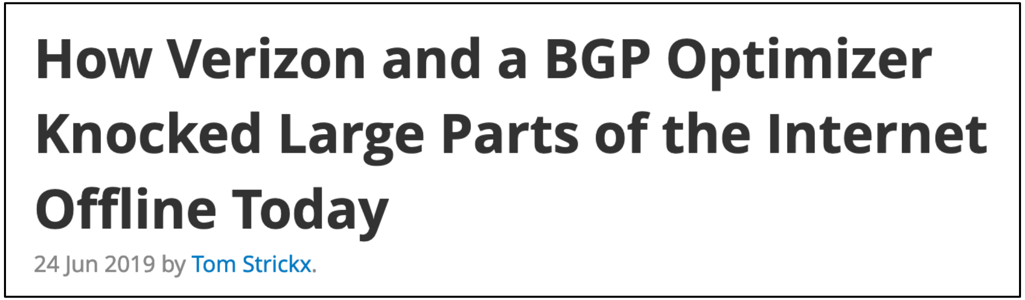
Securing Internet Routing

Tashi Phuntsho (tashi@apnic.net)
Senior Network Analyst/Technical Trainer

Why should we bother?

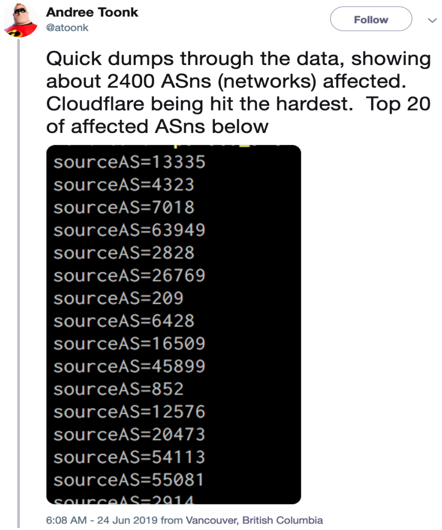
- As a Manager
  - I don’t want to be front page news of a IT paper, or an actual newspaper for routing errors

Headlines



How Verizon and a BGP Optimizer Knocked Large Parts of the Internet Offline Today

24 Jun 2019 by Tom Strickx.

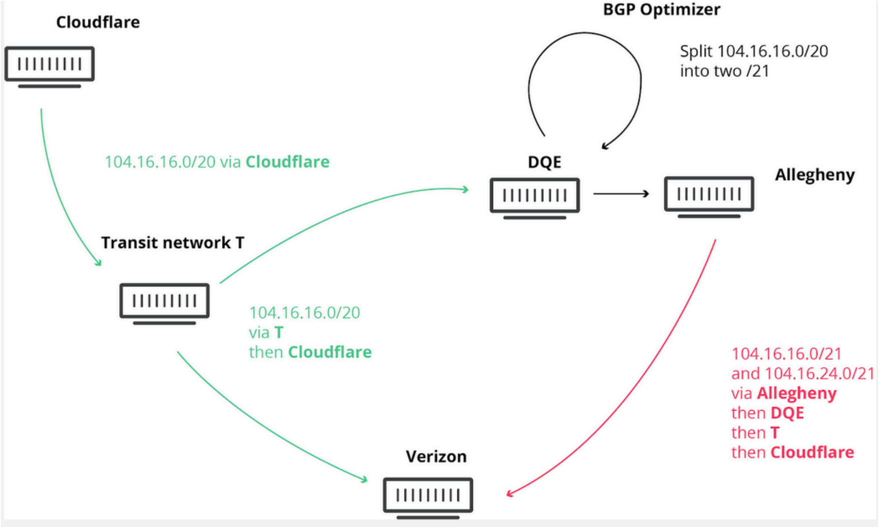


Andree Toonk
@atoonk

Quick dumps through the data, showing about 2400 ASns (networks) affected. Cloudflare being hit the hardest. Top 20 of affected ASns below

```
sourceAS=13335
sourceAS=4323
sourceAS=7018
sourceAS=63949
sourceAS=2828
sourceAS=26769
sourceAS=209
sourceAS=6428
sourceAS=16509
sourceAS=45899
sourceAS=852
sourceAS=12576
sourceAS=20473
sourceAS=54113
sourceAS=55081
sourceAS=2914
```

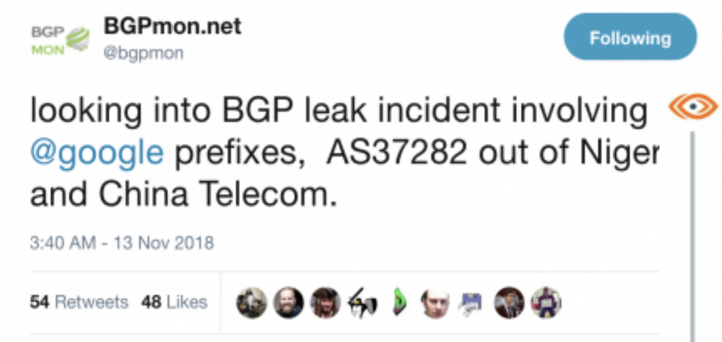
6:08 AM - 24 Jun 2019 from Vancouver, British Columbia


Cloudflare
BGP Optimizer
Split 104.16.16.0/20 into two /21
104.16.16.0/20 via Cloudflare
DQE
Allegheny
Transit network T
104.16.16.0/20 via T then Cloudflare
104.16.16.0/21 and 104.16.24.0/21 via Allegheny then DQE then T then Cloudflare
Verizon

https://twitter.com/atoonk/status/1143143943531454464/photo/1

https://blog.cloudflare.com/how-verizon-and-a-bgp-optimizer-knocked-large-parts-of-the-internet-offline-today/amp/

Headlines

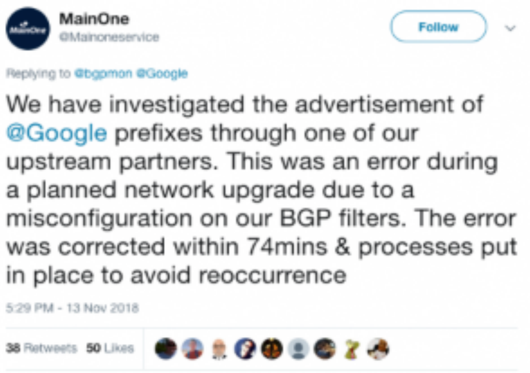


BGPmon.net
@bgpmon

looking into BGP leak incident involving @google prefixes, AS37282 out of Niger and China Telecom.

3:40 AM - 13 Nov 2018

54 Retweets 48 Likes



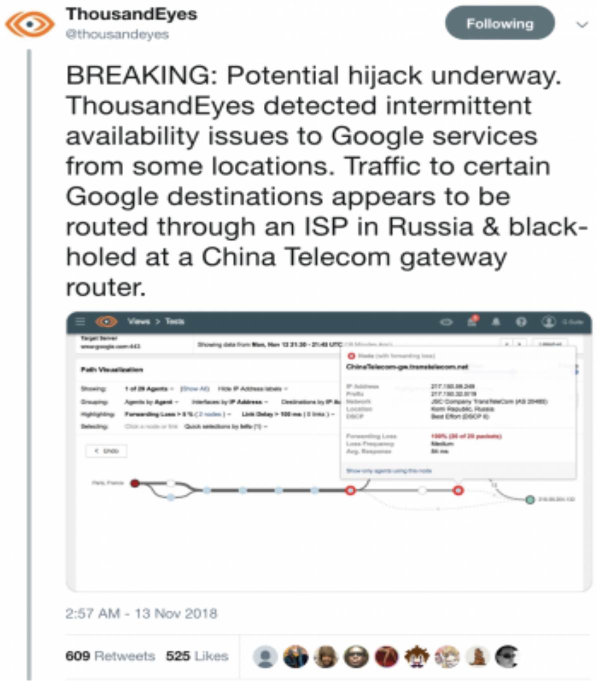
MainOne
@Mainoneservice

Replying to @bgpmon @Google

We have investigated the advertisement of @Google prefixes through one of our upstream partners. This was an error during a planned network upgrade due to a misconfiguration on our BGP filters. The error was corrected within 74mins & processes put in place to avoid reoccurrence

5:29 PM - 13 Nov 2018

38 Retweets 50 Likes

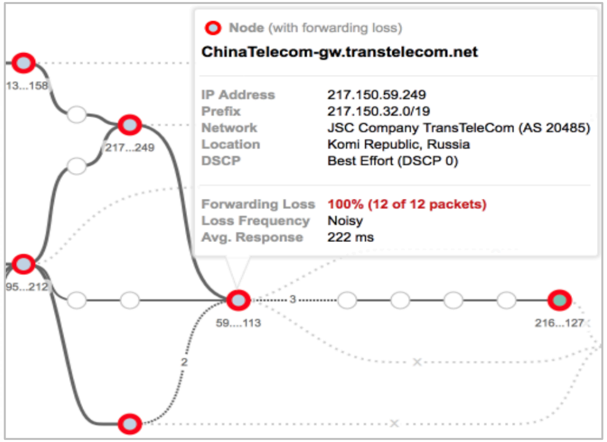


ThousandEyes
@thousandeyes

BREAKING: Potential hijack underway. ThousandEyes detected intermittent availability issues to Google services from some locations. Traffic to certain Google destinations appears to be routed through an ISP in Russia & black-holed at a China Telecom gateway router.

2:57 AM - 13 Nov 2018

609 Retweets 525 Likes



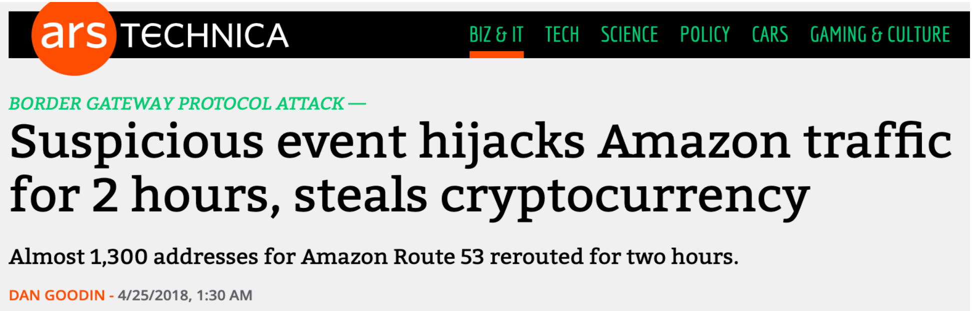
Node (with forwarding loss)

ChinaTelecom-gw.transtelecom.net

IP Address	217.150.59.249
Prefix	217.150.32.0/19
Network	JSC Company TransTeleCom (AS 20485)
Location	Komi Republic, Russia
DSCP	Best Effort (DSCP 0)
Forwarding Loss	100% (12 of 12 packets)
Loss Frequency	Noisy
Avg. Response	222 ms

https://blog.thousandeyes.com/internet-vulnerability-takes-down-google/

Headlines



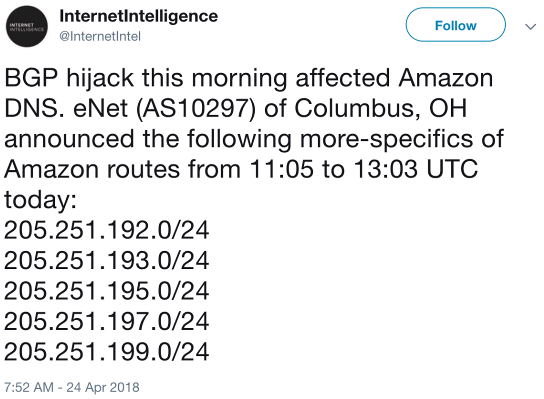
ars TECHNICA BIZ & IT TECH SCIENCE POLICY CARS GAMING & CULTURE

BORDER GATEWAY PROTOCOL ATTACK —

Suspicious event hijacks Amazon traffic for 2 hours, steals cryptocurrency

Almost 1,300 addresses for Amazon Route 53 rerouted for two hours.

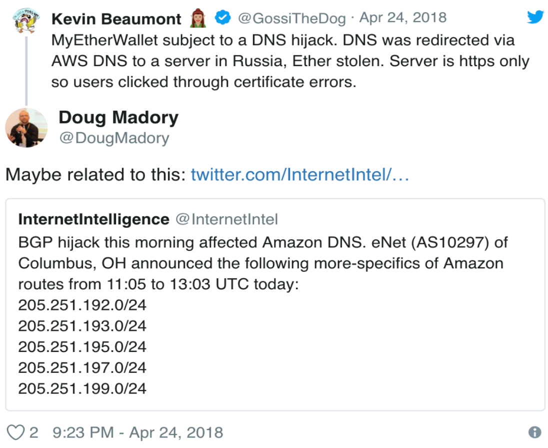
DAN GOODIN - 4/25/2018, 1:30 AM



InternetIntelligence @InternetIntel Follow

BGP hijack this morning affected Amazon DNS. eNet (AS10297) of Columbus, OH announced the following more-specifics of Amazon routes from 11:05 to 13:03 UTC today:
205.251.192.0/24
205.251.193.0/24
205.251.195.0/24
205.251.197.0/24
205.251.199.0/24

7:52 AM - 24 Apr 2018



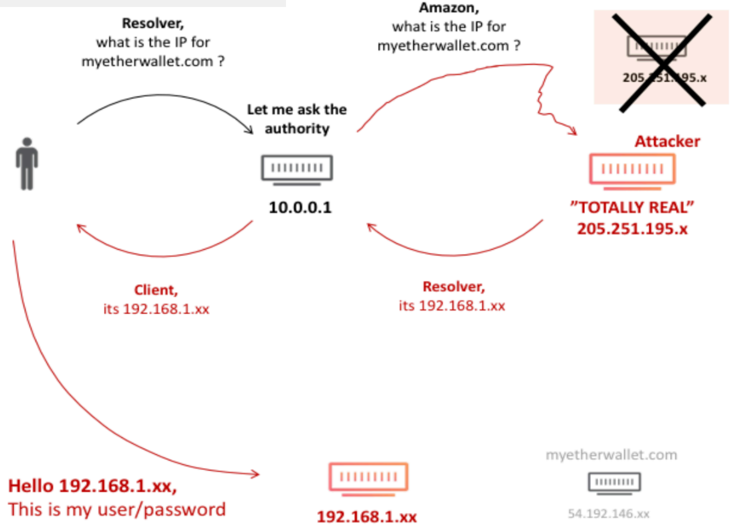
Kevin Beaumont @GossiTheDog · Apr 24, 2018
MyEtherWallet subject to a DNS hijack. DNS was redirected via AWS DNS to a server in Russia, Ether stolen. Server is https only so users clicked through certificate errors.

Doug Madory @DougMadory

Maybe related to this: twitter.com/InternetIntel/…

> **InternetIntelligence** @InternetIntel
> BGP hijack this morning affected Amazon DNS. eNet (AS10297) of Columbus, OH announced the following more-specifics of Amazon routes from 11:05 to 13:03 UTC today:
> 205.251.192.0/24
> 205.251.193.0/24
> 205.251.195.0/24
> 205.251.197.0/24
> 205.251.199.0/24

♡ 2 9:23 PM - Apr 24, 2018



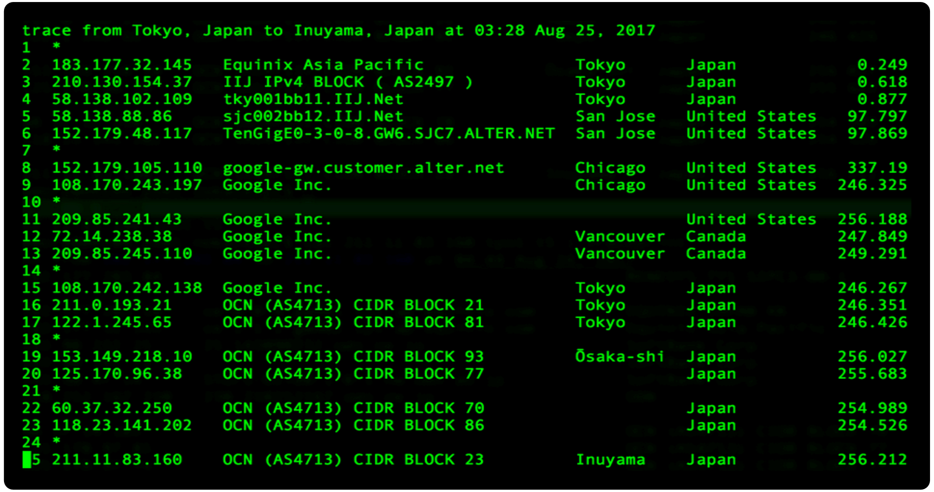
Resolver, what is the IP for myetherwallet.com ?
Amazon, what is the IP for myetherwallet.com ?
205.251.195.x
Let me ask the authority
10.0.0.1
Attacker
"TOTALLY REAL" 205.251.195.x
Client, its 192.168.1.xx
Resolver, its 192.168.1.xx
Hello 192.168.1.xx, This is my user/password
192.168.1.xx
myetherwallet.com
54.192.146.xx

https://blog.cloudflare.com/bgp-leaks-and-crypto-currencies

Headlines

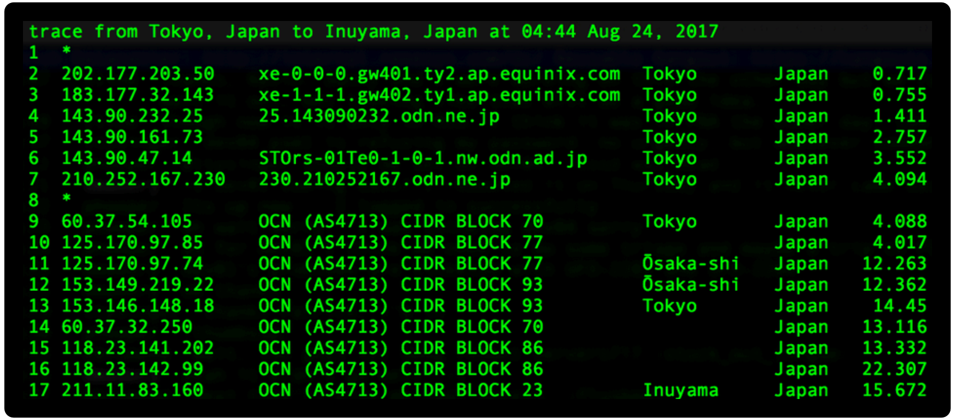
Large BGP Leak by Google Disrupts Internet in Japan

Research // Aug 28, 2017 // Doug Madory



```
trace from Tokyo, Japan to Inuyama, Japan at 03:28 Aug 25, 2017
1  *
2  183.177.32.145   Equinix Asia Pacific               Tokyo      Japan           0.249
3  210.130.154.37   IIJ IPv4 BLOCK ( AS2497 )          Tokyo      Japan           0.618
4  58.138.102.109   tky001bb11.IIJ.Net                 Tokyo      Japan           0.877
5  58.138.88.86     sjc002bb12.IIJ.Net                 San Jose   United States  97.797
6  152.179.48.117   TenGigE0-3-0-8.GW6.SJC7.ALTER.NET  San Jose   United States  97.869
7  *
8  152.179.105.110  google-gw.customer.alter.net       Chicago    United States  337.19
9  108.170.243.197  Google Inc.                        Chicago    United States 246.325
10 *
11 209.85.241.43    Google Inc.                                   United States 256.188
12 72.14.238.38     Google Inc.                        Vancouver  Canada        247.849
13 209.85.245.110   Google Inc.                        Vancouver  Canada        249.291
14 *
15 108.170.242.138  Google Inc.                        Tokyo      Japan         246.267
16 211.0.193.21     OCN (AS4713) CIDR BLOCK 21         Tokyo      Japan         246.351
17 122.1.245.65     OCN (AS4713) CIDR BLOCK 81         Tokyo      Japan         246.426
18 *
19 153.149.218.10   OCN (AS4713) CIDR BLOCK 93         Ōsaka-shi  Japan         256.027
20 125.170.96.38    OCN (AS4713) CIDR BLOCK 77                    Japan         255.683
21 *
22 60.37.32.250     OCN (AS4713) CIDR BLOCK 70                    Japan         254.989
23 118.23.141.202   OCN (AS4713) CIDR BLOCK 86                    Japan         254.526
24 *
█5 211.11.83.160    OCN (AS4713) CIDR BLOCK 23         Inuyama    Japan         256.212
```

After (JP->JP)

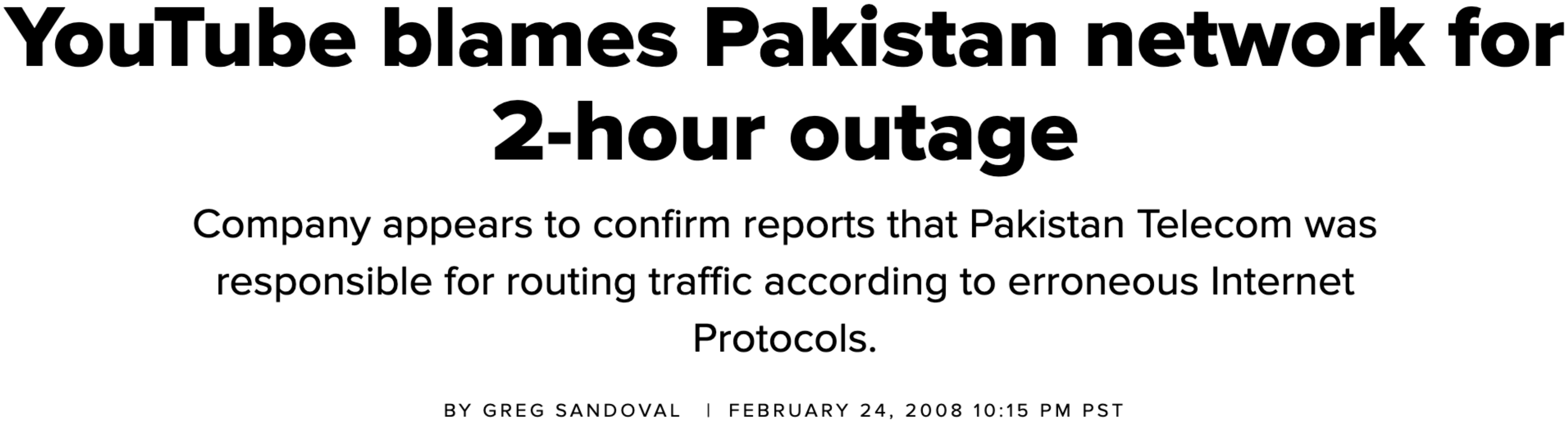


```
trace from Tokyo, Japan to Inuyama, Japan at 04:44 Aug 24, 2017
1  *
2  202.177.203.50   xe-0-0-0.gw401.ty2.ap.equinix.com  Tokyo      Japan   0.717
3  183.177.32.143   xe-1-1-1.gw402.ty1.ap.equinix.com  Tokyo      Japan   0.755
4  143.90.232.25    25.143090232.odn.ne.jp             Tokyo      Japan   1.411
5  143.90.161.73                                       Tokyo      Japan   2.757
6  143.90.47.14     STOrs-01Te0-1-0-1.nw.odn.ad.jp     Tokyo      Japan   3.552
7  210.252.167.230  230.210252167.odn.ne.jp            Tokyo      Japan   4.094
8  *
9  60.37.54.105     OCN (AS4713) CIDR BLOCK 70         Tokyo      Japan   4.088
10 125.170.97.85    OCN (AS4713) CIDR BLOCK 77                    Japan   4.017
11 125.170.97.74    OCN (AS4713) CIDR BLOCK 77         Ōsaka-shi  Japan  12.263
12 153.149.219.22   OCN (AS4713) CIDR BLOCK 93         Ōsaka-shi  Japan  12.362
13 153.146.148.18   OCN (AS4713) CIDR BLOCK 93         Tokyo      Japan   14.45
14 60.37.32.250     OCN (AS4713) CIDR BLOCK 70                    Japan  13.116
15 118.23.141.202   OCN (AS4713) CIDR BLOCK 86                    Japan  13.332
16 118.23.142.99    OCN (AS4713) CIDR BLOCK 86                    Japan  22.307
17 211.11.83.160    OCN (AS4713) CIDR BLOCK 23         Inuyama    Japan  15.672
```

Before (JP->JP)

https://dyn.com/blog/large-bgp-leak-by-google-disrupts-internet-in-japan/

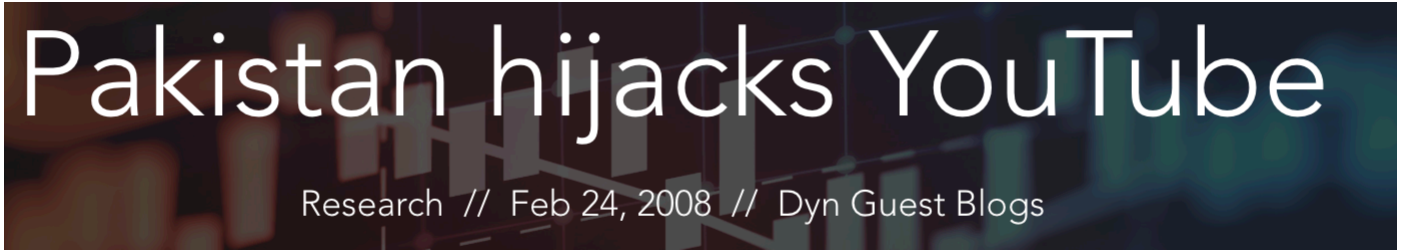
Headlines



YouTube blames Pakistan network for 2-hour outage

Company appears to confirm reports that Pakistan Telecom was responsible for routing traffic according to erroneous Internet Protocols.

BY GREG SANDOVAL | FEBRUARY 24, 2008 10:15 PM PST



Pakistan hijacks YouTube

Research // Feb 24, 2008 // Dyn Guest Blogs

Why do we keep seeing these?

- Because NO ONE is in charge?
  - No single authority model for the Internet
    - No reference point for what’s right in routing

Why do we keep seeing these?

- Routing works by RUMOUR
  - Tell what you know to your neighbors, and Learn what your neighbors know
  - Assume everyone is correct (and *honest*)
    - Is the originating network the rightful owner?

Why do we keep seeing these?

- Routing is VARIABLE
  - The view of the network depends on where you are
    - Different routing outcomes at different locations
  - ~ no reference view to compare the local view ☹

Why do we keep seeing these?

- Routing works in REVERSE
  - Outbound advertisement affects inbound traffic
  - Inbound (*Accepted*) advertisement influence outbound traffic

Why do we keep seeing these?

- And as always, there is no E-bit
  - a bad routing update does not identify itself as BAD
    - RFC 3514 😉

- So tools/techniques try to identify GOOD updates

Why should we worry?

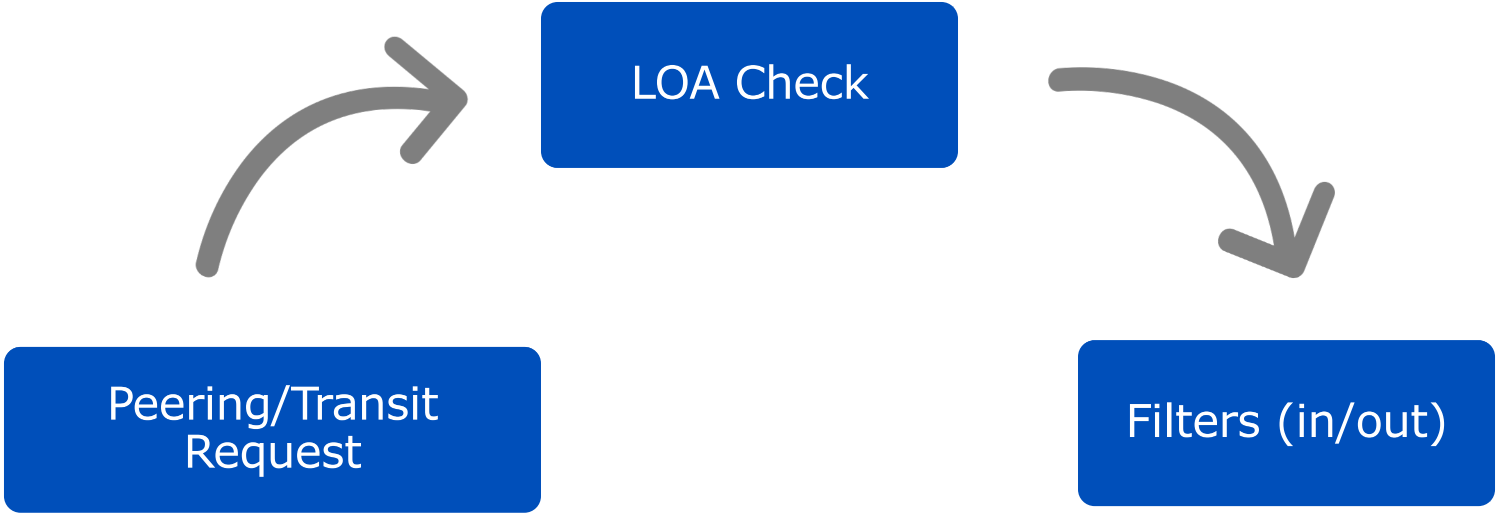
- Because it’s just so easy to do bad in routing!

By Source (WP:NFCC#4), Fair use,
https://en.wikipedia.org/w/index.php?curid=42515224

Why should we bother?

- As a Engineer
  - I don’t want to be told at 3AM my routing is broken

Current Practice

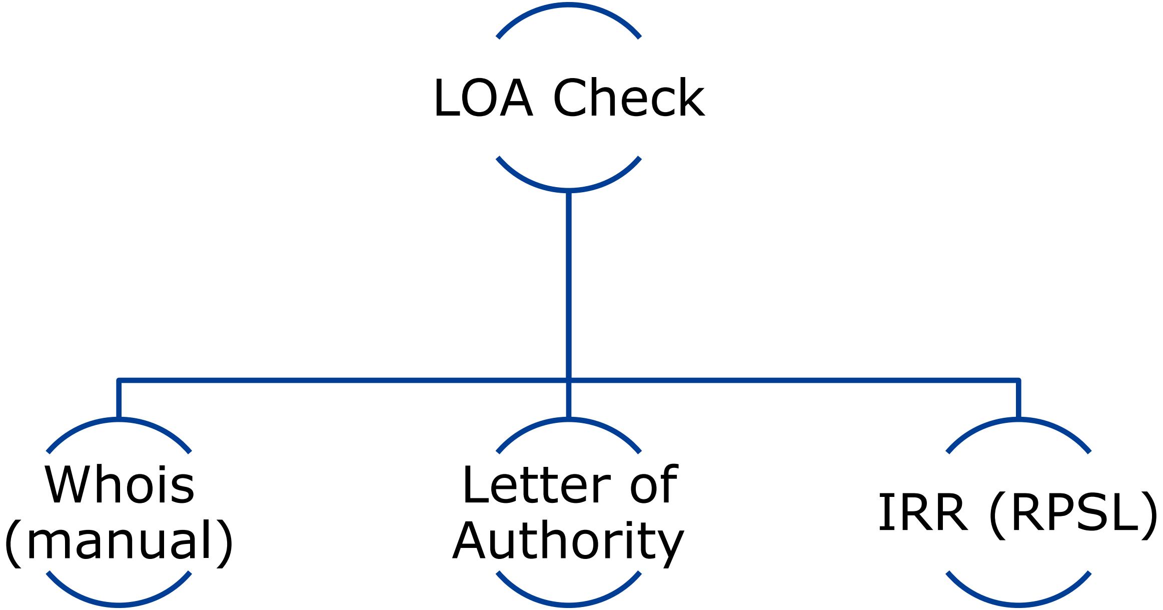


Peering/Transit Request

LOA Check

Filters (in/out)

Tools & Techniques



LOA Check

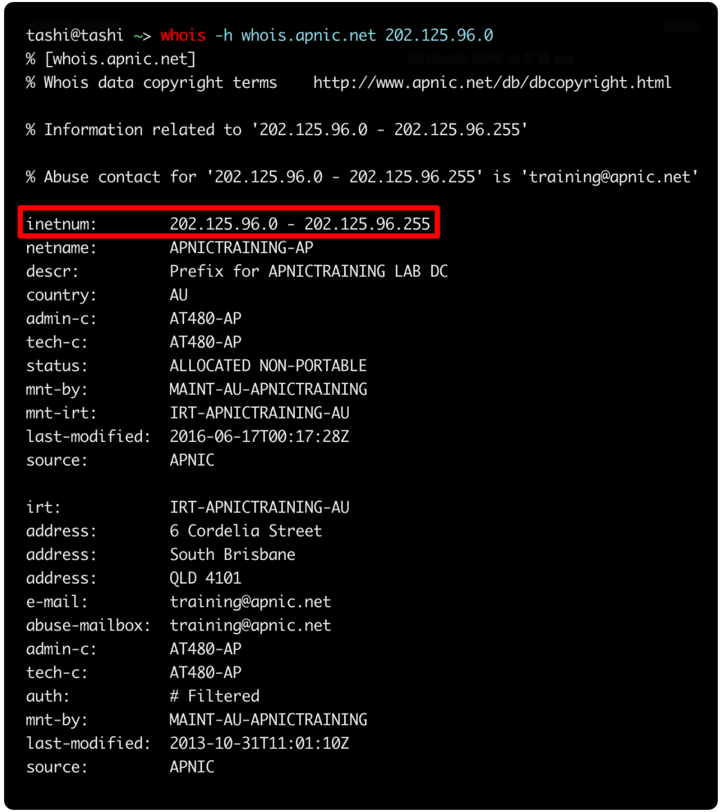
Whois (manual)

Letter of Authority

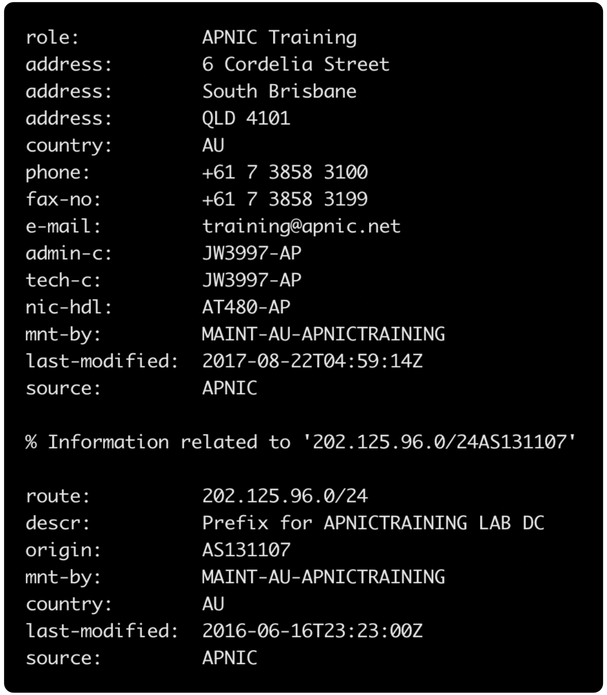
IRR (RPSL)

Tools & Techniques

- Look up **whois**
  - verify holder of a resource



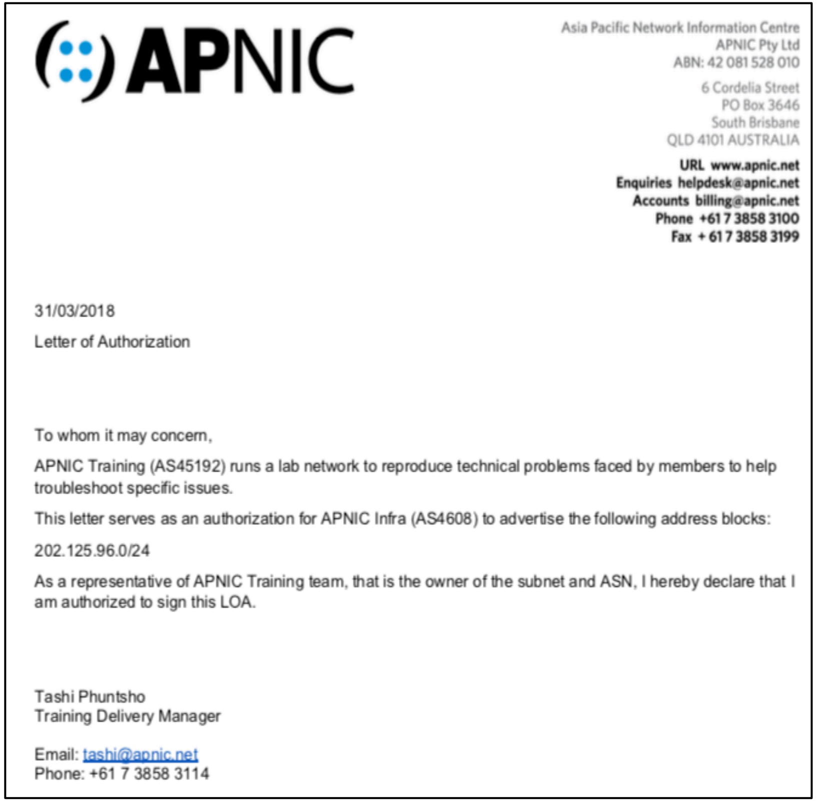
```
tashi@tashi ~> whois -h whois.apnic.net 202.125.96.0
% [whois.apnic.net]
% Whois data copyright terms    http://www.apnic.net/db/dbcopyright.html

% Information related to '202.125.96.0 - 202.125.96.255'

% Abuse contact for '202.125.96.0 - 202.125.96.255' is 'training@apnic.net'

inetnum:        202.125.96.0 - 202.125.96.255
netname:        APNICTRAINING-AP
descr:          Prefix for APNICTRAINING LAB DC
country:        AU
admin-c:        AT480-AP
tech-c:         AT480-AP
status:         ALLOCATED NON-PORTABLE
mnt-by:         MAINT-AU-APNICTRAINING
mnt-irt:        IRT-APNICTRAINING-AU
last-modified:  2016-06-17T00:17:28Z
source:         APNIC

irt:            IRT-APNICTRAINING-AU
address:        6 Cordelia Street
address:        South Brisbane
address:        QLD 4101
e-mail:         training@apnic.net
abuse-mailbox:  training@apnic.net
admin-c:        AT480-AP
tech-c:         AT480-AP
auth:           # Filtered
mnt-by:         MAINT-AU-APNICTRAINING
last-modified:  2013-10-31T11:01:10Z
source:         APNIC
```



```
role:           APNIC Training
address:        6 Cordelia Street
address:        South Brisbane
address:        QLD 4101
country:        AU
phone:          +61 7 3858 3100
fax-no:         +61 7 3858 3199
e-mail:         training@apnic.net
admin-c:        JW3997-AP
tech-c:         JW3997-AP
nic-hdl:        AT480-AP
mnt-by:         MAINT-AU-APNICTRAINING
last-modified:  2017-08-22T04:59:14Z
source:         APNIC

% Information related to '202.125.96.0/24AS131107'

route:          202.125.96.0/24
descr:          Prefix for APNICTRAINING LAB DC
origin:         AS131107
mnt-by:         MAINT-AU-APNICTRAINING
country:        AU
last-modified:  2016-06-16T23:23:00Z
source:         APNIC
```

Tools & Techniques

- Ask for a **Letter of Authority**
  - Absolve from any liabilities



Asia Pacific Network Information Centre
APNIC Pty Ltd
ABN: 42 081 528 010

6 Cordelia Street
PO Box 3646
South Brisbane
QLD 4101 AUSTRALIA

URL **www.apnic.net**
Enquiries **helpdesk@apnic.net**
Accounts **billing@apnic.net**
Phone **+61 7 3858 3100**
Fax **+ 61 7 3858 3199**

31/03/2018

Letter of Authorization

To whom it may concern,

APNIC Training (AS45192) runs a lab network to reproduce technical problems faced by members to help troubleshoot specific issues.

This letter serves as an authorization for APNIC Infra (AS4608) to advertise the following address blocks:

202.125.96.0/24

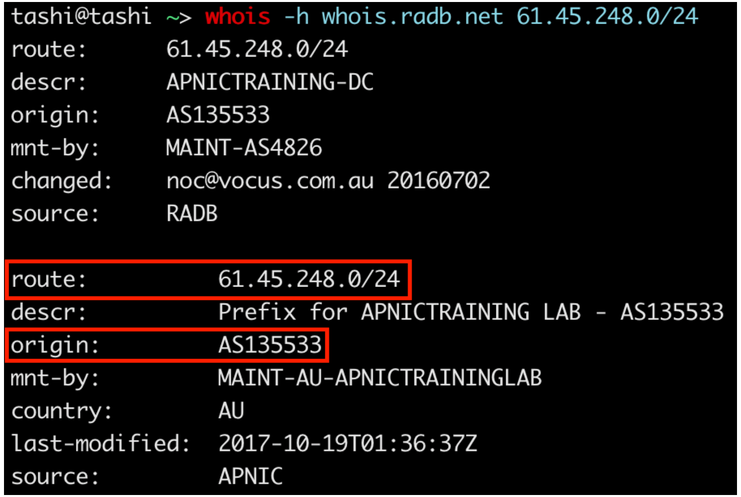
As a representative of APNIC Training team, that is the owner of the subnet and ASN, I hereby declare that I am authorized to sign this LOA.

Tashi Phuntsho
Training Delivery Manager

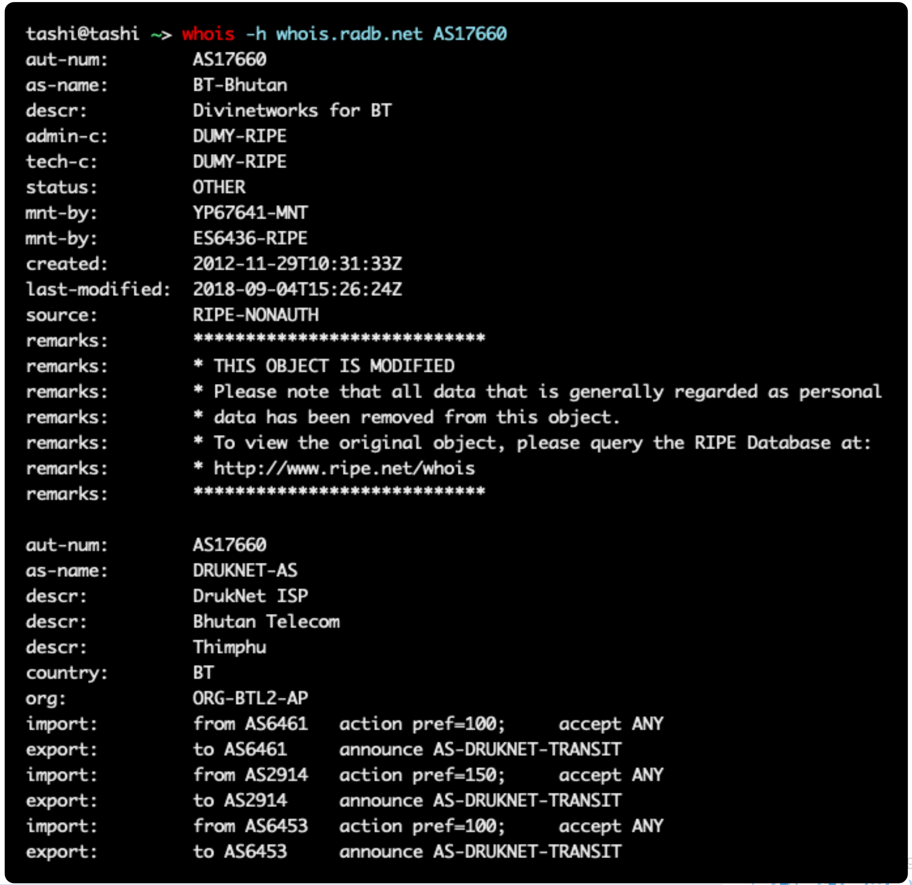
Email: tashi@apnic.net
Phone: +61 7 3858 3114

Tools & Techniques

- Look up/ask to enter details in **IRR**
  - describes route origination and inter-AS routing policies



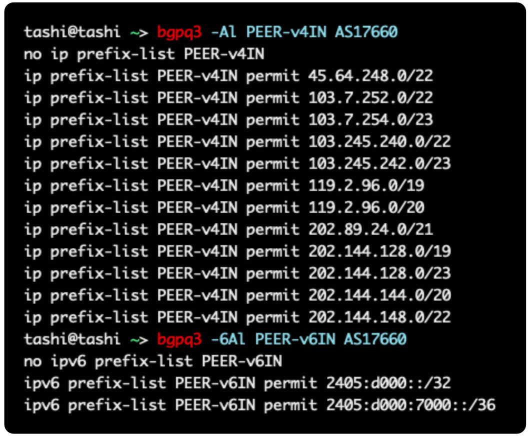
```
tashi@tashi ~> whois -h whois.radb.net 61.45.248.0/24
route:       61.45.248.0/24
descr:       APNICTRAINING-DC
origin:      AS135533
mnt-by:      MAINT-AS4826
changed:     noc@vocus.com.au 20160702
source:      RADB

route:          61.45.248.0/24
descr:          Prefix for APNICTRAINING LAB - AS135533
origin:         AS135533
mnt-by:         MAINT-AU-APNICTRAININGLAB
country:        AU
last-modified:  2017-10-19T01:36:37Z
source:         APNIC
```



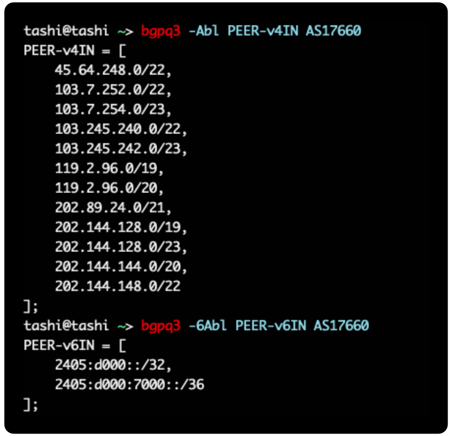
```
tashi@tashi ~> whois -h whois.radb.net AS17660
aut-num:        AS17660
as-name:        BT-Bhutan
descr:          Divinetworks for BT
admin-c:        DUMY-RIPE
tech-c:         DUMY-RIPE
status:         OTHER
mnt-by:         YP67641-MNT
mnt-by:         ES6436-RIPE
created:        2012-11-29T10:31:33Z
last-modified:  2018-09-04T15:26:24Z
source:         RIPE-NONAUTH
remarks:        ****************************
remarks:        * THIS OBJECT IS MODIFIED
remarks:        * Please note that all data that is generally regarded as personal
remarks:        * data has been removed from this object.
remarks:        * To view the original object, please query the RIPE Database at:
remarks:        * http://www.ripe.net/whois
remarks:        ****************************

aut-num:        AS17660
as-name:        DRUKNET-AS
descr:          DrukNet ISP
descr:          Bhutan Telecom
descr:          Thimphu
country:        BT
org:            ORG-BTL2-AP
import:         from AS6461   action pref=100;     accept ANY
export:         to AS6461     announce AS-DRUKNET-TRANSIT
import:         from AS2914   action pref=150;     accept ANY
export:         to AS2914     announce AS-DRUKNET-TRANSIT
import:         from AS6453   action pref=100;     accept ANY
export:         to AS6453     announce AS-DRUKNET-TRANSIT
```

Tools & Techniques

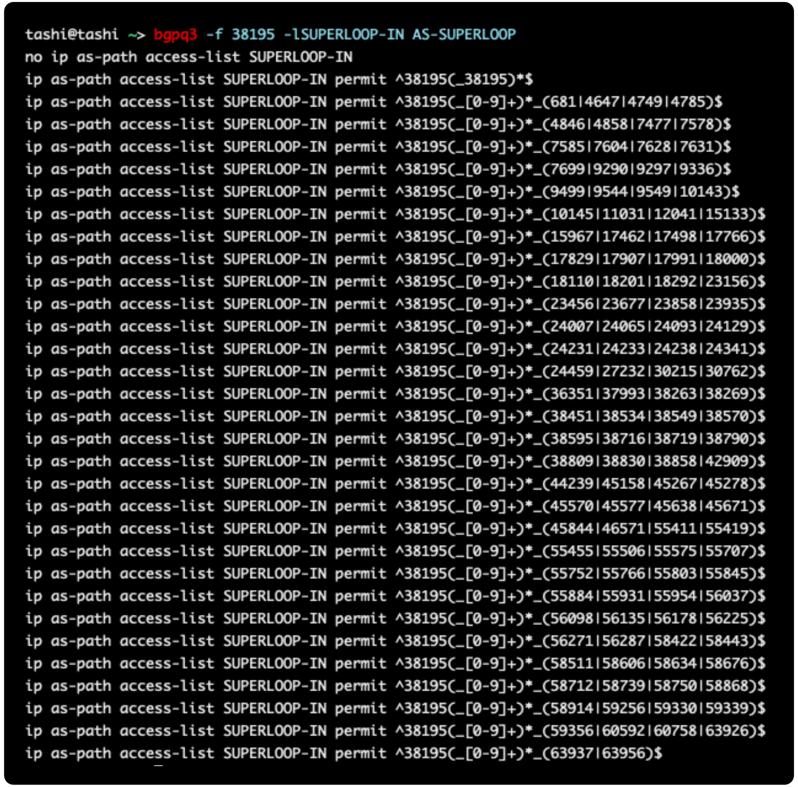
- **IRR**
  - *Helps generate network (prefix & as-path) filters using RPSL tools*
    - Filter out route advertisements not described in the registry



```
tashi@tashi ~> bgpq3 -Al PEER-v4IN AS17660
no ip prefix-list PEER-v4IN
ip prefix-list PEER-v4IN permit 45.64.248.0/22
ip prefix-list PEER-v4IN permit 103.7.252.0/22
ip prefix-list PEER-v4IN permit 103.7.254.0/23
ip prefix-list PEER-v4IN permit 103.245.240.0/22
ip prefix-list PEER-v4IN permit 103.245.242.0/23
ip prefix-list PEER-v4IN permit 119.2.96.0/19
ip prefix-list PEER-v4IN permit 119.2.96.0/20
ip prefix-list PEER-v4IN permit 202.89.24.0/21
ip prefix-list PEER-v4IN permit 202.144.128.0/19
ip prefix-list PEER-v4IN permit 202.144.128.0/23
ip prefix-list PEER-v4IN permit 202.144.144.0/20
ip prefix-list PEER-v4IN permit 202.144.148.0/22
tashi@tashi ~> bgpq3 -6Al PEER-v6IN AS17660
no ipv6 prefix-list PEER-v6IN
ipv6 prefix-list PEER-v6IN permit 2405:d000::/32
ipv6 prefix-list PEER-v6IN permit 2405:d000:7000::/36
```



```
tashi@tashi ~> bgpq3 -Abl PEER-v4IN AS17660
PEER-v4IN = [
    45.64.248.0/22,
    103.7.252.0/22,
    103.7.254.0/23,
    103.245.240.0/22,
    103.245.242.0/23,
    119.2.96.0/19,
    119.2.96.0/20,
    202.89.24.0/21,
    202.144.128.0/19,
    202.144.128.0/23,
    202.144.144.0/20,
    202.144.148.0/22
];
tashi@tashi ~> bgpq3 -6Abl PEER-v6IN AS17660
PEER-v6IN = [
    2405:d000::/32,
    2405:d000:7000::/36
];
```



```
tashi@tashi ~> bgpq3 -f 38195 -lSUPERLOOP-IN AS-SUPERLOOP
no ip as-path access-list SUPERLOOP-IN
ip as-path access-list SUPERLOOP-IN permit ^38195(_38195)*$
ip as-path access-list SUPERLOOP-IN permit ^38195(_[0-9]+)*_(681|4647|4749|4785)$
ip as-path access-list SUPERLOOP-IN permit ^38195(_[0-9]+)*_(4846|4858|7477|7578)$
ip as-path access-list SUPERLOOP-IN permit ^38195(_[0-9]+)*_(7585|7604|7628|7631)$
ip as-path access-list SUPERLOOP-IN permit ^38195(_[0-9]+)*_(7699|9290|9297|9336)$
ip as-path access-list SUPERLOOP-IN permit ^38195(_[0-9]+)*_(9499|9544|9549|10143)$
ip as-path access-list SUPERLOOP-IN permit ^38195(_[0-9]+)*_(10145|11031|12041|15133)$
ip as-path access-list SUPERLOOP-IN permit ^38195(_[0-9]+)*_(15967|17462|17498|17766)$
ip as-path access-list SUPERLOOP-IN permit ^38195(_[0-9]+)*_(17829|17907|17991|18000)$
ip as-path access-list SUPERLOOP-IN permit ^38195(_[0-9]+)*_(18110|18201|18292|23156)$
ip as-path access-list SUPERLOOP-IN permit ^38195(_[0-9]+)*_(23456|23677|23858|23935)$
ip as-path access-list SUPERLOOP-IN permit ^38195(_[0-9]+)*_(24007|24065|24093|24129)$
ip as-path access-list SUPERLOOP-IN permit ^38195(_[0-9]+)*_(24231|24233|24238|24341)$
ip as-path access-list SUPERLOOP-IN permit ^38195(_[0-9]+)*_(24459|27232|30215|30762)$
ip as-path access-list SUPERLOOP-IN permit ^38195(_[0-9]+)*_(36351|37993|38263|38269)$
ip as-path access-list SUPERLOOP-IN permit ^38195(_[0-9]+)*_(38451|38534|38549|38570)$
ip as-path access-list SUPERLOOP-IN permit ^38195(_[0-9]+)*_(38595|38716|38719|38790)$
ip as-path access-list SUPERLOOP-IN permit ^38195(_[0-9]+)*_(38809|38830|38858|42909)$
ip as-path access-list SUPERLOOP-IN permit ^38195(_[0-9]+)*_(44239|45158|45267|45278)$
ip as-path access-list SUPERLOOP-IN permit ^38195(_[0-9]+)*_(45570|45577|45638|45671)$
ip as-path access-list SUPERLOOP-IN permit ^38195(_[0-9]+)*_(45844|46571|55411|55419)$
ip as-path access-list SUPERLOOP-IN permit ^38195(_[0-9]+)*_(55455|55506|55575|55707)$
ip as-path access-list SUPERLOOP-IN permit ^38195(_[0-9]+)*_(55752|55766|55803|55845)$
ip as-path access-list SUPERLOOP-IN permit ^38195(_[0-9]+)*_(55884|55931|55954|56037)$
ip as-path access-list SUPERLOOP-IN permit ^38195(_[0-9]+)*_(56098|56135|56178|56225)$
ip as-path access-list SUPERLOOP-IN permit ^38195(_[0-9]+)*_(56271|56287|58422|58443)$
ip as-path access-list SUPERLOOP-IN permit ^38195(_[0-9]+)*_(58511|58606|58634|58676)$
ip as-path access-list SUPERLOOP-IN permit ^38195(_[0-9]+)*_(58712|58739|58750|58868)$
ip as-path access-list SUPERLOOP-IN permit ^38195(_[0-9]+)*_(58914|59256|59330|59339)$
ip as-path access-list SUPERLOOP-IN permit ^38195(_[0-9]+)*_(59356|60592|60758|63926)$
ip as-path access-list SUPERLOOP-IN permit ^38195(_[0-9]+)*_(63937|63956)$
```

Tools & Techniques

- Problem(s) with IRR
  - No single authority model
    - How do I know if a RR entry is genuine and correct?
    - How do I differentiate between a current and a lapsed entry?
  - Many RRs
    - If two RRs contain conflicting data, which one do I trust and use?
  - Incomplete data - Not all resources are registered in an IRR
    - If a route is not in a RR, is the route invalid or is the RR just missing data?
  - Scaling
    - How do I apply IRR filters to upstream(s)?

Back to basics – identify GOOD

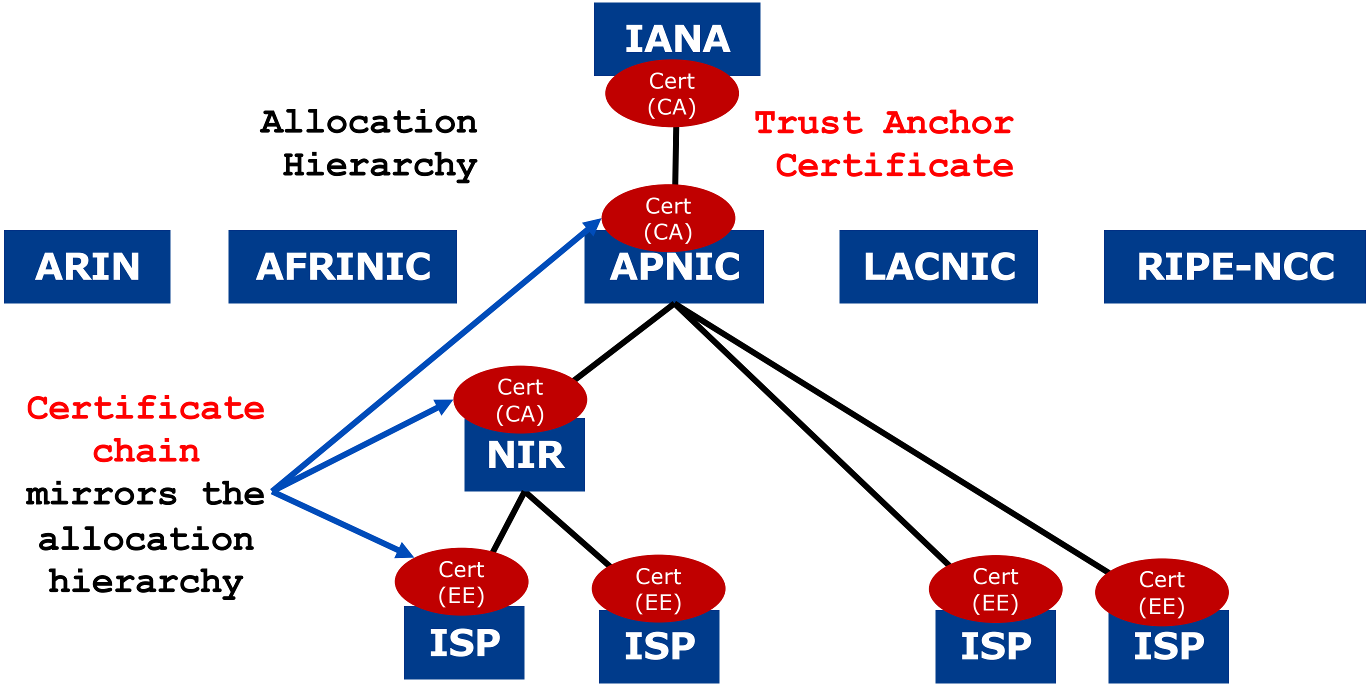
- Using digital signatures to convey the "*authority to use*"?
  - A private key to *sign* the *authority*, and
  - the public key to *validate* that *authority*

How about trust?

- Follows the resource allocation/delegation hierarchy

```
IANA → RIRs → NIRs/LIRs → End Holders
         |
         v
    End Holders
```

Chain of Trust - RPKI



Resource Certificates

- When an address holder A (*IRs) allocates resources (*IP address/ASN*) to B (end holders)
  - ***A** issues a resource certificate that binds the allocated address with **B's** public key, all signed by **A's** (CA) private key*
  - *proves the holder of the private key (**B**) is the legitimate holder of the resource!*

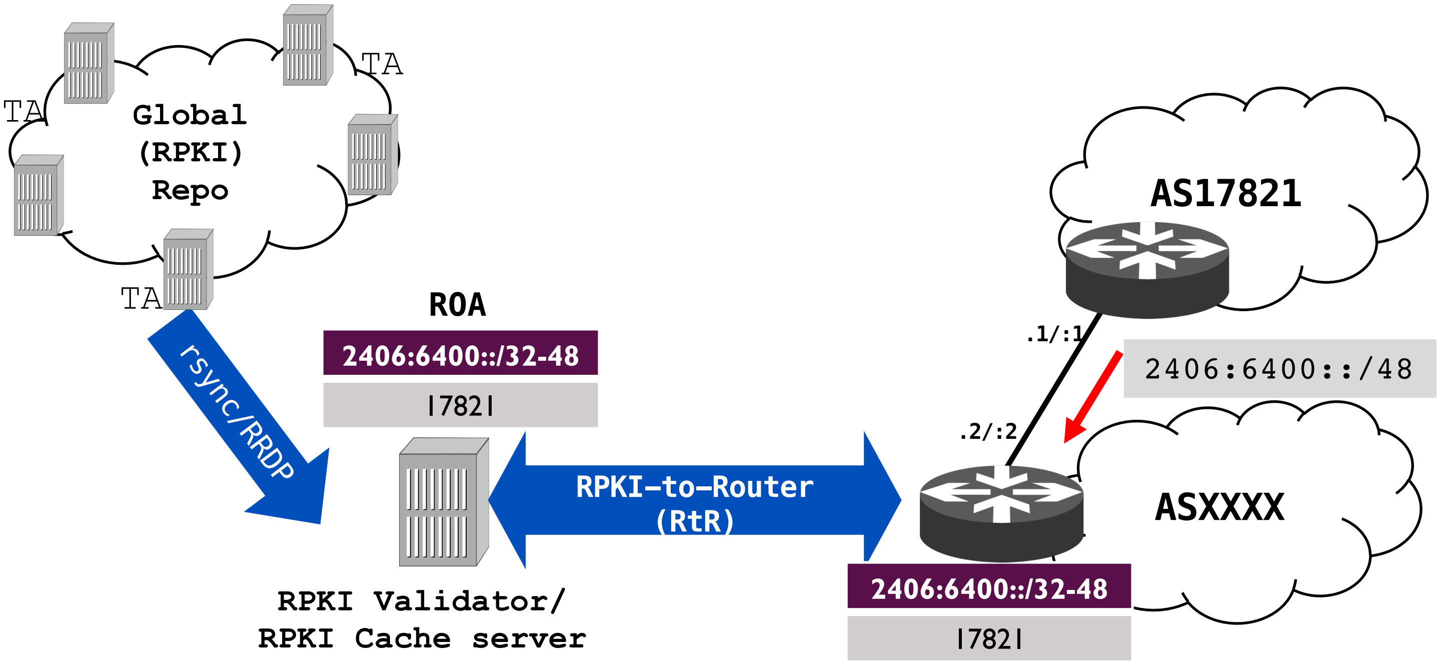
Route Origin Authority

- B can now sign *authorities* using its private key,
  - which can be validated by any third party against the TA

- For routing, the address holder can *authorize* a network (ASN) to *originate* a route, and **sign** this permission with its private key (ROA)

Prefix	202.144.128.0/19
Max-length	/24
Origin ASN	**AS17660**

Filtering with ROAs – Route Origin Validation

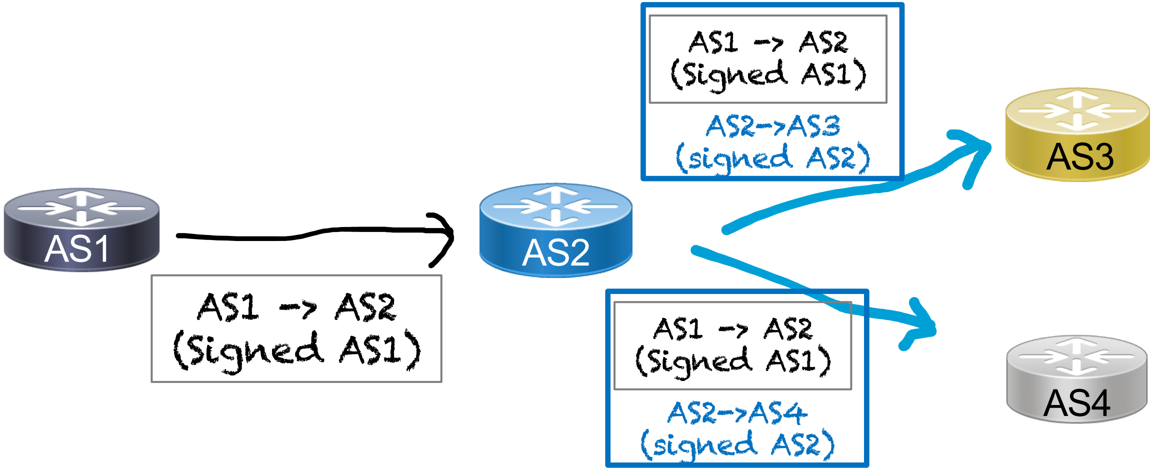


Are ROAs enough?

- What if I forge the origin AS in the AS path?
  - Would be accepted as “good” – pass origin validation!

- Which means, we need to secure the AS path as well
  - need AS path validation (per-prefix)

AS-PATH validation (BGPsec)



- A BGPsec speaker validates the received update by checking:
  - If there is a ROA that describes the prefix and origin AS, and
  - If the received AS path can be validated as a chain of signatures (for each AS in the AS path) using the AS keys

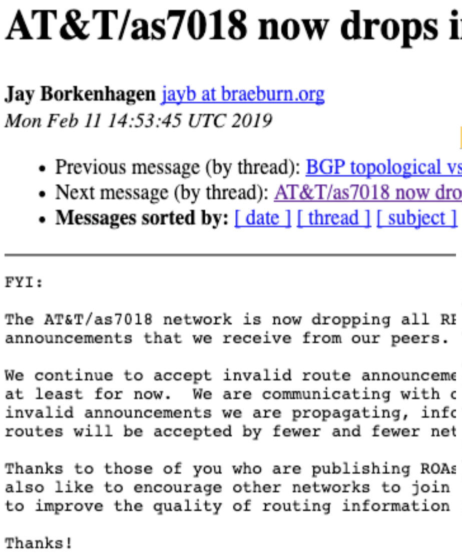
AS-PATH validation issues…

- More resources
  - CPU - high crypto overhead to validate signatures, and
  - Memory
    - Updates in BGPsec would be per prefix – update packing??
    - New attributes carrying signatures and certs/key-id for every AS in the AS path
- How do we distribute the certificates required?
- Can we have partial adoption?
- Given so much overhead, can it do more - Route leaks?

So, what can we do?

- Basic BGP OpSec hygiene – RFC7454/RFC8212
  - *RFC 8212* – BGP default reject or something similar
  - Filters with your *customers* and *peers*
    - *Prefix filters, Prefix limit*
    - *AS-PATH filters, AS-PATH limit*
    - Use IRR objects (source option) or ROA-to-IRR
  - Filter what you receive from your *upstream(s)*
  - Create ROAs for your resources
  - Filter inbound routes based on ROAs ~ ROV
- Join industry initiatives like MANRS
  - https://www.manrs.org/

Industry Trends

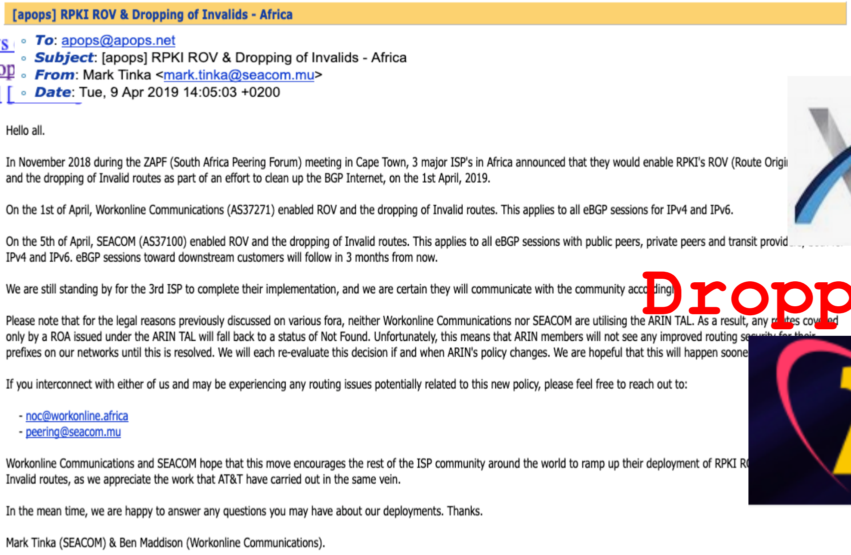


AT&T/as7018 now drops invalid prefixes from peers

Jay Borkenhagen jayb at braeburn.org
Mon Feb 11 14:53:45 UTC 2019

- Previous message (by thread): BGP topological vs
- Next message (by thread): AT&T/as7018 now drop
- **Messages sorted by:** [date] [thread] [subject] [

```
FYI:

The AT&T/as7018 network is now dropping all RI
announcements that we receive from our peers.

We continue to accept invalid route announceme
at least for now.  We are communicating with c
invalid announcements we are propagating, infc
routes will be accepted by fewer and fewer net

Thanks to those of you who are publishing ROAs
also like to encourage other networks to join
to improve the quality of routing information

Thanks!
```



[apops] RPKI ROV & Dropping of Invalids - Africa

- ***To***: apops@apops.net
- ***Subject***: [apops] RPKI ROV & Dropping of Invalids - Africa
- ***From***: Mark Tinka <mark.tinka@seacom.mu>
- ***Date***: Tue, 9 Apr 2019 14:05:03 +0200

Hello all.

In November 2018 during the ZAPF (South Africa Peering Forum) meeting in Cape Town, 3 major ISP's in Africa announced that they would enable RPKI's ROV (Route Origi
and the dropping of Invalid routes as part of an effort to clean up the BGP Internet, on the 1st April, 2019.

On the 1st of April, Workonline Communications (AS37271) enabled ROV and the dropping of Invalid routes. This applies to all eBGP sessions for IPv4 and IPv6.

On the 5th of April, SEACOM (AS37100) enabled ROV and the dropping of Invalid routes. This applies to all eBGP sessions with public peers, private peers and transit provid
IPv4 and IPv6. eBGP sessions toward downstream customers will follow in 3 months from now.

We are still standing by for the 3rd ISP to complete their implementation, and we are certain they will communicate with the community accordingl

Please note that for the legal reasons previously discussed on various fora, neither Workonline Communications nor SEACOM are utilising the ARIN TAL. As a result, any routes covered
only by a ROA issued under the ARIN TAL will fall back to a status of Not Found. Unfortunately, this means that ARIN members will not see any improved routing se
prefixes on our networks until this is resolved. We will each re-evaluate this decision if and when ARIN's policy changes. We are hopeful that this will happen soone

If you interconnect with either of us and may be experiencing any routing issues potentially related to this new policy, please feel free to reach out to:

- noc@workonline.africa
- peering@seacom.mu

Workonline Communications and SEACOM hope that this move encourages the rest of the ISP community around the world to ramp up their deployment of RPKI R
Invalid routes, as we appreciate the work that AT&T have carried out in the same vein.

In the mean time, we are happy to answer any questions you may have about our deployments. Thanks.

Mark Tinka (SEACOM) & Ben Maddison (Workonline Communications).

MMIX
Myanmar Internet Exchange

Dropping Invalids!

MYREN
MALAYSIAN RESEARCH & EDUCATION NETWORK

Acknowledgement

- **Geoff Huston**, APNIC
- **Randy Bush**, IIJ Labs/Arrcus

THANK YOU