A Look At The Unidentified Half of Netflow (With an Additional Tutorial On How to Use The Internet2 Netflow Data Archives)

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Notes: All opinions expressed in this talk are strictly those of the author. These slides are provided in detailed format for ease of indexing, for the convenience of those who can't attend today's session in person, and to insure accessibility for both the hearing impaired and for those for whom English is a secondary language.

You Should Know Your Network Traffic

- When thinking about **network security**, an exhortation you'll commonly hear is to **"know your network traffic."** After all…
  -- if you don't know what your normal "baseline" traffic looks like, you're going to be hard pressed to identify **suspicious traffic** patterns, right?
  -- you'll need to understand your network traffic patterns if you're ever required to deploy a perimeter **firewall**, and
  -- you'll need to measure your network traffic if you want to do **network capacity planning**

- Just as you need a feel for your local and regional traffic, the I2 community should strive to understand the traffic on the national backbone. New programs such as the Commercial Peering Service and the FCC Rural Health Care initiative may make this all the more important.

What Is Netflow?

- Netflow is an open (but proprietary) Cisco protocol, but that term is used commonly to refer to any/all flow based analyses, including network flow data collected from non-Cisco routers, flow data gleaned from passive optical taps, etc.
- Netflow data is normally exported from one or more Netflow-enabled routers to a Netflow collector box (typically a fairly beefy dedicated PC server with lots of CPU and copious disk space)
- As data from the routers is received, it is periodically written to disk on the collector box (I2 writes flow data every five minutes).
- Applications can then be run against those saved Netflow data files to process the flow data into various summary reports.
- Many of you may run Netflow locally, but even if you don't, I2 collects flow data for all traffic passing across the Internet2 Network, grinding that data into a weekly summary which is available at http://netflow.internet2.edu/

NetFlow report for the week of 20071231 - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://netflow.internet2.edu/weekly/20071231/

Internet2 NetFlow: Weekly Reports: Week of 20071231

1. Introduction
2. Bulk TCP
   - Throughputs
   - Transfer Sizes
   - Durations
   - Selected Points from Distribution Graphs
   - Average Packet Sizes
   - Popular Applications
   - Fastest Measurement Flows with Unique AS Source and Destination
   - Fastest Non-Measurement Flows with Unique AS Source and Destination
   - Concurrency
3. Full Data Set
   - Aggregated Application Types
   - Detailed Application Types

And In Fact, That I2 Weekly Netflow Report Is Really What Inspired This Talk…

- If you look at a copy of the Internet2 Netflow Weekly Report, you'll see it covers at a wide range of topics, including:

  -- what's the throughput of bulk data transfers (transfers >=10MB)?
  -- what applications are being used on the network?
  -- is the MTU just 1500, or are jumbo frames being used?
  -- is all traffic best effort, or are DSCP code points being used to tag traffic for expedited service or for scavenger treatment?

- When categorizing flows, the report does its best to assign flows to applications, but **sometimes there are flows which don't fit any known application. Those flows then go into an "unidentified" category, a category which over time has grown to ~50% of all octets as the applications seen on the network have evolved.**

http://netflow.internet2.edu/weekly/20071231/

Table 6. Aggregated Application Types (Full Data Set)

Type	Octets		Packets	
Data Transfers	31.35%	159.1T	33.71%	223.1G
Encrypted Traffic	5.52%	28.01T	6.10%	40.40G
Audio/Video	5.09%	25.83T	1.79%	11.87G
File Sharing	2.86%	14.51T	2.87%	19.01G
Advanced Apps	2.62%	13.29T	2.35%	15.56G
Misc	2.29%	11.61T	5.81%	38.46G
Measurement	0.50%	2.549T	1.47%	9.702G
Games	0.39%	1.989T	0.52%	3.465G
Unidentified	49.38%	250.6T	45.37%	300.3G
Total	100.00%	507.6T	100.00%	661.9G

~50% Unidentified Traffic Is NOT a "One-Off" Phenomenon

Report Date	% Unidentified	Unidentified Octets
20071224	58.34%	268.8T
20071217	52.17%	343.8T
20071210	47.21%	358.8T
20071203	43.31%	295.2T
20071126	45.79%	363.9T
20071112	48.34%	340.3T
20071105	47.51%	379.0T
20071029	46.62%	362.1T
20071022	45.94%	352.4T
20071015	46.99%	368.4T
20071008	51.23%	324.6T
20071001	53.37%	338.5T
20070924	57.60%	443.5T
20070917	55.24%	415.2T

At The Risk Of Sounding Somewhat Obsessive/Compulsive, Seeing Roughly Half of All Octets "Unidentified" Bothered Me...

- If I'd seen a **few percent** unidentified, or maybe even **ten or twenty percent unidentified**, I'd be willing to shrug and forget about that traffic, but **seeing roughly half of all traffic end up in a residual "unidentified" category bothered me – what was it?**

  -- An important bread-and-butter application with non-standard port usage habits?
  -- Stealthy P2P or other bandwidth intensive apps intentionally trying to hide?
  -- Attack traffic? (you can always spot security types, can't you?)
  -- Something else?

- I decided I wanted to try to find out, grinding the data myself in my favorite statistical package, SAS. But would Internet2 Netflow data be routinely available for analysis? Well, it turns out, yes…

Gaining Access to Internet2's Netflow Data

http://abilene.internet2.edu/observatory/data-collections.html#netflow

Abilene Netflow Data

The Abilene NetFlow data is available using rsync from abilene-netflow.itec.oar.net. Flows are stored in flow-tools format. Access to netflow data is by special arrangement. To obtain an rsynC account to download the netflow data, please send mail to abilene@internet2.edu. More information on how to obtain the data is available at Proposal Process. Note that the IP addresses in the data have their low-order eleven bits set to zero, meaning the finest granularity one can see in the data is /21.

Data for each router is obtained at local collectors in the Abilene racks on a five minute interval. They are regularly pulled back to the central storage device, and on a daily basis, combined into a daily aggregated file that is router dependent. Logs for each day are available along with nighly summary reports.

For more detailed instructions, click here.

http://abilene.internet2.edu/observatory/proposal-process.html

- "The following information would be useful to the Abilene Observatory Program, and is necessary in the case of obtaining Netflow data. Please submit to abilene@internet2.edu:
  -- Give a brief description of the research project, including a title
  -- List the project leads and participants
  -- Include URLs if appropriate and available
  -- Indicate any potential issues with data resulting from the project, including any potential privacy issues.
  -- Should the project be listed as a participant on the Abilene Observatory web page?
  -- Submit an id and password to be used with rsync
  -- Submit a range or a set of individual ip addresses that will be used to access the data (range can be e.g., /28, /30, /32, etc.)
  -- Indicate any recommendations for additional data sets.

  "If Abilene data is used in research papers or articles, please send future citations to be included with the above information. Researchers are encouraged to cite the use of this data in papers and articles. […]"

"You've Been Approved!"

- Once approved, you'll have a personal username and password* which you can use to get rsync access to Internet2 flow data in flow-tools format (see http://www.splintered.net/sw/flow-tools/). Those records will have basically everything you'd normally see in regular Netflow records:
  -- src and dest IP addresses *(albeit with the last 11 bits zero'd)*
  -- src and dest autonomous system numbers
  -- src and dest port numbers
  -- protocol type (tcp, udp, etc.)
  -- number of packets and number of octets
  -- flow start and stop times
  -- tcp flags and TOS bits, input/output interface numbers and next hop IPs, etc.
- An 11 bit mask ==> the finest granularity IP address information available will be aggregated at the /21 level (e.g., netblocks with up to 2048 dotted quads). At that level of anonymization it may be effectively impossible to "pair up" sequential client/server query/response network flows for some busy systems.

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* Because that password will be stored unencrypted on the system you use to rsync data, pick a password used **only** for that rsync account, chmod the pwd file appropriately, and carefully limit the IP addresses allowed to have rsync access

"So Is Flow Data Useful At All If The Lowest 11 Bits of the IPs Are Zero'd?"

- Absolutely! Keep in mind that it is **very** uncommon to be able to get **any** netflow data (or **any** sort of passively collected data) for a national-scale network. Most backbones treat netflow (and other passively collected data) as confidential/business proprietary, and they do not make that data publicly available in **any** form for any purpose whatsoever, even if the data's been anonymized.
- Internet2, on the other hand, has always viewed support for those studying the network to be an integral part of its role, and that support has been made tangible via things such as sharing data.
- From an analyst's point of view, it would (obviously) be *trés commode* if flow data were to be completely unanonymized, but that need has to be carefully balanced against the larger need to respect the privacy of Internet2 users. An 11 bit mask is the result.

Sampled Netflow

- There's another complication: because of the line rates involved, the netflow data you get from Internet2 is only sampled at a rate of 1:100. That is, you don't get flows for every packet, but flows which result from sampling every one in a hundred packets.
  If you need to obtain absolute estimates for total traffic, you'll need to scale the totals you receive from sampled netflow accordingly (e.g., scale total octets or total packets by multiplying by 100)
- You may wonder WHY sampled netflow is necessary – why can't the router just export records for all the traffic it sees? The answer is that doing netflow imposes overhead, and if the router is exporting every flow associated with any packet, it may slow down and have trouble keeping up with its primary job of routing packets
- [Aside: Should Internet2 be deploying non-router-based passive flow-monitoring hardware appliances, at least on some links?]

No IPv6, Either

- In addition to only seeing sampled data rather than full flow data, don't be disappointed when you learn that you won't currently get to see native IPv6 flow records, even though that traffic **is** present on the backbone.
- Why is there no native IPv6 flow data? Well, Netflow version 5 (the traditional Netflow format used at most sites, including Internet2), doesn't support IPv6 traffic -- you need to be running the more recent Netflow version 9 if you want to collect data on IPv6 network flows.
- Q. "So what's the IPv6 (protocol 41) traffic I see in the Internet2 weekly summaries, eh?"
  A. "That's legacy IPv6 over IPv4 traffic, not native IPv6 traffic."

  [Aside #2: Should Internet2's Netflow collections be migrated to Netflow Version 9 so as to support native IPv6 Netflow?]

"So Are You Going to Look at A Week/Month/Year's Worth of Data or ?"

- We're just going to look at an **hour's** worth of data collected on Wednesday, 2008-01-16 at 2100 UTC (4PM EST, 3PM CST, 2PM MST, 1PM PST, etc.). I believe that that hour's worth of data is similar to larger data windows, exhibiting the same sort of characteristic "uncategorized" traffic as larger samples.

- True, there may be some traffic which is scheduled to run in the middle of the night in the US, traffic which we might miss by only picking a "prime time" observation point, but that's okay: this isn't meant to be a rigorous and long term analysis, but rather an experiment, an introduction and exploration, perhaps inspiring YOU to do a better/more complete job than I've done.

Even An Hour Of Sampled Netflow Data Is A LOT of Data

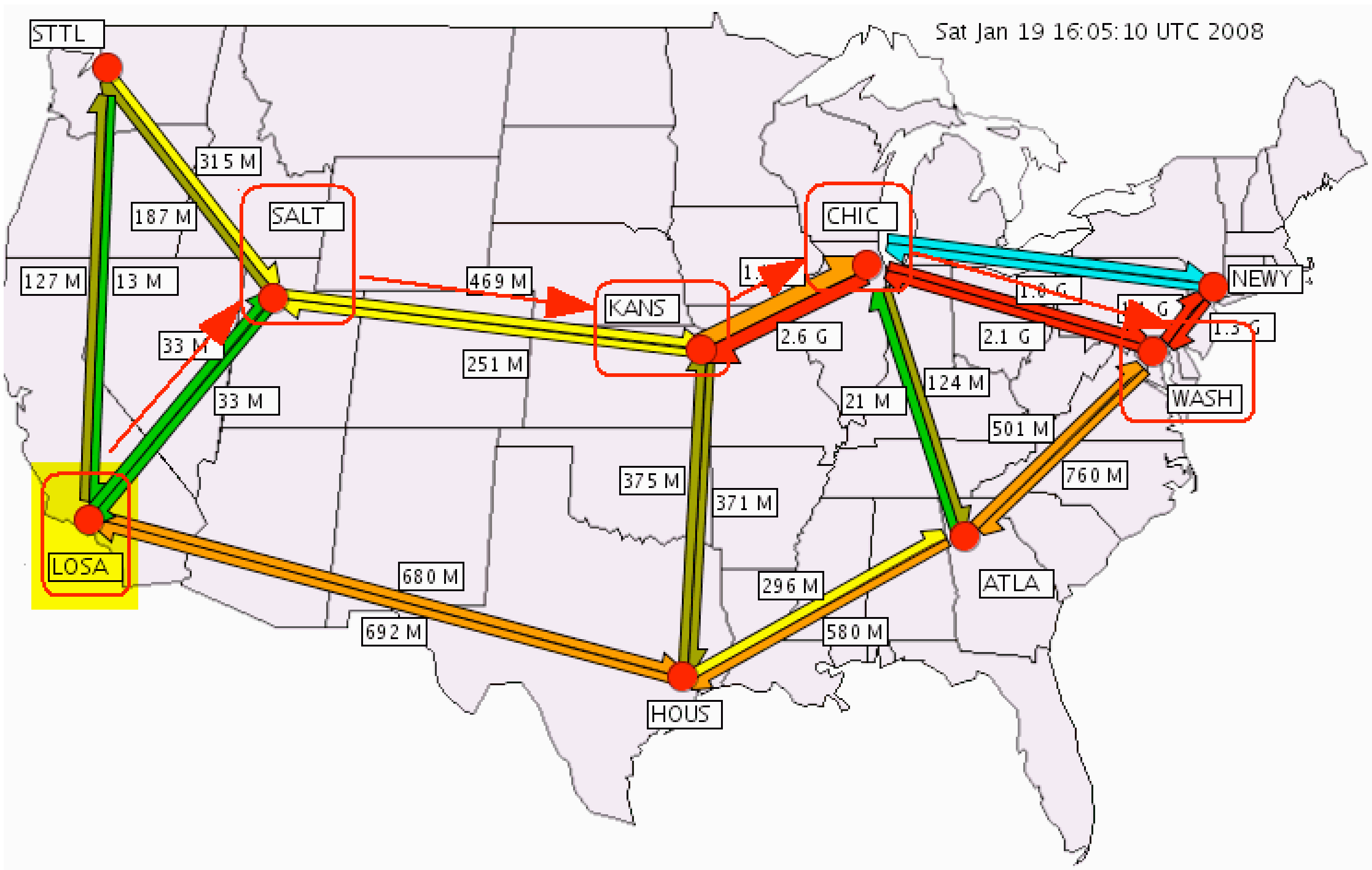
- Even sampling 1:100, it is easy to underestimate the volumes associated with Netflow data. Consider just our **single hour's worth** of data from 2008-01-16 2100 UTC:

ATLA:	3.36 million records
CHIC:	11.9 million records
HOUS:	1.97 million records
KANS:	5.08 million records
LOSA:	2.51 million records
NEWY:	8.08 million records
SALT:	3.97 million records
STTLng:	3.62 million records
WASH:	7.18 million records
	47.7 million records (all values rounded)

Avoiding Overcounting

- Because flow data is collected at **each node** on Abilene, a single flow, say from Oregon to Washington DC, might show up in the netflow data for five nodes as it travels across the country. Having that data included at each site is great -- **if** you're **just** looking at the total traffic for one of those routing nodes. But if you're trying to get a picture of the **total** traffic entering the I2 Network nationally, you don't want to "overcount" a transcontinental flow simply because it is flowing across multiple backbone nodes.
- Fortunately, I2 routinely corrects for this phenomenon in the Weekly Report, and I2 provides a router node-by-router node mapping showing how interfaces are used, which allows you to identify backbone flows to exclude. For example, to get mapping data for 2008-01-16, an authorized user would rsync: flows/logs/2008/2008-01/2008-01-16/nfilter and/or flows/logs/2008/2008-01/2008-01-16/ifAlias.* deleting flows from backbone interfaces (they'll already have been counted elsewhere)

A Flow From LOSA to WASH Should Only Be Counted Once, Not Five Times



With Redundant Backbone Flows Deleted…

- After removing redundant backbone flows, the size of our 2008-01-16 2100 UTC hour dataset drops substantially to:

ATLA:	1.46 million records
CHIC:	8.88 million records
HOUS:	0.34 million records
KANS:	1.73 million records
LOSA:	1.51 million records
NEWY:	6.82 million records
SALT:	0.70 million records
STTLng:	1.67 million records
WASH:	4.05 million records
	27.16 million records (all values rounded)

- That's still a **LOT** of data, but much less than 47.7 million records

Protocol/Ports and Network Flows

- A flow can be conceptualized as "a unidirectional stream of packets between a source and destination—both defined by a network-layer IP address and transport-layer port number"* (plus the flow's protocol, TOS, and input interface)
- Note that each network flow has **directionality**, with packets flowing **from** a source IP address **to** a destination IP address. Most applications involve network flows in both directions, however those flows should be conceptualized as two related but separate flows, one in each direction, rather than a single bidirectional pipe.
- The protocol and ports associated with a flow can give us hints about the application which may be generating that traffic.
- What protocols do we see for our hour's worth of Internet2 Netflow data?

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* *http://www.cisco.com/en/US/docs/ios/12_0s/feature/guide/12s_sanf.html*

Octets Per Protocol Breakdown

PROTOCOL Breakdown, Wed 2008-01-16, Hour Beginning 2100 UTC

	TOTAL	ATLA	CHIC	HOUS	KANS	LOSA	NEWY	SALT	STTLng	WASH
TCP	**92.43%**	88.34%	91.94%	84.29%	94.00%	82.89%	93.63%	97.45%	93.23%	94.91%
UDP	**5.13%**	9.56%	3.52%	14.71%	5.77%	7.77%	5.71%	2.11%	6.74%	4.85%
GRE	**2.11%**	0.36%	4.42%	0.93%	0.06%	9.16%	0.07%	0.16%	0.01%	0.06%
ESP	**0.30%**	1.72%	0.10%	0.01%	0.14%	0.14%	0.56%	0.27%	0.01%	0.16%
ICMP	**0.02%**	0.02%	0.01%	0.06%	0.03%	0.04%	0.03%	0.01%	0.01%	0.02%
Total above	**99.99%**	100.00%	99.99%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

Some quick notes:

-- No, you're not expected to read tiny fonts on screen, but if you can, I'm impressed :-) You might find it easier to look at these slides on your laptop while I talk. A couple of quick highlights…

-- TCP is still largely the dominant protocol overall at 92.43%, with UDP chugging along at about 5% (we'll focus largely on that TCP traffic for the rest of the this talk)

-- You'll notice that there are differences from node-to-node. For example, I found it interesting that GRE is surprisingly high at over 9% at LOSA, and ESP (a secure tunneling protocol) is at roughly 1.7% of octets at ATLA

Enough About Protocols, What About Port Usage?

- **While you'd never believe it from looking at actual Netflow data, port numbers *<u>are</u>* an IANA-assigned number resource.**
- In particular, see http://www.iana.org/assignments/port-numbers
  - -- "Well Known Ports are those from **0 through 1023**. […] Well Known ports SHOULD NOT be used without IANA registration."
  - -- "The Registered Ports are those from **1024 through 49151** […] Registered ports SHOULD NOT be used without IANA registration."
  - -- "The Dynamic and/or Private Ports are those from **49152 through 65535**"
- Thus, application programmers **should not** just casually pick and begin to offer services using port numbers <= 49151 – doing so invites eventual chaos, and can reduce our ability to understand network loads. [The port 465 ("URD" vs. "SMTPS") mess is a nice example of why randomly using unassigned ports is a bad idea.]

Top Destination Ports by Unscaled Octets (TCP Only), Wed 2008-01-16, Hour Beginning 2100 UTC (1/10th of 1% or more)

64901 total distinct ports seen

Port	IANA Assignment	Unscaled Octets	Percent	Cummulative Octets	Cummulative Percent
80	HTTP	2.75E+09	5.01	2.75E+09	5.01
40000	SafetyNET	1.20E+09	2.19	3.96E+09	7.2
40003	Unassigned	1.08E+09	1.97	5.04E+09	9.17
22	SSH	9.24E+08	1.68	5.96E+09	10.85
25	SMTP	6.47E+08	1.18	6.61E+09	12.03
40001	Unassigned	5.52E+08	1.01	7.16E+09	13.04
119	NNTP	5.03E+08	0.92	7.66E+09	13.95
40004	Unassigned	4.56E+08	0.83	8.12E+09	14.79
20000	DNP	4.52E+08	0.82	8.57E+09	15.61
20001	MicroSAN	4.19E+08	0.76	8.99E+09	16.37
40002	Unassigned	3.91E+08	0.71	9.38E+09	17.08
443	HTTPS	3.79E+08	0.69	9.76E+09	17.77
40005	Unassigned	3.47E+08	0.63	1.01E+10	18.4
20002	Commtact HTTP	2.60E+08	0.47	1.04E+10	18.88
20003	Commtact HTTPs	1.75E+08	0.32	1.05E+10	19.2
5500	fcp-addr-srvr1	1.75E+08	0.32	1.07E+10	19.51
20004	Unassigned	1.62E+08	0.3	1.09E+10	19.81
20005	Unassigned	1.46E+08	0.27	1.10E+10	20.08
6881	Unassigned	1.35E+08	0.25	1.12E+10	20.32
60011	Dynamic/Private	1.17E+08	0.21	1.13E+10	20.54
40006	Unassigned	1.06E+08	0.19	1.14E+10	20.73

9001	ETL Service Manager	1.01E+08	0.18	1.15E+10	20.91
20008	Unassigned	96390036	0.18	1.16E+10	21.09
43536	Unassigned	86984732	0.16	1.17E+10	21.25
20007	Unassigned	80879823	0.15	1.18E+10	21.39
20006	Unassigned	78360316	0.14	1.18E+10	21.54
20009	Unassigned	74820897	0.14	1.19E+10	21.67
20010	Unassigned	60268207	0.11	1.20E+10	21.78
5101	Talarian-TCP	58686545	0.11	1.20E+10	21.89
40007	Unassigned	56404724	0.1	1.21E+10	21.99
20	FTP	54025330	0.1	1.21E+10	22.09

While The Preceding Chart Looks at Destination Ports, What About Source Ports?

- In client-server applications, a relatively small query sent to a server will typically generate a potentially much larger "reply" or "response" flow.

- That response flow will commonly "reverse" the source and destination ports, so that (for example) http response traffic "coming back from" a web server to a web client might legitimately and routinely have **source** port 80, with what may look like a "random" destination port.

- For example, on the following chart of traffic by source ports, you'll see that http traffic accounts for over 36% of all TCP traffic in and of itself

Top Source Ports by Unscaled Octets (TCP Only), Wed 2008-01-16, Hour Beginning 2100 UTC (1/10th of 1% or more)

64886 distinct ports seen

Port #	IANA Assignment	Unscaled Octets	Percent	Cummulative Octets	Cummulative Percent
80	http	2.01E+10	36.51	2.01E+10	36.51
443	https	1.06E+09	1.93	2.11E+10	38.44
22	ssh	8.64E+08	1.57	2.20E+10	40.01
388	unidata	7.85E+08	1.43	2.28E+10	41.44
20	ftp	6.71E+08	1.22	2.34E+10	42.66
1935	macromedia flash	5.43E+08	0.99	2.40E+10	43.65
873	rsync	3.93E+08	0.72	2.44E+10	44.37
2128	net-steward	3.73E+08	0.68	2.47E+10	45.05
19101	unassigned	3.58E+08	0.65	2.51E+10	45.7
8080	http alternate	2.78E+08	0.51	2.54E+10	46.2
554	rtsp	2.32E+08	0.42	2.56E+10	46.63
8000	irdmi	2.24E+08	0.41	2.58E+10	47.03
20004	unassigned	1.51E+08	0.28	2.60E+10	47.31
119	nntp	1.47E+08	0.27	2.61E+10	47.58
3128	ndl-aas	1.45E+08	0.26	2.63E+10	47.84
6881	unassigned	1.42E+08	0.26	2.64E+10	48.1
20005	unassigned	1.39E+08	0.25	2.66E+10	48.35
20002	commtact-http	1.31E+08	0.24	2.67E+10	48.59
20006	unassigned	1.18E+08	0.21	2.68E+10	48.8

20007	unassigned	1.16E+08	0.21	2.69E+10	49.02
20003	commtact-https	1.16E+08	0.21	2.70E+10	49.23
20001	microsan	1.15E+08	0.21	2.72E+10	49.44
20013	unassigned	1.07E+08	0.19	2.73E+10	49.63
20000	dnp	1.05E+08	0.19	2.74E+10	49.82
20011	unassigned	98216157	0.18	2.75E+10	50
4452	ctiprogramload	92616503	0.17	2.76E+10	50.17
20008	unassigned	90289843	0.16	2.76E+10	50.33
20014	opendeploy	85290984	0.16	2.77E+10	50.49
20015	unassigned	77324913	0.14	2.78E+10	50.63
20009	unassigned	77205114	0.14	2.79E+10	50.77
9001	etlservicemgr	76902022	0.14	2.80E+10	50.91
20012	unassigned	75969755	0.14	2.80E+10	51.05
20010	unassigned	74744372	0.14	2.81E+10	51.19
20023	unassigned	70777376	0.13	2.82E+10	51.31
20016	unassigned	69390314	0.13	2.83E+10	51.44
20024	unassigned	69039900	0.13	2.83E+10	51.57
20025	unassigned	66750721	0.12	2.84E+10	51.69
20017	unassigned	61307317	0.11	2.85E+10	51.8
993	imaps	61286716	0.11	2.85E+10	51.91
50002	dynamic/private	59763002	0.11	2.86E+10	52.02
24500	unassigned	59079012	0.11	2.86E+10	52.13
20027	unassigned	58733028	0.11	2.87E+10	52.23
2180	mc-gt-srv	58707772	0.11	2.87E+10	52.34
15734	unassigned	58689143	0.11	2.88E+10	52.45
3074	xbox	57438620	0.1	2.89E+10	52.55
58704	dynamic/private	53152545	0.1	2.89E+10	52.65
20018	unassigned	52662214	0.1	2.90E+10	52.75

What Are Some of Those Non-Standard Ports Seen?

- Some applications running on dedicated machines may intentionally use non-standard ports, or even a wide "block" or "range" of ports. Choice of those ports may end up happening at, um, "local discretion."

- We know that at least some of these applications using unusual ports are crucial measurement tools or core applications driving a material fraction of the Internet2 Network's traffic.

- For example, one of the top destination ports seen on the table a few slides back is port 5101/tcp. What's <u>that?</u>

5101/TCP: Talarian_TCP, Y!M, or ?

src_as	dst_as	srcport	dstport	prot	raw doctets
AS668 DREN	AS11537 I2	33207	5101	TCP[6]	11,736,000
AS7847 NASA-HPCC-ESS	AS11537 I2	34272	5101	TCP[6]	7,677,000
AS7847 NASA-HPCC-ESS	AS11537 I2	46487	5101	TCP[6]	6,921,000
AS7847 NASA-HPCC-ESS	AS11537 I2	52600	5101	TCP[6]	6,894,000
AS7847 NASA-HPCC-ESS	AS11537 I2	56799	5101	TCP[6]	6,336,000

- IANA says that 5101/tcp is assigned to "Talarian_TCP"
- If you Google for port 5101/tcp, you'll see web pages such as http://www.cert.org/advisories/CA-2002-16.html which states "Yahoo! Messenger typically listens for peer-to-peer requests on port 5101/TCP […]" – but these flows seemed large for Y!M to me
- Since the destination ASN was Internet2, I inquired (thanks again, as always, Matt!) and learned that these are actually known nuttcp-related flows (nuttcp is a measurement tool similar to iperf, see http://www.wcisd.hpc.mil/nuttcp/Nuttcp-HOWTO.html)

What About LHC Traffic?

- Looking at an earlier snapshot of some Internet2 Netflow traffic, I observed traffic coming from AS3152 (FNAL) to AS7896 (U Nebraska), a well-known LHC site, with destination ports 20001/TCP, 20002/TCP, 20003/TCP, 56133/TCP, etc.

- Given the size and source/destination of those flows, I contacted UNL and was able to confirm that these were indeed likely LHC-related flows involving the application "PhEDEx" (see https://lhcatfnal.fnal.gov/shift-operations/sitracker/data-transfer and "PhEDEx High-Throughput Data Transfer Management System" http://www.gridpp.ac.uk/papers/chep06_tuura.pdf for more information about PhEDEx)

- What about the Access Grid, or Globus' GSIFTP, say?

http://www.accessgrid.org/agdp/guide/ports/1.03/c65.html

Chapter 4. Port Usage of the Access Grid and Related Software

4.1. AG2 client

If you are using an AG2 client, it will need to connect to:

- port 8000/TCP (Virtual Venue Server port) on the machine hosting the AG2 venue server.
- port 8002/TCP (Event port) on the machine hosting the AG2 venue server.
- port 8004/TCP (Text port) on the machine hosting the AG2 venue server.
- port 8006/TCP (Data port) on the machine hosting the AG2 venue server.

(Note that additional ports must be opened for the video and audio tools. See the sections VIC/IGvideo, RAT/IGaudio and/or Multicast-Unicast bridges)

NB. Note that these ports can be changed at the server side, so always check whether those ports are correct. It is frequent to find servers that listen on ports 9000, 9002, 9004 and 9006.

http://dev.globus.org/wiki/FirewallHowTo

NS1.FACILMARKETI... The Spamhaus Proje... CastleCops® Spam In... Anubis: Analyz

For xinetd add an env line to your /etc/xinet.d/gsiftp file. For example:

```
service gsiftp
{
     socket_type = stream
     protocol = tcp
     wait = no
     user = root
     server = GLOBUS_LOCATION/sbin/in.ftpd
     server_args = -l -a
     disable = no
     env += GLOBUS_TCP_PORT_RANGE=40000,45000
}
```

The above string would need to be customized to reflect your configuration by replacing GLOBUS_LOCATION with the actual value of $GLOBUS_LOCATION and 40000,45000 with you choice of port range.

Ports and <u>Intentional</u> Attempts at Obfuscation

Other application programmers view the network environment as an adversarial/hostile place (sometimes for well founded reasons!), and may use non-standard ports in an effort to resist traffic analysis, app identification, and traffic shaping or blocking. For instance:

-- Bandwidth intensive P2P applications may employ per-session **dynamic port assignment** (for example, uTorrent allows you to "randomize port each time uTorrent starts") or **encryption** (see www.azureuswiki.com/index.php/Message_Stream_Encryption) in an effort to avoid port-based traffic analysis or deep packet inspection, helping those programs to resist traffic identification

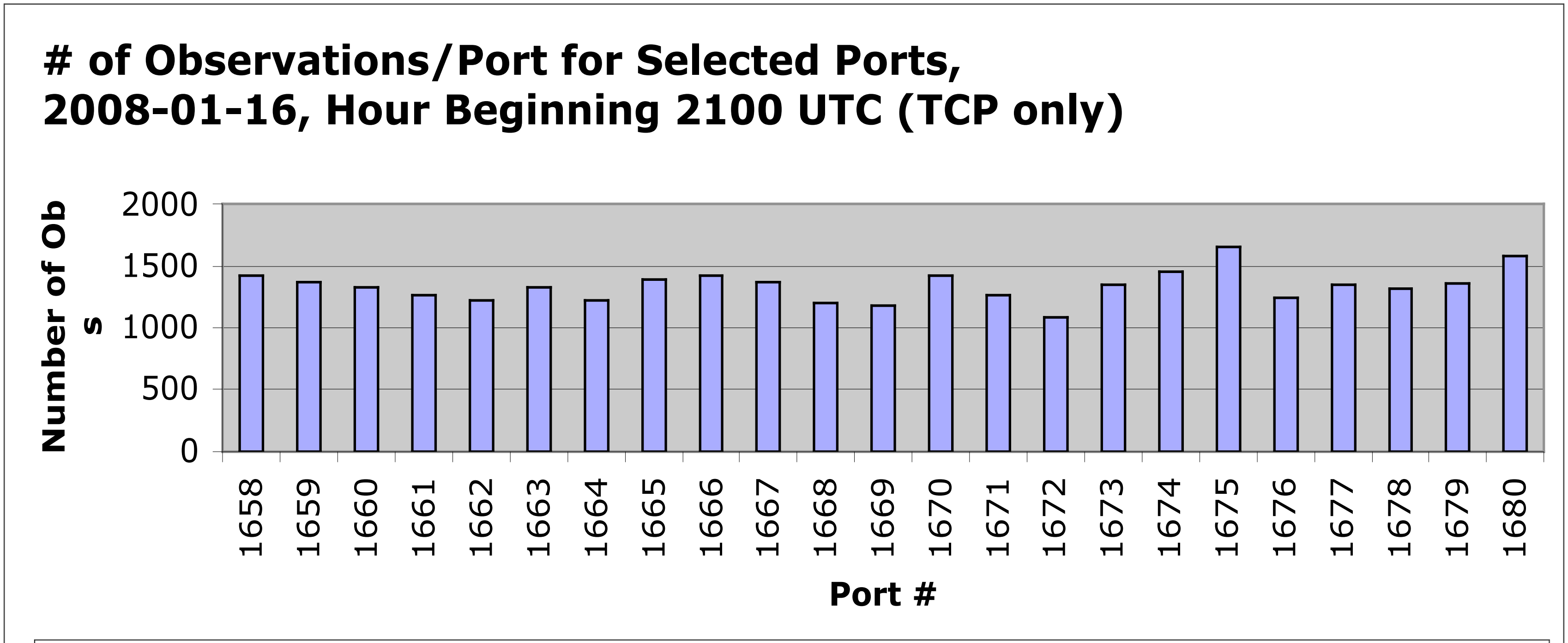
-- Other applications may resort to tunneling **"everything over port 80"** in an effort to circumvent restrictive perimeter firewall policies which may have closed everything except for a few ports (e.g., see forum.skype.com/lofiversion/index.php/t15582.html)

The Result of Intentional Obfuscation or Random Selection of Port Numbers

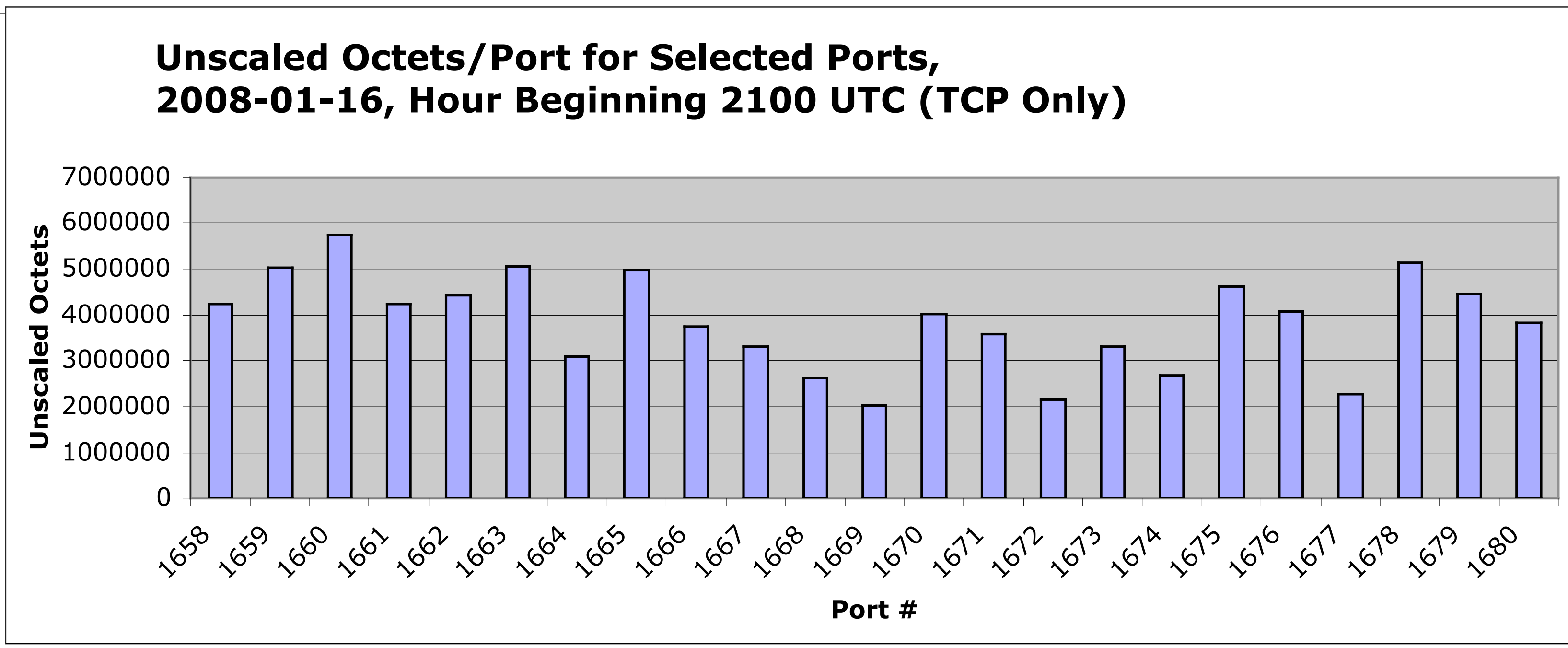
- If users or applications randomly choose ports for application use, at the limiting case, traffic would be randomly distributed over more-or-less the entire set of all possible ports, with (potentially) 100/65K=0.00152% of all traffic on each of the 65K ports.
- On the other hand, if users employed the alternative strategy mentioned previously, e.g., repurposing port 80 to carry virtually everything, in the limiting case you'd only see traffic on a small number of ports.
- Either way, **attempts at port-based traffic analysis might be rendered difficult at best, if not pointless altogether**.
- The following slide shows an example of a range of ports where I believe port numbers are not particularly illuminating, and traffic is mundanely distributed.

Sample Octets/Destination Port,
Selected Port Range, Wed 2008-01-16, Hour Beginning 2100 UTC (TCP only)

dstport	observ	octets
1658	1417	4240518
1659	1373	5025278
1660	1324	5739176
1661	1264	4226562
1662	1217	4427273
1663	1326	5052479
1664	1223	3096388
1665	1389	4977454
1666	1418	3741051
1667	1371	3307103
1668	1205	2632335
1669	1178	2037709
1670	1417	4007572
1671	1264	3583603
1672	1080	2157328
1673	1352	3316073
1674	1449	2675771
1675	1653	4632105
1676	1241	4085883
1677	1345	2266441
1678	1319	5124177
1679	1362	4451876
1680	1585	3820040



# of Observations/Port for Selected Ports,
2008-01-16, Hour Beginning 2100 UTC (TCP only)
Number of Obs
2000
1500
1000
500
0
1658
1659
1660
1661
1662
1663
1664
1665
1666
1667
1668
1669
1670
1671
1672
1673
1674
1675
1676
1677
1678
1679
1680
Port #



Unscaled Octets/Port for Selected Ports,
2008-01-16, Hour Beginning 2100 UTC (TCP Only)
Unscaled Octets
7000000
6000000
5000000
4000000
3000000
2000000
1000000
0
1658
1659
1660
1661
1662
1663
1664
1665
1666
1667
1668
1669
1670
1671
1672
1673
1674
1675
1676
1677
1678
1679
1680
Port #

Application Hinting Associated With Traffic Source and Destination Addresses

- In addition to ports and protocols, the source address and the destination address of each flow may also provide hints as to the type of application associated with a given flow.
- One obvious example would be dst addresses of multicast flows
- In other cases, simply hearing a particular organization's **name** (such as "Youtube"), can be enough to tell you a lot about the application traffic you're probably seeing (although these sort of associations must be viewed as suggestive rather than conclusive).
- One caution: mapping a /11 masked anonymized source address or destination address to a specific organization is not always possible. For example, a single /21 aggregate may encompass multiple independently assigned smaller blocks, and identifying which of the multiple sites in a /21 "owns" a particular flow may simply not be possible.

Top 50 SOURCES (/11 Mask Anonymized), Wed 2008-01-16, Hour Beginning 2100 UTC, TCP Only

71,716 Different (/11 Mask Anonymized) Sources
Top 50 of Those Account for Nearly 47% of All Traffic by Octets

Destination IP	IP Whois	Unscasled Octets	Percent	Cummulative Unscaled Octets	Cummulative Percent
131.225.200.0	Fermilab	2.94E+09	5.36	2.94E+09	5.36
64.15.112.0	YouTube	1.67E+09	3.04	4.61E+09	8.4
131.154.128.0	INFN, IT	1.55E+09	2.82	6.16E+09	11.22
193.48.96.0	RENATER, FR	1.36E+09	2.48	7.52E+09	13.7
202.169.168.0	Acad Sinica Comp Centre	1.28E+09	2.33	8.81E+09	16.04
208.111.152.0	indeterminate* (AS22822 llnw.net)	1.15E+09	2.1	9.96E+09	18.14
68.142.72.0	indeterminate* (AS22822 llnw.net)	1.05E+09	1.92	1.10E+10	20.05
140.211.160.0	Oregon State Sys of HE	1.02E+09	1.85	1.20E+10	21.9
192.108.40.0	U Sttutgart, DE	1.01E+09	1.84	1.30E+10	23.75
128.142.176.0	CERN-LHC	9.12E+08	1.66	1.40E+10	25.41
130.14.24.0	National Library of Medicine	7.10E+08	1.29	1.47E+10	26.7
64.15.120.0	YouTube	6.72E+08	1.22	1.53E+10	27.92
74.125.8.0	Google	6.36E+08	1.16	1.60E+10	29.08
129.93.232.0	UNL	6.33E+08	1.15	1.66E+10	30.23
131.225.184.0	Fermilab	5.69E+08	1.04	1.72E+10	31.27
18.7.24.0	MIT	5.42E+08	0.99	1.77E+10	32.26
140.90.32.0	NOAA	4.78E+08	0.87	1.82E+10	33.13
198.9.0.0	NASA	4.43E+08	0.81	1.86E+10	33.93
208.117.224.0	YouTube	4.32E+08	0.79	1.91E+10	34.72
193.109.168.0	ICGNET, Kiev UA	4.18E+08	0.76	1.95E+10	35.48
209.73.184.0	Altavista	3.35E+08	0.61	1.98E+10	36.09
72.52.96.0	indeterminate* (AS6939 Hurricane Electric)	3.13E+08	0.57	2.01E+10	36.66

198.118.192.0	NASA	3.12E+08	0.57	2.04E+10	37.23
128.109.192.0	MCNC	2.86E+08	0.52	2.07E+10	37.75
207.46.192.0	Microsoft	2.65E+08	0.48	2.10E+10	38.23
193.146.192.0	RedIRIS	2.57E+08	0.47	2.13E+10	38.7
208.111.168.0	indeterminate* (AS22822 llnw.net)	2.57E+08	0.47	2.15E+10	39.17
128.117.136.0	NCAR	2.36E+08	0.43	2.18E+10	39.6
205.234.216.0	indeterminate* (AS23352 ServerCentral.net)	2.36E+08	0.43	2.20E+10	40.03
64.233.160.0	Google	2.33E+08	0.42	2.22E+10	40.45
146.137.96.0	Argonne	2.16E+08	0.39	2.24E+10	40.85
68.142.120.0	indeterminate* (AS22822 llnw.net)	2.12E+08	0.39	2.26E+10	41.23
128.30.48.0	MIT	2.11E+08	0.38	2.29E+10	41.62
210.138.96.0	indeterminate* AS2497 (IIJ, Japan)	2.09E+08	0.38	2.31E+10	42
165.112.0.0	National Institute of Health	2.08E+08	0.38	2.33E+10	42.37
208.65.152.0	YouTube	2.07E+08	0.38	2.35E+10	42.75
72.14.200.0	Google	1.94E+08	0.35	2.37E+10	43.1
130.246.176.0	Rutherford Appleton Lab, UK	1.92E+08	0.35	2.39E+10	43.45
74.125.0.0	Google	1.86E+08	0.34	2.41E+10	43.79
128.31.0.0	MIT	1.78E+08	0.32	2.42E+10	44.12
156.56.240.0	Indiana U	1.72E+08	0.31	2.44E+10	44.43
134.9.32.0	Lawrence Livermore	1.69E+08	0.31	2.46E+10	44.74
192.12.208.0	Los Alamos	1.67E+08	0.3	2.47E+10	45.04
72.164.152.0	Indeterminate* (EBSCO?)	1.67E+08	0.3	2.49E+10	45.35
152.46.0.0	NCREN	1.61E+08	0.29	2.51E+10	45.64
156.26.32.0	Wichita State	1.51E+08	0.27	2.52E+10	45.92
198.119.128.0	NASA	1.50E+08	0.27	2.54E+10	46.19
131.247.248.0	U South Florida	1.46E+08	0.27	2.55E+10	46.46
63.250.192.0	Yahoo Broadcast Services	1.46E+08	0.27	2.57E+10	46.72
216.178.40.0	Myspace	1.42E+08	0.26	2.58E+10	**46.98**

Top 50 DESTINATIONS (/11 Mask Anonymized), Wed 2008-01-16, Hour Beginning 2100 UTC, TCP

104,297 Different (/11 Mask Anonymized) Destinations
Top 50 of Those Account for Over 29% of All Traffic by Octets

Destination IP	IP Whois	Unscaled Octets	Percent	Cummulative Unscaled Octets	Cummulative Percent
18.7.24.0	MIT	4.32E+09	7.86	4.32E+09	7.86
129.93.232.0	UNL	4.10E+09	7.47	8.42E+09	15.33
131.225.184.0	Fermilab	9.82E+08	1.79	9.40E+09	17.12
144.92.176.0	Wisconsin-Madison	6.73E+08	1.22	1.01E+10	18.35
198.32.40.0	Exchange Point Blocks	6.11E+08	1.11	1.07E+10	19.46
192.239.80.0	Level 3	4.50E+08	0.82	1.11E+10	20.28
131.154.128.0	INFNET1 - INFN CNAF, IT	4.19E+08	0.76	1.16E+10	21.04
202.169.168.0	Acad Sinica Comp Centre	2.67E+08	0.49	1.18E+10	21.53
152.61.0.0	USGS EROS Data Center	2.27E+08	0.41	1.21E+10	21.94
65.55.208.0	Microsoft	2.21E+08	0.4	1.23E+10	22.34
72.246.88.0	Akamai	1.96E+08	0.36	1.25E+10	22.7
155.101.16.0	U Utah	1.74E+08	0.32	1.26E+10	23.02
131.169.96.0	DESY, Hamburg DE	1.56E+08	0.28	1.28E+10	23.3
199.8.24.0	Indiana Wesleyan U	1.36E+08	0.25	1.29E+10	23.55
128.104.104.0	Wisconsin-Madison	1.36E+08	0.25	1.31E+10	23.8
169.154.200.0	NASA	1.35E+08	0.25	1.32E+10	24.04
192.67.128.0	indeterminate*	1.27E+08	0.23	1.33E+10	24.27
128.255.32.0	U Iowa	1.25E+08	0.23	1.35E+10	24.5
128.112.136.0	Princeton	1.24E+08	0.23	1.36E+10	24.73
64.233.160.0	Google	1.23E+08	0.22	1.37E+10	24.95
134.158.168.0	INP23, FR	1.23E+08	0.22	1.38E+10	25.18
168.91.0.0	IVYTech Comm Coll of Indiana	1.23E+08	0.22	1.40E+10	25.4

128.174.80.0	U Illinois	1.17E+08	0.21	1.41E+10	25.61
155.33.216.0	Northeastern U	1.15E+08	0.21	1.42E+10	25.82
64.251.48.0	CT Education Network	1.12E+08	0.2	1.43E+10	26.03
216.178.32.0	Myspace	1.08E+08	0.2	1.44E+10	26.22
134.174.88.0	Longwood Medical, Mass.	1.07E+08	0.2	1.45E+10	26.42
131.154.192.0	INFN, IT	1.02E+08	0.19	1.46E+10	26.6
128.138.128.0	U Colorado	93125843	0.17	1.47E+10	26.77
129.55.200.0	MIT Lincoln Lab	91922672	0.17	1.48E+10	26.94
65.54.240.0	Microsoft	91365153	0.17	1.49E+10	27.11
128.211.200.0	Purdue	90054381	0.16	1.50E+10	27.27
205.213.104.0	WiscNet	87148797	0.16	1.51E+10	27.43
128.128.176.0	Woods Hole	83945856	0.15	1.52E+10	27.58
130.14.24.0	National Library of Medicine	83854190	0.15	1.52E+10	27.73
131.247.240.0	U South Florida	83028074	0.15	1.53E+10	27.89
129.186.184.0	Iowa State	79738187	0.15	1.54E+10	28.03
128.211.208.0	Purdue	78492489	0.14	1.55E+10	28.17
129.93.248.0	UNL	76757341	0.14	1.56E+10	28.31
130.111.72.0	U Maine System	75249085	0.14	1.56E+10	28.45
128.102.104.0	NASA	74143515	0.14	1.57E+10	28.59
128.112.24.0	Princeton	73159718	0.13	1.58E+10	28.72
141.214.16.0	U Mich Medical Center	72761983	0.13	1.58E+10	28.85
144.92.128.0	Wisconsin-Madison	70214428	0.13	1.59E+10	28.98
128.118.168.0	Penn State	68694824	0.13	1.60E+10	29.1
129.55.64.0	MIT Lincoln Lab	67411221	0.12	1.61E+10	29.23
193.62.200.0	Hinxton Hall Ltd, UK	64941350	0.12	1.61E+10	**29.35**
			Total:	5.49E+10	

* known multiple customer SWIPs within this /21

SAS Will Let You Easily Write Port Based Rules to Categorize Traffic

```
[* * *]
type2='not classified';
if prot=17 then type2='udp';
else if prot=50 then type2='esp';
else if prot=1 then type2='icmp';
else if prot=47 then type2='gre';
else if prot=6 then do;
   if (srcport=80) or (dstport=80) or
      (srcport=8000) or (dstport=8000) or
      (srcport=8080) or (dstport=8080) then type2='http';
   else if (srcport=443) or (dstport=443) then
      type2='https';
   else if (srcport=22) or (dstport=22) then type2='ssh';
   else if (srcport=25) or (dstport=25) then type2='smtp';
   else if (srcport=388) or (dstport=388) then
       type2='unidata';
   else if (srcport=20) or (dstport=20) then type2='ftp';
[etc]
```

Traffic Classification (all TCP except as otherwise noted)
Wed 2008-01-16, Hour Beginning 2100 UTC

application	**octets**	**percentage**	**cummulative octets**	**cummulative percentage**
http	2.33E+10	39.28	2.33E+10	39.28
not_classified	**1.55E+10**	**26.00**	**3.88E+10**	**65.29**
port_40000-40030	4.31E+09	7.26	4.31E+10	72.54
port_20000-20030	4.13E+09	6.95	4.72E+10	79.50
udp	3.05E+09	5.13	5.03E+10	84.63
ssh	1.79E+09	3.01	5.21E+10	87.64
https	1.44E+09	2.42	5.35E+10	90.06
gre	1.25E+09	2.11	5.48E+10	92.17
unidata	8.05E+08	1.36	5.56E+10	93.53
ftp	7.25E+08	1.22	5.63E+10	94.75
smtp	6.98E+08	1.18	5.70E+10	95.92
nntp	6.50E+08	1.09	5.76E+10	97.02
flash_macromedia	5.68E+08	0.96	5.82E+10	97.97
rsync	4.19E+08	0.71	5.86E+10	98.68
rtsp	2.53E+08	0.42	5.89E+10	99.10
esp	1.78E+08	0.30	5.91E+10	99.40
squid	1.55E+08	0.26	5.92E+10	99.66
imaps	69910447	0.12	5.93E+10	99.78
xbox	59616659	0.10	5.93E+10	99.88
nuttcp	57312000	0.10	5.94E+10	99.98
icmp	13002046	0.02	5.94E+10	100.00

Of What's Left, Where's It Coming From/Going To?

srcaddr	doctets	percent	site
193.48.96.0	1.3632E9	8.82	Renater
192.108.40.0	5.6564E8	3.66	U Stuttgart
202.169.168.0	4.5723E8	2.96	Academia Sinica
198.9.0.0	4.4243E8	2.86	NASA
140.90.32.0	3.9196E8	2.54	NOAA
131.154.128.0	3.0826E8	2.00	INFN CNAF
130.14.24.0	3.0395E8	1.97	Natl Lib of Med
198.118.192.0	2.664E8	1.72	NASA
130.246.176.0	1.9162E8	1.24	Rutherford Appleton
165.112.0.0	1.7309E8	1.12	NIH
193.109.168.0	1.5452E8	1.00	ICGNET, Ukraine

[etc]

dstaddr	doctets	percent	site
129.93.232.0	2.058E9	13.32	UNL
198.32.40.0	5.5729E8	3.61	EP.Net
144.92.176.0	5.5315E8	3.58	Wisconsin Madison
192.239.80.0	4.492E8	2.91	Level3

[etc]

Conclusion

- At this point, I hope you have a sense of the sort of analyses you may be able to do using Internet2 Netflow data, even though I wouldn't begin to claim that I've even come close identifying the "missing half" of I2 Netflow data.
- Maybe some of you here today, or network researchers back at your campuses, will be inspired to give this data a closer look, and begin to explore and work with the Internet2 Netflow data archives.
- For those of you who may be interested, I've also attached a brief tutorial with some notes on the mechanics of working with Internet2 Netflow data, although we won't go over those slides today due to our limited time.
- Thanks for the chance to talk today!

A Brief Tutorial on The Use of Internet2's Netflow Archive

Assumptions

- You've already applied for, and been approved for access to Internet2 Netflow data, as previously described earlier in these slides.
- You've retrieve and built flow-tools on a Unix or Linux host, again, as previously mentioned
- You want to do analyses that are easiest/best done using a traditional statistical package such as SAS

Browsing Directories With rsync

- Data is stored on netflow.internet2.edu and is organized by the nine Internet2 router nodes:

  ATLA, CHIC, HOUS, KANS, LOSA, NEWY, SALT, STTLng, and WASH (note that's STTLng, not STTL)

- To **view** all available datasets for the KANS node for 2008-01-16:

```
% rsync --password-file ./rsync.passwd -v -n \
usrname@netflow.internet2.edu::flows/data\
/KANS/2008/2008-01/2008-01-16/  [note: spaces matter!]
```

- File collection times may vary by a second or two, so don't be surprised if file naming reflects that jitter.

Actually Retrieving Flow Data With rsync

- Once you've identified the files you'd like to retrieve, such as all datasets for 2008-01-16 for a particular hour, such as 2100 UTC (4PM EST, 3PM CST, 2PM MST, 1PM PST, etc.), you can retrieve those files using a command such as:

```
% rsync --recursive --password-file ./rsync.passwd \
-v usrname@netflow.internet2.edu::flows/data/\
KANS/2008/2008-01/2008-01-16/ft-v05.2008-01-16.21* \
KANS/ft-v05.2008-01-16          [note: spaces matter!]
```

Exporting Flow-Tools Format Files To Comma Separated Variables

- While flow-tools is a great package, the statistical package I like to use is SAS (for information on SAS, see http://www.sas.com/), and that meant getting the data into a format that SAS could read.

- To export a flow-tools data file (be sure you've installed the flow-tools package from http://www.splintered.net/sw/flow-tools/ first):

```
% flow-export -f2 < ft-v05.2008-01-16.210001+0000 \
> ft-v05.2008-01-16.210001.csv [note: spaces matter!]
```

Sample CSV Export Format Observations

- The contents of the resulting csv data file looks like:

```
#:unix_secs,unix_nsecs,sysuptime,exaddr,dpkts,
doctets,first,last,engine_type,engine_id,srcaddr,
dstaddr,nexthop,input,output,srcport,dstport,prot,
tos,tcp_flags,src_mask,dst_mask,src_as,dst_as
```

That header record is actually ***IN*** the exported flow-tools file! At least some statistical packages will allow you to skip over that record without reading it; others may read that record but simply disregard its contents.

A sample (real!) export Netflow record look likes:

```
1200517203,0,3029563200,127.0.0.1,1,40,3029543377,
3029543377,0,0,134.197.8.0,204.179.120.0,64.57.28.42,
68,26,49371,80,6,0,16,16,24,3851,6932
```

Reading the Exported Data Into SAS

- Once the data had been exported into a readily accessible format, it still needed to be read into SAS.
- For your convenience, I've made the SAS code I used to do that available at http://www.uoregon.edu/~joe/missing-half/sas/ (there's not room, time or need to go over all that code here)
  If you DO decide to use that SAS code, please note that it is provided as-is, with no warranty, and if you choose to use it, you do so at your own risk. Carefully confirm that it does what you want before you attempt to use it.
- Please see
  http://www.uoregon.edu/~joe/missing-half/sas/readme.txt
  for a description of the various SAS files I've provided and how they all "fit together"

Weighting Flows and Removing Doubly Counted Flows

- When analyzing flows, each flow record typically represents multiple octets or multiple packets. As part of the process of analyzing netflow data, be sure you weight the flows you're looking at appropriately (this sort of functionality is routinely provied in most stat packages).

- Be sure you also remember to drop "duplicate" observations (flows which might have been recorded at multiple points on the backbone), as discussed on slides 17-18, earlier in these slides.

What If I Wanted to Replicate I2's Weekly Netflow Report Classification Process?

- To do that, you need to know what ports have been mapped to a given application. For example, the Internet2 Weekly Report categorizes 80/tcp, 81/tcp and 8080/tcp as http, and 25/tcp, 109/tcp, 110/tcp, 143/tcp, 220/tcp, 465/tcp, 585/tcp, 587/tcp, and 993/tcp as mail.
- Because some of those mappings might be hard to otherwise infer, I obtained a copy of an I2 report describing nfstat, complete with a copy of the actual self-documenting nfstat CWEB* code.
- One of the SAS files I make available includes an approximately equivalent SAS version of the rules incorporated in the original CWEB code, if you'd like to use that as a starting point.

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* http://www-cs-faculty.stanford.edu/~knuth/cweb.html

"Why Do You Say 'An Approximately Equivalent' Mapping?"

- I hedged for a number of reasons, including:

  -- the ordering of tests is not exactly the same, and since this is a "sieve" process where first match wins, that can make the ordering of matching rules potentially important

  -- some port-to-applications documented in the CWEB program have evolved over time. For example, ports 5500-5503 are associated in the Weekly Report with the peer-to-peer application Hotline, but I believe that that 5500/tcp and some nearby ports are also in common use in conjunction with VNC (e.g., see: http://www.accessgrid.org/agdp/guide/ports/1.03/x149.html)

  -- Unlike the weekly report, I split out applications traffic which users both tcp and udp traffic

If You Try Working With Internet2 Netflow Data And Run Into A Problem...

- Please feel free to drop me a note -- I'd be delighted to help you out in any way if I can!