RPKI-Based Origin Validation, Routers, & Caches

AfNOG / Lusaka
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Agenda

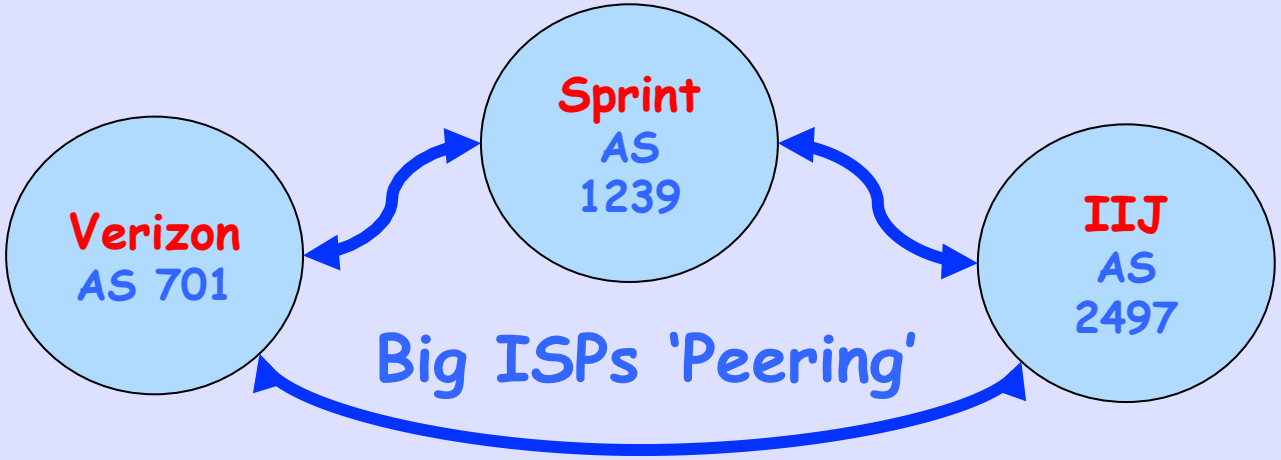
- Some Technical Background
- Mis-Origination - YouTube Incident
- The RPKI – Needed Infrastructure
- RPKI-Based Origin Validation
- Use the GUI to make ROAs and look at the result on a router
- Build Your Own RPKI Cache
- Discussion

This is Not New

- 1986 – Bellovin & Perlman identify the vulnerability in DNS and Routing
- 1999 - National Academies study called it out
- 2000 – S-BGP – X.509 PKI to support Secure BGP - Kent, Lynn, et al.
- 2003 – NANOG S-BGP Workshop
- 2006 – RPKI.NET(for ARIN) & APNIC start work on RPKI. RIPE starts in 2008.
- 2009 – RPKI.NET Open Testbed and running code in test routers

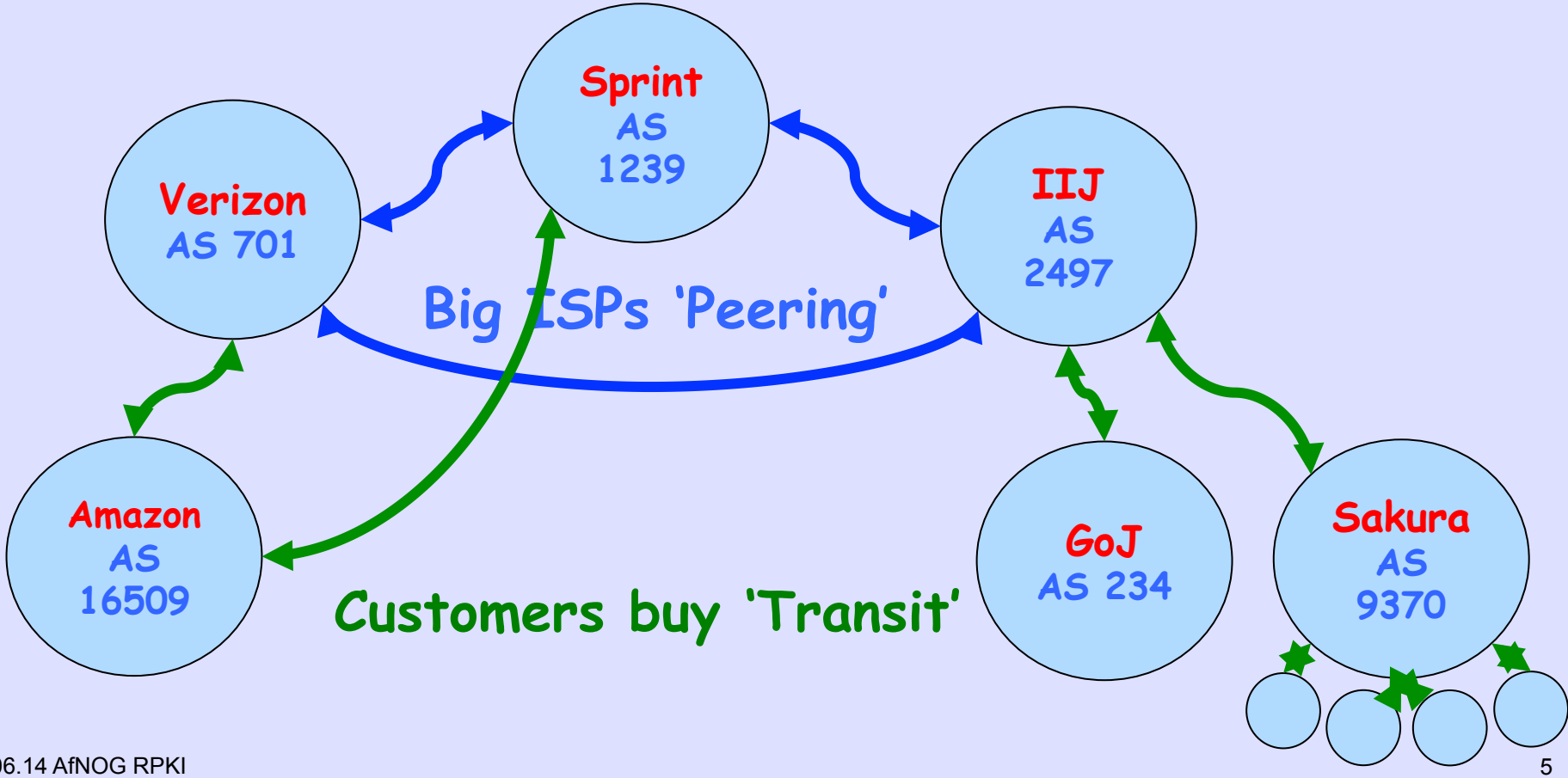
What is an AS?

An ISP or End Site

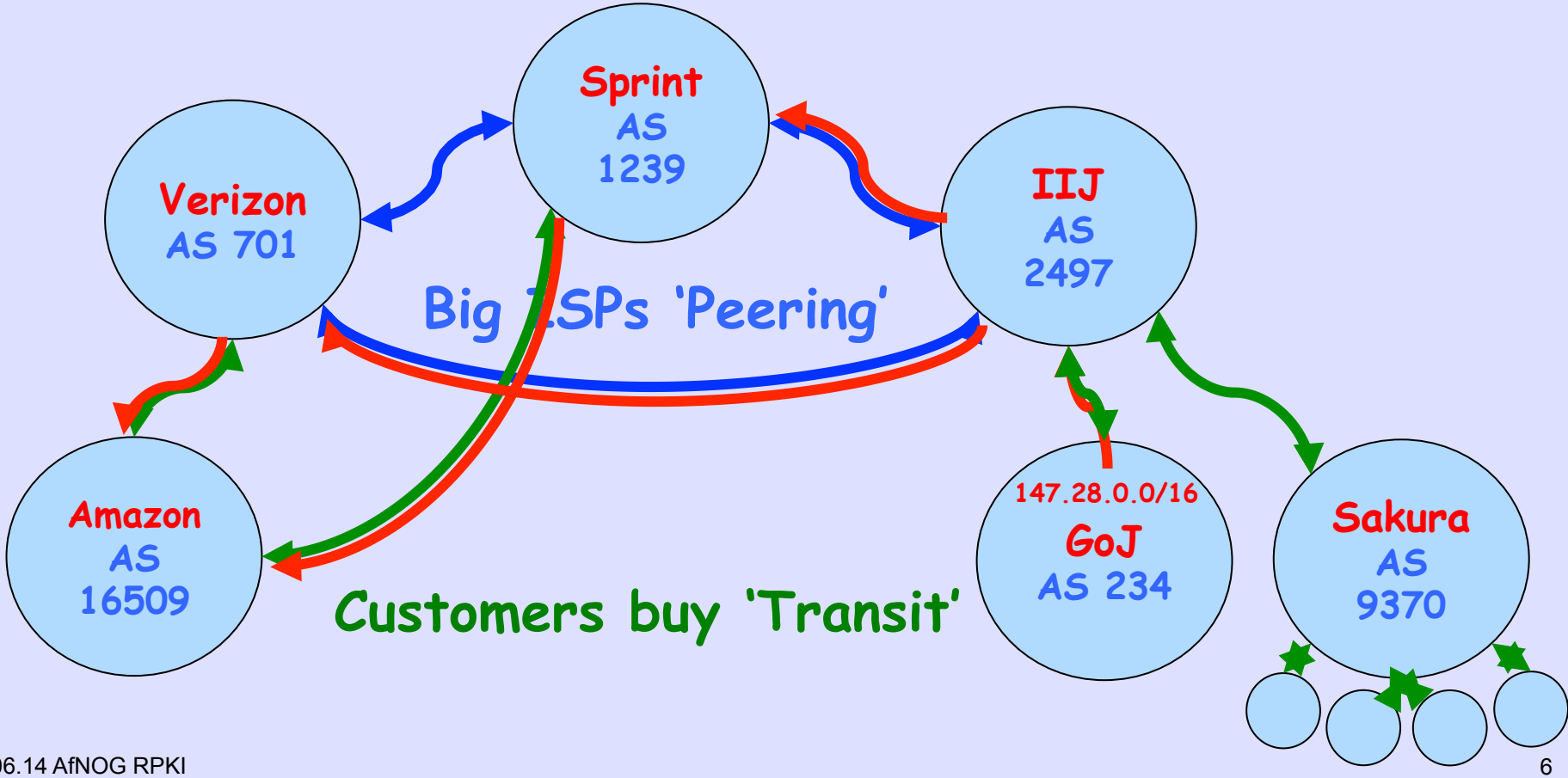


What is an AS?

An ISP or End Site



An IP Prefix is Announced & Propagated



From Inside a Router

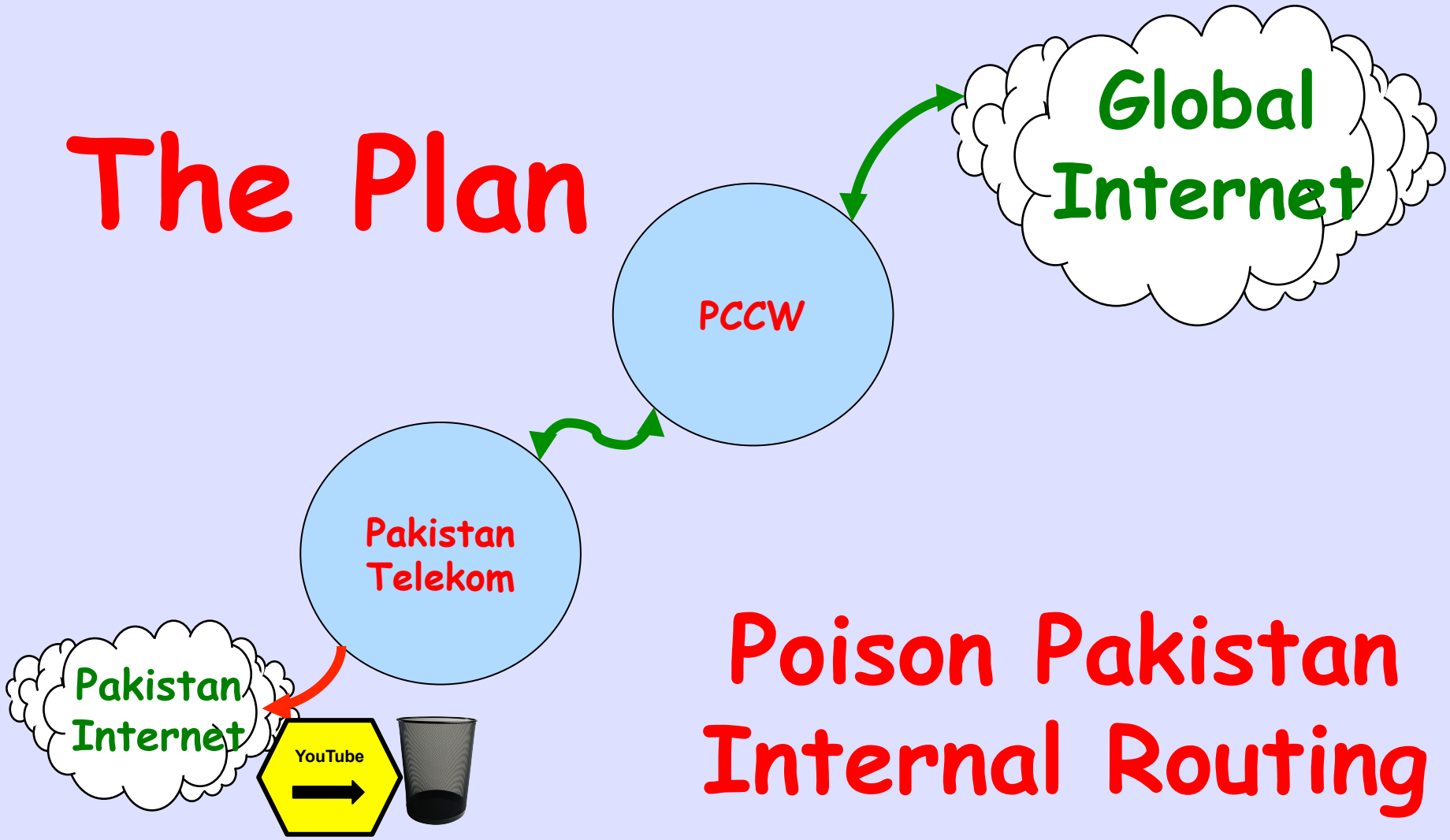
BGP routing table entry for 147.28.0.0/16

Of Course it's Uglier ☺

```
r1.iad#sh ip bgp 147.28.0.0/16
BGP routing table entry for 147.28.0.0/16, version 21440610
Paths: (2 available, best #1, table default)
  Advertised to update-groups:
     1
  Refresh Epoch 1
  16509   1239   2497   234
    144.232.18.81 from 144.232.18.81 (144.228.241.254)
      Origin IGP, metric 841, localpref 100, valid, external, best
      Community: 3297:100 3927:380
      path 67E8FFCC RPKI State valid
  Refresh Epoch 1
  16509   701  2497   234
    129.250.10.157 (metric 11) from 198.180.150.253 (198.180.150.253)
      Origin IGP, metric 95, localpref 100, valid, internal
      Community: 2914:410 2914:1007 2914:2000 2914:3000 3927:380
      path 699A867C RPKI State valid
```

The YouTube Incident

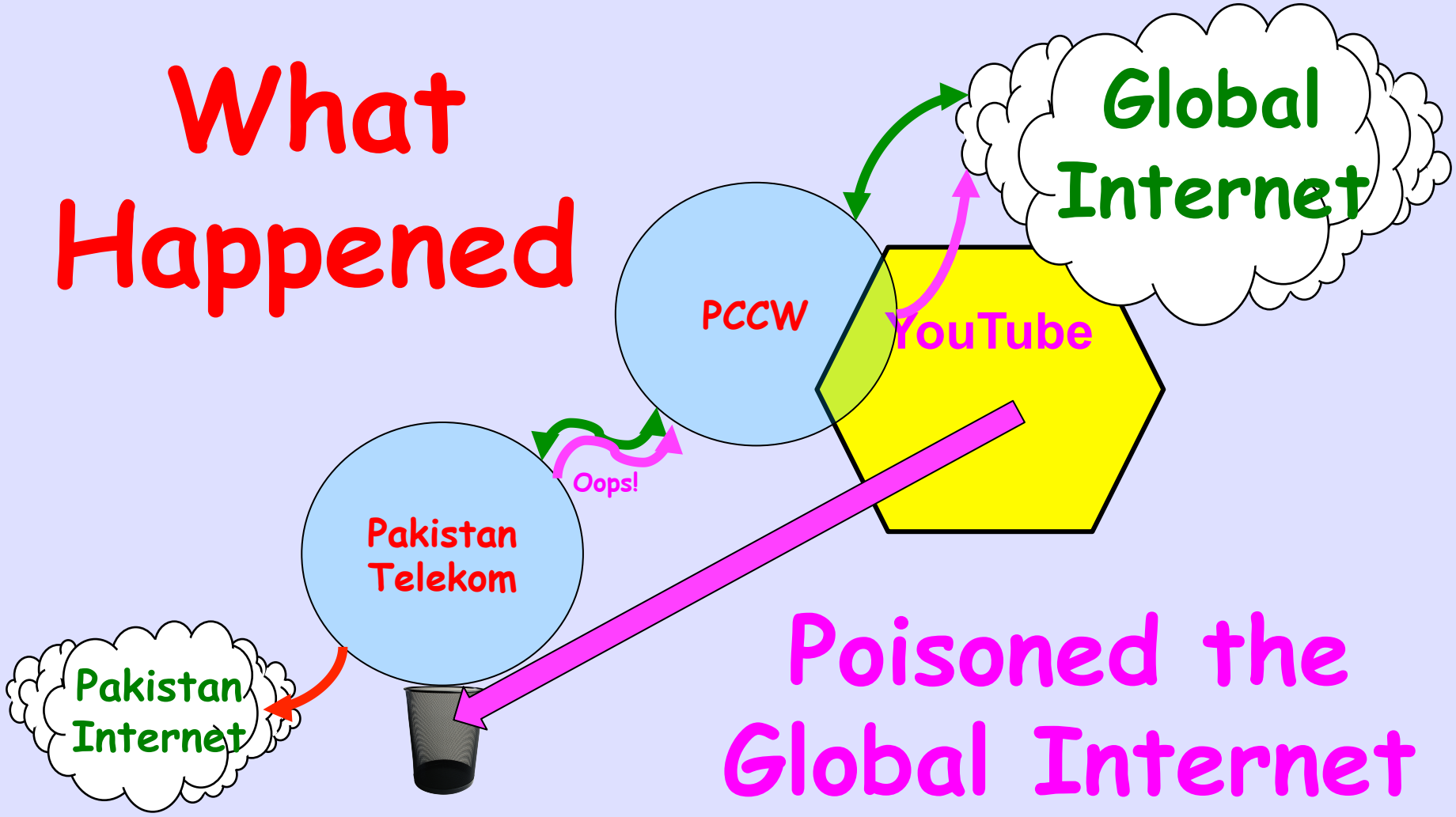
The Plan



Poison Pakistan Internal Routing

The YouTube Incident

What Happened



Poisoned the Global Internet

We Call this *Mis-Origination*

a Prefix is Originated by an AS Which Does Not Own It

I Do Not Call it *Hijacking*

Because that *Assumes* Negative Intent

And These Accidents Happen Every Day

Usually to Small Folk Sometimes to Large

So,

What's the Plan?

Three Pieces

- **RPKI** – Resource Public Key Infrastructure, the Certificate Infrastructure to Support the other Pieces (deployed at all RIRs)
- **Origin Validation** – Using the RPKI to detect and prevent mis-originations of someone else's prefixes (in deployment)
- **AS-Path Validation** AKA **BGPsec** – Prevent Path Attacks on BGP (future work)

Why Origin Validation?

- Prevent YouTube accident & Far Worse
- Prevent 7007 accident, UU/Sprint 2 days!
- Prevents most accidental announcements
- Does not prevent malicious path attacks such as the Kapela/Pilosov DefCon attack
- That requires *Path Validation*, the third step, a few years away

We Need to be Able to Authoritatively Prove Who Owns an IP Prefix And What AS(s) May Announce It

Prefix Ownership Follows the Allocation Hierarchy

IANA, RIRs, ISPs, …

X.509-Based IP Resource PKI

RFCs Have Been Long Published

Deployed by All RIRs

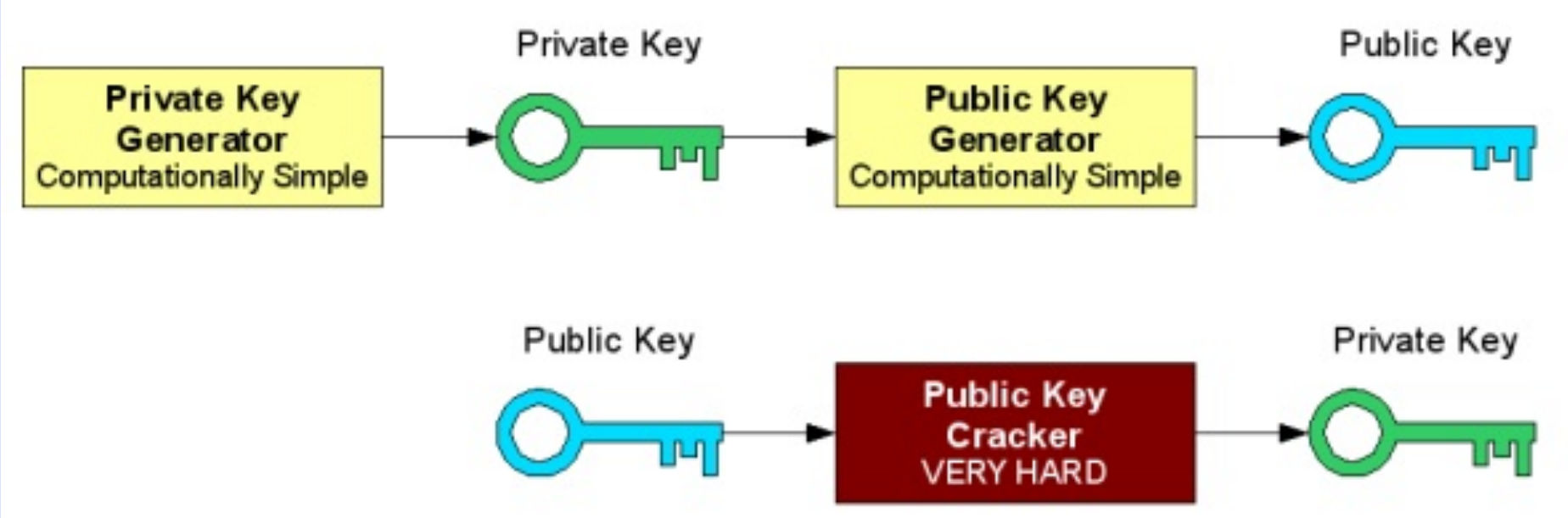
ROAs Registered by > 1,000 Operators

In Live Routers

Public-Key Concepts

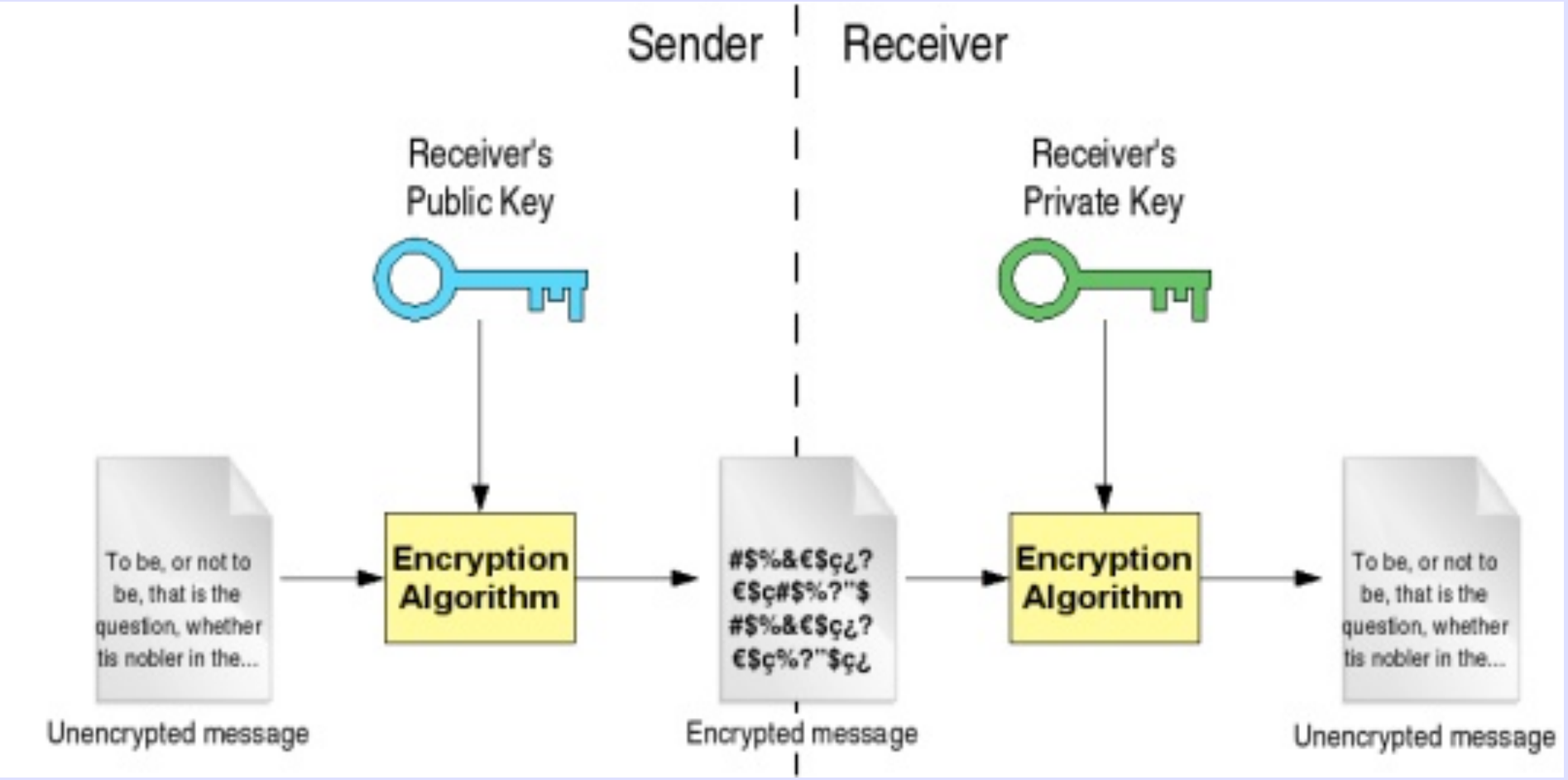
- **Private key**: This key must be known *only* by its owner.
- **Public key**: This key is known to everyone (it is *public*)
- **Relation between both keys**: What one key encrypts, the other one decrypts, and vice versa. That means that if you encrypt something with my public key (which you would know, because it's public :-), I would need my private key to decrypt the message.

Key Generation

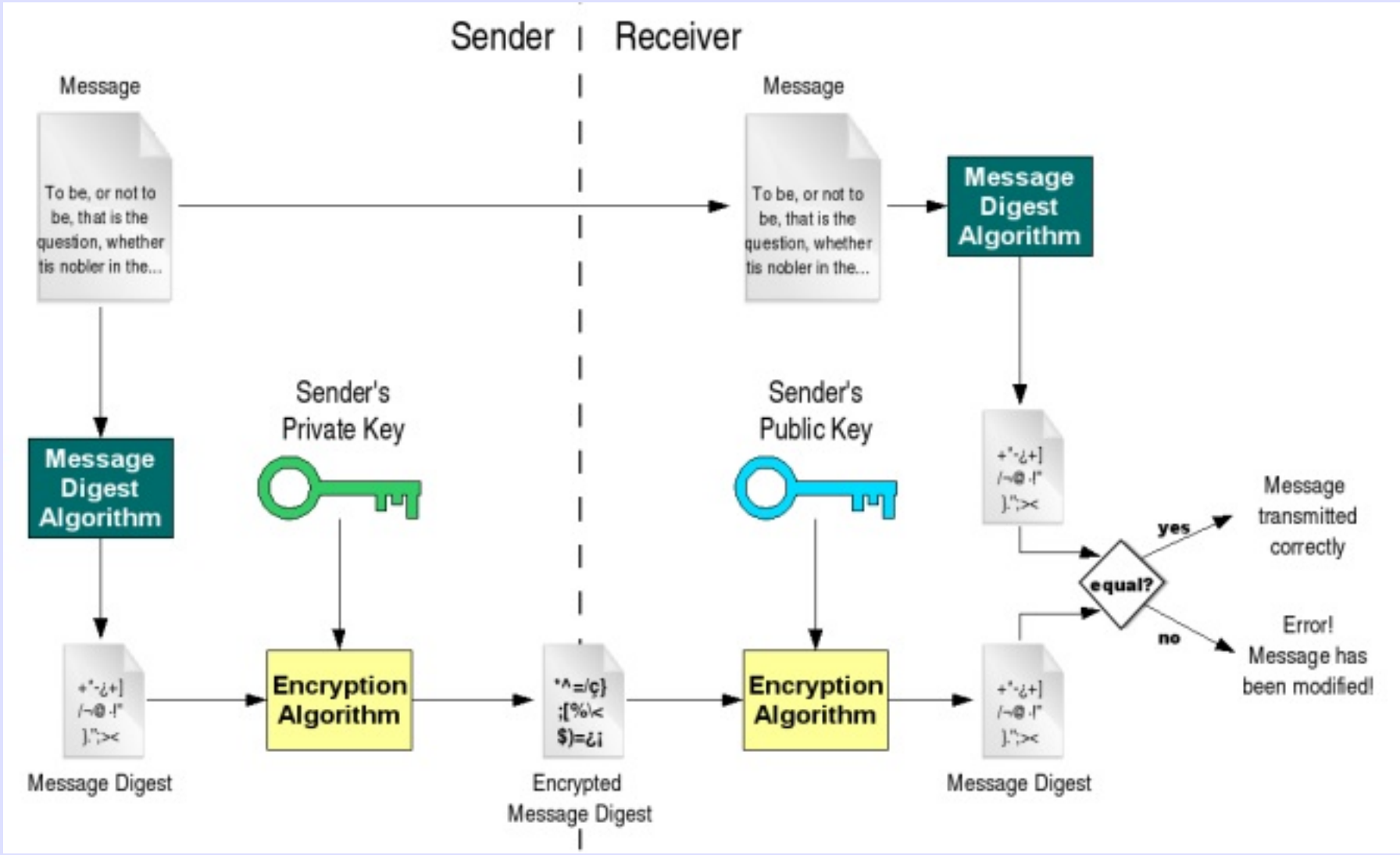


Stolen from - http://gdp.globus.org/gt4-tutorial/multiplehtml/ch09s03.html

En/DeCryption

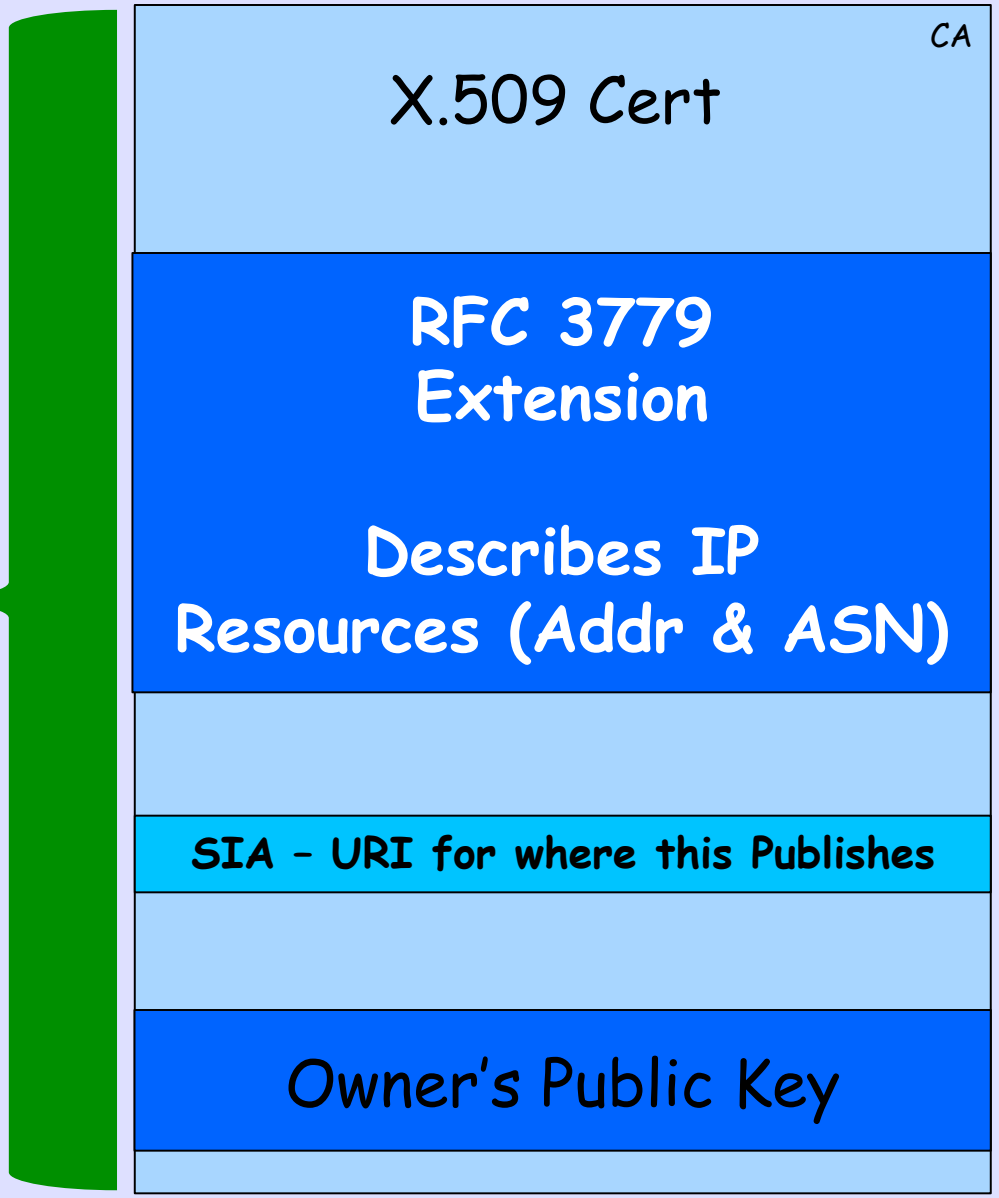


Digital Signature

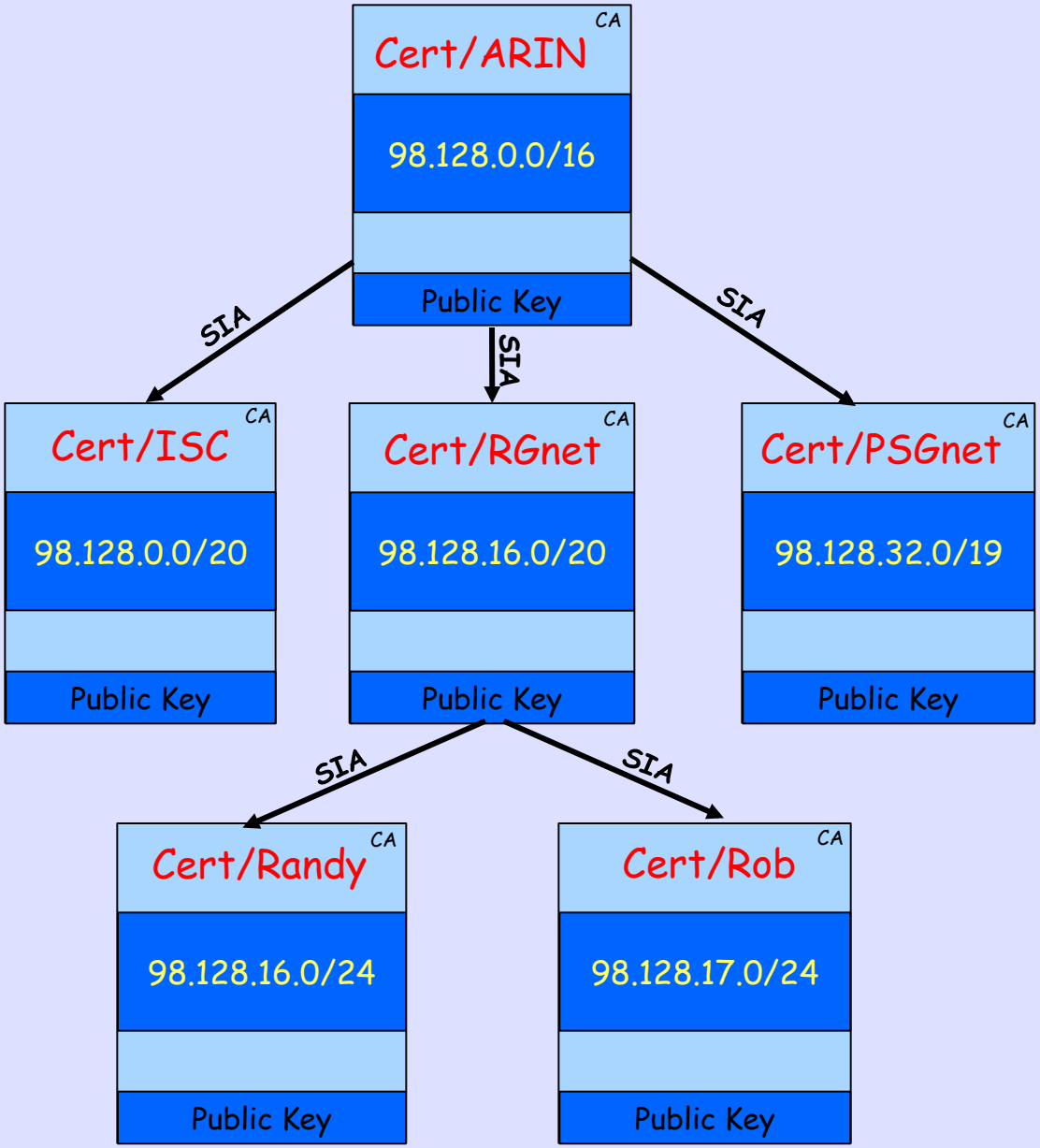


X.509 Certificate w/ 3779 Ext

Signed by Parent's Private Key

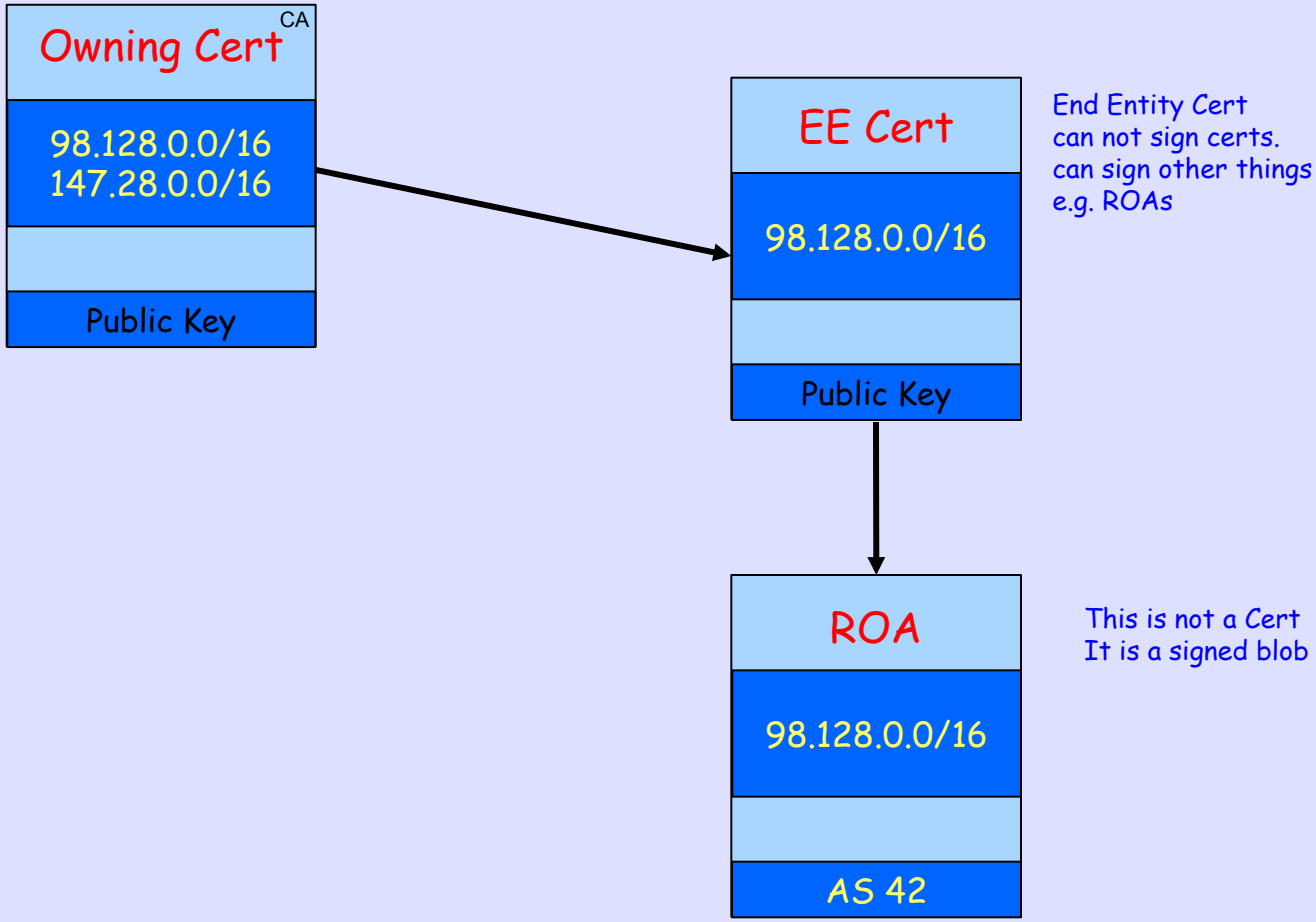


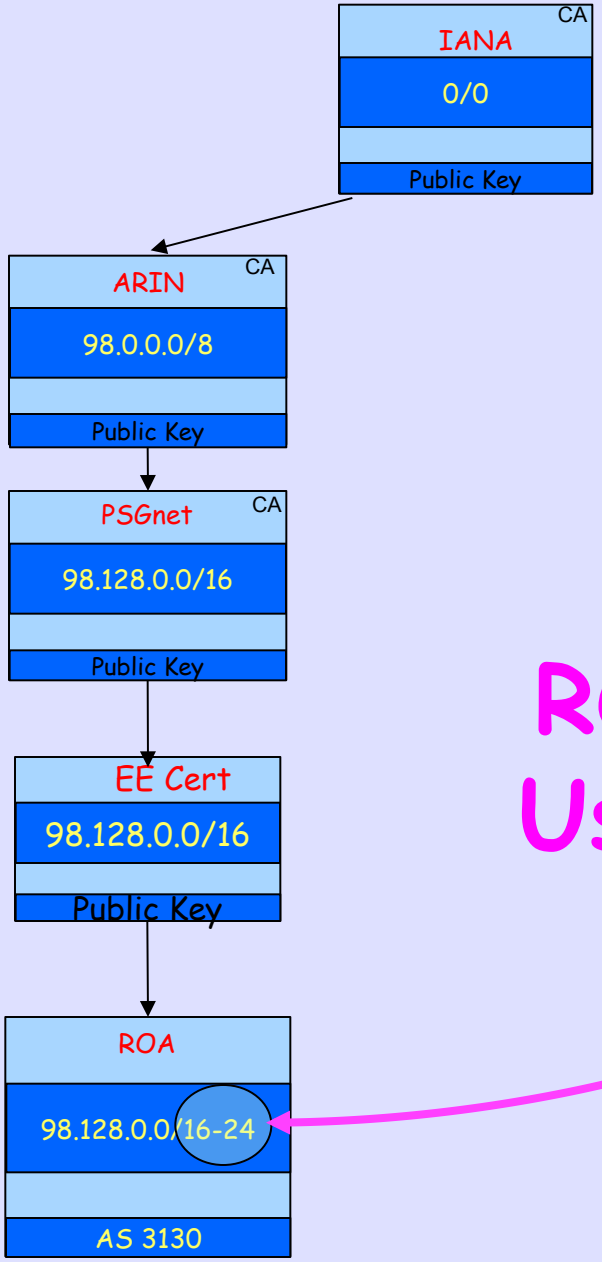
Certificate Hierarchy follows Allocation Hierarchy



That's Who Owns It
but
Who May Route It?

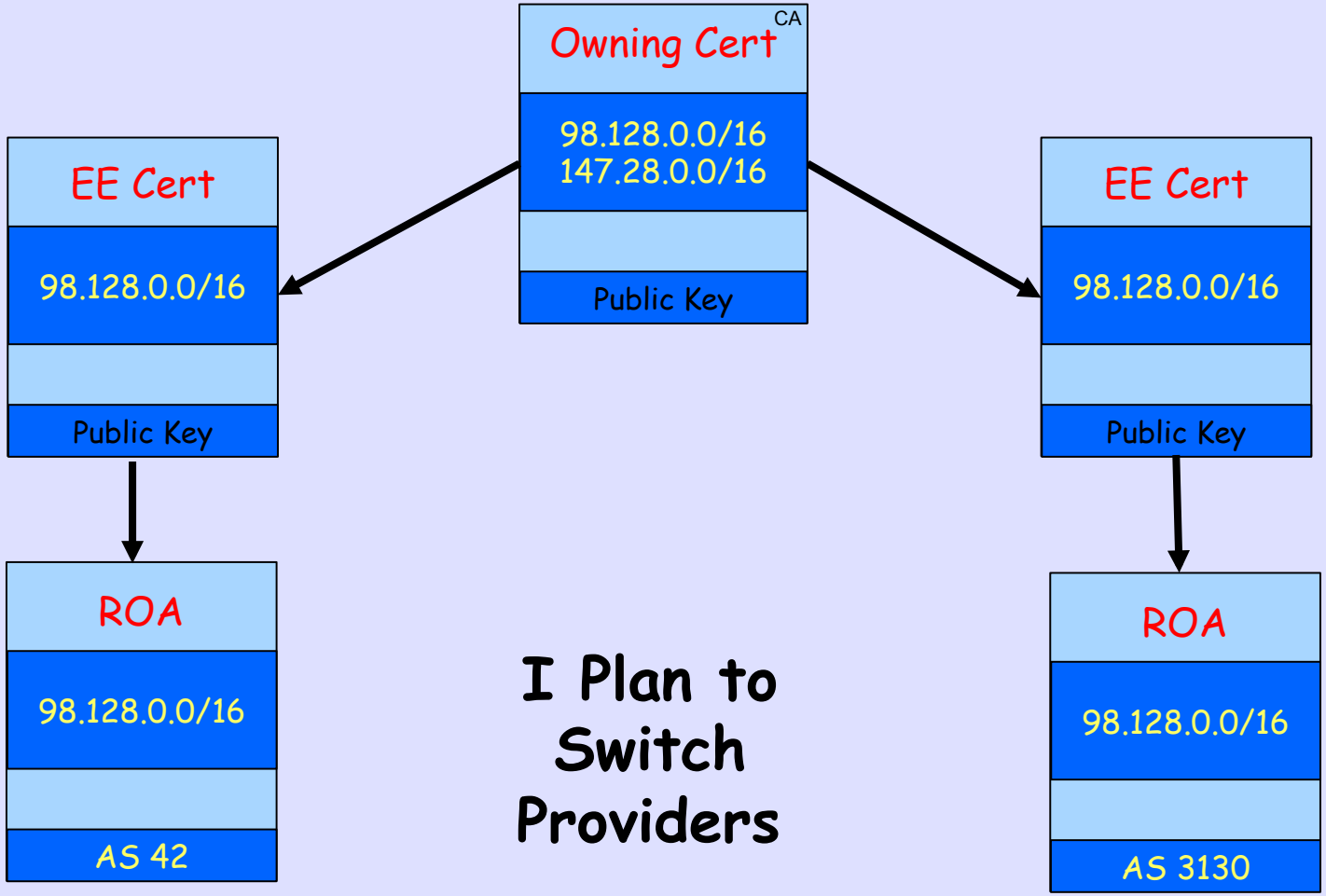
Route Origin Authorization (ROA)



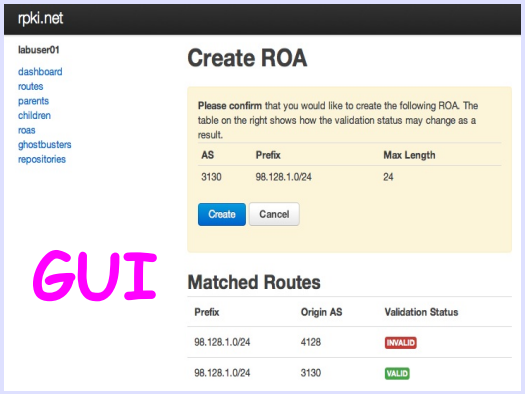


ROA Aggregation Using Max Length

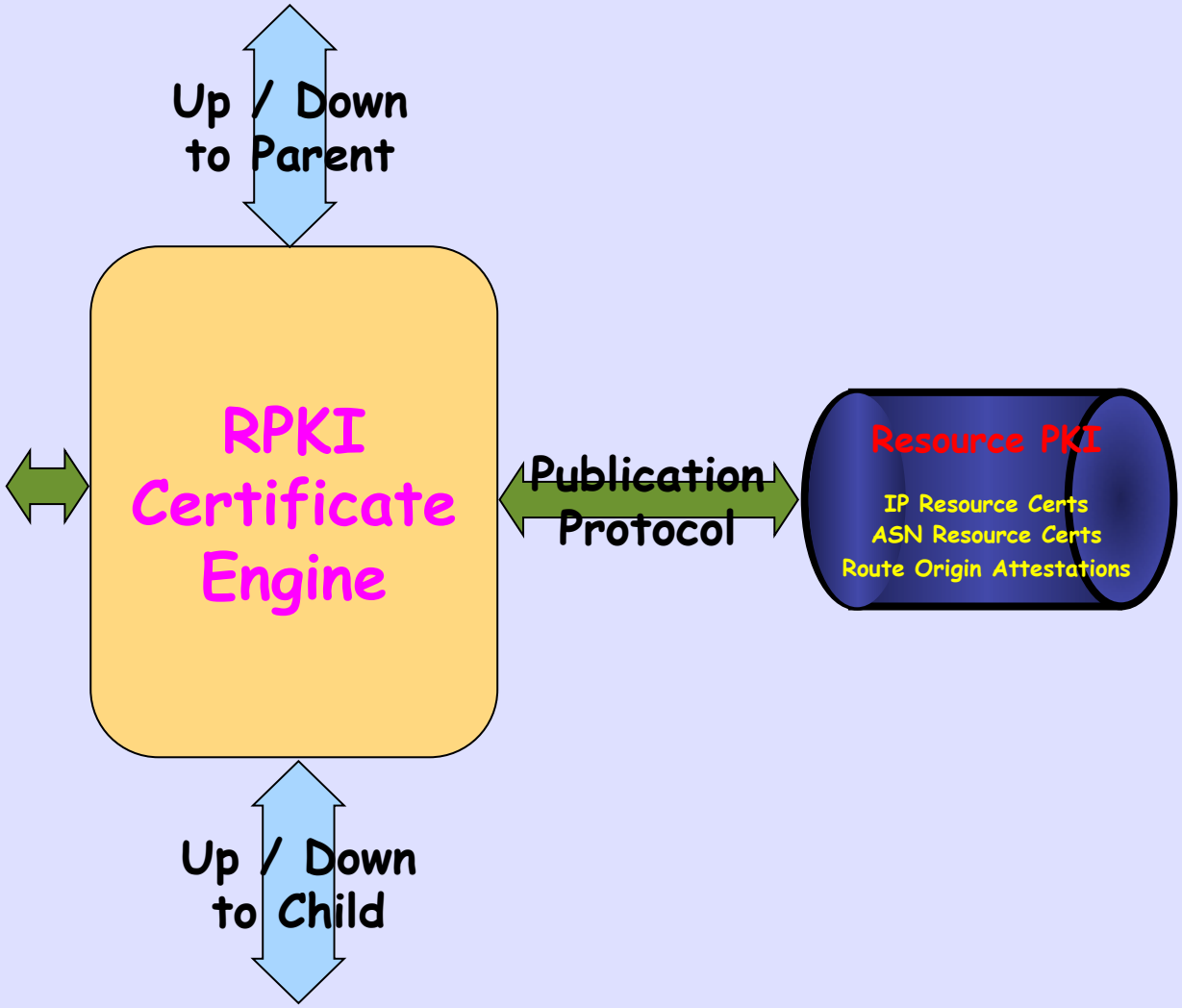
Multiple ROAs Make Before Break



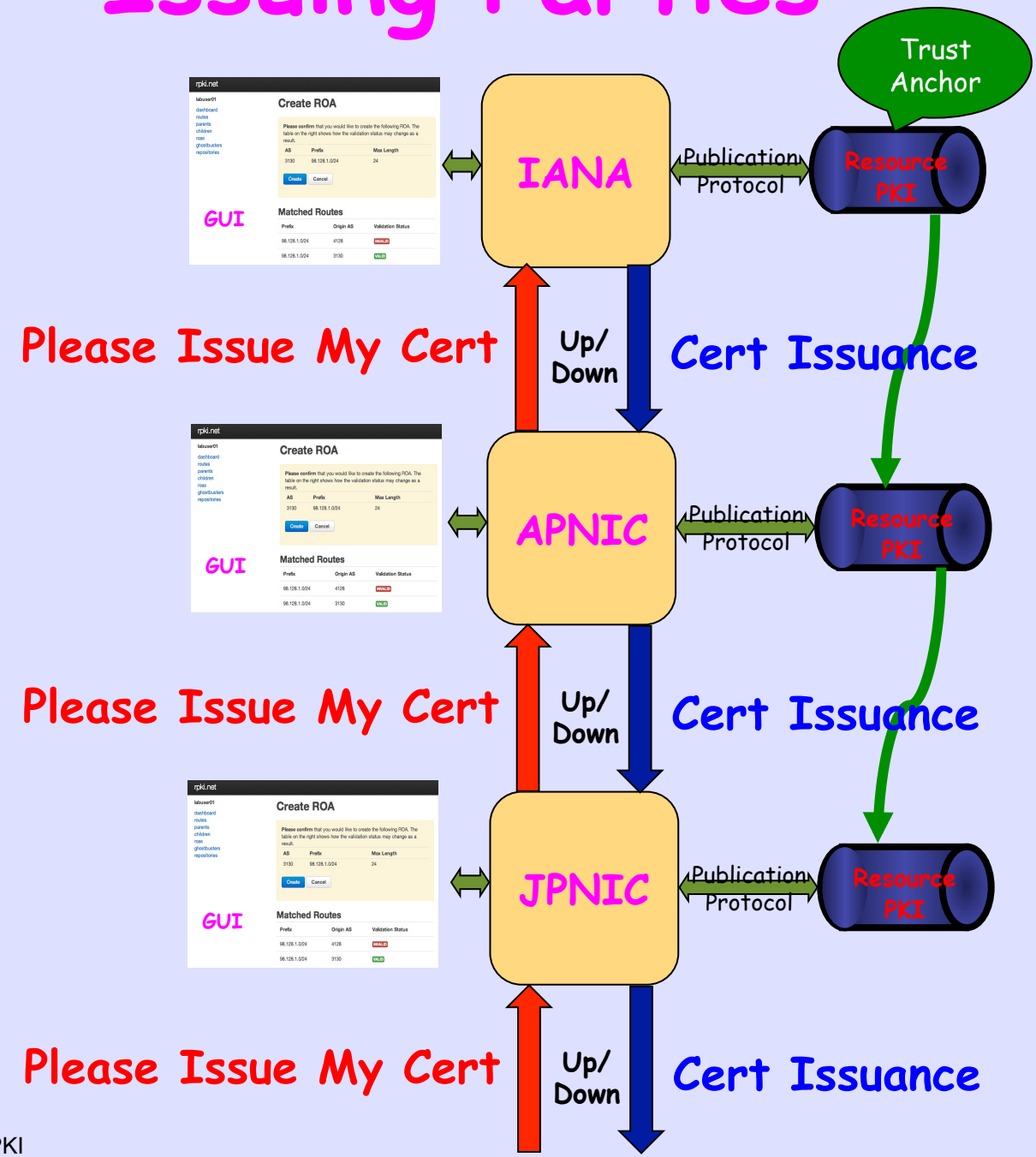
How RPKI is Generated



GUI



Issuing Parties



Hosted vs Delegated

Hosted
Web GUI

98% of an RIR's Users
10% of an RIR's IP Space

RPKI Engine

Keys for Talking to IR BackEnd

Resources [OrgID]

IR's Database(s)

My RightsToRoute

Delegations to Custs

Local Data Management

Internal

Protocol

ID=Me

Public RPKI Keys

Internal CA Data

Up/Down EE Public Keys

My Misc Config Options

Certs Issued to DownStreams

Issued ROAs

Publication Protocol

Publication Point

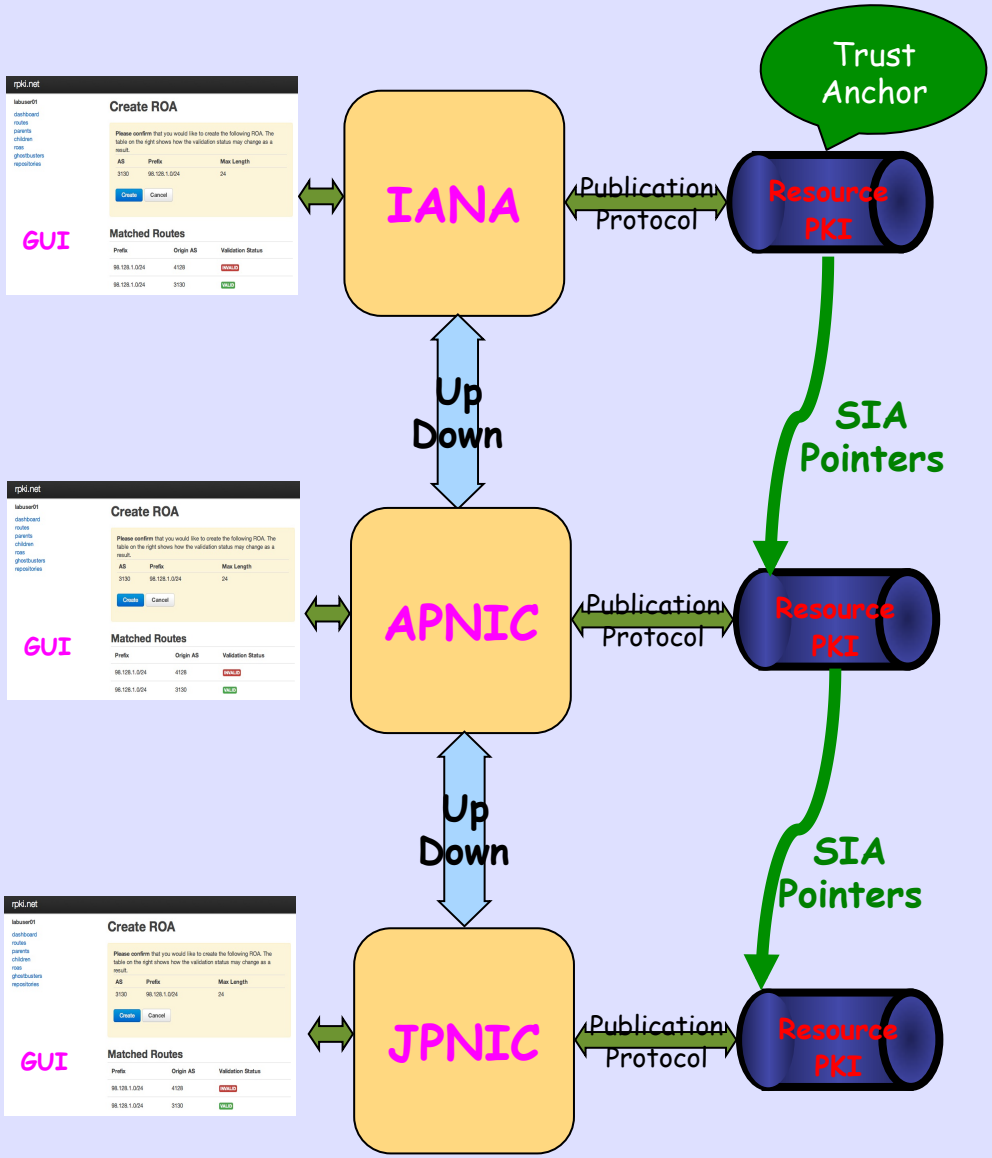
Contract Out?

Delegated
a la DNS

Up / Down Protocol

2% of an RIR's Users
90% of an RIR's IP Space

Issuing Parties



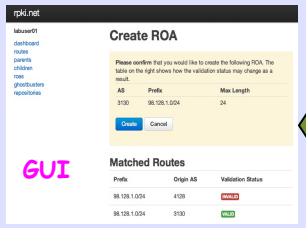
Trust Anchor Locator

rsync://ca0.rpki.net/tal/root.cer

MIIBIjANBgkqhkiG9w0BAQEFAAOCAQ8AMIIBCgKCAQEAzPSPpQxa0rxz9sbbvYGr
UlpgyBVxSIt+k/WDKbr+VW7CjUoz6cc5KMFANkQWw3D6ER4kCwX4WJkD58AGGbw/
WeAe6m3aHcORUVRkr45a4qSrYiG7Wq9RAXtwbhlXofB3zo+O90IlXDaVP2U9bw+Q
yoJBJuAmZONt0bRgrktv8QhVtKvuYkH5ZIe7DkXJcJzBn6gv09dZsdwZm3xV3soX
HEKrz5pY6Sb2xoL1CyPqzGOfVFxl0G5+dmcD/degPKxrEycAzjnHUzN1gus2jg26
dtkix7KG/Mn1h/k53j0FdQD+zqPwakgwqjvCOdSdHMRmsikj0EF9WrZIOjZUXV6q
6wIDAQAB

A URL and a Public Key that must be able to Decrypt the Certificate that is found at the URL so you know you can trust it

Issuing Parties Relying Parties



IANA

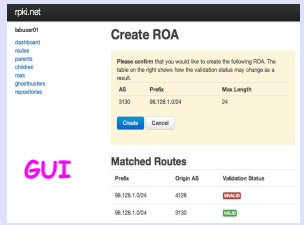
Publication Protocol

Trust Anchor

Resource PKI

Up Down

SIA Pointers



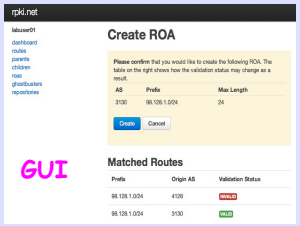
APNIC

Publication Protocol

Resource PKI

Up Down

SIA Pointers



JPNIC

Publication Protocol

Resource PKI

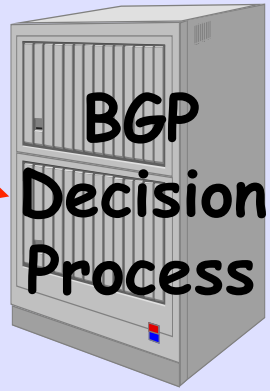
RCynic Gatherer

Validated Cache

Pseudo IRR

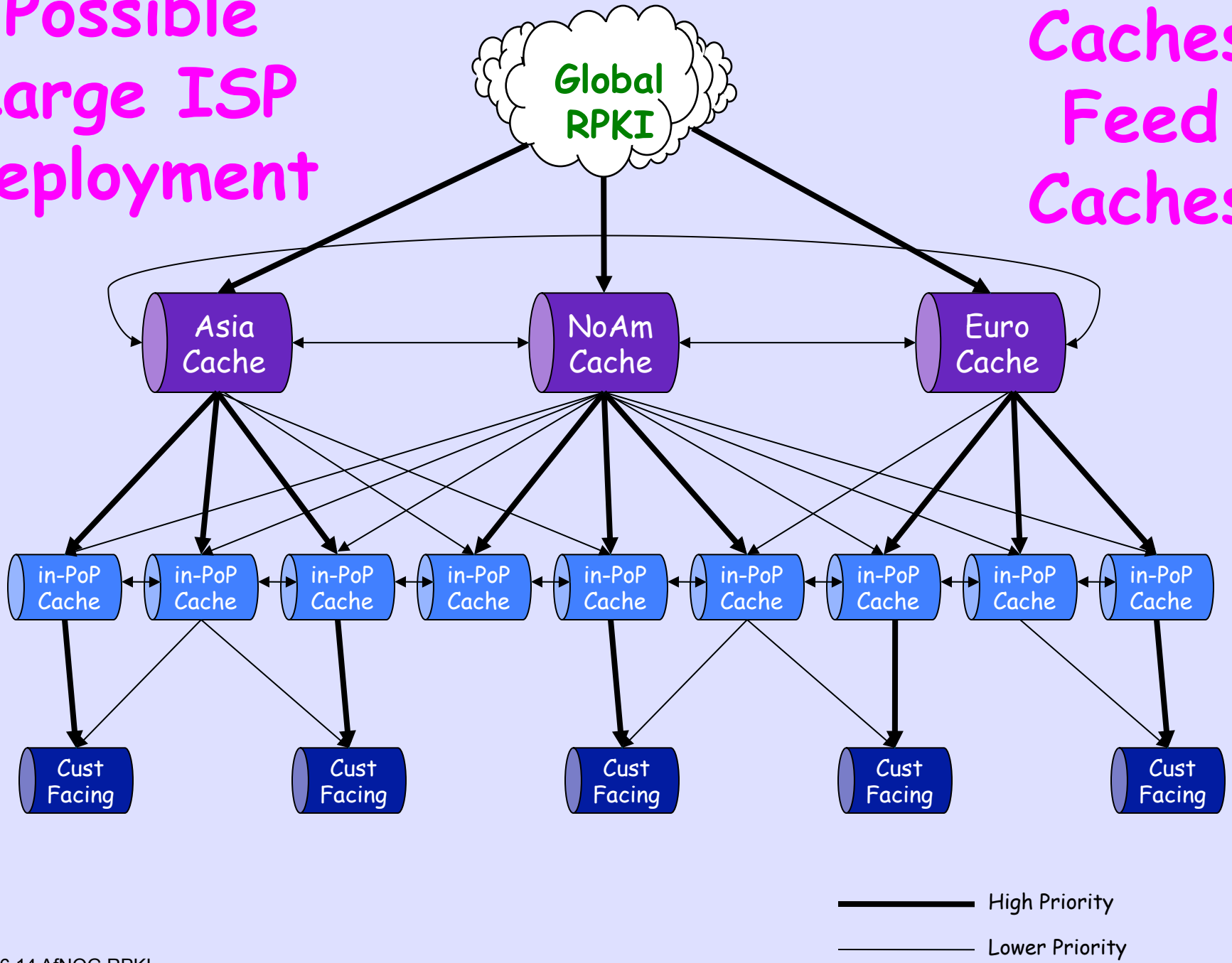
```
route:    147.28.0.0/16
descr:    147.28.0.0/16-16
origin:   AS3130
notify:   irr-hack@rpki.net
mnt-by:   MAINT-RPKI
changed:  irr-hack@rpki.net 20110606
source:   RPKI
```

NOC Tools

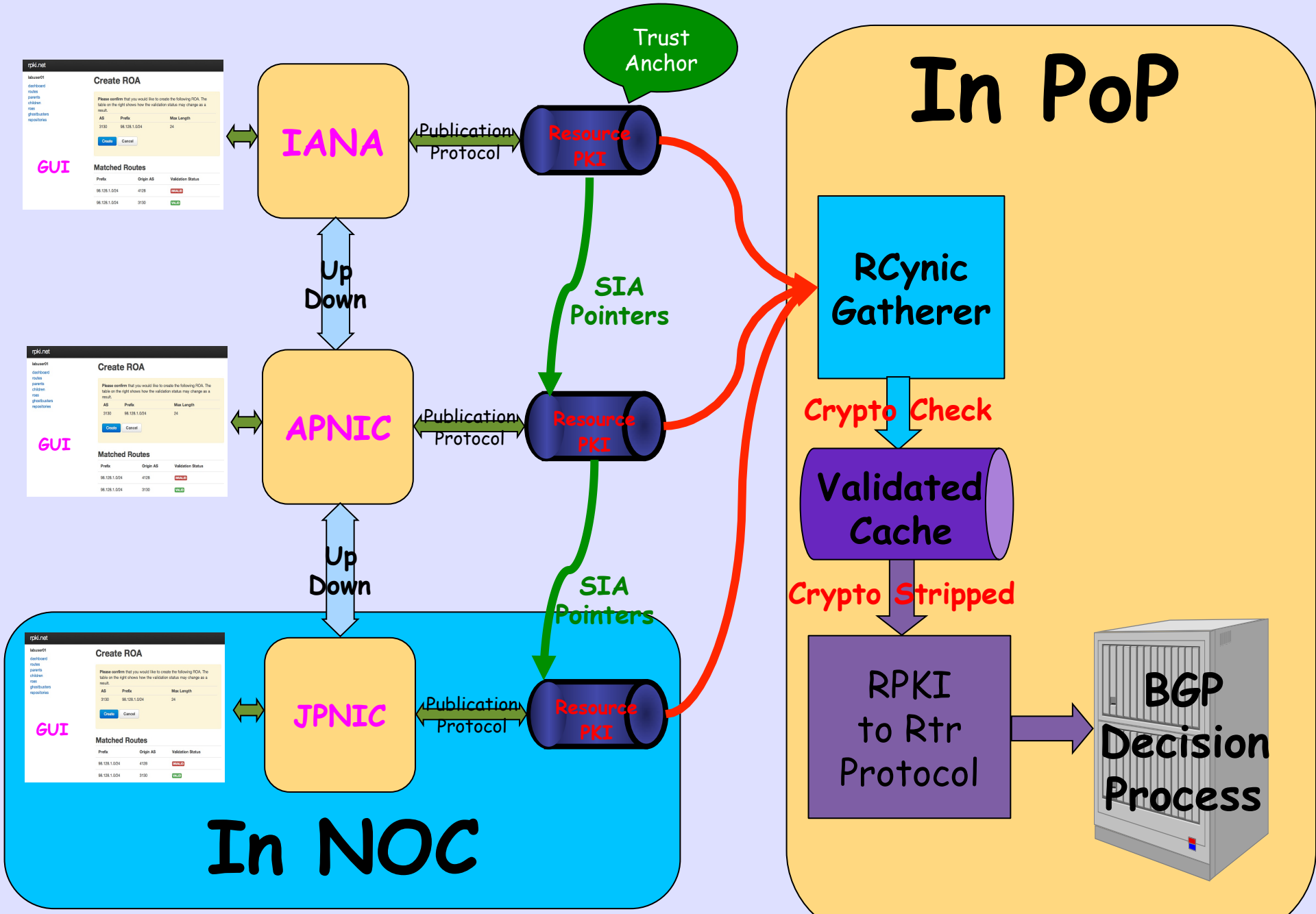


Possible Large ISP Deployment

Caches Feed Caches



How Do ROAs Affect BGP Updates?


Trust Anchor
In PoP
IANA
Publication Protocol
Resource PKI
GUI
Up Down
SIA Pointers
RCynic Gatherer
APNIC
Publication Protocol
Resource PKI
GUI
Up Down
SIA Pointers
Crypto Check
Validated Cache
Crypto Stripped
JPNIC
Publication Protocol
Resource PKI
GUI
RPKI to Rtr Protocol
BGP Decision Process
In NOC

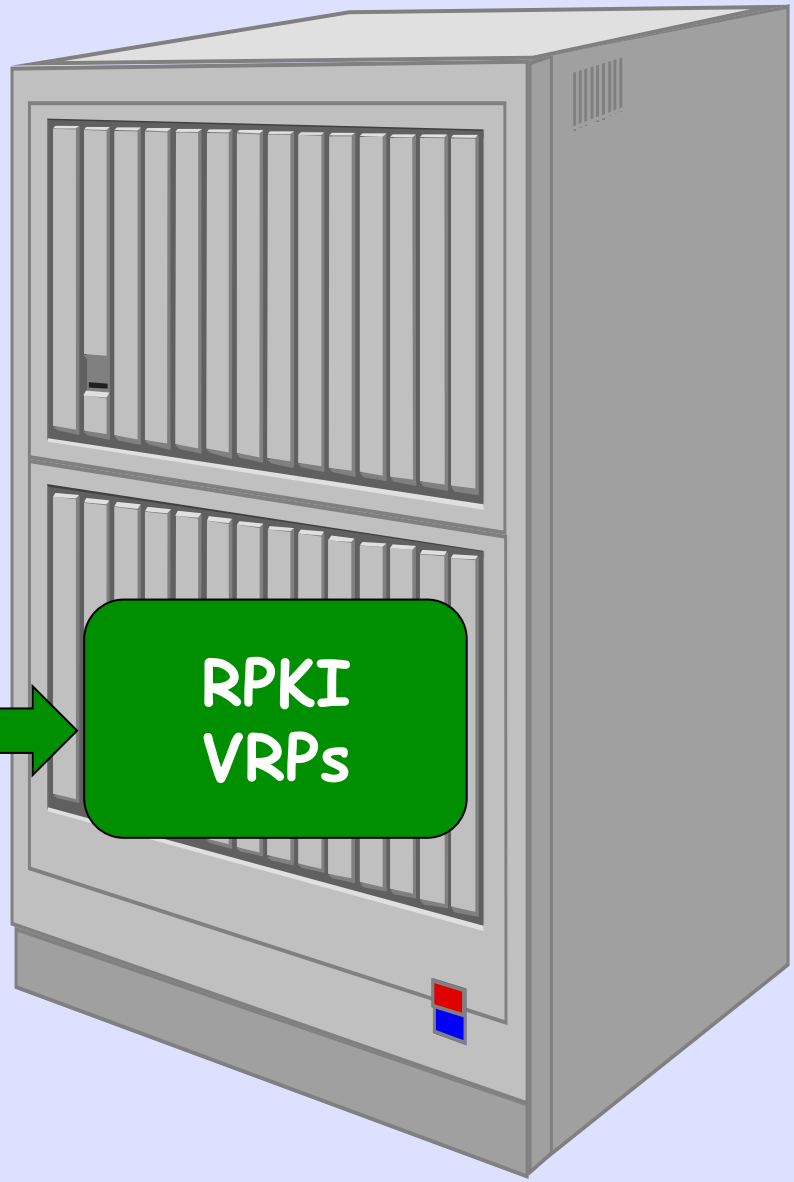
ROAs Become Router VRPs

Want to Run on
Current Hardware

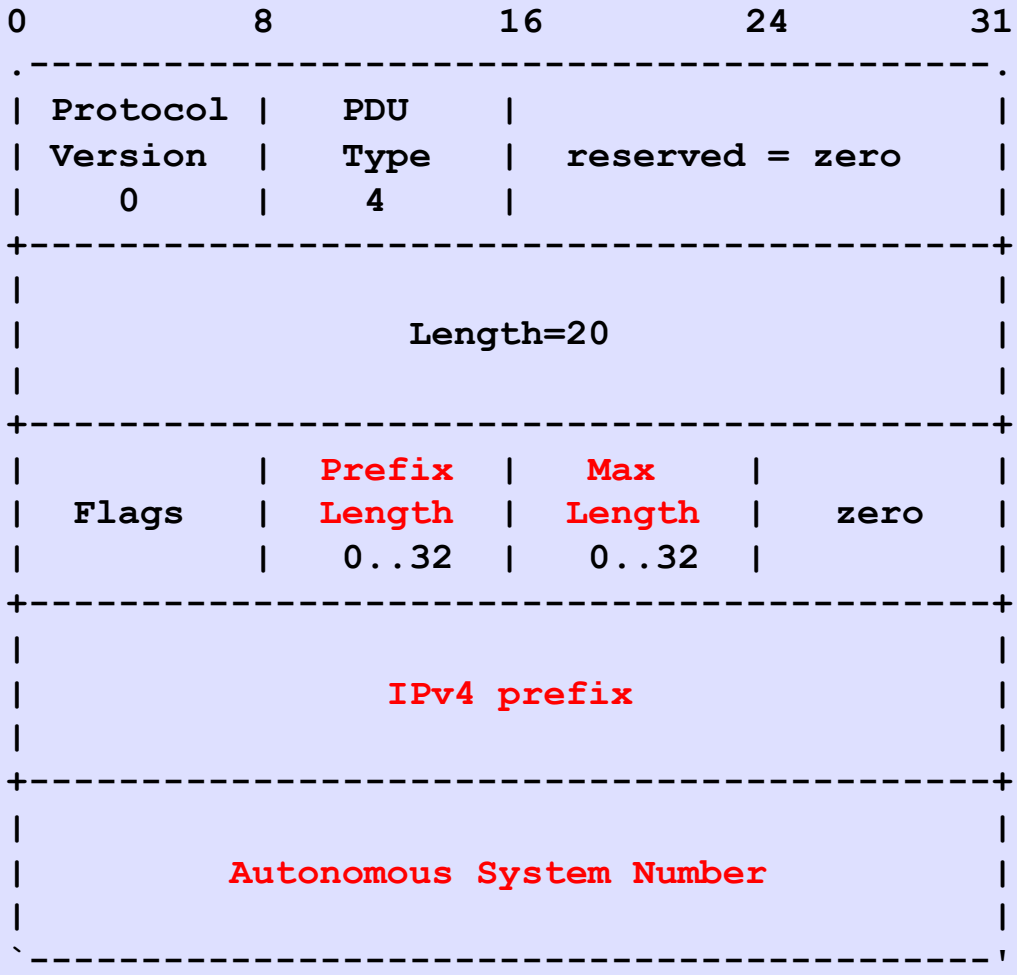
RPKI
Cache

RPKI-Rtr
Protocol

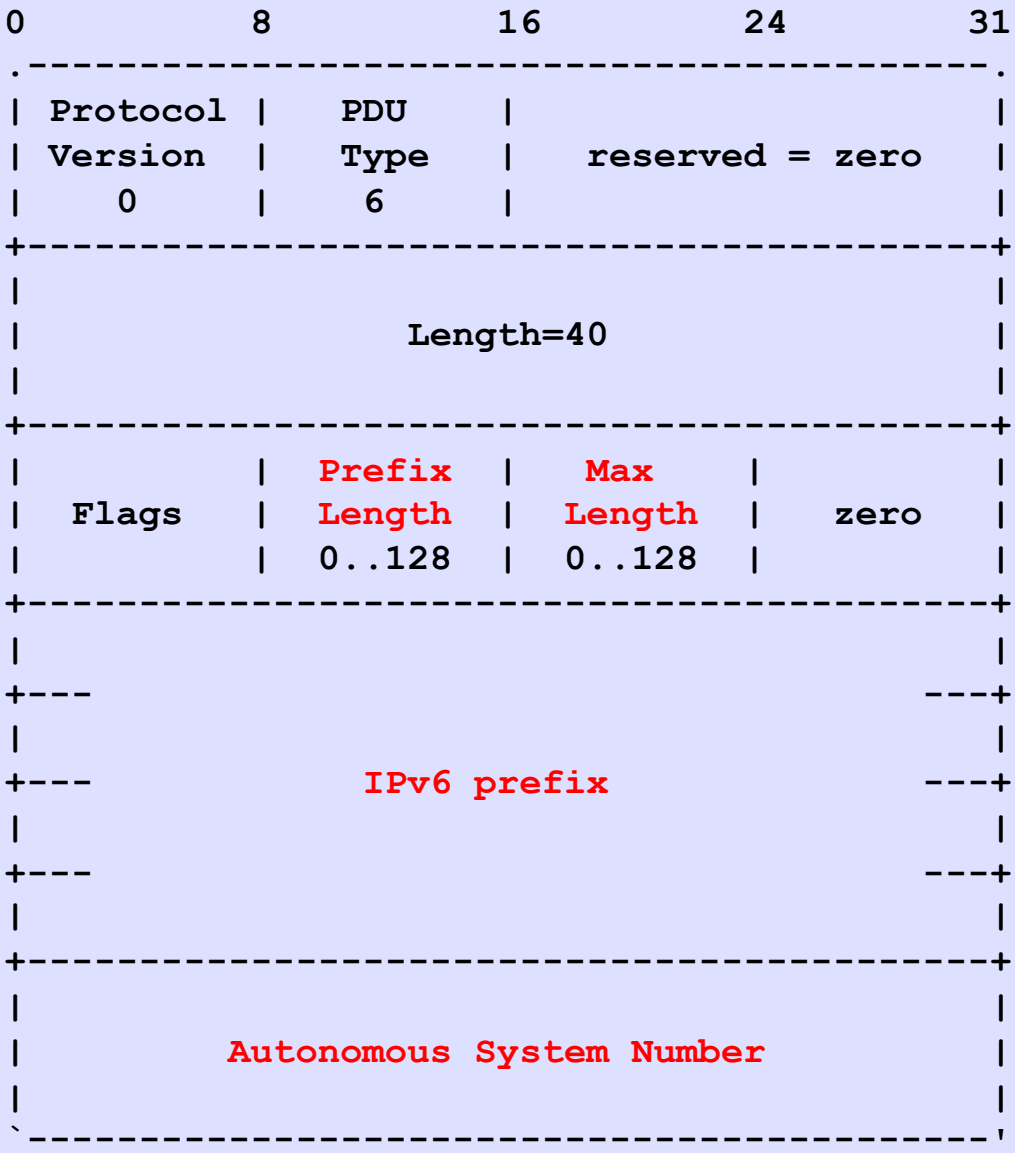
Crypto is
Stripped



IPv4 Prefix


0
8
16
24
31
Protocol Version
0
PDU Type
4
reserved = zero
Length=20
Flags
Prefix Length
0..32
Max Length
0..32
zero
IPv4 prefix
Autonomous System Number

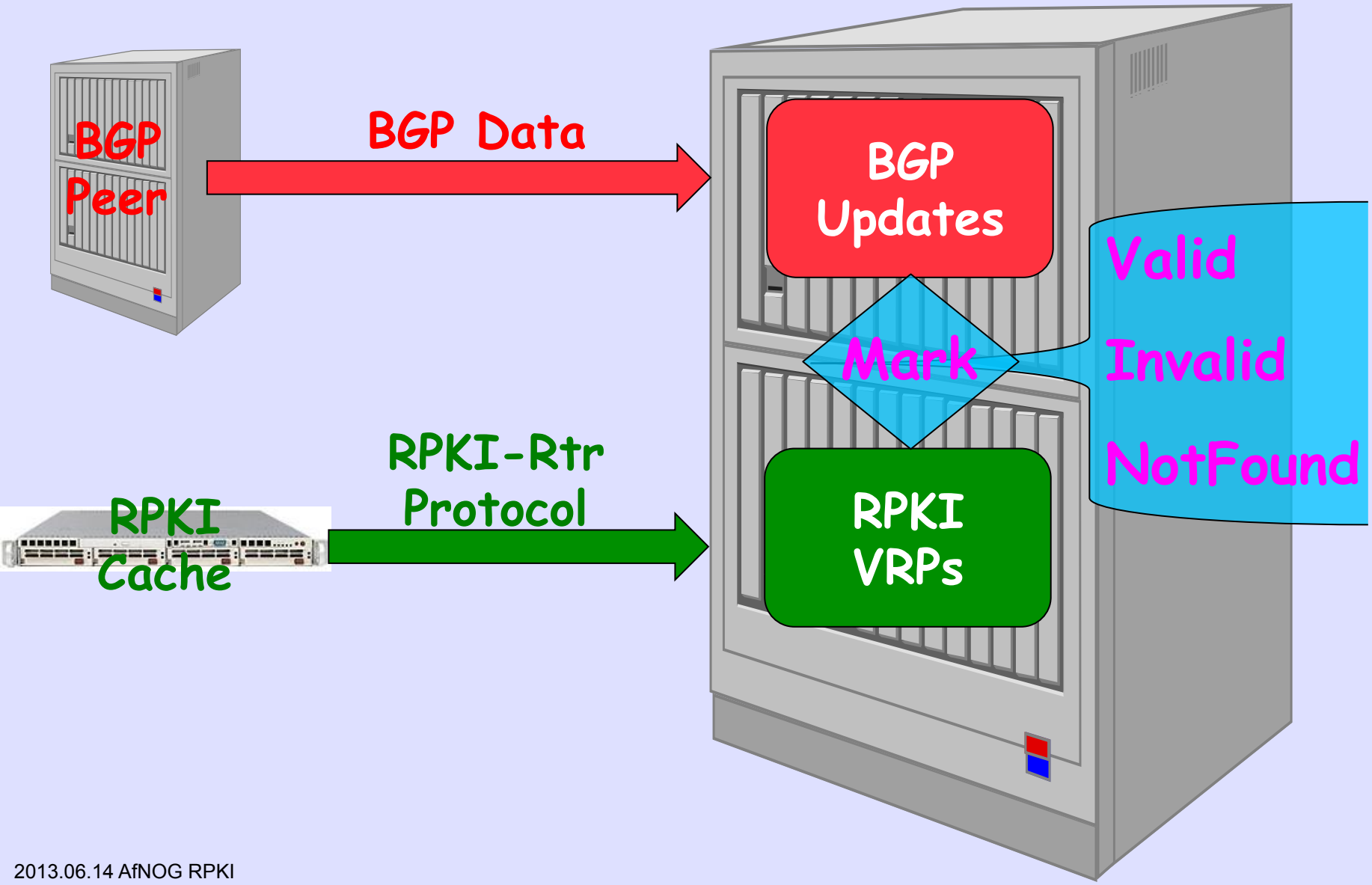
IPv6 Prefix



96 More Bits
No Magic

BGP Updates are compared with ROA Data loaded from the RPKI

Marking BGP Updates



Result of Check

- **Valid** – A matching/covering VRP was found with a matching AS number
- **Invalid** – A covering VRP was found, but the AS number did not match, and there was no other matching one
- **NotFound** – No matching or covering VRP was found, same as today

Configure Router to Get ROAs

```
router bgp 651nn
 …
 bgp rpki server tcp 198.180.150.1 port 43779 refresh 3600
 bgp rpki server tcp 147.28.0.35 port 93920 refresh 3600
 …
```

Valid!

```
r0.sea#show bgp 192.158.248.0/24
BGP routing table entry for 192.158.248.0/24, version 3043542
Paths: (3 available, best #1, table default)
 6939 27318
    206.81.80.40 (metric 1) from 147.28.7.2 (147.28.7.2)
      Origin IGP, metric 319, localpref 100, valid, internal,
best
      Community: 3130:391
      path 0F6D8B74 RPKI State valid
 2914 4459 27318
    199.238.113.9 from 199.238.113.9 (129.250.0.19)
      Origin IGP, metric 43, localpref 100, valid, external
      Community: 2914:410 2914:1005 2914:3000 3130:380
      path 09AF35CC RPKI State valid
```

Invalid!

```
r0.sea#show bgp 198.180.150.0
BGP routing table entry for 198.180.150.0/24, version 2546236
Paths: (3 available, best #2, table default)
  Advertised to update-groups:
     2           5           6           8
  Refresh Epoch 1
  1239 3927
    144.232.9.61 (metric 11) from 147.28.7.2 (147.28.7.2)
      Origin IGP, metric 759, localpref 100, valid, internal
      Community: 3130:370
      path 1312CA90 RPKI State invalid
```

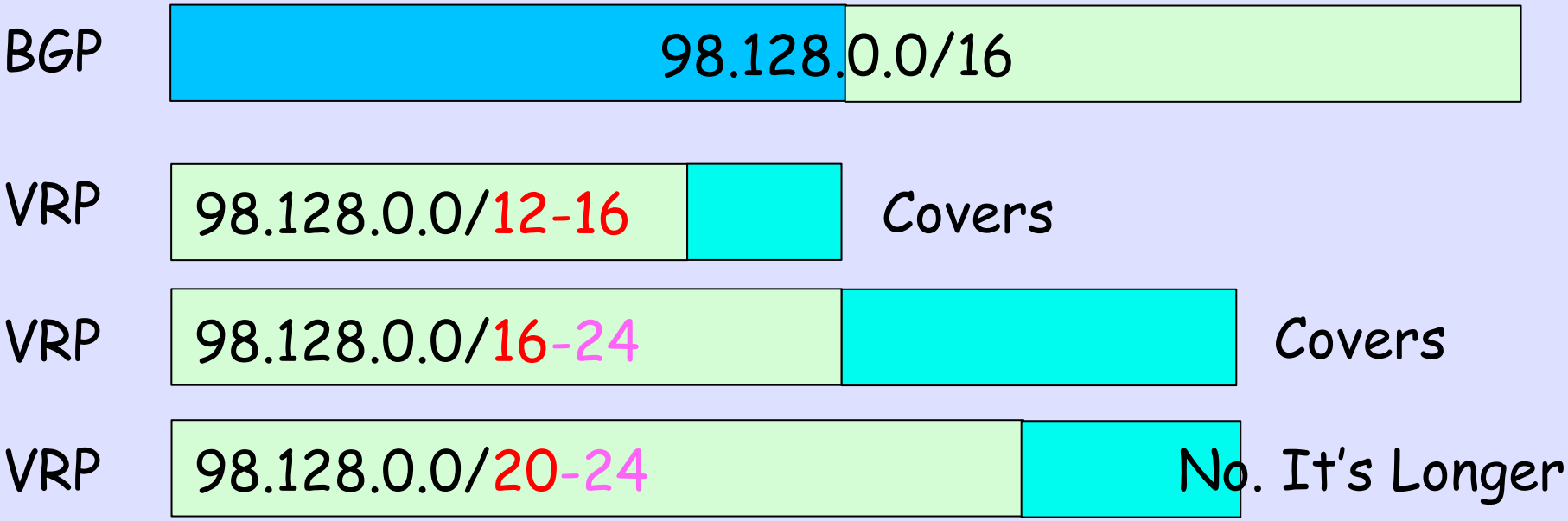
NotFound

```
r0.sea#show bgp 64.9.224.0
BGP routing table entry for 64.9.224.0/20, version 35201
Paths: (3 available, best #2, table default)
  Advertised to update-groups:
     2           5           6
  Refresh Epoch 1
  1239 3356 36492
    144.232.9.61 (metric 11) from 147.28.7.2 (147.28.7.2)
      Origin IGP, metric 4, localpref 100, valid, internal
      Community: 3130:370
      path 11861AA4 RPKI State not found
```

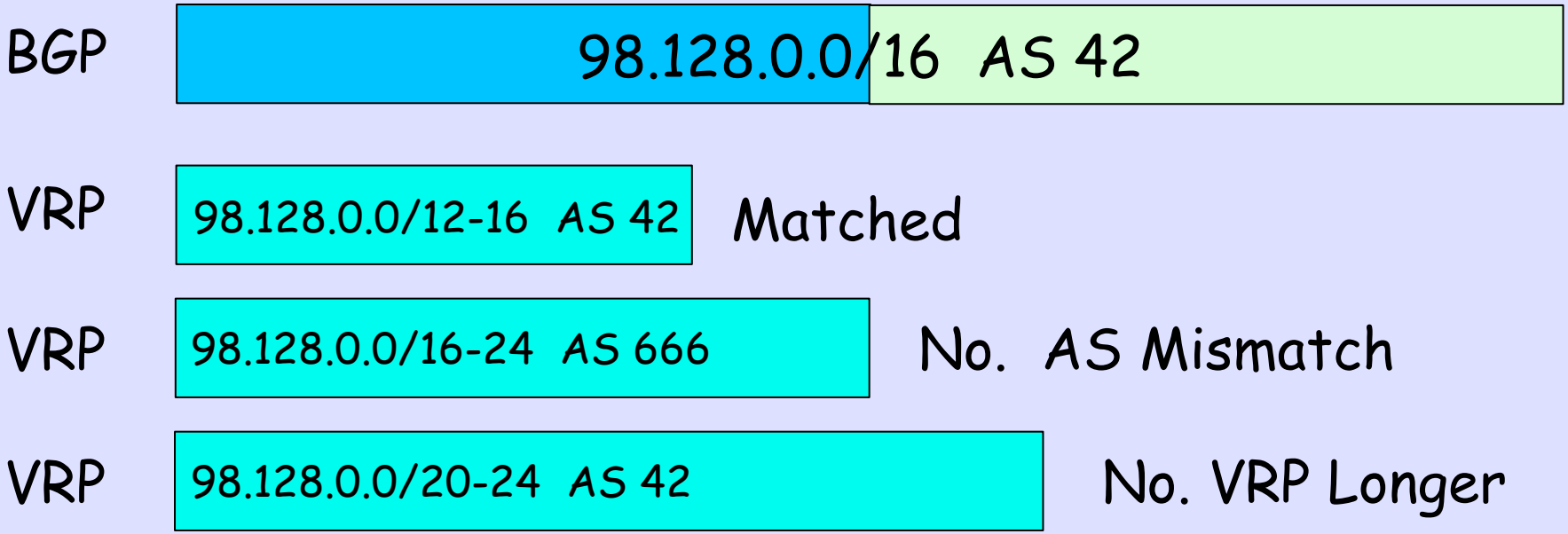
What are the BGP / VRP[1] Matching Rules?

[1] Validated ROA Payload

A Prefix is **Covered** by a VRP when the VRP prefix length is less than or equal to the Route prefix length



Prefix is Matched by a VRP when the Prefix is Covered by that VRP , prefix length is less than or equal to the VRP max-len, and the Route Origin AS is equal to the VRP's AS



Matching and Validity

VRP_0	98.128.0.0/16-24 AS 6
VRP_1	98.128.0.0/16-20 AS 42

BGP	98.128.0.0/12	AS 42	NotFound, shorter than VRPs
BGP	98.128.0.0/16	AS 42	Valid, Matches VRP_1
BGP	98.128.0.0/20	AS 42	Valid, Matches VRP_1
BGP	98.128.0.0/24	AS 42	Invalid, longer than VRP with AS 42
BGP	98.128.0.0/24	AS 6	Valid, Matches VRP_0

The Operator Tests the Mark and then Applies Local Policy

Fairly Secure

```
route-map validity-0
  match rpki valid
  set local-preference 100
route-map validity-1
  match rpki not-found
  set local-preference 50
! invalid is dropped
```

Paranoid

```
route-map validity-0
  match rpki valid
  set local-preference 110
! everything else dropped
```

Security Geek

```
route-map validity-0
  match rpki invalid
  set local-preference 110
! everything else dropped
```

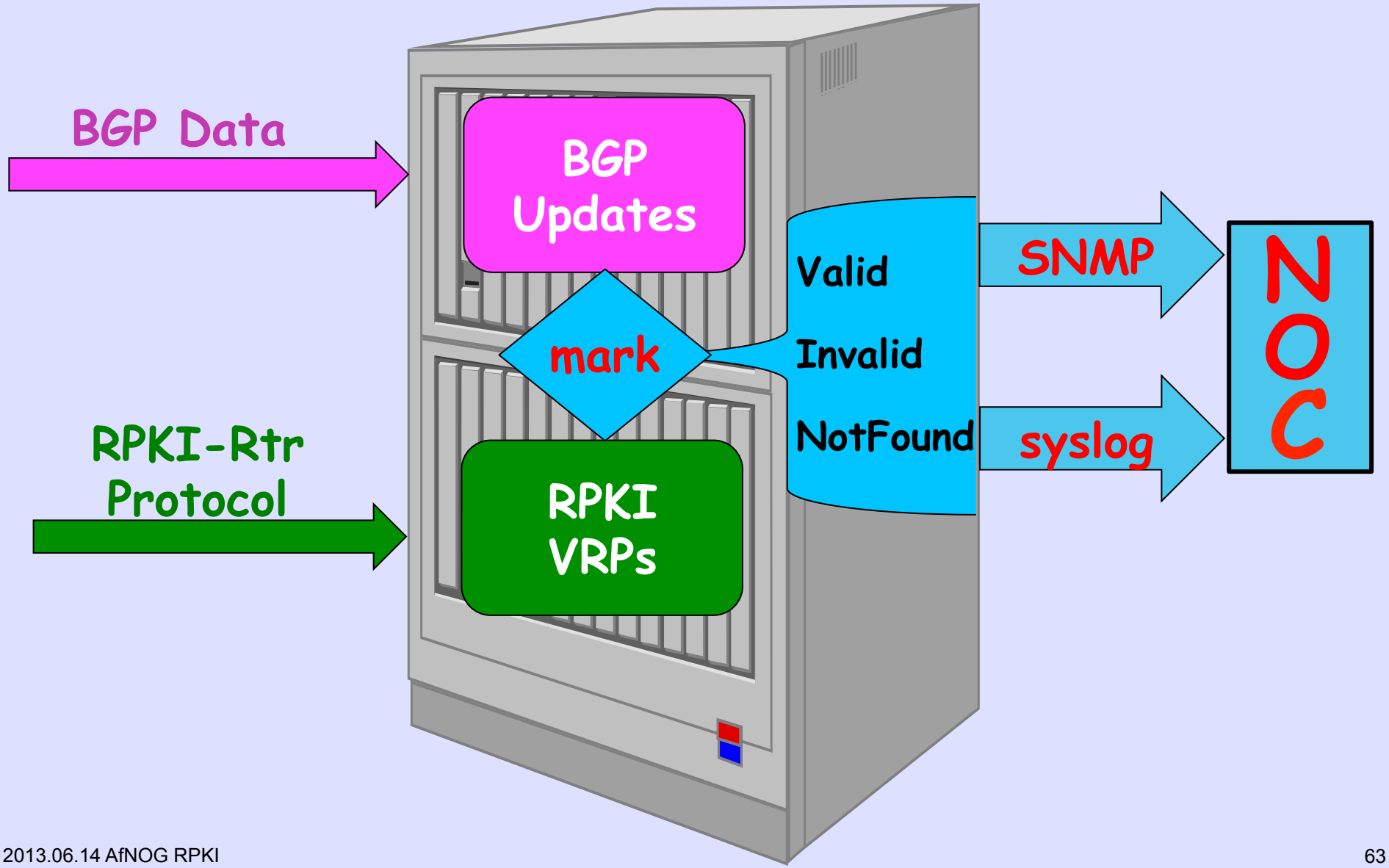
After AS-Path

```
route-map validity-0
 match rpki not-found
   set metric 100
route-map validity-1
   match rpki invalid
   set metric 150
route-map validity-2
   set metric 50
```

Set a Community

```
route-map validity-0
  match rpki valid
  set community 3130:400
route-map validity-1
  match rpki invalid
  set community 3130:200
route-map validity-2
  set community 3130:300
```

And it is All Monitored



But in the End, You Control Your Policy

"Announcements with Invalid origins SHOULD NOT be used, but MAY be used to meet special operational needs. In such circumstances, the announcement SHOULD have a lower preference than that given to Valid or NotFound."

-- draft-ietf-sidr-origin-ops

But if we do not reject Invalid, What is all this work for?

RPKI at the Registries

- RIPE seriously deployed with a few thousand LIRs and thousands of ROAs
- APNIC is operational and moving forward, moving to RIPE's GUI
- ARIN is doing their best to make RPKI deployment very hard
- LACNIC is deployed and has O(100) LIRs
- AFRINIC is deployed with O(25) LIRs

Router Origin Validation

- Cisco IOS – solid in 15.2
- Cisco IOS/XR – shipped in 4.3.2
- Juniper – shipped in 12.2
- AlcaLu – in development

RPKI Implementations

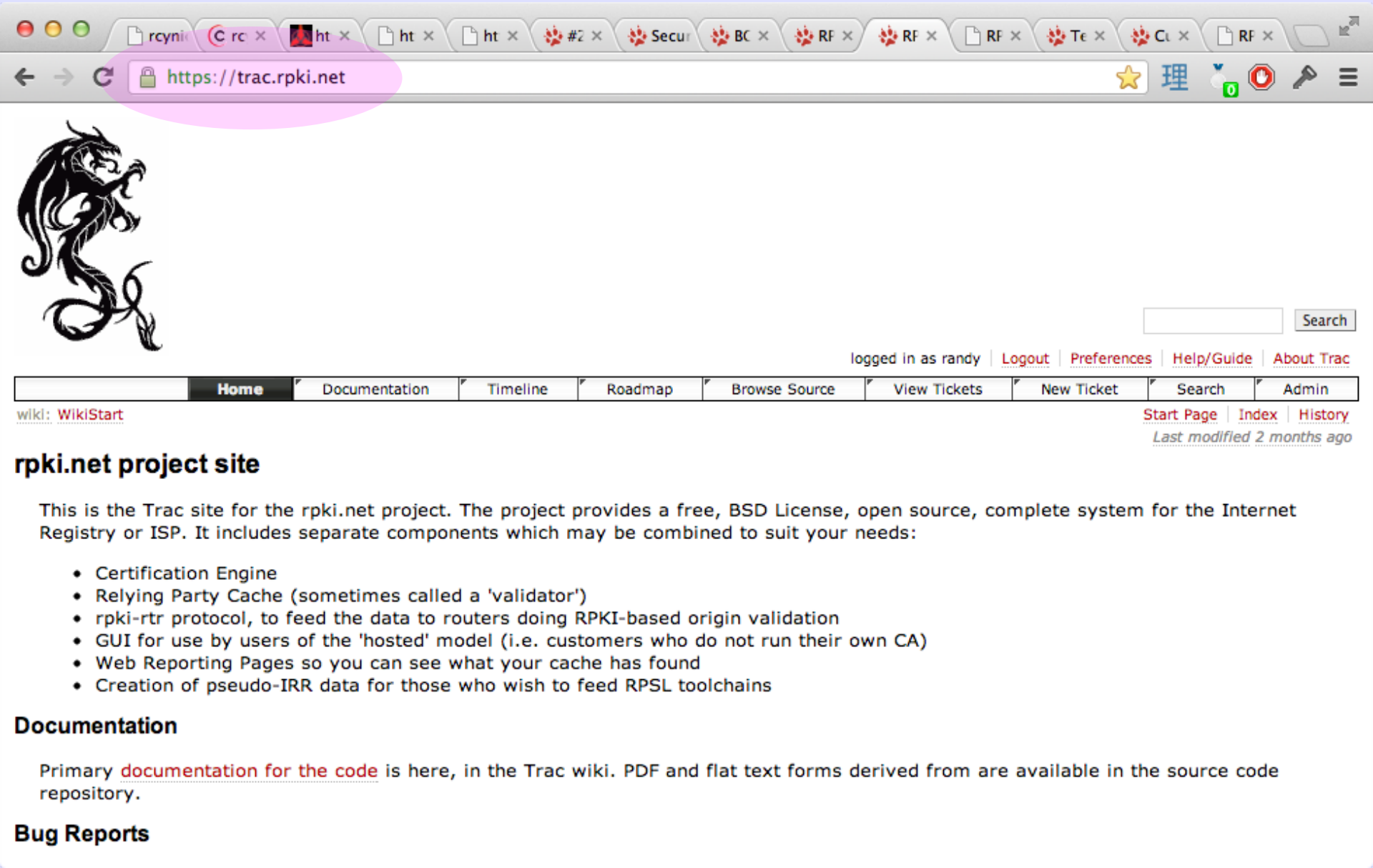
- RIPE/NCC – CA (partial closed) & RP (partial open)
- APNIC – CA only – Closed Source
- RTRlib/Berlin – RP only – Open Source
- BBN – RP Only – Open Source
- RPKI.NET – CA & RP – Open Source

Today - RPKI.NET

- Open Source BSD License
- CA – Hosted and Delegated Models, GUI
- RP – RPKI-RTR, NOC Tools, IRR Gen
- FreeBSD, Ubuntu, Debian, … Packaged (docs still catching up)

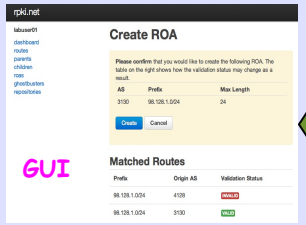
Recent Hackathons

- JaNOG January – LIRs bring up Relying Party. Few Attended, Most Succeeded
- JPNIC 20 Feb – RP only, 3 ISPs were successful
- APRICOT February - TW, & KR have CAs in internal test
- Beirut March – 18 LIRs as RPs


https://trac.rpki.net
Search
logged in as randy | Logout | Preferences | Help/Guide | About Trac
Home | Documentation | Timeline | Roadmap | Browse Source | View Tickets | New Ticket | Search | Admin
wiki: WikiStart
Start Page | Index | History
Last modified 2 months ago
rpki.net project site
This is the Trac site for the rpki.net project. The project provides a free, BSD License, open source, complete system for the Internet Registry or ISP. It includes separate components which may be combined to suit your needs:
Certification Engine
Relying Party Cache (sometimes called a 'validator')
rpki-rtr protocol, to feed the data to routers doing RPKI-based origin validation
GUI for use by users of the 'hosted' model (i.e. customers who do not run their own CA)
Web Reporting Pages so you can see what your cache has found
Creation of pseudo-IRR data for those who wish to feed RPSL toolchains
Documentation
Primary documentation for the code is here, in the Trac wiki. PDF and flat text forms derived from are available in the source code repository.
Bug Reports

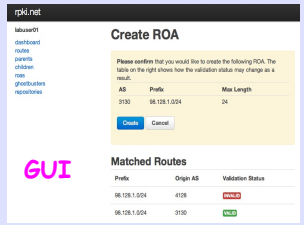
Issuing Parties

Relying Parties



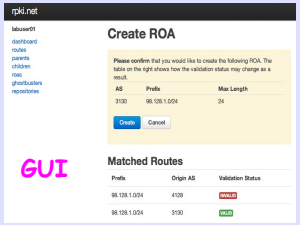
altCA

Up
Down



JPNIC

Up
Down



IIJ

Publication Protocol

Publication Protocol

Publication Protocol

Trust Anchor

Resource PKI

Resource PKI

Resource PKI

SIA Pointers

SIA Pointers

RCynic Gatherer

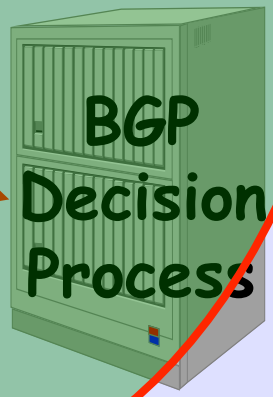
Validated Cache

Pseudo IRR

```
route:    147.28.0.0/16
descr:    147.28.0.0/16-16
origin:   AS3130
notify:   irr-hack@rpki.net
mnt-by:   MAINT-RPKI
changed:  irr-hack@rpki.net 20110606
source:   RPKI
```

NOC Tools

Our Focus Today



Today

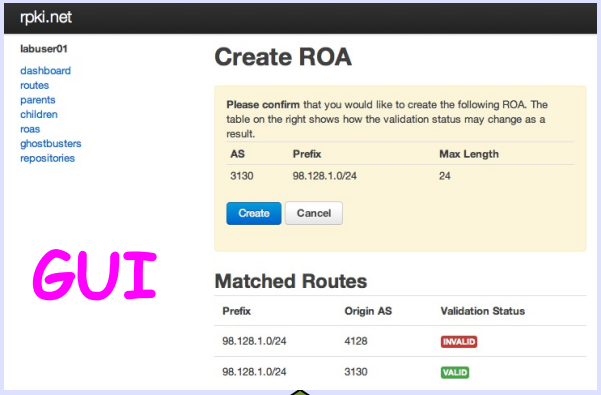
- Register Our Prefixes in CA
- Issue ROAs Using CA's Web Portal
- Configure Routers to get ROAs from Caches
- Build RP Caches to Fetch from CAs

Get Copy of This Preso

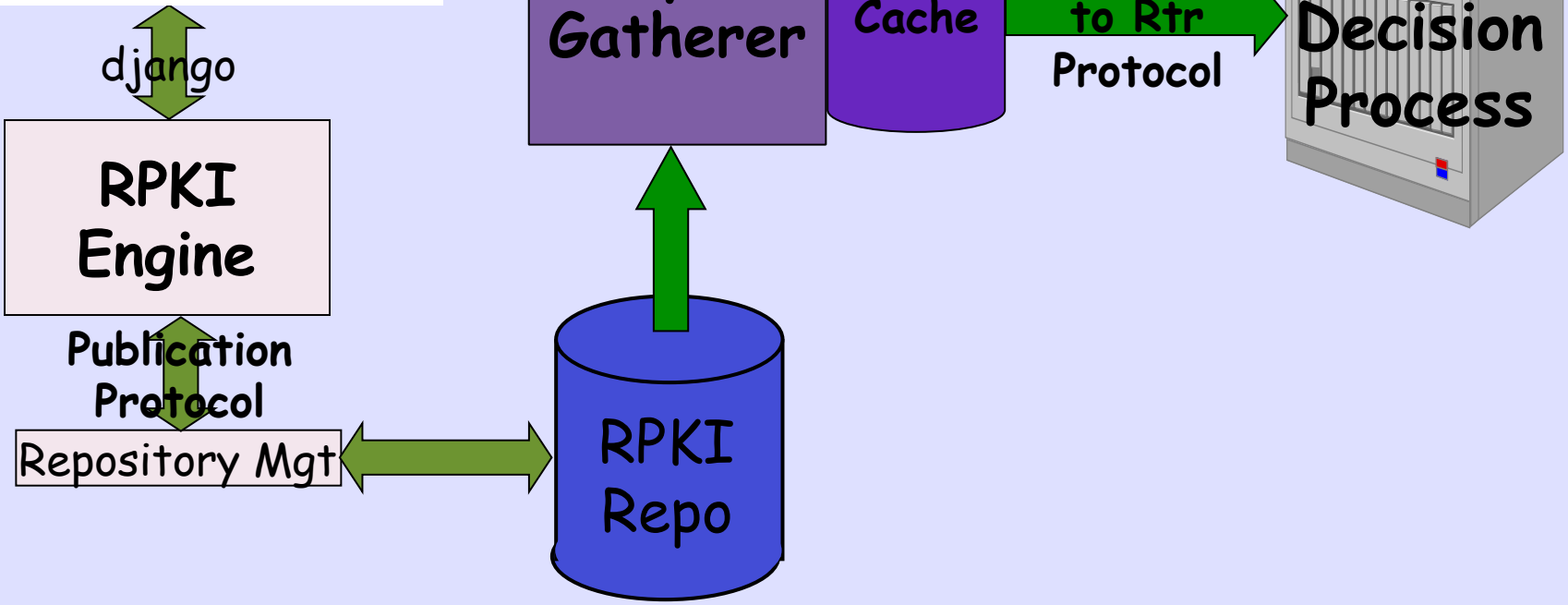
https://psg.com/130614.pdf

So You Can
Copy and Paste

Lab Overview



GUI



Lab Environment

ubu01

ubu02

ubu03

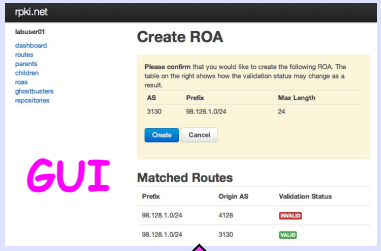
ubu04

ubu05

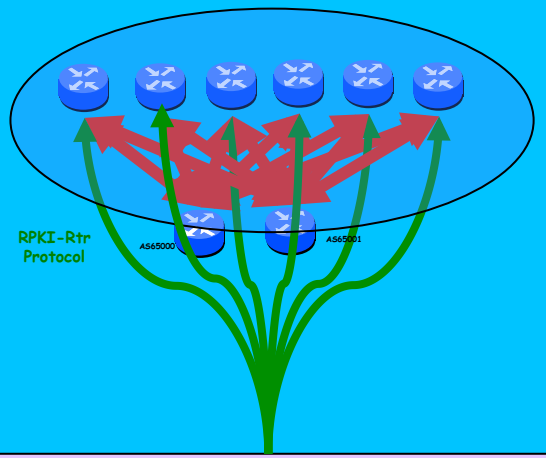
⋮

ubu16

Ubuntu/KVM Server in Ashburn



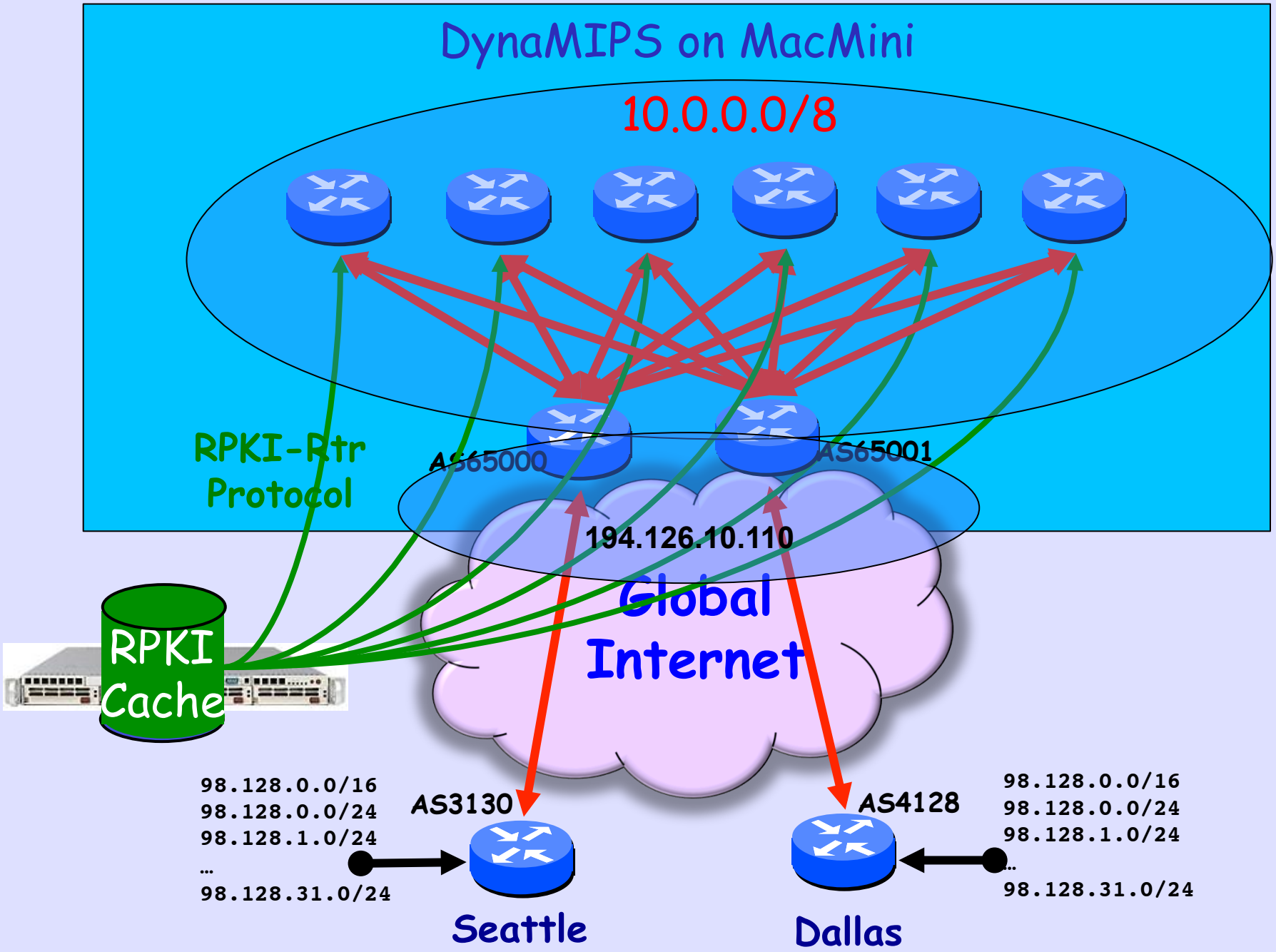
GUI



RP - cache0.vmini

CA - ca0.vmini

Mac Mini running Ubuntu KVM


DynaMIPS on MacMini
10.0.0.0/8
RPKI-Rtr Protocol
AS65000
AS65001
194.126.10.110
Global Internet
RPKI Cache
98.128.0.0/16
98.128.0.0/24
98.128.1.0/24
…
98.128.31.0/24
AS3130
Seattle
AS4128
Dallas
98.128.0.0/16
98.128.0.0/24
98.128.1.0/24
…
98.128.31.0/24

IP Address Allocation

98.128.0.0/16 ARIN Experimental Allocation

98.128.0.0/24 Instructors Play

98.128.1.0/24 labuser01

98.128.2.0/24 labuser02

…

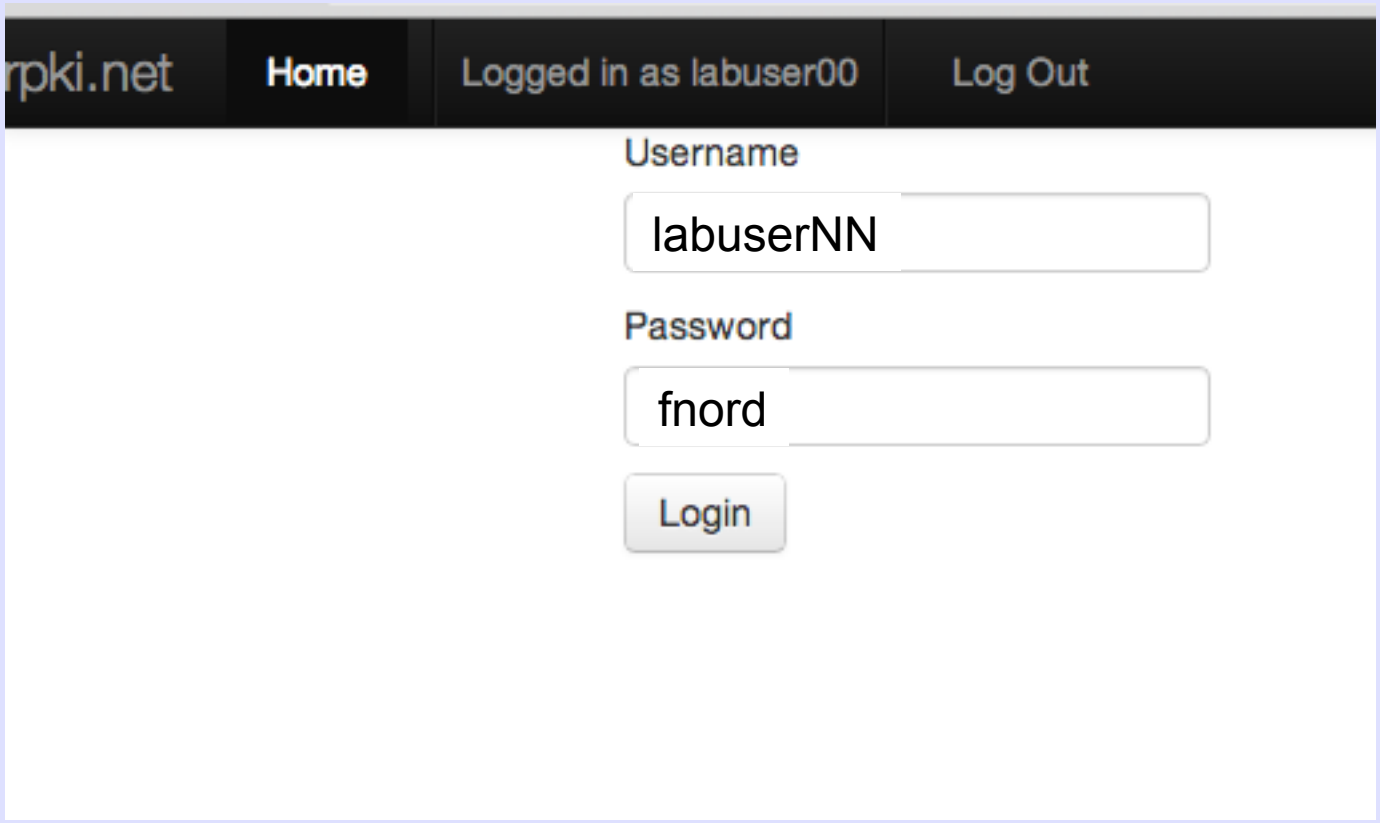
98.128.32.0/24 labuser32

GUI Accounts

https://ca0.vmini.rpki.net/

UserID	Password
labuser01	fnord
labuser02	fnord
labuser03	fnord
…	
labuser16	fnord

https://ca0.vmini.rpki.net/



The Dashboard

rpki.net | Home | Logged in as labuser01 | Log Out

labuser01

dashboard
routes

export identity

Resources

Resource	Valid Until	Parent
98.128.1.0/24	April 29, 2013, 10:18 p.m.	rgnet

refresh

Unallocated Resources

The following resources have not been allocated to a child, nor appear in a ROA.

IPv4

Prefix	Action
98.128.1.0/24	ROA

ROA Requests

Prefix	Max Length	AS

Create

Ghostbuster Requests

Full Name	Organization	Email	Telephone

Create

Children

Handle

Import

Parents

Handle
rgnet

Import

Create a ROA

labuser01

dashboard
routes

Create ROA Request

Prefix

98.128.1.0/24

Max Prefix Length

AS

4128

Preview Cancel

Routes matching your prefix:

Prefix	AS

What Will Happen?

Confirm ROA Request

Please confirm that you would like to create the following ROA. The accompanying table indicates how the validation status may change as a result.

AS	Prefix	Max Length
4128	98.128.1.0/24	24

Create Cancel

Matched Routes

Prefix	Origin AS	Validation Status
98.128.1.0/24	4128	valid
98.128.1.0/24	3130	invalid

Router Accounts

% telnet vmini.rpki.net 20NN

user: isplab

password: lab-PW

enable: lab-PW

Ask Me to Assign a Router to You

Configure RPKI Server

```
router bgp 651nn
  bgp rpki server tcp 196.200.223.180 port
  43779 refresh 180

  ! inject your prefix into BGP
  network 98.128.nn.0 mask 255.255.255.0
```

Check Server

```
r0.sea#show ip bgp rpki servers
BGP SOVC neighbor is 198.180.150.1/43779 connected to port 43779
Flags 0, Refresh time is 600, Serial number is 1304239609
InQ has 0 messages, OutQ has 0 messages, formatted msg 345
Session IO flags 3, Session flags 4008
 Neighbor Statistics:
  Nets Processed 624

Connection state is ESTAB, I/O status: 1, unread input bytes: 0
Connection is ECN Disabled
Mininum incoming TTL 0, Outgoing TTL 255
Local host: 199.238.113.10, Local port: 57932
Foreign host: 198.180.150.1, Foreign port: 43779
Connection tableid (VRF): 0
```

Look at Table

```
router1#show ip bgp rpki table
76 BGP sovc network entries using 6688 bytes of memory
78 BGP sovc record entries using 1560 bytes of memory
Network              Maxlen  Origin-AS  Source  Neighbor
98.128.0.0/24        24      3130       0       198.180.150.1/4242
98.128.0.0/16        16      3130       0       198.180.150.1/4242
98.128.6.0/24        24      4128       0       198.180.150.1/4242
98.128.9.0/24        24      3130       0       198.180.150.1/4242
98.128.30.0/24       24      1234       0       198.180.150.1/4242
128.224.1.0/24       24      3130       0       198.180.150.1/4242
129.6.0.0/17         17      49         0       198.180.150.1/4242
129.6.112.0/24       24      10866      0       198.180.150.1/4242
129.6.128.0/17       17      49         0       198.180.150.1/4242
147.28.0.0/16        16      3130       0       198.180.150.1/4242
```

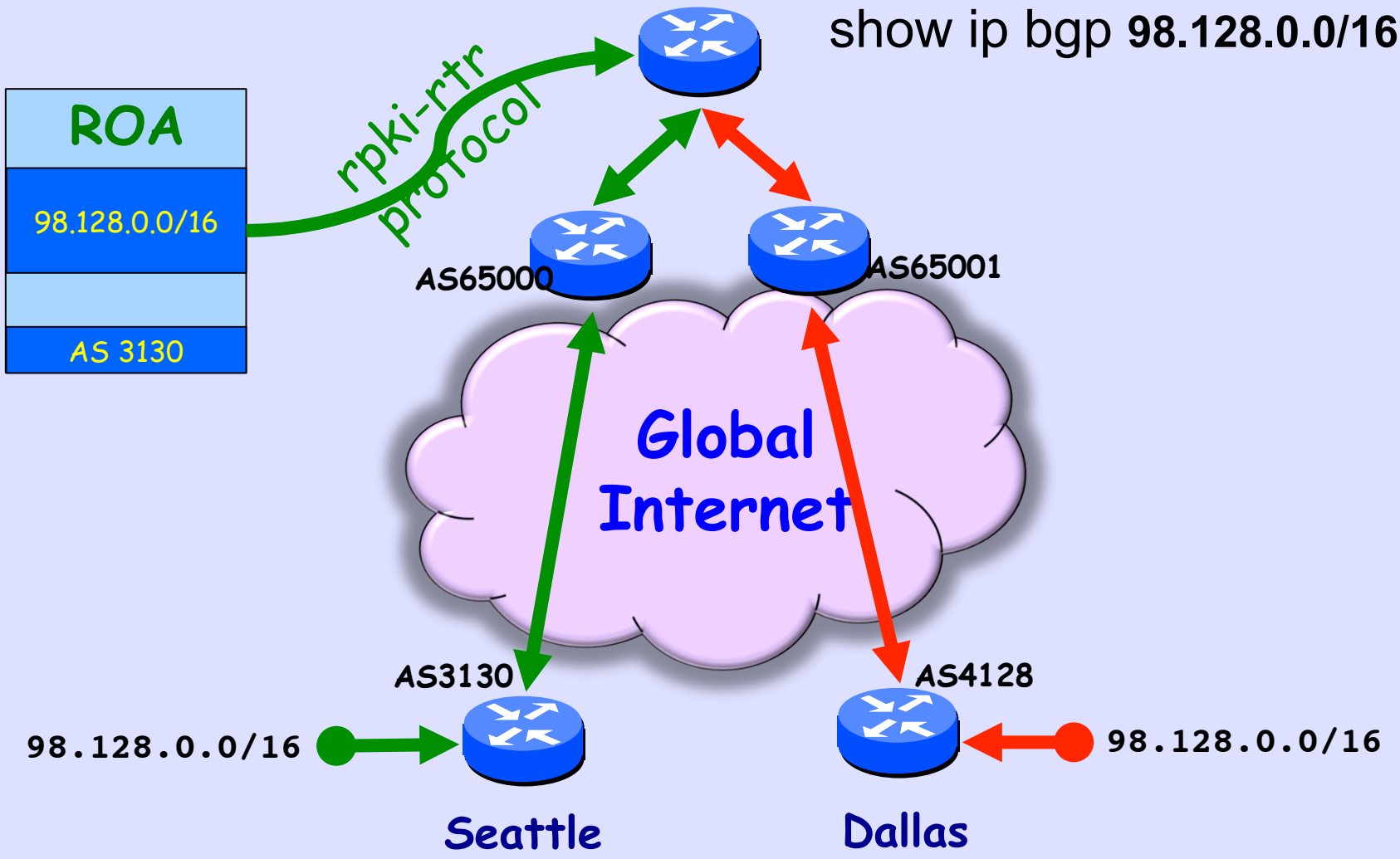
Look at BGP Table

```
r0.sea#sh ip bgp
     Network          Next Hop            Metric LocPrf Weight Path
* i I198.180.150.0    144.232.9.61   100  0 1239 3927 i
*>  I                 199.238.113.9       0 2914 3927 i
*   I                 129.250.11.41       0 2914 3927 i
*>  V198.180.152.0    199.238.113.9       0 2914 4128 i
*   V                 129.250.11.41       0 2914 4128 i
*>  N198.180.155.0    199.238.113.9       0 2914 22773 i
*   N                 129.250.11.41       0 2914 22773 i
*>  N198.180.160.0    199.238.113.9       0 2914 23308 13408 5752 i
*   N                 129.250.11.41       0 2914 23308 13408 5752 i
```

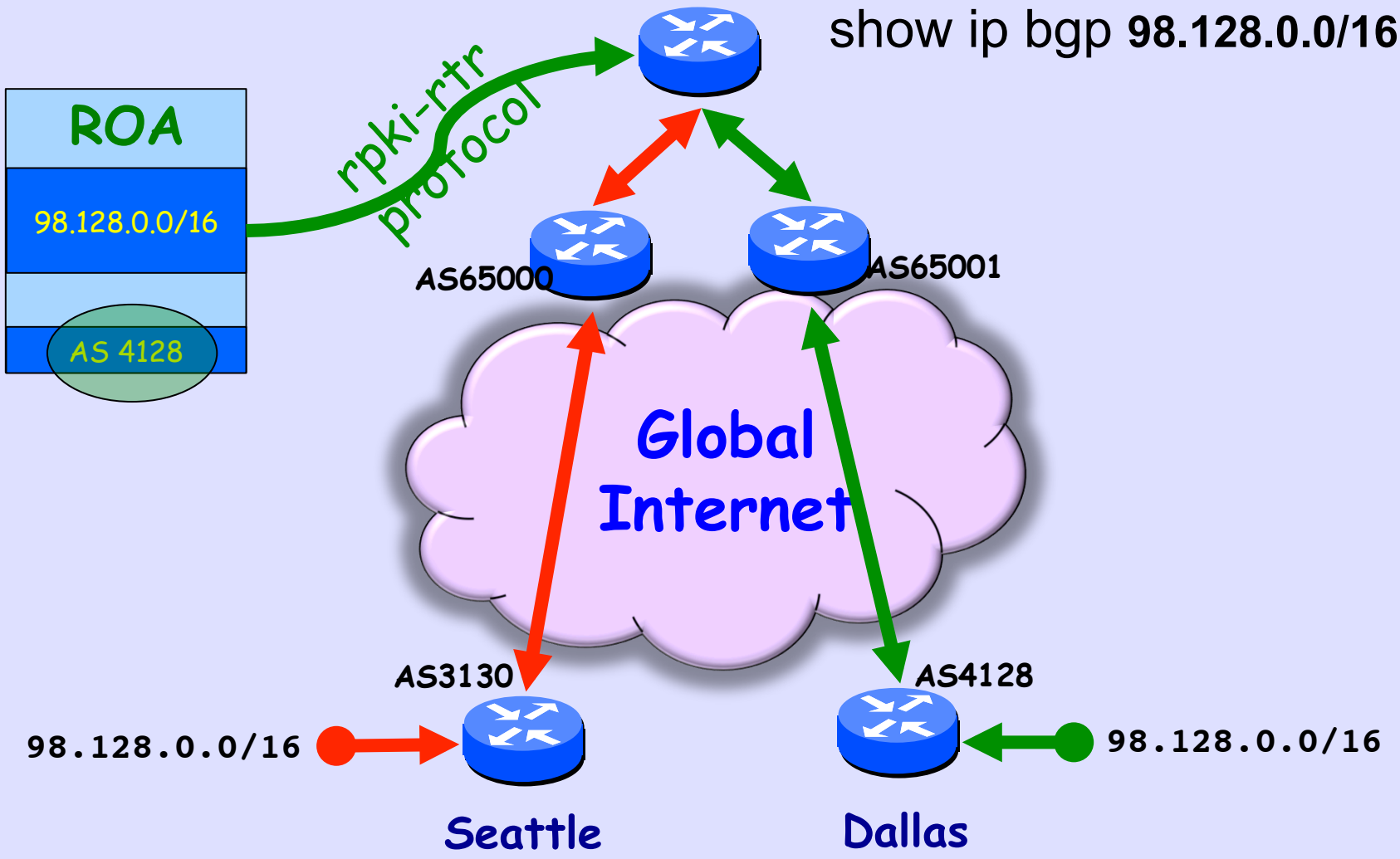
Look at a Prefix

```
R3#show ip bgp 98.128.0.0/24
BGP routing table entry for 98.128.0.0/24, version 360
Paths: (2 available, best #1, table default)
 65000 3130
    10.0.0.1 from 10.0.0.1 (193.0.24.64)
      Origin IGP, localpref 100, valid, external, best
      path 680D859C RPKI State valid
  65001 4128
    10.0.1.1 from 10.0.1.1 (193.0.24.65)
      Origin IGP, localpref 100, valid, external
      path 680D914C RPKI State invalid
```

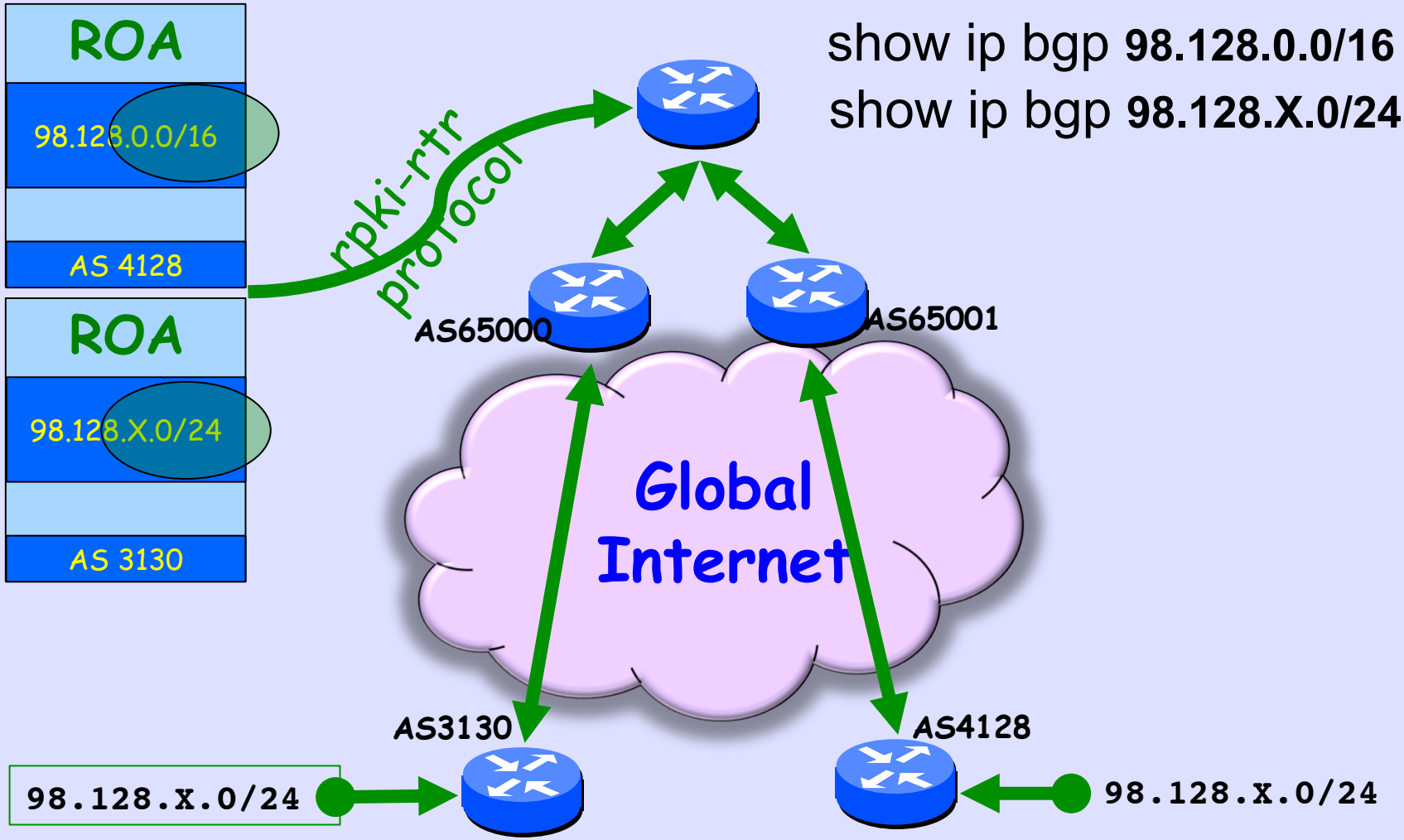
Fat-Finger Detected



ROA Controls Validity



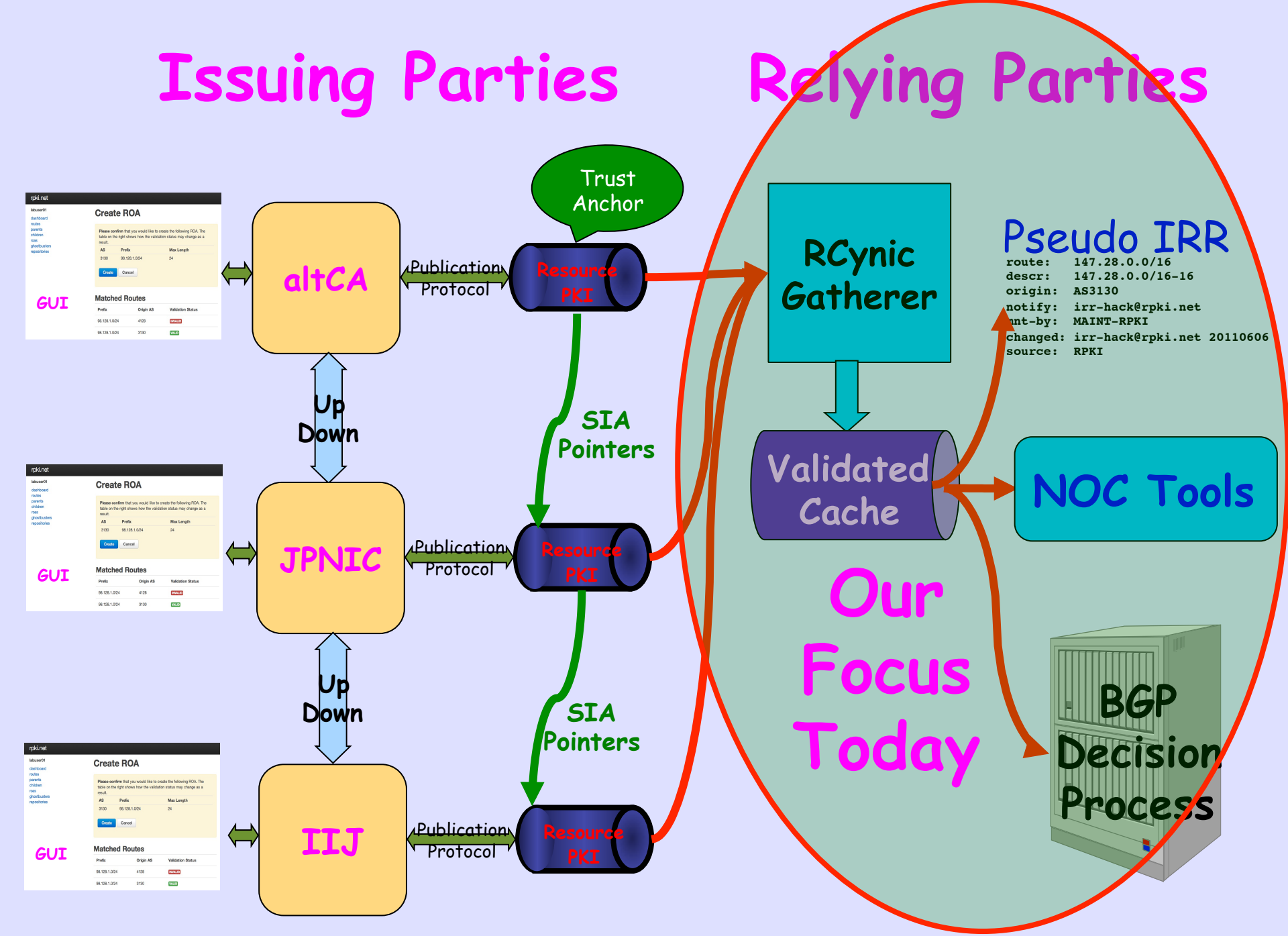
Try Your Own /24



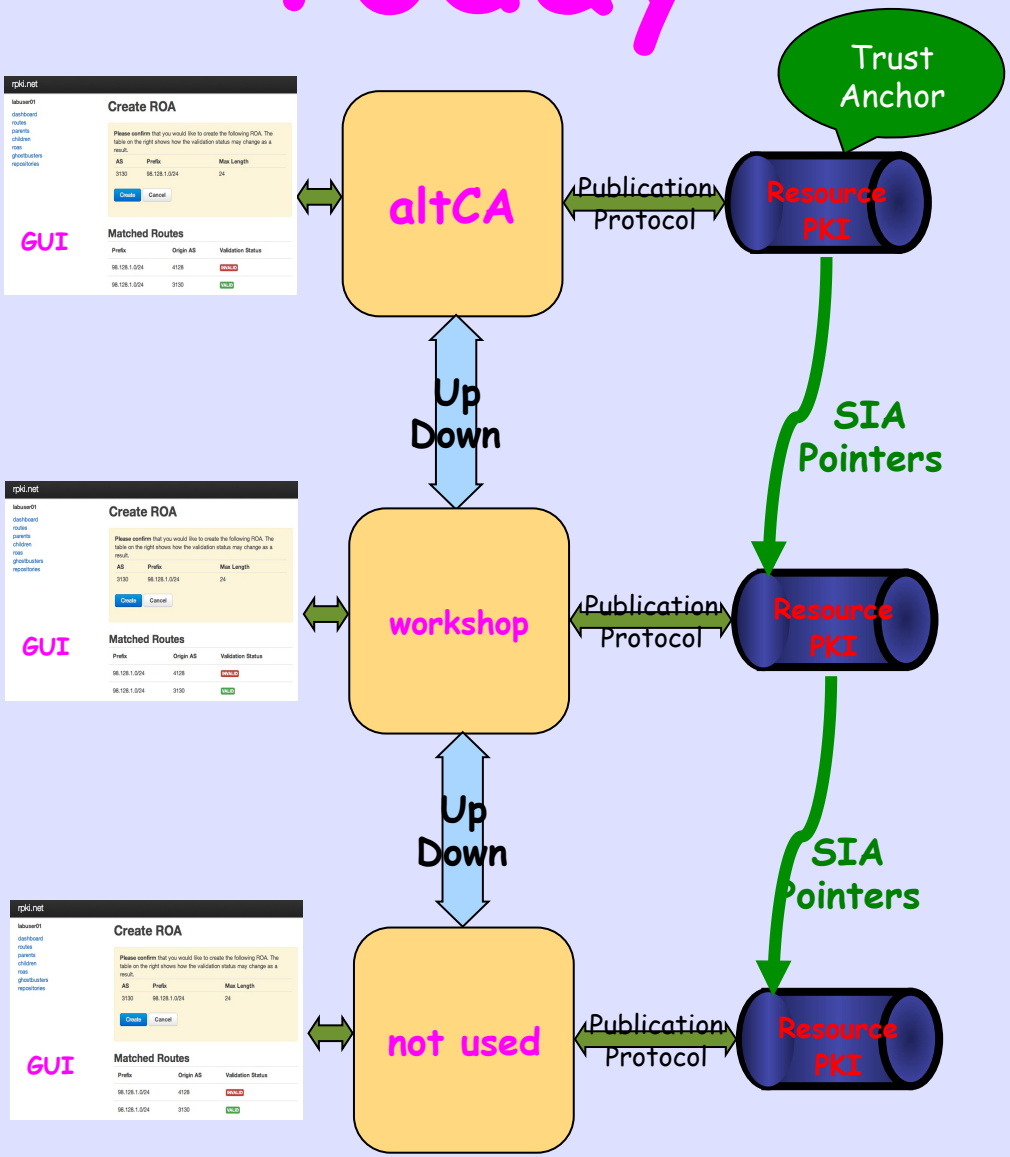
show ip bgp **98.128.0.0/16**
show ip bgp **98.128.X.0/24**

Mis-Origination Caught

```
R3#sh ip bgp 98.128.0.0/24
BGP routing table entry for 98.128.0.0/24, version 94
Paths: (2 available, best #2, table default)
  Advertised to update-groups:
     1
  Refresh Epoch 1
  65000 3130
    10.0.0.1 from 10.0.0.1 (65.38.193.12)
      Origin IGP, localpref 100, valid, external
      path 6802D4DC RPKI State invalid
  Refresh Epoch 1
  65001 4128
    10.0.1.1 from 10.0.1.1 (65.38.193.13)
      Origin IGP, localpref 100, valid, external, best
      path 6802D7C8 RPKI State valid
```


Issuing Parties
Relying Parties
Trust Anchor
altCA
JPNIC
IIJ
GUI
GUI
GUI
Publication Protocol
Publication Protocol
Publication Protocol
Resource PKI
Resource PKI
Resource PKI
Up Down
Up Down
SIA Pointers
SIA Pointers
RCynic Gatherer
Validated Cache
Pseudo IRR
route: 147.28.0.0/16
descr: 147.28.0.0/16-16
origin: AS3130
notify: irr-hack@rpki.net
mnt-by: MAINT-RPKI
changed: irr-hack@rpki.net 20110606
source: RPKI
NOC Tools
Our Focus Today
BGP Decision Process

Today


Trust Anchor
rpki.net
Create ROA
GUI
Matched Routes
altCA
Publication Protocol
Resource PKI
Up Down
SIA Pointers
workshop
not used

altCA TAL

So You Can Copy & Paste

```
rsync://ca0.rpki.net/tal/root.cer

MIIBIjANBgkqhkiG9w0BAQEFAAOCAQ8AMIIBCgKCAQEAzPSPpQxa0rxz9sbbvYGr
UlpgyBVxSIt+k/WDKbr+VW7CjUoz6cc5KMFANkQWw3D6ER4kCwX4WJkD58AGGbw/
WeAe6m3aHcORUVRkr45a4qSrYiG7Wq9RAXtwbhlXofB3zo+O90IlXDaVP2U9bw+Q
yoJBJuAmZONt0bRgrktv8QhVtKvuYkH5ZIe7DkXJcJzBn6gv09dZsdwZm3xV3soX
HEKrz5pY6Sb2xoL1CyPqzGOfVFxl0G5+dmcD/degPKxrEycAzjnHUzN1gus2jg26
dtkix7KG/Mn1h/k53j0FdQD+zqPwakgwqjvCOdSdHMRmsikj0EF9WrZIOjZUXV6q
6wIDAQAB
```

altCA TAL

Also At

https://wiki.rg.net/wiki/RPKI

Routers

- Use Your Own! (in production images from C&J)
- 16 DynaMIPS 7200s
- 7200s in Live Internet

Be Careful !

- Some Caches Have a LOT of ROAs
- Do Not Configure DynaMIPS to a Server With RIR TALs Because RIPE Data Has Thousands of ROAs
- dfw0, 198.180.152.11 Has Full BGP Table if you want to crash DynaMIPS

7200s in Live Internet

```
$ ssh demo@r0.sea.rg.net
Password: demo
```

or

```
$ ssh demo@r1.iad.rg.net
Password: demo
```

Sorry, no enable ☺

BGP Configuration

```
router bgp 651nn
 bgp rpki server tcp 172.16.10.192 \
      port 43779 refresh 600
 ! inject your prefix into BGP
  network 98.128.nn.0 255 255 255.0
```

That's All!!

Take a Look!

```
r0.sea#show ip bgp 198.180.150.0
  1239 3927
    144.232.9.61 (metric 11) from 147.28.7.2 (147.28.7.2)
      Origin incomplete, metric 750, localpref 110, valid,
   internal, best
      path 14CB1C54 RPKI State valid
2914 3927
    199.238.113.9 from 199.238.113.9 (129.250.0.167)
      Origin IGP, metric 90, localpref 100, valid, external
      Community: 2914:410 2914:1001 2914:2000 2914:3000 3130:380
      path 196F0E70 RPKI State valid
```

Cisco Adventure

```
r0.sea#show ip bgp rpki ?
  servers  Display RPKI cache server information
  table    Display RPKI table entries
```

Install RP Cache SW

On Your Laptop

(FreeBSD, Ubuntu, …)

or

Remote (Virtual) Ubuntu Server

Borrowing a VM

- Servers in Ashburn, Virginia US
- Ubuntu 12.04.2 LTS Server
- ssh labuserNN@ubuNN.rpki.net
- Password is Vattood1
- You are in sudoers
- Do not worry, machines are snapshotted

Installing RP Package

Copy and Paste from

https://trac.rpki.net/wiki/doc/RPKI/Installation/UbuntuPackages

```
$ wget -q -O - http://download.rpki.net/APT/apt-gpg-key.asc | sudo apt-key add -

$ sudo wget -q -O /etc/apt/sources.list.d/rpki.list http://download.rpki.net/APT/rpki.ubuntu.list

$ sudo apt-get update

$ sudo apt-get install rpki-rp
```

Upgrading RP Package

```
$ sudo apt-get update

$ sudo apt-get install rpki-rp
```

Select Trust Anchors

- We are going to use emulated routers on DynaMIPS, and it is memory limited
- So we can not feed it all the ROAs in the Global RPKI
- Edit /etc/rcynic.conf

```
trust-anchor-directory  = \
        /etc/rpki/trust-anchor/altca.tal
```

Speed it Up

- We do not want to wait an hour for ROAs to propagate
- Make rcynic run frequently
- `$ sudo crontab -e -u rcynic`

```
0/2 * * * *     exec /usr/bin/rcynic-cron
```

Is RPKI-Rtr Running?

```
$ rtr-origin --client tcp localhost 43779
2013-03-09 23:10:19 rtr-origin/client[17089]: [Startup]
2013-03-09 23:10:19 rtr-origin/client[17089]: [Starting raw TCP
   connection to localhost:43779]
2013-03-09 23:10:19 rtr-origin/client[17089]: [reset_query]
2013-03-09 23:10:19 rtr-origin/client[17089]: [cache_response,
   nonce 37394]
2013-03-09 23:10:19 rtr-origin/client[17089]: +    12322
   78.192.0.0/10-10
   00:04:00:00:00:00:00:14:01:0A:0A:00:4E:C0:00:00:00:00:30:22
2013-03-09 23:10:19 rtr-origin/client[17089]: +     3320
   79.192.0.0/10-10
   00:04:00:00:00:00:00:14:01:0A:0A:00:4F:C0:00:00:00:00:0C:F8
```

Cache Has Web Site!

ubu00.rpki.net/rcynic/

rcynic summary 2013-06-14T13:23:19Z

Overview Repositories Problems All Details

Grand totals for all repositories

	AKI extension issuer mismatch	Object rejected	AIA doesn't match issuer	Stale CRL or manifest	Tainted by stale CRL	Tainted by stale manifest	Tainted by not being in manifest	Object accepted	rsync transfer succeeded
									2
current .cer	1	1	1				1	39	
current .crl				3				39	
current .gbr					1	1		3	
current .mft				3	3			39	
current .roa					12	12		29	
Total	1	1	1	6	16	13	1	149	2

Overview for repository ca0.rpki.net

	AKI extension issuer mismatch	Object rejected	AIA doesn't match issuer	Stale CRL or manifest	Tainted by stale CRL	Tainted by stale manifest	Tainted by not being in manifest	Object accepted	rsync transfer succeeded
									2
current .cer	1	1	1				1	39	
current .crl				3				39	
current .gbr					1	1		3	
current .mft				3	3			39	
current .roa					12	12		29	
Total	1	1	1	6	16	13	1	149	2

Configure Router to Use Your Cache

```
router bgp 651nn
 bgp rpki server tcp 198.180.150.6n \
      port 43779 refresh 180
 ! inject your prefix into BGP
  network 98.128.nn.0 255 255 255.0
```

Check Server

```
r0.sea#show ip bgp rpki servers
BGP SOVC neighbor is 198.180.150.1/43779 connected to port 43779
Flags 0, Refresh time is 600, Serial number is 1304239609
InQ has 0 messages, OutQ has 0 messages, formatted msg 345
Session IO flags 3, Session flags 4008
 Neighbor Statistics:
  Nets Processed 624

Connection state is ESTAB, I/O status: 1, unread input bytes: 0
Connection is ECN Disabled
Mininum incoming TTL 0, Outgoing TTL 255
Local host: 199.238.113.10, Local port: 57932
Foreign host: 198.180.150.1, Foreign port: 43779
Connection tableid (VRF): 0
```

Look at ROA/VRF Table

```
router1#show ip bgp rpki table
76 BGP sovc network entries using 6688 bytes of memory
78 BGP sovc record entries using 1560 bytes of memory
Network                Maxlen  Origin-AS  Neighbor
98.128.0.0/24          24      3130       198.180.150.1/42420
98.128.0.0/16          16      3130       198.180.150.1/42420
98.128.6.0/24          24      4128       198.180.150.1/42420
98.128.9.0/24          24      3130       198.180.150.1/42420
98.128.30.0/24         24      1234       198.180.150.1/42420
128.224.1.0/24         24      3130       198.180.150.1/42420
129.6.0.0/17           17      49         198.180.150.1/42420
129.6.112.0/24         24      10866      198.180.150.1/42420
129.6.128.0/17         17      49         198.180.150.1/42420
147.28.0.0/16          16      3130       198.180.150.1/42420
```

Look at BGP Table

```
r0.sea#sh ip bgp
     Network          Next Hop            Metric LocPrf Weight Path
* i I198.180.150.0    144.232.9.61   100  0 1239 3927 i
*>  I                 199.238.113.9       0 2914 3927 i
*   I                 129.250.11.41       0 2914 3927 i
*>  V198.180.152.0    199.238.113.9       0 2914 4128 i
*   V                 129.250.11.41       0 2914 4128 i
*>  N198.180.155.0    199.238.113.9       0 2914 22773 i
*   N                 129.250.11.41       0 2914 22773 i
*>  N198.180.160.0    199.238.113.9       0 2914 23308 13408 5752 i
*   N                 129.250.11.41       0 2914 23308 13408 5752 i
```

Look at a Prefix

```
R3#show ip bgp 98.128.0.0/24
BGP routing table entry for 98.128.0.0/24, version 360
Paths: (2 available, best #1, table default)
 65000 3130
    10.0.0.1 from 10.0.0.1 (193.0.24.64)
      Origin IGP, localpref 100, valid, external, best
      path 680D859C RPKI State valid
  65001 4128
    10.0.1.1 from 10.0.1.1 (193.0.24.65)
      Origin IGP, localpref 100, valid, external
      path 680D914C RPKI State invalid
```

Fun Things to Do

- Look at your neighbors' prefixes
- Use the GUI to change the ROA for your prefix, and wait for it to propagate
- Attack your neighbor's prefix by configuring your bgp to announce it

```
router bgp 651nn
  network 98.128.<neighbor>.0 255 255 255.0
```

Notice it Did Not Work

```
router bgp 651nn
  network 98.128.<neighbor>.0 255 255 255.0

show ip bgp 98.128.<neighbor>.0
```

- **It is marked Invalid on your own router! It caught you injecting a bad prefix. To cheat you need to**

```
router bgp 651nn
  no bgp bestpath prefix-validate local
```

- **Now ask others to look for your announcement. They should see it as Invalid**

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At Home