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A primer on network flow visualization

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Problem: Seeing the Forest through the trees

"Too much information"

- Abilene generating 5-6,000 flows/second
- Typically about 270,000-350,000 "active" active flows during the day

"Raw" data analysis inadequate

- Forest through trees

SNORT raw log file example

```
] (spp_portscan2) Portscan detected from 207.75.xxx.xxx: 4 targets 21 ports in 28 seconds [**]
5.727011 207.75.xxx.xxx:80 -> 149.165.xxx.xxx:49194
S:0x0 ID:0 IpLen:20 DgmLen:60 DF
 0xD756E195  Ack: 0xDDC23C59  Win: 0x16A0  TcpLen: 40
6) => MSS: 1460 NOP NOP TS: 518109736 2681681736
> NOP WS: 0

1] (snort_decoder): Short UDP packet, length field > payload length [**]
8.526214 149.165.xxx.xxx:0 -> 149.165.xxx.xxx:0
OS:0x0 ID:16642 IpLen:20 DgmLen:206


] ICMP Destination Unreachable (Communication Administratively Prohibited) [**]
on: Misc activity] [Priority: 3]
1.494517 128.109.xxx.xxx -> 149.165.xxx.xxx
TOS:0x0 ID:0 IpLen:20 DgmLen:56
13  DESTINATION UNREACHABLE: ADMINISTRATIVELY PROHIBITED,
ED
ATAGRAM DUMP:
xx -> 149.168.xxx.xxx
TOS:0x0 ID:2394 IpLen:20 DgmLen:92
P

] (spp_rpc_decode) Incomplete RPC segment [**]
2.345311 64.12.xxx.xxx:5190 -> 149.165.xxx.xxx:32771
OS:0x0 ID:45414 IpLen:20 DgmLen:98 DF
 0xD9256CFA  Ack: 0xC79F78B9  Win: 0x4000  TcpLen: 20

] (spp_stream4) STEALTH ACTIVITY (FIN scan) detection [**]
0.235714 66.250.xxx.xxx:25111 -> 149.165.xxx.xxx:13091
S:0x0 ID:59791 IpLen:20 DgmLen:52 DF
 0x32BE0760  Ack: 0x0  Win: 0xFFFF  TcpLen: 32
3) => NOP NOP TS: 234082903 0
```

Problems with that

Visually unattractive

- "Angry Fruit Salad"

Information overload

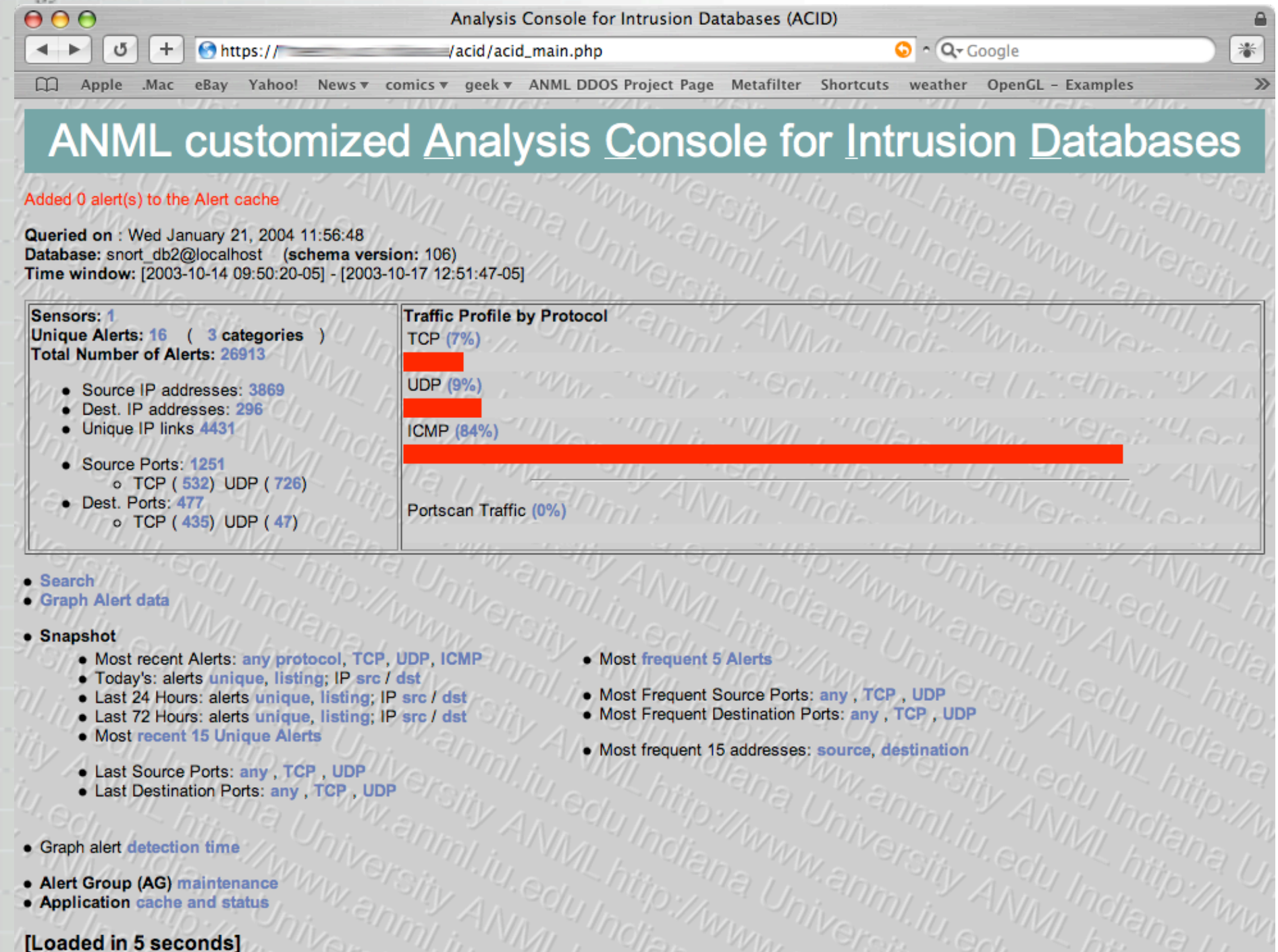
False-positives

Forest through the trees

Evolution of visualization techniques

- Text-Based
- 2D visualization of old text information
  - I.e. ACID interface to SNORT

ACID display



ACID display

Ok, getting better. System is doing some aggregating for us.

We have some visualization (traffic profile)

But still showing us the same alerts, the vast majority of which are not actually issues.

Emergence of statistical tools

Next step was emergence of so-called statistical tools

Idea of establishing a baseline of “normal” activity

Detect deviations from “normal”

Throw a nice 2D front-end on it

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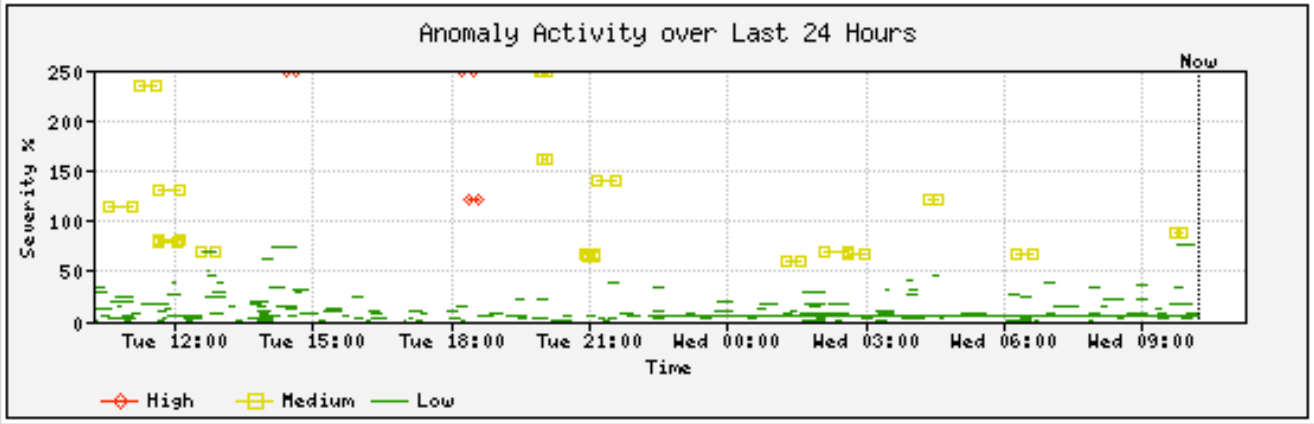
ARBOR display

napshot

Totals		High	Medium	Low
	[23]:	0	0	23
	[2227]:	4	37	2186
	[2225]:	4	18	2203



Statistical tools

But the bias is still there

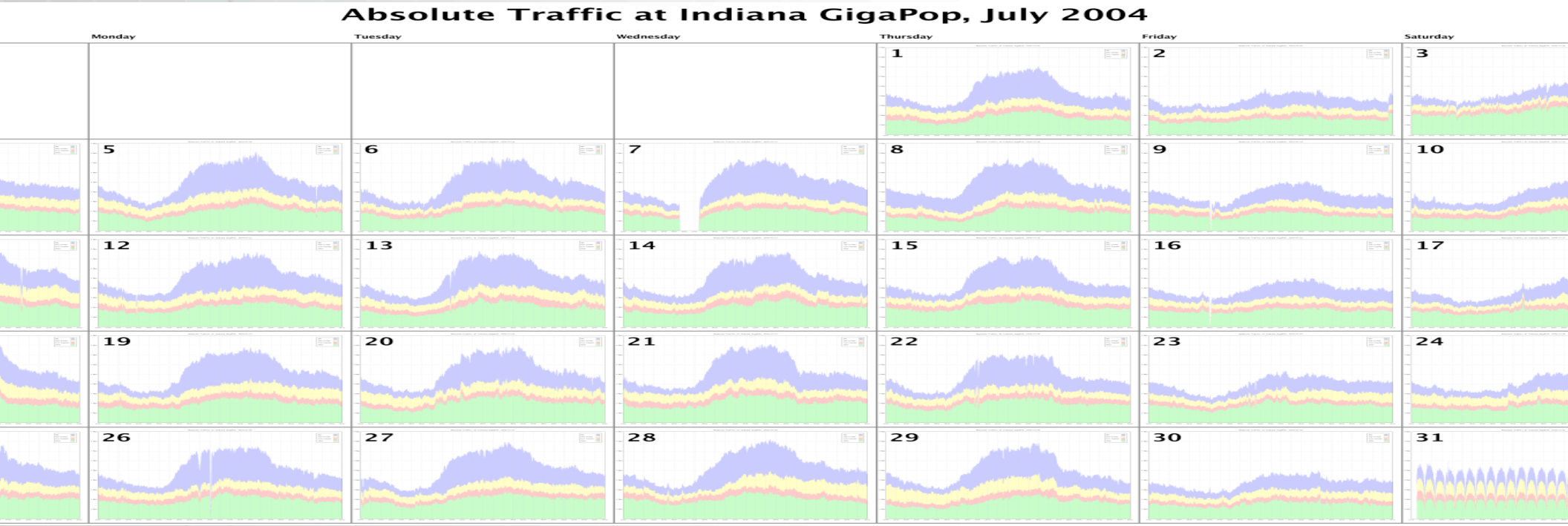
- What's more damning, overreporting or underreporting

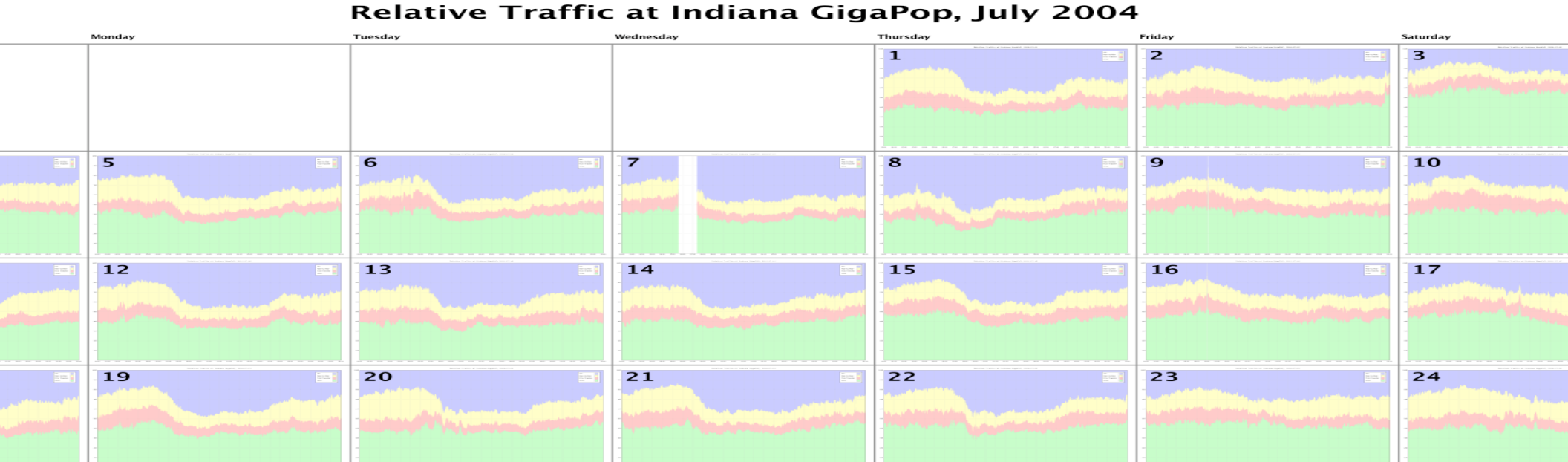
And you have to be able to establish a baseline of "normal" activity

- Not possible in dynamic environment
- Miss low-level "noise" activity

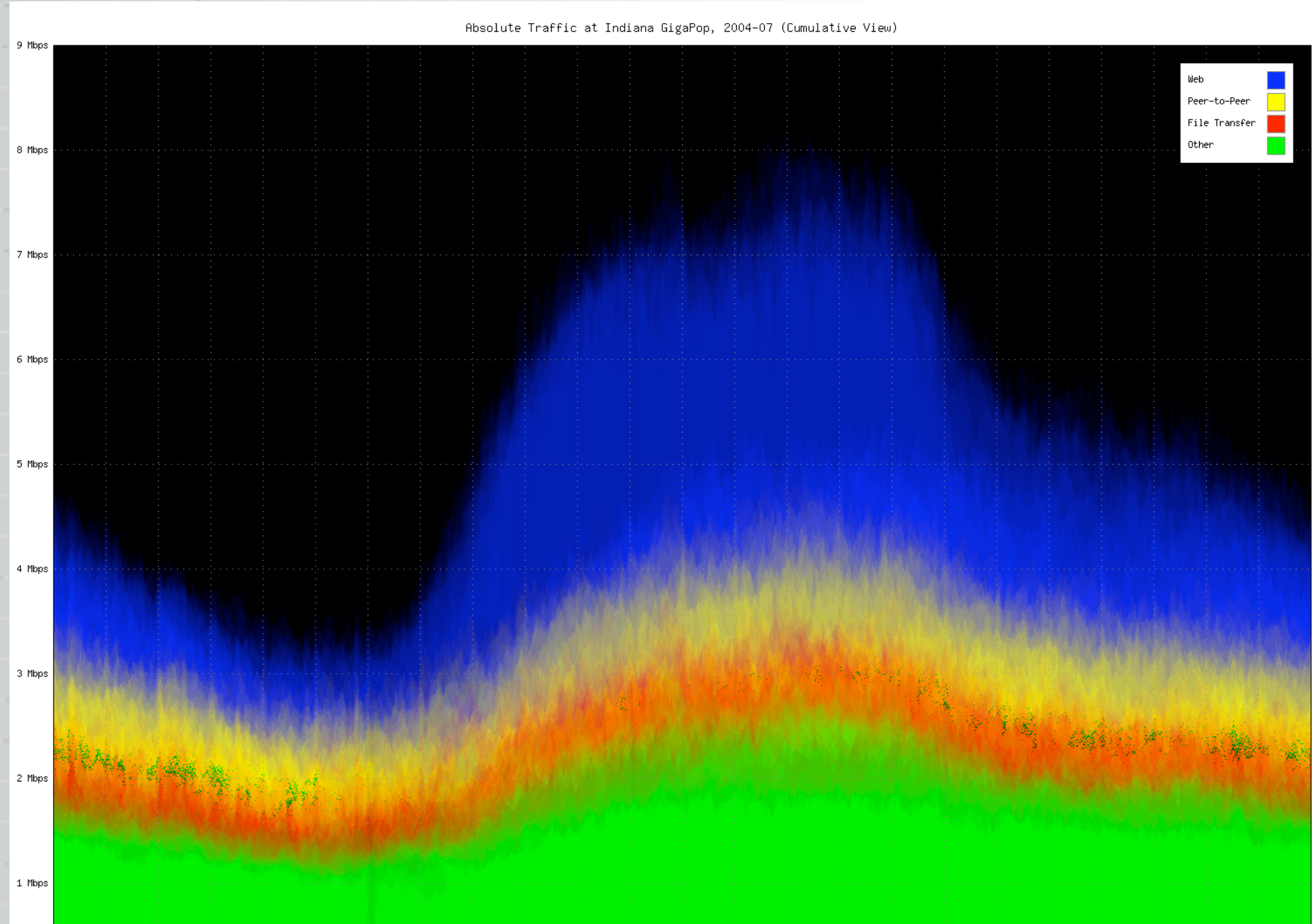
Some more examples

Pure Visualization Tools

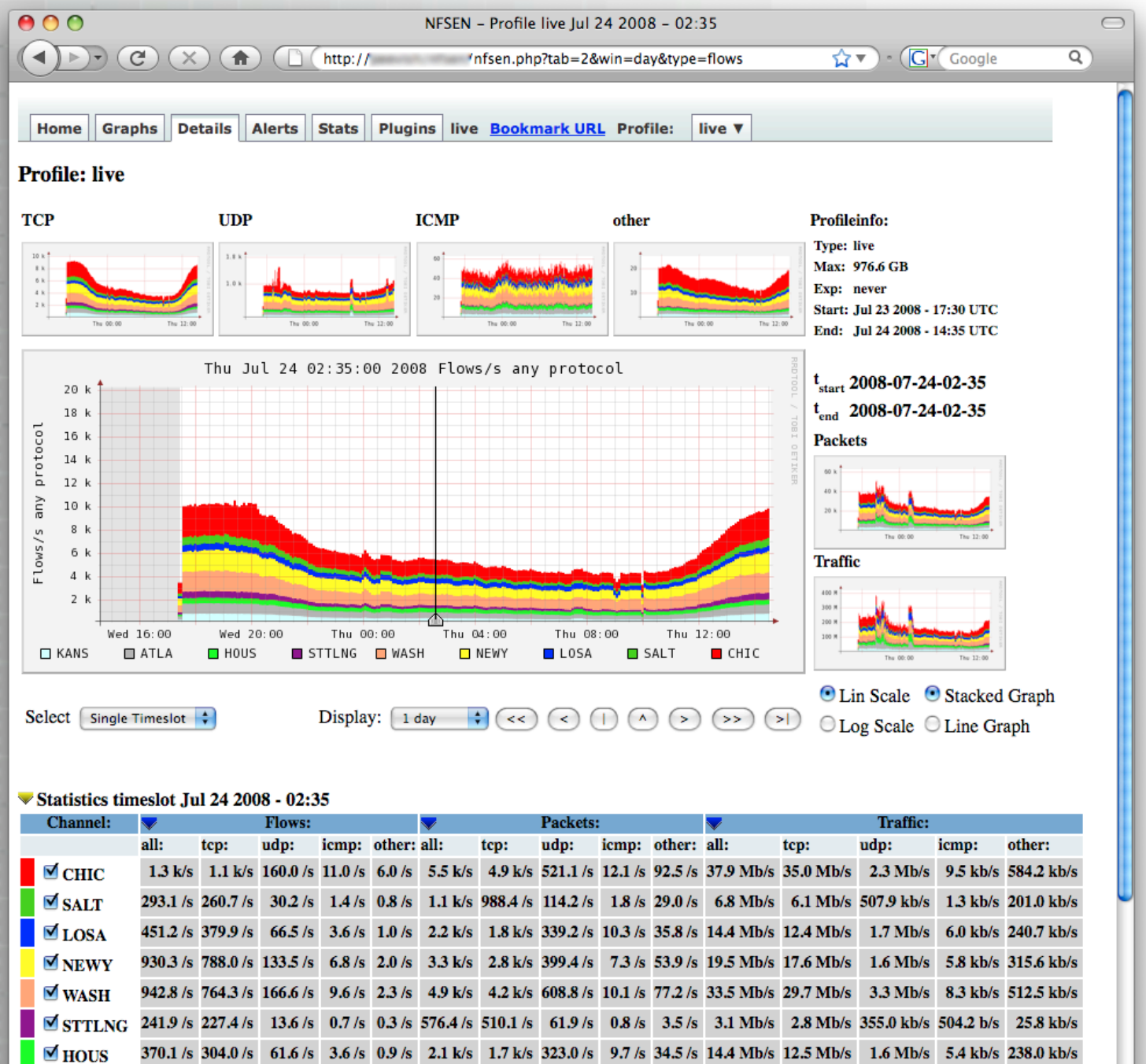




Same thing, only different

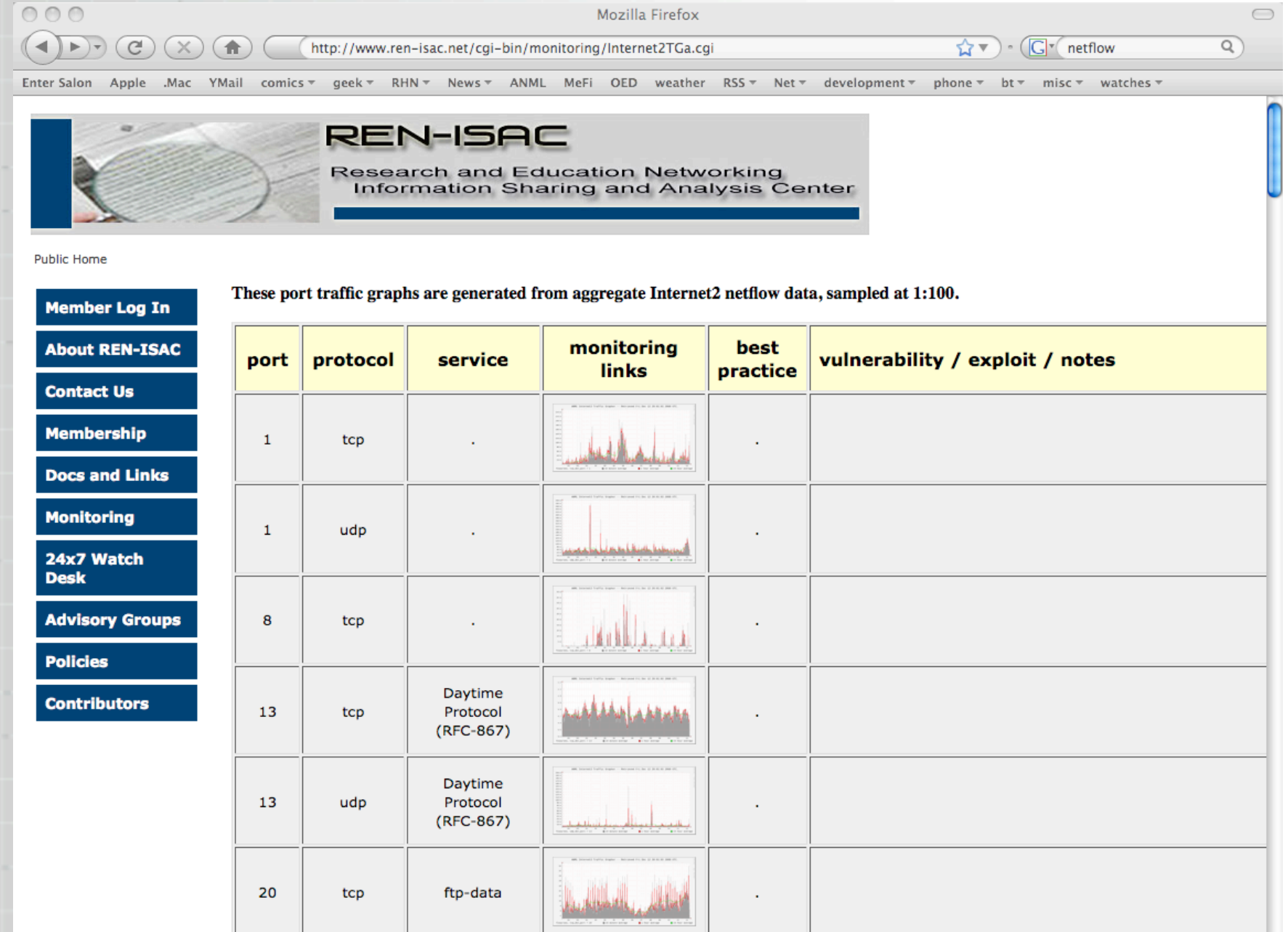


NFSEN



Channel:	Flows:					Packets:					Traffic:				
	all:	tcp:	udp:	icmp:	other:	all:	tcp:	udp:	icmp:	other:	all:	tcp:	udp:	icmp:	other:
CHIC	1.3 k/s	1.1 k/s	160.0 /s	11.0 /s	6.0 /s	5.5 k/s	4.9 k/s	521.1 /s	12.1 /s	92.5 /s	37.9 Mb/s	35.0 Mb/s	2.3 Mb/s	9.5 kb/s	584.2 kb/s
SALT	293.1 /s	260.7 /s	30.2 /s	1.4 /s	0.8 /s	1.1 k/s	988.4 /s	114.2 /s	1.8 /s	29.0 /s	6.8 Mb/s	6.1 Mb/s	507.9 kb/s	1.3 kb/s	201.0 kb/s
LOSA	451.2 /s	379.9 /s	66.5 /s	3.6 /s	1.0 /s	2.2 k/s	1.8 k/s	339.2 /s	10.3 /s	35.8 /s	14.4 Mb/s	12.4 Mb/s	1.7 Mb/s	6.0 kb/s	240.7 kb/s
NEWY	930.3 /s	788.0 /s	133.5 /s	6.8 /s	2.0 /s	3.3 k/s	2.8 k/s	399.4 /s	7.3 /s	53.9 /s	19.5 Mb/s	17.6 Mb/s	1.6 Mb/s	5.8 kb/s	315.6 kb/s
WASH	942.8 /s	764.3 /s	166.6 /s	9.6 /s	2.3 /s	4.9 k/s	4.2 k/s	608.8 /s	10.1 /s	77.2 /s	33.5 Mb/s	29.7 Mb/s	3.3 Mb/s	8.3 kb/s	512.5 kb/s
STTLNG	241.9 /s	227.4 /s	13.6 /s	0.7 /s	0.3 /s	576.4 /s	510.1 /s	61.9 /s	0.8 /s	3.5 /s	3.1 Mb/s	2.8 Mb/s	355.0 kb/s	504.2 b/s	25.8 kb/s
HOUS	370.1 /s	304.0 /s	61.6 /s	3.6 /s	0.9 /s	2.1 k/s	1.7 k/s	323.0 /s	9.7 /s	34.5 /s	14.4 Mb/s	12.5 Mb/s	1.6 Mb/s	5.4 kb/s	238.0 kb/s

REN-ISAC Threat Monitoring



port	protocol	service	monitoring links	best practice	vulnerability / exploit / notes
1	tcp	.		.	
1	udp	.		.	
8	tcp	.		.	
13	tcp	Daytime Protocol (RFC-867)		.	
13	udp	Daytime Protocol (RFC-867)		.	
20	tcp	ftp-data		.	

Problems with those approaches

Can only "see" ports you've decided to see.

Need to manually intervene to set up what to watch

Forest through the trees

Evolution of visualization techniques

- Text-Based
- 2D visualization of old text information
  - I.e. ACID interface to SNORT
- 3D visualization?

Other 3-D Visualizers

VIAssist (Commercial)

Nvision

DAVIX (Similar to gCube, but more extensive)

UniVis

www.vizsec.org (clearinghouse of network visualizers)

gCube

Nascent effort to develop a *useful* & *lightweight* 3D modeling capability.

Not an original idea (Shakespeare had it first)

- Saw a similar tool at SC2003
  - Steve Lau (LBNL) Cube of potential doom
    - BRO project (http://www.icir.org/vern/bro.html)

Nor the end of the line (see DAVIX, VIAssist, etc.)

What is it?

Simple & Basic version is 3D view of "flow" activity

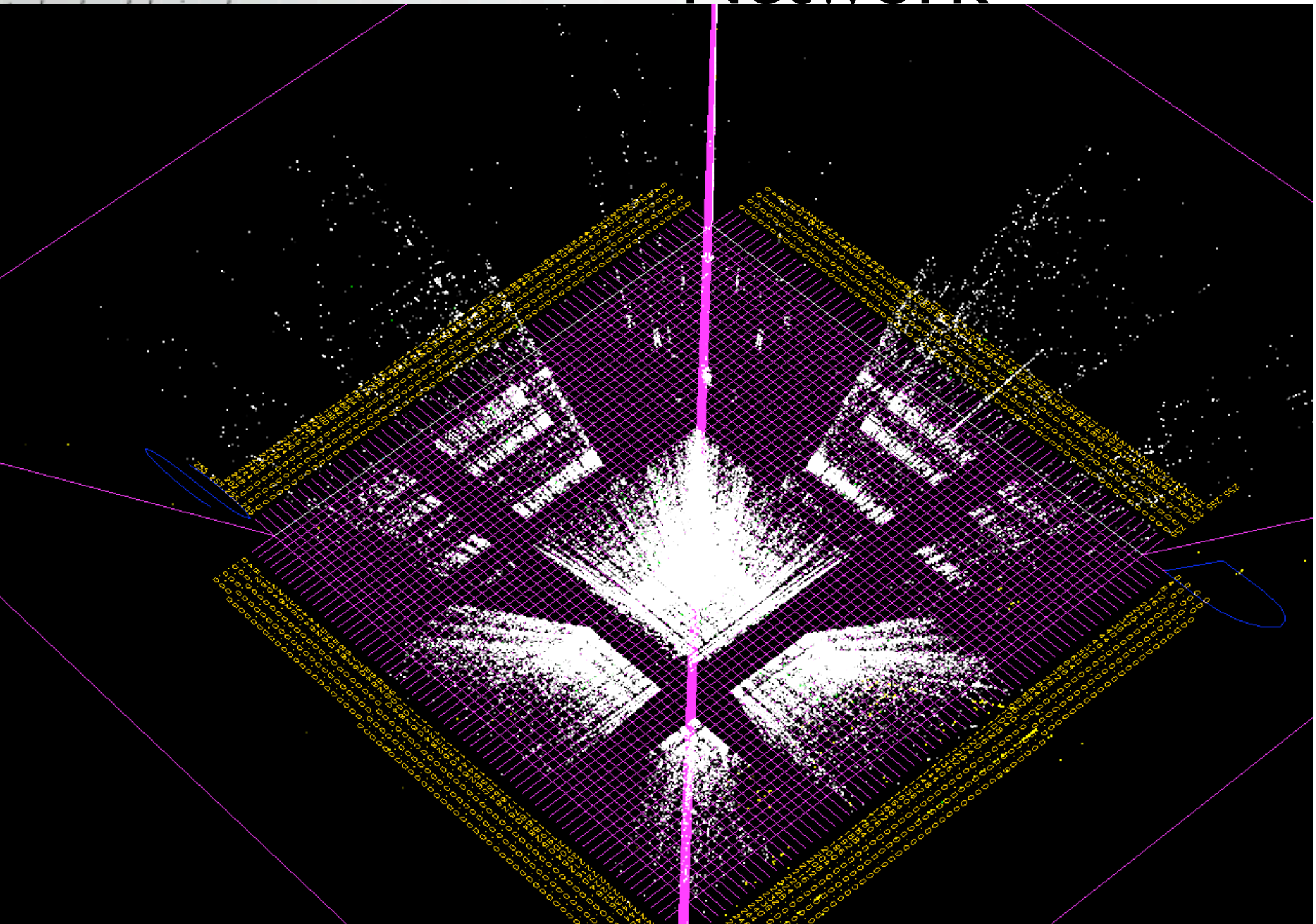
- X/Z axis determined by source/destination IP
- Y axis determined by port number
  - Usually destination port number

Where does it get its input?

Three possible inputs:

- Direct NETFLOW feed
- Archived NETFLOW (files)
- PCAP view of local network

Looking down on the Internet2 Network

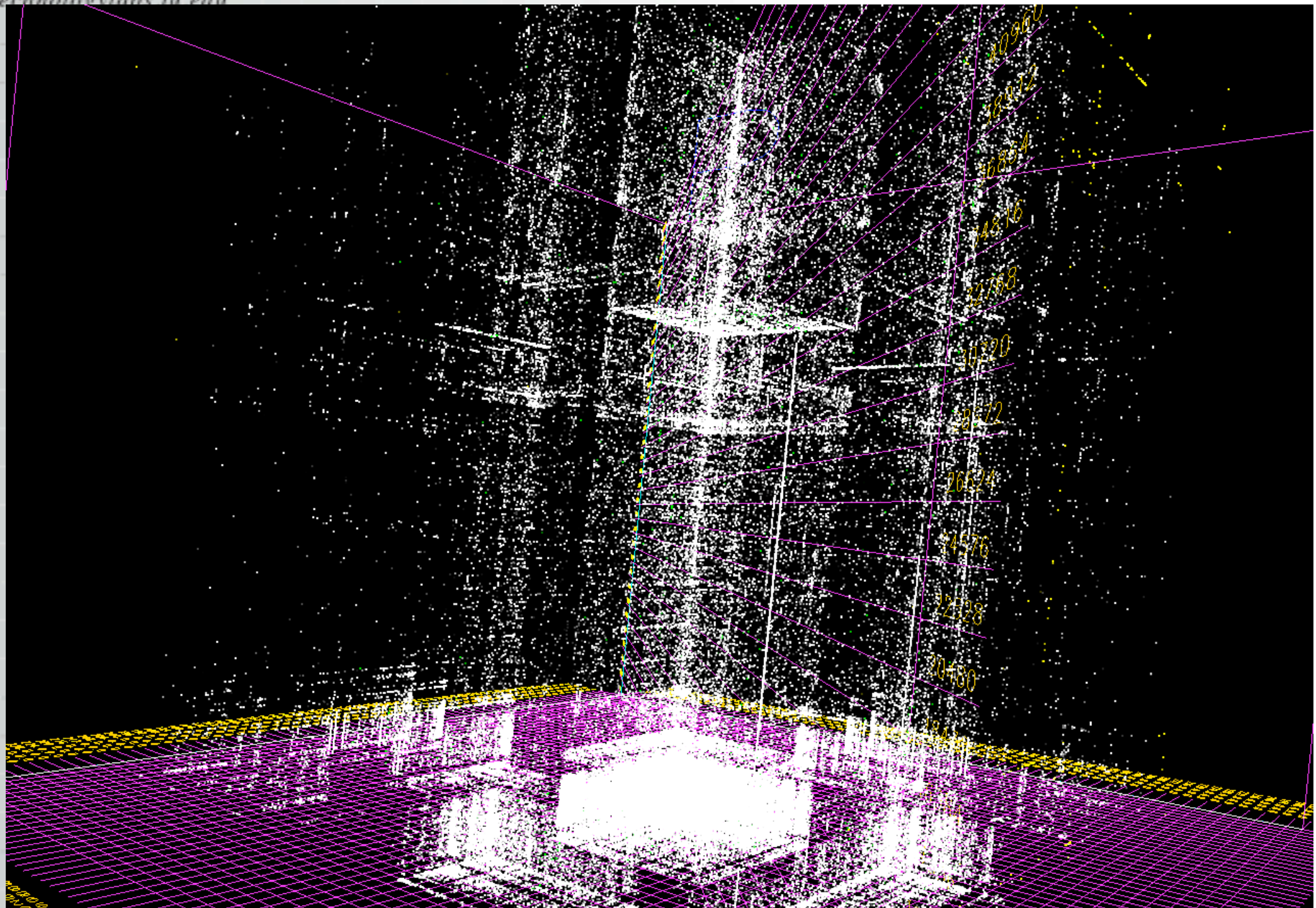


What are we seeing?

Entire IPv4 address space (all 4 billion possible source and destination addresses)

- Blank areas represent portions of IP space not allocated to Abilene-connected institutions
- Allocation pattern is interesting
  - 4 “towers”
  - Early remnants of class-A allocations
    - MIT, .gov, etc.

Side view of I2



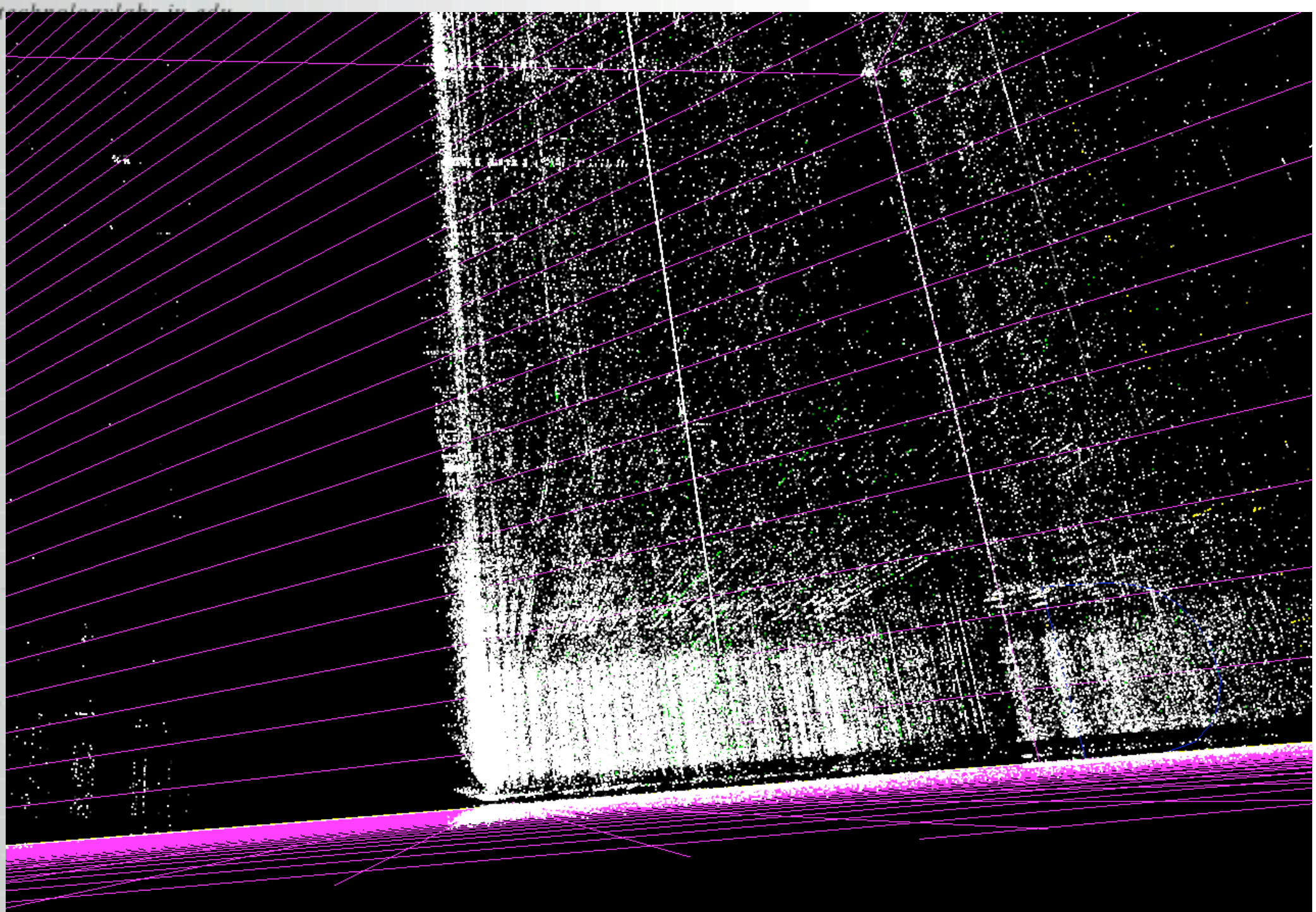
What structures are visible?

Special “floors”

- 32K port allocation floor
- 40K port allocation floor
- Density of port allocations at lower levels

An apparent port scan!

The low level

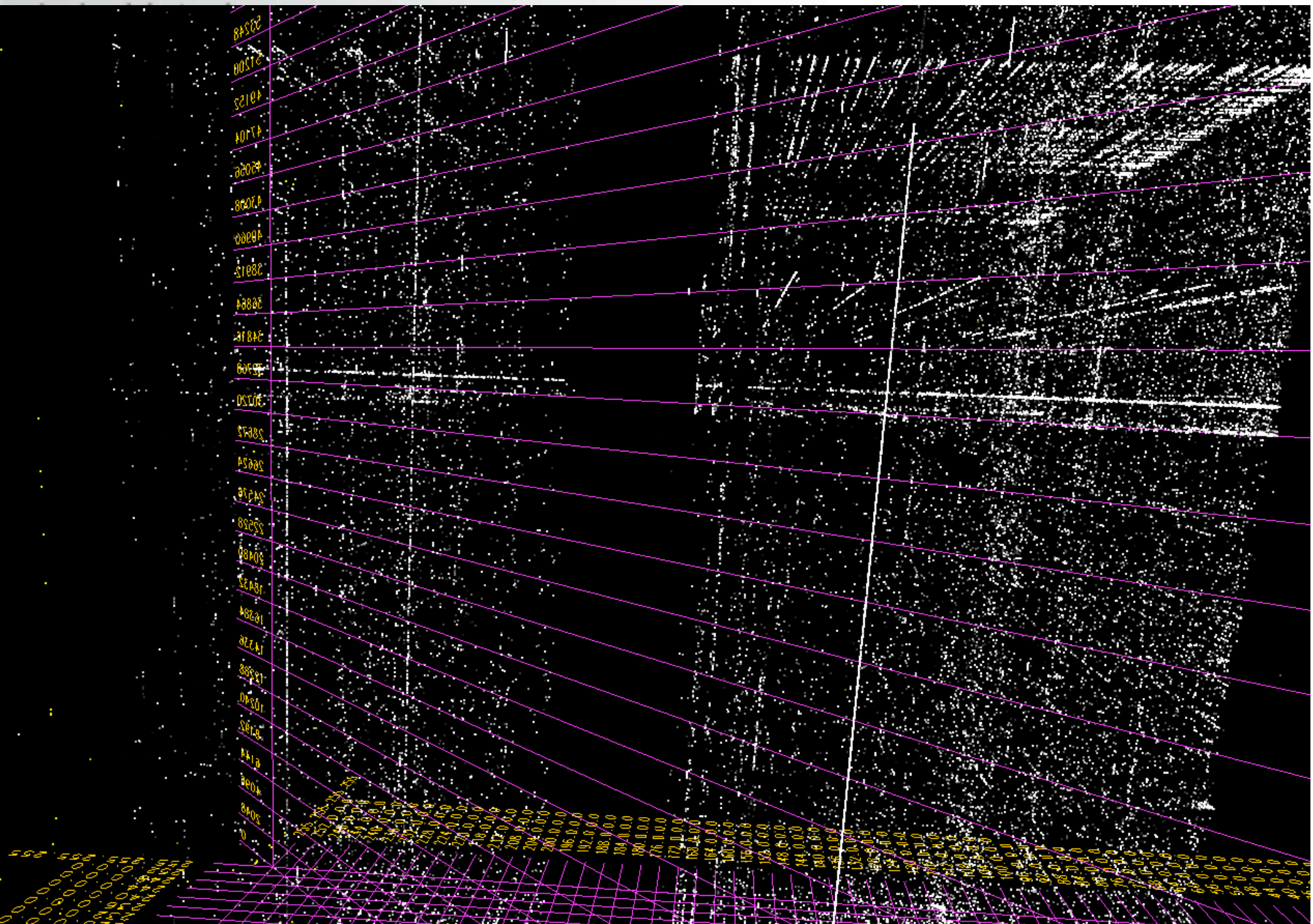


Visualizing DDoS with gCube

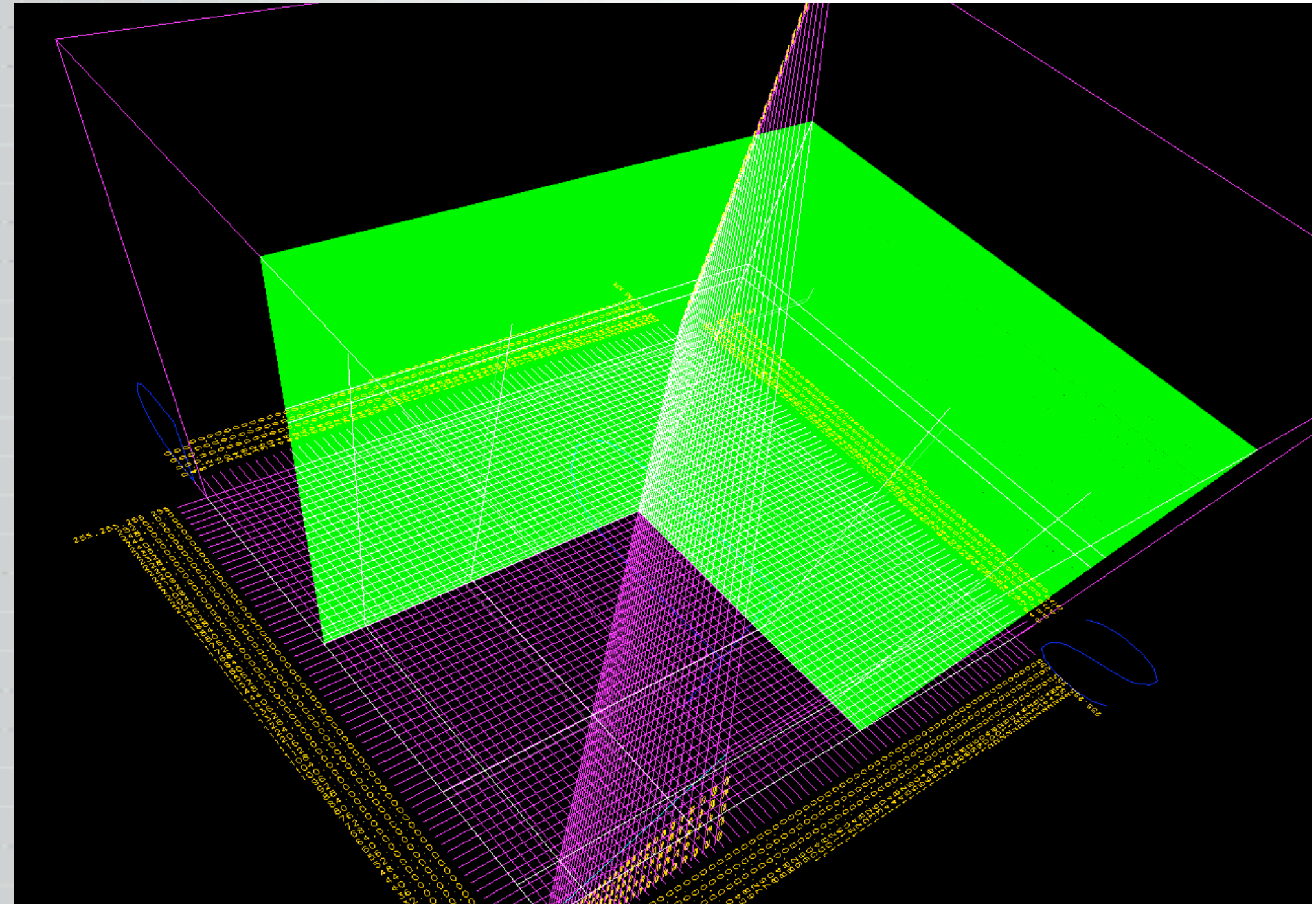
Eventual hope is to develop gCube into a DDoS visualization tool

- Particularly good at detecting
  - Port Scans
  - Host Scans
  - Scans into "abnormal" IP space
    - I.e. Slammer type stuff
  - Rate/bandwidth anomalies

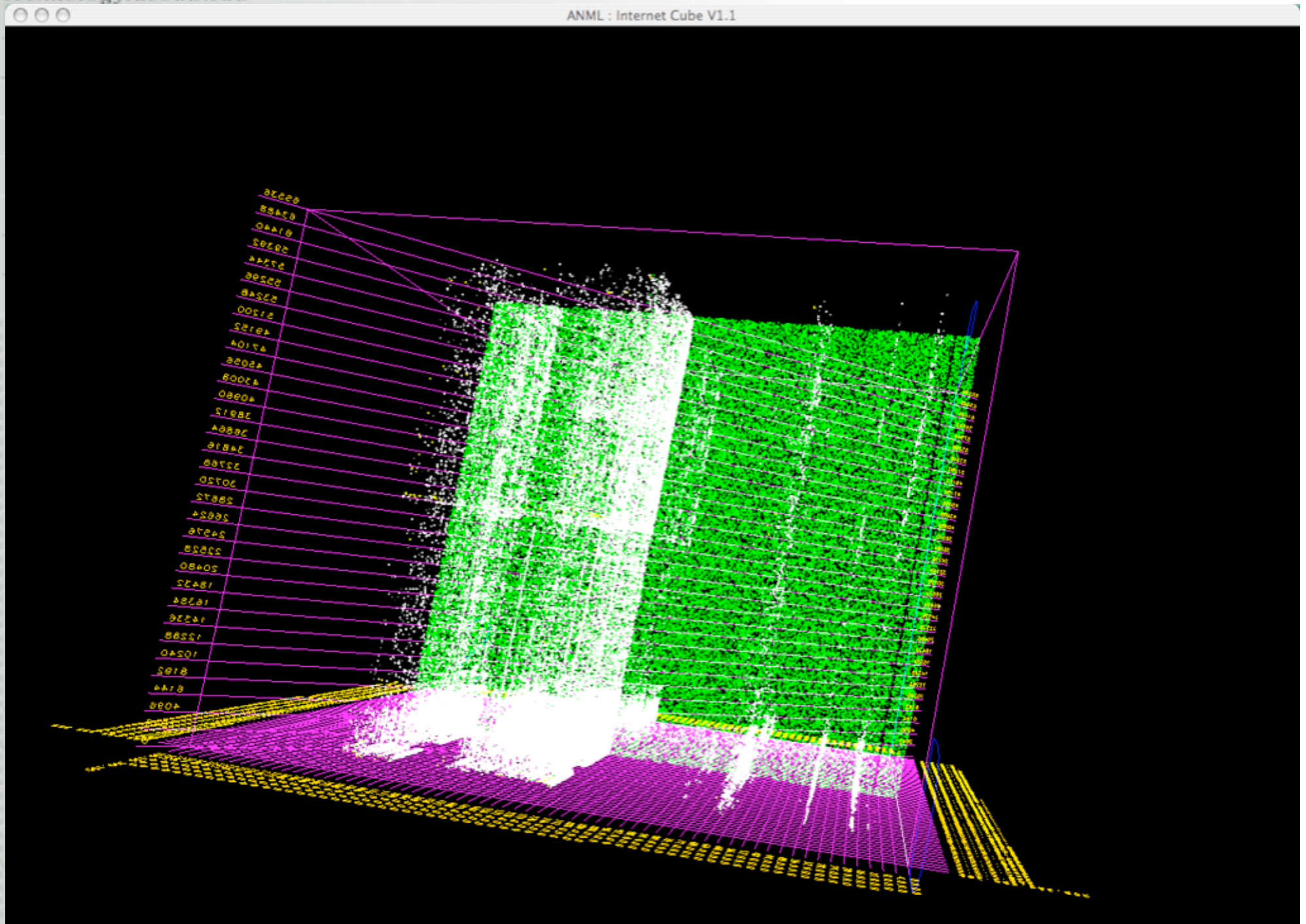
Simple case, portscan



Simulated Portscan



DDoS in the real world



What is that?

January 14th, 2003, ~2-3PM EST

Port scan of a destination address

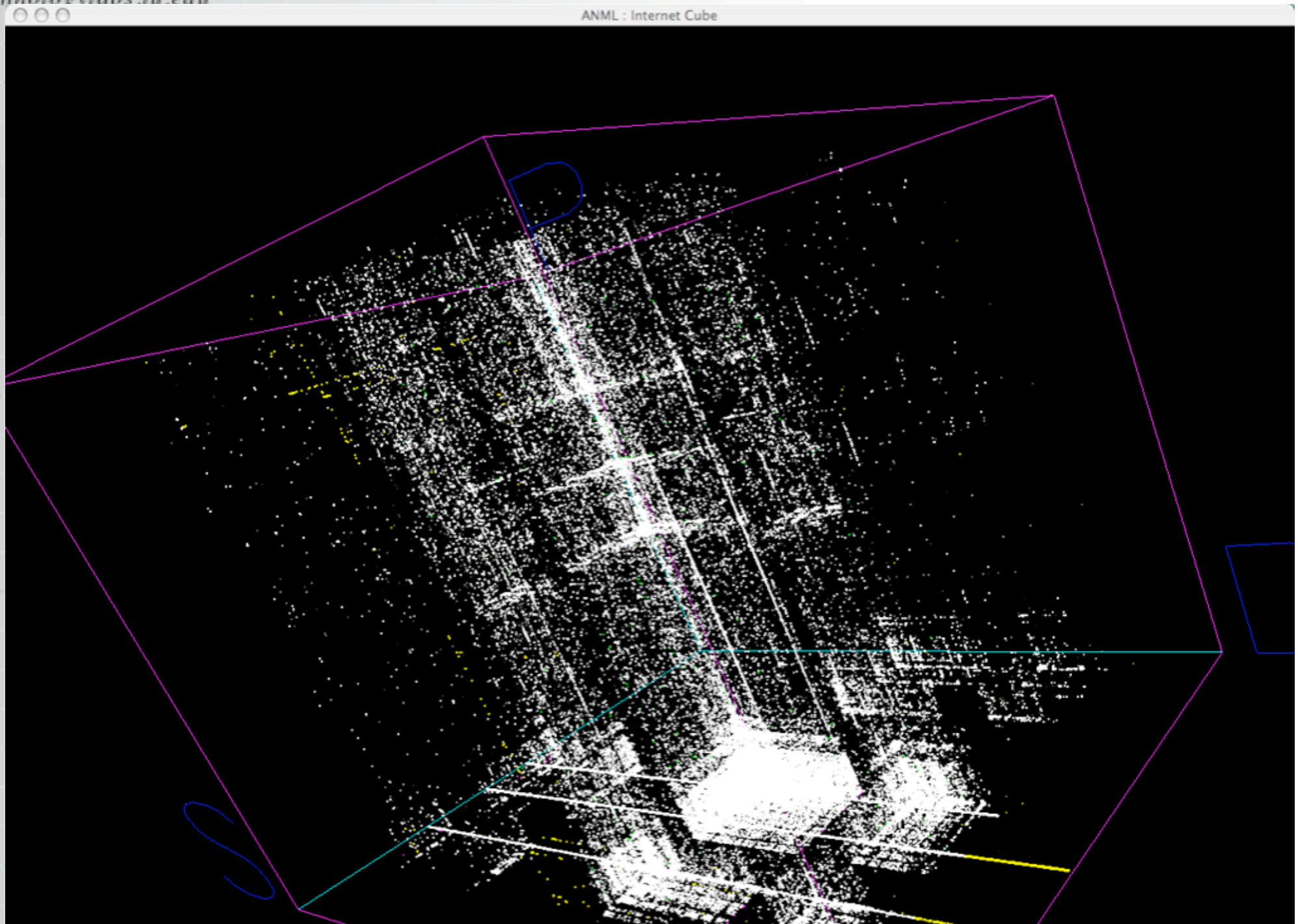
Spoofed source IP addresses

- Distributed equally through IP space

Had been preceded by apparent "experiments" earlier in the day and earlier in the week (Jan 5th)

- Experiments used only a single or few test ports

Experiments



Note

Attacks to three separate IPs/closely clustered groups of IPs

Spoofed source IPs

- But possibly from as many as three different organizations

At least one real source appeared to be suppressing sources from the multicast space

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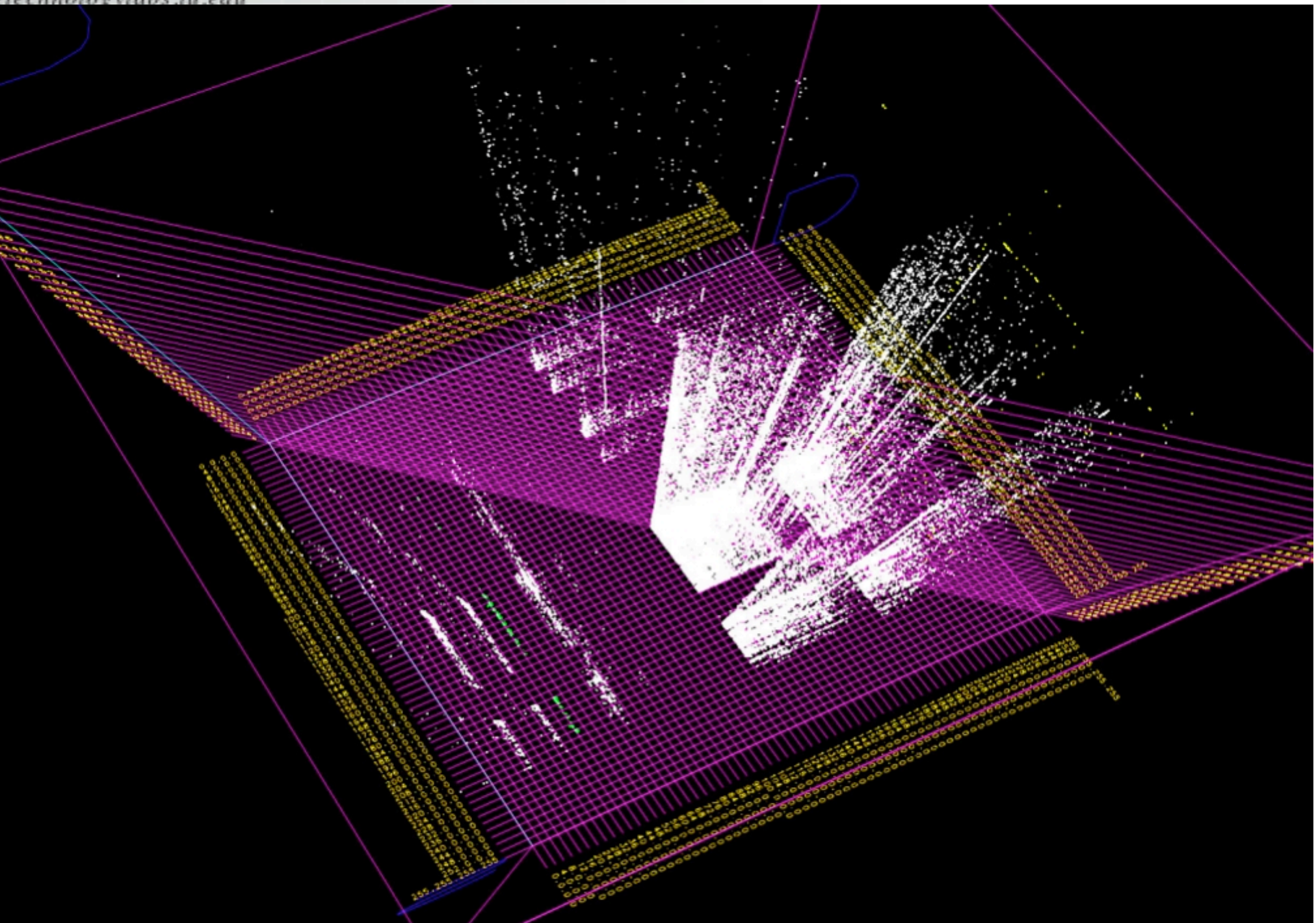
Backscatter



Backscatter