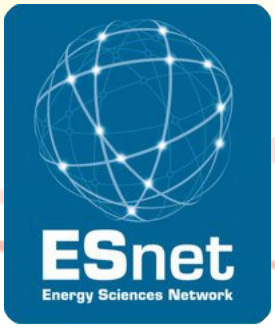

July 22nd 2013, XSEDE Network Performance Tutorial

Jason Zurawski – Internet2/ESnet

Kathy Benninger - Pittsburgh Supercomputing Center

Hardware & Network Placement Overview

Agenda

- Hardware
  - The Basics
  - Time (is not) on Your Side
  - Use Cases
    - Latency
    - Bandwidth
  - Good Choices
  - Poor Choices
- Network Placement
  - Overview
  - Zones
  - Strategies
- Regular Testing Plan
  - Importance
  - Visualizations

The Basics

- Choosing hardware for a measurement node is not a complicated process
- Some basic guidelines:
  - Bare Metal (more on this later)
  - x86 or 64Bit Architecture
  - "Modern" limits for RAM, CPU Speed, Main Storage
    - E.g. it doesn't need to be brand new, but it should be no older than 8 years (e.g. we have evidence of old Pentium II desktop machines working, but not working well ☺)
  - Recycling is fine, unless you have money to burn on a new device (and who doesn't!)

The Basics - Considerations

- The measurement device should fit neatly into your existing infrastructure.
  - E.g. if you have free rack space, a 1U server near the routing devices works
  - If you don't have rack space, perhaps something on the floor makes sense
- Homogenous device choice often means spares parts are available
  - E.g. if you expect failing hard drives and NICs
- Modern hardware is better about power management, resiliency to failure
- Accuracy is what we strive for in measurements:
  - We want accurate, stable clocks
  - We want capable NIC hardware/device drivers
  - We want to have a machine that can handle the moderate load of heavyweight network testing

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Time (is not) on Your Side

- The biggest requirement from the server's perspective, is being able to accurately represent time
- This is done in two ways
  - Computers have a local clock (features a battery backup).
    - New exception to this rule are machines similar to a Raspberry PI.
  - Computerized methods exist to keep the local clock honest
- If the clock is hosed, measurements are hosed

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What is NTP?

- NTP is a protocol designed to synchronize the clocks of computers over a network to UTC
  - Servers will present the data in timezones as needed
  - Synchronize to Internet time servers or other sources, such as a radio or satellite receiver or telephone modem service.
- It can also be used as a server for dependent clients
- Attempts to keep time ***monotonically increasing*** while minimizing offset and skew
  - Sends signals to system clock to correct
  - 'skipping' may be large to start
- Provides accuracies typically ***less than a millisecond on LANs*** and ***up to a few milliseconds on WANs***
- Typical NTP configurations utilize multiple redundant servers and diverse network paths in order to achieve high accuracy and reliability.
  - Redundancy – enough choices to pick a 'good' clock
  - Diverse Paths – Minimize the effect of congestion on a common path

Utility for Measurement

- Scheduling requires coarse grain agreement on time (lets start/end together)
  - Agreement must be "global" in scope – UTC
  - Individual servers communicate with multiple other hosts
- Stability/Accuracy are important
  - Virtualization is still tricky…
- One-Way latency requirements
  - Jitter (requires stability of offset within sample)
  - Latency (requires accuracy)
- Sensible compromise
  - Well defined error representation

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Acceptable clock use

- NTP should stabilize the clock over time
- Measurements (e.g. OWAMP) will reflect this change
  - Less 'skipping'
  - No more 'negative' measurements
- NTP will remain in a steady state unless there are network/host problems
  - Selecting constantly between the best 'peer' clocks
  - Network routing causing delay between peers
  - Host temperature fluctuations, CPU variability

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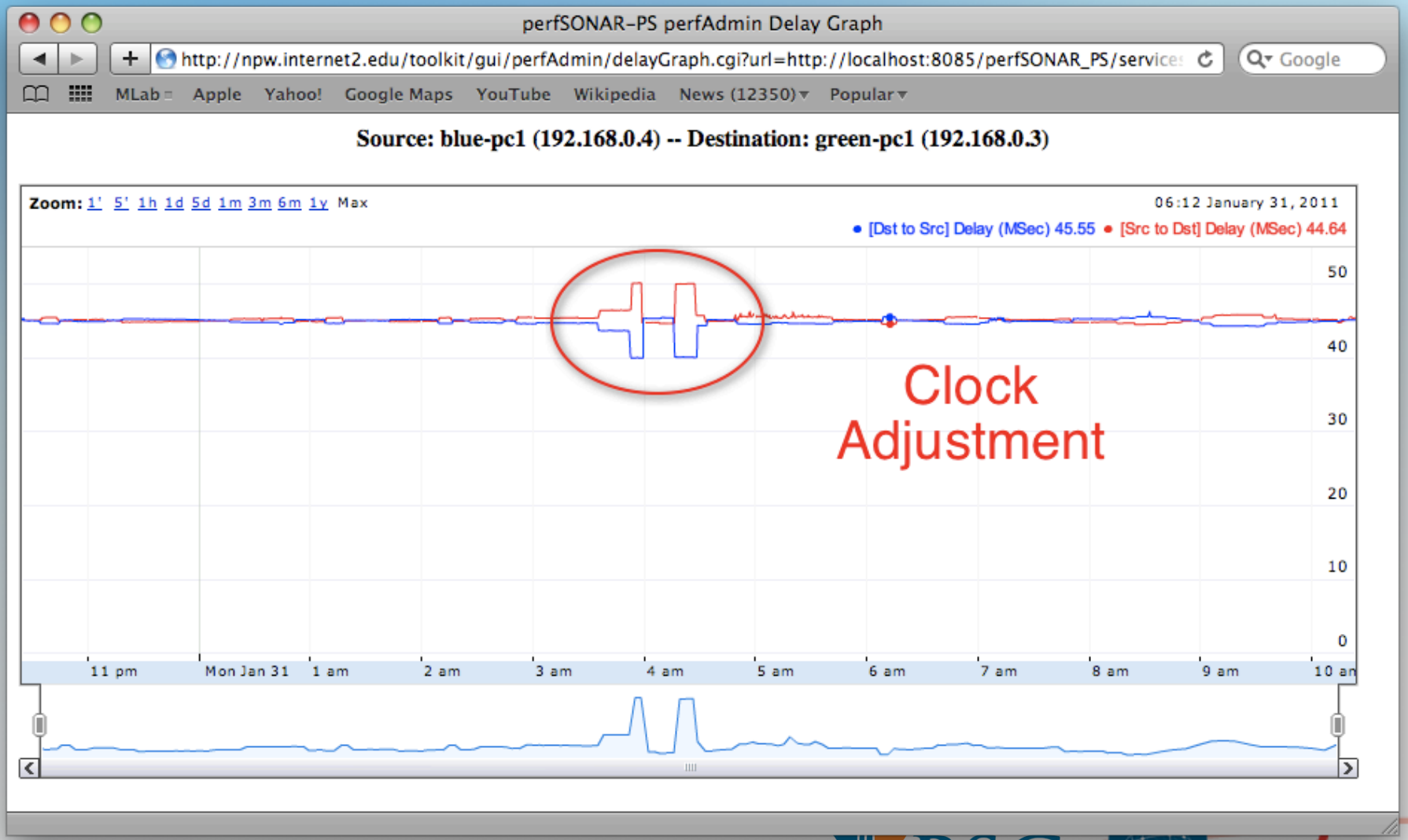
Acceptable clock use – OWAMP Data



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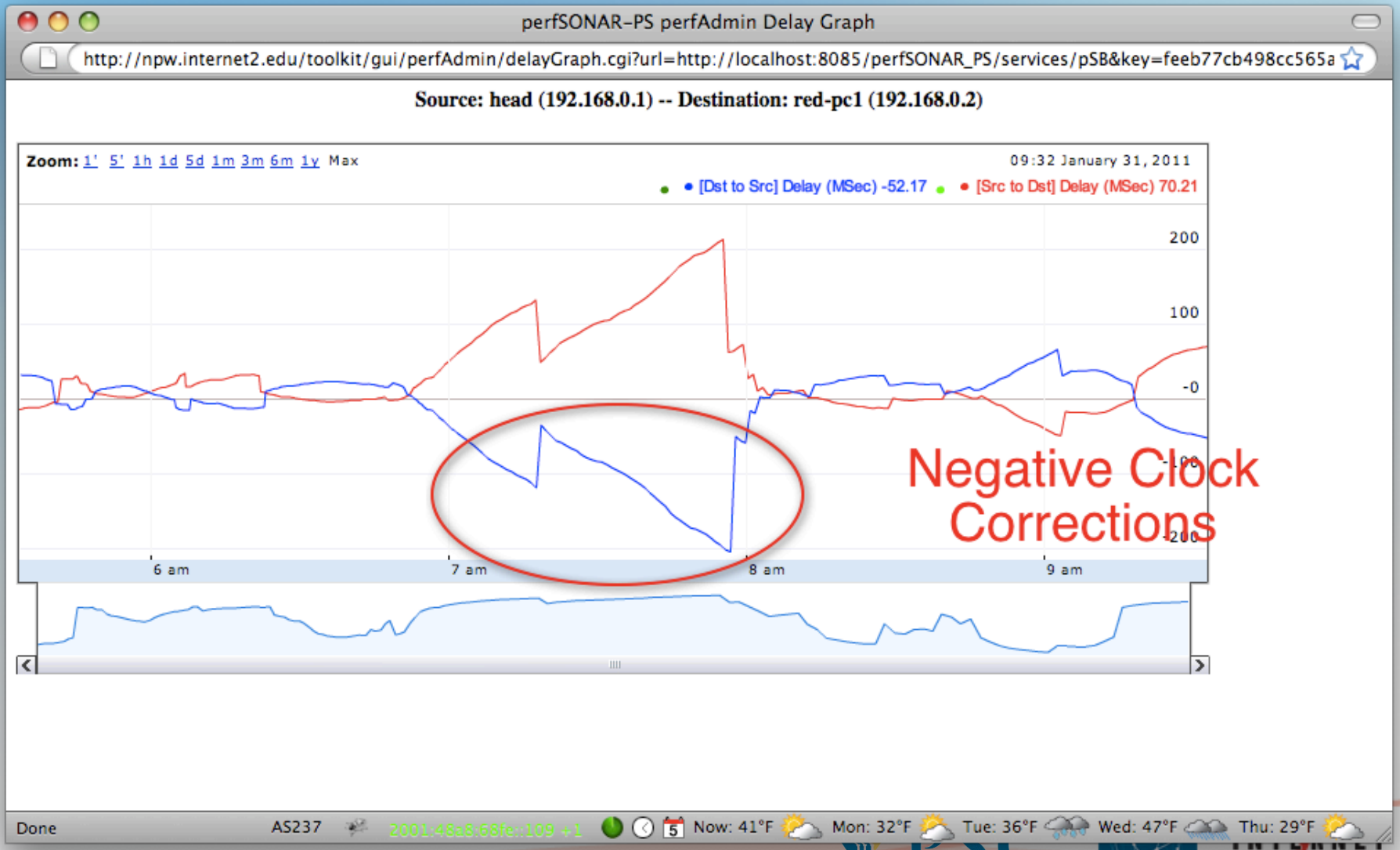
Poor clock use

- NTP cannot stabilize the clock
  - CMOS battery failure
  - Poor selection of peers
  - Network congestion
  - Host invariability (temperature, CPU)
- Frequent skips in perceived time
- Measurement is unreliable (negative latencies)
- High Jitter

Poor clock use – Skew in OWAMP Data



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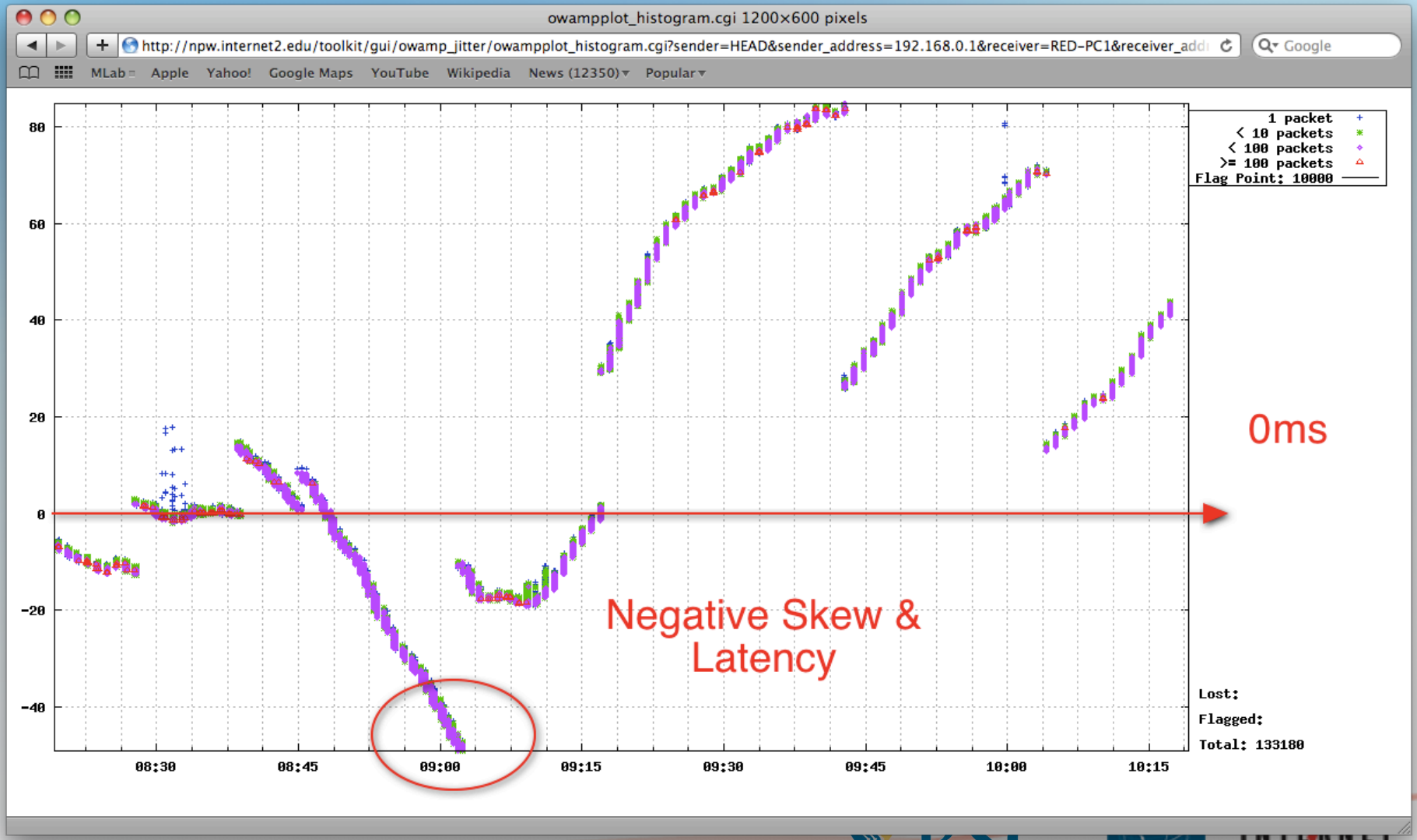
Poor clock use – Jitter in OWAMP Data



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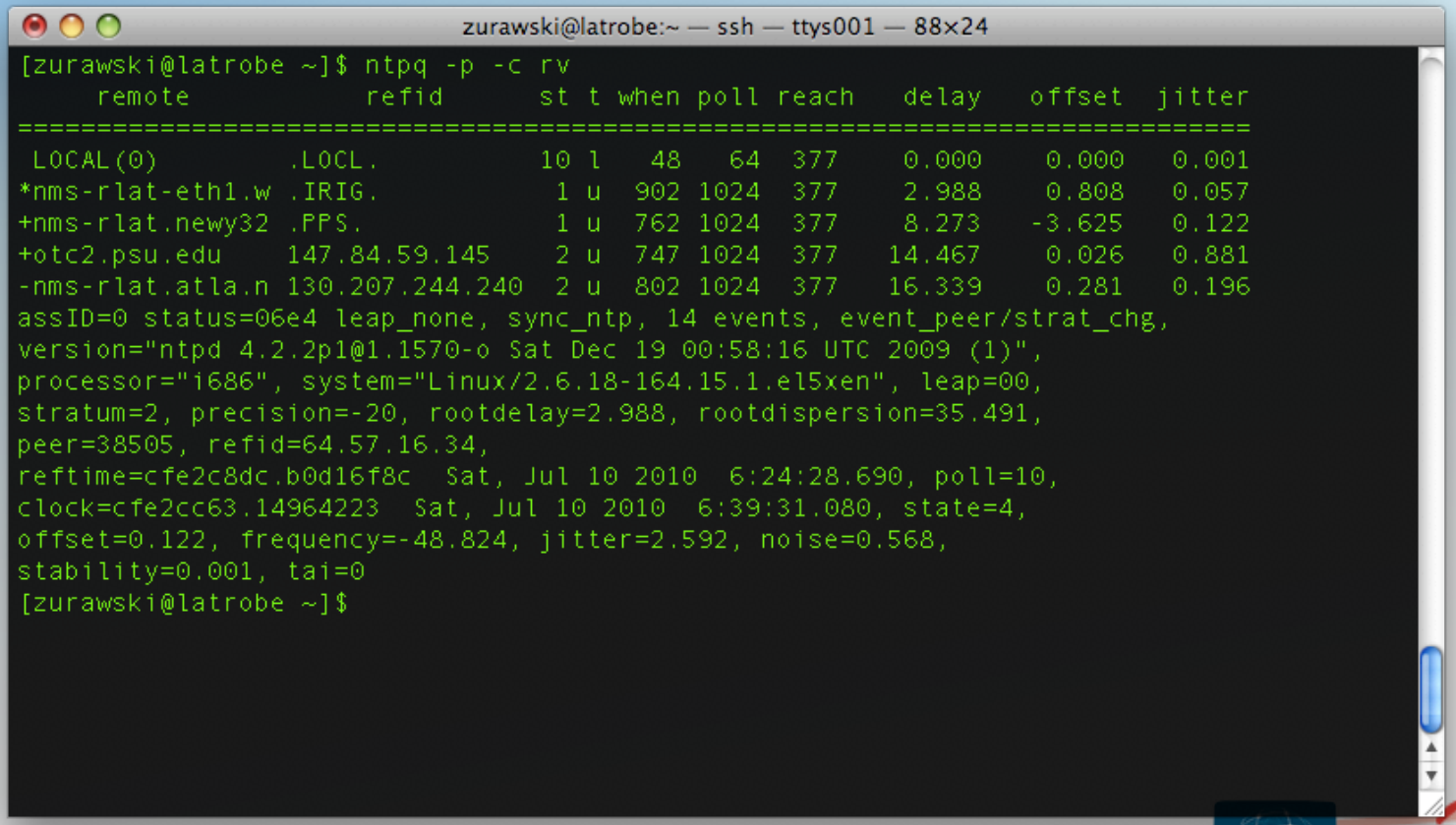
Verify NTP – Do this live if you Like

- **`ntpq –p –c rv`**



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Use Cases

- When selecting hardware, consider there are two basic use cases in the measurement world:
  - Lightweight Testing, normally related to Latency (Ping, Traceroute, OWAMP, Passive Measurements)
  - Heavier Testing, normally related to Bandwidth (BWCTL, IPERF, NUTTCP, NPAD, NDT)
- Hardware requirements can be relaxed in the case of the former

Use Cases - Latency

- A 10G card isn't really need, 1G is recommended (100M would be ok as well, just be sure the driver is recent)
  - Be careful with TCP offload on some NICs, it can introduce OOP
- CPU load is minimal, single core single CPU is fine. Doesn't need to be a whole lot of MHz/GHz
  - Multi-core/processor systems can sometimes introduce jitter on their own if interpret processing is not handled efficiently
- RAM is also minimal, enough to support a modern Linux distro (1G should be sufficient)
- Main Memory is where you do need some power. OWAMP Regular testing data can build up over time. Several G a month depending on who you are testing against.
  - This can be cleaned out if you are space constrained
  - We recommend 200G to be safe.

Use Cases - Bandwidth

- 1G is a common use case, but if you can do 10G aim for this
  - Same caveat about drivers – there are some nasty kernel/driver interactions stories out there …
- CPU should be beefy, you do want a pretty good pentium/xeon on your side. Multi-cores/ processors are not a requirement
- RAM should be consistent with the CPU, 2G+ is good
- The main memory requirements are not as great as the latency machine, 100G is more than enough.

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Good Choices

- Modern Server Class Hardware
  - Internet2 uses Dell Power Edge 1950s (from 2005!) and these are still kicking
  - I have been testing some Dell R310s lately. Pretty cost effective (EDU pricing of around $1.5k if you add on a 10G card and some LR optics)
  - Supermicro makes a nice 1U/Half Size machine with an Atom processor. These are excellent for Latency testing (don't push it with the bandwidth though

Good Choices

- Desktop Towers
  - I don't test these often, most are probably ok for temporary use cases.
  - "Energy Saving" models are a little suspect, these could reduce CPU power and effect the clock
- Laptops
  - I wouldn't recommend this for longer term use, but for diagnostics they are mobile and effective

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Poor Choices

- Virtual Machines
  - Our largest concern is the clock
    - A VM gets its time updates from the Hyporvisor
    - The HV gets updates via the system (hopefully it is running NTP)
    - If the VM is also running NTP, it will attempt to keep the clock stable, but the 'backdoor' updates to the VM clock from the HV will skip time forward/backward – confusing NTP
    - Think about what happens if the VM is swapped out …
  - Situations where a VM is ok:
    - NDT/NPAD Beacon
    - 1G bandwidth testing
    - SNMP Collection, NAGIOS Operation
  - Situations where it is not:
    - OWAMP measurements
    - 10G Throughput

Poor Choices

- Mac Mini and similar micro-machines
  - Largest concern here is that the 1G NIC is on the motherboard, and competes for BUS resources.
    - This introduces jitter in latency measurements
    - Reduces throughput tests
  - Power management can be funky too
- Desktops/Laptops (for permanent placement)
  - Power management is a concern for aforementioned reasons
  - Onboard NICs are common here as well

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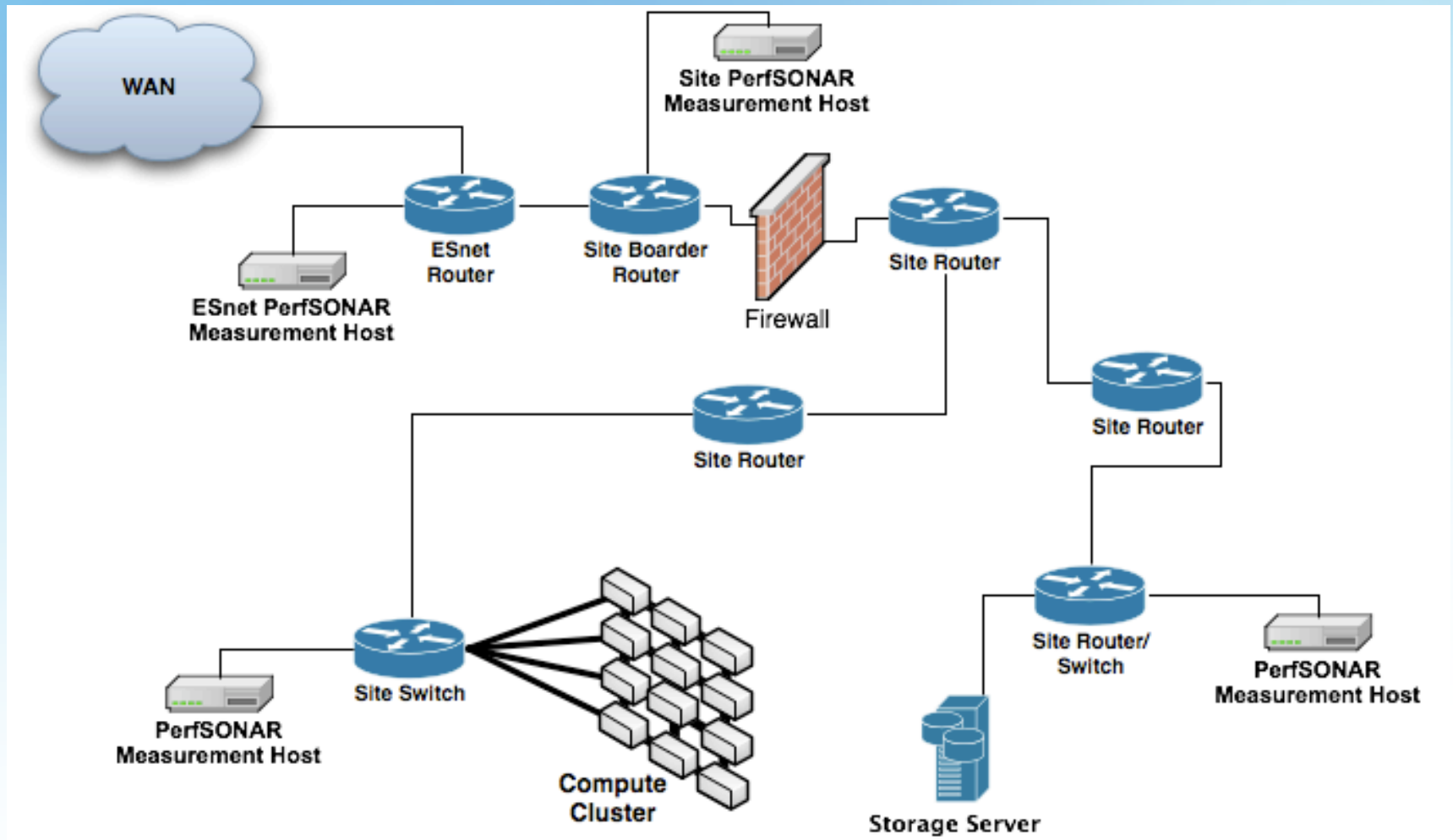
perfSONAR Deployment Locations

- Critical to deploy such that you can test with useful semantics
- perfSONAR hosts allow parts of the path to be tested separately
  - Reduced visibility for devices between perfSONAR hosts
  - Rely on counters or other means where perfSONAR can't go
- Effective test methodology derived from protocol behavior
  - TCP suffers much more from packet loss as latency increases
  - TCP is more likely to cause loss as latency increases
  - Testing should leverage this in two ways
    - Design tests so that they are likely to fail if there is a problem
    - Mimic the behavior of production traffic as much as possible
- ***N.B.*** don't design your tests to succeed – ***it is not helpful***

Why is Placement Important

- Placement of a tester should depend on two things:
  - Where a tester will have the most positive of impacts for find/ preventing problems
  - Where space/resources are available
- We want to find certain sets of problems:
  - Edge of your network to edge of your upstream provider
    - E.g. University to Regional Network
    - Regional Network to Backbone Network
  - Core of your network to Edge of your network and upstream providers
    - Campus core facility to demarcation point
    - Campus core to WAN Connectivity
  - Location of important devices to remote facilities and points in between
    - Data centers to consumers of said data (e.g. campus to campus)
    - Data centers to WAN Connectivity

Sample Site Deployment



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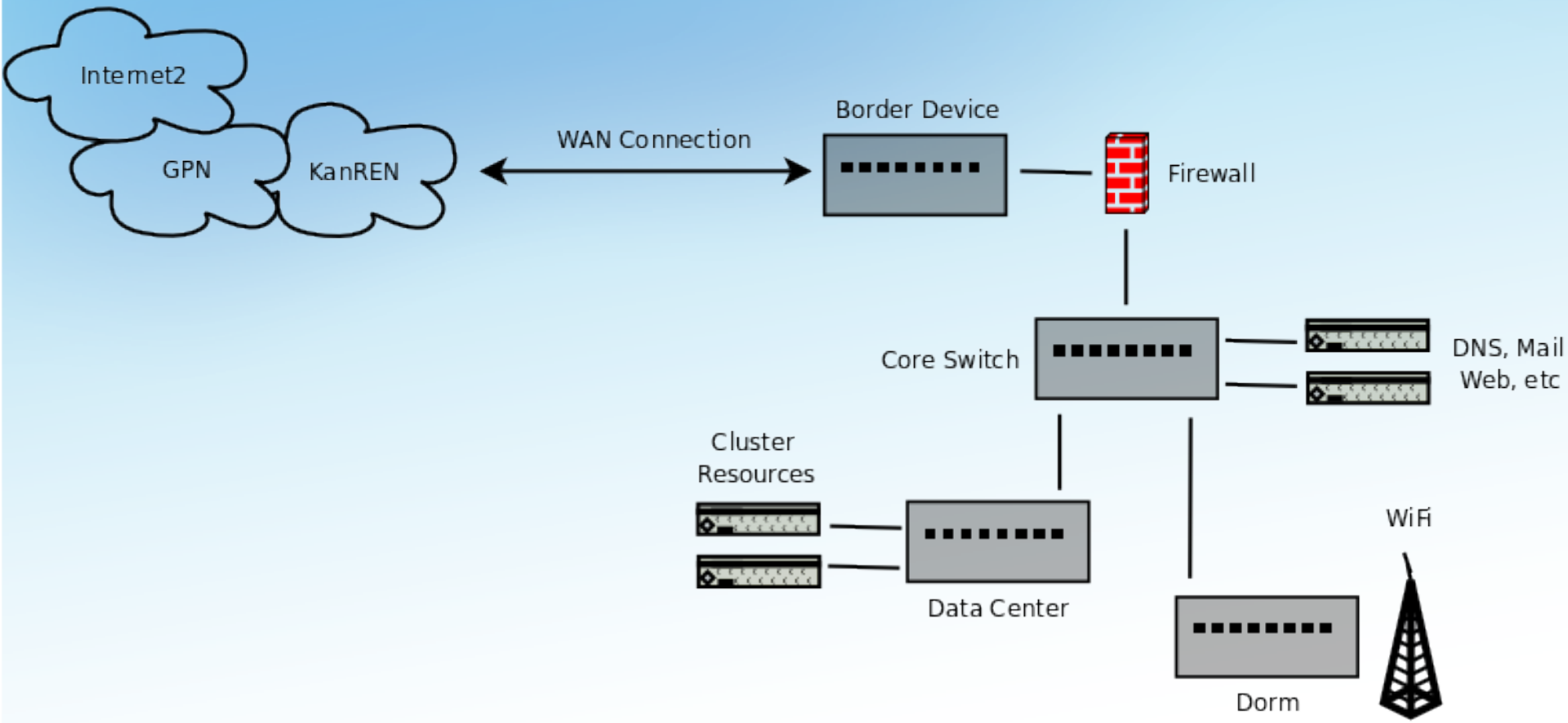
Constructing Zones

- Networks are large and complex, but can be broken into a couple of common components:
  - Main Distribution Frame (MDF) where the WAN connectivity will land.
  - Intermediate Distribution Frames (IDF) in other buildings (major components on a LAN)
  - The Network "core" which may be data center that houses key components (Mail, DNS, HTTP, Telephony)
  - Population centers (Dorms, Offices, Labs, Data Centers)

The Network


Internet2
GPN
KanREN
WAN Connection
Border Device
Firewall
Core Switch
DNS, Mail
Web, etc
Cluster
Resources
Data Center
WiFi
Dorm

Constructing Zones - Demarcation

- MDFs where the WAN connectivity Lands
  - May have provider hardware there too – position either between, or on your end of the demarcation
  - Some providers (e.g. ESnet) locate a server on their end too.
- If you have rack space/power, try to allocate a server directly connected to the border device
  - ***DO NOT*** put it behind the firewall/shaper(!!)
  - To get the best indication of "network" performance, we need to remove network devices from the equation.
- If security is really a concern, consider using a LiveCD and calling it an 'appliance'. This works at US National Labs ☺

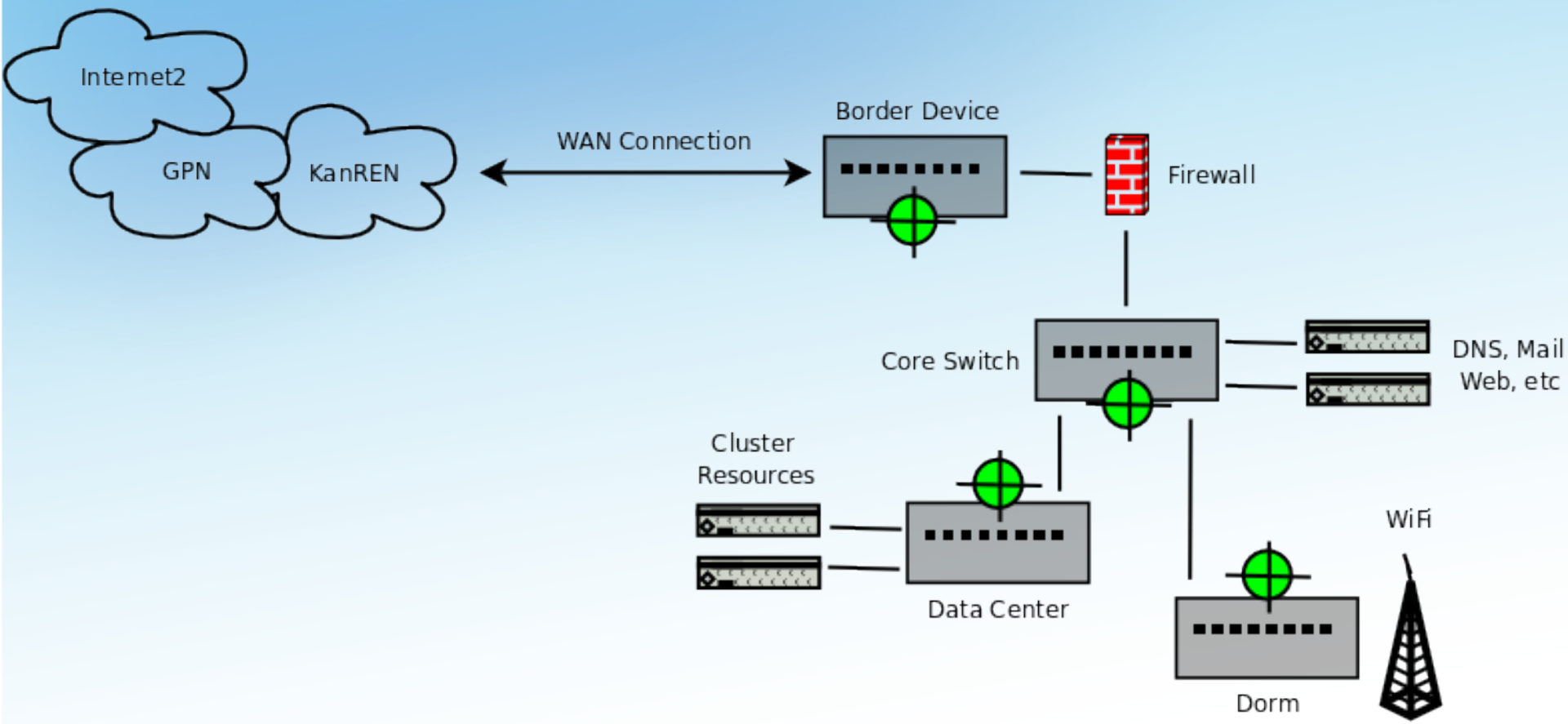
Constructing Zones - Core

- Most likely essential services are in a temperature controlled environment somewhere on campus.
- Rack a device here if power/space allow
  - Ideally it should be on the main Switch/Router for this facility.
  - This CAN be behind firewalls/shapers (but remember this when you are looking at results)
    - Packet loss/jitter/low bandwidth may be caused by the firewall shaper.
    - Comparing performance from behind the firewall to a remote location (KanREN) vs from in front of it is a fun exercise.
- Having the device here will allow testing from all over campus to the most central part of the network

Constructing Zones – Busy Areas

- Busy areas:
  - High Performance Computing Centers (HPCCs)
  - Large Labs
  - Offices/Dorms with a large population of untrusted users
  - Aggregation Points (e.g. ingress of several connections before using a larger access link)
- Space/Power rules apply (e.g. the access switch in a dorm may be in a cramped closet).
- If you are a mostly WiFi shop, put it near the controller.
- Portable devices may be a good choice here, for diagnostic use instead of regular testing

Placement Strategy



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Testing Strategies

- Once the machines are placed, think about use patterns:
  - Internal performance assurance around the campus
    - For the users
    - For the operations team
  - Keeping the upstream providers honest (verifying SLAs)
  - Testing end to end, verifying that multi-domain uses (video, data movement) will work

Testing Strategies - Internal

- Edge Machine
  - Use this as a beacon, allow the Core and Population Center machines to test toward this
- Core Machine
  - Test to the Edge and all Population Centers
- Population Centers
  - Test to the Edge and Core – testing to other population centers is not required.

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Importance of Regular Testing

- You can't wait for users to report problems and then fix them (soft failures can go unreported for years!)
  - Things just break sometimes
    - Failing optics
    - Somebody messed around in a patch panel and kinked a fiber
    - Hardware goes bad
- Problems that get fixed have a way of coming back
  - System defaults come back after hardware/software upgrades
  - New employees may not know why the previous employee set things up a certain way and back out fixes
- Important to continually collect, archive, and alert on active throughput test results

Develop a Plan

- What are you going to measure?
  - Achievable bandwidth
    - 2-3 regional destinations
    - 4-8 important collaborators
    - 4-10 times per day to each destination
    - 20 second tests within a region, longer across oceans and continents
  - Loss/Availability/Latency
    - OWAMP: ~10 collaborators over diverse paths
    - PingER: use to monitor paths to collaborators who don't support owamp
  - Interface Utilization & Errors
- What are you going to do with the results?
  - NAGIOS Alerts
  - Reports to user community
  - Post to Website

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Dashboards – What the Serious Use

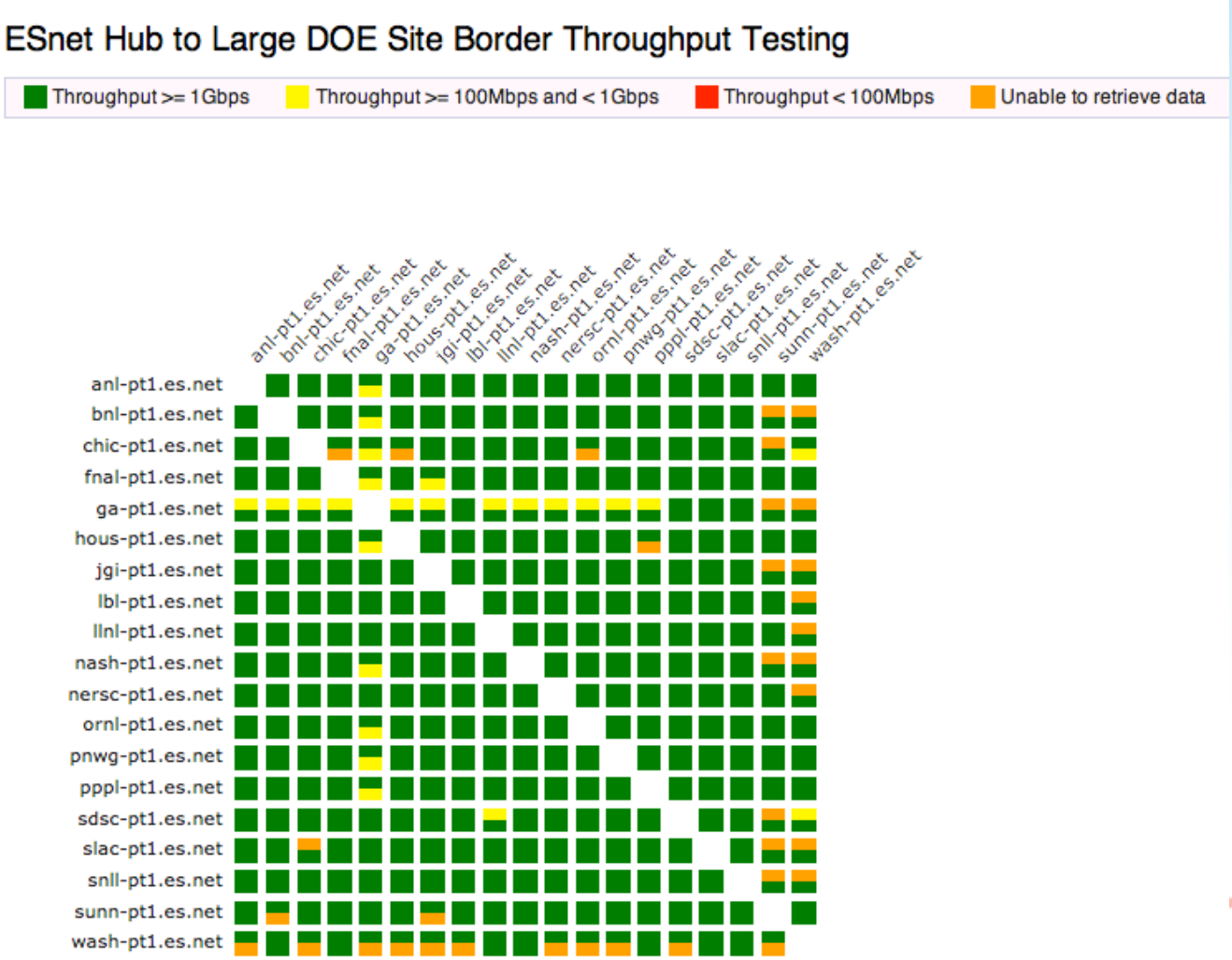
Status of perfSONAR Throughput Matrix

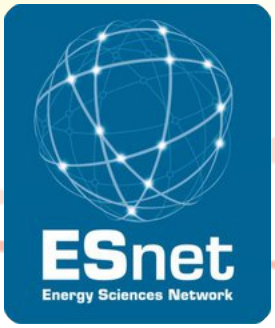
-	0	1	2	3	4	5	6	7	8
0:atlas-npt2.bu.edu	-	OK OK	OK OK	OK OK	OK OK	OK OK	UNKNOWN OK	OK OK	OK OK
1:lhcmon.bnl.gov	OK OK	-	OK OK	OK OK	OK OK	OK OK	OK OK	OK UNKNOWN	OK OK
2:ps2.ochep.ou.edu	OK OK	OK OK	-	OK OK	OK OK	OK OK	OK UNKNOWN	OK OK	OK OK
3:psmsu02.aglt2.org	OK OK	OK OK	OK OK	-	OK OK	OK OK	UNKNOWN UNKNOWN	OK OK	OK OK
4:netmon2.atlas-swt2.org	OK UNKNOWN	UNKNOWN OK	OK OK	OK OK	-	OK UNKNOWN	OK UNKNOWN	OK OK	OK OK
5:iut2-net2.iu.edu	OK OK	OK OK	OK OK	OK OK	OK OK	-	OK OK	OK OK	OK OK
6:psnr-bw01.slac.stanford.edu	OK UNKNOWN	OK OK	UNKNOWN OK	UNKNOWN UNKNOWN	UNKNOWN UNKNOWN	OK OK	-	OK OK	UNKNOWN UNKNOWN
7:uct2-net2.uchicago.edu	OK OK	OK OK	OK OK	OK OK	OK OK	OK OK	OK OK	-	OK OK
8:psum02.aglt2.org	OK OK	OK OK	OK OK	OK OK	OK OK	OK OK	UNKNOWN UNKNOWN	OK OK	-

Dashboards – What the Serious Use

2: ESnet to ESnet Throughput Testing Dashboard

ESnet Hub to Large DOE Site Border Throughput Testing





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perfSONAR powered