
Routing diff observations

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Objective

Comparison of routes in global routing table as seen across various large networks.

Why?

To see if announcements are actually global & find reason for difference in number of routes from various networks.

What we already know?

- Large networks carry relatively similar number of routes
- Route announcements can be limited by use of BGP community & hence may result in difference in number of routes
- Eyeball networks announce more specific routes to steer inbound traffic across various circuits

But we also know...

- Large networks carry relatively similar number of routes <- *But there's a visible difference of few thousand routes!*
- Route announcements can be limited by use of BGP community & hence may result in difference in number of routes <- *Can that alone result in difference of thousands of routes?*
- Eyeball networks announce more specific routes to steer inbound traffic across various circuits <- *But if route reaches default free zone, it should reach everywhere else!*

Networks considered in the study

1. AT&T - AS7018
2. Century Link / Level3 / Global Crossing - AS3549
3. Cogent - AS174
4. GTT - AS3257
5. Hurricane Electric - AS6939
6. KPN - AS286
7. NTT - AS2914
8. Sprint - AS1239
9. Verizon - AS701



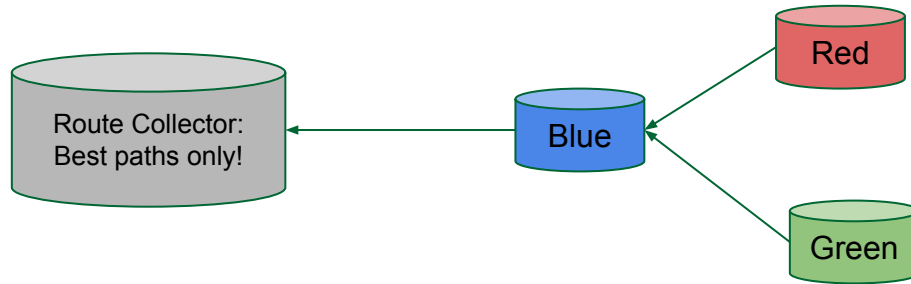
Why specifically these networks?

1. Large networks by size & reach
2. Full routes are visible at RIPE RIS and Oregon Route Views. For other's it's either no visibility at popular collectors
3. Routes in default free zone without no-export (or similar community) should reach everyone else

Note: Remember downstream give a picture but the picture is separate from what upstream gets it

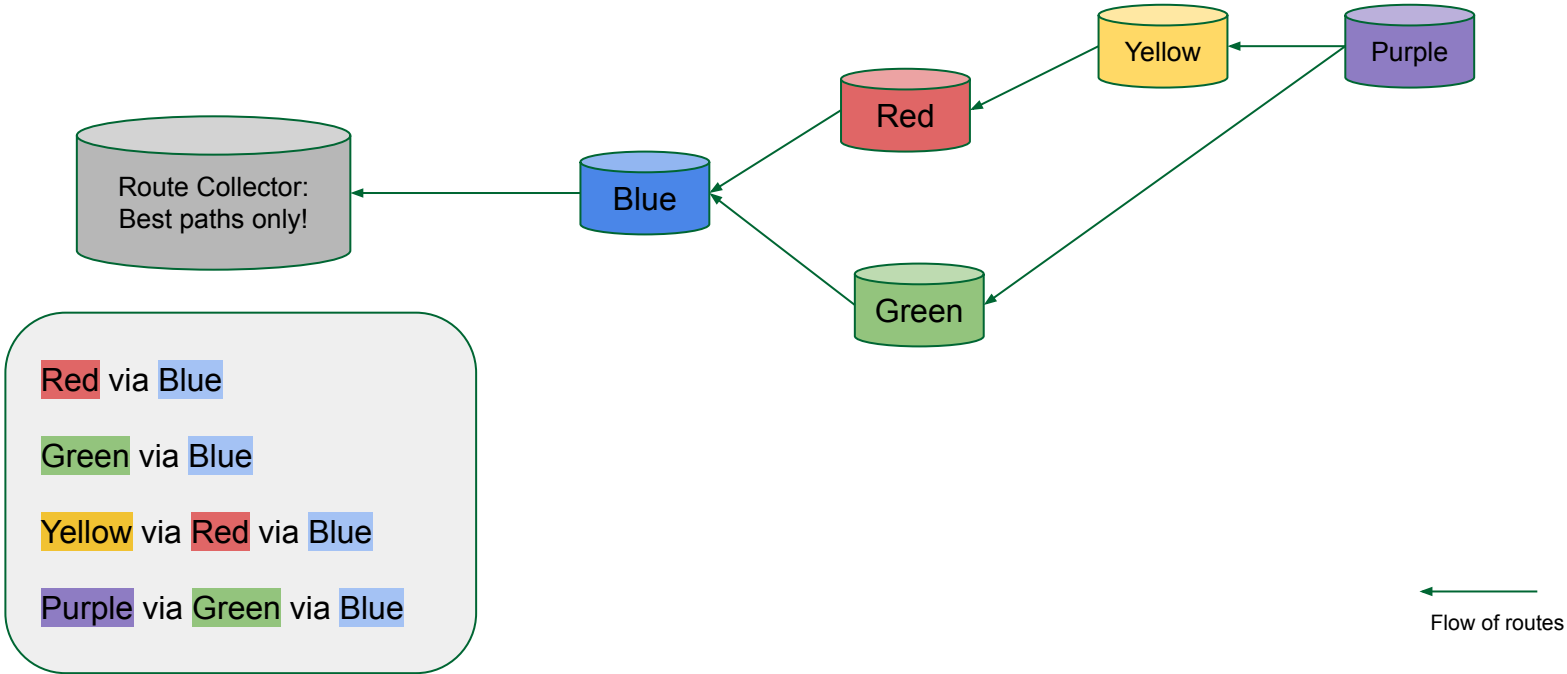


Best path propagation only

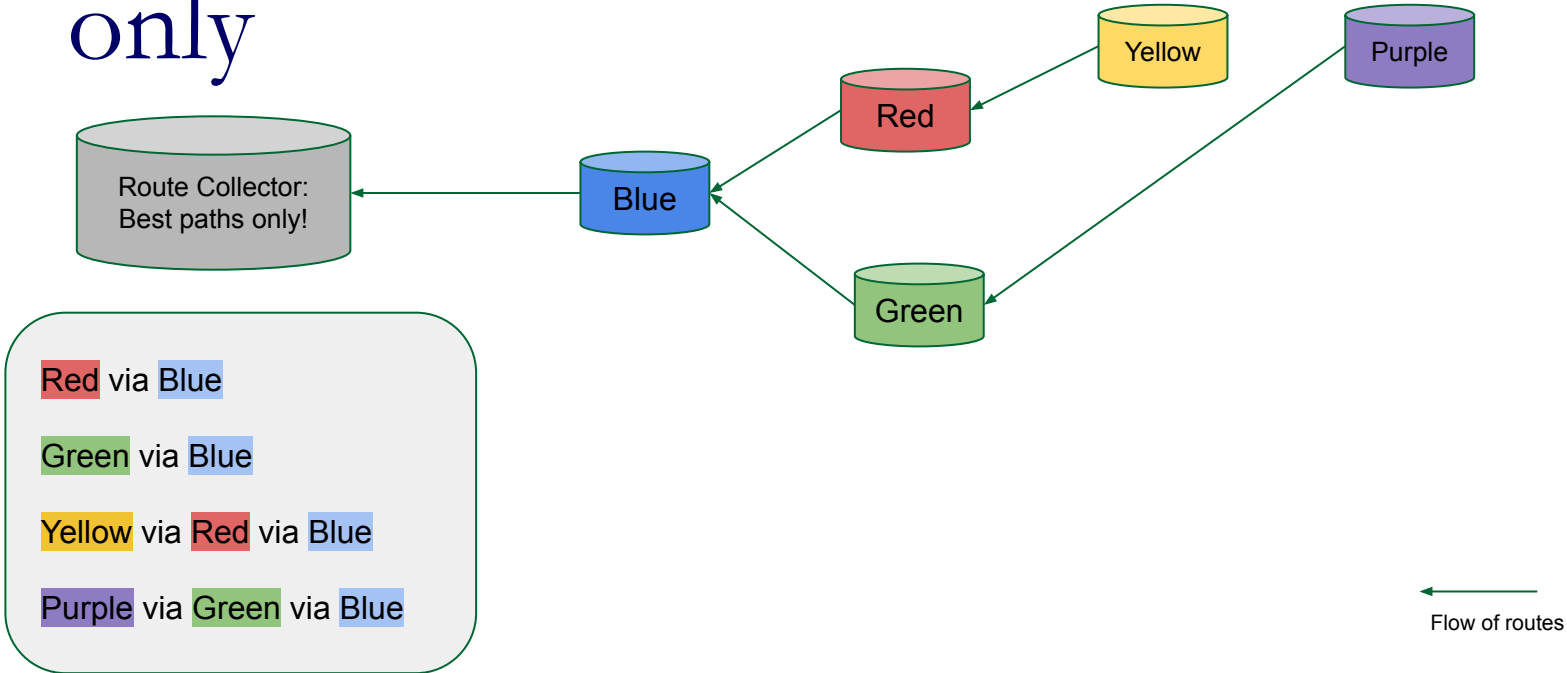


←
Flow of routes

Best path propagation only



Route collector's view - best paths only



Warning! Slides with lot of numbers ahead!



Comparing routes

Total unique IPv4 Prefixes: 8,02,156

Prefixes with limited visibility: 34,872

That's 4.34% routes!



Removing announcements smaller than /24...

Comparing routes

Total unique IPv4 Prefixes: 801834

Prefixes with limited visibility: 34565

ASNs with limited visibility: 3866

Prefixes with limited visibility + invalid ROAs: 4477

ASNs with limited visibility + invalid ROAs: 987

That's 4.31% routes!



Comparing routes (cont.)

ASN	IPv4 Prefixes	Diff from total	Missing %
AS7018	769143	32691	4.08
AS174	769917	31917	3.98
AS3257	772781	29053	3.62
AS6939	796930	4904	0.61
AS286	772654	29180	3.64
AS2914	773027	28807	3.59
AS1239	771004	30830	3.84
AS701	771563	30271	3.78

Top 10 countries with limited visibility

Country	Prefix Count	Percentage
Turkey	5770	16.69
Brazil	3856	11.16
Germany	3411	9.87
United States	3002	8.69
China	2281	6.60
Russia	1290	3.73
Australia	1218	3.52
Indonesia	1207	3.49
India	1203	3.48
Vietnam	1050	3.04



Missing routes in AS7018

Prefix	Origin ASN	AS Name	RPKI State
167.206.238.0/24	32195	ESI-EMR - Eisai Inc., US	Invalid
167.206.44.0/24	19720	CABLEVISION-CORP - Cablevision Systems Corp., US	Invalid
167.206.58.0/24	25987	WESTCHESTER-LIBRARY - Westchester Library System, US	Invalid
167.206.77.0/24	54004	OPTIMUM-WIFI2 - Optimum WiFi, US	Invalid
167.206.80.0/24	33245	-Reserved AS-, ZZ	Invalid
167.206.86.0/24	20398	S-AS - Controlled Networks and Communications Solutions, Inc	Invalid
167.250.49.0/24	263767	CORPORACI◆◆N GALA IT, C.A., VE	Invalid
167.250.50.0/24	263767	CORPORACI◆◆N GALA IT, C.A., VE	Invalid
168.195.217.0/24	263799	CARIBBEAN COMMUNICATION SERVICES, SR	Invalid
168.195.218.0/24	263799	CARIBBEAN COMMUNICATION SERVICES, SR	Invalid
168.195.219.0/24	263799	CARIBBEAN COMMUNICATION SERVICES, SR	Invalid
168.196.140.0/22	263754	SN COMUNICACIONES, AR	Invalid
168.228.141.0/24	264689	Luciano Gabriel Chersanaz (Ubnnet Datacenter), AR	Invalid

Missing routes in AS174

Prefix	Origin ASN	AS Name	RPKI State
103.36.200.0/22	23650	CHINANET-JS-AS-AP AS Number for CHINANET jiangsu province backbone, CN	NotFound
103.36.204.0/22	23650	CHINANET-JS-AS-AP AS Number for CHINANET jiangsu province backbone, CN	NotFound
103.37.12.0/22	58540	CHINATELECOM-HUNAN-ZHUZHOU-MAN Zhuzhou, CN	NotFound
103.37.20.0/24	132968	KPMG-AS KPMG, IN	NotFound
103.37.21.0/24	132968	KPMG-AS KPMG, IN	NotFound
103.37.47.0/24	23650	CHINANET-JS-AS-AP AS Number for CHINANET jiangsu province backbone, CN	NotFound
103.38.16.0/22	133633	MULTITECHONLINE-BD MultiTech Online, BD	NotFound
103.38.16.0/24	133633	MULTITECHONLINE-BD MultiTech Online, BD	NotFound
103.38.17.0/24	133633	MULTITECHONLINE-BD MultiTech Online, BD	NotFound
103.38.18.0/24	133633	MULTITECHONLINE-BD MultiTech Online, BD	NotFound
103.38.184.0/22	63930	READYSERVER-SG READY SERVER PTE LTD, SG	NotFound
103.38.19.0/24	133633	MULTITECHONLINE-BD MultiTech Online, BD	NotFound
103.38.196.0/22	38565	NCELL-AS-NP Ncell Pvt. Ltd., NP	Valid
103.38.196.0/23	38565	NCELL-AS-NP Ncell Pvt. Ltd., NP	Valid
103.38.198.0/23	38565	NCELL-AS-NP Ncell Pvt. Ltd., NP	Valid



Missing routes in AS3257

Prefix	Origin ASN	AS Name	RPKI State
103.44.63.0/24	4594	HKISL-ASN Internet Solutions Limited, HK	NotFound
103.46.146.0/23	38851	TNET-NET TNET Communication Inc., TW	NotFound
103.46.190.0/23	38851	TNET-NET TNET Communication Inc., TW	Invalid
103.47.202.0/23	64096	BIH-GLOBAL BIH-Global Internet Harbor, HK	Invalid
103.47.202.0/24	64096	BIH-GLOBAL BIH-Global Internet Harbor, HK	Invalid
103.47.242.0/24	63888	TISP-AS TISP LIMITED, HK	NotFound
103.48.143.0/24	133929	TWOWINCOLIMITED-AS-AP TWOWIN CO., LIMITED, HK	NotFound
103.5.102.0/23	38851	TNET-NET TNET Communication Inc., TW	NotFound
103.5.109.0/24	132031	TAYLORCOMMUNICATIONS-AS-AP Taylor Communications Ltd, NZ	NotFound
103.5.110.0/24	132031	TAYLORCOMMUNICATIONS-AS-AP Taylor Communications Ltd, NZ	NotFound
103.5.111.0/24	132031	TAYLORCOMMUNICATIONS-AS-AP Taylor Communications Ltd, NZ	NotFound
103.5.165.0/24	24220	HOSTCENTRAL-AS-AP Hostcentral, AU	Valid
103.5.166.0/24	24220	HOSTCENTRAL-AS-AP Hostcentral, AU	Valid
103.5.167.0/24	24220	HOSTCENTRAL-AS-AP Hostcentral, AU	Valid
103.5.55.0/24	131477	SHHJ-AS Shanghai Huajuan Information Technology Co., Ltd., CN	NotFound



Missing routes in AS286

Prefix	Origin ASN	AS Name	RPKI State
103.135.100.0/24	4842	TIANHAI-AS-AP Tianhai InfoTech, CN	Invalid
103.135.101.0/24	4842	TIANHAI-AS-AP Tianhai InfoTech, CN	Invalid
103.135.16.0/24	138145	ADVANCED-AS-AP Advanced Information Company Limited, HK	Invalid
103.135.17.0/24	138145	ADVANCED-AS-AP Advanced Information Company Limited, HK	Invalid
103.135.18.0/24	138145	ADVANCED-AS-AP Advanced Information Company Limited, HK	Invalid
103.135.19.0/24	138145	ADVANCED-AS-AP Advanced Information Company Limited, HK	Invalid
103.136.125.0/24	136743	IKGCL-AS-AP Internet Keeper Global (Group) Co., Limited, HK	NotFound
103.137.109.0/24	138023	CREATION-AS-AP Creation Online, BD	Valid
103.137.13.0/24	137409	GSLNETWORKS-AS-AP GSL Networks Pty LTD, AU	NotFound
103.137.15.0/24	137409	GSLNETWORKS-AS-AP GSL Networks Pty LTD, AU	NotFound
103.137.247.0/24	131642	PQS-AS-TW Peter Qiao Technology Company, TW	Valid
103.137.63.0/24	131642	PQS-AS-TW Peter Qiao Technology Company, TW	Valid
103.137.64.0/24	136038	HDTIDCCLOUD-AS-AP HDTIDC LIMITED, HK	Invalid
103.137.72.0/24	138197	WINKNETWORK-AS-AP WINK NETWORK, BD	Invalid
103.137.74.0/24	137453	ORANGE2-AS-AP Orange Communication, BD	Invalid
103.138.163.0/24	45773	HECPERN-AS-PK PERN AS Content Servie Provider, Islamabad, Pakistan, PK	Invalid
103.139.109.0/24	45259	BRUHAAS-BN Bruhaas (B) Sdn Bhd, BN	Valid



Missing routes in AS2914

Prefix	Origin ASN	AS Name	RPKI State
103.20.123.0/24	136565	CYBERWORLD CyberWorld, TH	NotFound
103.20.181.0/24	38067	RADIANT Radiant Communications Limited, BD	NotFound
103.20.239.0/24	58708	CRP-HK CRP-, HK	NotFound
103.200.113.0/24	131477	SHHJ-AS Shanghai Huajuan Information Technology Co., Ltd., CN	Invalid
103.206.245.0/24	23947	MORATELINDONAP-AS-ID PT.Mora Telematika Indonesia, ID	NotFound
103.209.247.0/24	45665	EDITCO-AS-AP EdIT Counsel, AU	NotFound
103.210.149.0/24	45152	ZONENETWORKS-AS-AP Zone Networks Pty Ltd, Managed Hosting Solutions, AU	NotFound
103.210.240.0/24	58411	GTDCL-HK Unit A-E, 13/F, Golden Sun Centre, HK	NotFound
103.210.241.0/24	58411	GTDCL-HK Unit A-E, 13/F, Golden Sun Centre, HK	NotFound
103.210.242.0/24	58411	GTDCL-HK Unit A-E, 13/F, Golden Sun Centre, HK	NotFound
103.210.243.0/24	58411	GTDCL-HK Unit A-E, 13/F, Golden Sun Centre, HK	NotFound
103.210.25.0/24	135126	OCCOMPTYLTD-AS-AP Occom Pty Ltd, AU	NotFound
103.210.26.0/24	135126	OCCOMPTYLTD-AS-AP Occom Pty Ltd, AU	NotFound
103.210.27.0/24	135126	OCCOMPTYLTD-AS-AP Occom Pty Ltd, AU	NotFound
103.210.78.0/23	45437	RWTS-AS-AP Real World - The Core, AU	NotFound
103.211.121.0/24	9245	COMPASS-NZ-AP COMPASS, NZ	NotFound
103.211.122.0/24	9245	COMPASS-NZ-AP COMPASS, NZ	NotFound



Missing routes in AS1239

Prefix	Origin ASN	AS Name	RPKI State
222.167.80.0/20	9908	HKCABLE2-HK-AP HK Cable TV Ltd, HK	NotFound
222.249.129.0/24	4847	CNIX-AP China Networks Inter-Exchange, CN	NotFound
223.119.65.0/24	58453	CMI-INT-HK Level 30, Tower 1, HK	NotFound
223.17.236.0/24	9304	HUTCHISON-AS-AP HGC Global Communications Limited, HK	NotFound
223.208.32.0/19	17964	DXTNET Beijing Dian-Xin-Tong Network Technologies Co., Ltd., CN	NotFound
223.208.64.0/18	17964	DXTNET Beijing Dian-Xin-Tong Network Technologies Co., Ltd., CN	NotFound
223.209.0.0/19	9395	GXBLNET BeiJing Guoxin bilin Telecom Technology Co.,Ltd, CN	NotFound
223.209.32.0/19	9395	GXBLNET BeiJing Guoxin bilin Telecom Technology Co.,Ltd, CN	NotFound
223.210.0.0/19	4847	CNIX-AP China Networks Inter-Exchange, CN	NotFound
223.210.224.0/19	17964	DXTNET Beijing Dian-Xin-Tong Network Technologies Co., Ltd., CN	NotFound
223.210.32.0/20	4847	CNIX-AP China Networks Inter-Exchange, CN	NotFound
223.210.48.0/22	4847	CNIX-AP China Networks Inter-Exchange, CN	NotFound
223.210.52.0/22	17964	DXTNET Beijing Dian-Xin-Tong Network Technologies Co., Ltd., CN	NotFound
223.210.56.0/21	17964	DXTNET Beijing Dian-Xin-Tong Network Technologies Co., Ltd., CN	NotFound
223.210.64.0/19	17964	DXTNET Beijing Dian-Xin-Tong Network Technologies Co., Ltd., CN	NotFound
223.211.224.0/19	17964	DXTNET Beijing Dian-Xin-Tong Network Technologies Co., Ltd., CN	NotFound
223.223.192.0/21	4847	CNIX-AP China Networks Inter-Exchange, CN	NotFound
223.223.200.0/22	4847	CNIX-AP China Networks Inter-Exchange, CN	NotFound



Missing routes in AS701

AS Name	RPKI State	AS701	AS1239
CMI-INT-HK Level 30, Tower 1, HK	NotFound	Not found	Found
CMI-INT-HK Level 30, Tower 1, HK	NotFound	Not found	Not found
HUTCHISON-AS-AP HGC Global Communications Limited, HK	NotFound	Not found	Not found
DXTNET Beijing Dian-Xin-Tong Network Technologies Co., Ltd., CN	NotFound	Not found	Not found
DXTNET Beijing Dian-Xin-Tong Network Technologies Co., Ltd., CN	NotFound	Not found	Not found
GXBLNET BeiJing Guoxin bilin Telecom Technology Co.,Ltd, CN	NotFound	Not found	Not found
GXBLNET BeiJing Guoxin bilin Telecom Technology Co.,Ltd, CN	NotFound	Not found	Not found
CNIX-AP China Networks Inter-Exchange, CN	NotFound	Not found	Not found
DXTNET Beijing Dian-Xin-Tong Network Technologies Co., Ltd., CN	NotFound	Not found	Not found
CNIX-AP China Networks Inter-Exchange, CN	NotFound	Not found	Not found
CNIX-AP China Networks Inter-Exchange, CN	NotFound	Not found	Not found
DXTNET Beijing Dian-Xin-Tong Network Technologies Co., Ltd., CN	NotFound	Not found	Not found
DXTNET Beijing Dian-Xin-Tong Network Technologies Co., Ltd., CN	NotFound	Not found	Not found
DXTNET Beijing Dian-Xin-Tong Network Technologies Co., Ltd., CN	NotFound	Not found	Not found
DXTNET Beijing Dian-Xin-Tong Network Technologies Co., Ltd., CN	NotFound	Not found	Not found



Top 10 origin ASNs with limited visibility

ASN	Prefix Count	Prefix %	AS Name
47331	5453	15.78	TTNET, TR
31334	3203	9.27	KABELDEUTSCHLAND-AS, DE
18403	983	2.84	FPT-AS-AP The Corporation for Financing & Promoting Technology, VN
45090	481	1.39	CNNIC-TENCENT-NET-AP Shenzhen Tencent Computer Systems Company Limited, CN
4787	447	1.29	ASN-CBN PT Cyberindo Aditama, ID
7545	427	1.24	TPG-INTERNET-AP TPG Telecom Limited, AU
24955	359	1.04	UBN-AS, RU
24560	298	0.86	AIRTELBROADBAND-AS-AP Bharti Airtel Ltd., Telemedia Services, IN
38333	275	0.80	SYMBIO-AS-AU-AP Symbio Networks, AU
9808	225	0.65	CMNET-GD Guangdong Mobile Communication Co.Ltd., CN



Possible reasons for the difference

1. RPKI based filtering by networks like AS7018, AS1299 etc and dropping 4k+ invalids in diff list
2. IRR based filtering resulting in drop due to bad route object by certain networks
3. IRR based filtering resulting in drop due to missing AS-SET in the chain
4. Route announcement by anycast sensitive networks with no-export to these specific networks
5. Delays due to slow BGP convergence
6. Misconfiguration - Announcing route only to a “peer” and not all default free zone peers or transit
7. BGP filtering: Some networks filtering downstream & found with unopened filters for few days while some accepted without filtering.

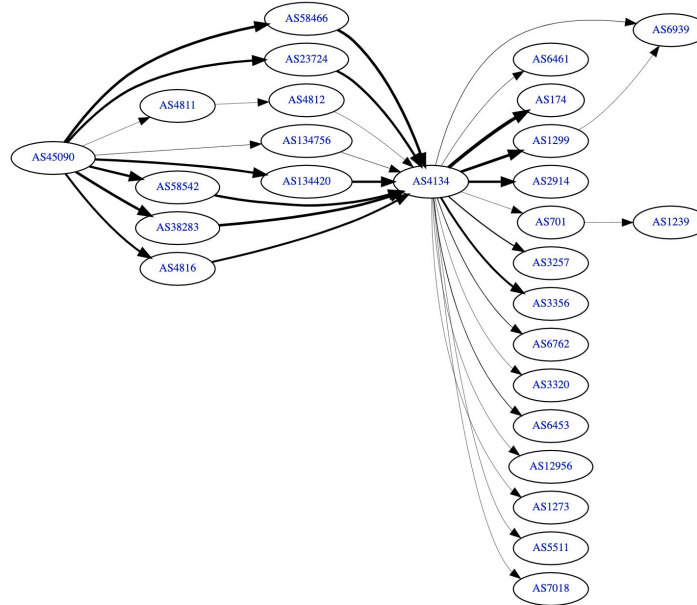


Some misc things...

1. Large operators like AS18101 signed prefixes and missed to create ROAs for smaller chunks assigned & announced by downstream resulting in RPKI invalids
2. Bad operational practice like removing a prefix without covering prefix from “link 1” and announcing on “link 2”
3. Around 454 routes of AS45090 were missing specifically from AS701 and AS1239
4. In total 1178 routes belonging to China not found from AS701 & AS1239 where ROAs were OK or not present (but not invalid)

AS45090 routing

AS45090 IPv4 Route Propagation



https://bgp.he.net/AS45090#_graph4

Some of missing routes from AS45090

Prefix	Origin ASN	AS Name
106.52.0.0/14	45090	CNNIC-TENCENT-NET-AP Shenzhen Tencent Computer Systems Company Limited, CN
106.52.0.0/15	45090	CNNIC-TENCENT-NET-AP Shenzhen Tencent Computer Systems Company Limited, CN
106.52.0.0/20	45090	CNNIC-TENCENT-NET-AP Shenzhen Tencent Computer Systems Company Limited, CN
106.52.112.0/20	45090	CNNIC-TENCENT-NET-AP Shenzhen Tencent Computer Systems Company Limited, CN
106.52.128.0/20	45090	CNNIC-TENCENT-NET-AP Shenzhen Tencent Computer Systems Company Limited, CN
106.52.144.0/20	45090	CNNIC-TENCENT-NET-AP Shenzhen Tencent Computer Systems Company Limited, CN
106.52.16.0/20	45090	CNNIC-TENCENT-NET-AP Shenzhen Tencent Computer Systems Company Limited, CN
106.52.160.0/20	45090	CNNIC-TENCENT-NET-AP Shenzhen Tencent Computer Systems Company Limited, CN
106.52.176.0/20	45090	CNNIC-TENCENT-NET-AP Shenzhen Tencent Computer Systems Company Limited, CN
106.52.192.0/20	45090	CNNIC-TENCENT-NET-AP Shenzhen Tencent Computer Systems Company Limited, CN



AS1239 missing routes

The screenshot shows the Sprint Looking Glass web interface. On the left is a dark sidebar with the Sprint logo and navigation links: Support, IP Network Maps, IP Network Performance, Looking Glass (highlighted), and SLA Performance. Below these is a 'COMPASS LOGIN' section with fields for Username and Password, and a Sign In button. The main content area has a navigation bar with Home, Support, Policies, FAQ, and Contacts. The 'Looking Glass' section contains three numbered steps: 1. Source (IPv4 selected, Anaheim, CA), 2. Command (show bgp route selected), and 3. Target (Network: 223.223.207.0/24, Example: 144.228.0.0/16). Below the form is a 'Query Results' section with the following text: 'Sprint Source: Anaheim, CA (sl-crs2-ana)', 'Performing: Show Route', 'IP Version: IPv4', 'Mon Feb 17 06:08:38.132 UTC', and '% Network not in table'. The status at the bottom of the results is 'Completed - Mon Feb 17 01:08:36 EST 2020'.



What operators can do to ensure global reachability?

1. Ensure proper IRR hygiene. Remember to create IRR route objects, maintain AS SETs (if you have downstream), ensure your ASN is in upstream's AS SET
2. Ensure RPKI hygiene. Ensure ROAs are present with correct origin AS and max length
3. If load balancing traffic with more specific, ensure covering prefix is always present to avoid convergence issues
4. Know the difference between your "Peers" and "Transit". Don't assume peers to be transit! :)





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Questions?

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