Many Uses of Flow

and

Flow-like Data

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kentik

Background: NetFlow

- NetFlow is:
  - 20-year old technology now supported in some variant by most network devices.
  - Workable on most common ISP/carrier devices now.
- sFlow came later, is simpler and more accurate in real-time because it’s just packet sampling.
- IPFIX and Netflow v9 are extensible via templates, and allow sending more than just ‘basic flow’ data via those templates.

‘Basic’ Flow

- Basic flow records contain byte and packet counters, TCP Flags, AS, next-hop, and other data aggregated by (usually) the ‘5 tuple’ of (protocol, srcip, dstip, srcport, dstport).
- Most devices support a fixed sampling rate.
- Despite the simplicity of data, there are many use cases for basic flow data for monitoring availability, efficiency, and security of networks, hosts, and applications.

State of Device Export

- sFlow is more common at the switch layer, and NetFlow/IPFIX is more common in routers, but many devices support both protocols.
- Still possible to negatively impact packet forwarding by enabling flow export, but accuracy and stability is generally fine w/ correct software versions. Much, much better than 5+ years ago.

State of Flow Tools

- Flow tools all have some suck. Some suck more and some suck less. No perfect eng+perf+BI+ops tool.
- OSS tools don't cluster, but popular.
- Most downloadable commercial sw has scale.
- Appliances are either expensive and security-focused, or over-aggregate and can't support high-res lookback.
- Many tools groups working with Hadoop-ish, Spark, Elastic, and/or live streaming/CEP tools.
- Newer vendors are taking more big-data approach and generally doing private and/or public cloud.
- Extensibility + openness key for augmented flow use cases.

Classic Flow Use Cases

- Classic use cases include:
  - Congestion analysis for providers and/or customers
  - Peering analytics
  - Trending, planning and forecasting
  - (d)DoS detection (primarily volumetric)
  - Basic forensic/historic (who did an IP talk to)
  - Modeling of TE, what-if analysis
  - Customer cost analysis (Flow + BGP communities)

Classic View: Traffic by Source ASN

Bits/s by AS_src

TIME OPTIONS Custom 2015-10-04 14:00 to 22:00 2015-10-04 UTC | GROUP BY METRIC Source AS Number | UNITS Bits/s | DATASET Auto | Apply | Reset

Devices Search

Select All / None Selected: 1

- [x] cat2_cloudhelix_com
- [ ] core_nyc_isp
- [ ] com
- [ ] rx1_cloudhelix_com

Single Multi

Filters

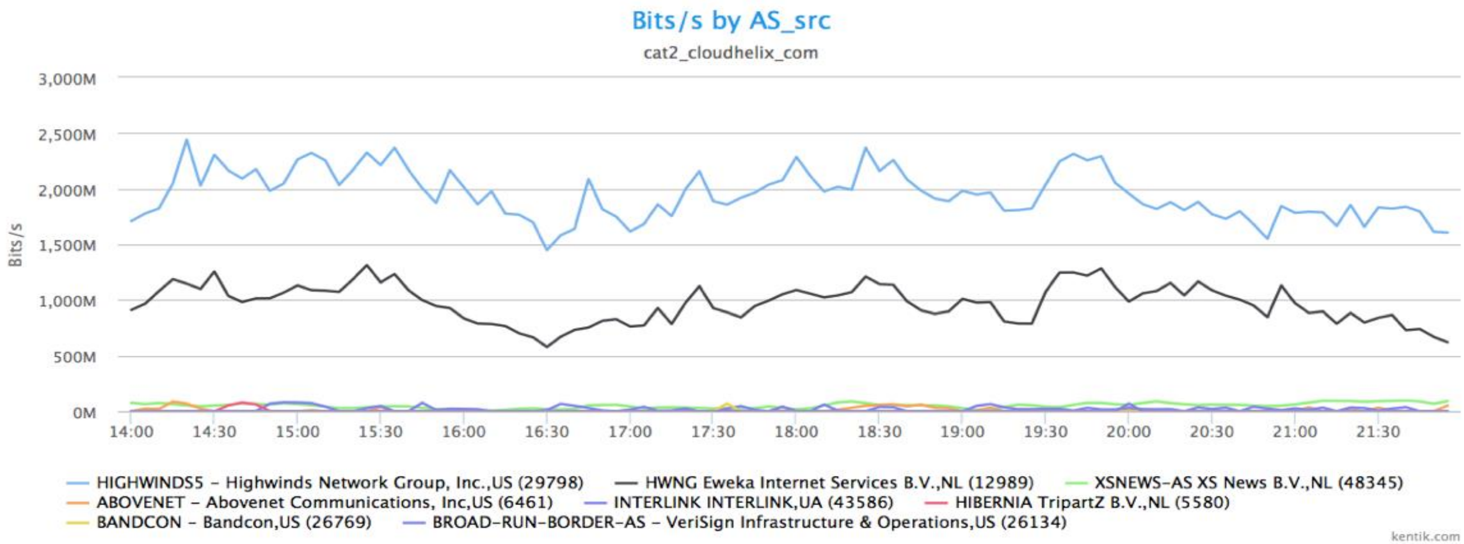
Add Group Clear All

Group 1

src_as <> 6450

Overlay - 0 days

Export SQL

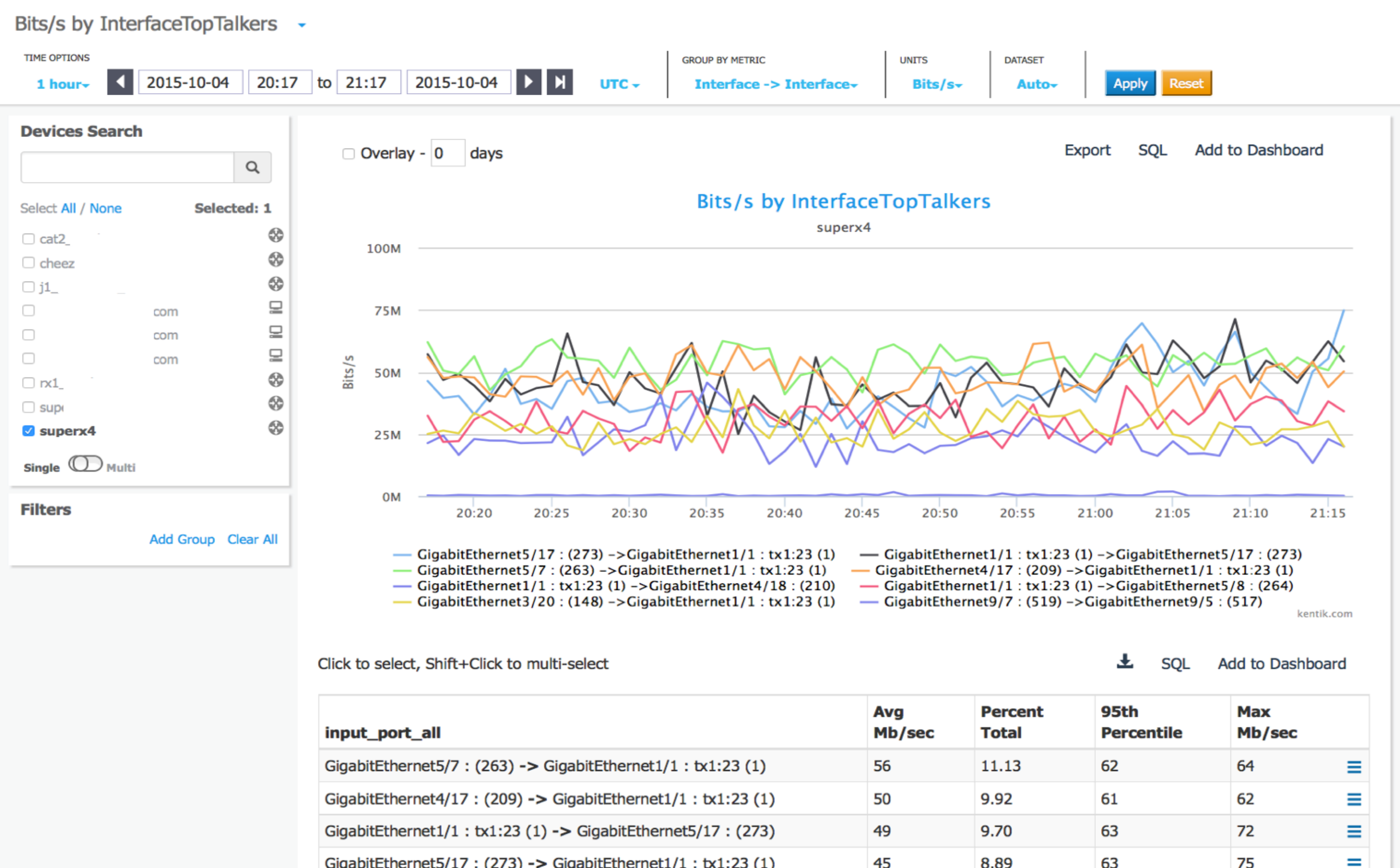


Click to select, Shift+Click to multi-select

SQL

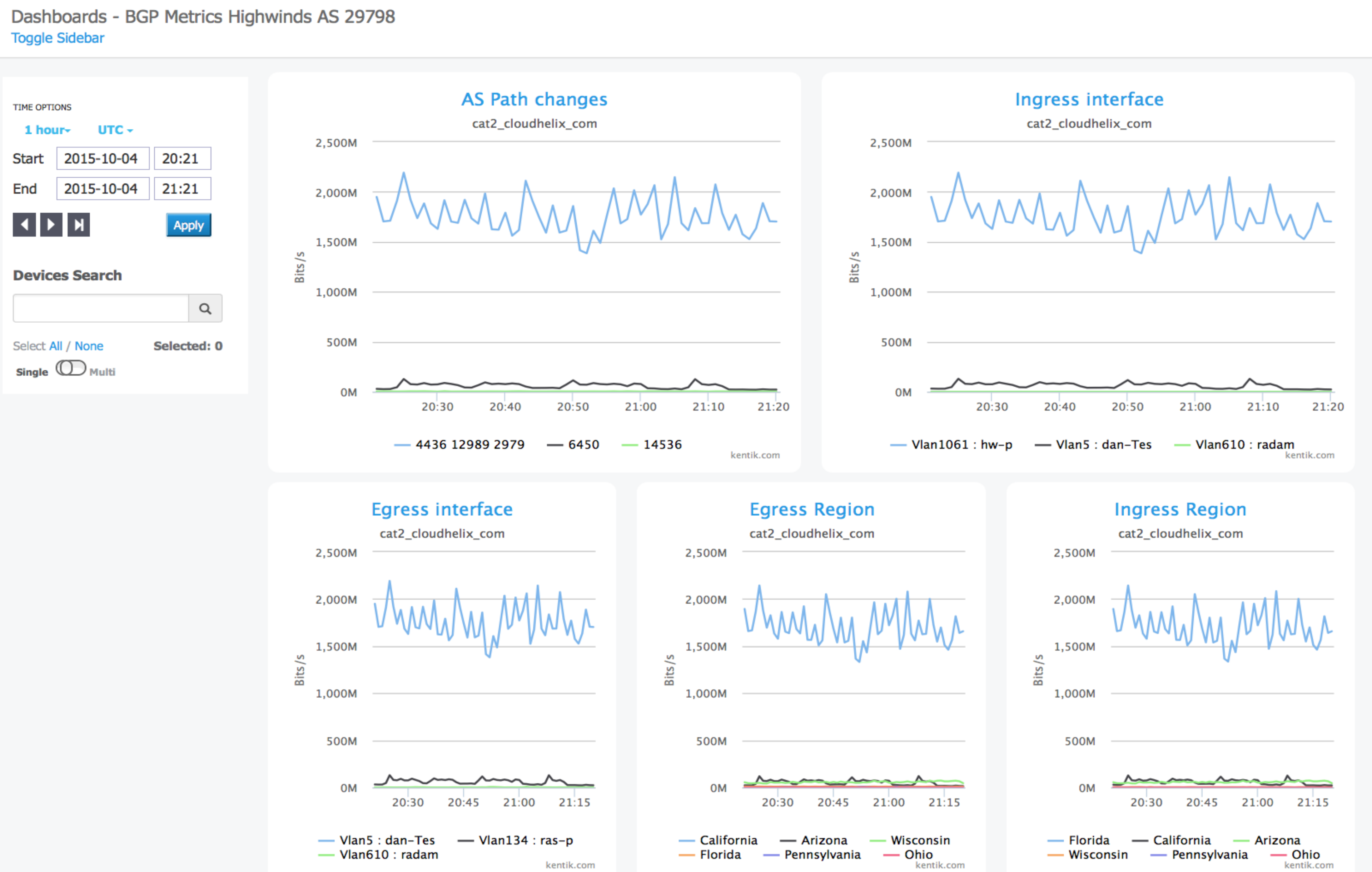
src_as	Avg Mb/sec	Percent Total	95th Percentile	Max Mb/sec
HIGHWINDS5 - Highwinds Network Group, Inc.,US (29798)	1,970	58.32	2,324	2,443
HWNG Eweka Internet Services B.V.,NL (12989)	981	29.02	1,247	1,315
XSNEWS-AS XS News B.V.,NL (48345)	52	1.53	92	96
COGENT-174 - Cogent Communications,US (174)	26	0.76	29	30
MICROSOFT-CORP-MSN-AS-BLOCK - Microsoft Corporation,US (8068)	22	0.65	32	32
HURRICANE - Hurricane Electric, Inc.,US (6939)	22	0.65	26	27
INTERLINK INTERLINK,UA (43586)	20	0.58	73	81

Classic View: Interface -> Interface Traffic



input_port_all	Avg Mb/sec	Percent Total	95th Percentile	Max Mb/sec
GigabitEthernet5/7 : (263) -> GigabitEthernet1/1 : tx1:23 (1)	56	11.13	62	64
GigabitEthernet4/17 : (209) -> GigabitEthernet1/1 : tx1:23 (1)	50	9.92	61	62
GigabitEthernet1/1 : tx1:23 (1) -> GigabitEthernet5/17 : (273)	49	9.70	63	72
GigabitEthernet5/17 : (273) -> GigabitEthernet1/1 : tx1:23 (1)	45	8.89	63	75

Classic View: Remote Network Analytics



Classic View: Traffic by top AS_PATHs

Bits/s by dst_bgp_aspath

TIME OPTIONS: 1 hour | 2015-10-04 | 20:23 | to | 21:23 | 2015-10-04 | UTC

GROUP BY METRIC: Dest BGP AS_Path

UNITS: Bits/s

DATASET: Auto

Apply | Reset

Devices Search

Select All / None Selected: 1

- cat2_cloudhelix_com
- core_nyc_isp
- .com
- rx1_cloudhelix_com

Single Multi

Filters

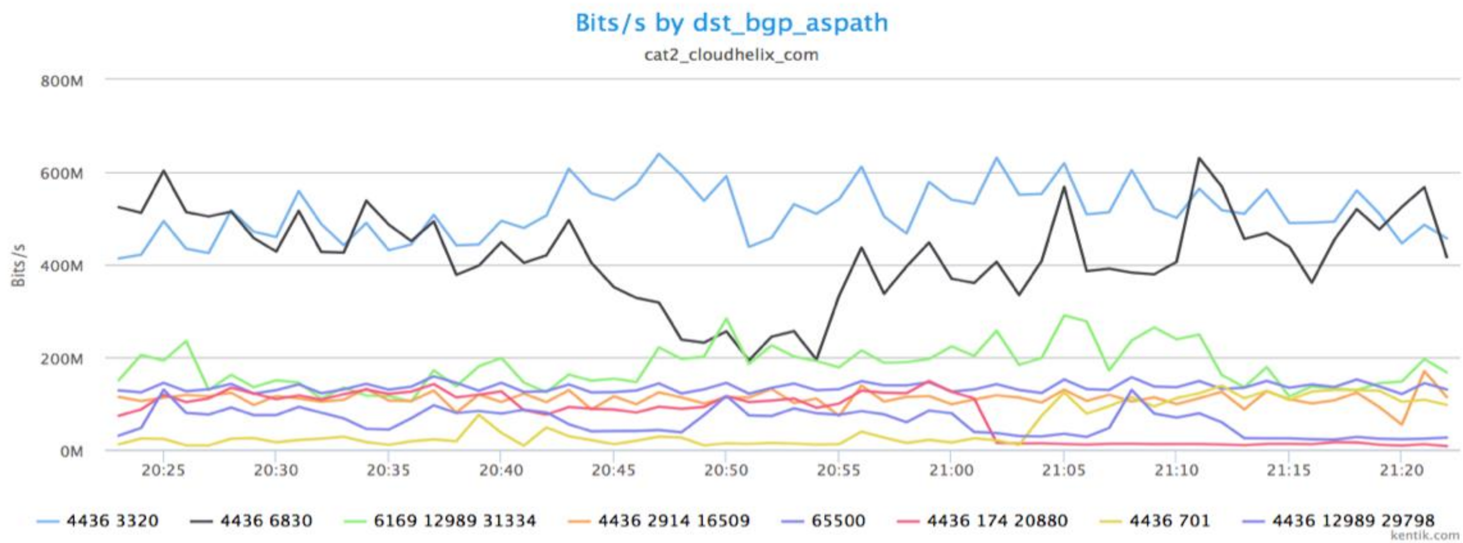
Add Group Clear All

Group 1

dst_bgp_aspath <> 6450

Overlay - 0 days

Export SQL



Click to select, Shift+Click to multi-select

SQL

dst_bgp_aspath	Avg Mb/sec	Percent Total	95th Percentile	Max Mb/sec
4436 3320	522	20.67	612	640
4436 6830	429	16.99	569	631
6169 12989 31334	183	7.22	264	290
65500	138	5.44	152	159
4436 2914 16509	113	4.46	132	170
14536	104	4.09	118	124
4436 4436 7065	80	3.14	95	112
4436 174 20880	77	3.02	130	149

Classic View: dDoS Detection

Key	Alert Name	Criticality	State	Key Type	Output 1 Name:Value	Output 2 Name:Value	Alert ID	Start	End	Time Over Threshold	Recent Comment
	many_src_ips_to_1_dst	Major	ACK_REQ	ipv4_dst_addr	src_ips : 189	pps : 3277	3536	2015-08-26 20:25	2015-08-26 20:46	45%	
	high_fps_per_dst_ip	Major	ACK_REQ	ipv4_dst_addr	fps : 110	pps : 118835	3537	2015-08-26 20:25	2015-08-26 20:45	42%	
	all_dst53_or_src53_to_1ip ...	Major	ACK_REQ	ipv4_dst_addr	pps : 51166	mbps : 576	462	2015-08-26 20:25	2015-08-26 20:44	31%	
	udp_srcdst0_	Major	ACK_REQ	ipv4_dst_addr	pps : 86391	mbps : 914	452	2015-08-26 20:25	2015-08-26 20:44	31%	
	many_src_ips_to_1_dst	Major	ACK_REQ	ipv4_dst_addr	src_ips : 137	pps : 13517	3536	2015-08-26 20:37	2015-08-26 20:47	33%	

Classic View: Device to AS to Geo

Home > Datasets

Dataset Details

Dataset Name

test2

Filter Set

No Filter Set

Min Mbps per path

10

Start Time

2015-08-03 00:00

End Time

2015-08-08 00:00

Devices

cat2_cloudhelix_com

Direction

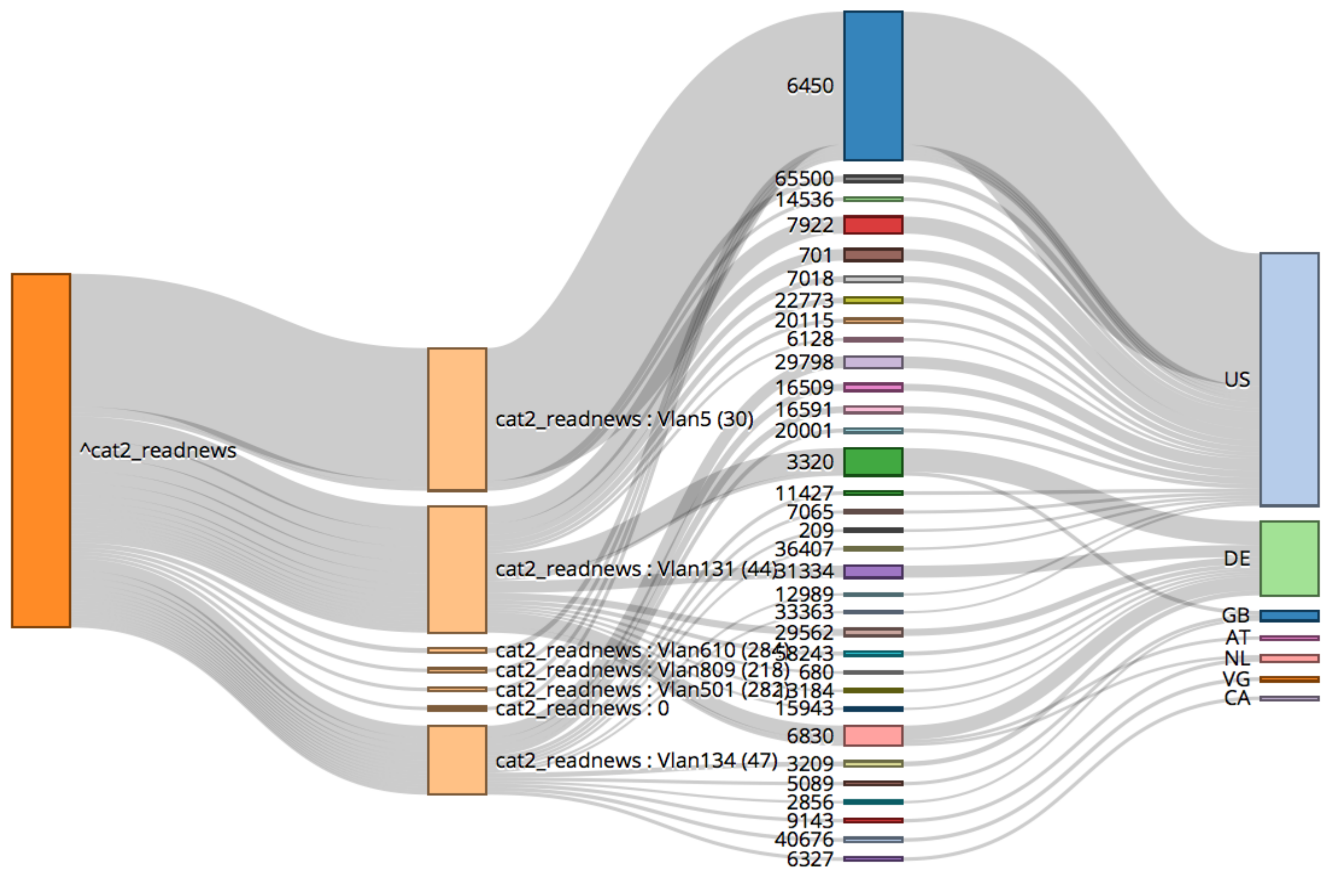
DST

☐ Ignore First-Hop except when displaying paths

Apply

Transit ASN's | BGP Paths | Origin ASN's | Next-Hop ASN's | Countries

Top Device -> Interface -> Origin ASN -> Dst Country, p95th Mbps



‘Augmented’ Flow

- ‘Who talked to who’ data is great, but if we can get:
  - Semantics (URL, DNS query, SQL query, …)
  - Application performance info (latency, TTFB, …)
  - Network performance info (RTT, loss, jitter, …)

  from passive observation, it unlocks even more/more interesting use cases!
- With many of the same basic report structures.
- Some of this is already available via IPFIX/V9.

Sources of 'Augmented' Flow

- Server-side
  - OSS sensor software: nprobe, argus
  - Commercial sensors: nBox, nPulse, and others
  - Packet Brokers: Ixia and Gigamon (IPFIX, potentially more)
  - IDS (bro) – a superset of most flow fields, + app decode
  - Web servers (nginx, varnish) – web logs + tcp_info for perf
  - Load balancers – advantage of seeing HTTPS-decoded URLs
  - CISCO AVC, Netflow Lite – generally only on small devices

- Common challenge: Some of the exporters don't support sampling, and many tools can't keep up with un-sampled flow.

augflow Examples: Cisco AVC

docwiki.cisco.com/wiki/AVC-Export:PfR#PfR_NetFlow_Export_CLI

```
Client: Option Active Performance
Exporter Format: NetFlow Version 9
Template ID     : 268
Source ID       : 0
Record Size     : 61
Template layout
```

Field	Type	Offset	Size
flow end	153	0	8
pfr br ipv4 address	39000	8	4
reason id	39002	12	4
counter packets dropped	37000	16	4
transport packets lost counter	37019	20	4
transport round-trip-time	37016	24	4
transport rtp jitter mean	37023	28	4
mos worst 100	42115	32	4
counter packets dropped permanent short	37001	36	4
transport packets lost counter permanen	37020	40	4
long-term round-trip-time	39006	44	4
flow class wide	95	48	6
interface output snmp short	14	54	2
pfr status	39001	56	2
flow active timeout	36	58	2
ip protocol	4	60	1

augflow Examples: Citrix AppFlow

http://docs.citrix.com/en-us/netscaler/10-5/ns-system-wrapper-10-con/ns-ag-appflow-intro-wrapper-con.html

https://github.com/splunk/ipfix/blob/master/app/Splunk_TA_IPFIX/bin/IPFIX/information-elements/netscaper-iana.xml_full

tcpRTT

The round trip time, in milliseconds, as measured on the TCP connection. This can be used as a metric to determine the client or server latency on the network.

httpRequestMethod

An 8-bit number indicating the HTTP method used in the transaction. An options template with the number-to-method mapping is sent along with the template.

httpRequestSize

An unsigned 32-bit number indicating the request payload size.

httpRequestURL

The HTTP URL requested by the client.

augflow Examples: nTop

http://ntop.org

template.c in nprobe (and elsewhere)

```
  { 0, BOTH_IPV4_IPV6, FLOW_TEMPLATE, SHORT_SNAPLEN, NTOP_ENTERPRISE_ID,
NTOP_BASE_ID+110, STATIC_FIELD_LEN, 4, numeric_format, dump_as_uint,
"RETRANSMITTED_OUT_PKTS", "", "Number of retransmitted TCP flow packets (dst->src)" },
  { 0, BOTH_IPV4_IPV6, FLOW_TEMPLATE, SHORT_SNAPLEN, NTOP_ENTERPRISE_ID,
NTOP_BASE_ID+101, STATIC_FIELD_LEN, 2,  ascii_format, dump_as_ascii,
"SRC_IP_COUNTRY", "", "Country where the src IP is located" },
  { 0, BOTH_IPV4_IPV6, FLOW_TEMPLATE, SHORT_SNAPLEN, NTOP_ENTERPRISE_ID,
NTOP_BASE_ID+86,  STATIC_FIELD_LEN, 4, numeric_format, dump_as_uint,
"APPL_LATENCY_SEC", "", "Application latency (sec)" },
  { 0, BOTH_IPV4_IPV6, FLOW_TEMPLATE, SHORT_SNAPLEN, NTOP_ENTERPRISE_ID,
NTOP_BASE_ID+82,  STATIC_FIELD_LEN, 4, numeric_format, dump_as_uint,
"CLIENT_NW_DELAY_SEC", "",  "Network latency client <-> nprobe (sec)" },
```

augflow Examples: nginx, bro

- http://nginx.org/en/docs/http/ngx_http_core_module.html#variables
- https://www.bro.org/sphinx/logs/index.html

nginx: log_format combined '$remote_addr - $remote_user [$time_local] ' '"$request" $status $body_bytes_sent ' '"$http_referer" "$http_user_agent"' '$tcpinfo_rtt, $tcpinfo_rttvar, $tcpinfo_snd_cwnd, $tcpinfo_rcv_space';

```
# cat conn.log | bro-cut id.orig_h id.orig_p id.resp_h duration
141.142.220.202    5353    224.0.0.251     -
fe80::217:f2ff:fed7:cf65  5353    ff02::fb        -
141.142.220.50     5353    224.0.0.251     -
141.142.220.118    43927   141.142.2.2     0.000435
141.142.220.118    37676   141.142.2.2     0.000420
141.142.220.118    40526   141.142.2.2     0.000392
141.142.220.118    32902   141.142.2.2     0.000317
141.142.220.118    59816   141.142.2.2     0.000343
141.142.220.118    59714   141.142.2.2     0.000375
141.142.220.118    58206   141.142.2.2     0.000339
[...]
```

Storing and Accessing Augmented Flow

- Data back-ends need to be able to understand and ingest the extra fields.
- Often requires integration (for OSS/big data tools) or vendor support.
- And if the tools aren't 'open' via API, SQL, or CLI, data can be trapped and not as useful.
- Many first use cases are ad-hoc to prove effectiveness, then drive to UI reports/dashboards.
- Holy grail: end user app perf + net perf + net flow + host perf + app internals insturmentation.

Extensible Flow Storage: fastbit

- https://sdm.lbl.gov/fastbit/
- https://github.com/CESNET/ipfixcol/
- http://www.ntop.org

```
(nprobe CLI)
fbquery -c
'DST_AS,L4_SRC_PORT,sum(IN_BYTES) as
inb,sum(OUT_BYTES) as outb' \
-q 'SRC_AS <> 3 AND L4_SRC_PORT <> 80' \
-g 'DST_AS,L4_SRC_PORT' \
-o 'inb' \
-r -L 10 -d .
```

Storing Augmented Flow in Fastbit

```
root@s5:/data/fb/333/dev1/3/2015/10/03/20/49# ls
APPLATENCY               IPV4_DST_ADDR.idx               OUT_PKTS
APPLATENCY.idx           IPV4_DST_ROUTE_PREFIX           OUT_PKTS.idx
CTIMESTAMP               IPV4_DST_ROUTE_PREFIX.idx       PROTOCOL
CTIMESTAMP.idx           IPV4_NEXT_HOP                   PROTOCOL.idx
DEFAULT_COLUMN           IPV4_NEXT_HOP.idx               SAMPLEDPKTSIZE
DEFAULT_COLUMN.idx       IPV4_SRC_ADDR                   SAMPLEDPKTSIZE.idx
DEVICE_ID                IPV4_SRC_ADDR.idx               SAMPLE_RATE
DEVICE_ID.idx            IPV4_SRC_ROUTE_PREFIX           SAMPLE_RATE.idx
DNS                      IPV4_SRC_ROUTE_PREFIX.idx       SRC_AS
DNSQ.idx                 IPV6_DST_ADDR_HIGH              SRC_AS.idx
DST_AS                   IPV6_DST_ADDR_HIGH.idx          SRC_GEO
DST_AS.idx               IPV6_DST_ADDR_LOW               SRC_GEO.idx
DST_GEO                  IPV6_DST_ADDR_LOW.idx           SRC_GEO_CITY
DST_GEO.idx              IPV6_SRC_ADDR_HIGH              SRC_GEO_CITY.idx
DST_GEO_CITY             IPV6_SRC_ADDR_HIGH.idx          SRC_GEO_REGION
DST_GEO_CITY.idx         IPV6_SRC_ADDR_LOW               SRC_GEO_REGION.idx
DST_GEO_REGION           IPV6_SRC_ADDR_LOW.idx           SRC_ROUTE_LENGTH
DST_GEO_REGION.idx       L4_DST_PORT                     SRC_ROUTE_LENGTH.idx
DST_ROUTE_LENGTH         L4_DST_PORT.idx                 TCP_FLAGS
DST_ROUTE_LENGTH.idx     L4_SRC_PORT                     TCP_FLAGS.idx
INPUT_PORT               L4_SRC_PORT.idx                 TCP_RETRANSMIT
INPUT_PORT.idx           MPLS_TYPE                       TCP_RETRANSMIT.idx
IN_BYTES                 MPLS_TYPE.idx                   TOS
IN_BYTES.idx             OUTPUT_PORT                     TOS.idx
IN_PKTS                  OUTPUT_PORT.idx                 URL
IN_PKTS.idx              OUT_BYTES                       URL.idx
IPV4_DST_ADDR            OUT_BYTES.idx
```

Use Case: Network Performance

- If the flow system can aggregate by arbitrary dimensions by AS, AS_PATH, Geo, Prefix, etc…
- Then looking at raw network performance from passive sources can be very useful.
- Ex: TCP rexmit by AS_PATH (i.e. from nprobe for a server or, via span/tap, a sensor).
- Important to weight absolute relevance (not just % loss if a few 3 pkt flows).

SQL -> Fastbit Querying for rexmit

Retransmits > .1% by ASN at prime-time for ASNs with > 10k pkts:

```
SELECT i_start_time, src_AS, dst_AS,
sum(tcp_retransmit) AS f_sum_tcp_retransmit,
sum(out_pkts) AS f_sum_out_pkts,
round((sum(tcp_retransmit)/sum(out_pkts))*1000)/10
AS Perc_retransmits FROM                _com WHERE
i_start_time >= '2015-01-09 22:00:00' AND
i_start_time < '2015-01-10 06:00:0' GROUP BY
src_AS, dst_AS, i_start_time HAVING sum(out_pkts) >
10000 AND (sum(tcp_retransmit)/sum(out_pkts))*100 >
0.1 ORDER BY Perc_retransmits DESC;
```

Augmented Flow: rexmit by Dest ASN

% Retransmits by AS_dst

TIME OPTIONS 1 hour 2015-10-04 20:57 to 21:57 2015-10-04 UTC

GROUP BY METRIC Dest AS Number

UNITS % Retransmits Min pps 500

DATASET Auto

Apply Reset

Devices Search

Select All / None Selected: 1

- cat2_cloudhelix_com
- core_nyc_isp
- com
- rx1_cloudhelix_com

Single Multi

Filters

Add Group Clear All

Group 1

dst_bgp_aspath <> 6450

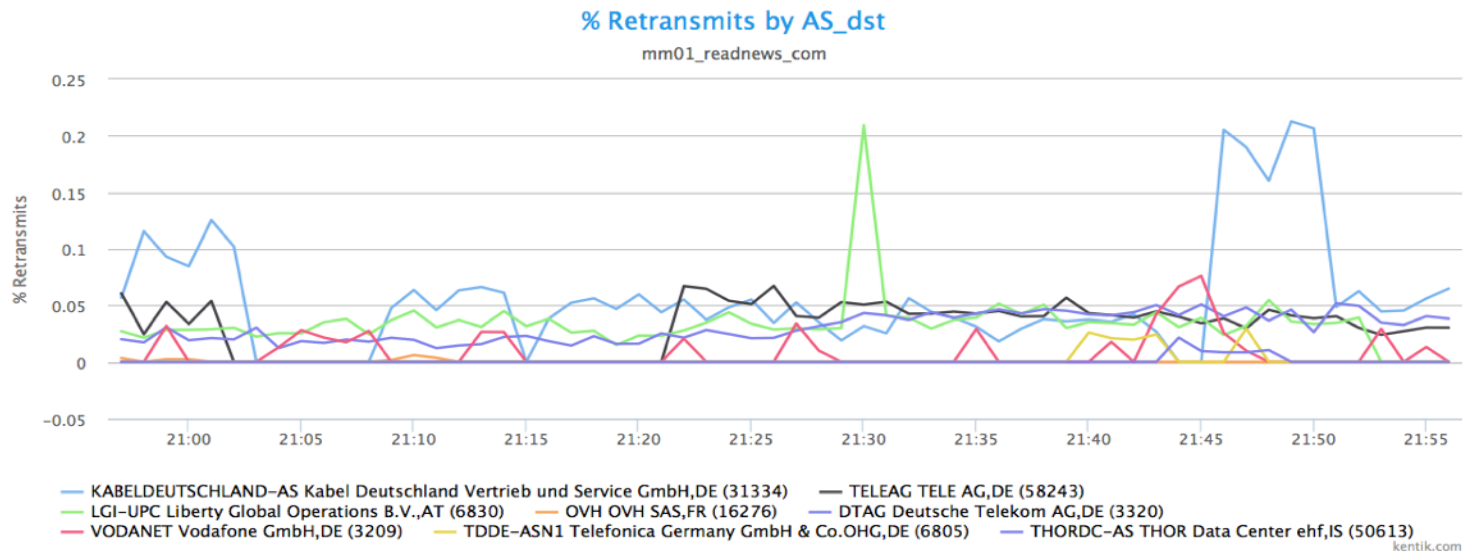
and

Group 2

dst_as <> 29562

Overlay - 0 days

Export SQL



Click to select, Shift+Click to multi-select

SQL

	# of Retransmits				% of Retransmits			Total Traffic	
dst_as	total	Avg /sec	95th percentile	Max/sec	Avg /sec	95th percentile	Max/sec	Avg mbps Sent	Avg pkts/s Sent
KABELDEUTSCHLAND-AS Kabel Deutschland Vertrieb und Service GmbH,DE (31334)	2015	0.55972	1.81667	2.03333	0.06236	0.20515	0.21272	36	898
LGI-UPC Liberty Global Operations B.V.,AT (6830)	2417	0.67139	0.96667	3.41667	0.03415	0.05154	0.20939	87	1,966
VODANET Vodafone GmbH,DE (3209)	236	0.06556	0.60000	0.71667	0.03096	0.06688	0.07601	8	212
TELEAG TELE AG,DE (58243)	1401	0.38917	0.80000	1.11667	0.04325	0.06483	0.06740	35	900
DTAG Deutsche Telekom AG,DE (3320)	3183	0.88417	1.50000	1.96667	0.03168	0.04959	0.05188	102	2,792

Augmented Flow: rexmit by 2nd hop ASN

% Retransmits by dst_second_asn

TIME OPTIONS 1 hour 2015-10-04 21:02 to 22:02 2015-10-04 UTC | GROUP BY METRIC Dest 2nd BGP_HOP AS Number | UNITS % Retransmits | Min pps 500 | DATASET Auto | Apply | Reset

Devices Search

Select All / None **Selected: 1**

- cat2_cloudhelix_com
- core_nyc_isp
- .com
- rx1_cloudhelix_com

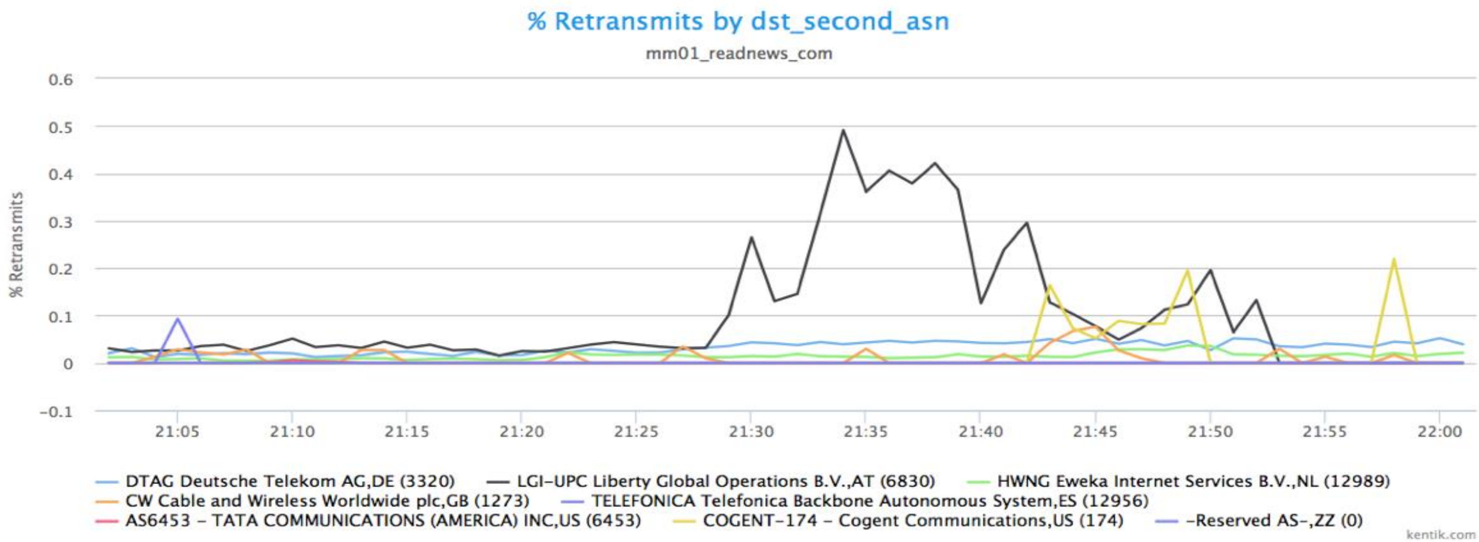
Single Multi

Filters

Add Group Clear All

Overlay - 0 days

Export SQL



Click to select, Shift+Click to multi-select

SQL

	# of Retransmits				% of Retransmits			Total Traffic	
dst_second_asn	**total**	**Avg /sec**	**95th percentile**	**Max/sec**	**Avg /sec**	**95th percentile**	**Max/sec**	**Avg mbps Sent**	**Avg pkts/s Sent**
LGI-UPC Liberty Global Operations B.V.,AT (6830)	6922	1.92278	8.51667	8.96667	0.10556	0.40556	0.49091	80	1,822
COGENT-174 - Cogent Communications,US (174)	517	0.14361	1.41667	1.41667	0.10247	0.21879	0.21879	5	141
TELEFONICA Telefonica Backbone Autonomous System,ES (12956)	35	0.00972	0.58333	0.58333	0.09290	0.09290	0.09290	1	11

Augmented Flow: rexmit by AS_PATH

% Retransmits by dst_bgp_aspath

TIME OPTIONS 1 hour 2015-10-04 20:55 to 21:55 2015-10-04 UTC | GROUP BY METRIC Dest BGP AS_Path | UNITS % Retransmits | Min pps 500 | DATASET Auto | Apply | Reset

Devices Search

Select All / None   Selected: 1

- cat2_cloudhelix_com
- core_nyc_isp
- com
- rx1_cloudhelix_com

Single Multi

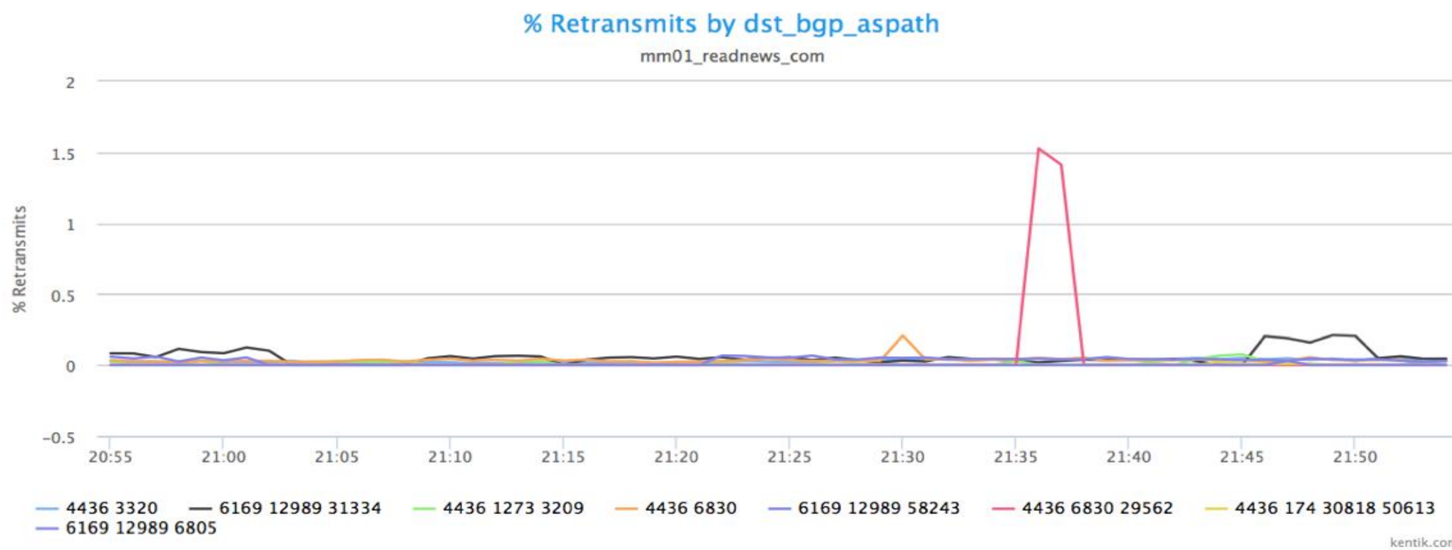
Filters

Add Group Clear All

Group 1

dst_bgp_aspath <> 6450

Overlay - 0 days   Export SQL



Click to select, Shift+Click to multi-select   SQL

	# of Retransmits				% of Retransmits			Total Traffic	
dst_bgp_aspath	**total**	**Avg /sec**	**95th percentile**	**Max/sec**	**Avg /sec**	**95th percentile**	**Max/sec**	**Avg mbps Sent**	**Avg pkts/s Sent**
4436 6830 29562	912	0.25333	7.95000	7.95000	1.46997	1.52733	1.52733	1	18
6169 12989 31334	2025	0.56250	1.81667	2.03333	0.06279	0.20515	0.21272	35	896
4436 6830	2451	0.68083	0.96667	3.41667	0.03415	0.05154	0.20939	88	1,994
4436 1273 3209	249	0.06917	0.60000	0.71667	0.03105	0.06688	0.07601	8	223
6169 12989 58243	1389	0.38583	0.80000	1.11667	0.04438	0.06483	0.06740	34	870
4436 3320	3071	0.85306	1.50000	1.96667	0.03092	0.04959	0.05188	102	2,760

Use Case: Application-Level Attacks

- With URL and performance data, many kinds of application attacks can be detected.
- To get * URL info in an HTTPS world, will need to get data from load balancers or web logs.
- Simplest is WAF – looking for SQL fragments, binary, or other known attack vectors.
- Can hook alerts to mitigation methods, even if running OOB (for example, send TCP FIN/RST in both directions)

Use Case: ‘APM Lite’

- Combining network with application data, you can answer questions like:
  - Show/aggregate cases where application performance is impaired but we know there is no network-layer issue (very useful), and agg by POP, server, app section.
  - Or where there is impairment in both.
  - And ignore network-layer issues where users are unaffected.
- Easy first use case: API perf debugging for web page assembly, or debugging CDN origin pull.

Use Case: Bot detection

- With performance information combined with URL, basic e-commerce bot detection is possible.
- Many attacks are advanced so may require a packet approach to get complete visibility, but basic visibility can often demonstrate a problem.
- Can sometimes be done with syslog analytics, but flow tools often aggregate in interesting ways (geo, AS) that syslog analytics don’t, at least out of the box.

Modern ‘Flow’ Format: kflow

- At today’s speeds, templated formats may not be the most efficient (space/CPU) implementation.
- Working on an open-spec format called kflow with open source tools to take to and from NetFlow, sFlow, IPFIX, nginx and bro logs, and Cisco, Citrix, ntop, and other vendor formats.
- Based on Cap’n Proto, which is a ‘serialization’ lib that is basically a struct with 0-packing - https://capnproto.org/
- Drawback: Can’t delete fields, just 0-pack them.
- Will shortly be live at https://github.com/Kentik

Flow with Cap'n Proto

```
struct kflow_v1 {
        version @44: Int64;
        timestampNano @0: Int64;
        dstAs @1: UInt32;
        dstGeo @2: UInt32;
        dstMac @3: UInt32;
        headerLen @4: UInt32;
        inBytes @5: UInt64;
        inPkts @6: UInt64;
        inputPort @7: UInt32;
        ipSize @8: UInt32;
        ipv4DstAddr @9: UInt32;
        ipv4SrcAddr @10: UInt32;
        tcpRetransmit @27: UInt32;
        dstBgpAsPath @34: Text;
        dstBgpCommunity @35: Text;
        <...>
```

Comments / Questions?

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