

Network Measurement Tools

ESnet Site Coordinators Meeting

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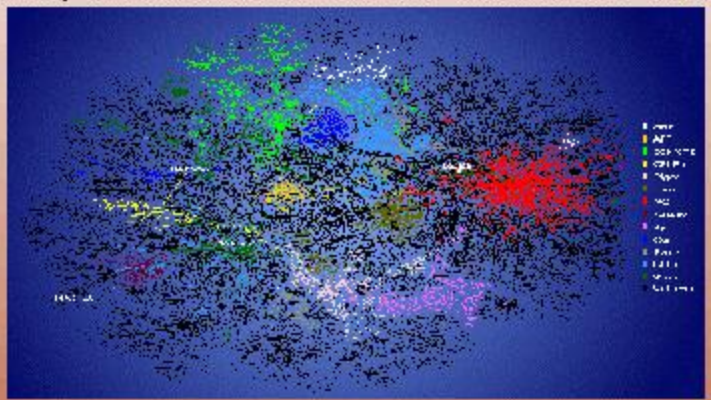
Net Monitoring/Management

- topology (mapping)
- workload characterization (passive)
- performance evaluation (active)
- routing (dynamics)
- visualization (massive datasets)
- network management (correlation & integration)



infrastructure–wide priorities

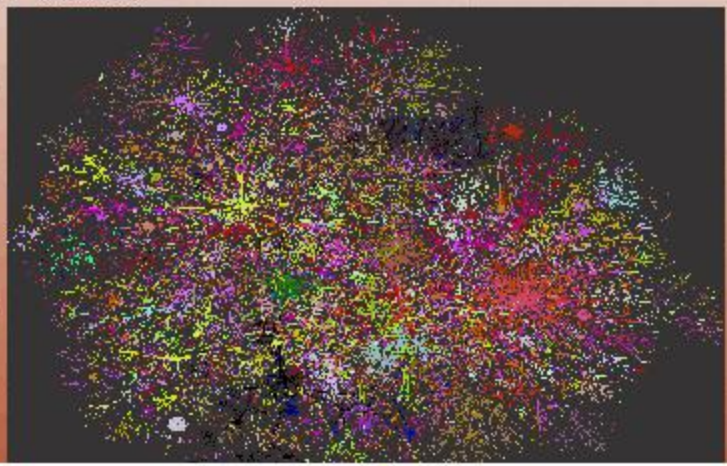
- dynamically discover/depict topology (& b/w)
- correlate effects with BGP routing changes
- correlate path performance with specific events
- identify critical infrastructure within the Internet





skitter: infrastructure wide measurements

- insights into inter-SP connectivity, routing, performance
- 18 monitors (inc. 1 root name server)
- multiple lists 29k servers / 56k 2nd root server destinations
- architecture:
  - parallel ICMP probes
  - 52-byte packets
  - kernel time stamping
  - ssh / Kerberos





infrastructure: DNS roots

- RSSAC, DNS technical advisory committee to ICANN
- co-locate skitter hosts w/ root servers
- demonstrate root server performance in serving target community
- develop techniques for evaluating architectural optimality for root server placement

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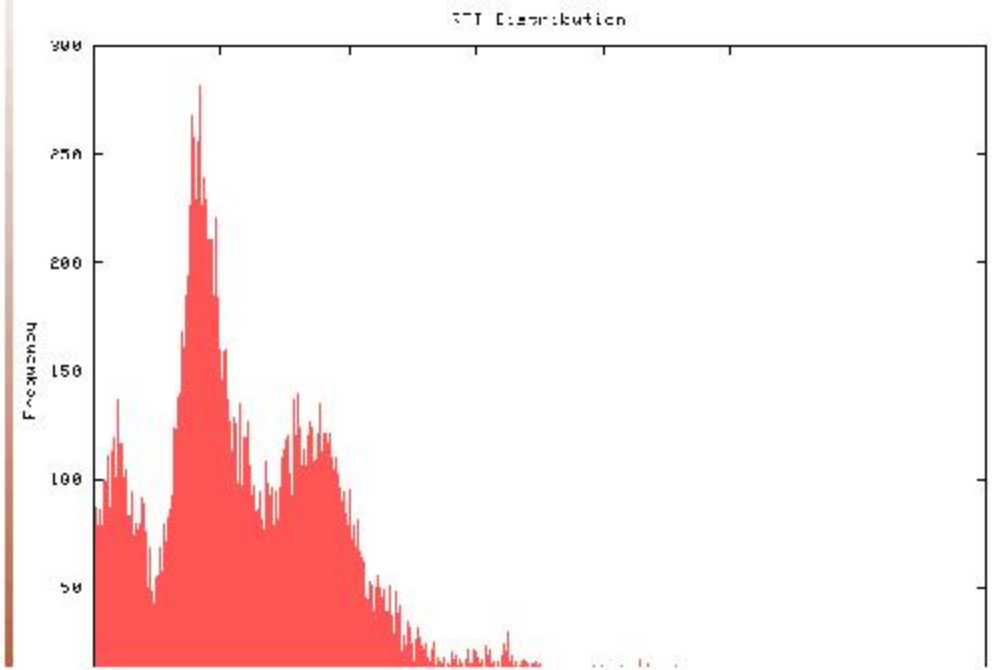
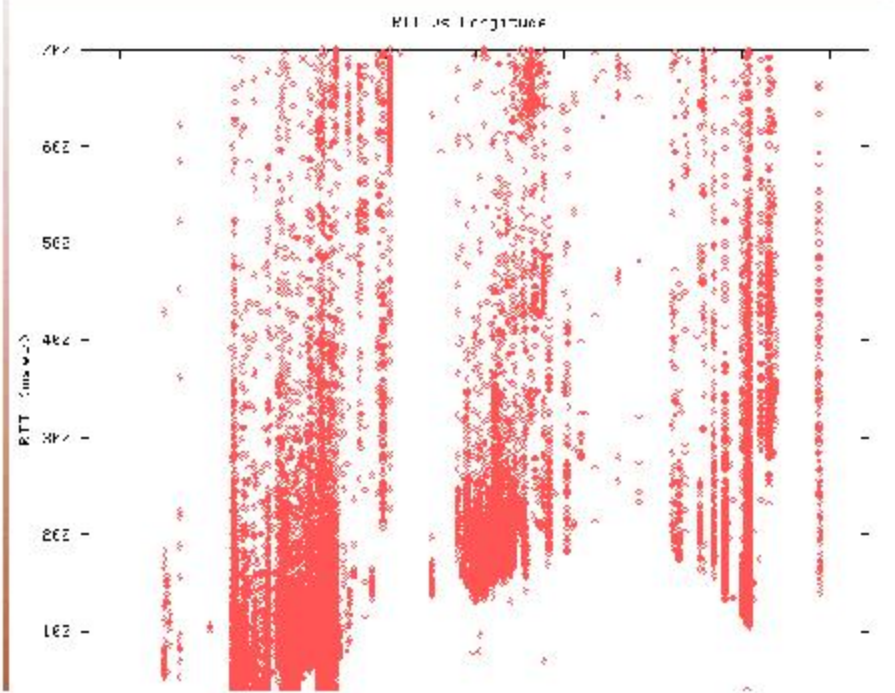
skitter: rtt distribution: tri modal



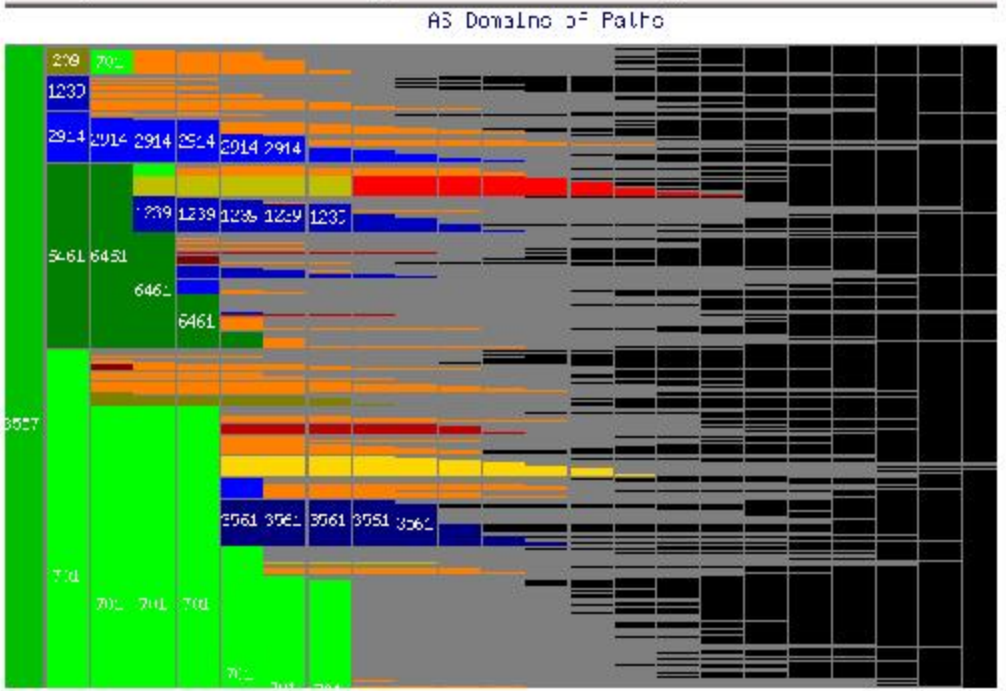


skitter: rtt vs longitude (light cone)





dispersion among ASes across paths


AS Domains of Paths
209
1239
2914
2914
2914
2914
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1239
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6461
6461
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3561
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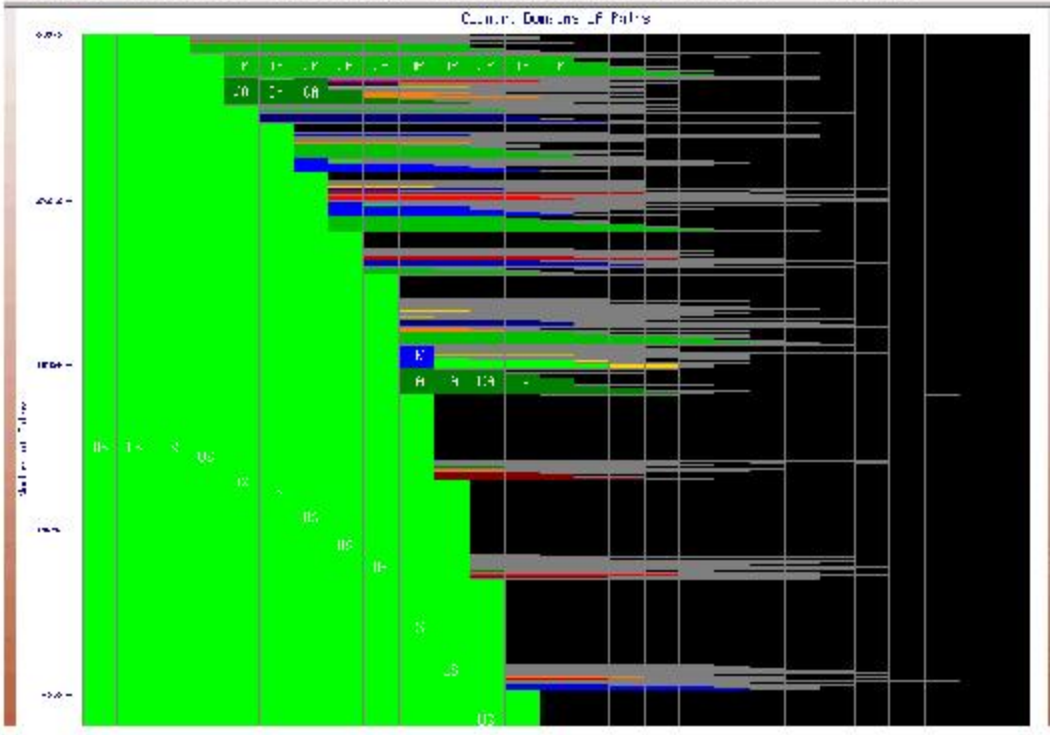
3561



dispersion among countries across paths





workload characterization (passive monitoring)

- uses: research, equipment design, operational (engineering/security/policing), & accounting
- router-based implementations, e.g., cflowd, netflow
- stand-alone monitors, e.g., CoralReef (OC3, 12, 48)
  - persistent real-time full frame collection
  - security: dynamic pkt filtering trigger by attack precursors
  - Dag 4.1 (OC48 POS) testing planned 6/00
- NLANR MOAT - 15 monitors collecting traces (http://moat.nlanr.net/pma)

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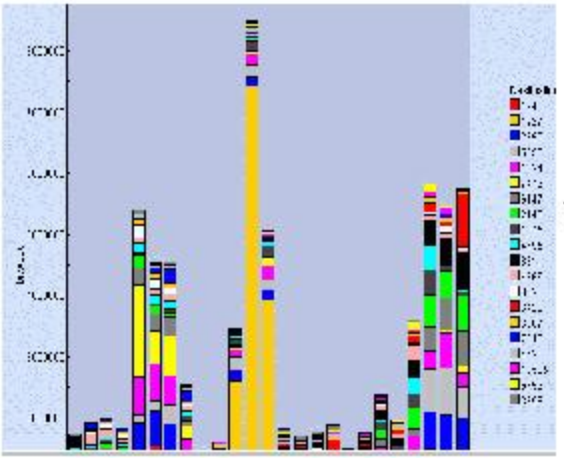
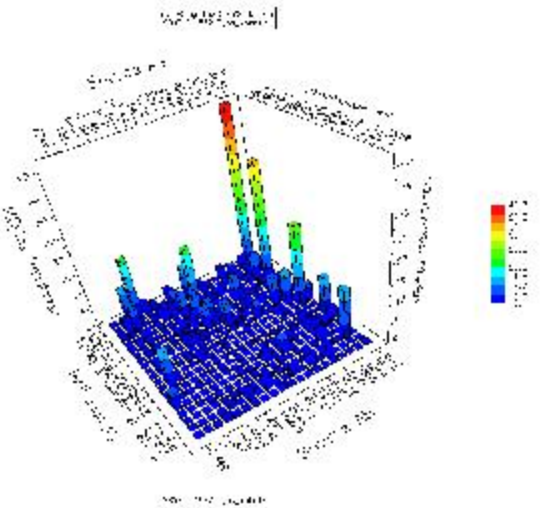
analysis for peering & capacity planning



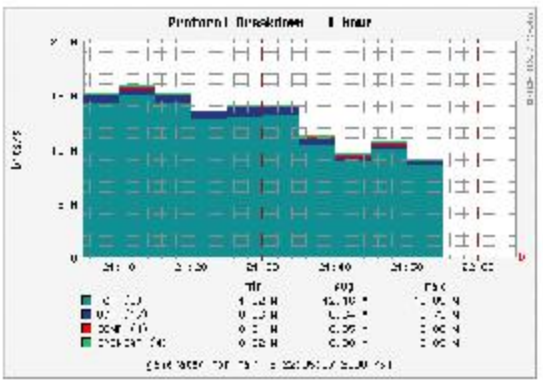


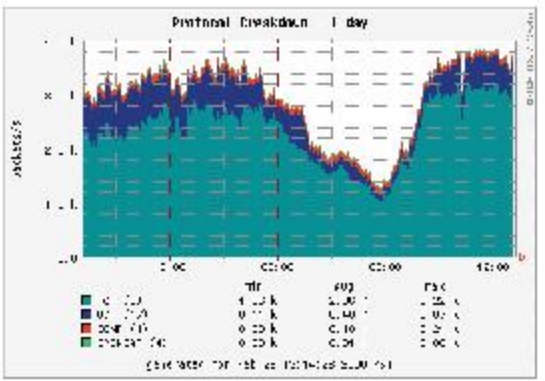
www.caida.org/tools/measurement/cflowd

www.caida.org/tools/measurement/coralreef/

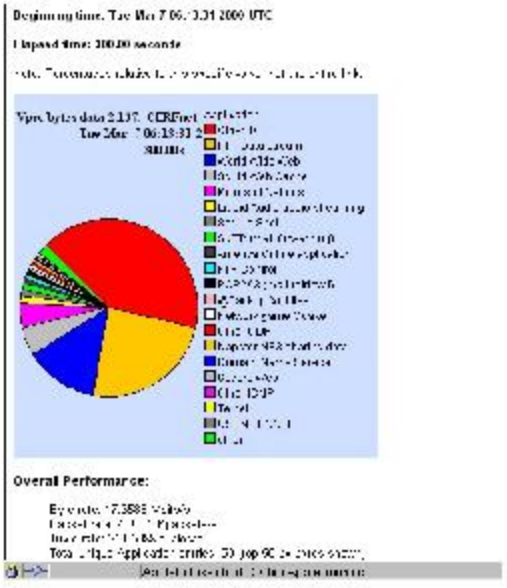
CoralReef: operational data

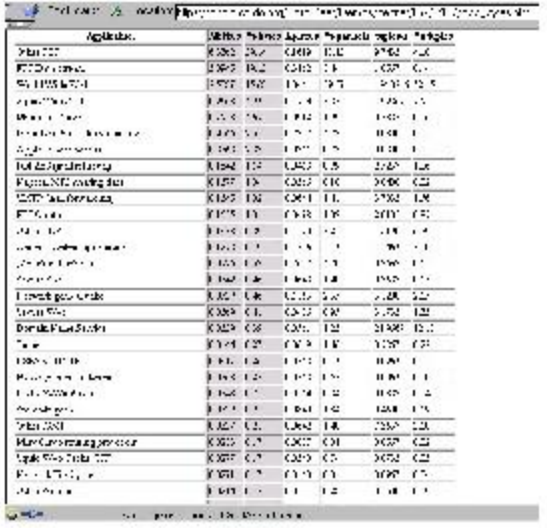
https://analacaida.org/CoralReef/Demos/cerfnet/link/

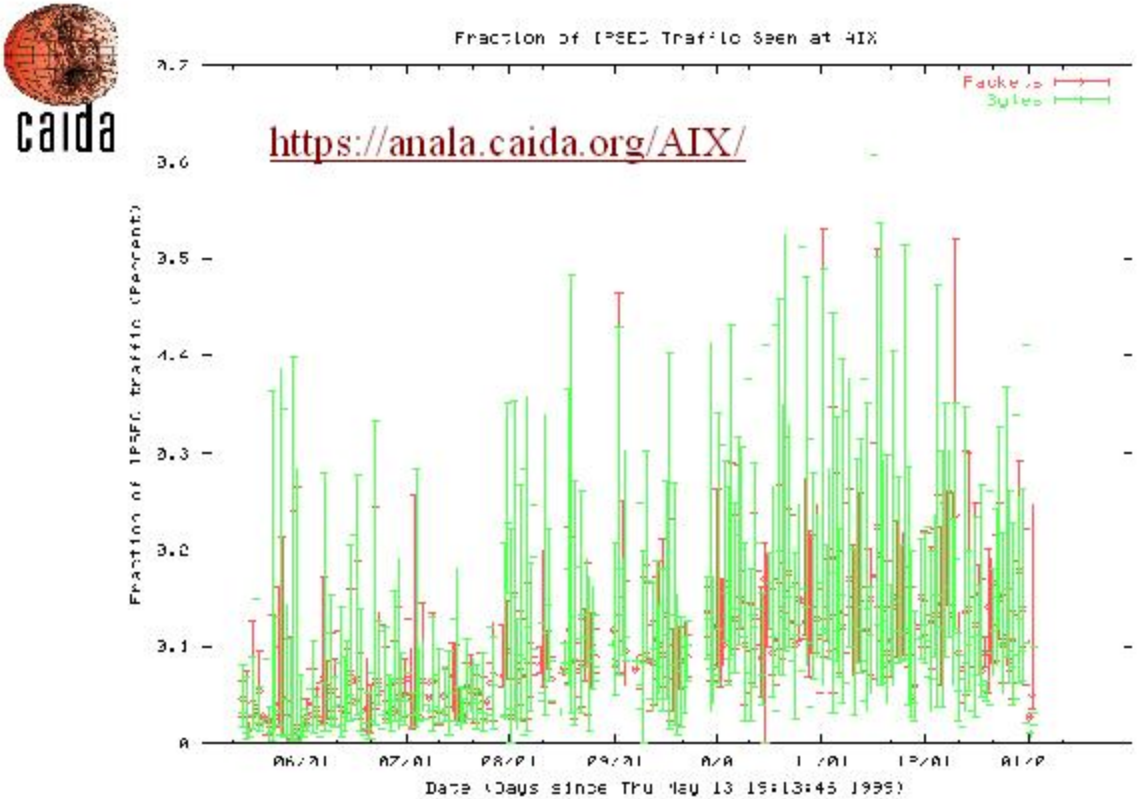




applications summaries



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Fraction of IPSEC Traffic Seen at AIX
https://anala.caida.org/AIX/
Packets
Bytes
Fraction of IPSEC traffic (Percent)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
06/01
07/01
08/01
09/01
10/01
11/01
12/01
01/02
Date (Days since Thu May 13 19:13:45 1999)



performance evaluation (active)

- network engineers to diagnose problems
- ISPs & users to verify SLAs & application performance
- Internet weather
- variations of traditional tools (ping & traceroute) used in most initiatives, e.g. NLANR/MOAT, SLAC, IPWT, Surveyor, commercial services (also treno, mping, & techniques measurement app perf.)
- passive methods emerging

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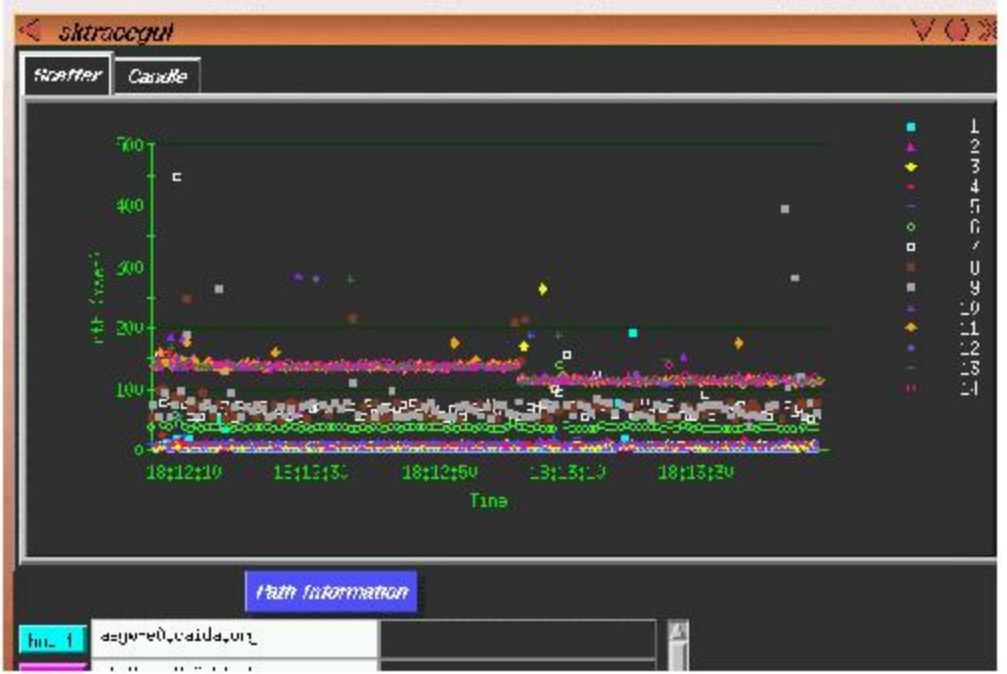
skping: rtt/loss & distribution





perf.eval: routing (path change)



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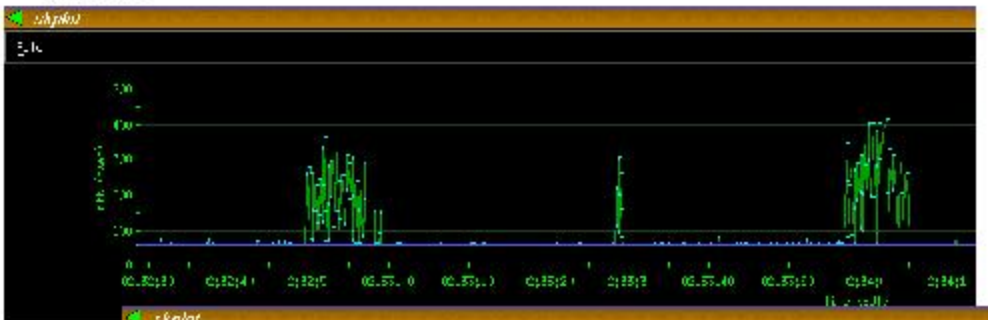
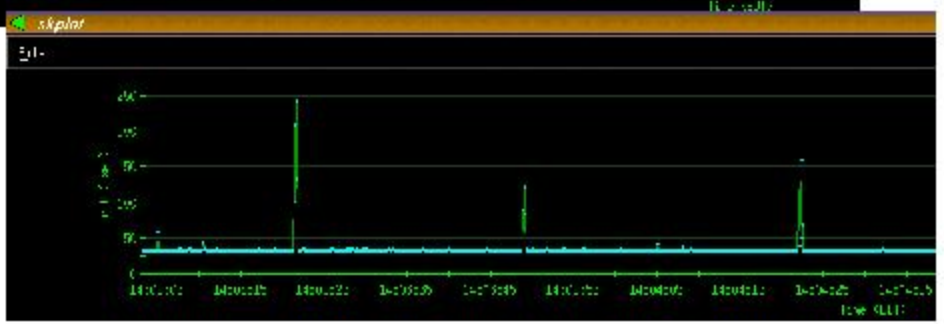
rtt performance: h/w







perf evaluation priorities

- definitions & metrics
  - working groups, IPPM & CAIDA
- bandwidth assessment techniques
- passive techniques
- correlation
  - across sources
  - w/ workload, routing data
- large scale deployment
- user interface to measurements



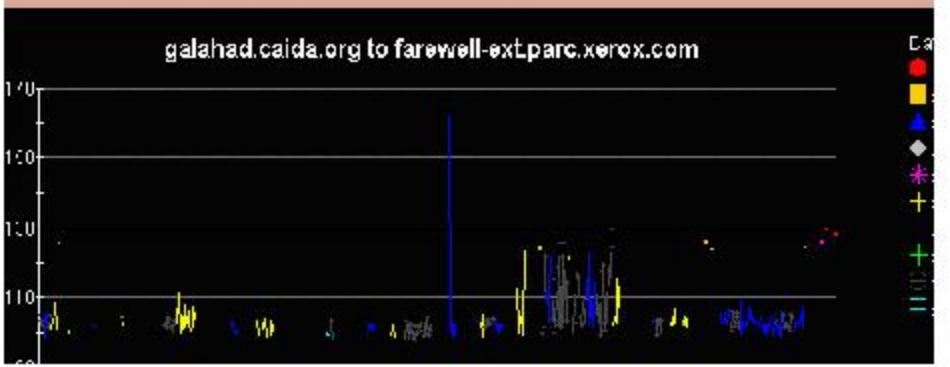
routing

- 15 year-old technology
- minimal measurement/windows makes it difficult to correlate with other data
  - access to tables infrequent
  - some route tables available, e.g., Oregon's RouteViews
- active measurement techniques used to gauge route stability



routing: example (instability)

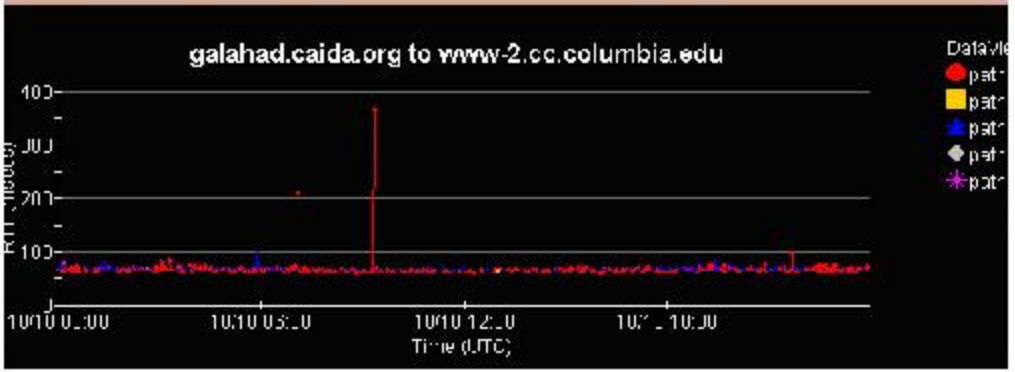
- RTT data changes color if path changes
- 10 unique paths over 24 hour period
- lots of jitter in data
  - unlikely to be intentional
- heavy tails predominate





routing: example (load balancing)

- RTT similar over predominantly two paths
- likely intentional load balancing





visualization ('big viz')

- massive datasets (terabytes)
- many data attributes (complex)
- multiple viz strategies needed
- integration into network utilities -- drill-down critical

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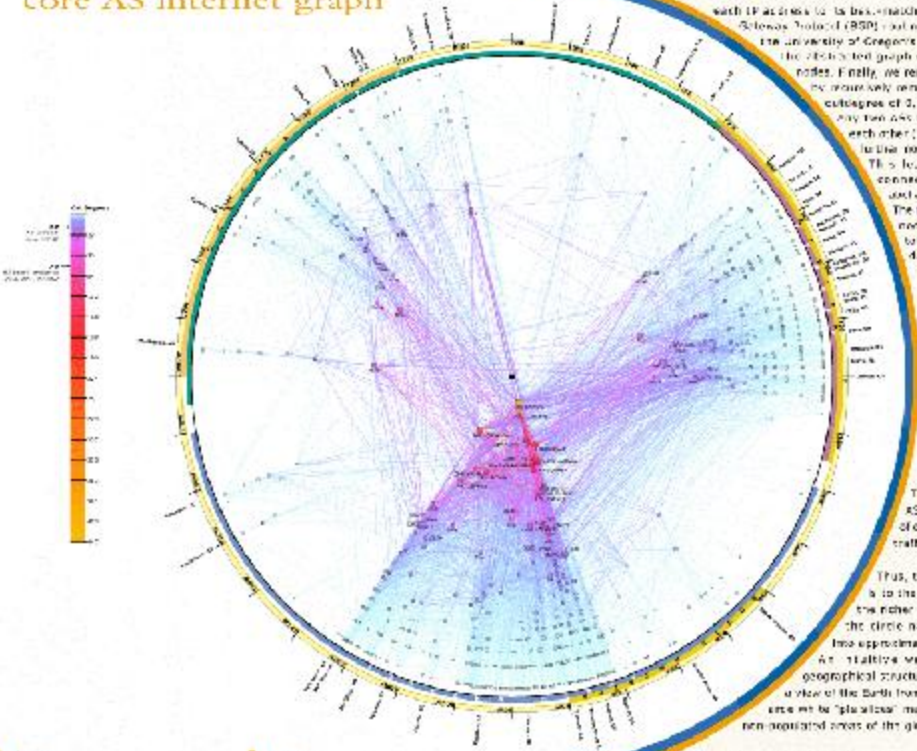
core AS internet graph



skitter ANALYSIS

This visualization represents a macroscopic snapshot of the Internet for sixteen days in mid-January 2000. The graph includes 220,330 nodes obtained by merging three datasets: one from Bill Cheswick on January 14, 2000; one gathered from traceroutes to Cheswick destinations from CAIDA's network in San Diego during January 15-22, 2000; and the backlinking data from 14 skitter monitors taken on January 08, 16, and 24, 2000.

This view of the network is then abstracted into a topology of Autonomous Systems (ASs), each of which approximately maps to an Internet Service Provider, or "ISP". This abstraction occurs by mapping each IP address to its best-match origin AS in Border Gateway Protocol (BGP) routing tables collected by the University of Oregon's RouteViews project. The abstracted graph consists of 5147 AS nodes. Finally, we remove "non-core" ASs by recursively removing all ASs with an outdegree of 0, as well as removing any two ASs that connect only to each other ("leaf" nodes), until no further nodes can be removed. This leaves a set of well-connected ASs, which we abstract "AS core" snapshot. The final AS core has 1316 nodes, or 25.7% of the total ASs seen in the data sets.

The position of each AS node is plotted in polar coordinates, *pos(radius, angle)* (*pos(r,θ)*), where:

$$r = \frac{\text{radius}}{\text{[illegible]}}$$

$$\theta = \frac{\text{[illegible]}}{\text{[illegible]}}$$

The "outdegree" of an AS reflects the number of other ASs that accepted traffic from that AS.

Thus, the closer an AS node is to the center of the graph, the richer its peering. Redill of the circle naturally cluster ASs into approximate geopolitical areas. An intuitive way to consider the geographical structure in this graph is as a view of the Earth from the North Pole. The area will be "pla[illegible]" map to oceans or other non-populated areas of the globe.

By graphing dimensions of peering richness versus geographic information, this graph clearly reveals the "highly core-connected" nature of ASs based in the United States. The top 15 ASs are all headquartered

skitter ANALYSIS TEAM

Bradley Huffaker

skitter COLLABORATORS

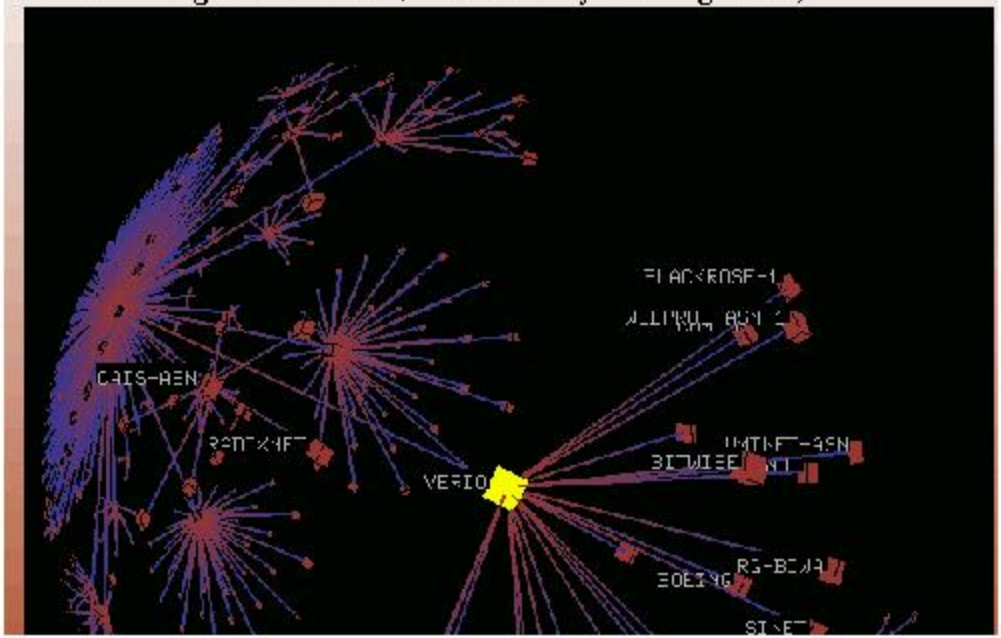
DARPA

MCI Worldcom



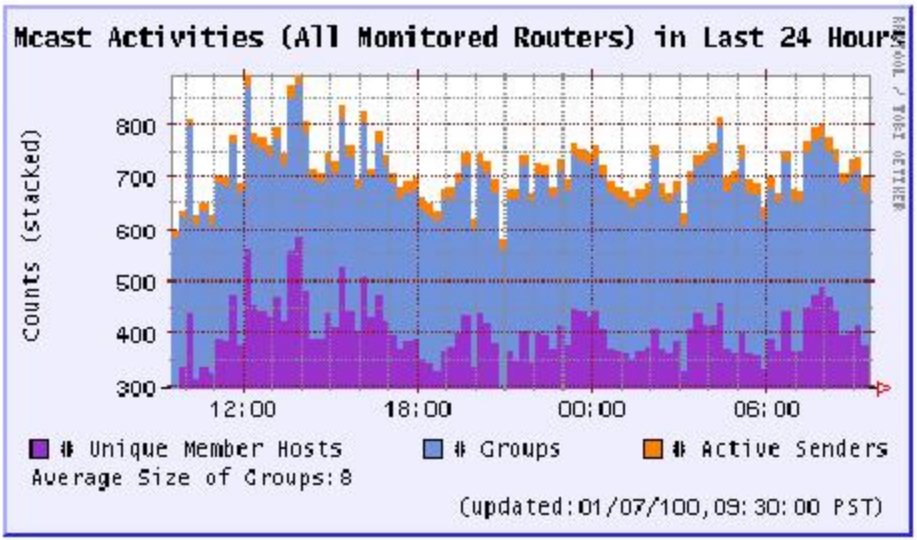
visualization: logical

BGP routing table data (connectivity among ASes)



multicast monitoring

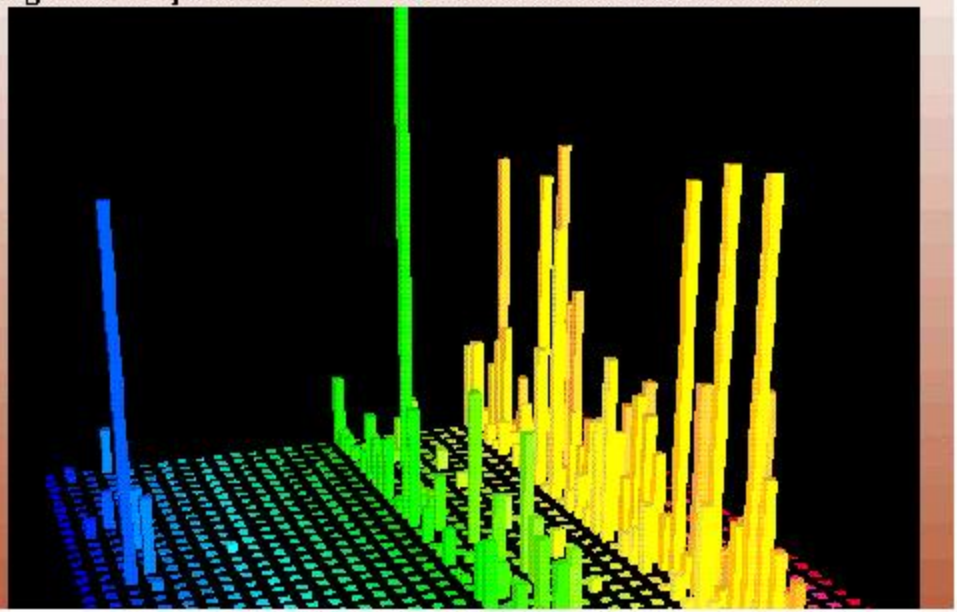
http://www.caida.org/tools/measurement/mantra/





routing: address usage of 'traffic' sample

32x32 'bitmap' matrix of address space
height is % packets with src IP in that address block





visualization: research priorities

- latency
- key routers/networks
- AS granularity
- geographic
- integration w mgt tools

obstacles:

mapping IP addresses to
- router
- geography
- AS
- service provider
- anything...

topology changes faster than can measure



network mgmt systems

- monitoring
  - real-time data - snmp data, measurement & configs
  - trend monitoring - important for planning & diagnostic purposes
  - integration of both with ticket tracking system & other databases
- databases
  - measurement data (binary file format, e.g. arts++)
  - RDBMS for net config, contacts, etc.
- viz:
  - intuitive, linked to utilities & drill-down
- correlation of multiple datasets
- simulations needed for planning, tweaking IGP metrics, etc.



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