



Internet measurement: abysmal science

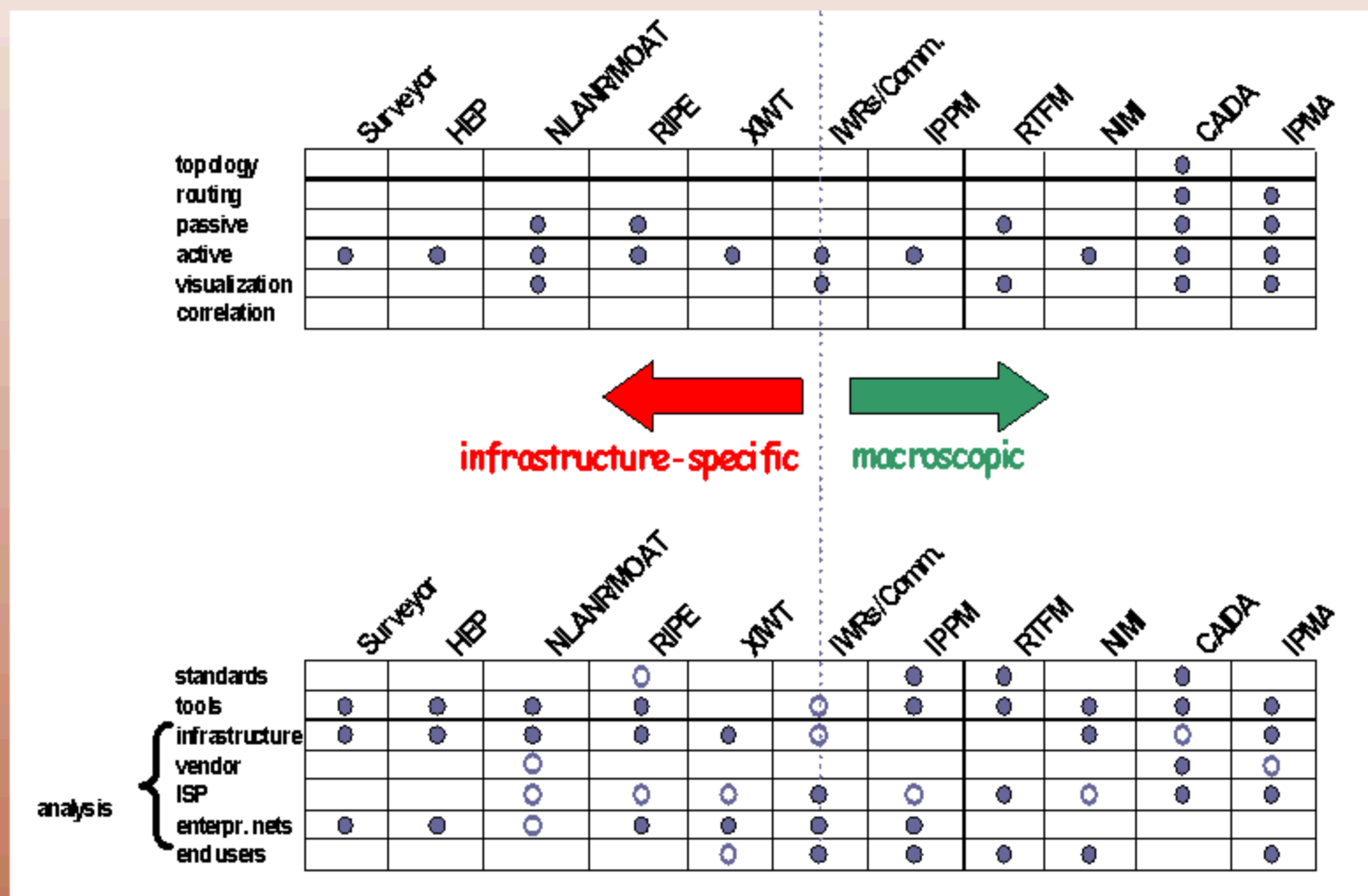
*scientific apparatus offers a window to knowledge,
but as they grow more elaborate,
scientists spend ever more time washing the windows.*
-- Isaac Asimov

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www.caida.org

abysmal but unsurprising

- little capacity to predict, depict, or even measure traffic behavior on current and advanced networks
- few tools to engineer/operate networks or identify traffic anomalies in real time
- doesn't stop researchers from building junk
- doesn't stop random users from doing random junk
- increasing cost to infrastructure

no dearth of activity



<http://www.caida.org/Tools/taxonomy.html>

payoffs

- insights for **vendors** re next generation hw/sw requirement
- calibration for **users**, e.g., monitoring service level agreements's
- diagnostic and planning tools for **ISPs**
- windows into the infrastructure for **researchers**

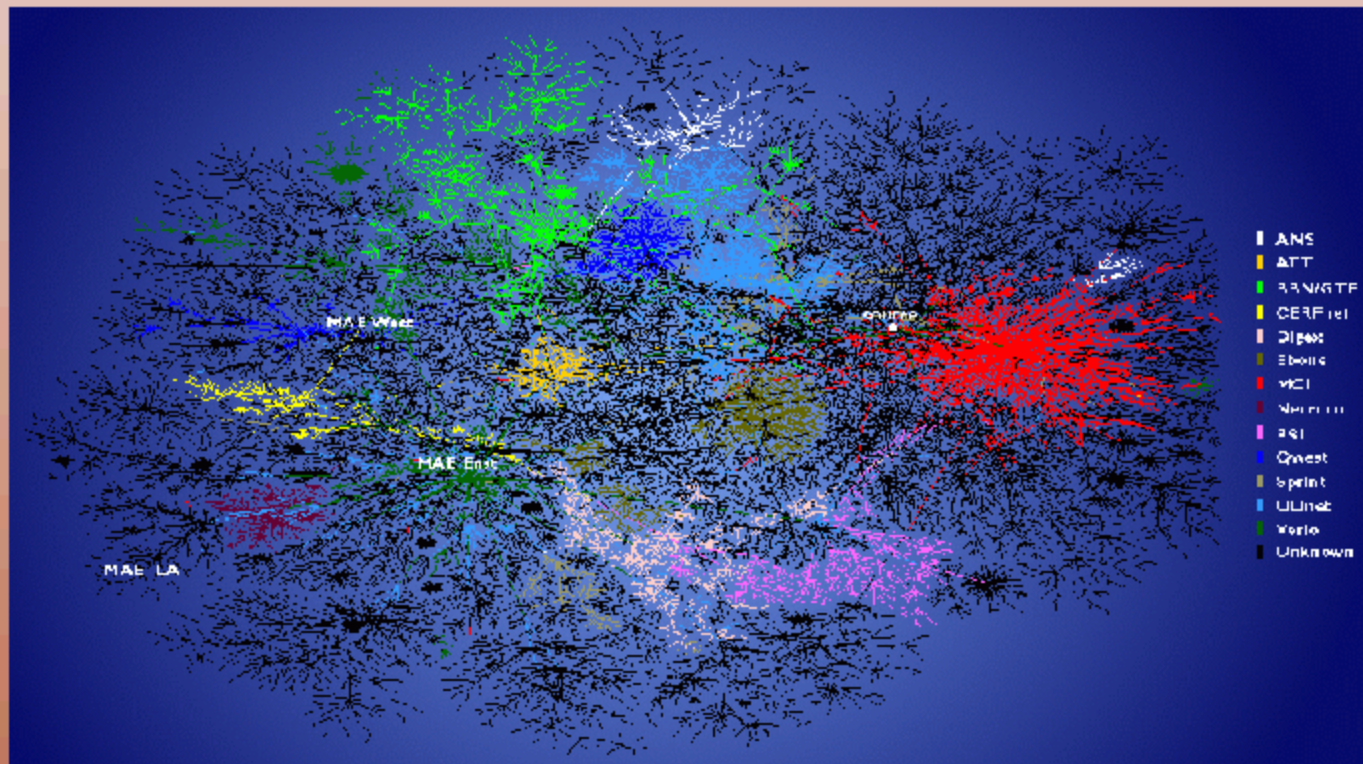
four areas of measurement

- topology
- workload characterization (passive)
- performance evaluation (active)
- routing (dynamics)

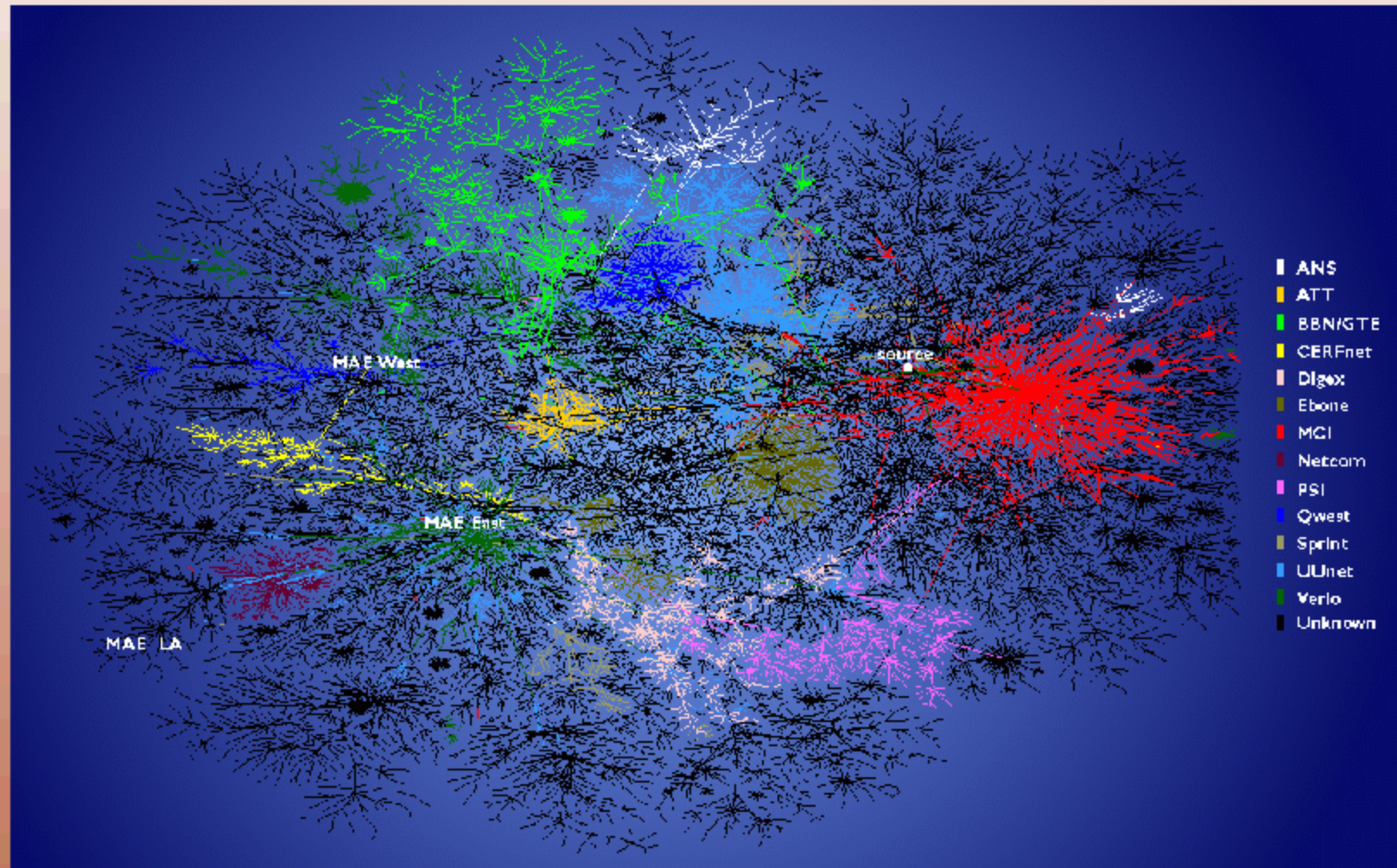
will show examples, priorities, obstacles

infrastructure-wide priorities

- dynamically discover/depict topology (& b/w)
- correlate effects of BGP routing changes
- correlate path performance with specific events

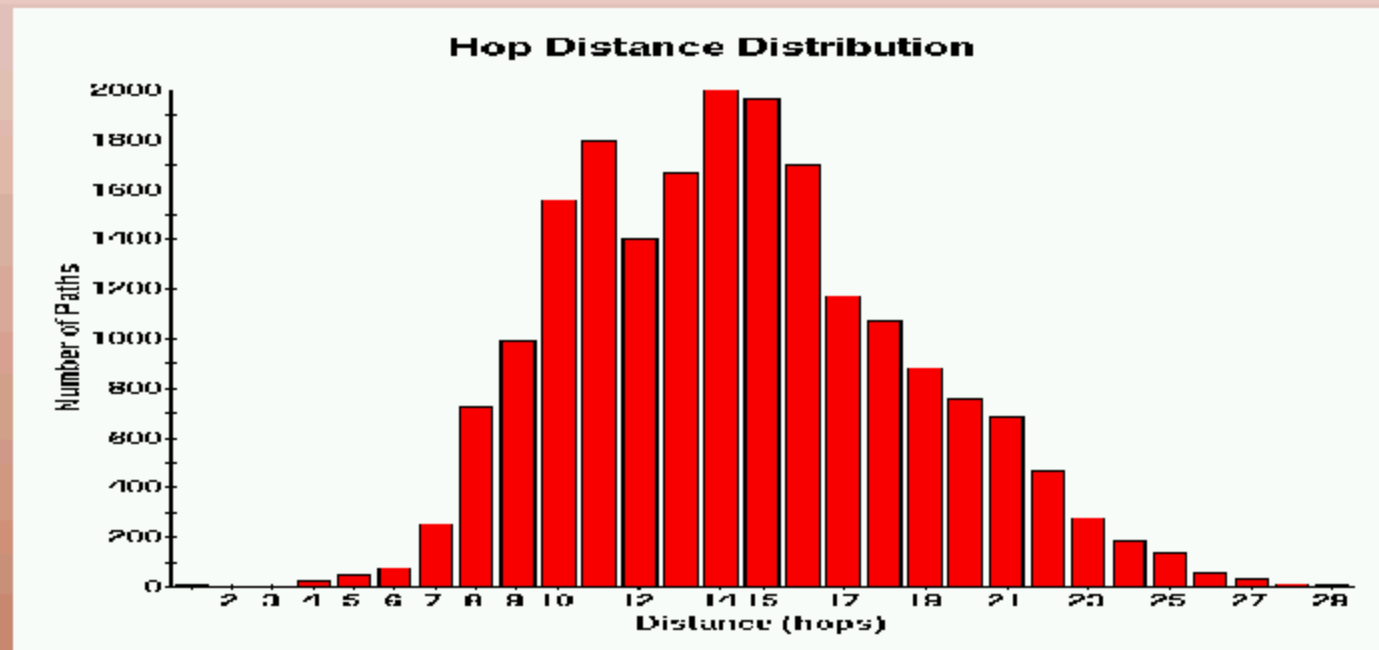


skitter (jul 1998)



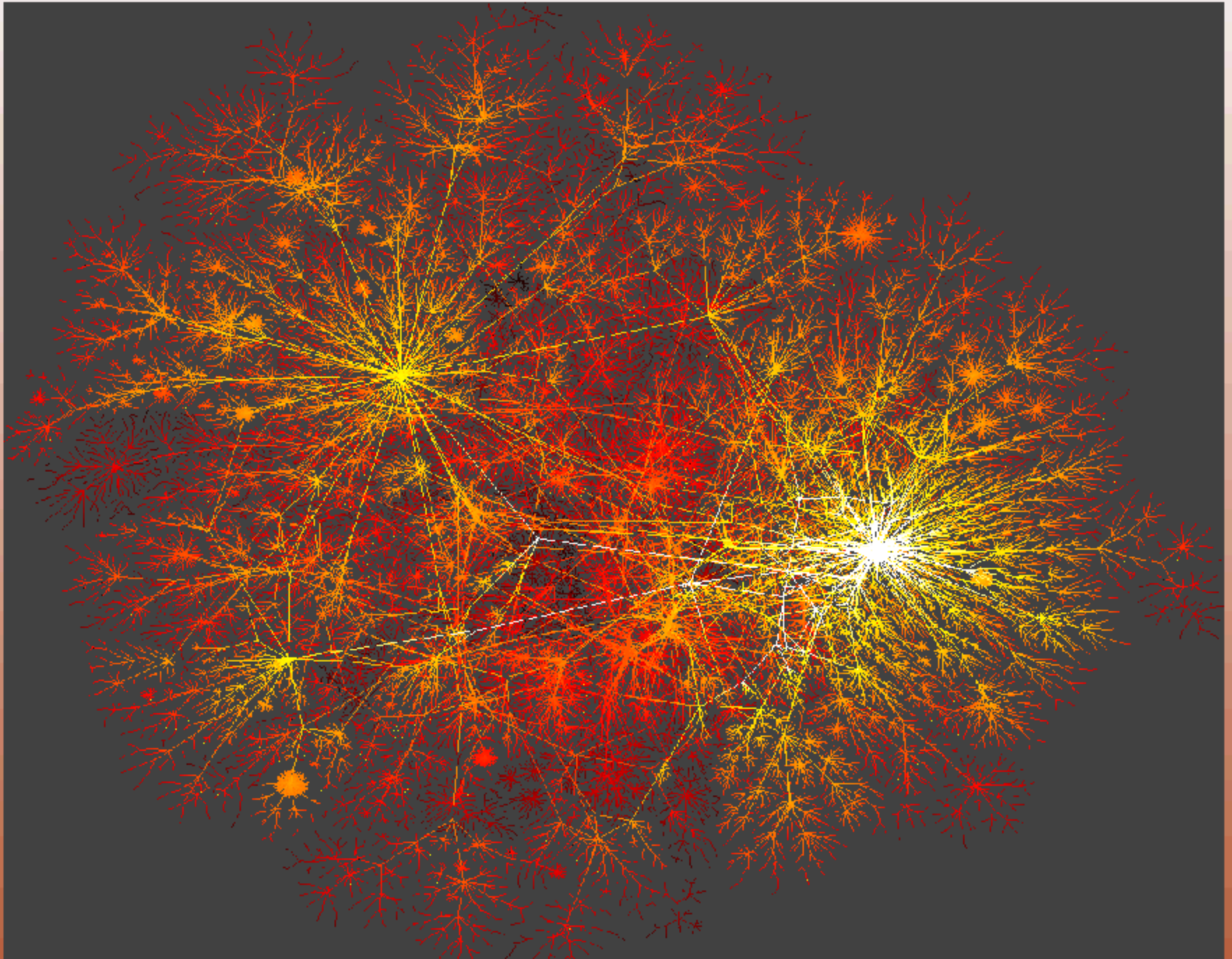
skitter: infrastructure-wide measurements

- 6 monitors
- 23k (eventually 60k) destinations
- architecture:
 - parallel ICMP probes
 - 52-byte packets
 - kernel time stamping
 - ssh / Kerberos

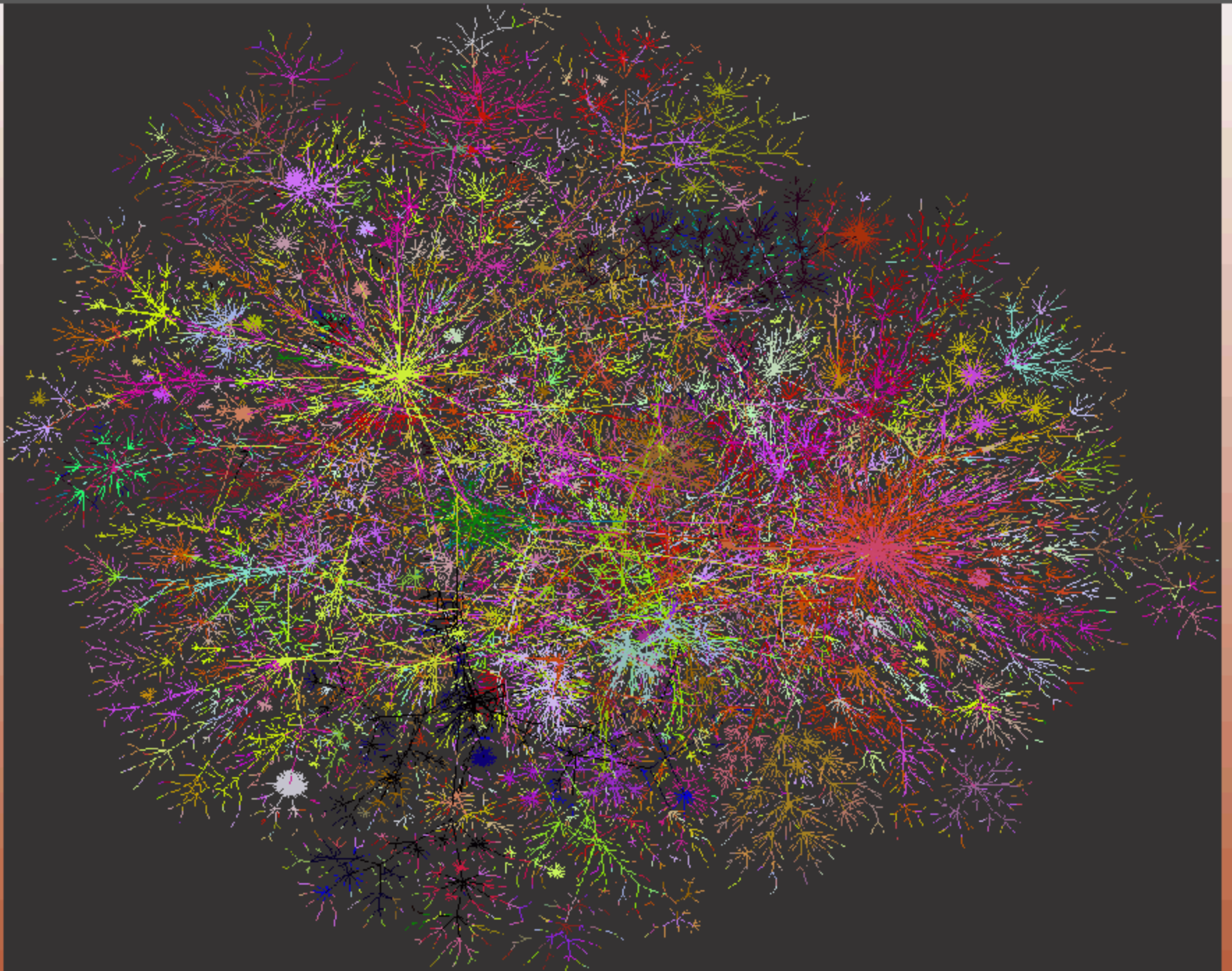


www.caida.org/ISMA/isma9808/slides/isma98-skitter/

skitter: colored by hop distance from src



skitter: colored by IP octets



skitter: AS interconnectivity

Netname:

(1717)

as-ebone(3215)

as-telianaetse(3301)

bbn/gte(1)

digex(2548)

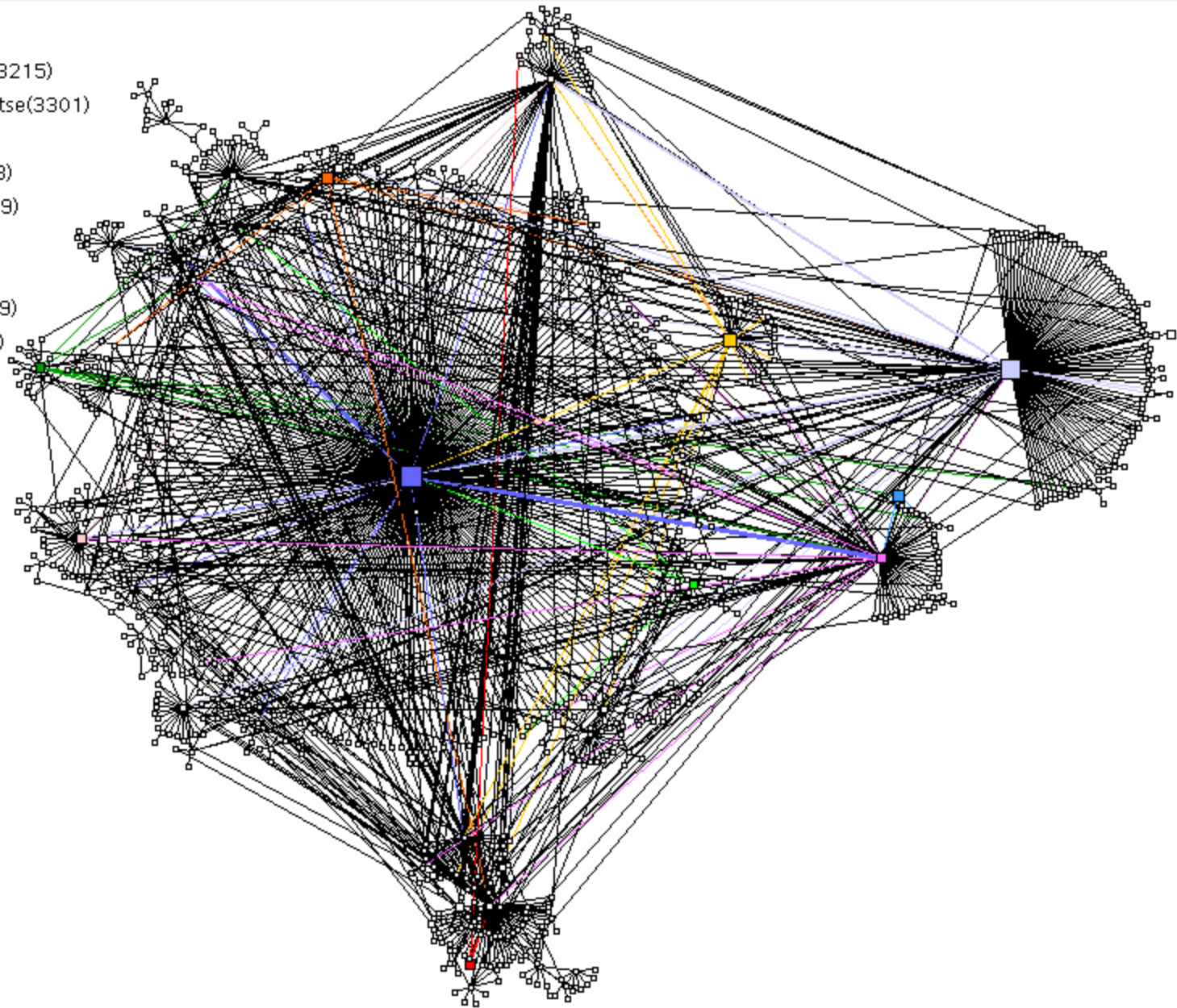
ebone(3269)

janet(786)

mci(3561)

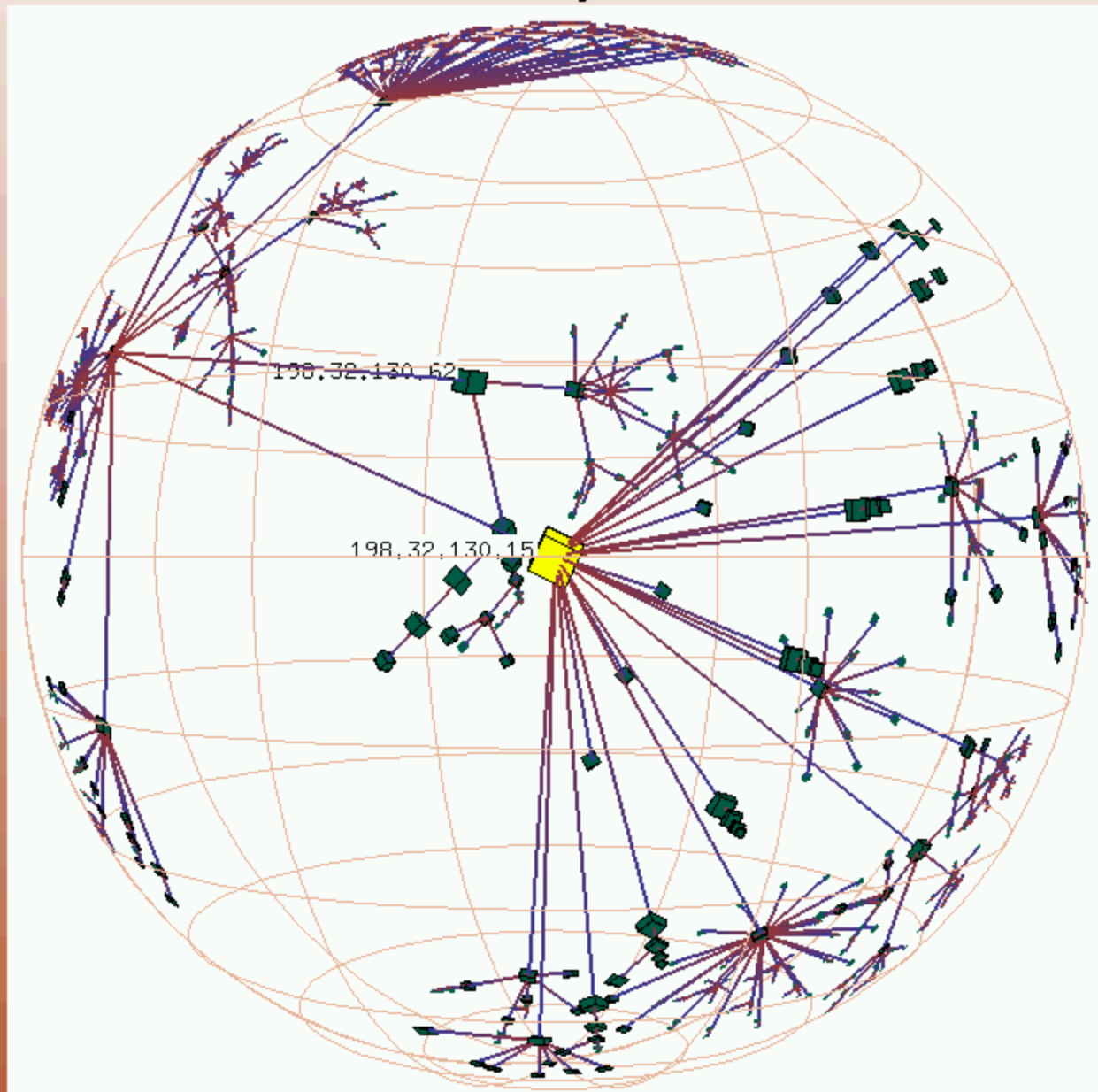
sprint(1239)

uunet(701)



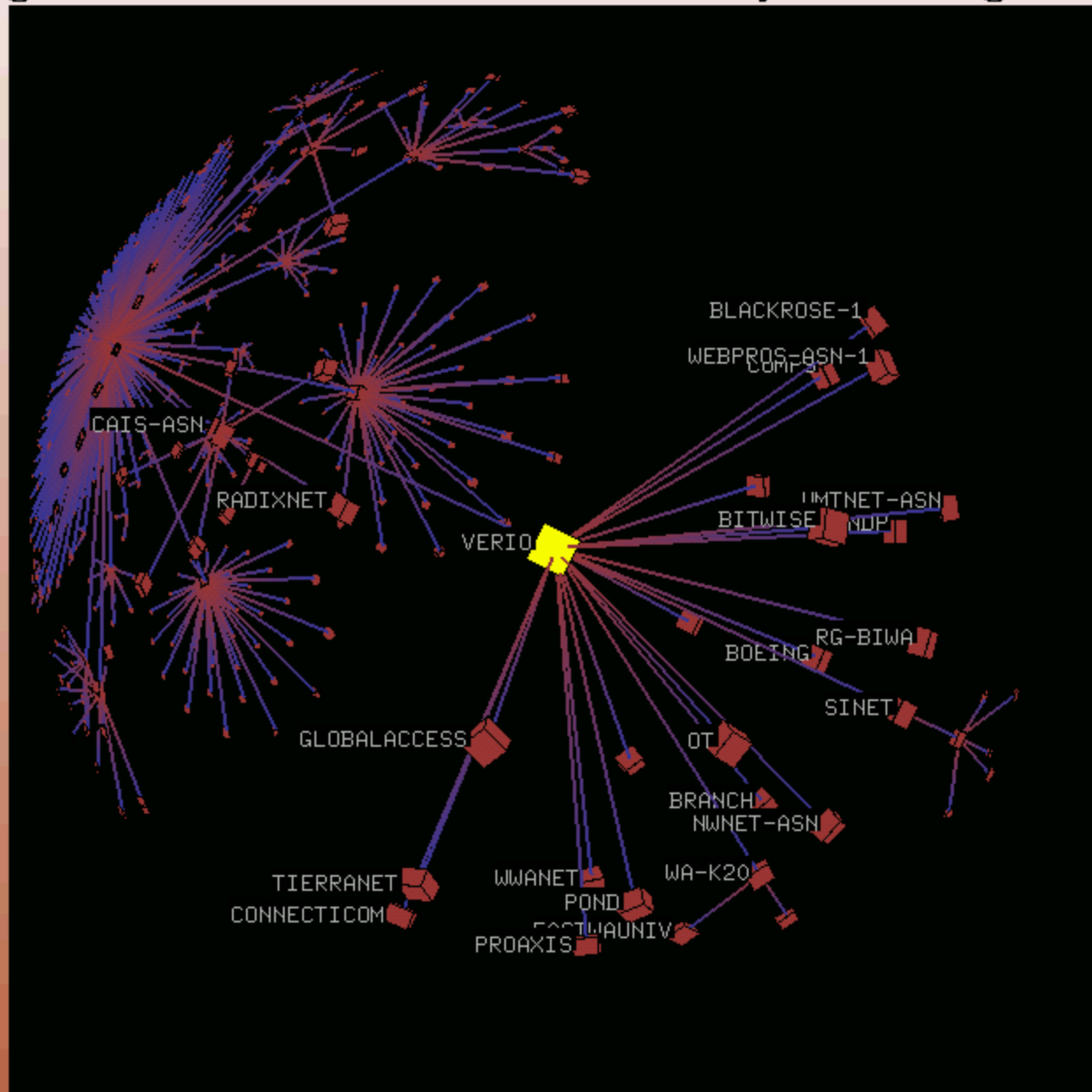
skitter: 3D hyperbolic (feb 1999)

198.32.130.15, still reflecting large portions elsewhere
tamara munzner (stanford) layout software



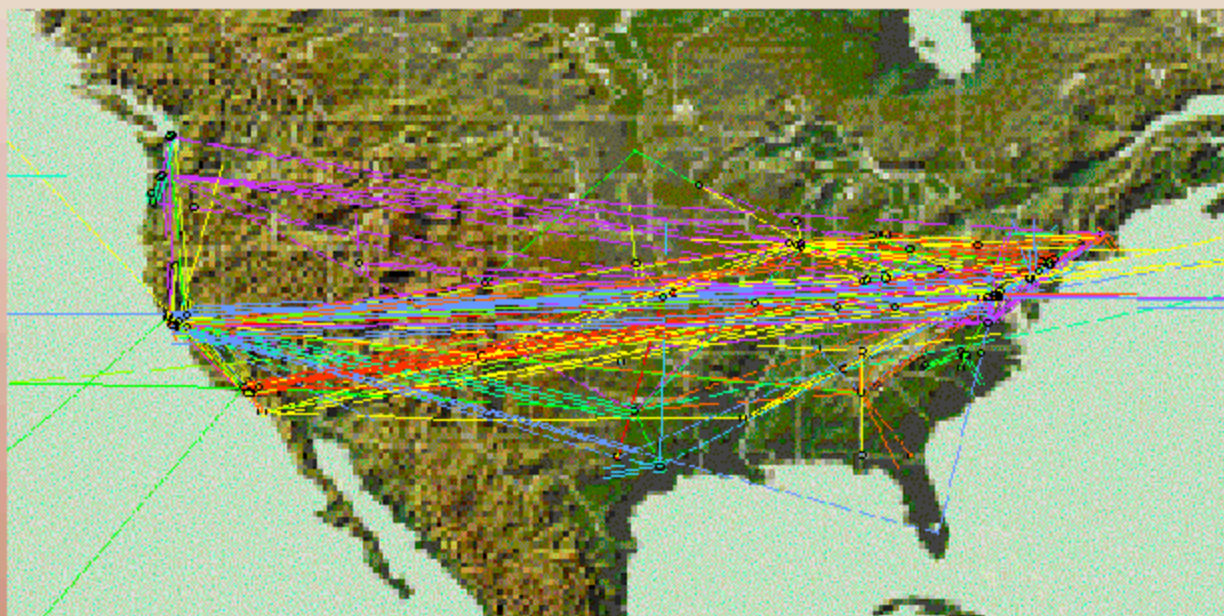
skitter: 3D hyperbolic

BGP routing table data (connectivity among ASes)



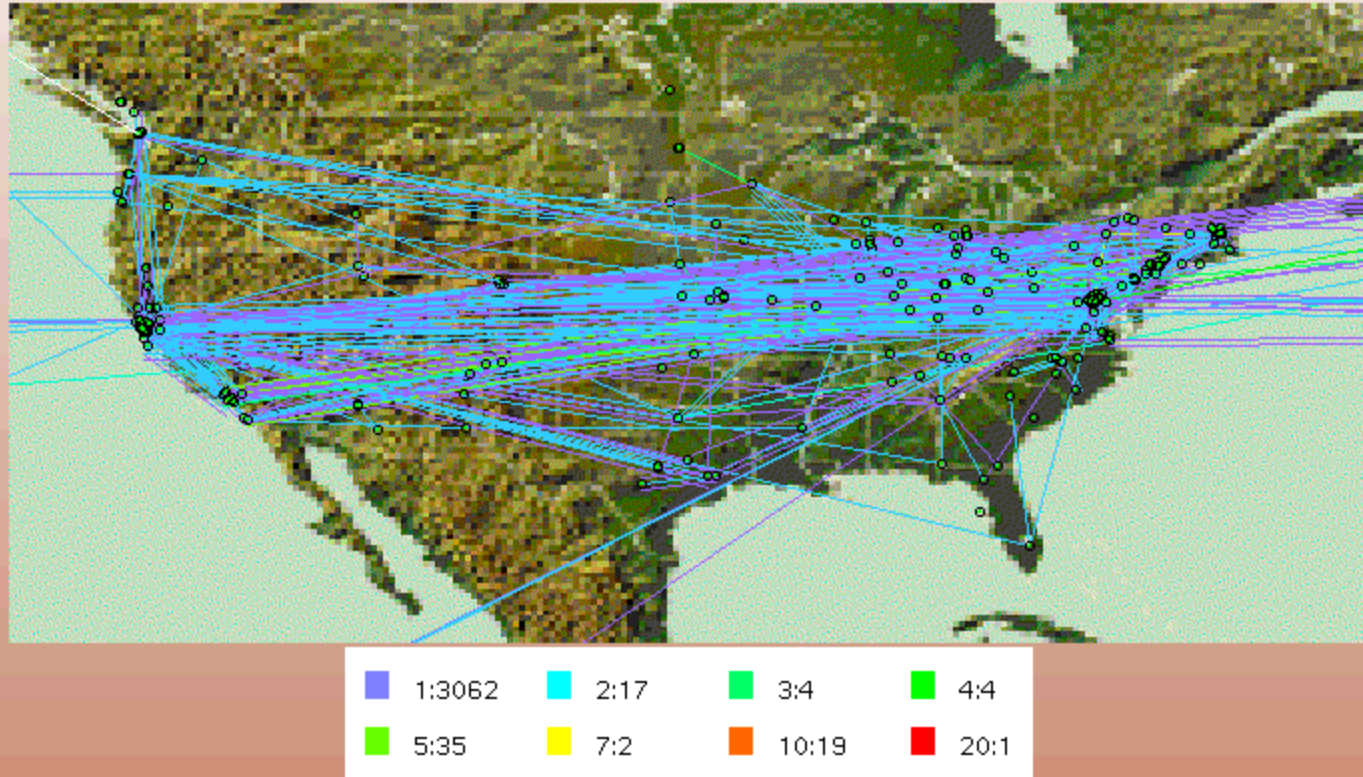
manta: visualizing the mbone

geographical placement of mbone using data from
mwatch/mrinfo utilities

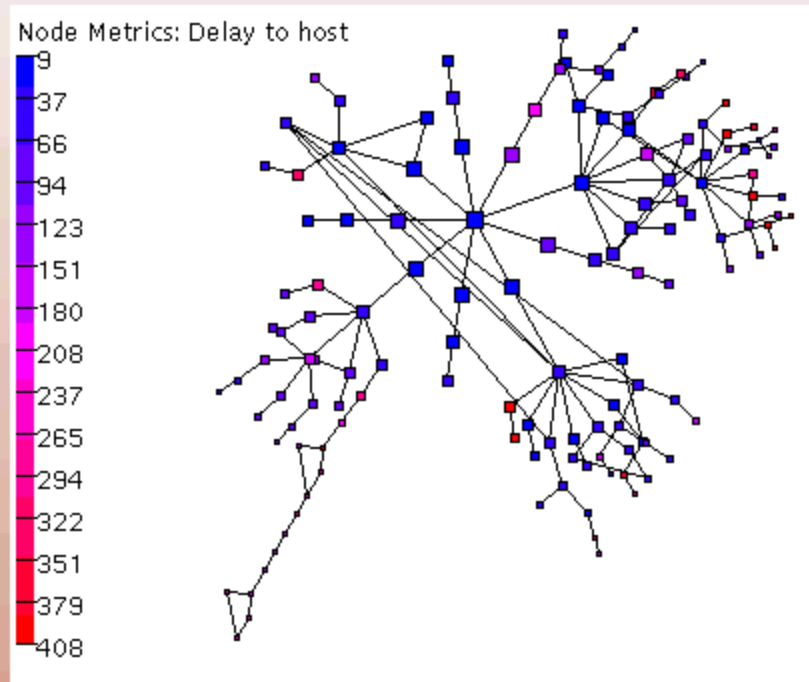


Bradley Huffaker (UCSD/CAIDA) developer

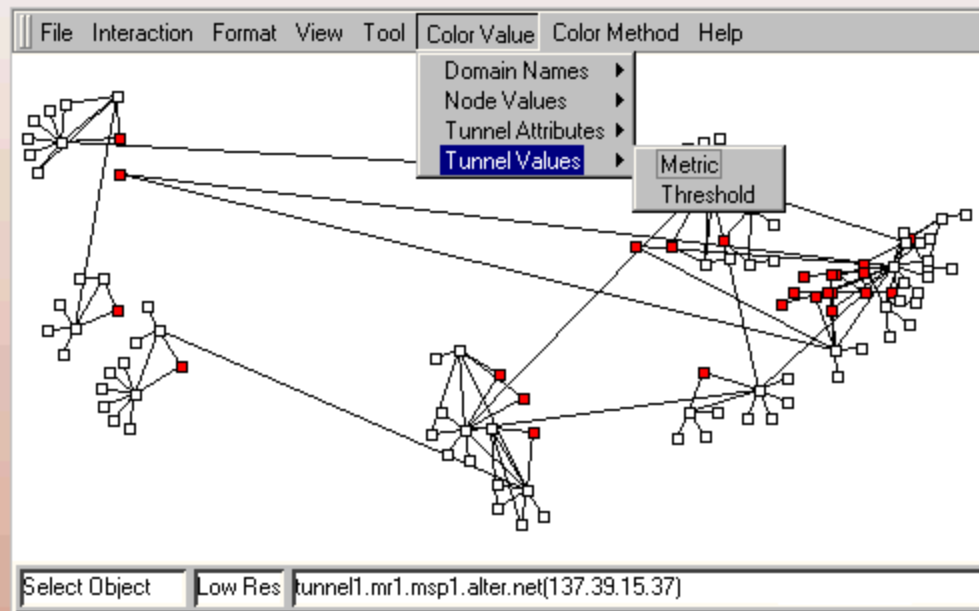
manta: mbone colored by metric



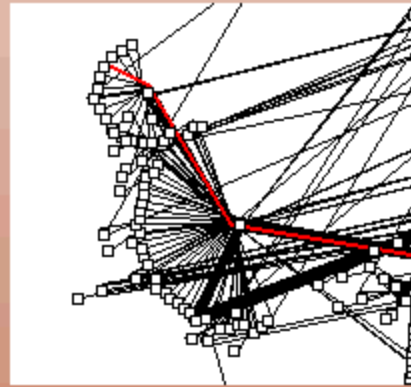
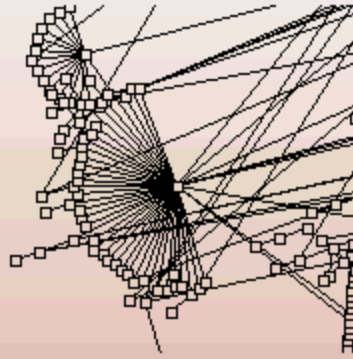
otter: general purpose viz tool



otter: main display



AS path data by adjacencies vs paths



topology: research priorities

■ visualization

- latency
- key routers/networks
- AS granularity
- geographic

■ obstacles:

mapping IP addresses to

- router
- geography
- AS
- service provider
- country
- anything...

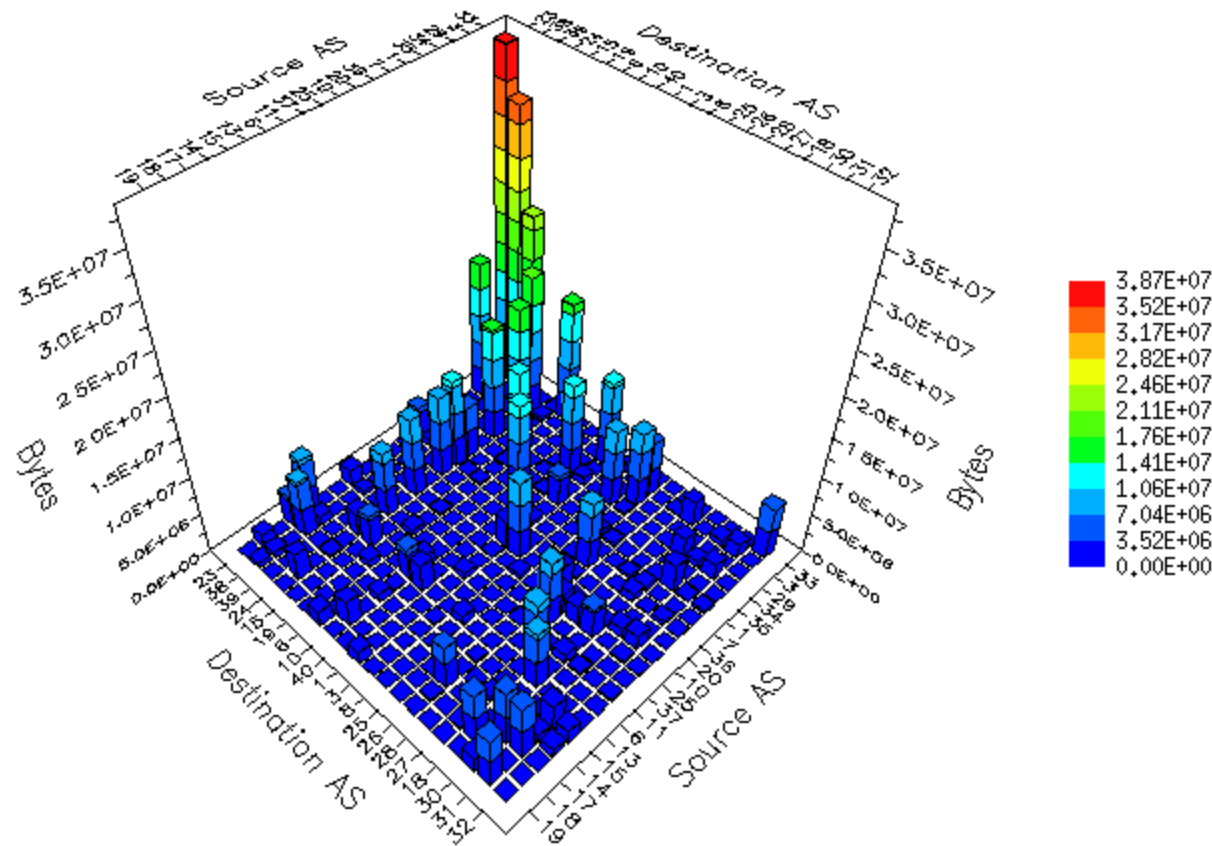
route changes faster than can measure

workload characterization

- workload profiling (s/w & h/w design, architecture optimizing, capacity planning)
- security
- performance analysis
- QOS assurance across ISPs
- accounting/billing
- tools: netramet, netflow, cflowd, coral
 - some suck less? ...evolution requires use

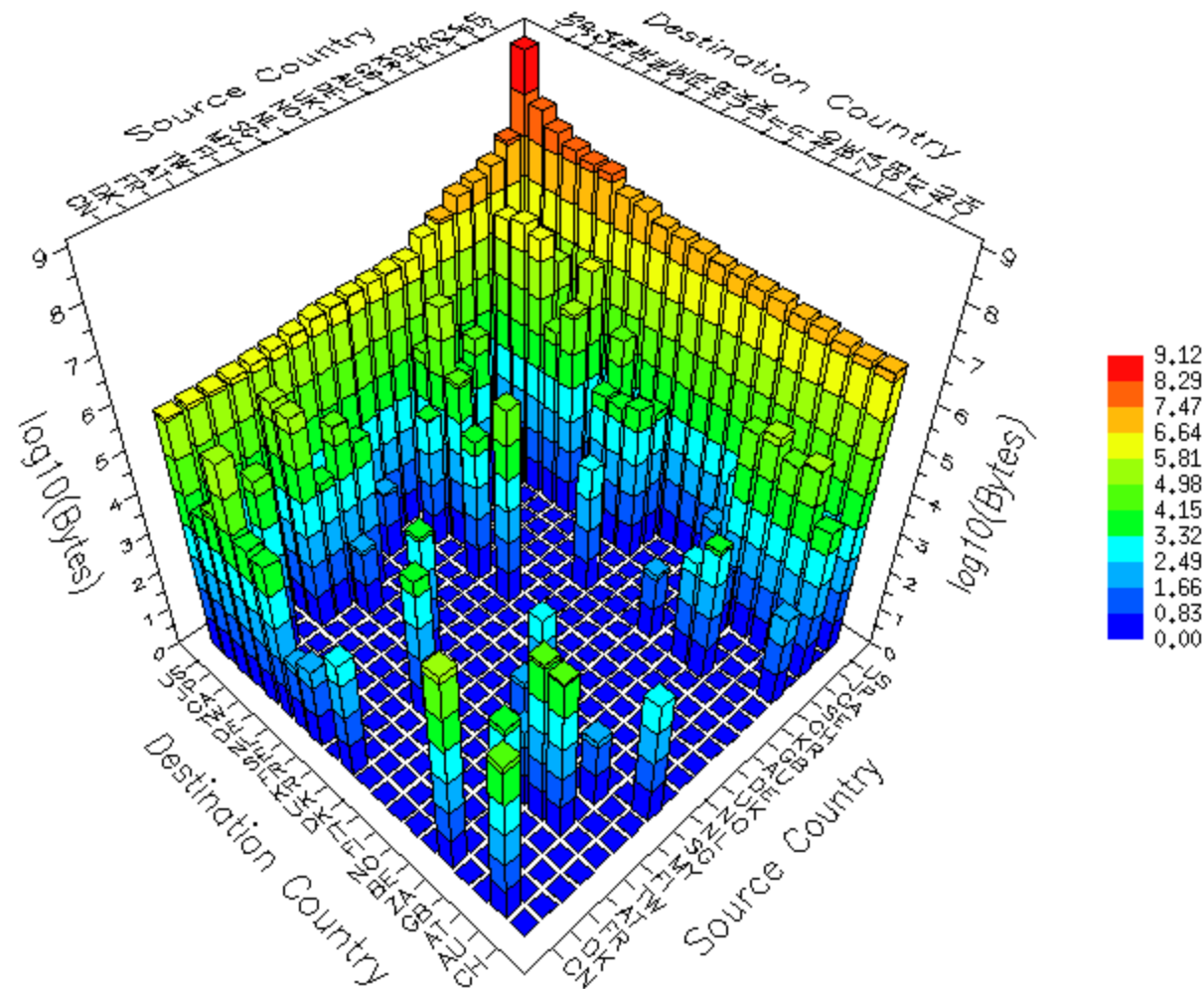
workload char.: traffic matrix (ASes)

12 march 98, 2 min sample, fixwest



workload char.: matrix (country)

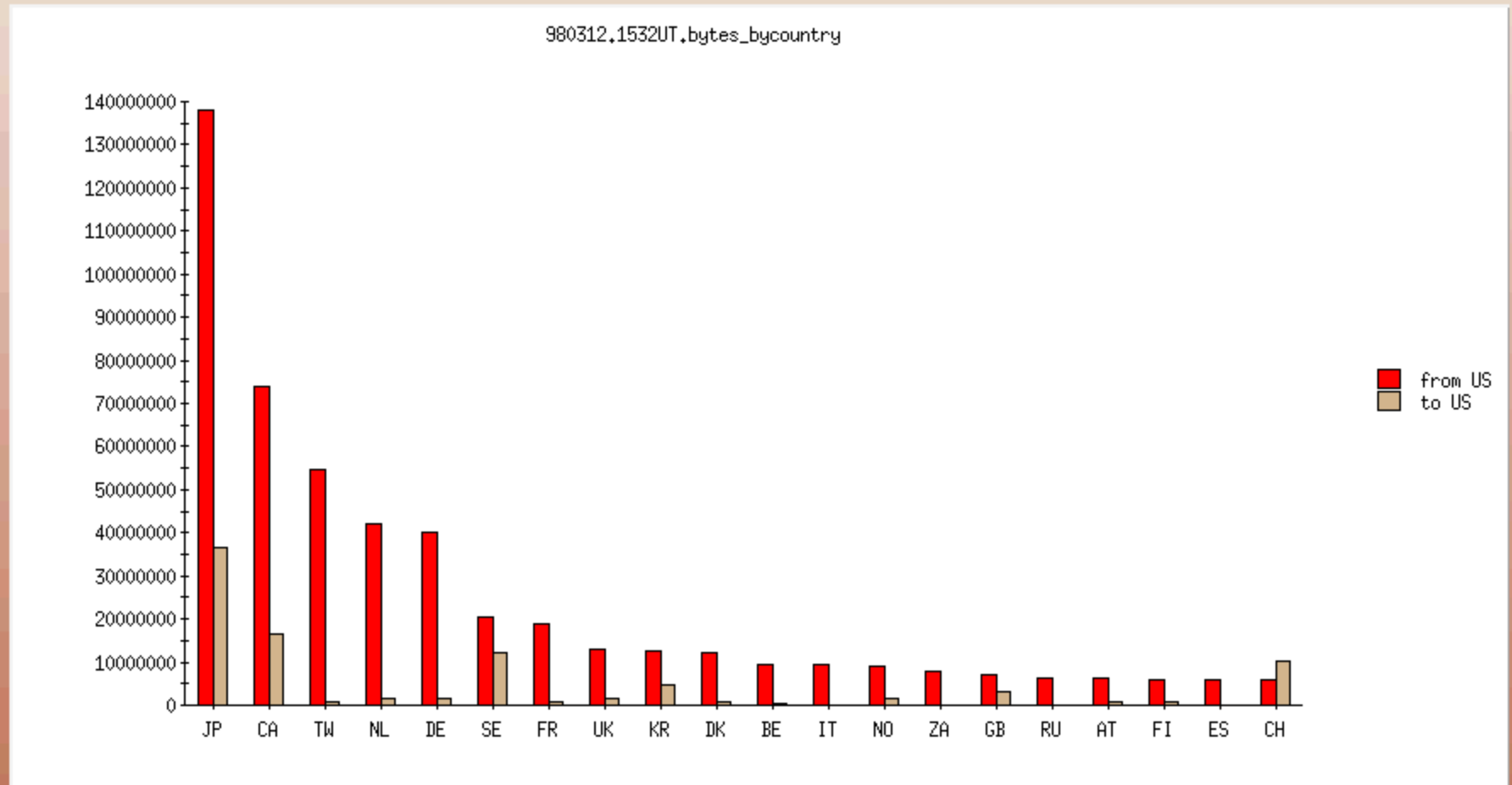
12 march 98, 2 min sample, fixwest



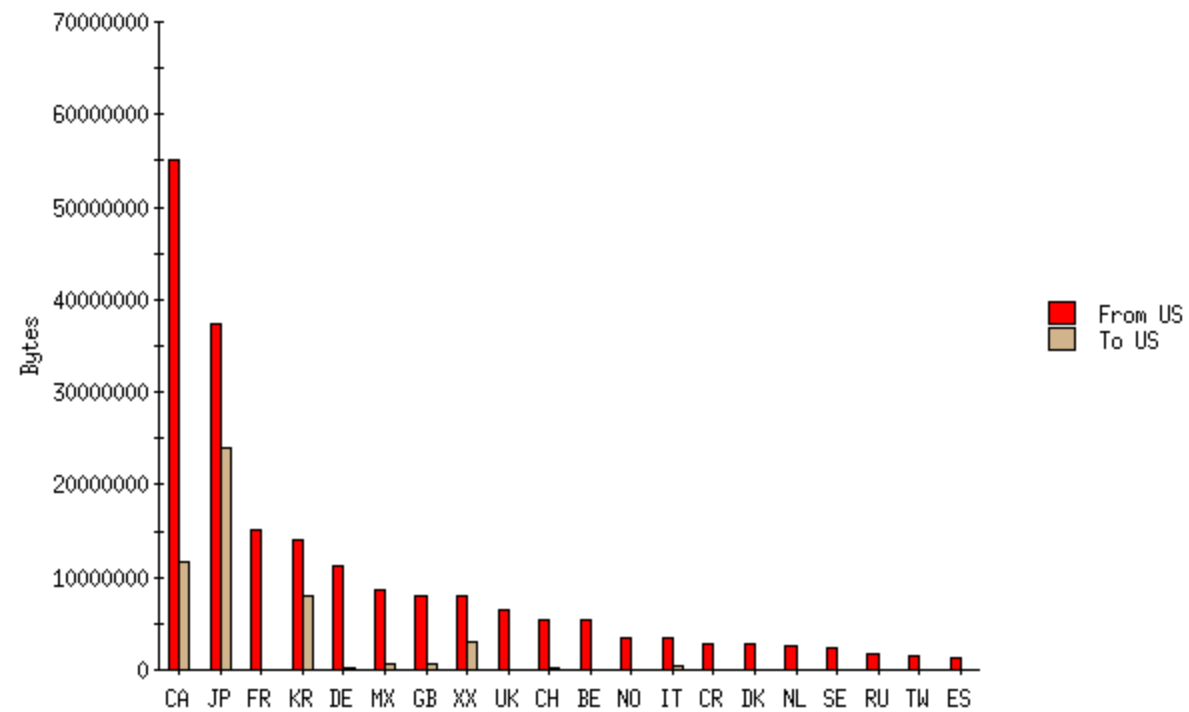
workload: IP trade balance (pkts)

12 march 98, 2 min sample, fixwest

US still net exporter of IP pkts (w/2 exceptions)

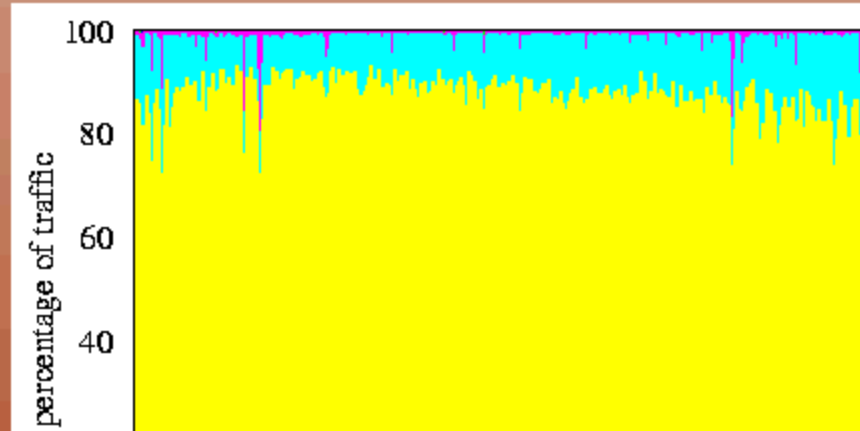
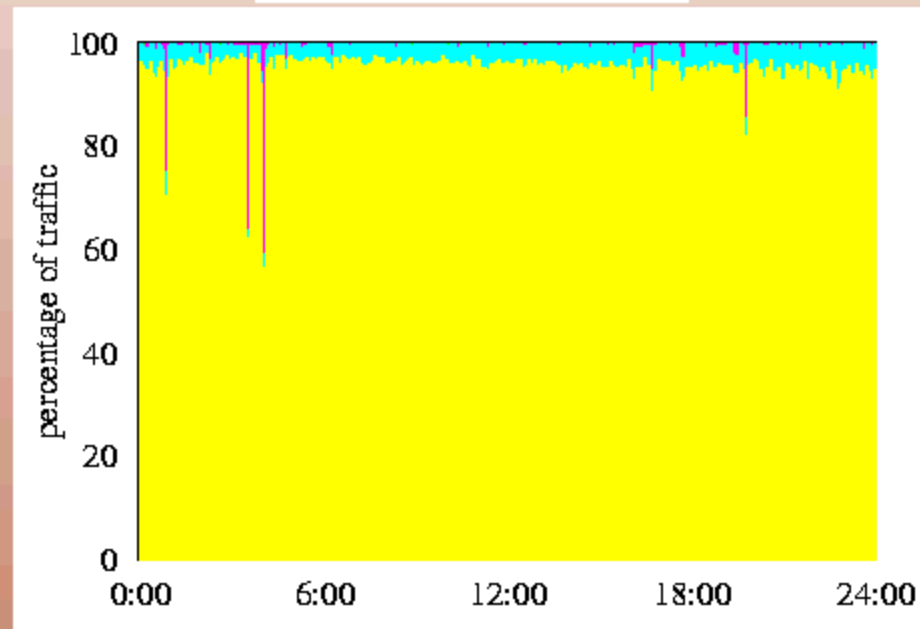
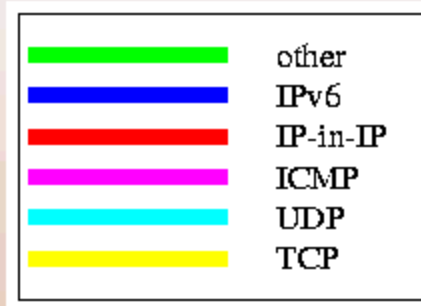


Internet Balance of Trade
AIX-926550229 Wed May 12 16:03:49 1999
4175402 Packets, 1744725675 Total Bytes



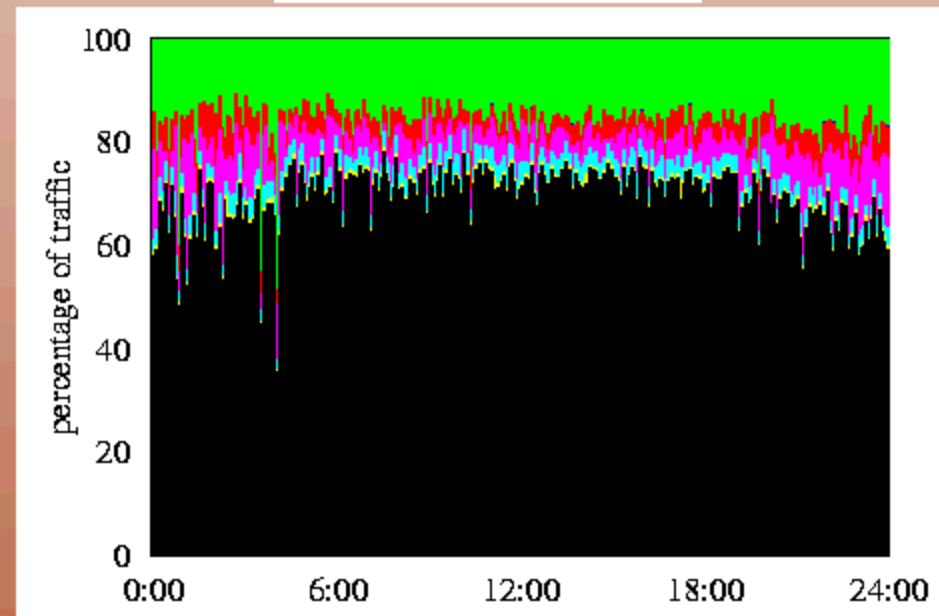
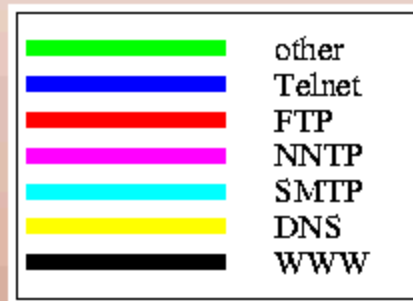
XX = Country Undetermined

key IP protocols (13 apr 98): bytes, pkts

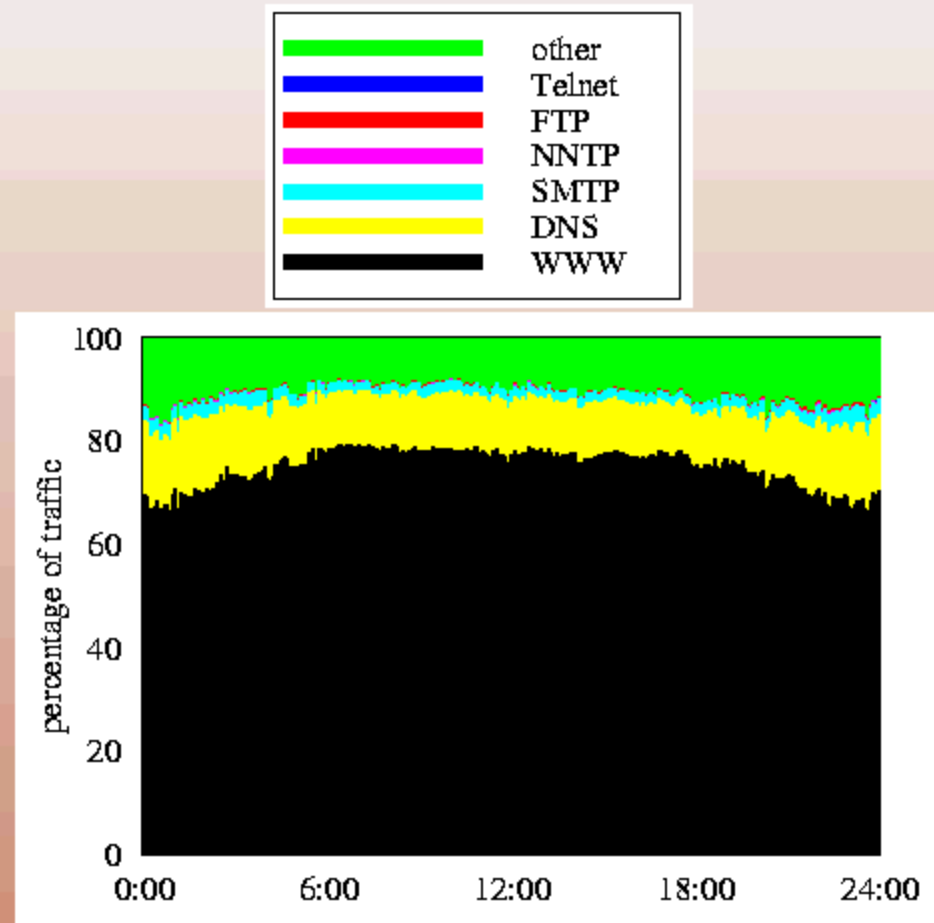


key applications

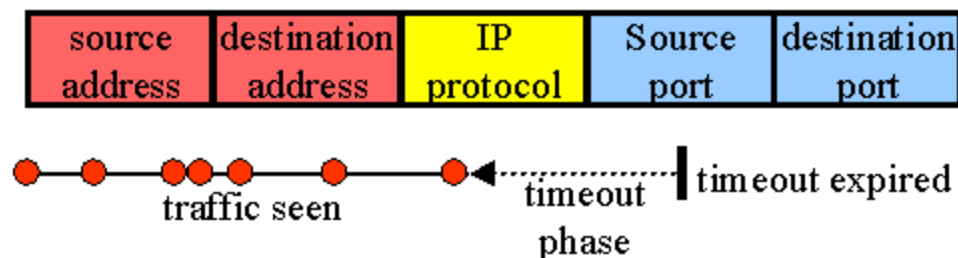
mci (now c&w) backbone trunk
24 hour period 13 apr 98
bytes (packets similar)



key applications (flows), 4/13/98 mci backbone

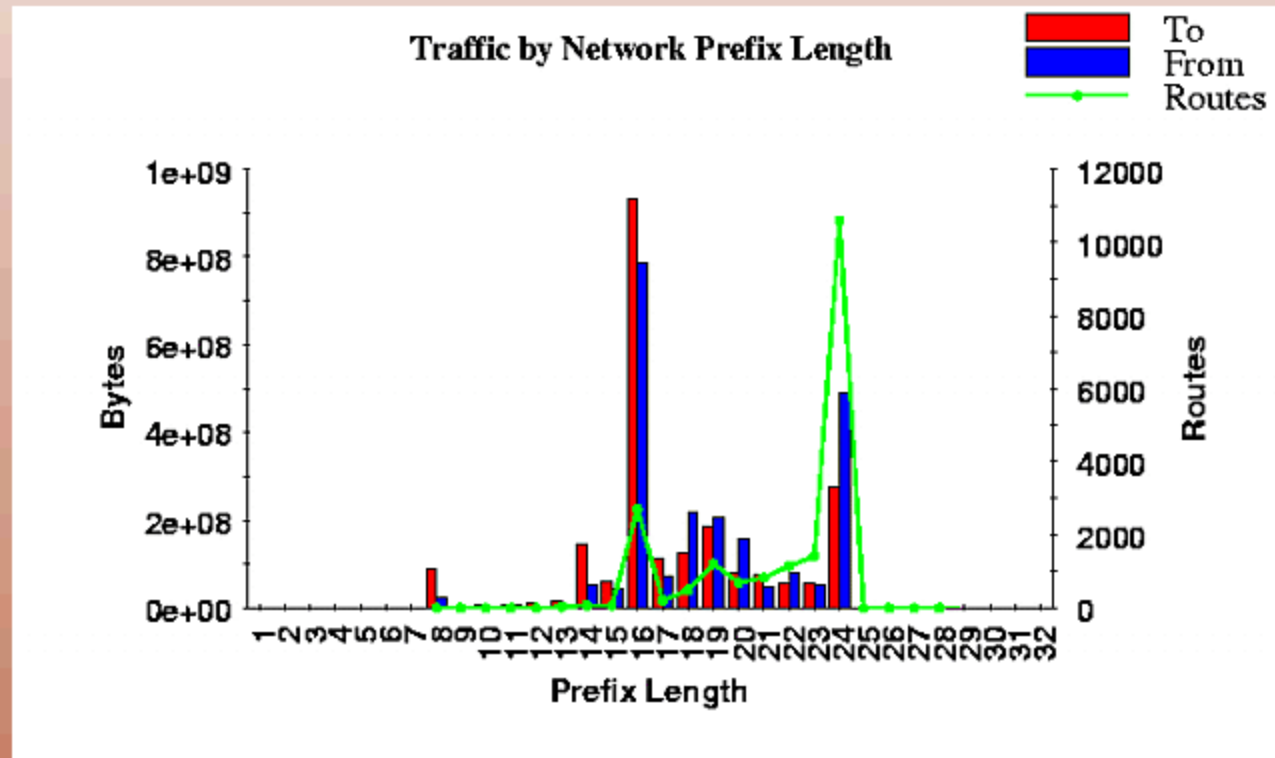


Flows: transaction impacts as the network sees them



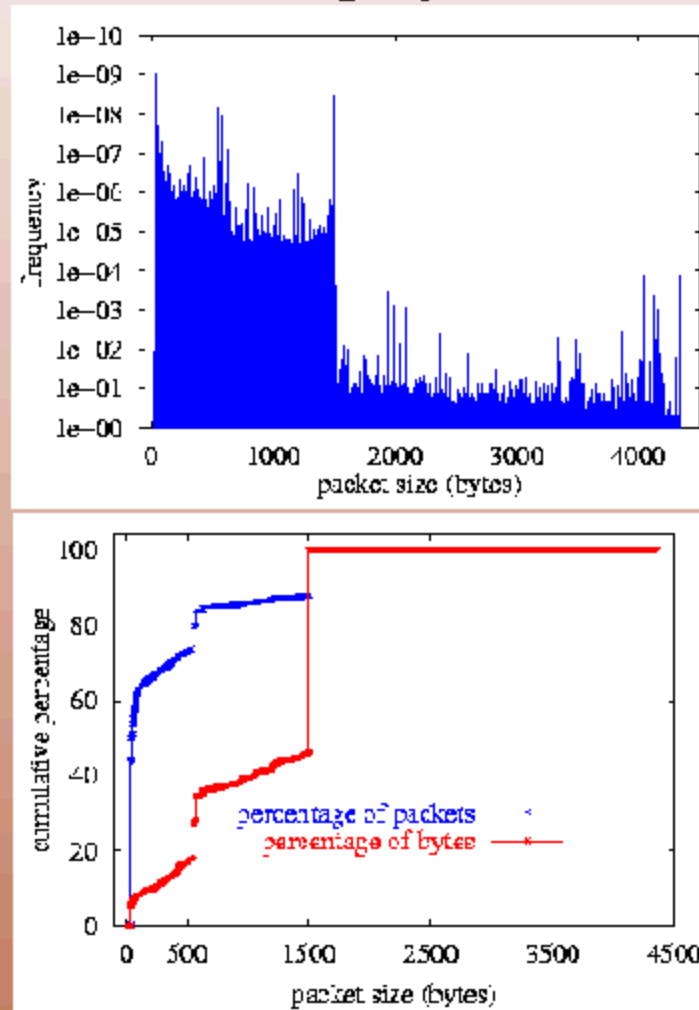
traffic vs prefix length

5 minutes, 5 dec 97, domestic mci link
routing table from UO route-views
depends much on ISP aggregation policies



packet sizes, 4/13/98 mci backbone

half pkts 40 bytes, half payload in 1500 byte pkts

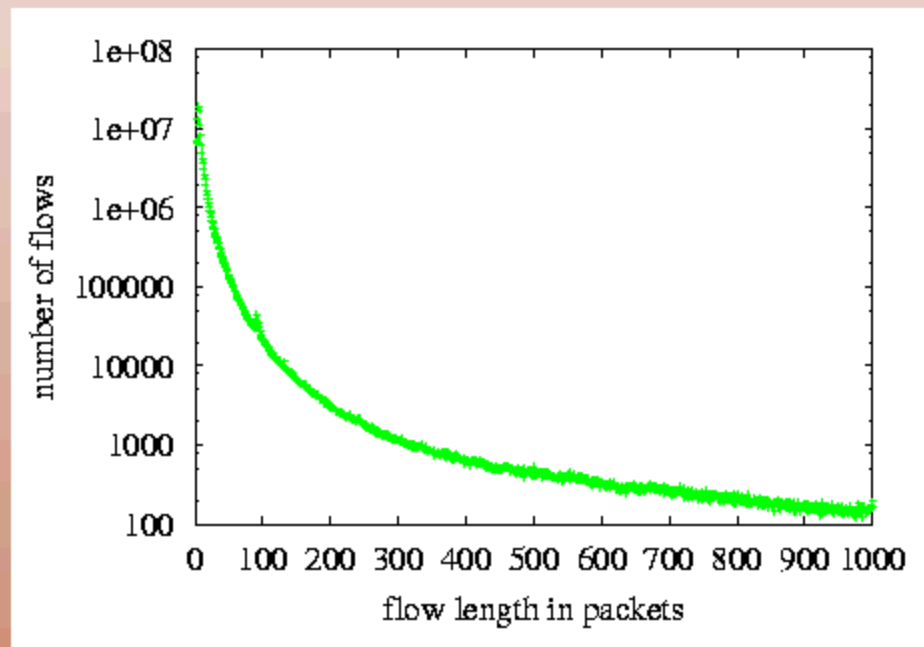


flow length distribution, 4/13/98 mci backbone

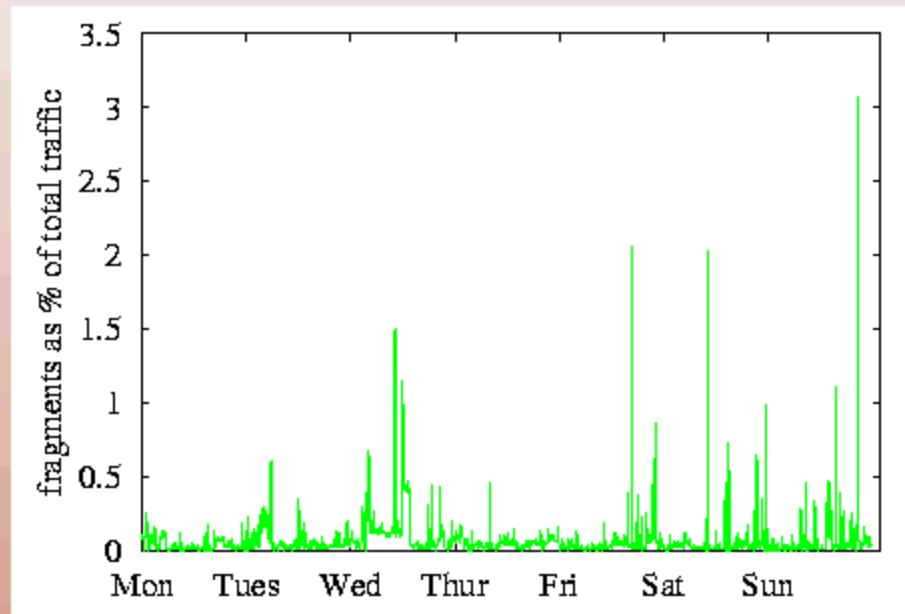
heavy tail (quite truncated)

if you only learn about one distribution this quarter...

flow defn creates artifacts (100 bytes)



IP fragmentation, 4/[13-20]/98 mci backbone trunk



workload characterization: priorities

- coral/ocXmons up to OC12 (OC48)
- persistent, real-time, full-frame collection
- dynamic packet filtering triggered by attack precursors
- security policy
 - compliance auditing (passive)
 - enforcement (active)

obstacles

- hardware expensive
- privacy issues
- IPsec

workload char: working w/vendors

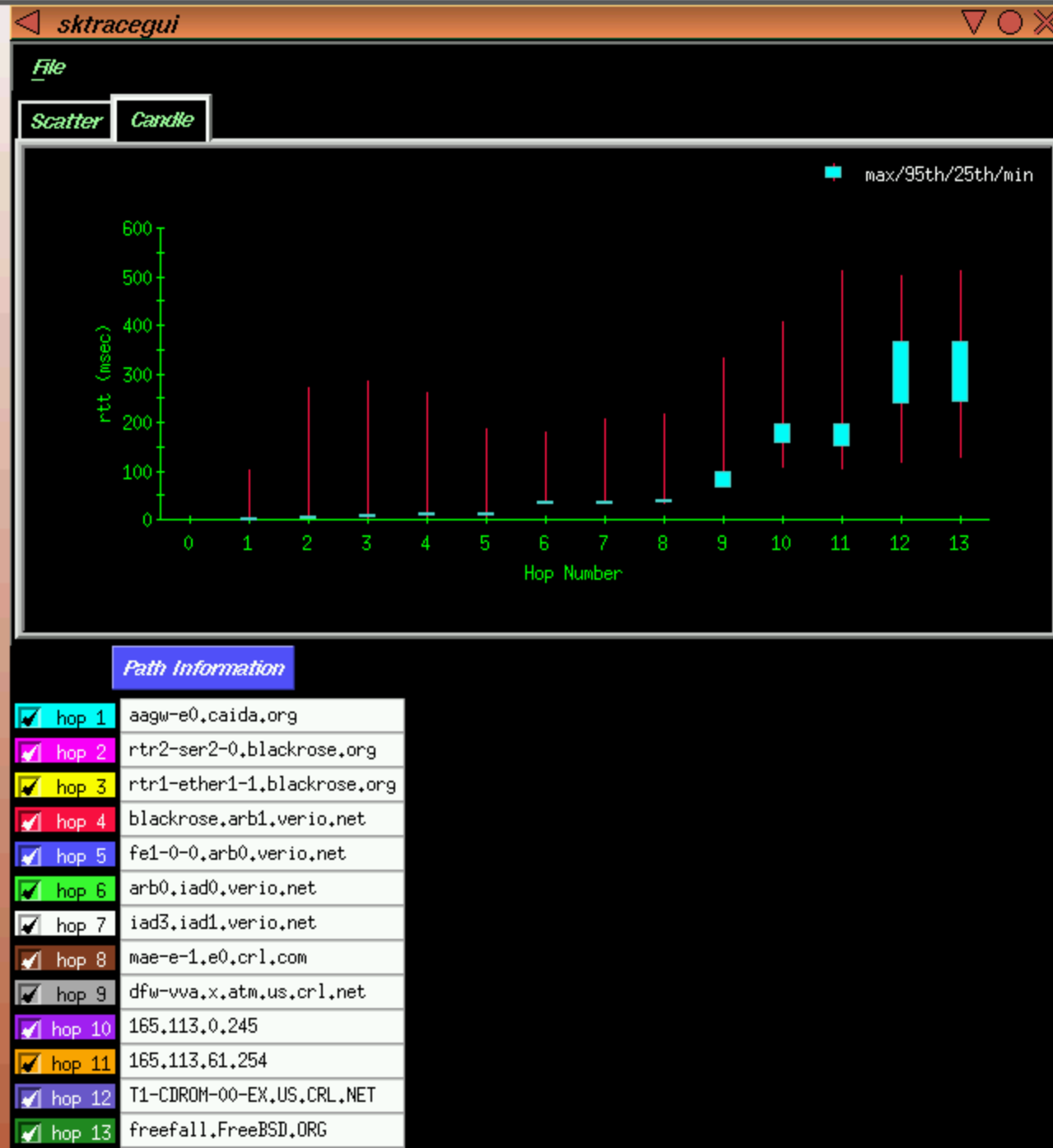
Cisco routers (cflowd) – up to OC3 speeds

- <http://www.caida.org/Tools/Cflowd>
- used primarily for capacity planning and trend analysis
 - AS-to-AS matrices
 - net-to-net matrices
 - port and protocol tables
 - forward IP path
- measurement specification
http://www.caida.org/Docs/meas_spec.html

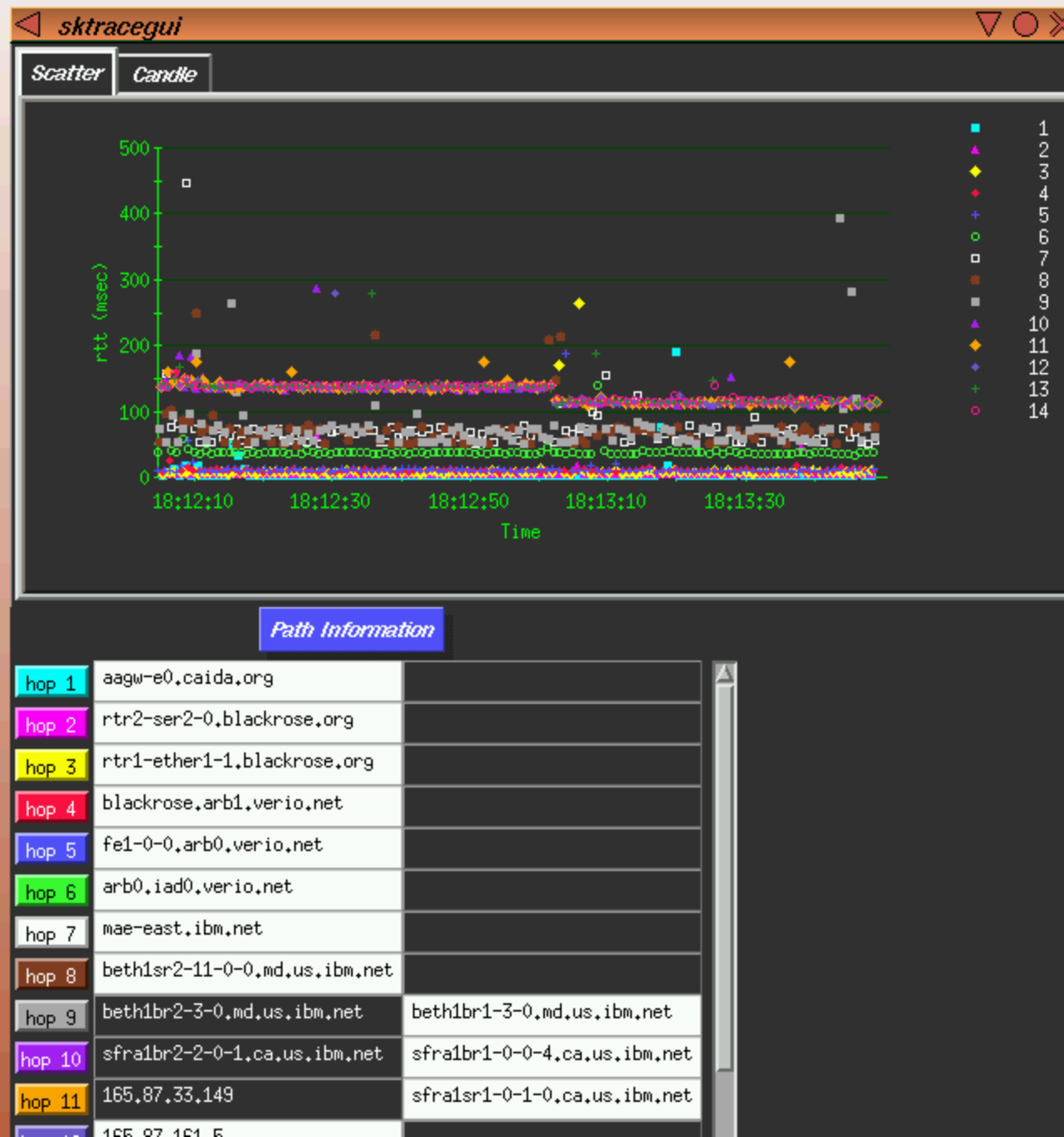
performance evaluation (active)

- network engineers to diagnose problems
- users to verify SLAs
- designers of real-time apps to predict software HCI
- Internet weather reports

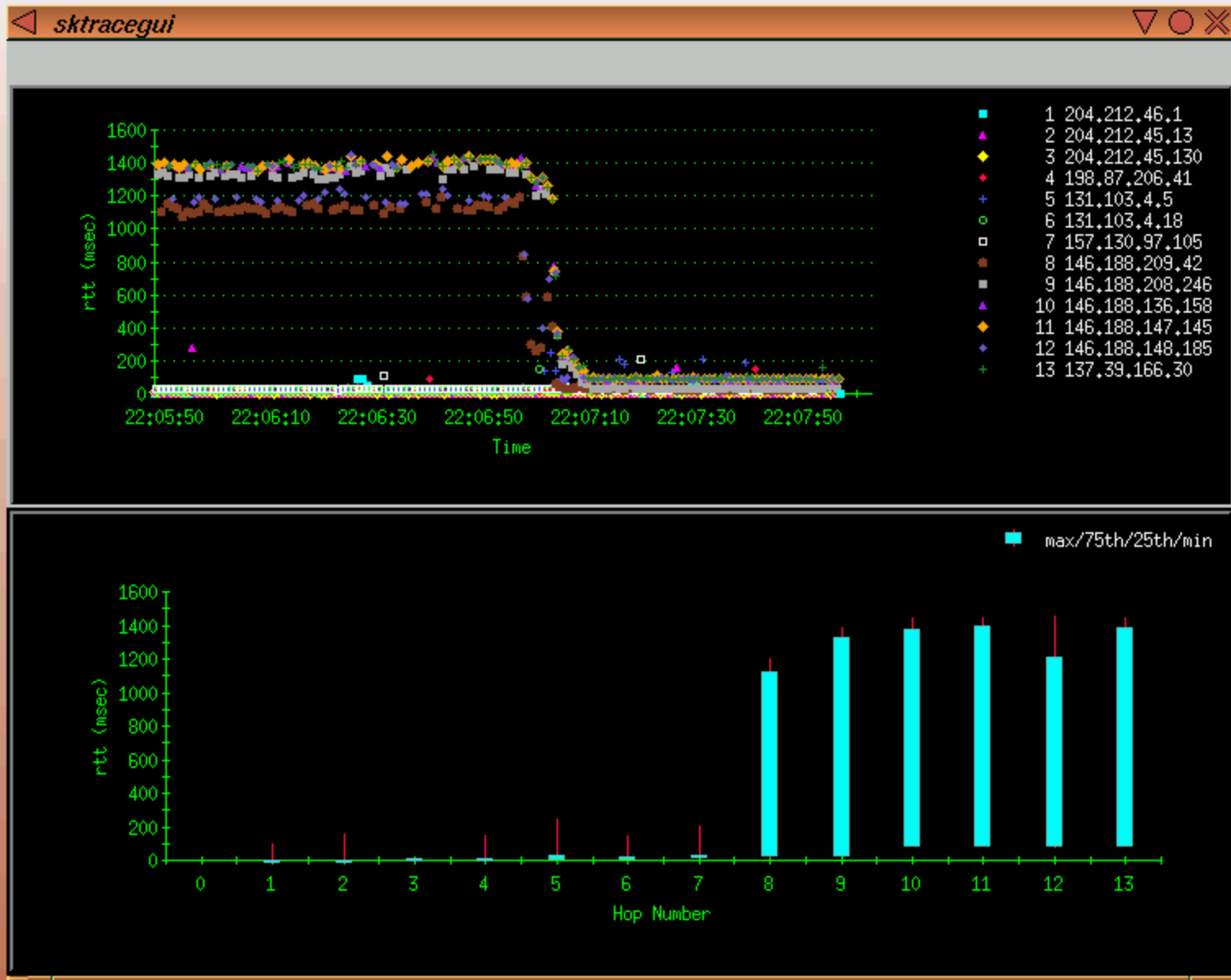
perf. eval: skping (www.freebsd.org)



perf.eval: routing (path change)



perf.eval: sktrace (www.cnet.com)



performance eval.: priorities

- definitions & metrics
- bandwidth assessment techniques
- correlation with workload data
- large scale deployment
- user interface to measurements

obstacles

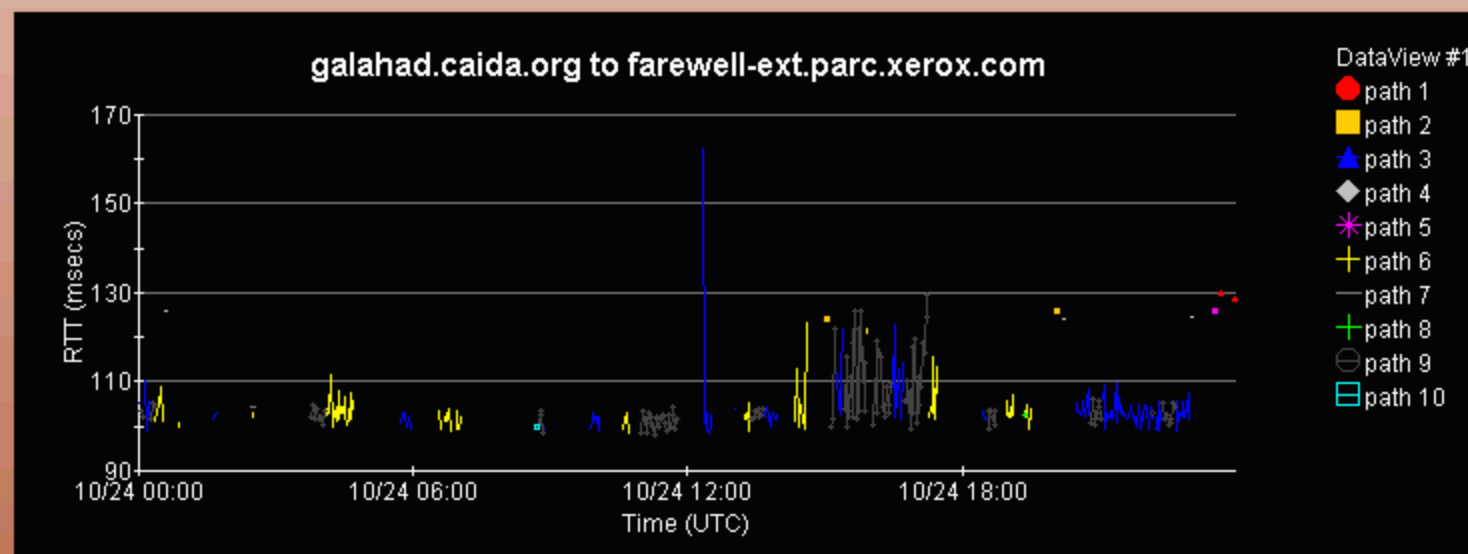
- core infrastructural access
- mathematicians needed
- statisticians needed

routing dynamics

- 1970's technology
- admittedly seems like pretty good stuff
- sausage/laws....
- incredibly inflexible, inefficient, incantation-driven

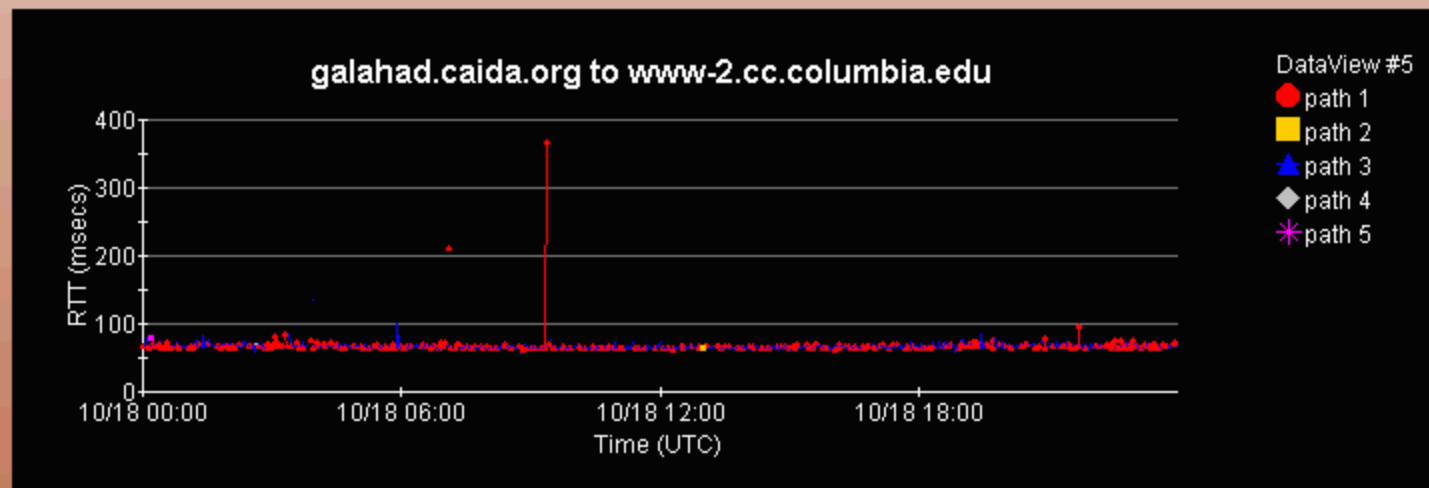
routing: example (instability)

- 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



routing: research priorities

- effects of outages on surrounding ISPs
- effects of topology changes on Internet performance
- unintended consequences of new policies
- detect areas for improving an individual networks' ability to respond to congestion and topology changes
- vulnerabilities created by dependencies on critical paths
- utilization of address space
- efficiency of routing table
- asymmetric, unstable routing by provider
- incongruity of unicast with multicast

routing: research obstacles

- canonical BGP (route table) data
(not so much anymore)
- mapping IP address to anything
(we've been here before)
- prudent security dictates making
research difficult

now what?

- ‘seamless’: no such thing
- measurement tools/infrastructure
 - well-considered
 - strategically deployed
 - collaboratively maintained
- more infrastructure-relevant research on resulting data
 - feedback into tool design
- correlation among data sources/types, simulation, visualization
- proactive participation
 - top-down (app devel’s scope constr.)
 - bottom-up (ISP cooperation)

researchers

- in difficult position
- responsible for creating windows into infrastructure
 - no access to glass
 - poke holes as methodically as possible
 - much activity w/much less integrity by others
- without trust & collaboration from ISPs, field not going anywhere, tools have to help them first
- funding sources should push relationships



www.caida.org/Presentations/

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