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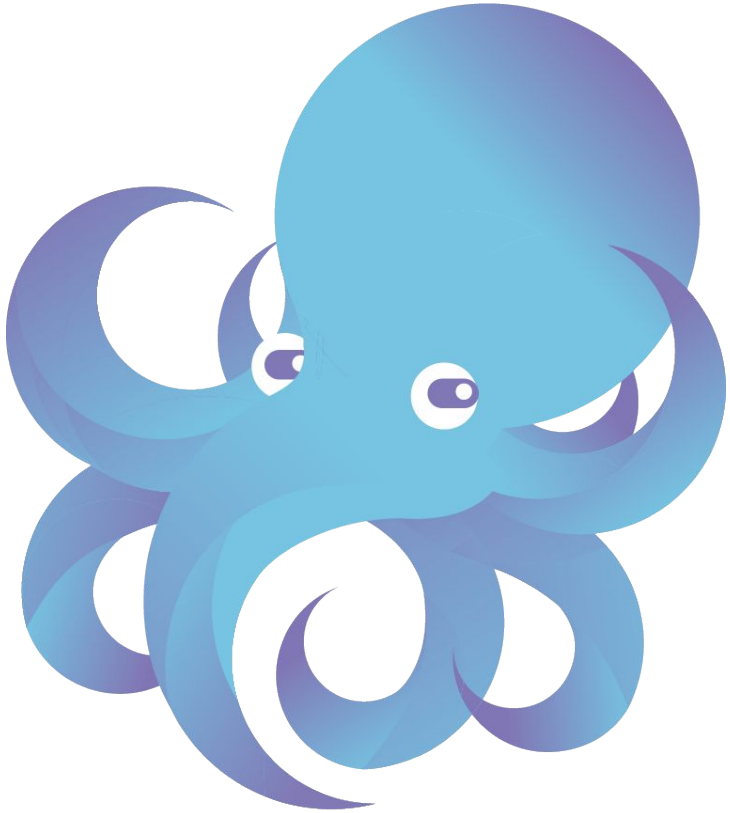

RPKI implementation Cloudflare

Louis Poinsignon

Introduction

Network Engineer at Cloudflare in San Francisco

Open-source projects including flows and RPKI

Network data collection (BGP, flows, peering-portal)

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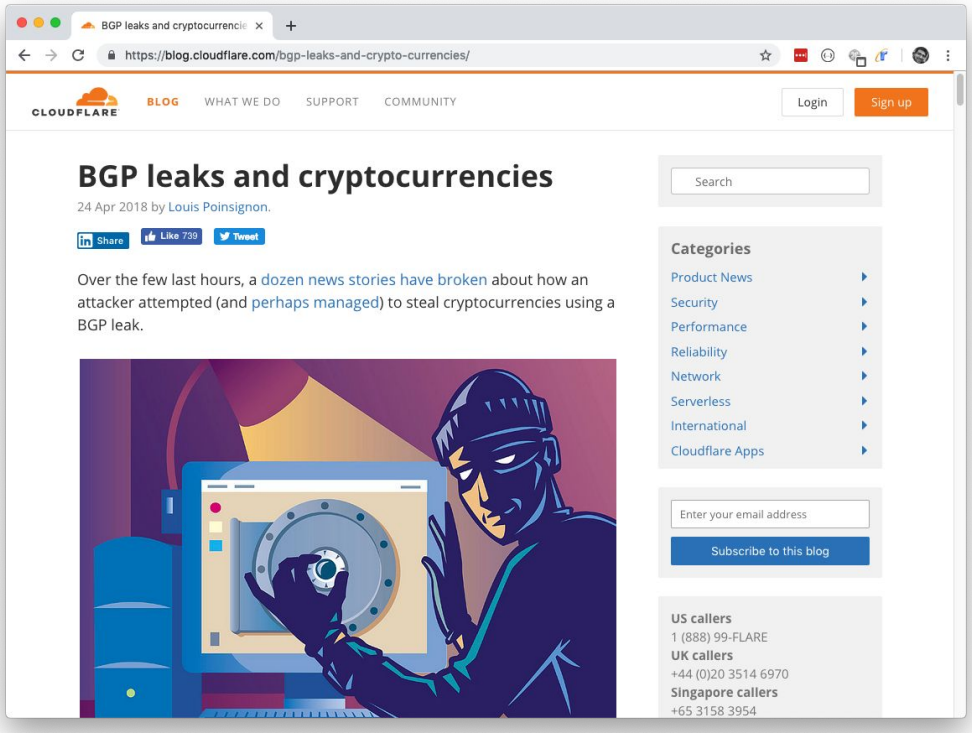
https://blog.cloudflare.com/rpki-details/
https://blog.cloudflare.com/rpki/

Story 1/4



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

Story 2/4

Authority DNS route hijack in April 2018.

This affected our DNS Resolver.

The route was sent to us on a Chicago peering session.

What should we do?

Story 3/4

At the time...

150+ PoPs, 26000 BGP sessions, IP space in 5 RIRs

Just the RIPE Validator[1]

How to distribute a prefix list efficiently?

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[1] Cloudflare is very grateful for the RIPE Validator s/w

Story 4/4

July: started deploying internally GoRTR.

August: open-source release.
https://github.com/cloudflare/gortr

September → December:

- Turn up RTR sessions
- Signing prefixes

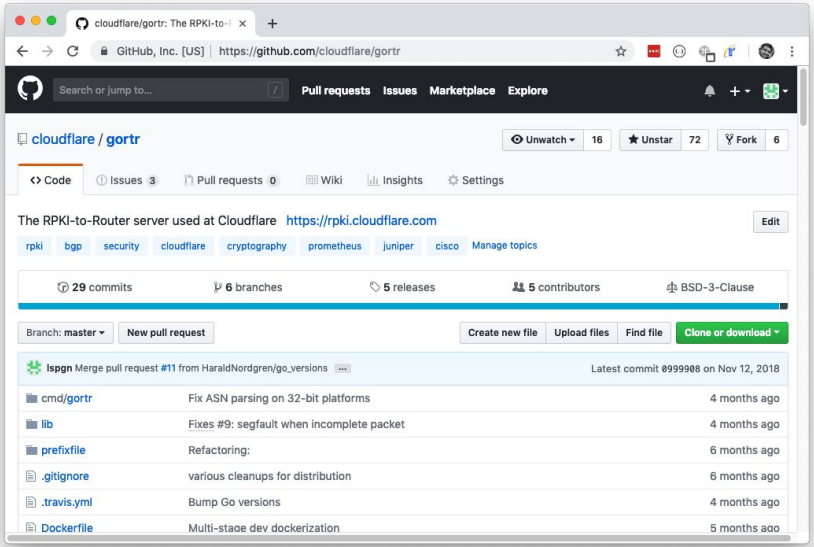

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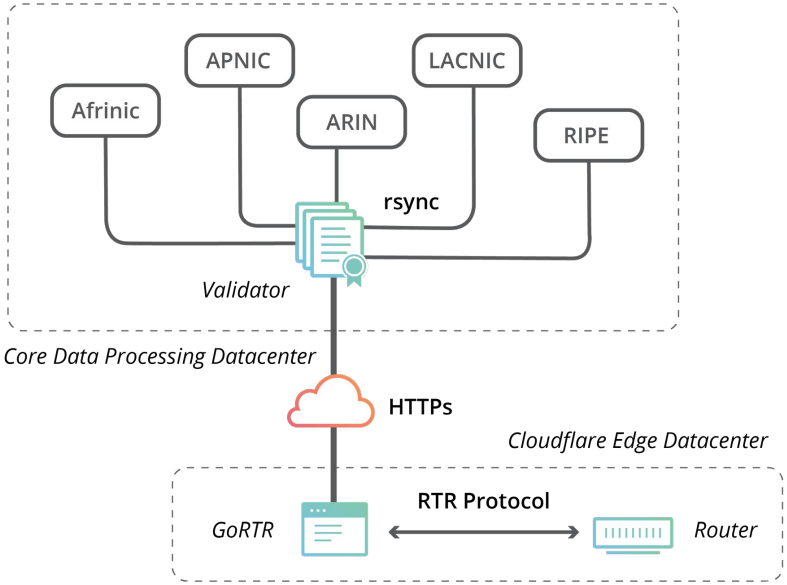
Diagram



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Behind the scene (until January 2019)

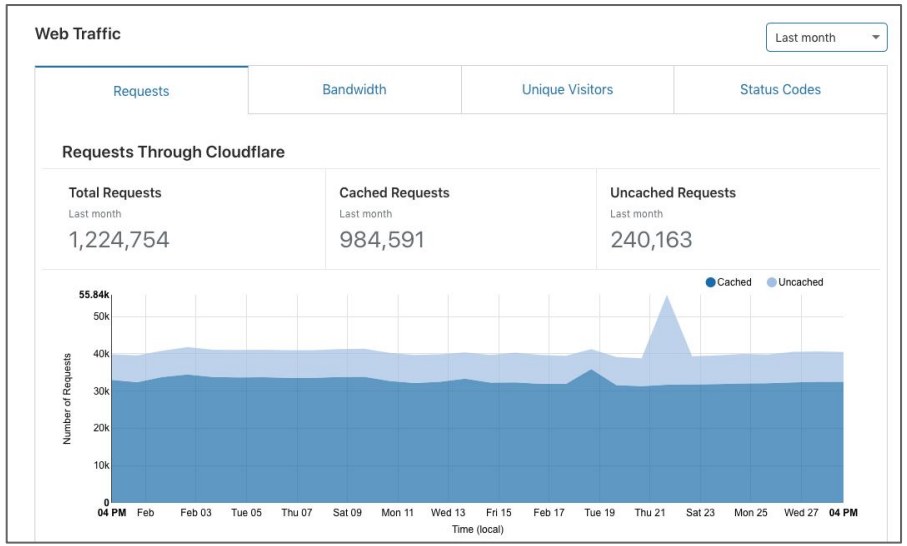
RIPE Validator providing list of prefixes.

Running in a Mesos cluster.

With a cronjob:

- Fetching the data
- Filtering it
  (remove > /24 and > /48 and duplicates)
- Signing it
- Making it available to our edge.

https://rpki.cloudflare.com/rpki.json was born.



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Effects

The question everyone asked us.

How much traffic was affected?

Many invalids. Little traffic in practice (default or valid less specific).

https://www.flickr.com/photos/thure/6287816628/

Except in one place. Few gigabits per seconds displaced due to geographical more specific.

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Signing the routes

Signing the routes

IP space in 5 RIRs (*no twnic/jpnic/cnnic*).

Not a unified experience.

RIR	Features	Ease of use	API
AFRINIC	⭐	⭐	⭐
APNIC	⭐⭐	⭐⭐	⭐
ARIN	⭐⭐	⭐⭐	⭐⭐
LACNIC	⭐	⭐⭐⭐	⭐
RIPE	⭐⭐⭐	⭐⭐⭐	⭐⭐⭐

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Rankings

Features: RRDP, 2 factors, extra info, CA.

Ease of use: steps to sign a ROA, multi user.

API: functional, complete and accessible.

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Comparison - AFRINIC

Hard to set up: client TLS certificate to create (BPKI) in order to do RPKI.

Buggy.

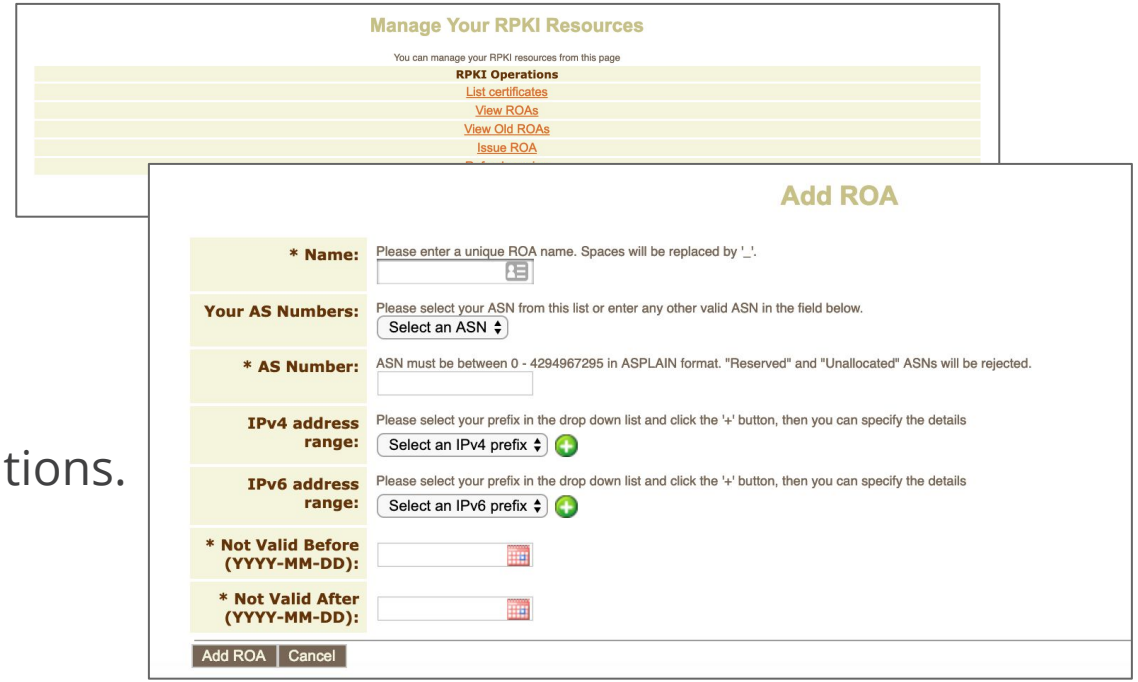
No RRDP.

No API.

No auto-renew.

Hosted CA possible.

Extensive certificate informations.



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Comparison - APNIC

Two factors or client certificate.

RRDP.

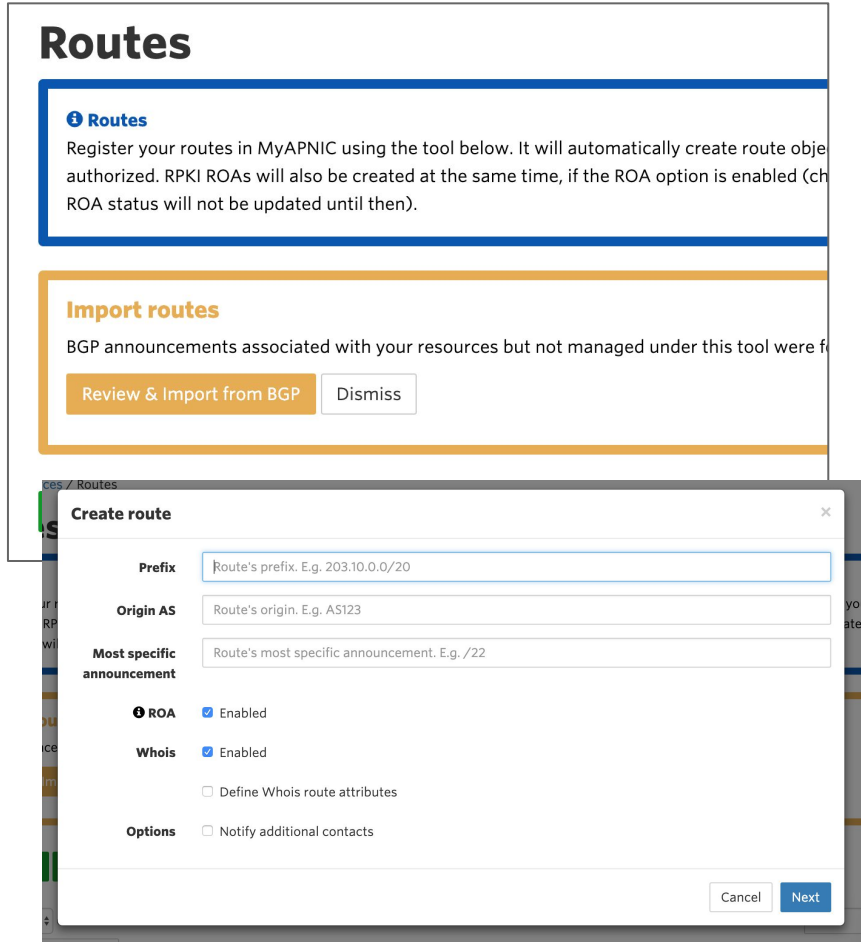
Auto-renew.

Allow BGP batch signing.

(slight bugs with big amount of prefixes).

Hosted CA possible.

Draft for API:
https://www.apnic.net/manage-ip/apnic-services/services-roadmap/public-api-draft-for-members/



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Comparison - ARIN

Two factors. Separate signing key.

No RRDP.

No auto-renew.

Semi-functional API (add).

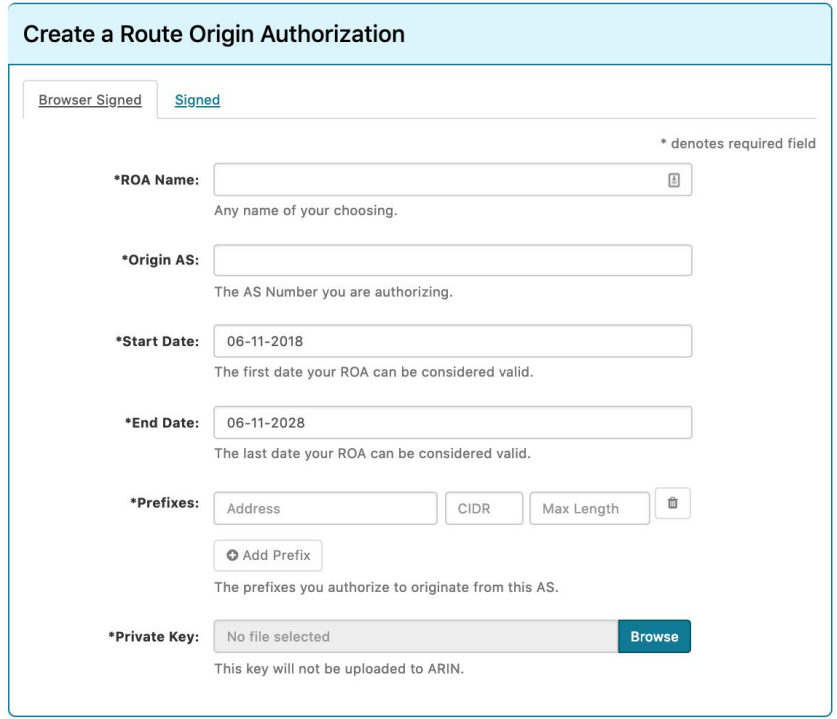
Dashboard not easy to find.

Hosted CA possible.

~~Slow rsync update (0000 and 1200 EST).~~

Edit: happens 4 times a day

Some certificate information.



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Comparison - LACNIC

No two factors. Single user.

No RRDP.

No API.

Auto-renew opt-in.

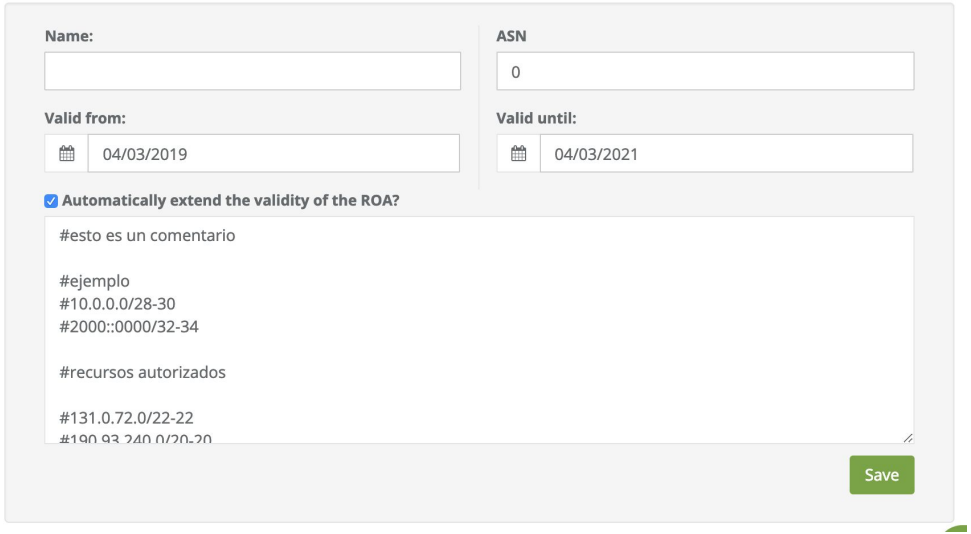
Allow BGP batch signing.

Based off RIPE.

No Hosted CA.

Some extra info (revoked, path).

Incorrect certificate encoding (BER). High turnover of certificate (few days).



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Comparison - RIPE

Two factors.

RRDP.

Auto-renew.

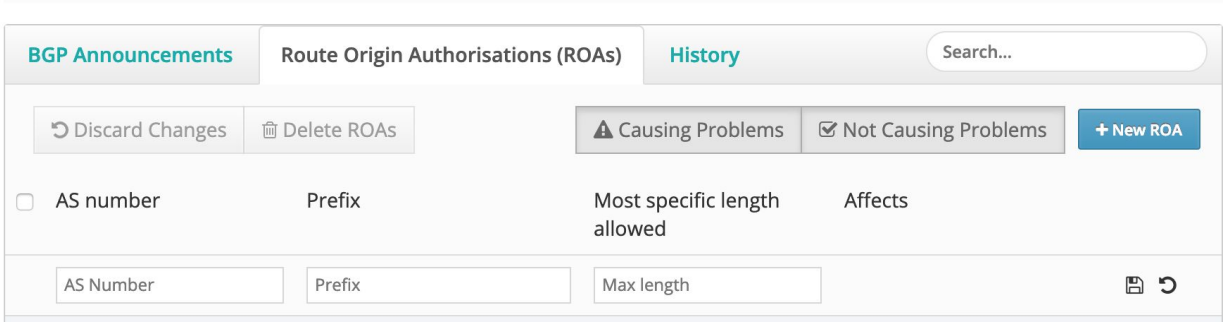
Nice API.

Allow BGP batch signing.

No Hosted CA (theoretically).

No extra information. But history.

Incorrect certificate encoding (BER).



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Automation

We automated prefixes adding on **ARIN** with a **Salt state**.

Two secrets to store (API key and signing key).

Cannot delete or list via API: very prone to mistakes if user wants to reduce the amount of ROA files.

```
def _format_payload(roas, signature):
    template = """-----BEGIN ROA REQUEST-----
{roas}
-----END ROA REQUEST-----
-----BEGIN SIGNATURE-----
{signature}
-----END SIGNATURE-----
    """
    payload = template.format(
        roas=roas, signature="\n".join(textwrap.wrap(signature, width=64))
    )
    return payload


def _make_roa(name, asn, t, start_val, end_val, prefix, length, maxlength):
    template = (
        '1|{time}|{name}|{asn}|{start_val}|{end_val}|{prefix}|{length}|{maxlength}|'
    )
    time_str = calendar.timegm(t.timetuple())
    start_val_str = start_val.strftime(_TIME_FORMAT)
    end_val_str = end_val.strftime(_TIME_FORMAT)
    roa = template.format(
        time=time_str,
        name=name,
        asn=asn,
        start_val=start_val_str,
        end_val=end_val_str,
        prefix=prefix,
        length=length,
        maxlength=maxlength,
    )
    return roa


def _sign(pkey, roas):
    signature = pkey.sign(roas.encode('utf-8'), padding.PKCS1v15(), hashes.SHA256())
    return base64.b64encode(signature).decode('utf-8')
```

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Validator

Why making a validator?

First release of Routinator in November 2018.
We were still using RIPE Validator.

We wanted something more custom: with monitoring and RRDP.

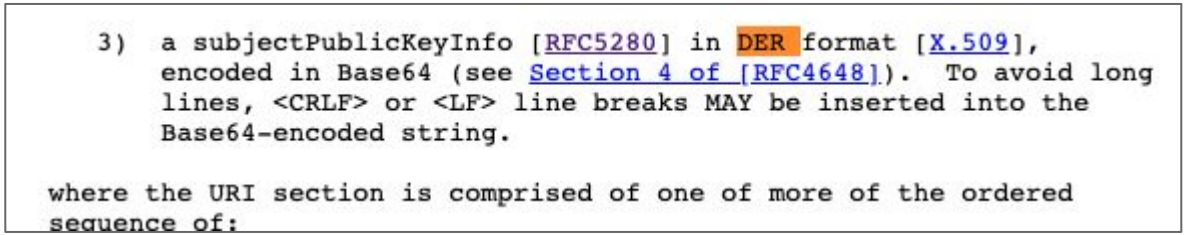
By building it in Go:

- Many APIs and easy for concurrency
- Community doing cryptography
- Cloudflare uses Go a lot (cfssl, sidh, etc.)

Challenges

Juniper bugs: Routing Validation disabled.

Difficulties: rsync, BER encoded instead of DER



3) a subjectPublicKeyInfo [RFC5280] in DER format [X.509], encoded in Base64 (see Section 4 of [RFC4648]). To avoid long lines, <CRLF> or <LF> line breaks MAY be inserted into the Base64-encoded string.

where the URI section is comprised of one of more of the ordered sequence of:

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Cloudflare’s RPKI Toolkit

Sets of libraries and tools written in Go.

Including ***OctoRPKI*** 

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https://blog.cloudflare.com/cloudflares-rpki-toolkit/

Cloudflare’s RPKI Toolkit

Libraries

- CER/ROA/MFT decoder
- PKI manager (exploring, validating)
- RRDP/Rsync fetcher

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Cloudflare’s RPKI Toolkit

Software

- Local validator (without RRDP/Rsync)
- API tools for a distributed version without filesystem
- OctoRPKI

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OctoRPKI - Features (1/2)

- Decodes TAL/CER/ROA/MFT
- Explore via Manifest or directory.
- RRDP support (and failover to Rsync)
- Monitoring (Prometheus and JSON API which includes logs)
- Dockerizeable
- Handle stability (generate file when done)

OctoRPKI - Features (2/2)

- Full compatibility with GoRTR (including signing the JSON file)
- Server + caching options for generated file (CDN friendly)
- Configuration options
    - Disable/Enable components
    - Modes (server, one-off)
- ~5-15 minutes for a full cold-start sync

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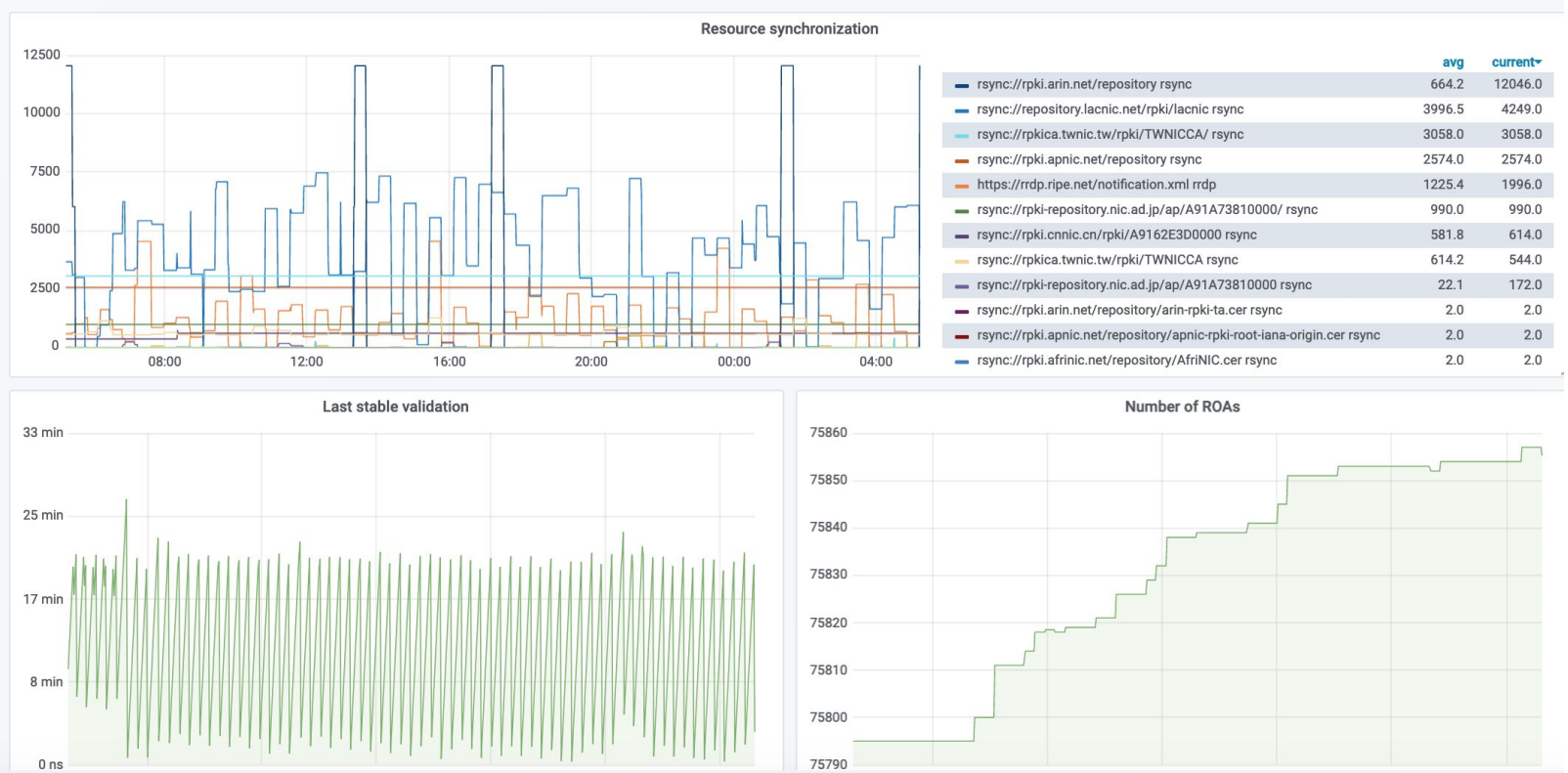
OctoRPKI - Compute footprint

OctoRPKI - Compute footprint

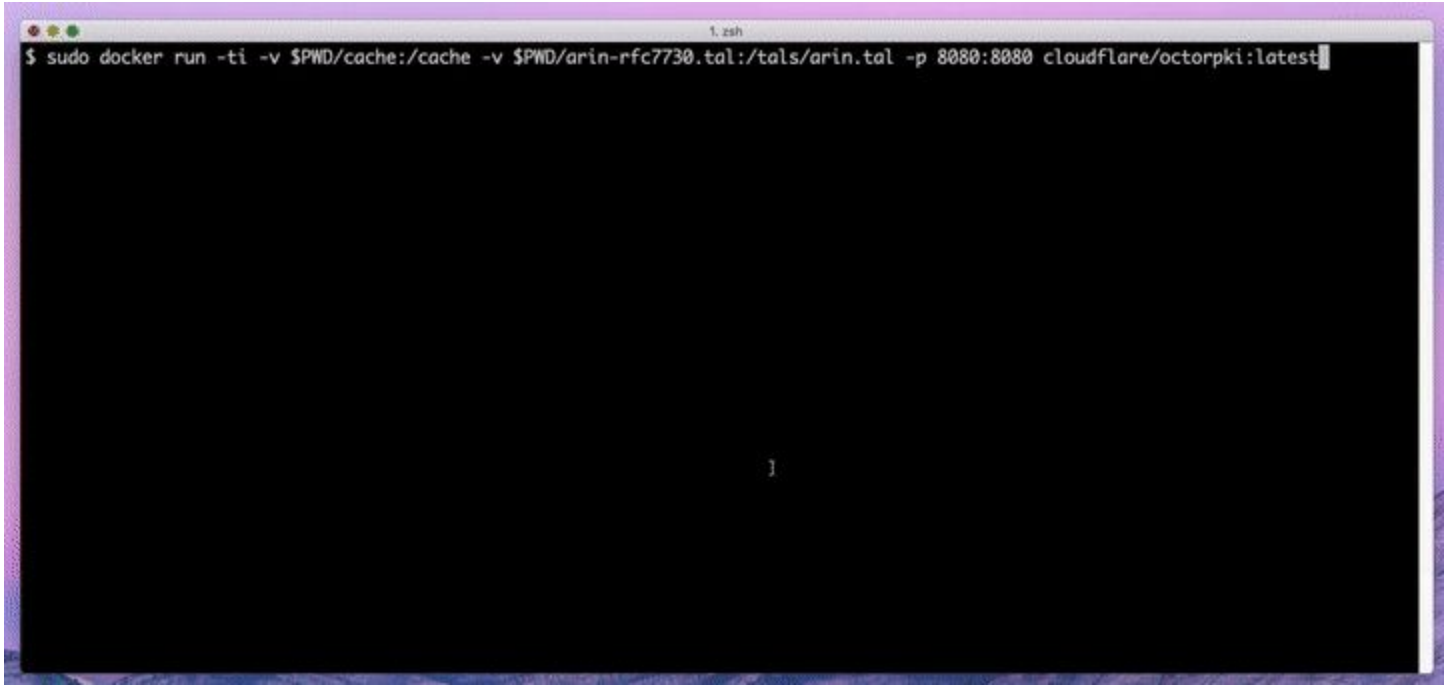
Why 800-1500MB of RAM?

- Buffer RRDP files. Not on disk
- Keeping every resource in memory
- Webserver + metrics
- *Possible Kubernetes overhead (file volume)*

Monitoring


Resource synchronization
12500
10000
7500
5000
2500
0
08:00
12:00
16:00
20:00
00:00
04:00
avg
current
rsync://rpki.arin.net/repository rsync 664.2 12046.0
rsync://repository.lacnic.net/rpki/lacnic rsync 3996.5 4249.0
rsync://rpkica.twnic.tw/rpki/TWNICCA/ rsync 3058.0 3058.0
rsync://rpki.apnic.net/repository rsync 2574.0 2574.0
https://rrdp.ripe.net/notification.xml rrdp 1225.4 1996.0
rsync://rpki-repository.nic.ad.jp/ap/A91A73810000/ rsync 990.0 990.0
rsync://rpki.cnnic.cn/rpki/A9162E3D0000 rsync 581.8 614.0
rsync://rpkica.twnic.tw/rpki/TWNICCA rsync 614.2 544.0
rsync://rpki-repository.nic.ad.jp/ap/A91A73810000 rsync 22.1 172.0
rsync://rpki.arin.net/repository/arin-rpki-ta.cer rsync 2.0 2.0
rsync://rpki.apnic.net/repository/apnic-rpki-root-iana-origin.cer rsync 2.0 2.0
rsync://rpki.afrinic.net/repository/AfriNIC.cer rsync 2.0 2.0
Last stable validation
33 min
25 min
17 min
8 min
0 ns
Number of ROAs
75860
75850
75840
75830
75820
75810
75800
75790

OctoRPKI - What it looks like



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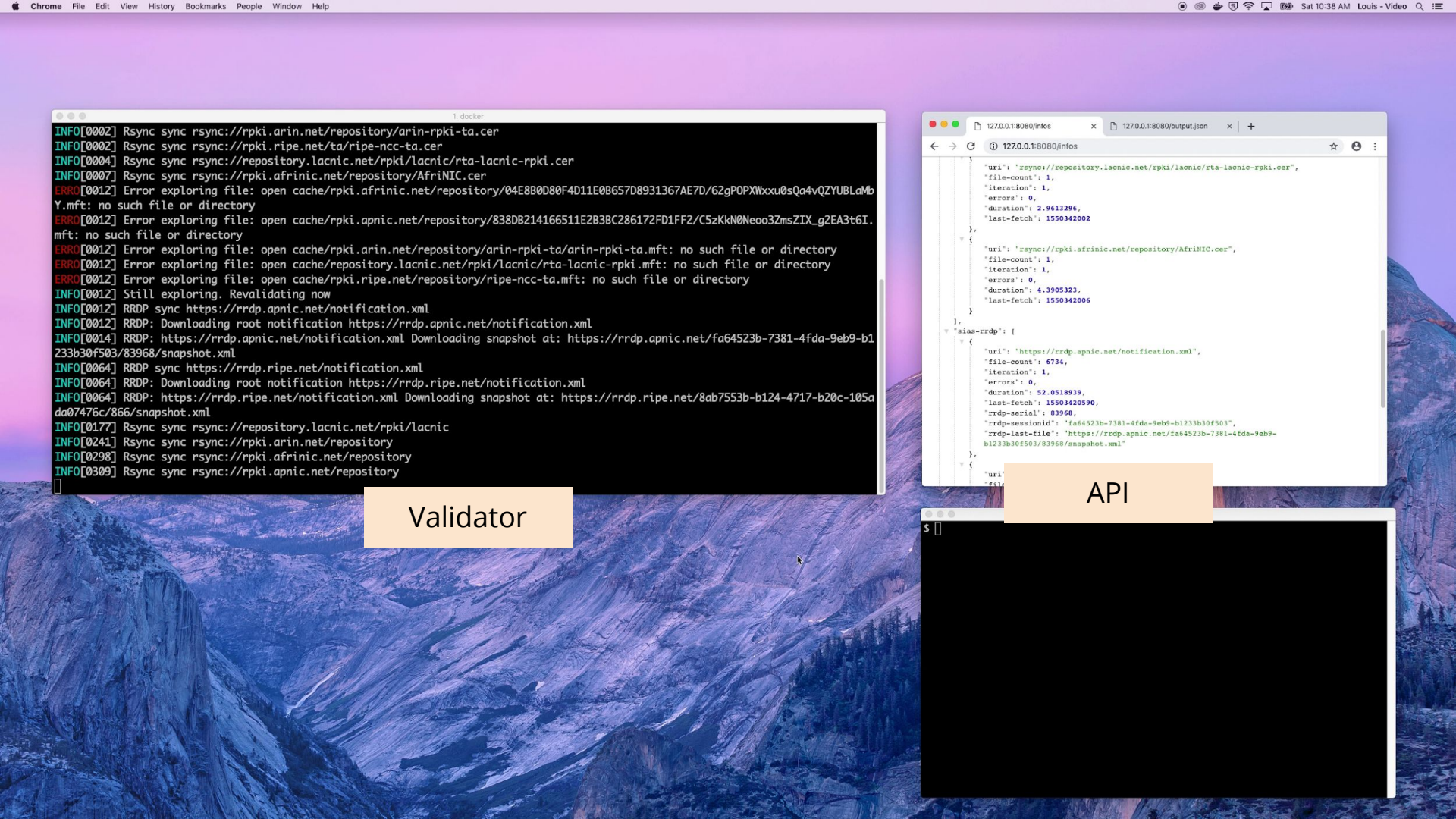
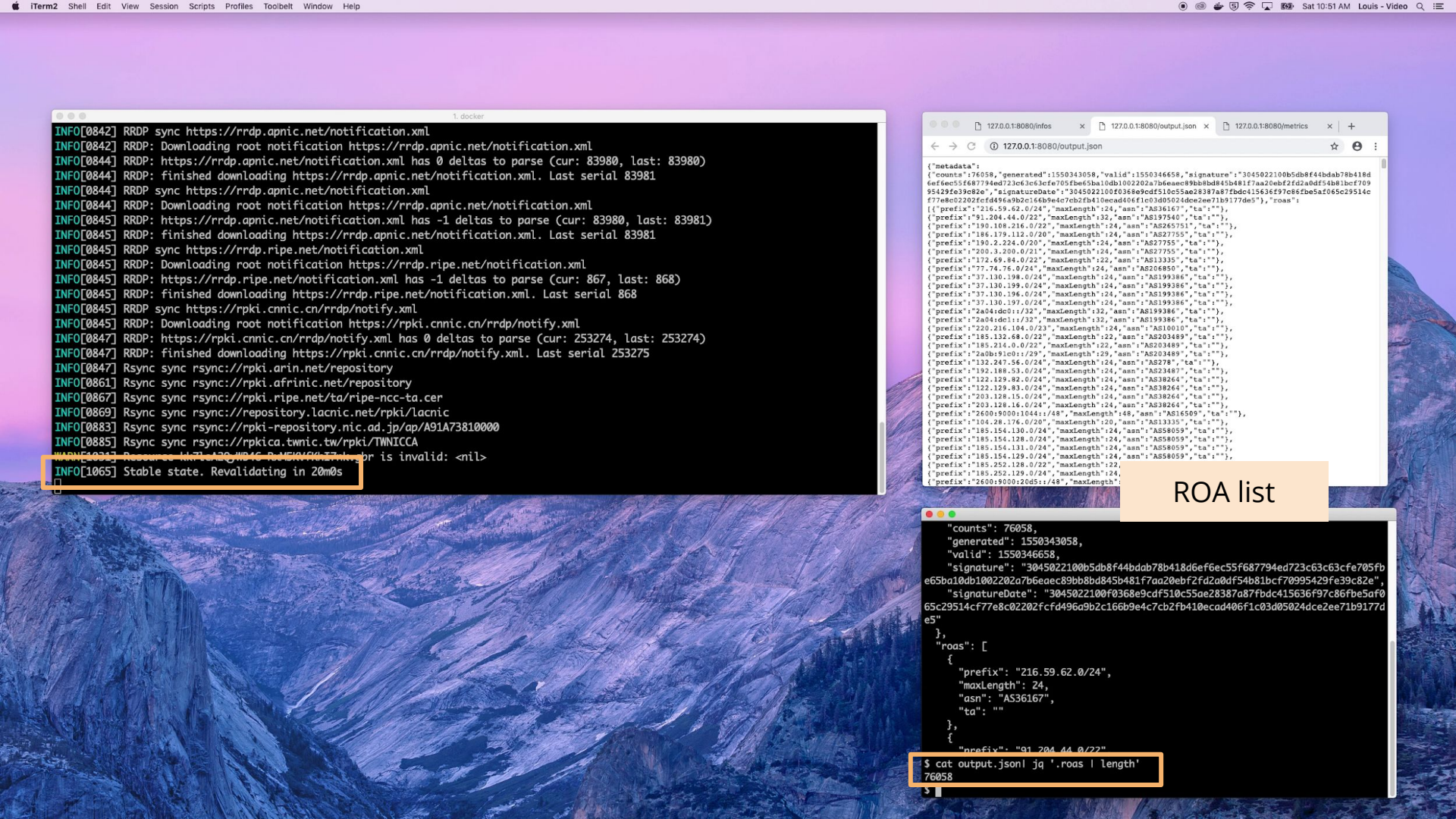

Chrome File Edit View History Bookmarks People Window Help
Sat 10:38 AM Louis - Video
1. docker
INFO[0002] Rsync sync rsync://rpki.arin.net/repository/arin-rpki-ta.cer
INFO[0002] Rsync sync rsync://rpki.ripe.net/ta/ripe-ncc-ta.cer
INFO[0004] Rsync sync rsync://repository.lacnic.net/rpki/lacnic/rta-lacnic-rpki.cer
INFO[0007] Rsync sync rsync://rpki.afrinic.net/repository/AfriNIC.cer
ERRO[0012] Error exploring file: open cache/rpki.afrinic.net/repository/04E8B0D80F4D11E0B657D8931367AE7D/6ZgPOPXWxxu0sQa4vQZYUBLaMbY.mft: no such file or directory
ERRO[0012] Error exploring file: open cache/rpki.apnic.net/repository/838DB214166511E2B3BC286172FD1FF2/C5zKkN0Neoo3ZmsZIX_g2EA3t6I.mft: no such file or directory
ERRO[0012] Error exploring file: open cache/rpki.arin.net/repository/arin-rpki-ta/arin-rpki-ta.mft: no such file or directory
ERRO[0012] Error exploring file: open cache/repository.lacnic.net/rpki/lacnic/rta-lacnic-rpki.mft: no such file or directory
ERRO[0012] Error exploring file: open cache/rpki.ripe.net/repository/ripe-ncc-ta.mft: no such file or directory
INFO[0012] Still exploring. Revalidating now
INFO[0012] RRDP sync https://rrdp.apnic.net/notification.xml
INFO[0012] RRDP: Downloading root notification https://rrdp.apnic.net/notification.xml
INFO[0014] RRDP: https://rrdp.apnic.net/notification.xml Downloading snapshot at: https://rrdp.apnic.net/fa64523b-7381-4fda-9eb9-b1233b30f503/83968/snapshot.xml
INFO[0064] RRDP sync https://rrdp.ripe.net/notification.xml
INFO[0064] RRDP: Downloading root notification https://rrdp.ripe.net/notification.xml
INFO[0064] RRDP: https://rrdp.ripe.net/notification.xml Downloading snapshot at: https://rrdp.ripe.net/8ab7553b-b124-4717-b20c-105ada07476c/866/snapshot.xml
INFO[0177] Rsync sync rsync://repository.lacnic.net/rpki/lacnic
INFO[0241] Rsync sync rsync://rpki.arin.net/repository
INFO[0298] Rsync sync rsync://rpki.afrinic.net/repository
INFO[0309] Rsync sync rsync://rpki.apnic.net/repository
Validator
127.0.0.1:8080/infos
127.0.0.1:8080/output.json
127.0.0.1:8080/infos
"uri": "rsync://repository.lacnic.net/rpki/lacnic/rta-lacnic-rpki.cer",
"file-count": 1,
"iteration": 1,
"errors": 0,
"duration": 2.9613296,
"last-fetch": 1550342002
"uri": "rsync://rpki.afrinic.net/repository/AfriNIC.cer",
"file-count": 1,
"iteration": 1,
"errors": 0,
"duration": 4.3905323,
"last-fetch": 1550342006
"sias-rrdp": [
"uri": "https://rrdp.apnic.net/notification.xml",
"file-count": 6734,
"iteration": 1,
"errors": 0,
"duration": 52.0518939,
"last-fetch": 15503420590,
"rrdp-serial": 83968,
"rrdp-sessionid": "fa64523b-7381-4fda-9eb9-b1233b30f503",
"rrdp-last-file": "https://rrdp.apnic.net/fa64523b-7381-4fda-9eb9-b1233b30f503/83968/snapshot.xml"
API
$


iTerm2 Shell Edit View Session Scripts Profiles Toolbelt Window Help
Sat 10:51 AM Louis - Video
1. docker
INFO[0842] RRDP sync https://rrdp.apnic.net/notification.xml
INFO[0842] RRDP: Downloading root notification https://rrdp.apnic.net/notification.xml
INFO[0844] RRDP: https://rrdp.apnic.net/notification.xml has 0 deltas to parse (cur: 83980, last: 83980)
INFO[0844] RRDP: finished downloading https://rrdp.apnic.net/notification.xml. Last serial 83981
INFO[0844] RRDP sync https://rrdp.apnic.net/notification.xml
INFO[0844] RRDP: Downloading root notification https://rrdp.apnic.net/notification.xml
INFO[0845] RRDP: https://rrdp.apnic.net/notification.xml has -1 deltas to parse (cur: 83980, last: 83981)
INFO[0845] RRDP: finished downloading https://rrdp.apnic.net/notification.xml. Last serial 83981
INFO[0845] RRDP sync https://rrdp.ripe.net/notification.xml
INFO[0845] RRDP: Downloading root notification https://rrdp.ripe.net/notification.xml
INFO[0845] RRDP: https://rrdp.ripe.net/notification.xml has -1 deltas to parse (cur: 867, last: 868)
INFO[0845] RRDP: finished downloading https://rrdp.ripe.net/notification.xml. Last serial 868
INFO[0845] RRDP sync https://rpki.cnnic.cn/rrdp/notify.xml
INFO[0845] RRDP: Downloading root notification https://rpki.cnnic.cn/rrdp/notify.xml
INFO[0847] RRDP: https://rpki.cnnic.cn/rrdp/notify.xml has 0 deltas to parse (cur: 253274, last: 253274)
INFO[0847] RRDP: finished downloading https://rpki.cnnic.cn/rrdp/notify.xml. Last serial 253275
INFO[0847] Rsync sync rsync://rpki.arin.net/repository
INFO[0861] Rsync sync rsync://rpki.afrinic.net/repository
INFO[0867] Rsync sync rsync://rpki.ripe.net/ta/ripe-ncc-ta.cer
INFO[0869] Rsync sync rsync://repository.lacnic.net/rpki/lacnic
INFO[0883] Rsync sync rsync://rpki-repository.nic.ad.jp/ap/ap/A91A73810000
INFO[0885] Rsync sync rsync://rpkica.twnic.tw/rpki/TWNICCA
is invalid: <nil>
INFO[1065] Stable state. Revalidating in 20m0s
127.0.0.1:8080/infos
127.0.0.1:8080/output.json
127.0.0.1:8080/metrics
127.0.0.1:8080/output.json
{"metadata":
{"counts":76058,"generated":1550343058,"valid":1550346658,"signature":"3045022100b5db8f44bdab78b418d6ef6ec55f687794ed723c63c63cfe705fbe65ba10db1002202a7b6eaec89bb8bd845b481f7aa20ebf2fd2a0df54b81bcf70995429fe39c82e","signatureDate":"3045022100f0368e9cdf510c55ae28387a87fbdc415636f97c86fbe5af065c29514cf77e8c02202fcfd496a9b2c166b9e4c7cb2fb410ecad406f1c03d05024dce2ee71b9177de5"},"roas":
[{"prefix":"216.59.62.0/24","maxLength":24,"asn":"AS36167","ta":""},
{"prefix":"91.204.44.0/22","maxLength":32,"asn":"AS197540","ta":""},
{"prefix":"190.108.216.0/22","maxLength":24,"asn":"AS265751","ta":""},
{"prefix":"186.179.112.0/20","maxLength":24,"asn":"AS27755","ta":""},
{"prefix":"190.2.224.0/20","maxLength":24,"asn":"AS27755","ta":""},
{"prefix":"200.3.200.0/21","maxLength":24,"asn":"AS27755","ta":""},
{"prefix":"172.69.84.0/22","maxLength":22,"asn":"AS13335","ta":""},
{"prefix":"77.74.76.0/24","maxLength":24,"asn":"AS206850","ta":""},
{"prefix":"37.130.198.0/24","maxLength":24,"asn":"AS199386","ta":""},
{"prefix":"37.130.199.0/24","maxLength":24,"asn":"AS199386","ta":""},
{"prefix":"37.130.196.0/24","maxLength":24,"asn":"AS199386","ta":""},
{"prefix":"37.130.197.0/24","maxLength":24,"asn":"AS199386","ta":""},
{"prefix":"2a04:dc0::/32","maxLength":32,"asn":"AS199386","ta":""},
{"prefix":"2a04:dc1::/32","maxLength":32,"asn":"AS199386","ta":""},
{"prefix":"220.216.104.0/23","maxLength":24,"asn":"AS10010","ta":""},
{"prefix":"185.132.68.0/22","maxLength":22,"asn":"AS203489","ta":""},
{"prefix":"185.214.0.0/22","maxLength":22,"asn":"AS203489","ta":""},
{"prefix":"2a0b:91c0::/29","maxLength":29,"asn":"AS203489","ta":""},
{"prefix":"132.247.56.0/24","maxLength":24,"asn":"AS278","ta":""},
{"prefix":"192.188.53.0/24","maxLength":24,"asn":"AS23487","ta":""},
{"prefix":"122.129.82.0/24","maxLength":24,"asn":"AS38264","ta":""},
{"prefix":"122.129.83.0/24","maxLength":24,"asn":"AS38264","ta":""},
{"prefix":"203.128.15.0/24","maxLength":24,"asn":"AS38264","ta":""},
{"prefix":"203.128.16.0/24","maxLength":24,"asn":"AS38264","ta":""},
{"prefix":"2600:9000:1044::/48","maxLength":48,"asn":"AS16509","ta":""},
{"prefix":"104.28.176.0/20","maxLength":20,"asn":"AS13335","ta":""},
{"prefix":"185.154.130.0/24","maxLength":24,"asn":"AS58059","ta":""},
{"prefix":"185.154.128.0/24","maxLength":24,"asn":"AS58059","ta":""},
{"prefix":"185.154.131.0/24","maxLength":24,"asn":"AS58059","ta":""},
{"prefix":"185.154.129.0/24","maxLength":24,"asn":"AS58059","ta":""},
{"prefix":"185.252.128.0/22","maxLength":22,
{"prefix":"185.252.129.0/24","maxLength":24,
{"prefix":"2600:9000:20d5::/48","maxLength"
ROA list
"counts": 76058,
"generated": 1550343058,
"valid": 1550346658,
"signature": "3045022100b5db8f44bdab78b418d6ef6ec55f687794ed723c63c63cfe705fbe65ba10db1002202a7b6eaec89bb8bd845b481f7aa20ebf2fd2a0df54b81bcf70995429fe39c82e",
"signatureDate": "3045022100f0368e9cdf510c55ae28387a87fbdc415636f97c86fbe5af065c29514cf77e8c02202fcfd496a9b2c166b9e4c7cb2fb410ecad406f1c03d05024dce2ee71b9177de5"
},
"roas": [
{
"prefix": "216.59.62.0/24",
"maxLength": 24,
"asn": "AS36167",
"ta": ""
},
{
"prefix": "91.204.44.0/22"
$ cat output.json| jq '.roas | length'
76058
$

OctoRPKI - Demo (videos)

Real-time:

https://www.youtube.com/watch?v=yykkoZxz6gE

Speed-up:

https://www.youtube.com/watch?v=OQwtf2m2hxU

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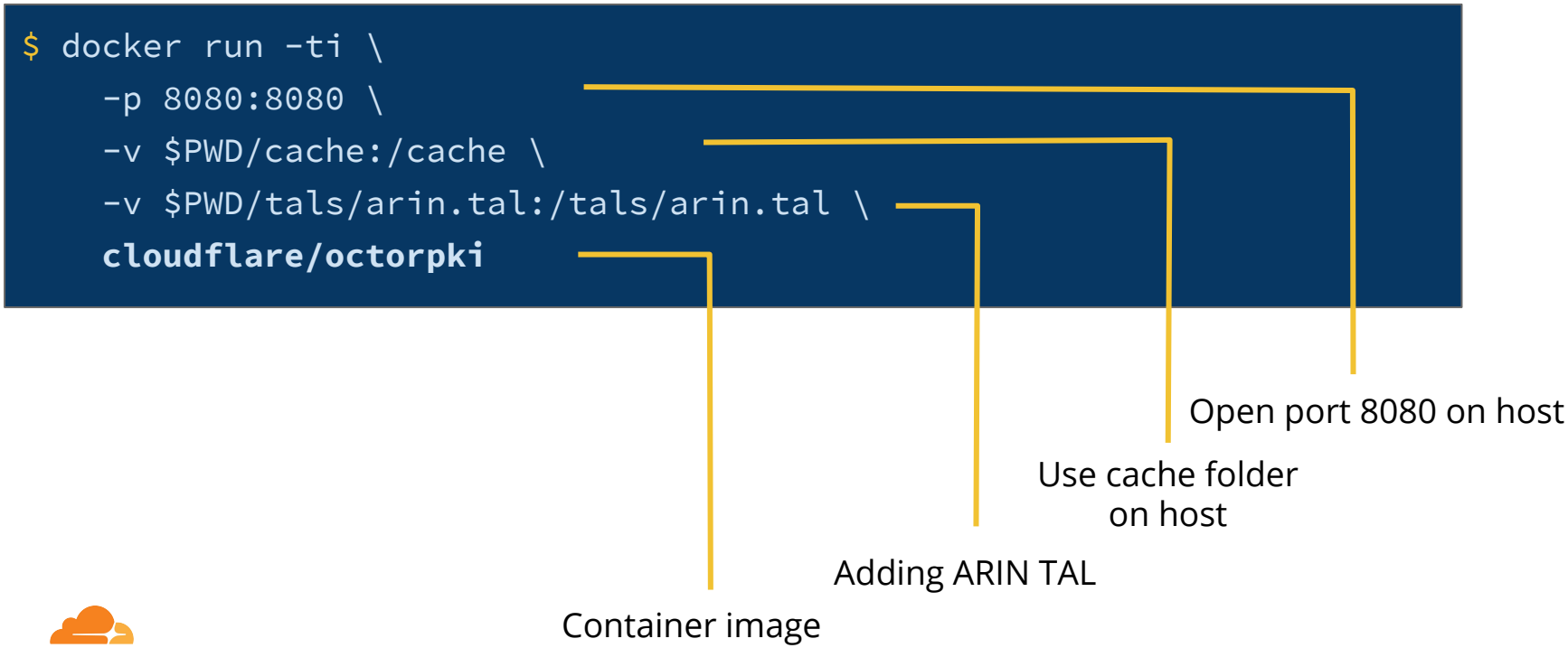
OctoRPKI - Run it yourself

```
$ docker run -ti \
    -p 8080:8080 \
    -v $PWD/cache:/cache \
    -v $PWD/tals/arin.tal:/tals/arin.tal \
    cloudflare/octorpki
```



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GoRTR

OctoRPKI does not embed a RTR server. Modular and independence!

Fully compatible with **GoRTR** https://github.com/cloudflare/gortr

Signs the prefix list to ensure a safe distribution of the file.

Can run natively on Juniper!

```
$ docker run -ti \
    -p 8082:8082 \
    -v $PWD/example.pub:/example.pub \
    cloudflare/gortr \
      -verify.key /example.pub \
      -cache https://YOUR_ROA_URL
```

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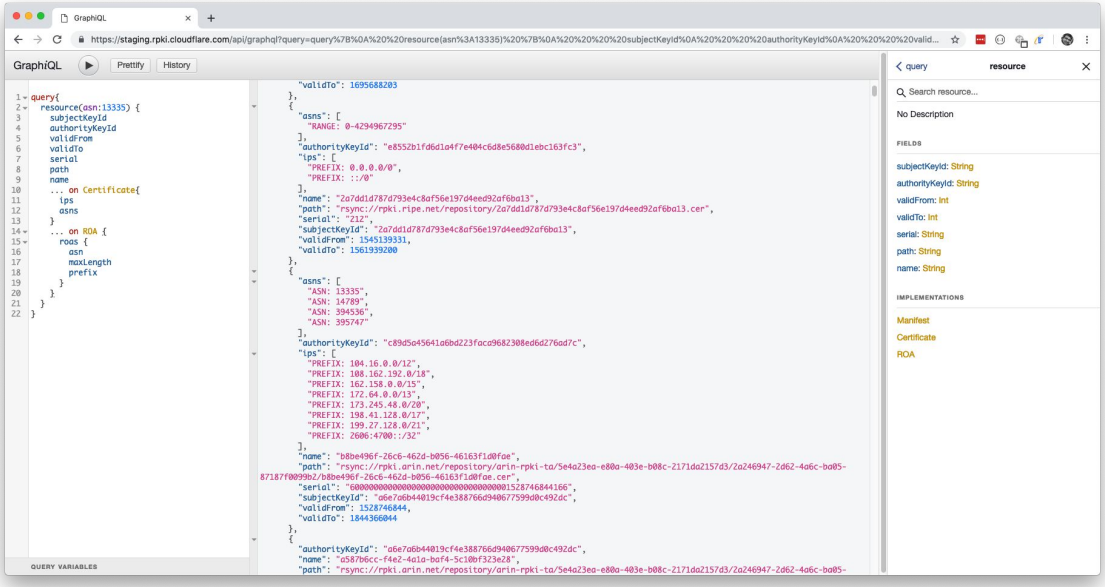
Cloudflare's Internal Version

Is providing:

https://rpki.cloudflare.com/rpki.json

But also a **GraphQL** API



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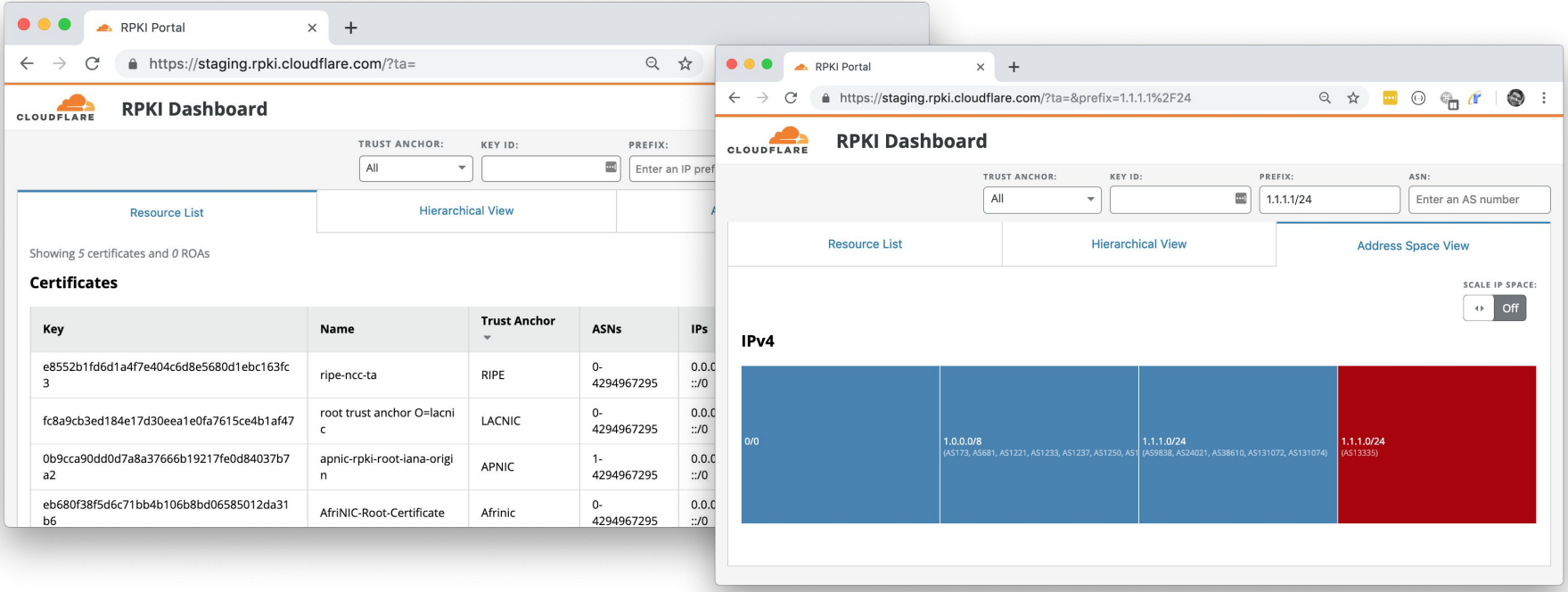
Dashboard preview



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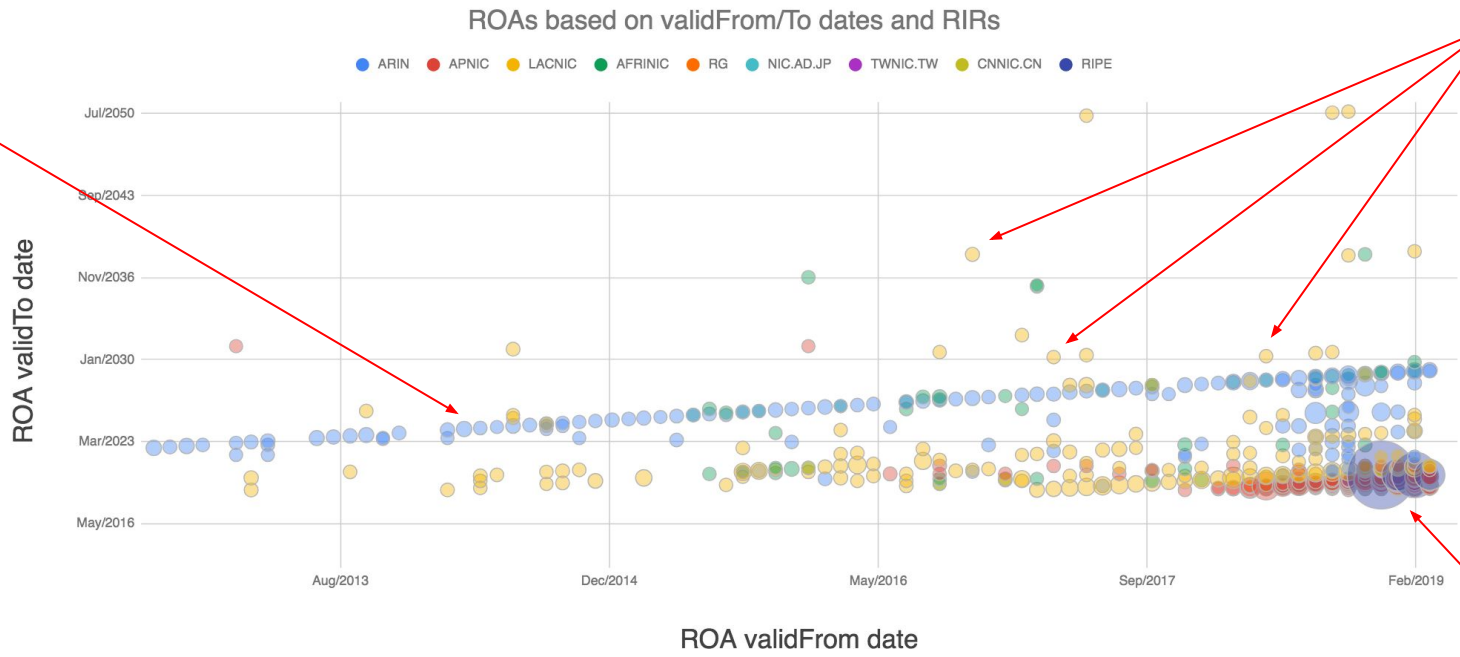
Other data - so how fresh are those ROAs?

ARIN uses ten year expire

LACNIC random expires



RIPE regenerates certificates!

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Future projects or ideas

RPKI validation tester using our CDN:

- Using a /23 (/47 IPv4) valid and a /24 (/48 IPv6) invalid

Certificate encoder

ASPA

More toolings and visualizations around RPKI (BGP collection)

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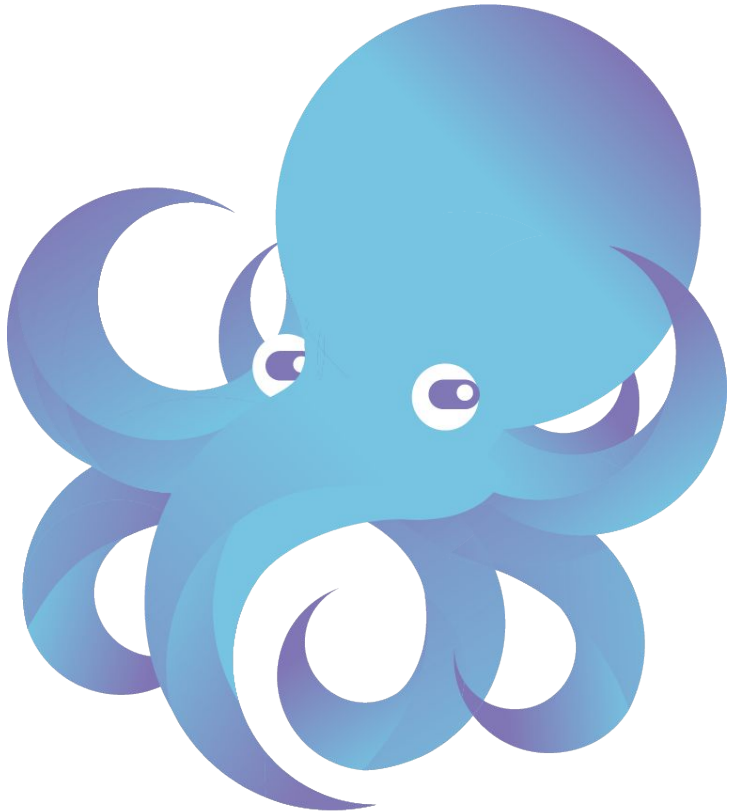
Thank you

Questions?

louis@cloudflare.com
@lpoinsig (twitter)



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