



Internet Measurement
& Analysis (IMA)

Internet Topology: Part I

Internet Topology Discovery with
Passive Measurements (BGP)

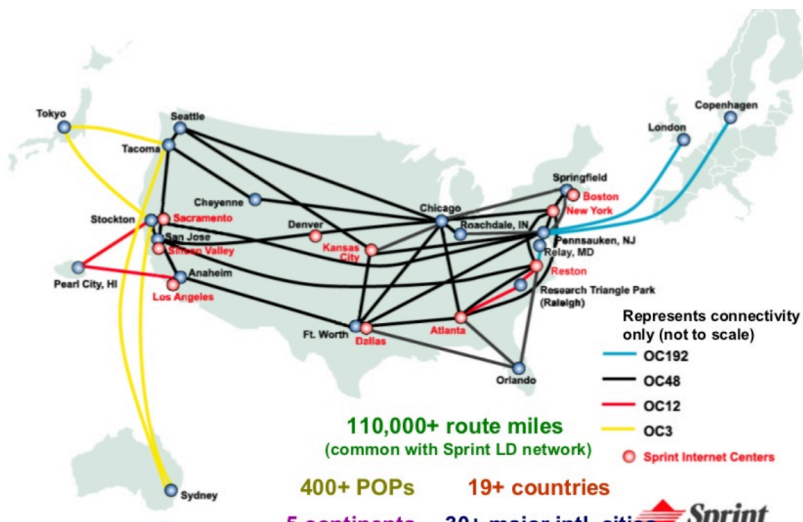
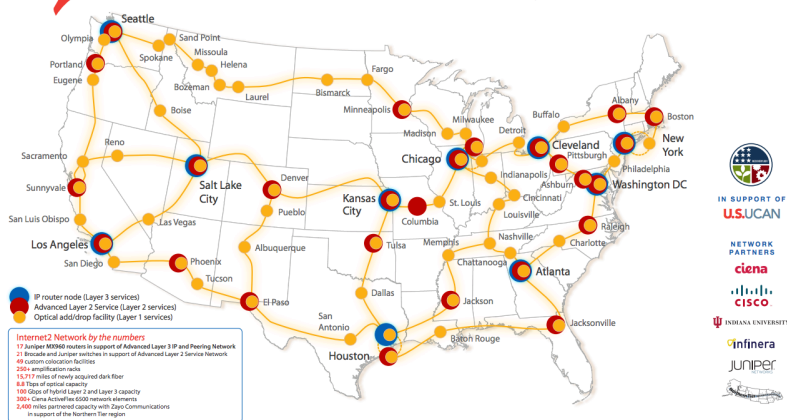
Prof. Georgios Smaragdakis, Ph.D.

Topologies at the Router Level



Internet2 Network Infrastructure Topology

July 2013



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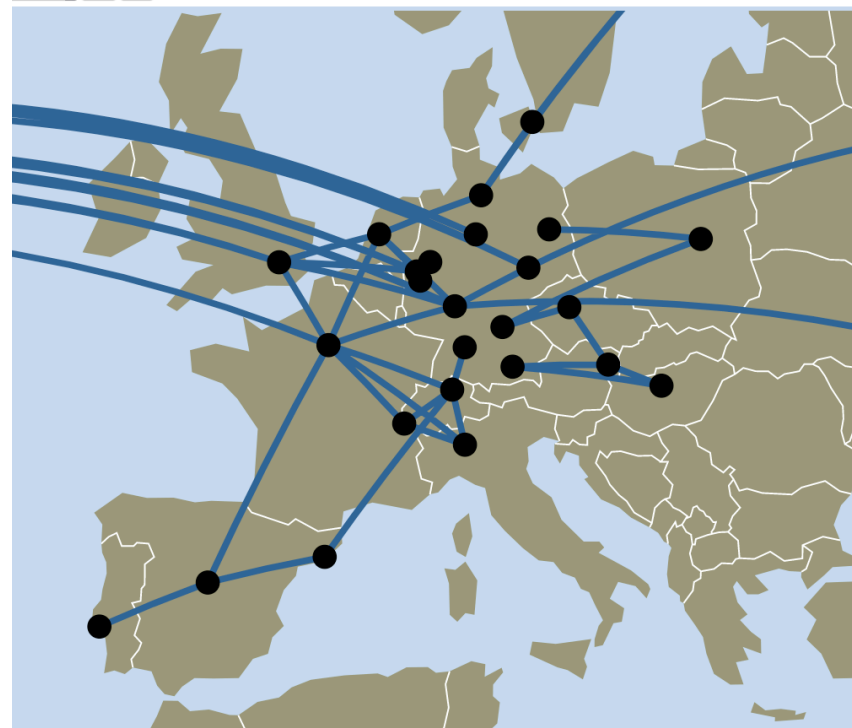
Keynote Talk, SANOG 9, Colombo, Sri Lanka, 23 January 2007

Courtesy: Jeff Chaltas
Sprint Public Relations

www.topology-zoo.org

Not Secure | www.topology-zoo.org/explore.html

Back | Next Deutsche Telekom 2010_08 (Global)



Topologies at the Physical Level (fiber)



Figure 1: Location of physical conduits for networks considered in the continental United States.



Figure 2: NationalAtlas roadway infrastructure locations.



Figure 3: NationalAtlas railway infrastructure locations.

“InterTubes: A Study of the US Long-haul Fiber-optic Infrastructure”, SIGCOMM 2015

Topologies at the AS Level (logical level)



HURRICANE ELECTRIC
INTERNET SERVICES

[AS6584 Microsoft Corporation](#)

Quick Links

[BGP Toolkit Home](#)
[BGP Prefix Report](#)
[BGP Peer Report](#)
[Exchange Report](#)
[Bogon Routes](#)
[World Report](#)
[Multi Origin Routes](#)
[DNS Report](#)
[Top Host Report](#)
[Internet Statistics](#)
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[Going Native](#)
[Contact Us](#)



<https://bgp.he.net>

AS Info

Graph v4

Graph v6

Prefixes v4

Prefixes v6

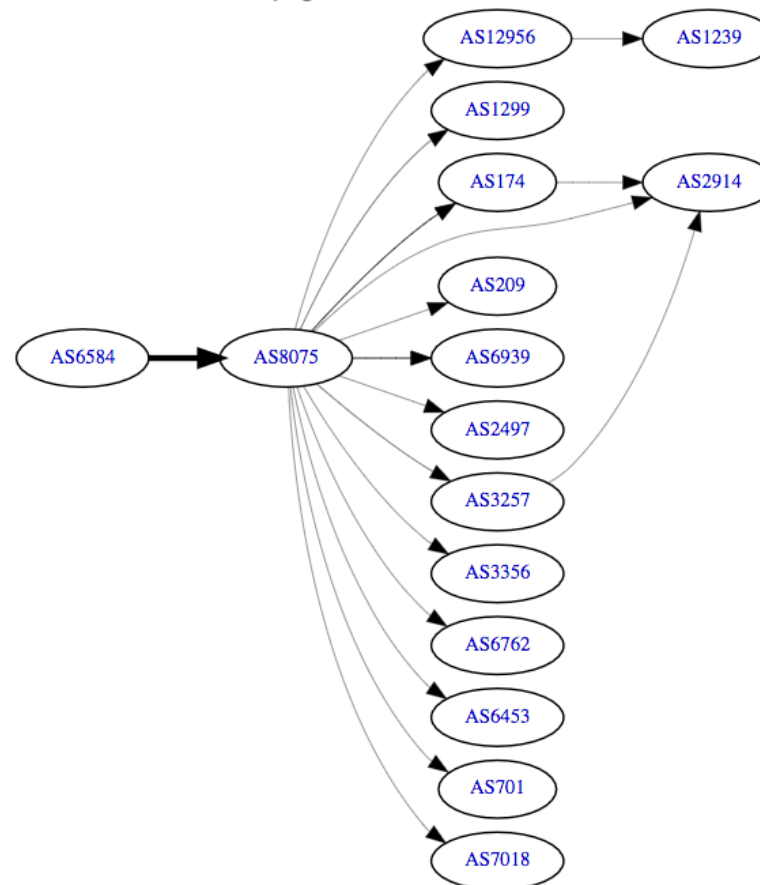
Peers v4

Peers v6

Whois

IRR

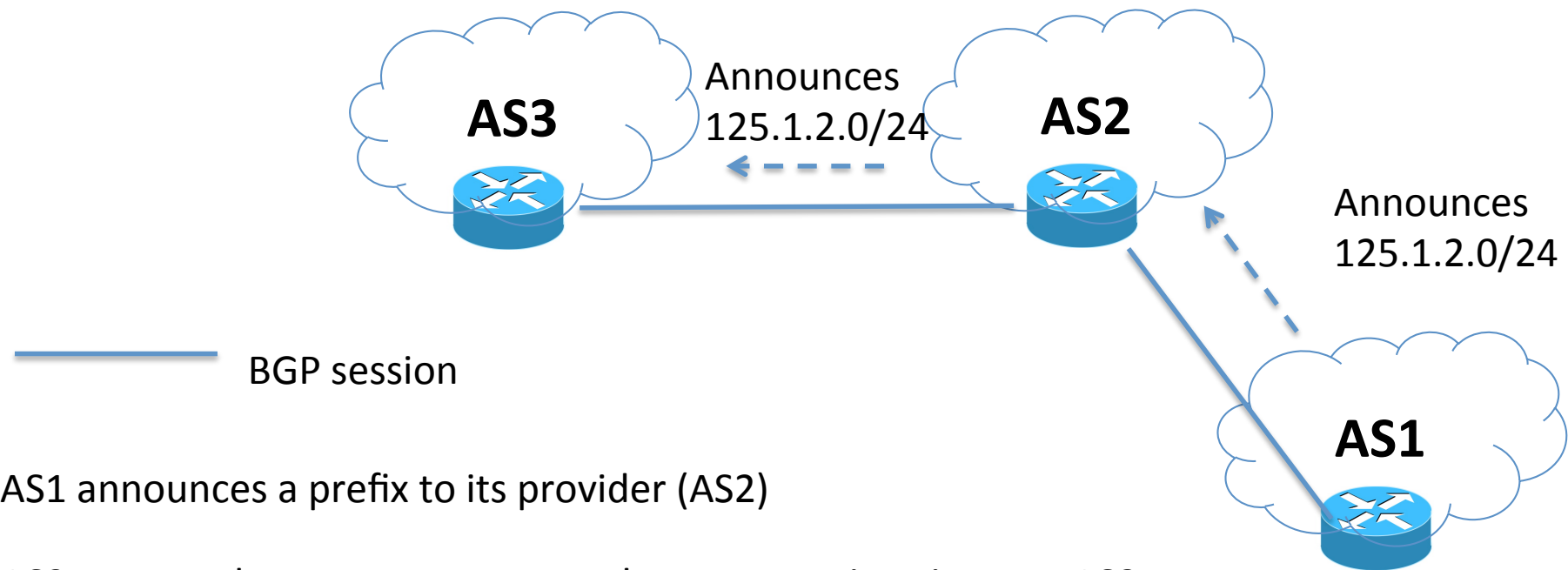
AS6584 IPv4 Route Propagation



Constructing the Internet Topology using BGP

- AS-level Topology from Control Plane
 - How different networks interconnect
 - Architecture of the Internet
 - Business relationships

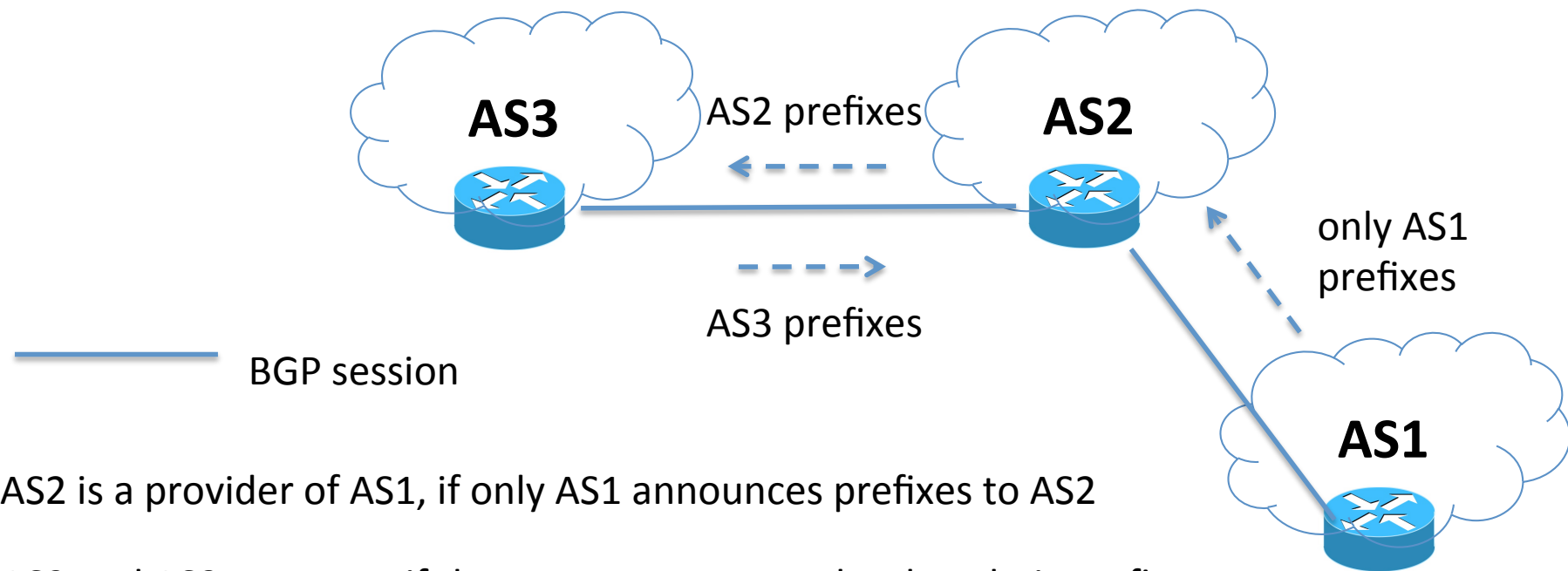
BGP Information



AS1 announces a prefix to its provider (AS2)

AS2 accepts the announcement and propagates it to its peer AS3

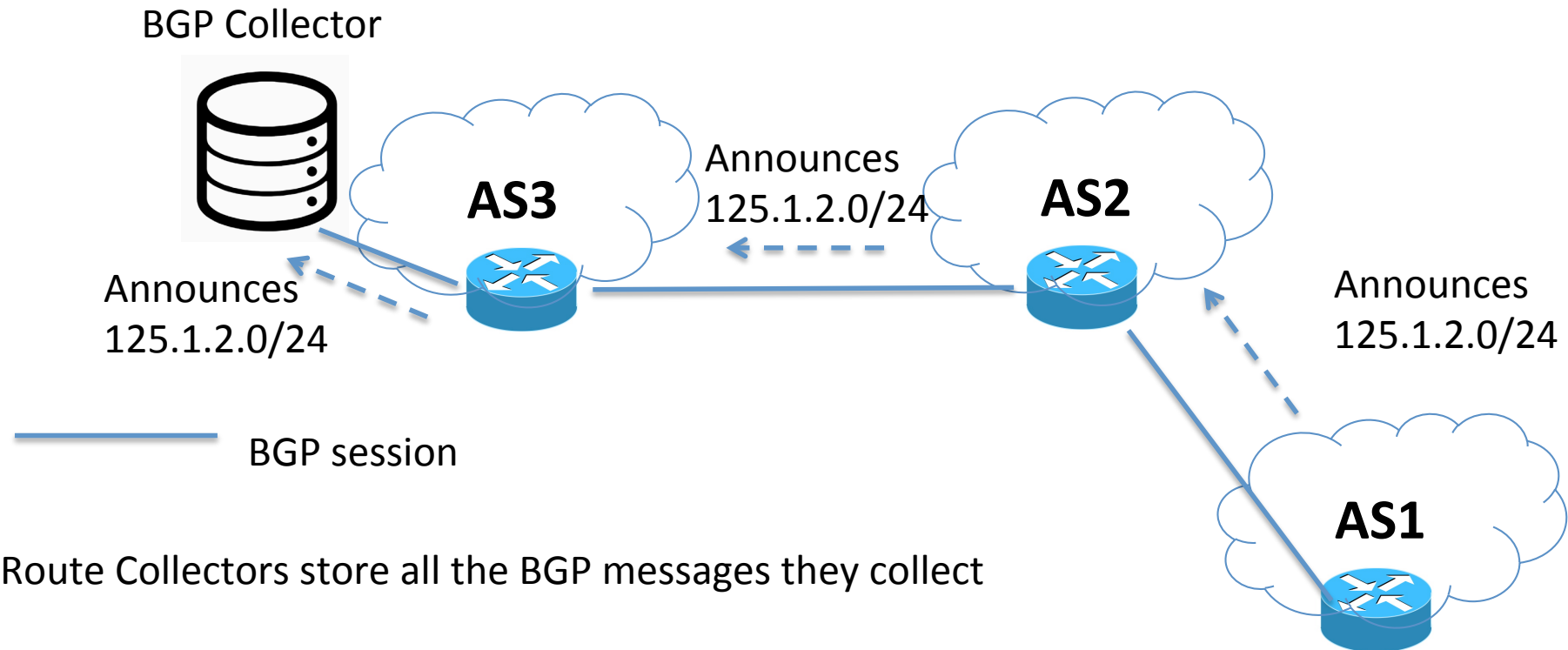
AS Relationships



AS2 is a provider of AS1, if only AS1 announces prefixes to AS2

AS2 and AS3 are peers if they announce to each other their prefixes (typically, this is a relationship between networks that exchange same order of traffic volume)

BGP Collector

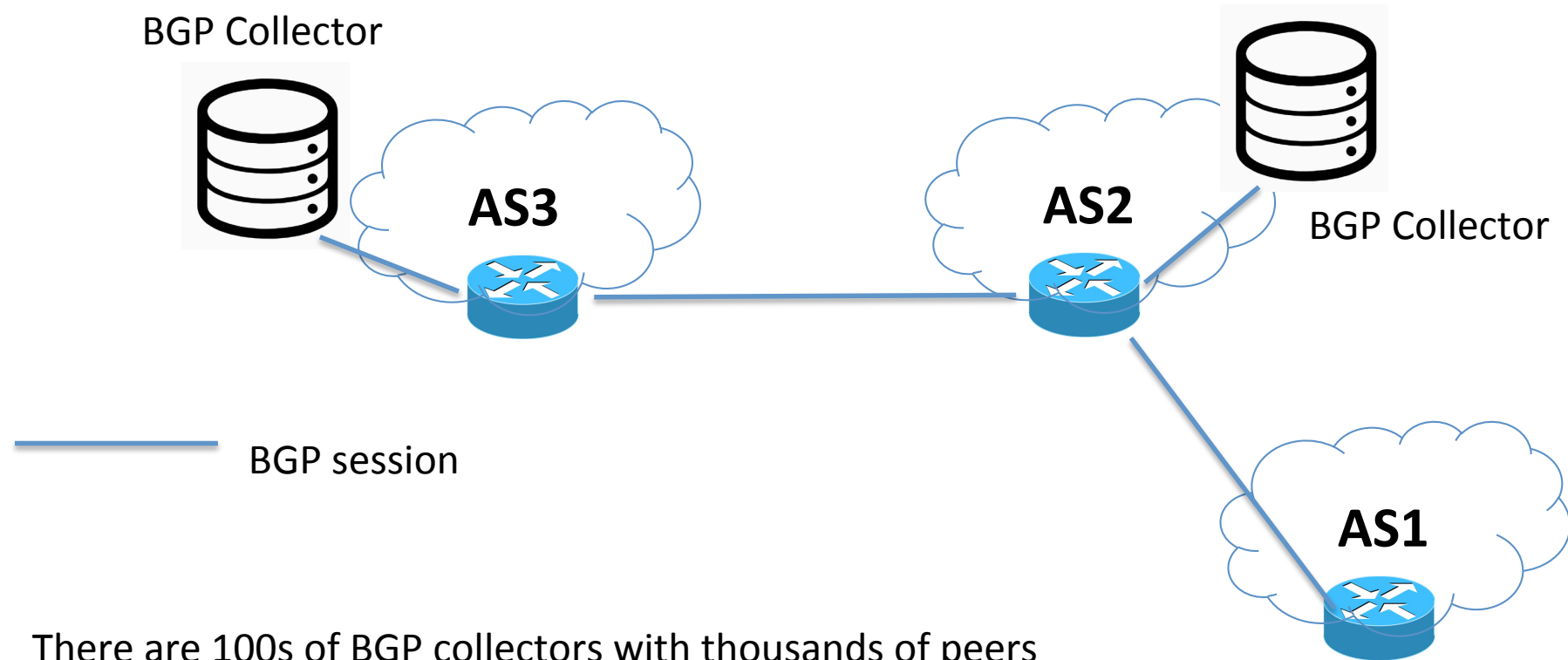


Route Collectors store all the BGP messages they collect

Time|IP-router3|AS3|125.1.2.0/24|AS3 AS2 AS1|...

AS1 is the origin of 125.1.2.0/24

BGP Collectors – Multiple Vantage Points



There are 100s of BGP collectors with thousands of peers around the globe

RIPE: Raw BGP Data

The screenshot shows the RIPE NCC website interface. At the top, there's a navigation bar with the RIPE NCC logo and the text 'RIPE NETWORK COORDINATION CENTRE'. To the right, there's a search bar labeled 'Search IP Address or ASN' and a 'Login' link. Below the navigation bar, there's a horizontal menu with links: 'Manage IPs and ASNs', 'Analyse', 'Participate', 'Get Support', 'Publications', and 'About Us'. The 'Analyse' link is highlighted. Below this, a breadcrumb trail reads: 'You are here: Home > Analyse > Internet Measurements > Routing Information Service (RIS) > RIS Raw Data'. On the left side, there's a sidebar menu with 'Analyse' selected, showing sub-links like 'Statistics', 'Internet Measurements' (which is expanded to show 'RIPE Atlas', 'Internet Traffic Maps', 'Analyses and Use Cases', 'Routing Information Service (RIS)', 'RIS Raw Data', 'RIS Peering Policy', 'RIS Routing Beacons', 'RIS Commercial Use', 'IXP Country Jedi (Alpha)', and 'OpenIPMap (Beta)'), 'DNS', 'Raw Datasets', and 'Archived Projects'. The main content area is titled 'RIS Raw Data' and contains a paragraph explaining that the page links to raw data collected by RRCs using Quagga routing software, stored in MRT format, and can be read using libbgpdump or PyBGPDump. It also mentions that all RIS tools handle 32-bit AS numbers. Below this, it states that two sets of files are available for each RRC: 'All BGP packets' and 'The entire BGP routing table'. A list of BGP Timer settings since 23 November 2006 is provided: Keepalives (60 seconds) and Holddown (180 seconds). On the right side, there are three sections: 'MAT Working Group', 'RIPE Atlas on RIPE Labs' (with links for 'Fixing Reachability to 1.1.1.1, GLOBALLY!' and 'Creating RIPE Atlas One-off Measurements with Blaauw'), and 'Related Items' (with a link for 'Routing Information Service (RIS)').

RIPE NCC
RIPE NETWORK COORDINATION CENTRE

RIPE Database (Whois) Website

Search IP Address or ASN

Manage IPs and ASNs > Analyse > Participate > Get Support > Publications > About Us >

You are here: Home > Analyse > Internet Measurements > Routing Information Service (RIS) > RIS Raw Data

Analyse <<

Statistics >

Internet Measurements >

RIPE Atlas

Internet Traffic Maps

Analyses and Use Cases

Routing Information Service (RIS)

RIS Raw Data

RIS Peering Policy

RIS Routing Beacons

RIS Commercial Use

IXP Country Jedi (Alpha)

OpenIPMap (Beta)

DNS >

Raw Datasets >

Archived Projects >

RIS Raw Data

This page links to the raw data collected by the RRCs using [Quagga routing software](#), stored in MRT format. This format is described in [RFC6396](#). These files can be read using [libbgpdump](#), a library written in C by Dan Ardelean, currently maintained by the RIPE NCC. A Python library also exists, [PyBGPDump](#) which provides access to MRT files via Python.

All RIS tools handle 32-bit AS numbers, complying with the guidelines set out in the Internet Draft '[Canonical Textual Representation of 4-byte AS Numbers](#)'.

Two sets of files are available for each of the RRC's:

- All BGP packets, created with the Zebra command `"dump bgp all ..."`. The filenames start with `updates` and are created every five minutes.
- The entire BGP routing table, created with the Zebra command `"dump bgp routes-mrt ..."`. These files are created every eight hours, the filenames start with `bview`.

BGP Timer settings since 23 November 2006:

- Keepalives:
 - 60 seconds
- Holddown:
 - 180 seconds

MAT Working Group

A forum in which the RIPE NCC and the community can collaborate in the areas of data, tools and analysis relating to the Internet and its infrastructure.

RIPE Atlas on RIPE Labs

[Fixing Reachability to 1.1.1.1, GLOBALLY!](#)
17 Apr, 2018

[Creating RIPE Atlas One-off Measurements with Blaauw](#)
16 Apr, 2018

[RIPE Atlas Measurement Tagging](#)
12 Apr, 2018

Related Items

[Routing Information Service \(RIS\)](#)

Source:

<https://www.ripe.net/analyse/internet-measurements/routing-information-service-ris/ris-raw-data>



Routeviews : Raw BGP Data

University of Oregon Route Views Archive Project

- Please see www.routeviews.org for a description of the route views project, bibliography, and additional information.
- For asn.routeviews.org zone files [click here](#) or ftp from: [ftp.routeviews.org/dnszones/](ftp://ftp.routeviews.org/dnszones/)
- Data Archives
 - [MRT format RIBs and UPDATES](#) (quagga bgpd, from route-views2.oregon-ix.net)
 - [MRT format RIBs and UPDATES](#) (quagga bgpd, from route-views3 as of Aug 13, 2013)
 - [MRT format RIBs and UPDATES](#) (quagga bgpd, from route-views4.routeviews.org)
 - [v6 MRT format RIBs and UPDATES](#) (quagga bgpd, from route-views6.oregon-ix.net)
 - [MRT format RIBs and UPDATES from Equinix Ashburn](#) (quagga bgpd, from route-views.eqix.routeviews.org)
 - [MRT format RIBs and UPDATES from ISC \(PAIX\)](#) (quagga bgpd, from route-views.isc.routeviews.org)
 - [MRT format RIBs and UPDATES from KIXP](#) (quagga bgpd, from route-views.kixp.routeviews.org)
 - [MRT format RIBs and UPDATES from JINX](#) (quagga bgpd, from route-views.jinx.routeviews.org)
 - [MRT format RIBs and UPDATES from LINX](#) (quagga bgpd, from route-views.linx.routeviews.org)
 - [MRT format RIBs and UPDATES from NAPAfrica](#) (quagga bgpd, from route-views.napafrika.routeviews.org)
 - [MRT format RIBs and UPDATES from NWAX](#) (quagga bgpd, from route-views.nwax.routeviews.org)
 - [MRT format RIBs and UPDATES from TELXATL](#) (quagga bgpd, from route-views.telxatl.routeviews.org)
 - [MRT format RIBs and UPDATES from DIXIE \(WIDE\)](#) (quagga bgpd, from route-views.wide.routeviews.org)
 - [MRT format RIBs and UPDATES from SYDNEY](#) (quagga bgpd, from route-views.sydney.routeviews.org)
 - [MRT format RIBs and UPDATES from SAOPAULO](#) (quagga bgpd, from route-views.saopaulo.routeviews.org)
 - [MRT format RIBs and UPDATES from SINGAPORE](#) (quagga bgpd, from route-views.sg.routeviews.org)
 - [MRT format RIBs and UPDATES from PERTH](#) (quagga bgpd, from route-views.perth.routeviews.org)
 - [MRT format RIBs and UPDATES from SFMIX](#) (quagga bgpd, from route-views.sfmix.routeviews.org)
 - [MRT format RIBs and UPDATES from SOXRS/Serbia](#) (quagga bgpd, from route-views.soxrs.routeviews.org)
 - [ipv6 data split out from the above files](#) (multiple collectors)
 - ['sh ip bgp' format RIBs](#) from route-views.route-views.org (to now)
 - [route dampening data](#) from route-views.route-views.org (to March 2008)
 - ['sh ip bgp' format RIBs](#) from route-views3.routeviews.org (to Mar 2012)

Source:

<http://archive.routeviews.org/>

PCH: Raw BGP Data



Login

About ▾

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Tools ▾

Resources ▾

Home

Resources

Raw Routing Data

MRT Routing Updates

PCH operates route collectors at more than 100 Internet Exchange Points around the world. Data from these route collectors is made available publicly for the benefit of the Internet's operational and research communities. PCH maintains two different, but complementary, kinds of data from these route collectors.

1. **Daily snapshots of the results of "show ip bgp" on PCH route collectors** These indicate the state of the routing table on PCH route collectors at the moment in time that the snapshot is taken. Note that the state of the routing table will change from moment to moment across the course of a day as a route collector receives new routing announcements from peers. These are available [here](#).
2. **Archives of MRT format files with BGP updates** These provide the raw stream of BGP updates received by PCH route collectors. While the "show ip bgp" data provides a daily overview of each route collector's routing table, these archives of BGP updates provide information on the changes in routing data received from PCH peers which contribute to moment to moment changes in a route collector's routing table. These are available below.

Note that the data collected by PCH represents the sum of inter-domain routing announcements received from PCH peers. This data does not, and cannot, reflect the status of every autonomous system at an IXP.

Name	Modified
route-collector.teraco-dur.pch.net	1 month ago
route-collector.ist.pch.net	3 months ago
route-collector.kin.pch.net	3 months ago
route-collector.lys.pch.net	3 months ago
route-collector.amsix-ord.pch.net	1 month ago
route-collector.mex.pch.net	3 months ago

Source:

https://www.pch.net/resources/Raw_Routing_Data/

BGP Raw Data

- BGP Table Dump, a snapshot of the view of the router:

TIME: 04/08/18 00:00:00

TYPE: TABLE_DUMP_V2/IPV4_UNICAST

PREFIX: 1.1.1.0/24

SEQUENCE: 0

FROM: 111.91.233.1 AS45896

ORIGINATED: 04/04/18 02:03:00

ORIGIN: IGP

ASPATH: 45896 3356

NEXT_HOP: 111.91.233.1

COMMUNITY: 3356:3 3356:9 3356:575 3356:200

BGP Raw Data

- BGP Announcement, are updates from the last BGP dump:

TIME: 04/08/18 22:40:00

TYPE: BGP4MP/MESSAGE/Update

FROM: 12.0.1.63 AS7018

TO: 193.0.4.28 AS12654

ORIGIN: IGP

ASPATH: 7018 3356 3549 263165 52832

NEXT_HOP: 12.0.1.63

COMMUNITY: 7018:5000 7018:37232

ANNOUNCE

177.53.180.0/22

BGP Raw Data

- BGP Withdrawal, are also updates from the last BGP dump:

TIME: 04/08/18 22:40:00

TYPE: BGP4MP/MESSAGE/Update

FROM: 79.143.241.12 AS29608

TO: 193.0.4.28 AS12654

WITHDRAW

205.108.244.0/22

BGP Compact Representation

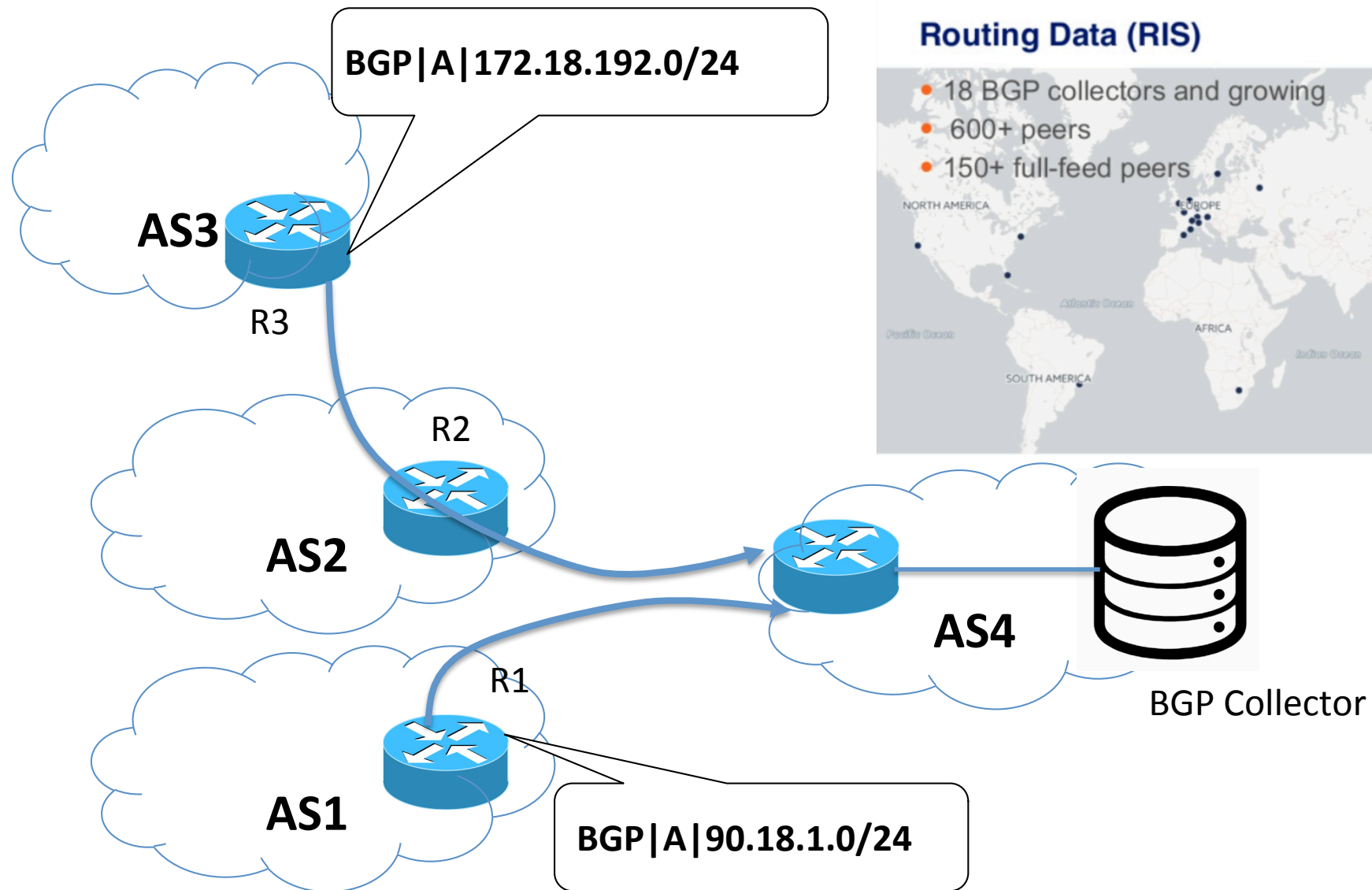
- BGP Dump:

```
TABLE_DUMP2|1523145600|B|111.91.233.1|45896|1.1.1.0/24|45896  
3356|IGP|111.91.233.1|0|0|3356:3 3356:9 3356:575 3356:2003|NAG||
```

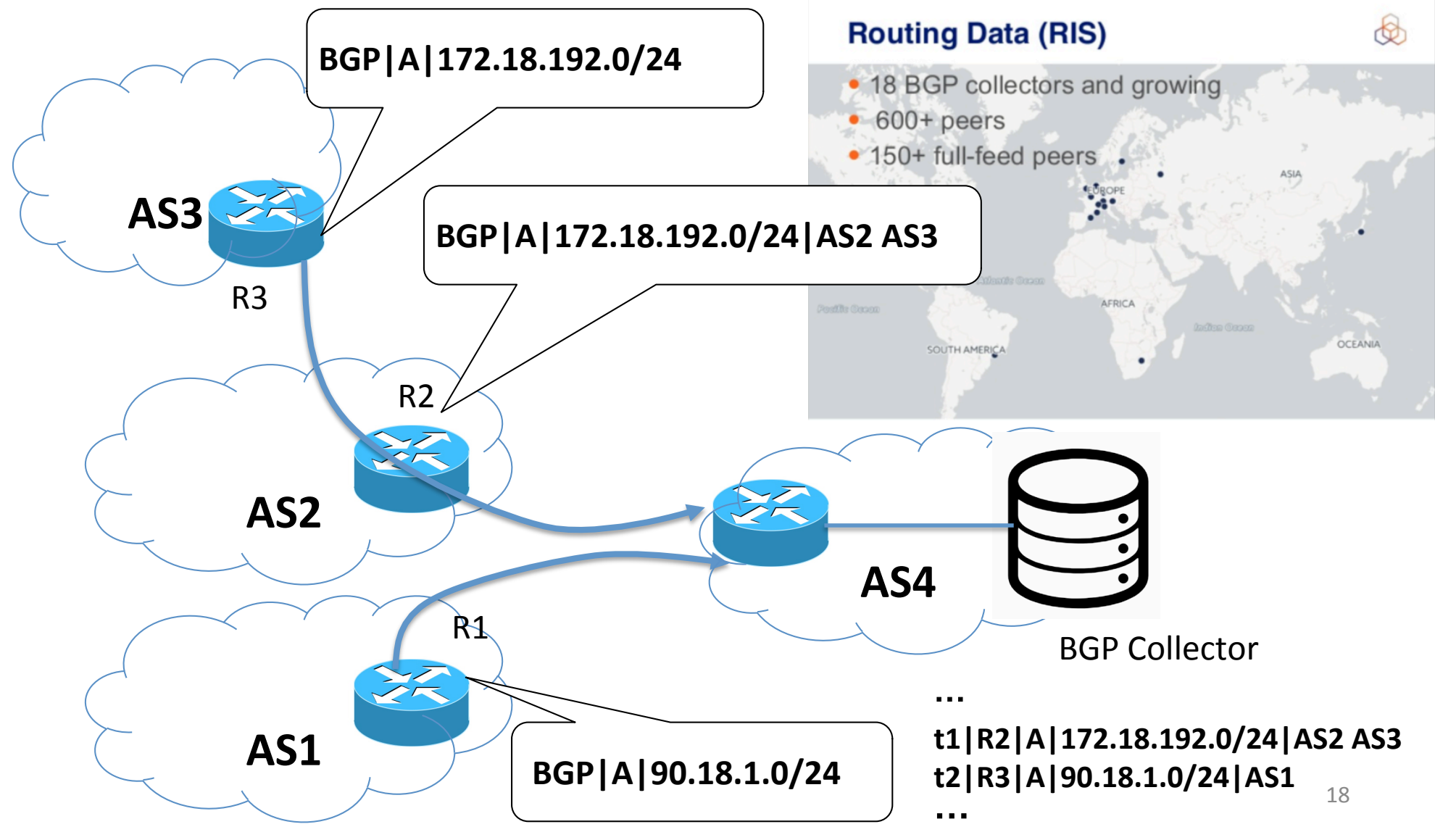
- BGP Messages:

- BGP4MP|1523227200|A|212.25.27.44|8758|44.136.224.0/24|8758
6830 4637 1221|INCOMPLETE|212.25.27.44|0|0|6830:17000
6830:17500 6830:23001 6830:34403 8758:110 8758:300|NAG||
- BGP4MP|1523227200|W|79.143.241.12|29608|205.108.244.0/22

Constructing the Internet Topology using BGP (AS-level)



Constructing the Internet Topology using BGP (AS-level)

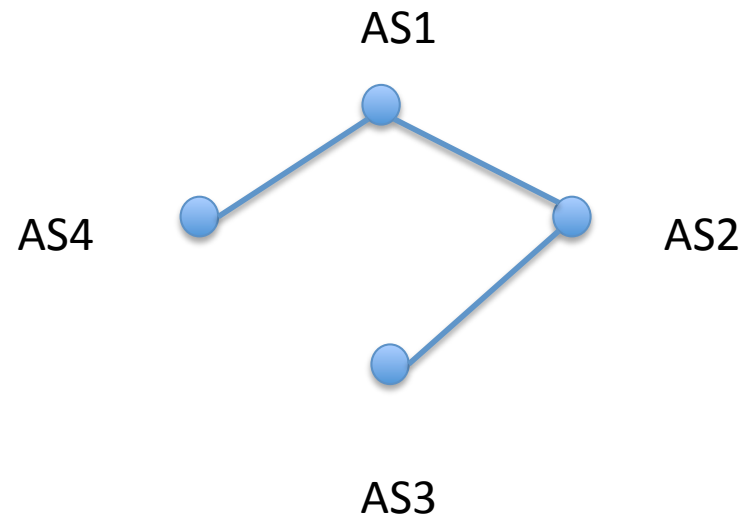


Connecting the Points

- AS3 AS2
- AS4 AS1
- AS3 AS2 AS1

AS-level Map: Connecting the Dots

- AS3 AS2
- AS4 AS1
- AS3 AS2 AS1



Internet-scale AS-level Map

To get the full view of the Internet connectivity for one day:

1. Download the first BGP dump from all the collectors at the beginning of the day
2. Find the AS-level topology
3. Update the AS-level topology using the announcements and withdrawals (updates)

Estimating the Number of AS-links

Year/Methodology	Est. # of customer-provider links in the Internet	Est. number of peering links in the Internet
2008 (BGP)*	~60,000	~15,000
2010 (BGP + traceroute)**	~90,000	~30,000
2012 (ground truth from a large IXP)***	~90,000	>200,000

**Next
Lectures**

* Dhamdhere et al., , ACM IMC 2008, IEEE/ACM Trans on Networking 2011

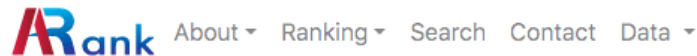
** Augustin et al., ACM IMC 2009

** K. Chen et al., ACM CoNEXT 2009

*** Ager et al., SIGCOMM 2012












Courtesy of Walter Willinger

Core of the Internet

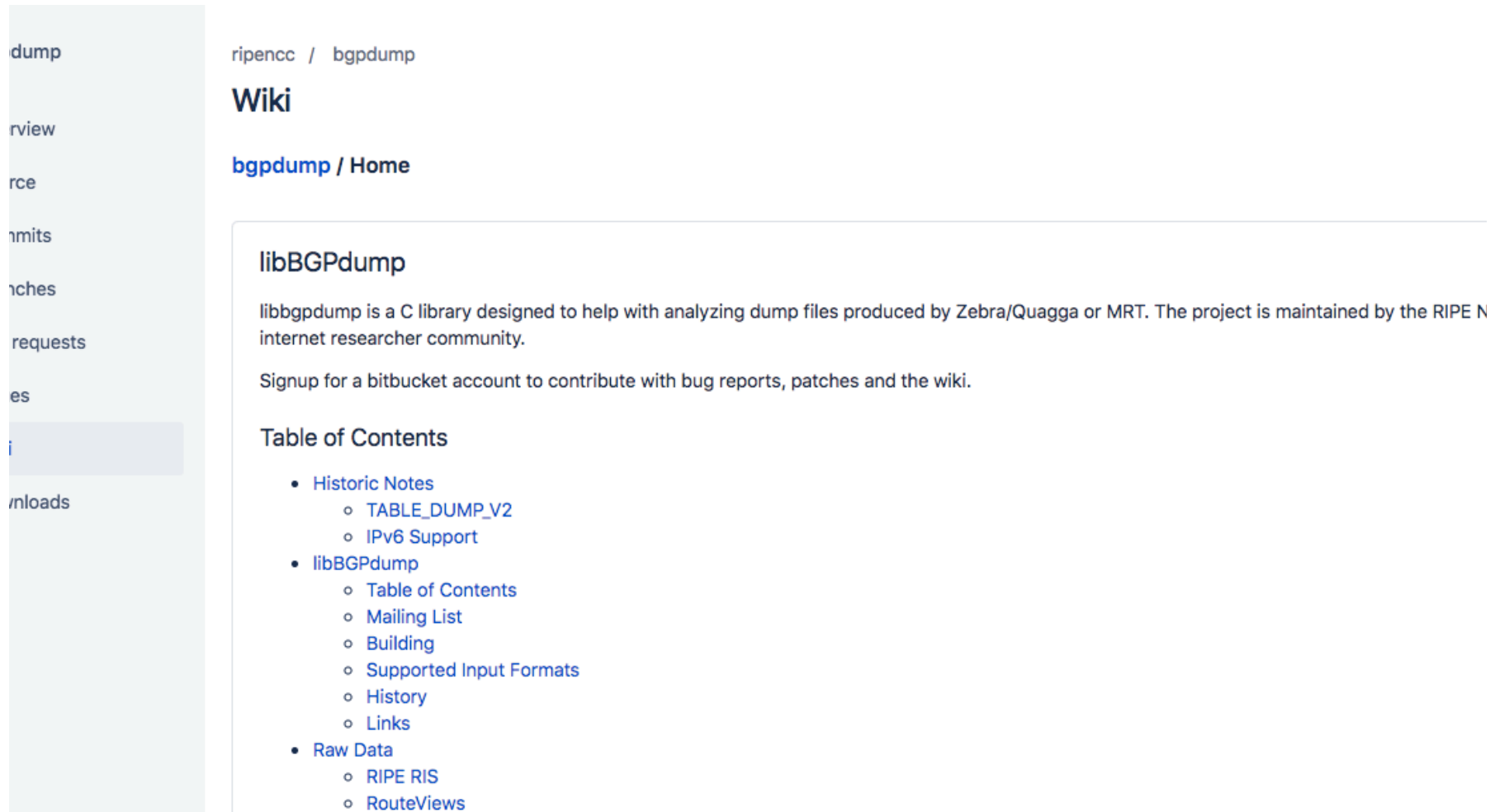


ASN name or number

1 2 3 4 .. 2250

AS Rank ▲	AS Number	Organization		Customer Cone						Transit ASN Degree ▼
				Number of			Percentages of All			
				ASNs ▼	Prefixes ▼	Addresses ▼	ASNs	Prefixes	Addresses	
1	3356	Level 3 Parent, LLC		36019	516117	1293145968	40.02%	55.04%	45.77%	5177
2	1299	Telia Company AB		28493	551873	1290079761	31.66%	58.85%	45.66%	1864
3	174	Cogent Communicatio...		25947	486058	1207165764	28.83%	51.83%	42.73%	5761
4	2914	NTT America, Inc.		24563	466401	992054726	27.29%	49.74%	35.12%	1769
5	3257	GTT Communications ...		23367	439683	833095190	25.96%	46.89%	29.49%	1796
6	6762	TELECOM ITALIA SPA...		15513	263025	447922042	17.24%	28.05%	15.86%	495
7	6939	Hurricane Electric LLC		15344	308552	579488179	17.05%	32.9%	20.51%	7566
8	6453	TATA COMMUNICATIO...		15189	383477	901968041	16.88%	40.89%	31.93%	740
9	3491	PCCW Global, Inc.		10233	243645	409527793	11.37%	25.98%	14.5%	640
10	6461	Zayo Bandwidth		7667	142021	357851577	8.52%	15.15%	12.67%	1896
11	1273	Vodafone Group PLC		6676	132707	296777756	7.42%	14.15%	10.51%	328

BGPdump Tool



The screenshot shows the homepage of the BGPdump Tool. On the left is a vertical navigation menu with links: dump, rview, rce, nmits, nches, requests, es, i, and nloads. The main content area has a breadcrumb trail 'ripencc / bgpdump' followed by a 'Wiki' heading and a link to 'bgpdump / Home'. Below this is a section titled 'libBGPdump' with a description: 'libbgpdump is a C library designed to help with analyzing dump files produced by Zebra/Quagga or MRT. The project is maintained by the RIPE N internet researcher community.' It also includes a call to action: 'Signup for a bitbucket account to contribute with bug reports, patches and the wiki.' A 'Table of Contents' section follows, listing: Historic Notes (with sub-items TABLE_DUMP_V2 and IPv6 Support), libBGPdump (with sub-items Table of Contents, Mailing List, Building, Supported Input Formats, History, and Links), and Raw Data (with sub-items RIPE RIS and RouteViews).

ripencc / bgpdump

Wiki

[bgpdump / Home](#)

libBGPdump

libbgpdump is a C library designed to help with analyzing dump files produced by Zebra/Quagga or MRT. The project is maintained by the RIPE N internet researcher community.

Signup for a bitbucket account to contribute with bug reports, patches and the wiki.

Table of Contents

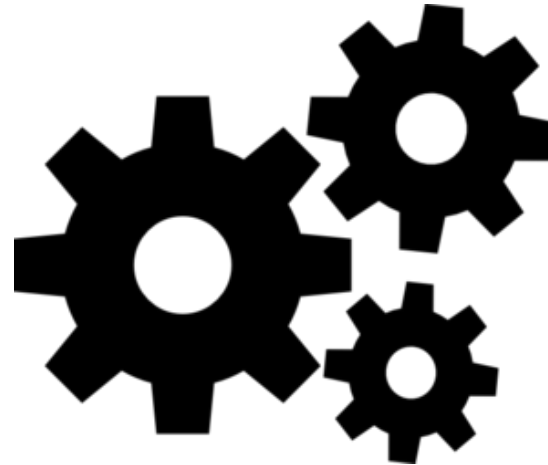
- [Historic Notes](#)
 - [TABLE_DUMP_V2](#)
 - [IPv6 Support](#)
- [libBGPdump](#)
 - [Table of Contents](#)
 - [Mailing List](#)
 - [Building](#)
 - [Supported Input Formats](#)
 - [History](#)
 - [Links](#)
- [Raw Data](#)
 - [RIPE RIS](#)
 - [RouteViews](#)

Source:

<https://bitbucket.org/ripencc/bgpdump/wiki/Home>

Hands-on Exercise

Using BGPdump to analyze RIPE Raw BGP data



Analyzing the BGP data from one collector

- Go to:

<https://www.ripe.net/analyse/internet-measurements/routing-information-service-ris/ris-raw-data>





- Choose a collector,
e.g., data.ris.ripe.net/rrc00
(rrc00 is in Amsterdam
And collects data since 1999)

Index of /rrc00

<u>Name</u>	<u>Last modified</u>	<u>Size</u>	<u>Description</u>
 Parent Directory		-	
 logs/	30-Aug-2016 12:55	-	
 latest-update.gz	18-Apr-2019 05:20	1.1M	
 latest-bview.gz	18-Apr-2019 00:39	219M	
 invalid/	19-Sep-2018 18:47	-	
 2019.04/	18-Apr-2019 05:25	-	
 2019.03/	01-Apr-2019 00:00	-	
 2019.02/	01-Mar-2019 00:00	-	

Analysis of rrc0/2019.04

Index of /rrc00/2019.04

Name	Last modified	Size	Description
 Parent Directory	-		
 updates.20190418.0620.gz	18-Apr-2019 06:25	1.1M	
 updates.20190418.0615.gz	18-Apr-2019 06:20	1.1M	
 bview.20190418.0000.gz	18-Apr-2019 00:39	219M	

Update:

updates.20190418.0620.gz

BGP dump:

bview.20190418.0000.gz

bgpdump updates.20190418.0620.gz

TIME: 04/18/19 06:20:00

TYPE: BGP4MP/MESSAGE/Update

FROM: 72.22.223.9 AS11708

TO: 193.0.4.28 AS12654

ORIGIN: IGP

ASPATH: 11708 32097 6939 3356 19058

NEXT_HOP: 72.22.223.9

ANNOUNCE

68.69.37.0/24

.....

Focusing on the AS paths

```
bgpdump updates.20190418.0620.gz | grep -e "ASPATH" | awk  
'{split($0,a,"ASPATH: "); print a[2]}'
```

```
11708 32097 6939 3356 19058  
206479 34549 1299 16509  
48821 205112 13030 9002 50923 44627 35564  
206499 34549 1299 3356 20485 8427  
202365 62240 6453 4761  
202365 62240 2914 4761  
202365 62240 2914 4761 38490  
202365 206499 34549 1299 174 16509  
202365 62240 2914 6453 4761 38490  
202365 206499 34549 3320 12956 18881 263442  
202365 206499 34549 13101 20485 8427 43812  
.....
```

Using a different representation

bgpdump -m updates.20190418.0620.gz

```
BGP4MP|1555568400|A|72.22.223.9|11708|68.69.37.0/24|11708 32097 6939
3356 19058|IGP|72.22.223.9|0|0||NAG||
BGP4MP|1555568400|A|185.120.22.16|206479|130.137.85.0/24|206479 34549
1299 16509|IGP|185.120.22.16|0|0|1299:30000 34549:100 34549:1299|NAG||
BGP4MP|1555568400|A|185.138.53.0|48821|80.242.50.0/24|48821 205112
13030 9002 50923 44627 35564|IGP|185.138.53.0|0|0|123:101 123:4901
13030:1 13030:4011 13030:7209 13030:50000 13030:51502 48821:3000
48821:3100|NAG||
BGP4MP|1555568400|A|185.215.214.1|206499|31.47.112.0/20|206499 34549
1299 3356 20485 8427|IGP|185.215.214.1|0|0|1299:25000 34549:100
34549:1299|NAG||
BGP4MP|1555568400|A|185.215.214.1|206499|212.21.0.0/19|206499 34549
1299 3356 20485 8427|IGP|185.215.214.1|0|0|1299:25000 34549:100
34549:1299|NAG||
.....
```

Using a different representation

```
bgpdump -m updates.20190418.0620.gz | awk '{split($0,a,"|");  
print a[7]}'
```

```
11708 32097 6939 3356 19058  
206479 34549 1299 16509  
48821 205112 13030 9002 50923 44627 35564  
206499 34549 1299 3356 20485 8427  
206499 34549 1299 3356 20485 8427  
.....
```

Has values only for announcements! Withdrawls do not have path information.

Find all the AS-level pairs (updates)

```
bgpdump -m updates.20190418.0620.gz | awk '{split($0,a,"|"); print a[7]}' |  
awk '{split($0, b, " "); for(i =1 ; i<length(b); i++){print b[i], b[i+1]}}
```

11708 32097

32097 6939

6939 3356

3356 19058

206479 34549

34549 1299

1299 16509

48821 205112

.....

Find all the AS-level pairs (BGP dump, file: bview.20190418.0000.gz)

```
bgpdump -m bview.20190418.0000.gz | awk '{split($0,a, "|"); print a[7]}' | awk  
'{split($0, b, " "); for(i =1 ; i<length(b); i++){print b[i], b[i+1]}}'
```

395152 14007

205523 50673

11708 32097

32097 1299

7018 6453

6453 13335

174 13335

1836 13335

15562 2914

.....

Directed and with duplications...

Find the **unique** AS level pairs (BGP dump, file: bview.20190418.0000.gz)

Use lexicographic order!

Why we find different results?

```
bgpdump -m bview.20190418.0000.gz | awk '{split($0,a,"|"); print a[7]}' |  
awk '{split($0, b," "); for(i =1 ; i<length(b); i++){if(b[i]<=b[i+1]){print b[i],  
b[i+1]} else{print b[i+1], b[i]]}}' | sort | uniq | wc -l
```

-> 24577

```
bgpdump -m bview.20190418.0000.gz | awk '{split($0,a,"|"); print a[7]}' |  
awk '{split($0, b," "); for(i =1 ; i<length(b); i++){if(b[i]<b[i+1]){print b[i], b[i+1]}  
if(b[i]>b[i+1]){print b[i+1], b[i]]}}' | sort | uniq | wc -l
```

-> 22894

(removing the AS path prepending)

What Filters to Consider?

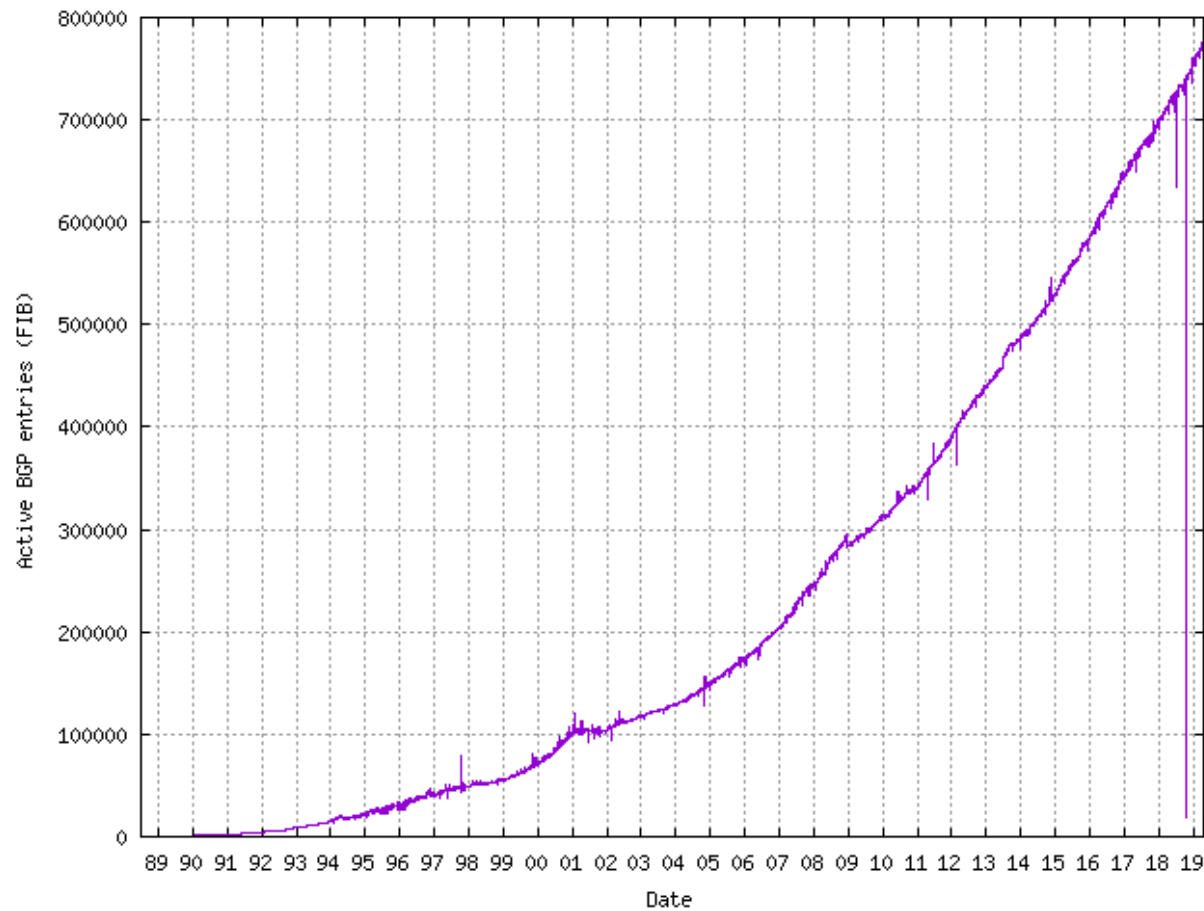
- For Prefixes?
 - More specific? Less specific?
 - Bogons
 - Prefixes that are private or reserved
 - Prefixes that have not been allocated to a regional registry by IANA
 - Allocated by not assigned by a regional registry
 - Hijack: prefixes that should not be announced by an ASN
 - Online lists, e.g.,
 - <http://team-cymru.com/bogon-reference-http.html>
 - <http://data.caida.org/datasets/bogon>
 - <https://www.cidr-report.org/as2.0/#Bogons>

What Filters to Consider?

- For ASNs?
 - AS path prepending
e.g., AS1 AS2 AS2 AS2 AS3 (AS2-AS2 appears as an AS-link)
 - AS path can be corrupted
 - Bogons
 - Including Private ASNs
 - Online lists, e.g.,
<http://team-cymru.com/bogon-reference-http.html>
<http://data.caida.org/datasets/bogon>

Route Table Increase (IPv4)

Active BGP entries (FIB)

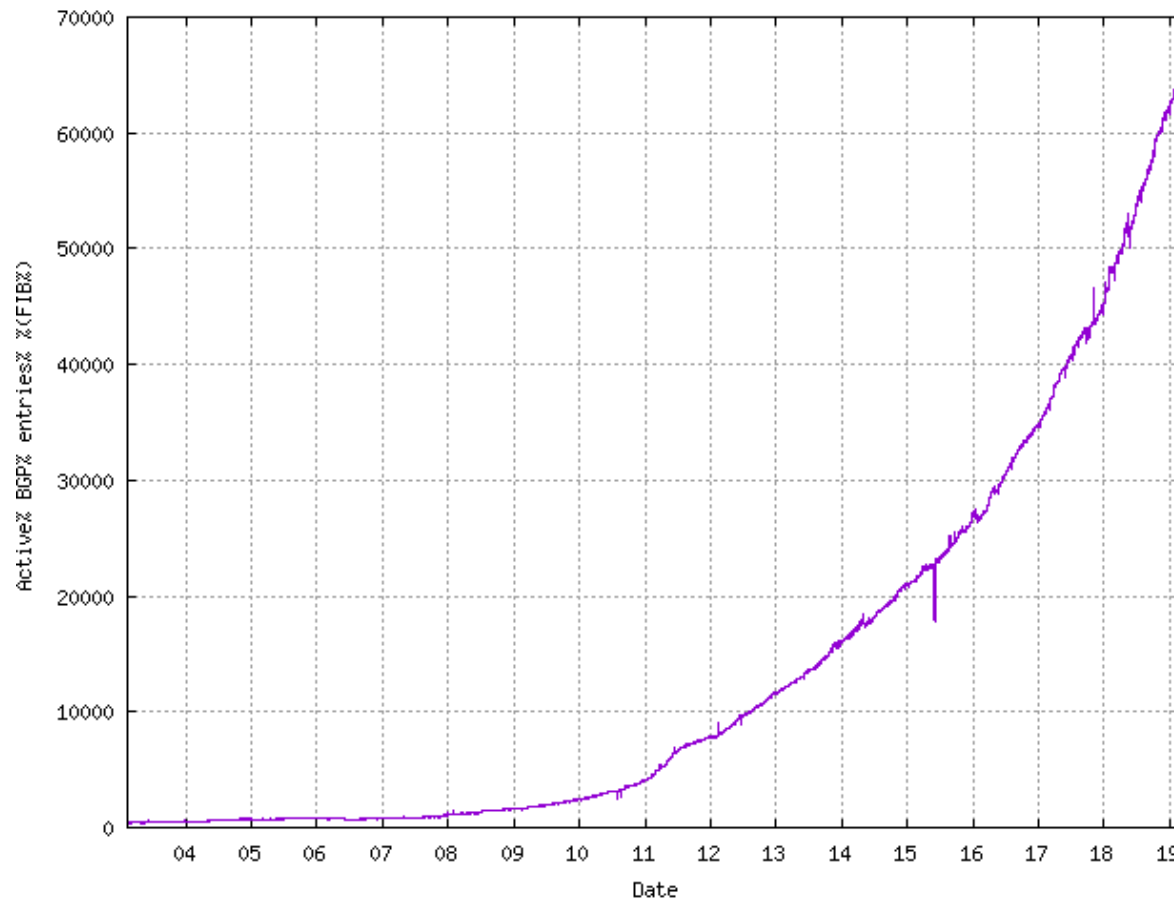


Plot Range: 30-Jun-1988 1430 to 18-Apr-2019 0518

Source: CIDR report, <https://www.cidr-report.org/as2.0/>

Route Table Increase (IPv6)

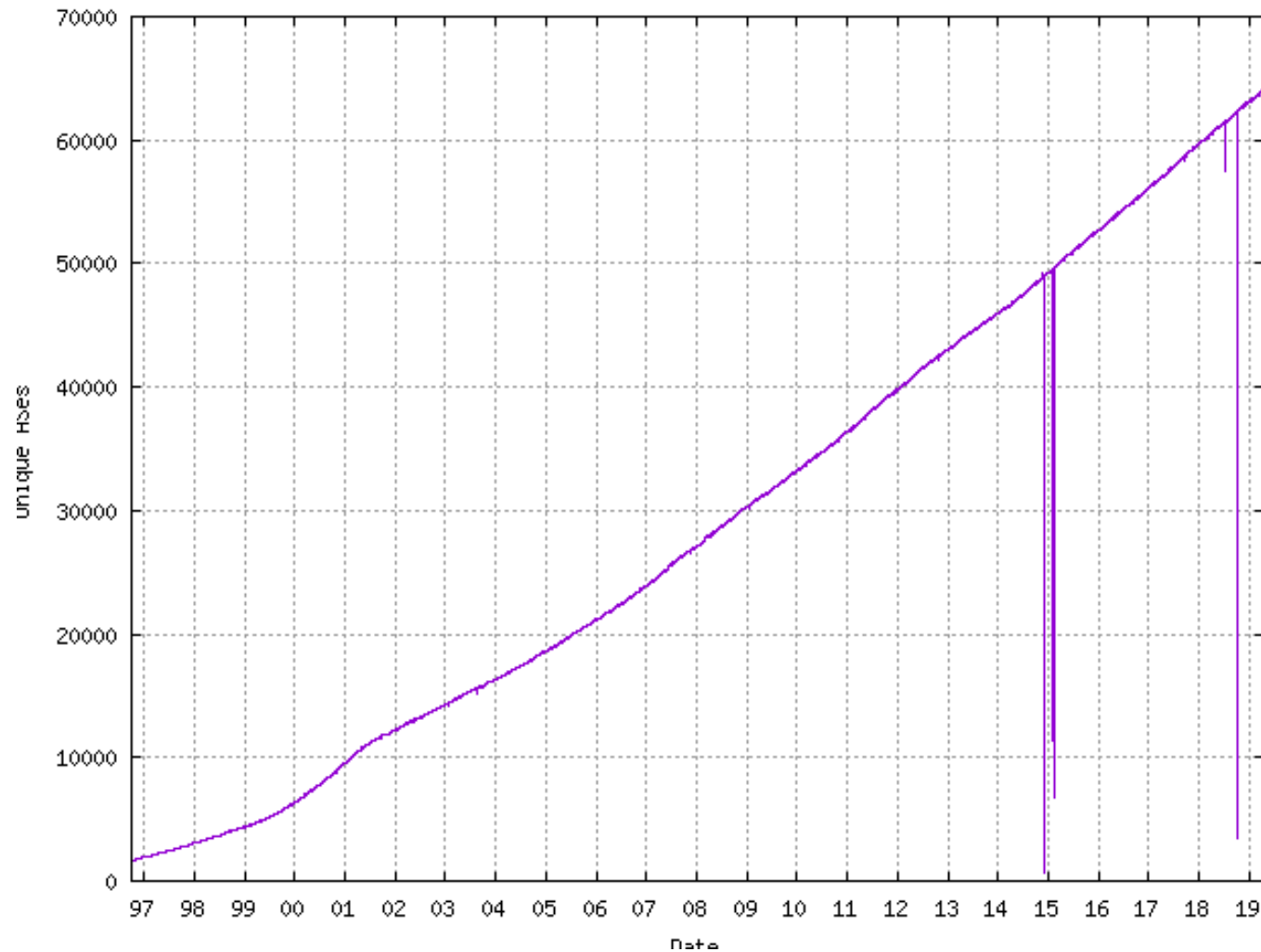
Active% BGP% entries% %(FIB%)



Plot Range: 10-Feb-2003 0910 to 18-Apr-2019 0518

Source: CIDR report, <http://www.cidr-report.org/v6/as2.0/>

Unique Ases (16-bit)



Source: CIDR report, <https://www.cidr-report.org/as2.0/>

Reading

“In Search of the Elusive Ground Truth:
Internet’s AS-level Connectivity Structure”,
R. Oliveira, D. Pei, W. Willinger, B. Zhang, and L
Zhang, in the proceedings of SIGMETRICS 2018

[These slides cover sections 1, 2, and 3; we will
cover the rest in the forthcoming lectures]