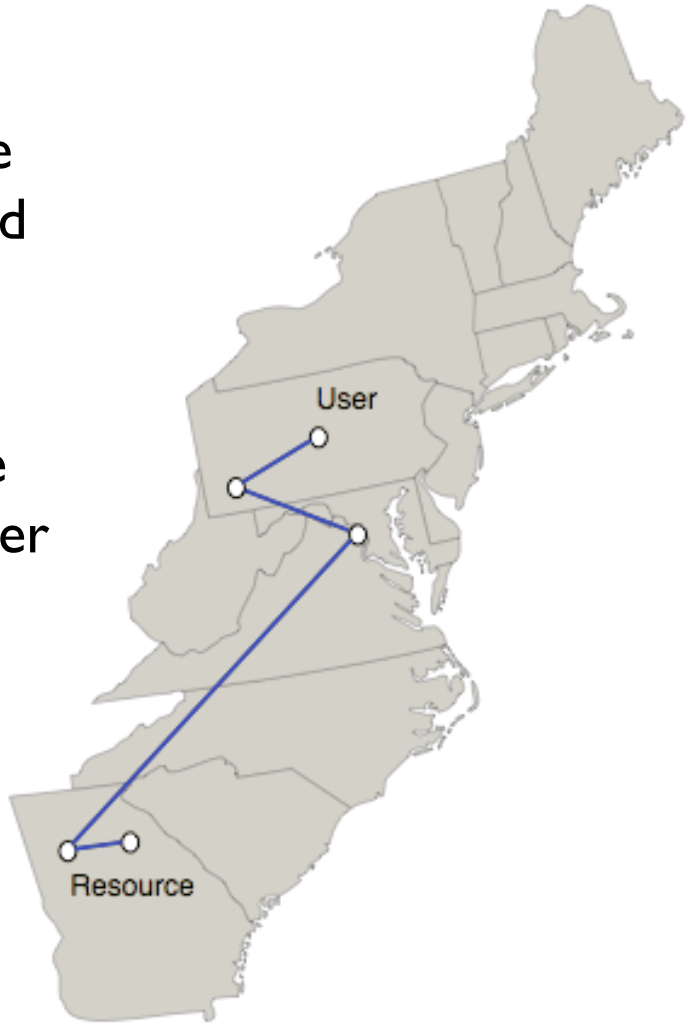
- Simple tools like ***traceroute*** can be used to determine the path traveled
- There could be a performance problem anywhere in here
- The problem may be something we could fix, but the chances are greater that it is not



Example perfSONAR Use Case

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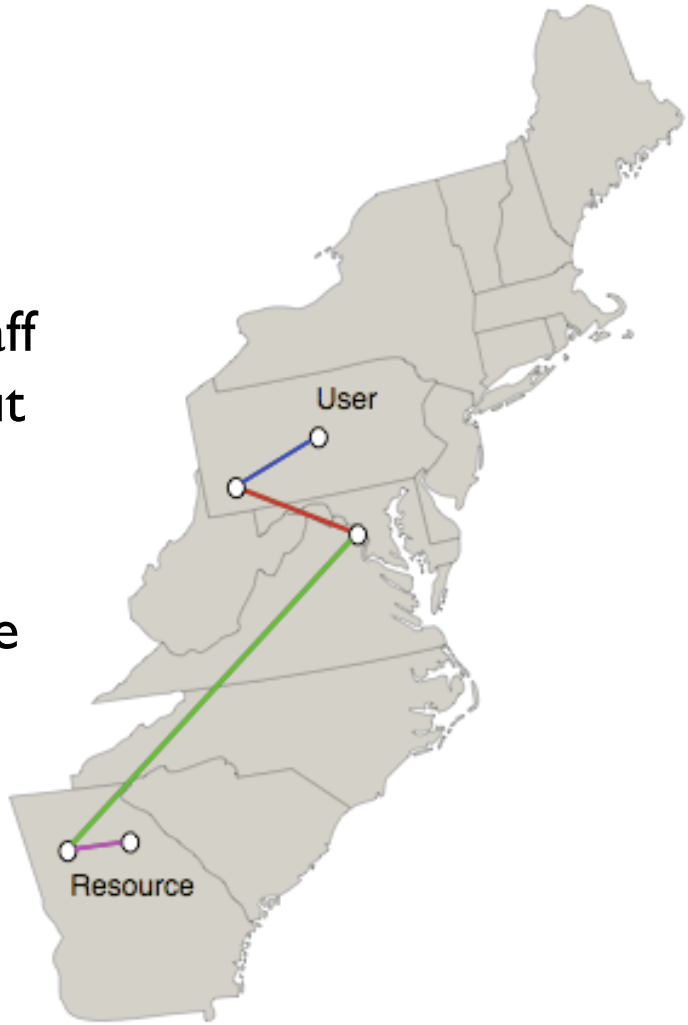
- Each segment of the path is controlled by a different domain.
- Each domain will have network staff that could help fix the problem, but how to contact them?
- All we really want is some information regarding performance



Example perfSONAR Use Case

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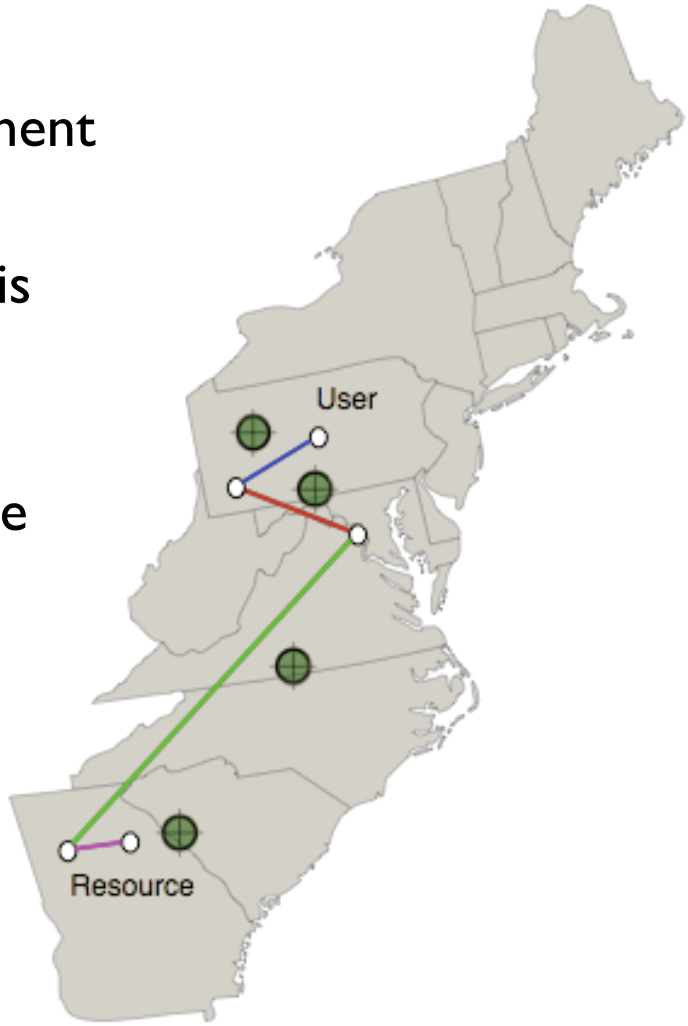
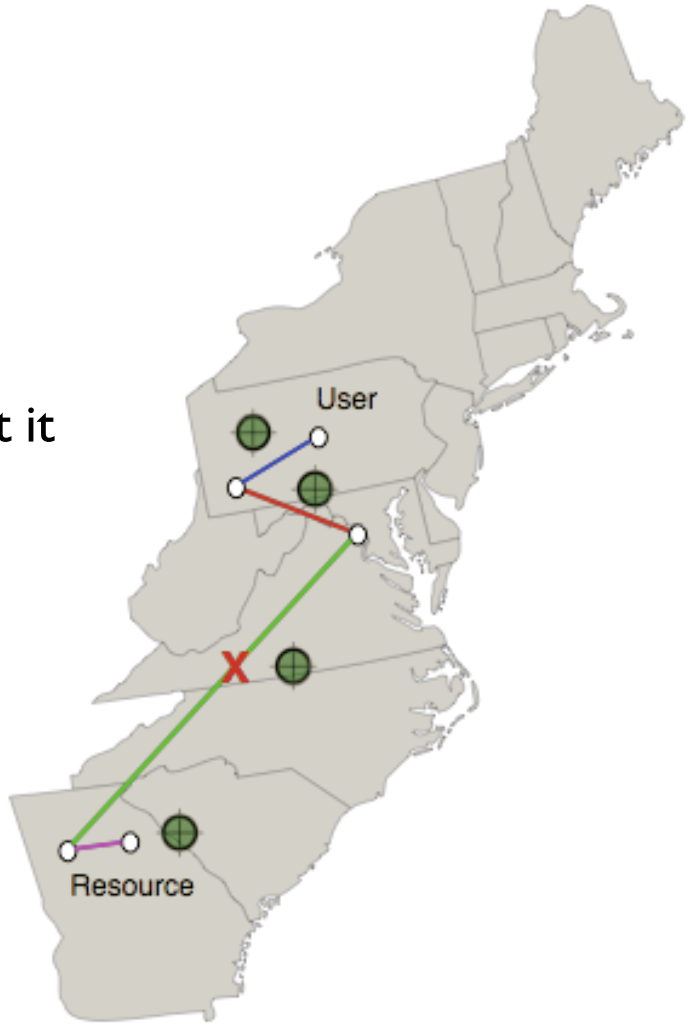
- Each domain has made measurement data available via perfSONAR
- The user was able to discover this automatically
- Automated tools such as visualizations and analyzers can be powered by this network data



Example perfSONAR Use Case

perfSONAR powered

- In the end, the problem is isolated based on testing.
  - May have gone unnoticed in some cases (e.g. a "soft failure")
  - Could have been observed by many others … that didn't think to report it
- The user (or operations staff) can contact the domain in question to inquire about this performance problem
- When fixed the transfer should progress as intended



What Does perfSONAR-PS Provide?

- Installing perfSONAR-PS on a host provides a number of tools and options
  - Instance can be configured to perform regularly scheduled tests: Bandwidth (BWCTL), Latency/Packet-loss (OWAMP), Traceroute and PingER (Round-trip times)
  - Provides an on-demand test point for the above
  - Has built-in diagnostic tools accessible via web:
    - NDT (Runs on http://<fqdn>:7123 by default)
    - NPAD (Runs on http://<fqdn>:8000 by default)

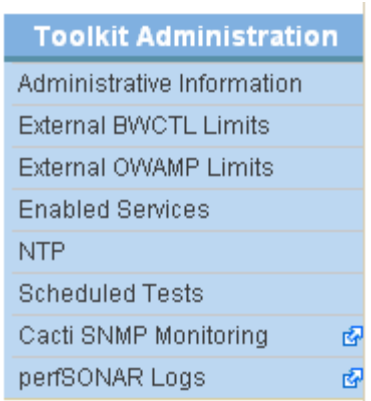
Installing perfSONAR-PS Toolkit

- Identify the hardware to use http://fasterdata.es.net/performance-testing/perfsonar/ps-howto/hardware/
  - Recommendation is two instances: one for latency/traceroute and one for bandwidth
- Get/assign DNS name and IP addresses
- Install (either on-disk via 'Netinstall' image or as an appliance via CDROM/USB image)
  - Quick start at http://code.google.com/p/perfsonar-ps/wiki/pSPerformanceToolkit33
- Configure it!

Configuring perfSONAR-PS

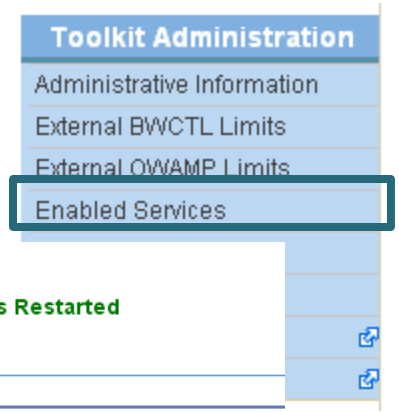
- Details in the quick start URL above
- Should supply "Administrative Information" information
  - On the http://<fqdn>/toolkit page

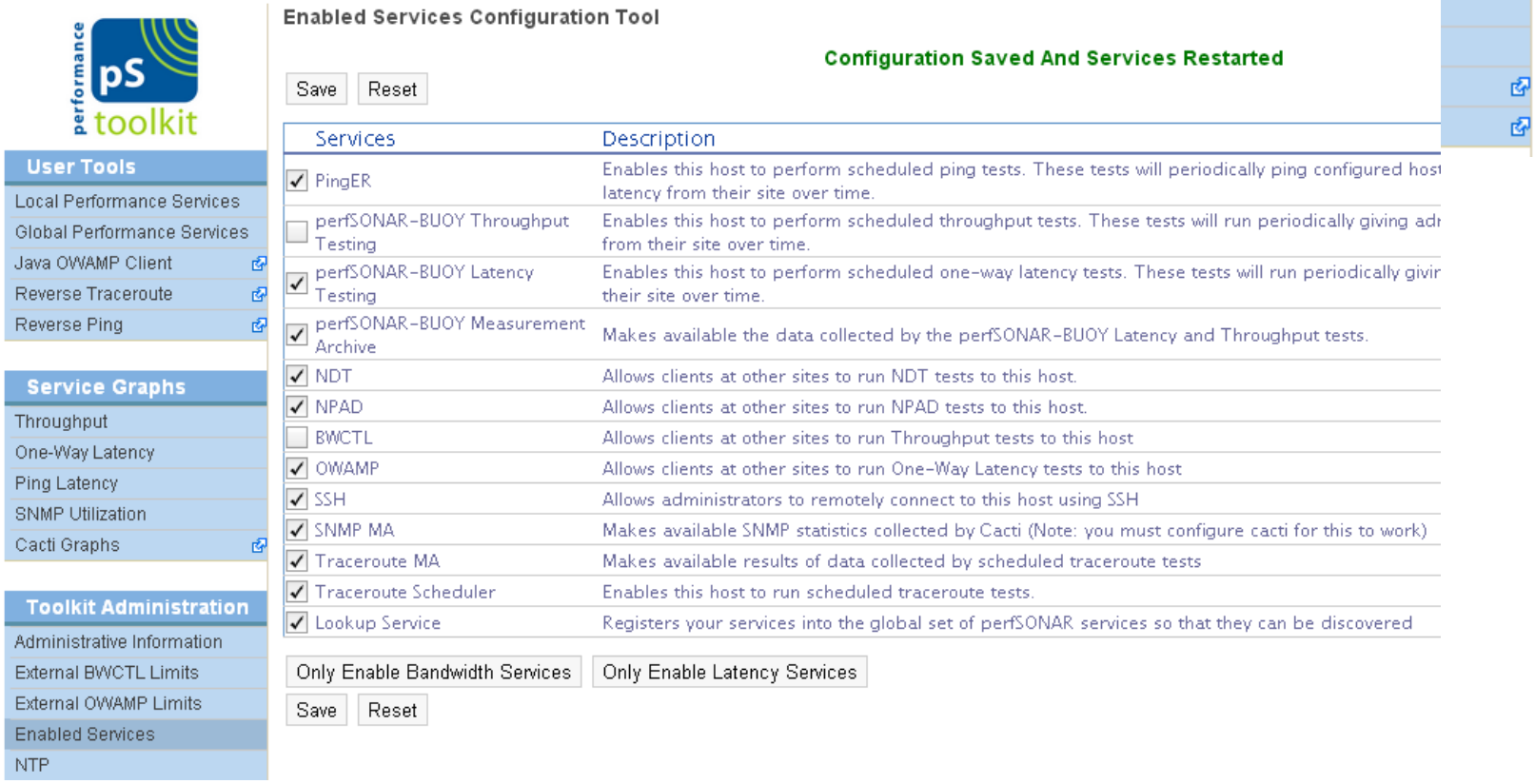
  there is a "Toolkit Administration" box:
- You will need credentials
  - (Created during install)
- Click on 'Administrative Information'
- Put in address/location of box suitable for finding in Google Maps for example
- Decide on relevant "Communities" to participate in



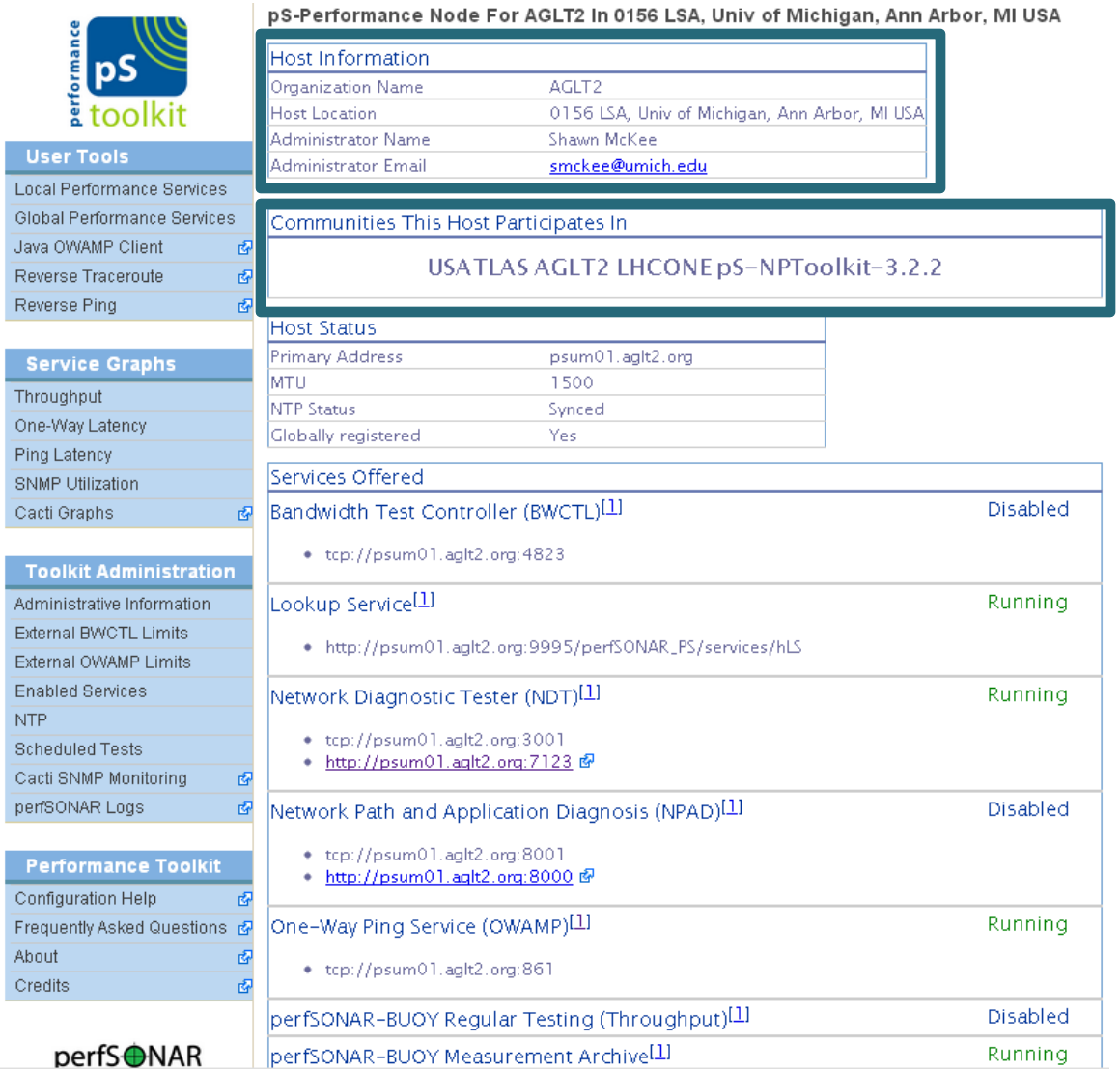
Configuring perfSONAR-PS (2)

- Define "Enabled Services"
  - Is this a latency or bandwidth node?





Example perfSONAR-PS WebGUI



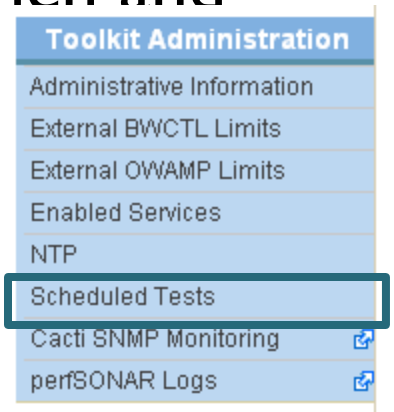
Using perfSONAR-PS Toolkit On-Demand

- The toolkit provides the ability to do on-demand tests
- NDT (Network Diagnostics Toolkit) can be invoked from any web browser which supports Java-script. Connect to a perfSONAR-PS **host http://<host>:7123**
  - Click "Start" and a 20 second test is run
- NPAD (Network Path and Application Diagnostics) can also be run
  - Connect to **http://<host>:8000**
- Both NDT and NPAD analyze the network by using a Web100 instrumented TCP stack
- OSG distributes "CLI client" versions of the tools to allow running from the command line

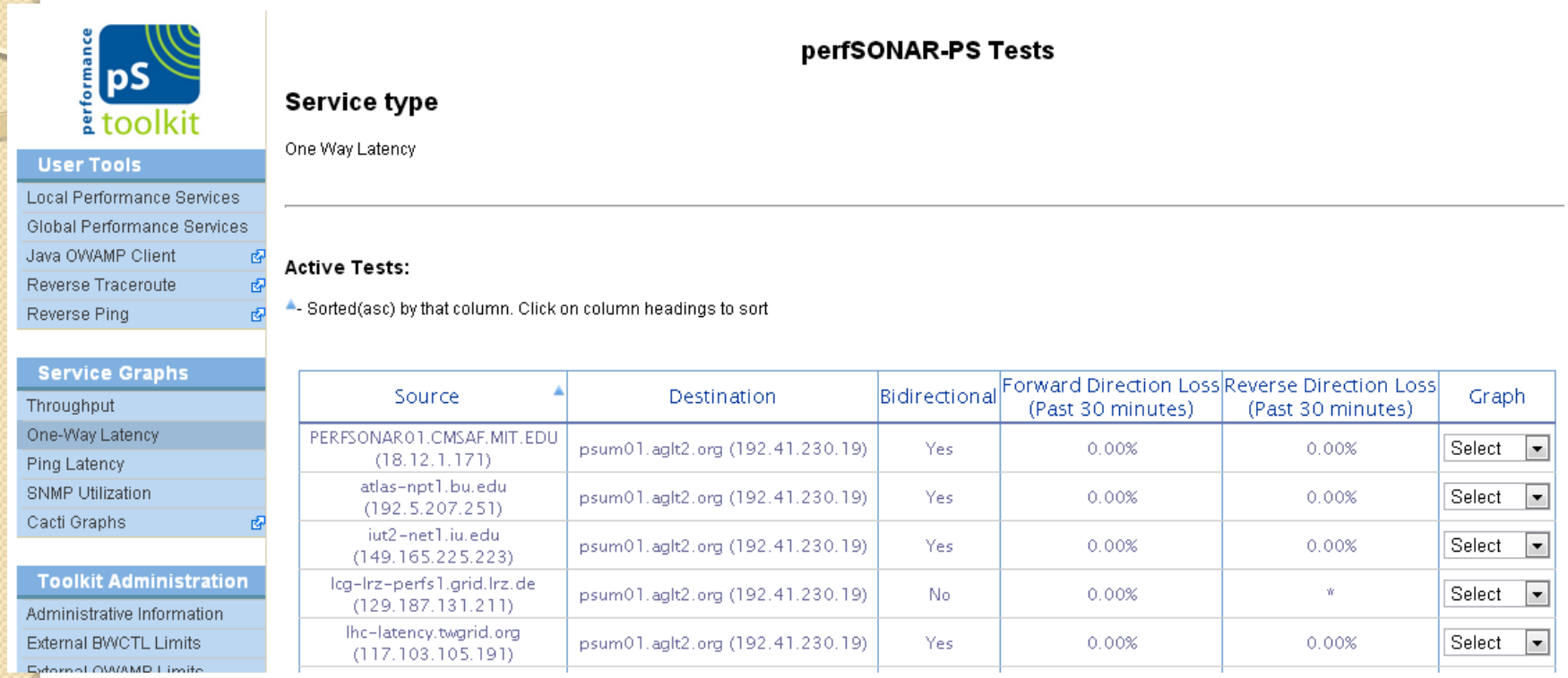
https://twiki.grid.iu.edu/bin/view/Documentation/Release3/NetworkPerformanceToolkit

Using Scheduled Testing

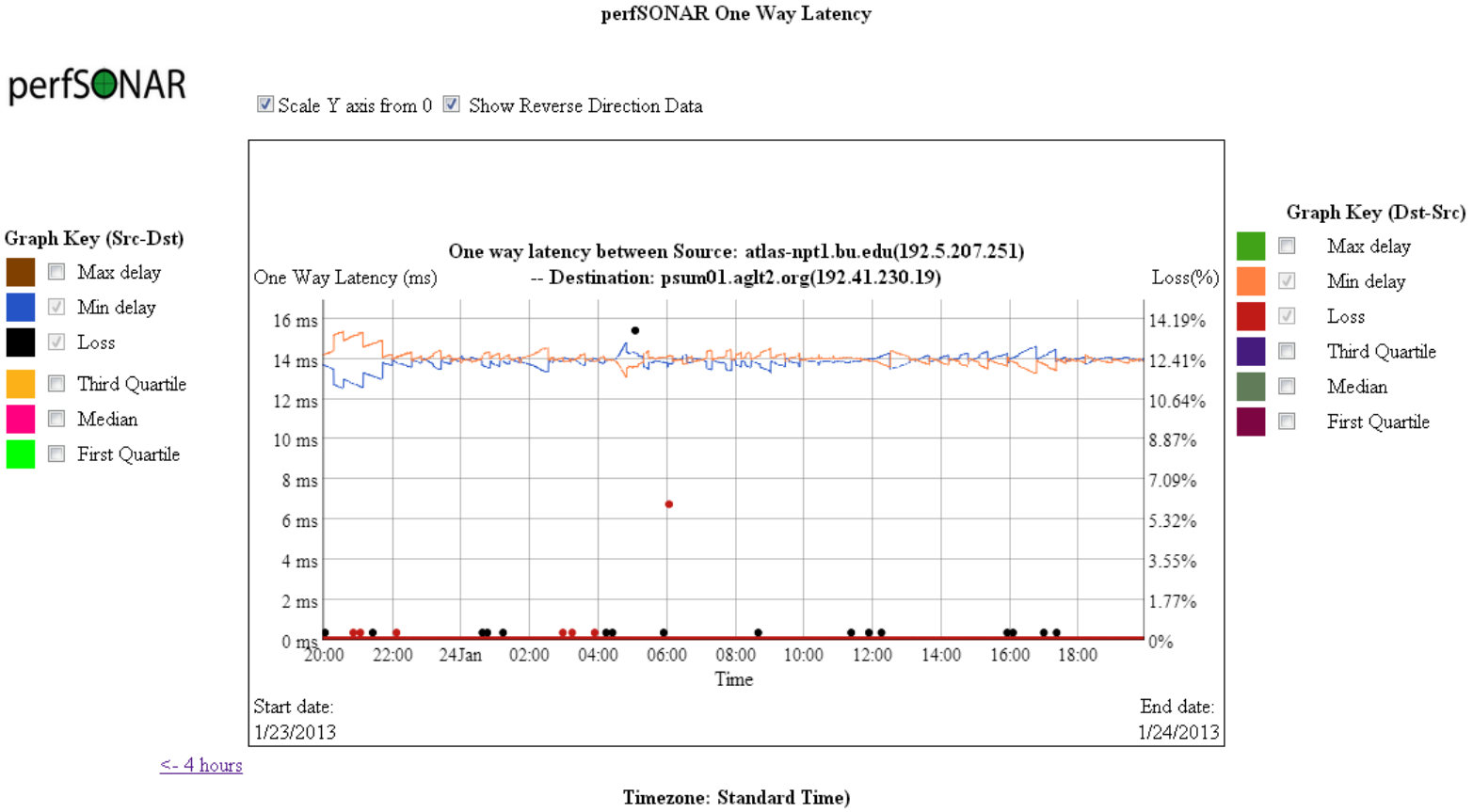
- Most sites installing perfSONAR-PS will want to setup some regularly scheduled tests to other relevant sites across the network
  - This creates a baseline to compare to
  - It can be useful for identifying when and where problems occur
- Click "Scheduled Tests"
- Setup tests



Example of OWAMP Tests

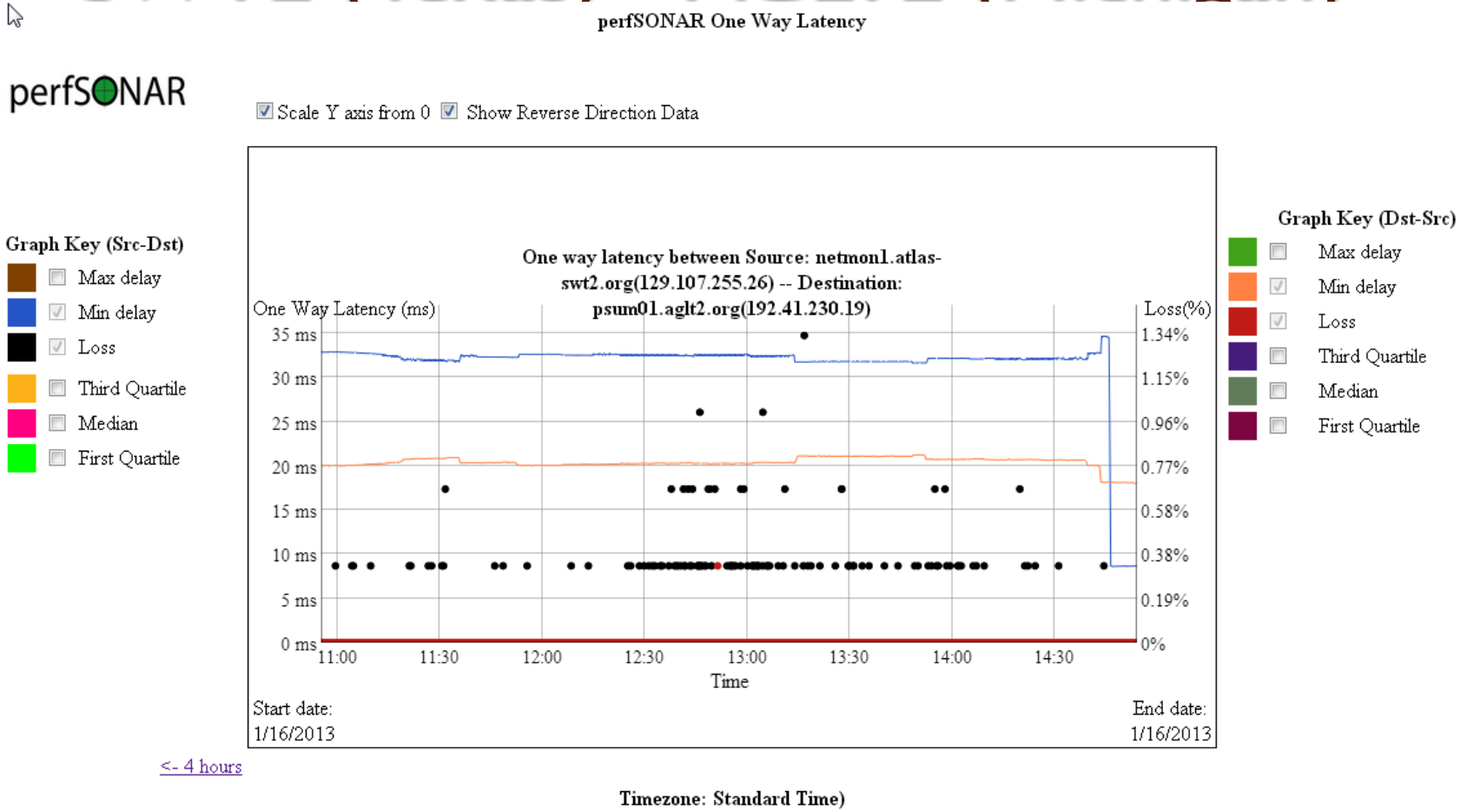


The 24 hour OWAMP Result BU (Boston) – AGLT2 (Michigan)



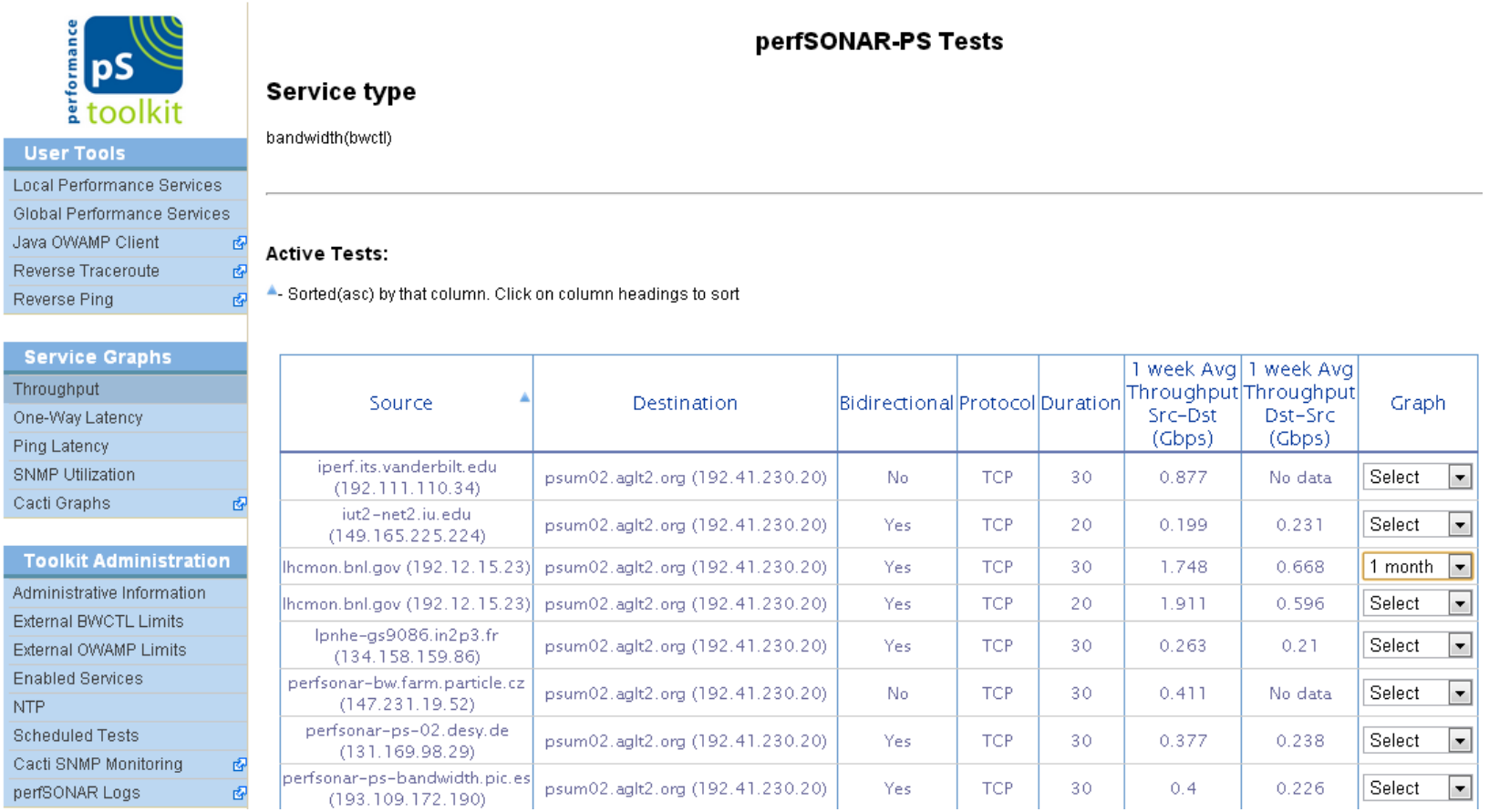
This plot shows results in both directions (tests are unidirectional). While the one-way latency can be useful, more important is the loss indication. This shows a path that while acceptable, is not as clean as we would like.

Another OWAMP Example: SWT2 (Texas) – AGLT2 (Michigan)

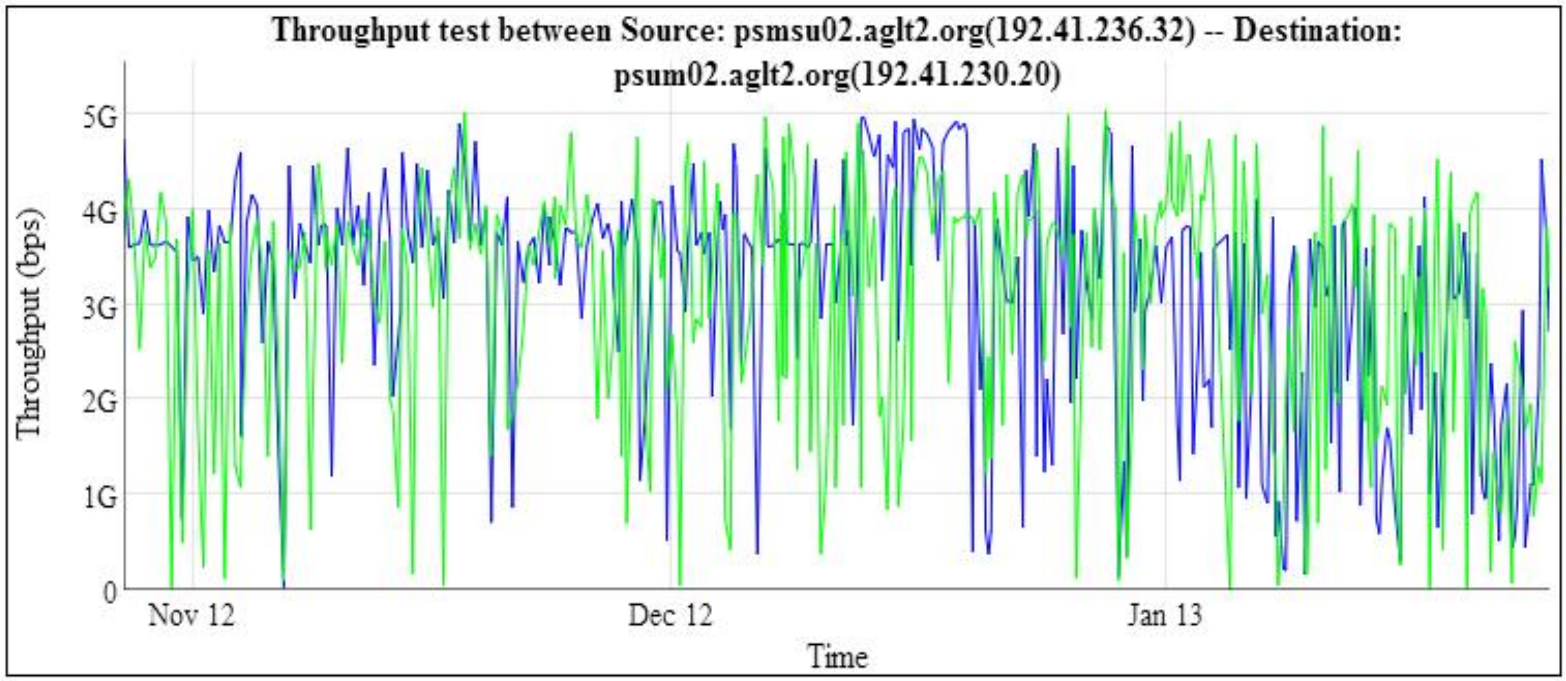


This plot shows results in both directions (tests are unidirectional). This shows an asymetric route (different latency in each direction). Loss is more frequent than the last example but not as large. This may have a larger impact on thruput.

Example of BWCTL Tests

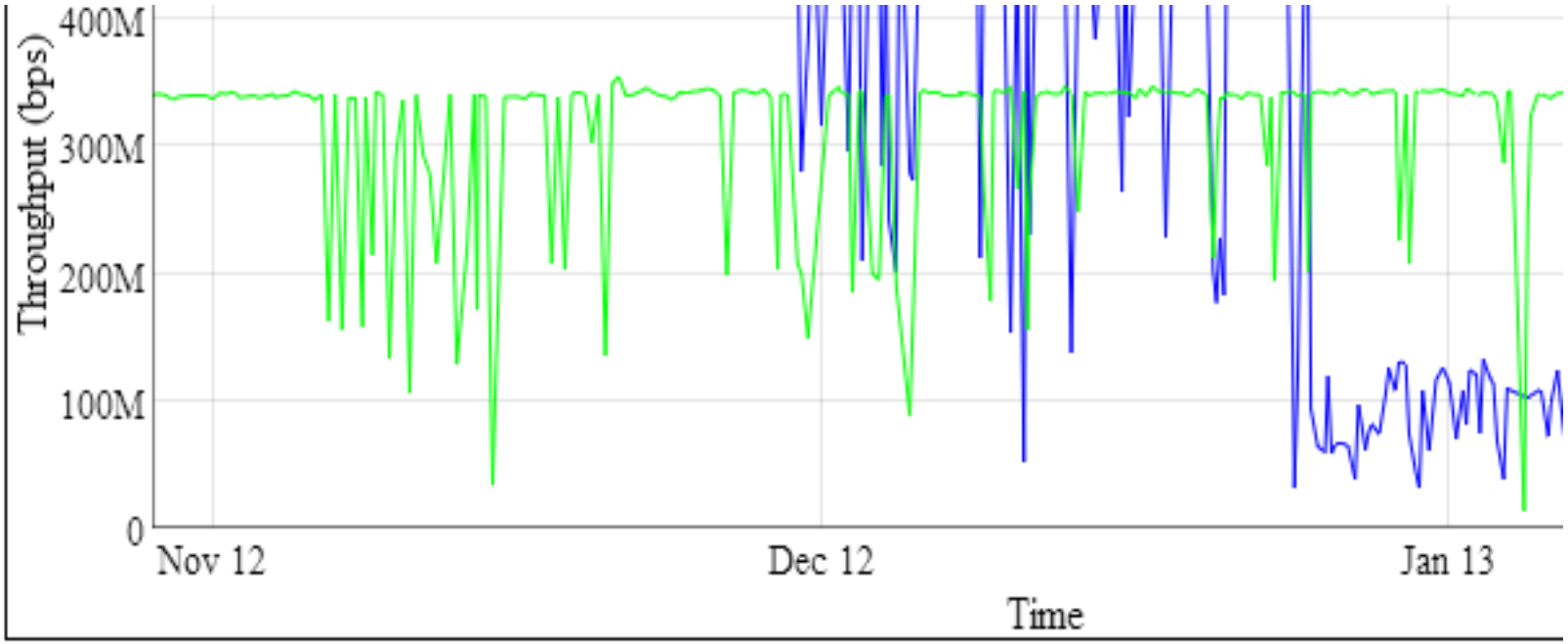


The 3-Month BWCTL Result AGLT2: Ann Arbor – East Lansing



This plot shows results in both directions Src->Dst is BLUE while Dst->Src is GREEN. These testers are obviously using 10 GE NICs. Measurements vary quite a bit, perhaps due to real loads (congestion).

The 3-Month BWCTL Result Michigan - Japan



This plot shows results in both directions between Michigan and Japan. These show some much more interesting behavior than the last test. Src->Dst is BLUE while Dst->Src is GREEN. Tests from Japan->Michigan started around the end of November. Something changed around Christmas. Recent change in Dst->Src?

Network Performance – Example of Use

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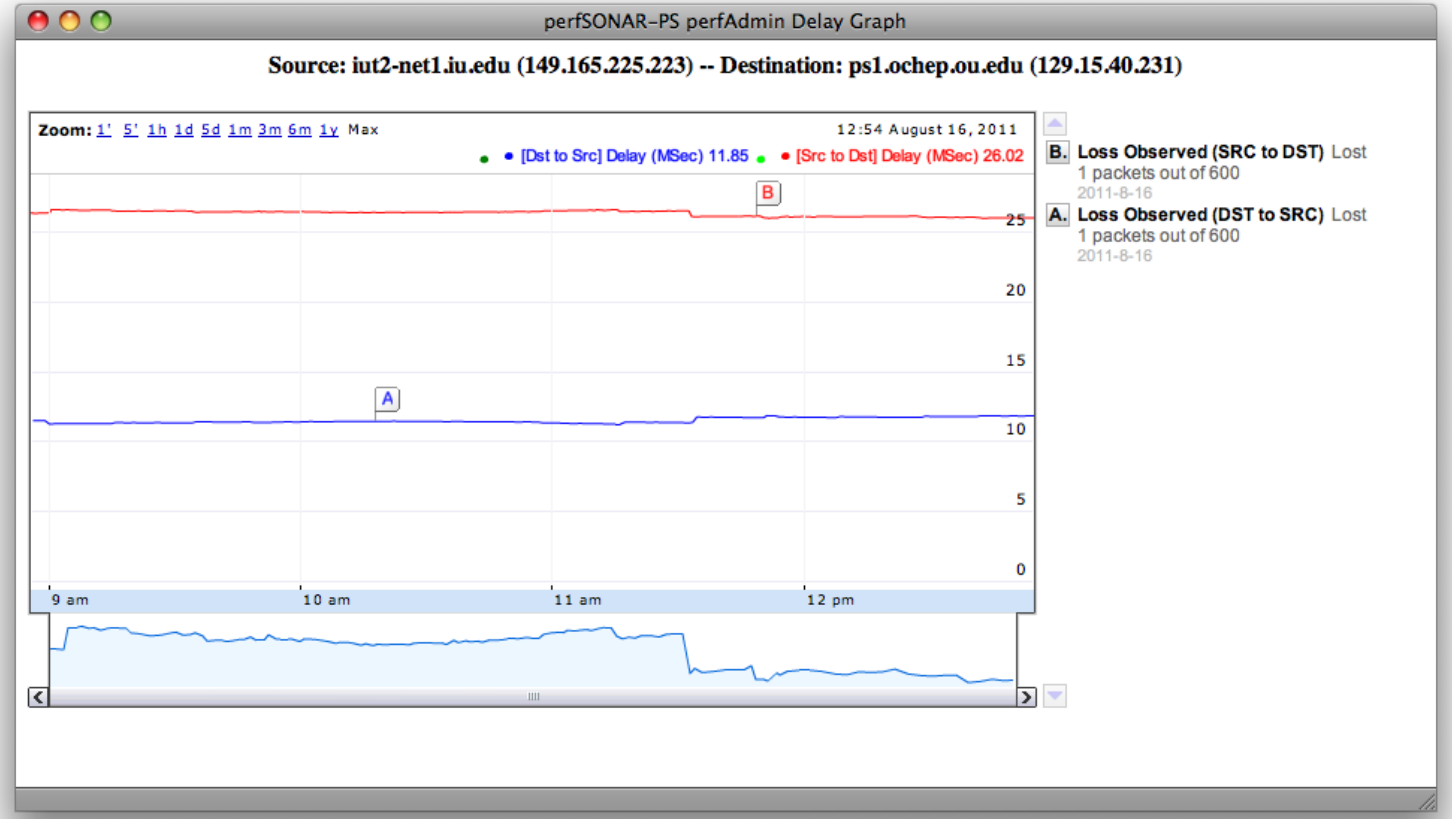
The following example of using perfSONAR-PS is from Jason Zurawski/Internet2 and demonstrates using perfSONAR-PS measurements to identify a problem and verify the solution.

This incident happened in USATLAS where we noticed poor performance between Indiana and Oklahoma.

Asymmetric Latency



- This is not a problem by itself
  - Only a problem if there is a real problem on either side
  - If one side has a problem – think who complains (uploaders vs. downloaders)

And What Does Bandwidth Say?

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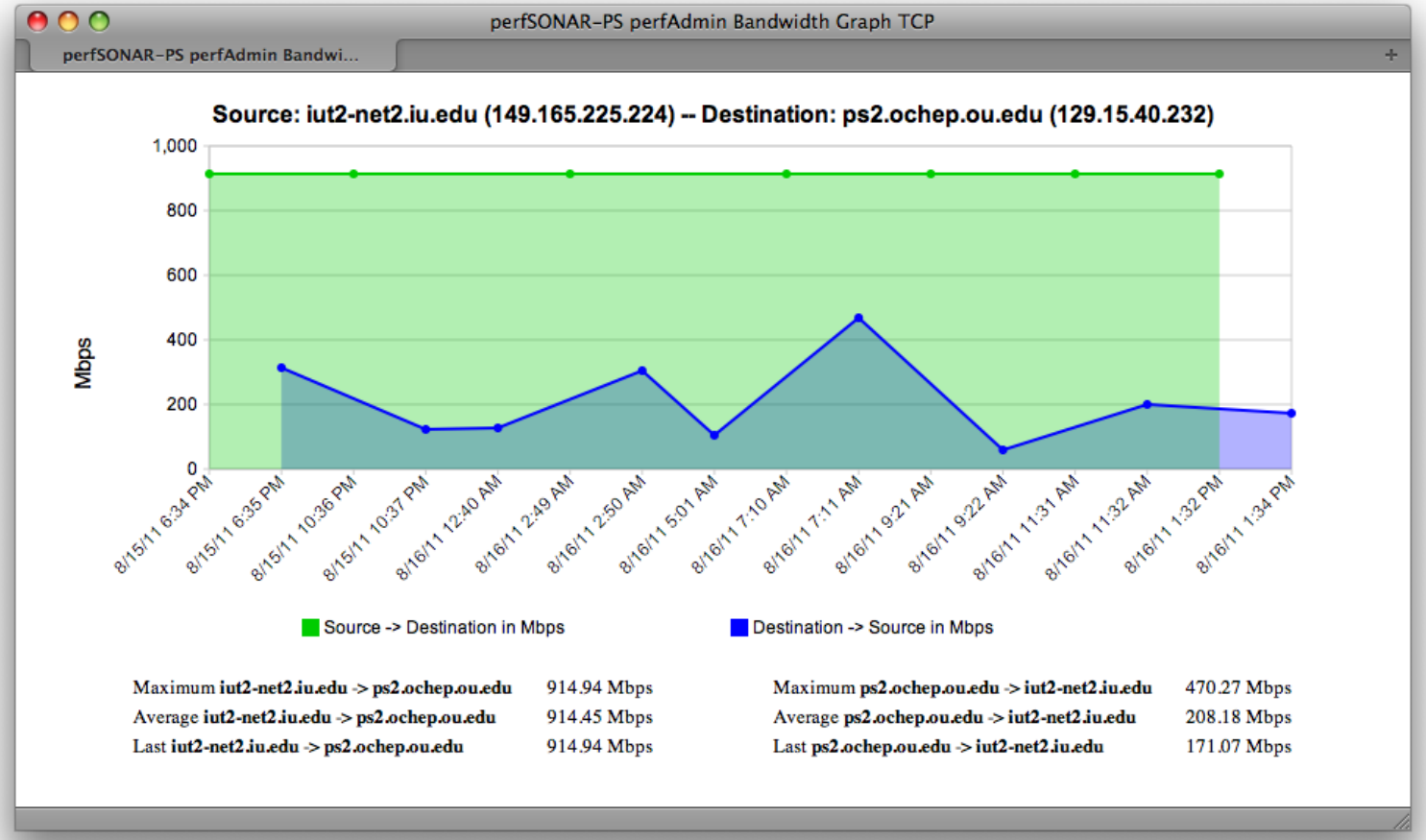

- One of the paths is doing poorly

Longer View (Problem Existed for a While)

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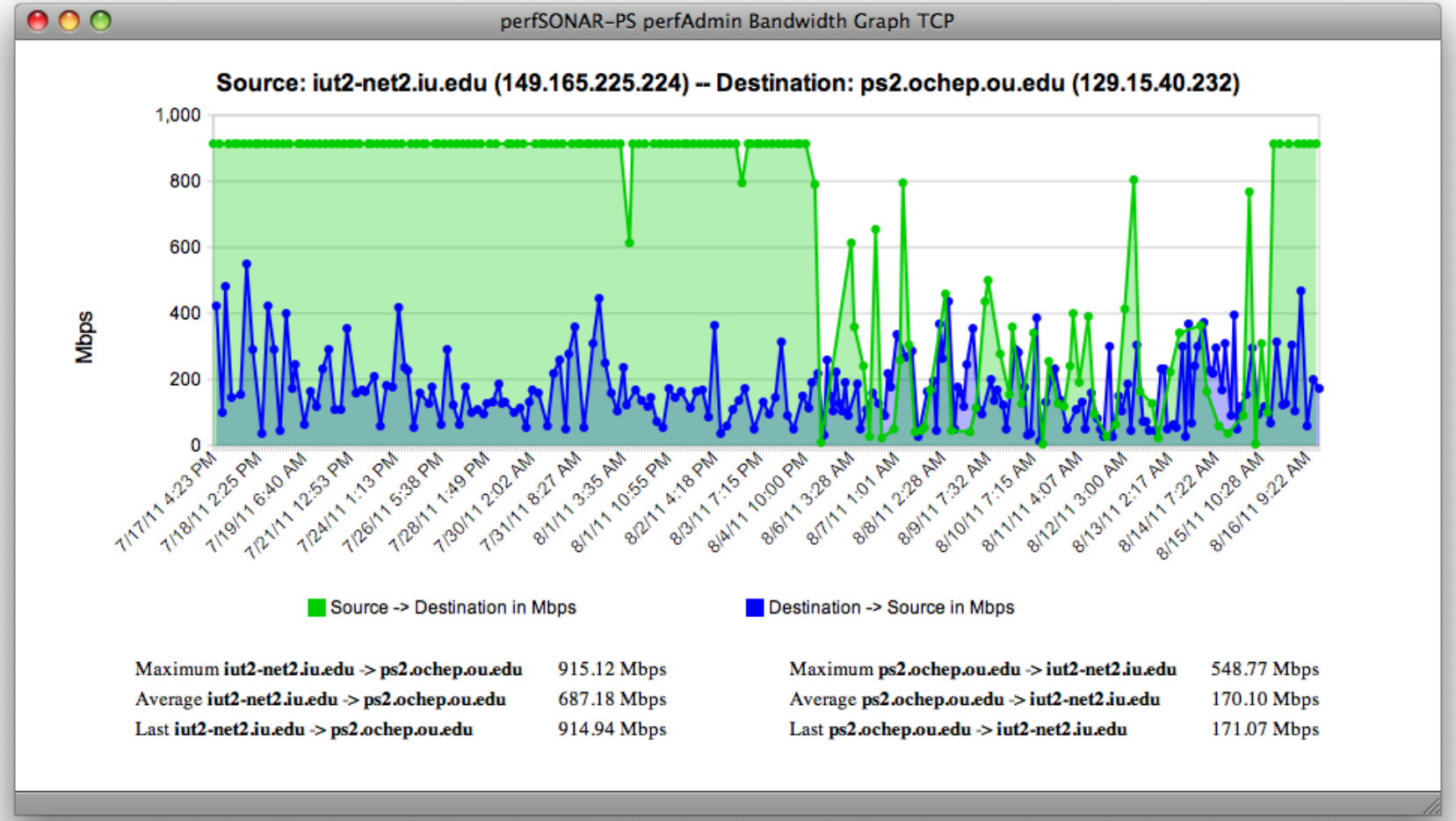

Possible Solution Space

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- Alter routing to use the same path
  - E.g. the 'good' path hopefully ☺
- Fix the "bad" path
- Note these two are often done together
  - Please refrain from just changing routing to avoid a problem and not telling anyone

Routing Change Results (Latency)

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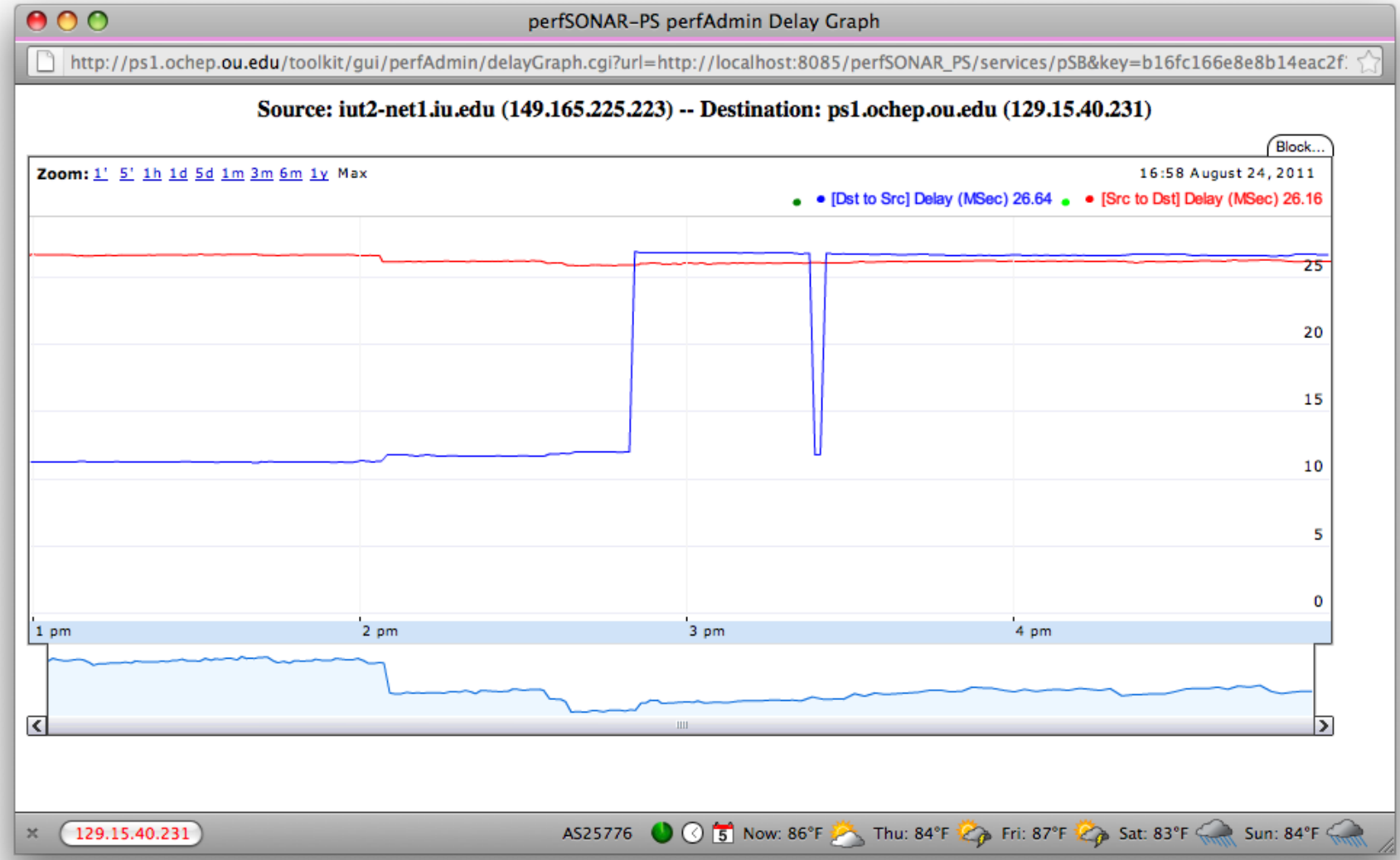

Routing Change Results (Bandwidth)

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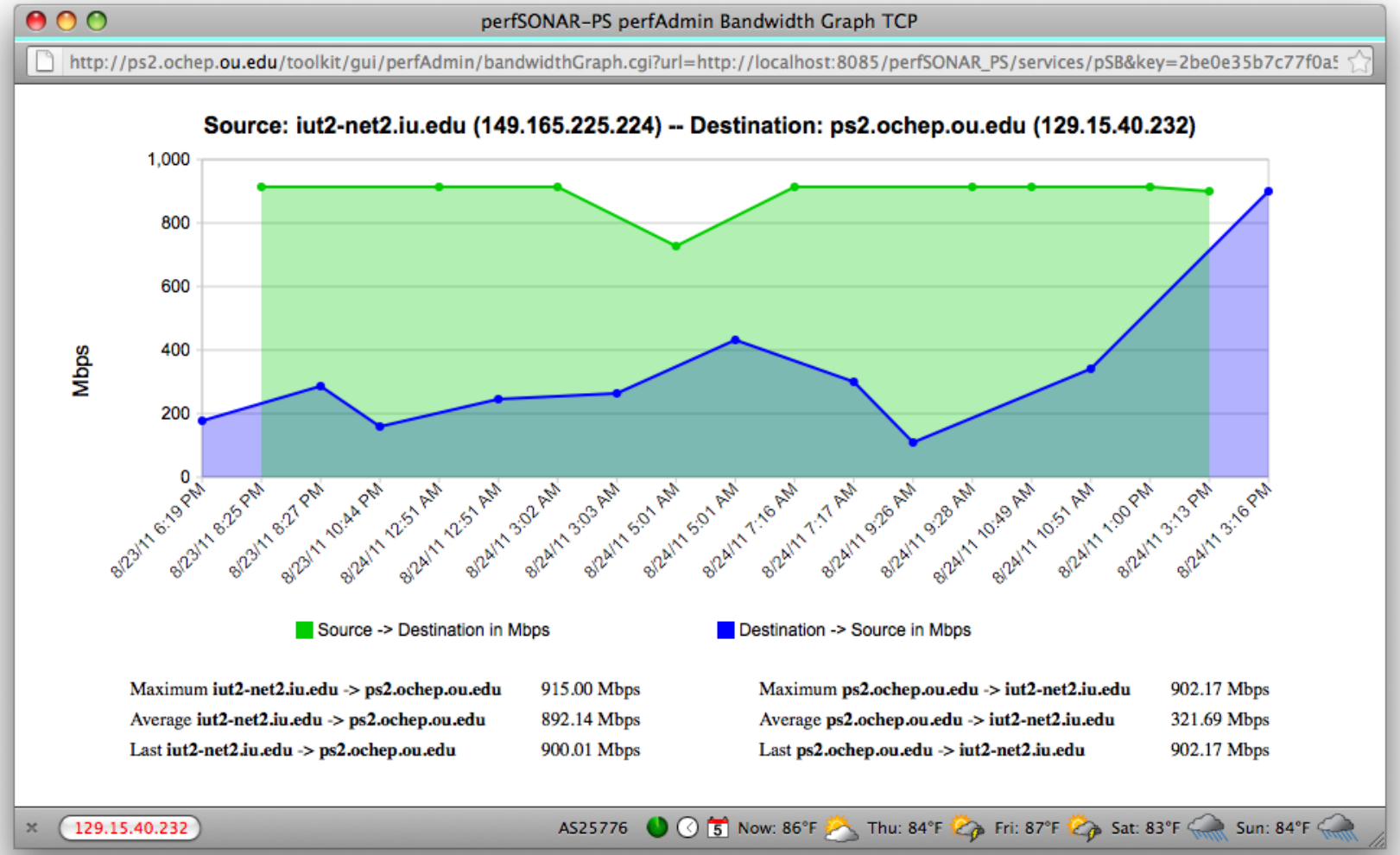

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Routing Change 1 Week Later (Latency)

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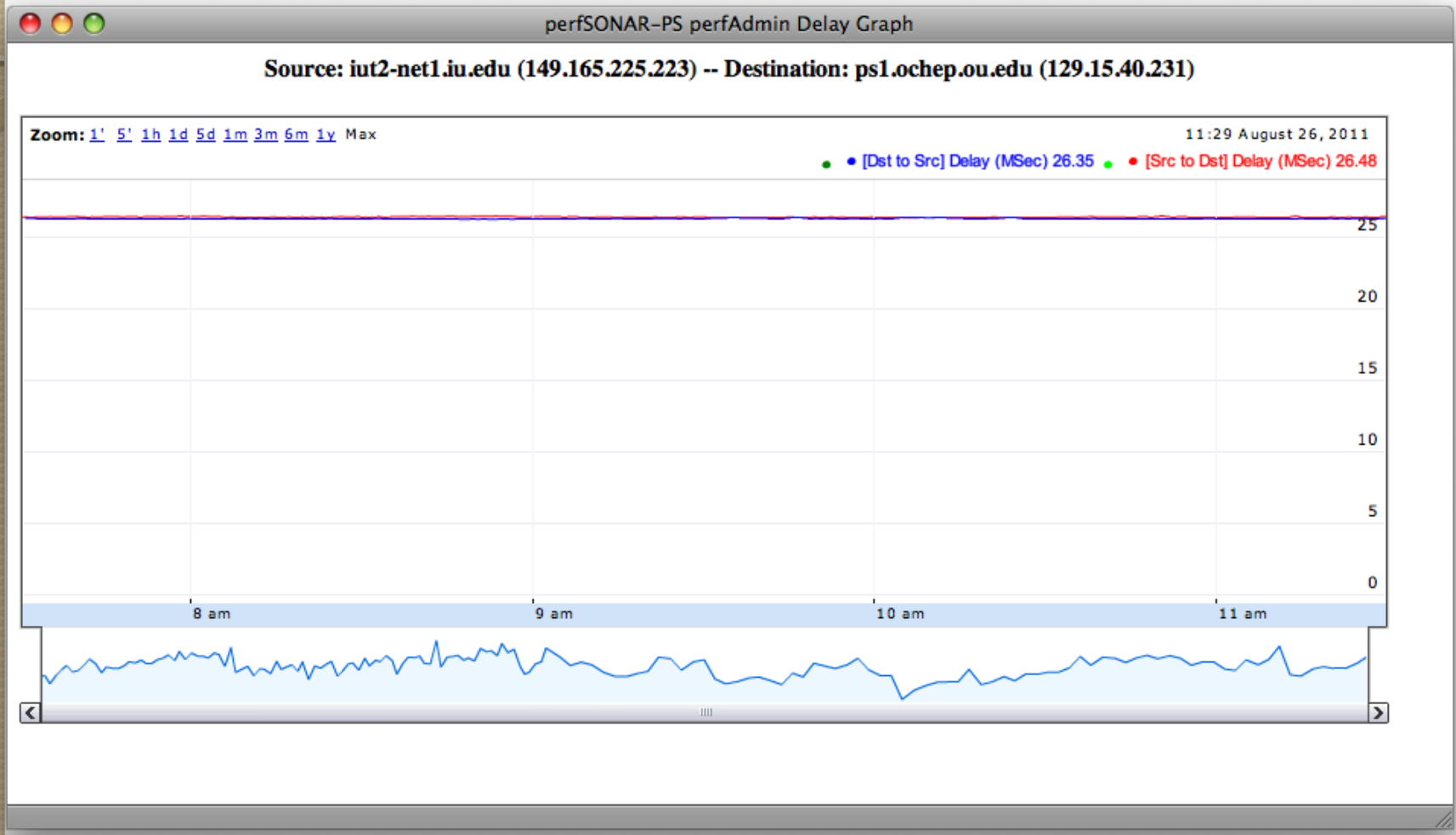

Routing Change 1 Week Later (BW)

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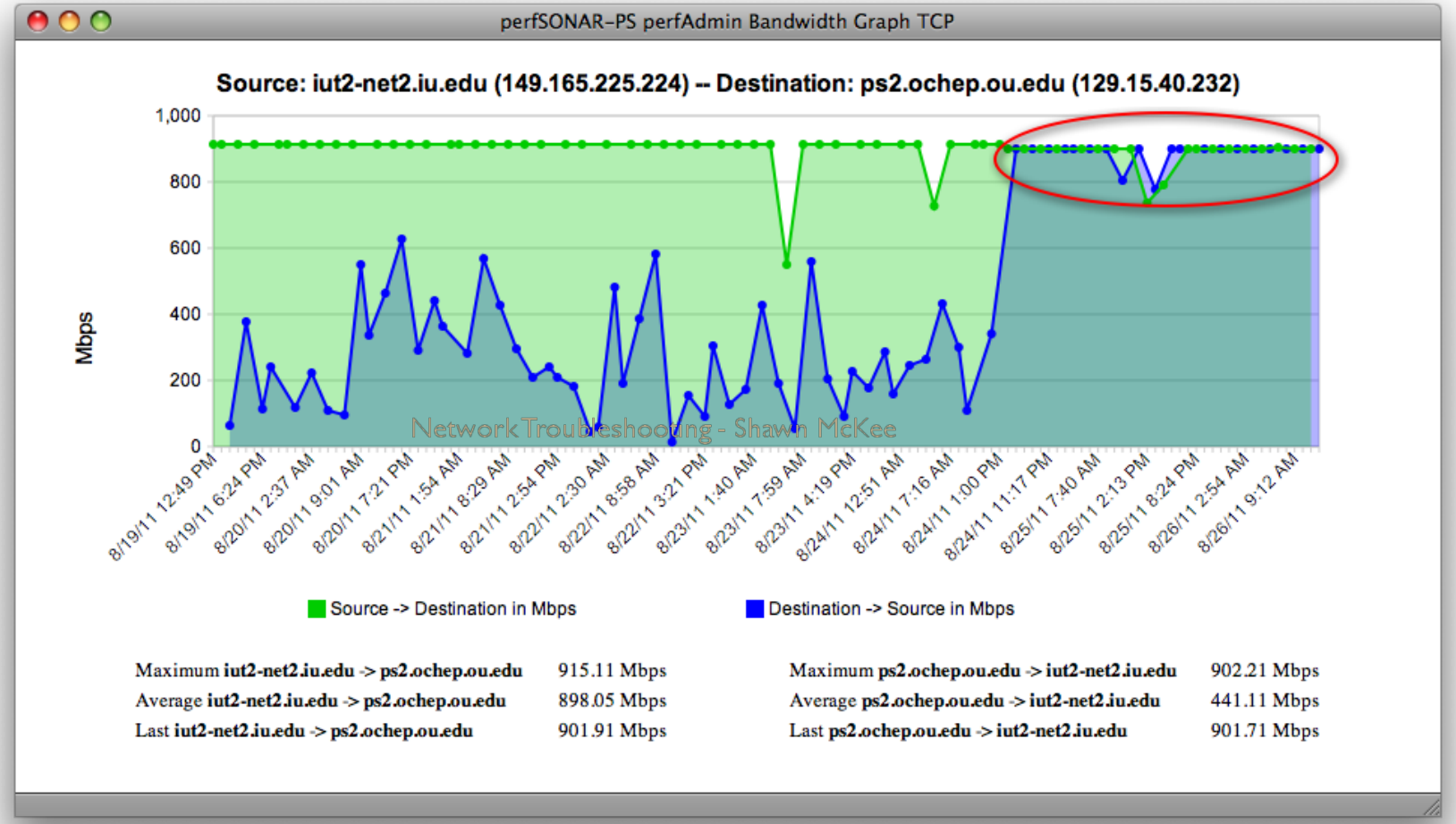

Things are MUCH better.

Checklist for Network Issues

- Check end-hosts for issues
- Use on-demand tests to verify a problem
- Examine any scheduled/existing network metrics for problems
- Gather the relevant data (application, host info source, destination, network metrics, problem)
- Contact your local network people with the information you collected. Also available:
  - - Research Support @ Internet2: rs@internet2.edu
  - - Trouble Reporting @ ESnet: trouble@es.net
- See http://fasterdata.es.net/performance-testing/perfsonar/troubleshooting/overview/ for a good summary of the troubleshooting process

The Future

- Open Science Grid has a new initiative in networking
  - Goal is to provide tools and service to support OSG sites regarding networking
  - New troubleshooting document being written
- There is a new project in GitHub focused on creating a new "Modular Dashboard" to gather, analyze and display perfSONAR metrics (see URLS at end of talk)
- perfSONAR-PS will continue to develop to meet the needs of its users

Summary

- Network issues can be difficult to understand and localize
  - End-users shouldn't be expected to fix network problems BUT they should report them with enough detail to allow experts to do so!
- perfSONAR-PS is a central component for finding network problems. Deploy it! It can help you (and others) find/fix network problems
- Make sure you know who to contact about network problems.

Questions or Comments?

Thanks!

Useful References

- OSG Networking: https://www.opensciencegrid.org/bin/view/Documentation/NetworkingInOSG
- perfSONAR-PS site http://psps.perfsonar.net/
- perfSONAR-PS Install/configuration guide: http://code.google.com/p/perfsonar-ps/wiki/pSPerformanceToolkit33
- ESnet Fasterdata website: http://fasterdata.es.net/
- Modular Dashboard: https://perfsonar.racf.bnl.gov:8443/exda/ or http://perfsonar.racf.bnl.gov:8080/exda/
- GitHub PerfModDash Organization: https://github.com/PerfModDash
- perfSONAR-PS Toolkit tips and maintenance: http://www.usatlas.bnl.gov/twiki/bin/view/Projects/LHCperfSONAR