



ARIN + NANOG

ON THE ROAD

Orlando, FL

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Security Overlays on Core Internet Protocols – DNSSEC and RPKI

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Why are DNSSEC and RPKI Important

- Two critical resources
 - DNS
 - Routing
- Hard to tell if compromised
 - From the user point of view
 - From the ISP/Enterprise
- Focus on government funding

Why DNSSEC? What is it?

- Standard DNS (forward or reverse) responses are not secure
 - Easy to spoof
 - Notable malicious attacks
- DNSSEC attaches signatures
 - Validates responses
 - Can not spoof

Reverse DNS at ARIN

- ARIN issues blocks without any working DNS
 - Registrant must establish delegations after registration
 - Then employ DNSSEC if desired
- Just as susceptible as forward DNS if you do not use DNSSEC

Reverse DNS at ARIN

- Authority to manage reverse zones follows allocations
 - “Shared Authority” model
 - Multiple sub-allocation recipient entities may have authority over a particular zone

Changes completed to make DNSSEC work at ARIN

- Permit by-delegation management
- Sign in-addr.arpa. and ip6.arpa. delegations that ARIN manages
- Create entry method for DS Records
 - ARIN Online
 - RESTful interface
 - Not available via templates

Changes completed to make DNSSEC work at ARIN

- Only key holders may create and submit Delegation Signer (DS) records
- DNSSEC users need to have signed a registration services agreement with ARIN to use these services

Reverse DNS in ARIN Online

First identify the network that you want to put Reverse DNS nameservers on...

REVERSE DNS INFORMATION FOR NET-192-149-252-0-1				
SELECT	DELEGATION	NAMESERVERS	DS RECORD KEY TAGS	AUTHORIZED ORGANIZATIONS
<input checked="" type="checkbox"/>	252.149.192.in-addr.arpa.	NS1.ARIN.NET NS2.ARIN.NET NS2.LACNIC.NET SEC1.APNIC.NET SEC1.AUTHDNS.RIPE.NET		ARIN Operations

[MODIFY NAMESERVERS](#)

[MODIFY DS RECORDS](#)

Reverse DNS in ARIN Online

...then enter the Reverse DNS nameservers...

Manage Reverse DNS

Using the text fields on the right, specify the hostnames (not the IP addresses) of the nameservers that should be authoritative for ALL the reverse DNS delegations listed on the left. Please note that any modifications will be applied to all listed delegations.

SELECTED DELEGATIONS IN - NET-192-149-252-0-1	HOSTNAMES OF NAMESERVERS
<u>252.149.192.in-addr.arpa.</u>	Nameserver 1: <input type="text" value="NS1.ARIN.NET"/> Nameserver 2: <input type="text" value="NS2.ARIN.NET"/> Nameserver 3: <input type="text" value="NS2.LACNIC.NET"/> Nameserver 4: <input type="text" value="SEC1.APNIC.NET"/> Nameserver 5: <input type="text" value="SEC1.AUTHDNS.RIPE.NET"/> Nameserver 6: <input type="text"/> Nameserver 13: <input type="text"/>
<div style="text-align: right;"> <input type="button" value="APPLY TO ALL"/> <input type="button" value="CANCEL"/> </div>	

DNSSEC in ARIN Online

...then apply DS record to apply to the delegation

DS RECORDS				
	KEY TAG	ALGORITHM	DIGEST TYPE	DIGEST

The DS records should be in the following format:

ZONE	CLASS	RR TYPE	KEY TAG	ALGORITHM	DIGEST TYPE	DIGEST
Optional, ignored	Optional, "IN"	Must be "DS"	2 byte integer	1 byte integer (5, 7 or 8)	1 byte integer (1 or 2)	The hex encoded digest

PASTE DS RECORD DATA BELOW Parse DS Record

Choose File No file chosen
UPLOAD FILE

File contents must be plain text

APPLY TO ALL
CANCEL

Reverse DNS: Querying ARIN's Whois

Query for the zone directly:

```
whois> 81.147.204.in-addr.arpa
```

```
Name:          81.147.204.in-addr.arpa.  
Updated:      2006-05-15  
NameServer:   AUTHNS2.DNVR.QWEST.NET  
NameServer:   AUTHNS3.STTL.QWEST.NET  
NameServer:   AUTHNS1.MPLS.QWEST.NET
```

```
Ref:    http://whois.arin.net/rest/rdns/81.147.204.in-addr.arpa.
```


DNSSEC in Zone Files

```

0.121.74.in-addr.arpa. 86400  IN NS   DNS1.ACTUSA.NET.
                        86400  IN NS   DNS2.ACTUSA.NET.
                        86400  IN NS   DNS3.ACTUSA.NET.
                        86400  DS     46693 5 1 (
                        AEEDA98EE493DFF5F3F33208ECB0FA4186BD
                        8056 )
                        86400  DS     46693 5 2 (
                        66E6D421894AFE2AF0B350BD8F4C54D2EBA5
                        DA72A615FE64BE8EF600C6534CEF )
                        86400  RRSIG  DS 5 5 86400 20140306210053 (
                        20140224210053 57974 74.in-addr.arpa.
                        n+aPxBHuf+sbzQN4LmHzl0i0C/hkaSV03q1y
                        6J0KjqNPzYqtxLgZjU+IL9qhtIOocgNQib9l
                        gFRmZ9inf2bER435GMsa/nnjpVVWW/MBRKxf
                        Pcc72w2i0AMu2G0prtVT08ENxtu/pBfnsOZK
                        nhCY8UOBOYLOLE5Whtk3X0uX9+U= )
NSEC                    10800  NSEC   1.121.74.in-addr.arpa. NS DS RRSIG
                        10800  RRSIG  NSEC 5 5 10800 20140306210053 (
                        20140224210053 57974 74.in-addr.arpa.
                        YvRowkdVDfv+PW42ySNUwW8S8jRyV6EKKRxe

```

...

DNSSEC Validating Resolvers

- www.internetsociety.org/deploy360/dnssec/
- www.isc.org/downloads/bind/dnssec/

Reverse DNS Management and DNSSEC in ARIN Online

- Available on ARIN's website

<http://www.arin.net/knowledge/dnssec/>



Using
**ARIN
ONLINE**

for Delegation Management
and DNSSEC



Click To Play

The image is a promotional graphic for ARIN Online. It features a screenshot of the ARIN Online web interface on the left, showing various navigation tabs and content. To the right of the screenshot, the text 'Using ARIN ONLINE' is displayed in large, bold, white letters, with 'ARIN ONLINE' underlined. Below this, the text 'for Delegation Management and DNSSEC' is written in a smaller, white font. At the bottom center, there is a white circular play button icon with a green triangle. Below the play button, the text 'Click To Play' is written in large, bold, yellow letters.

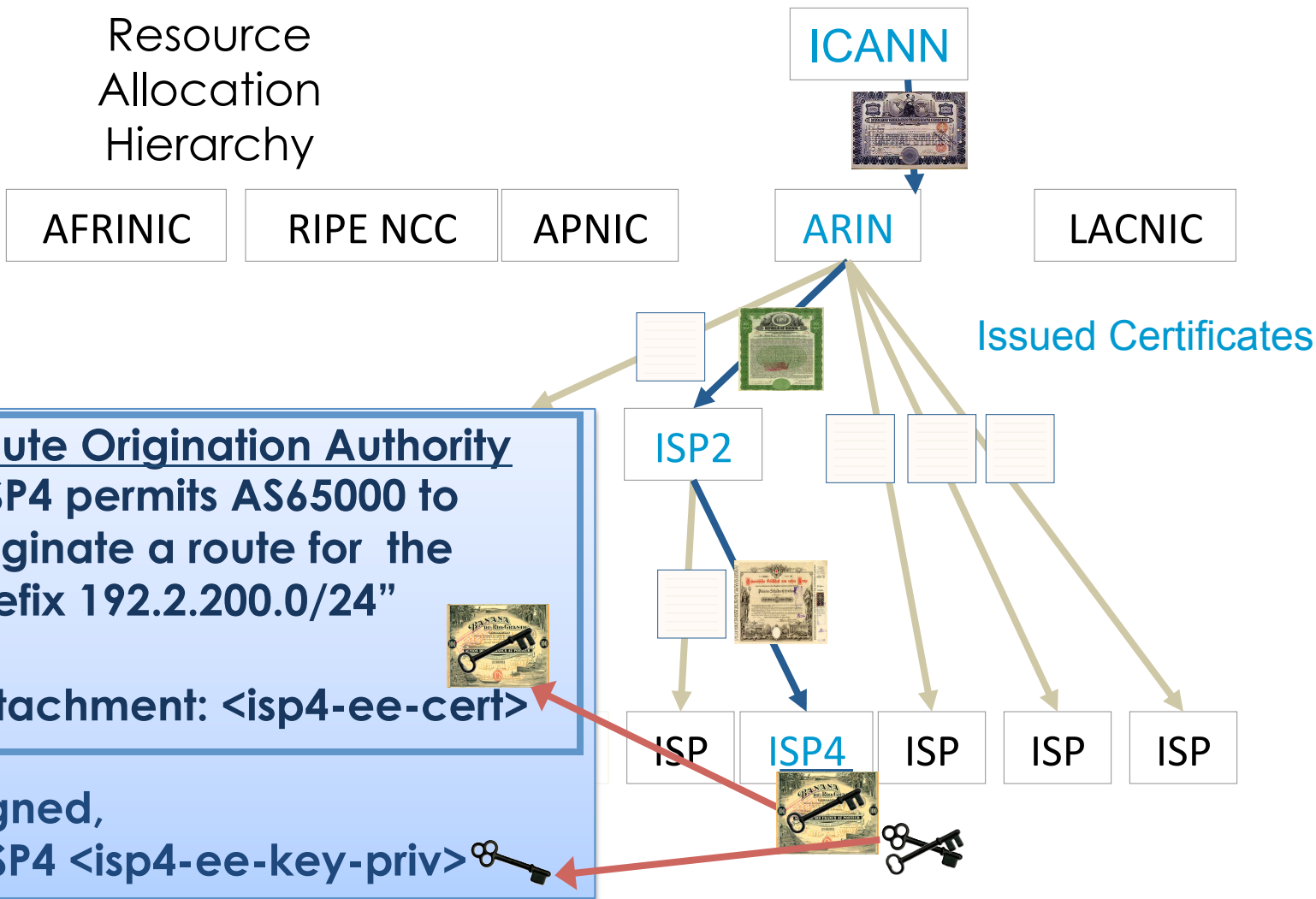
What is RPKI?

- **R**esource **P**ublic **K**ey **I**nfrastructure
- Attaches digital certificates to network resources
 - AS Numbers
 - IP Addresses
- Allows ISPs to associate the two
 - Route Origin Authorizations (ROAs)
 - Can follow the address allocation chain to the top

What does RPKI accomplish?

- Allows routers or other processes to validate route origins
- Simplifies validation authority information
 - Trust Anchor Locator
- Distributes trusted information
 - Through repositories

Resource
Allocation
Hierarchy



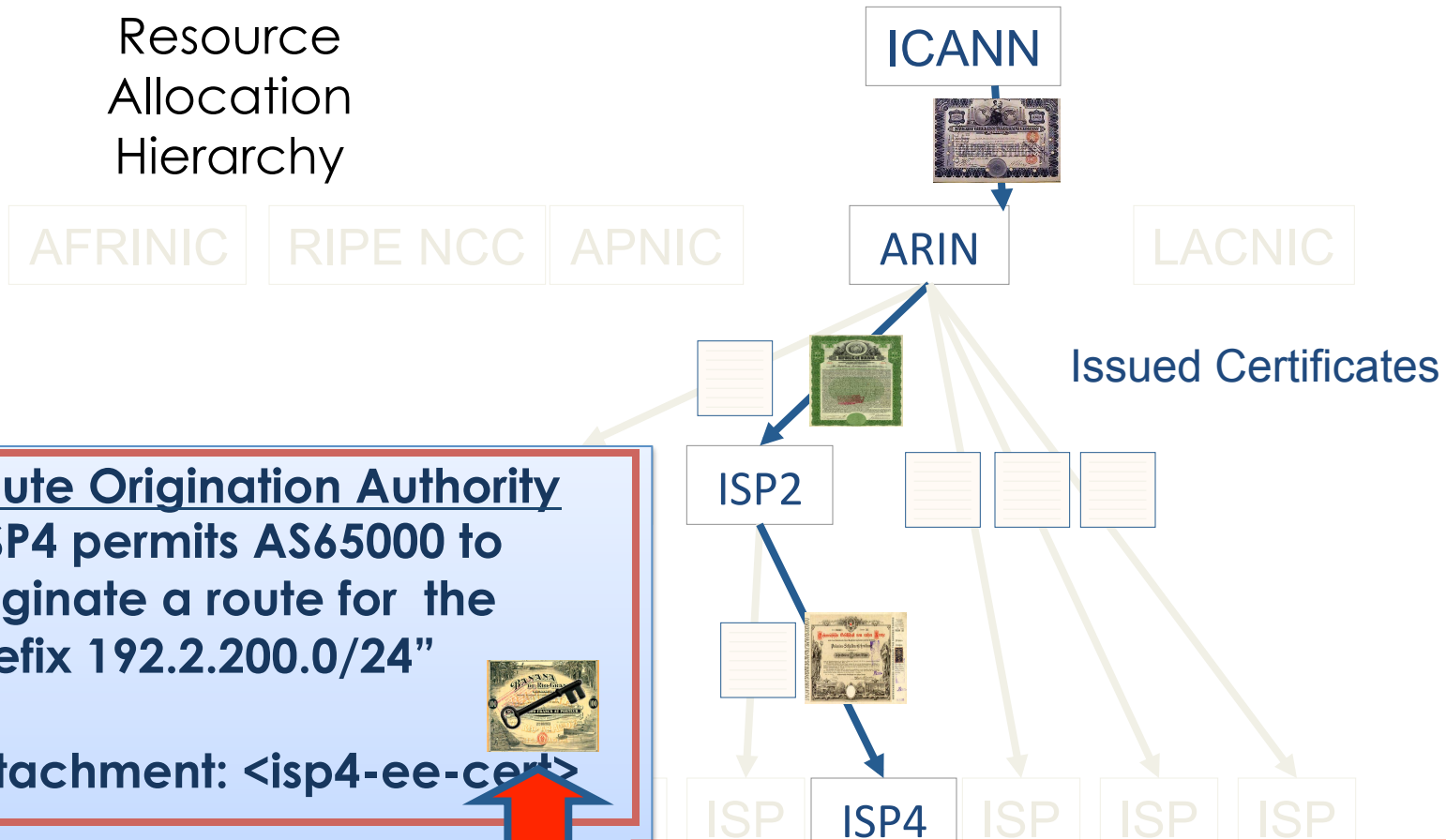
Route Origination Authority

"ISP4 permits AS65000 to originate a route for the prefix 192.2.200.0/24"

Attachment: <isp4-ee-cert>

Signed,
ISP4 <isp4-ee-key-priv>

Resource
Allocation
Hierarchy



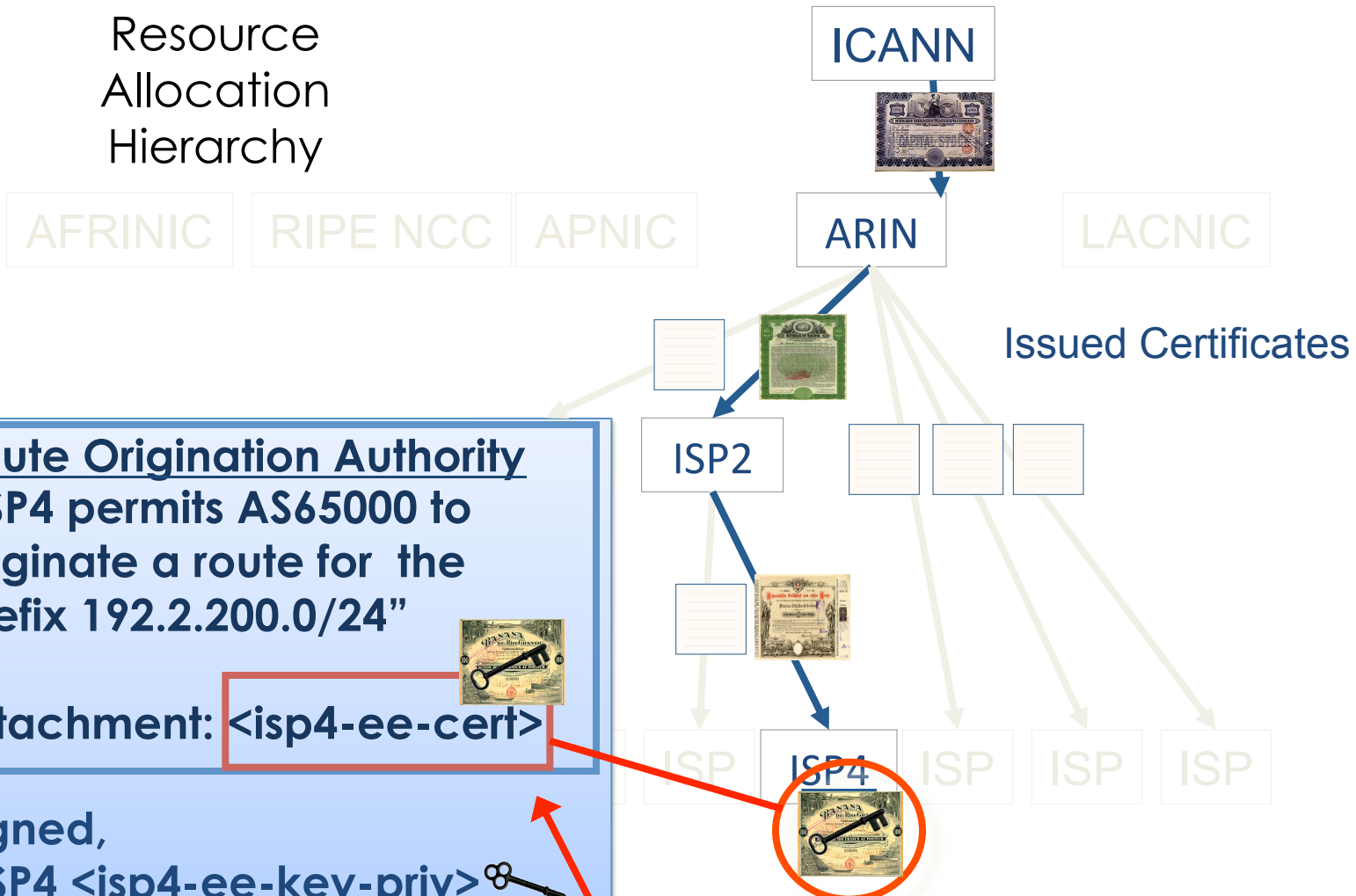
Route Origination Authority
"ISP4 permits AS65000 to originate a route for the prefix 192.2.200.0/24"

Attachment: `<isp4-ee-cert>`

Signed,
ISP4 `<isp4-ee-key-priv>`

1. Did the matching private key sign this text?

Resource
Allocation
Hierarchy



Route Origination Authority
“ISP4 permits AS65000 to originate a route for the prefix 192.2.200.0/24”

Attachment: `<isp4-ee-cert>`

Signed,
ISP4 `<isp4-ee-key-priv>`

2. Is this certificate valid?

Resource
Allocation
Hierarchy



ICANN



AN



ISP2



ISP

ISP4

ISP

ISP

ISP

Issued Certificates

Route Origination Authority
"ISP4 permits AS65000 to originate a route for the prefix 192.2.200.0/24"

Attachment: `<isp4-ee-cert>`

Signed,
ISP4 `<isp4-ee-key-priv>`

3. Is there a valid certificate path from a Trust Anchor to this certificate?

What does RPKI Create?

- It creates a repository
 - RFC 3779 (RPKI) Certificates
 - ROAs
 - CRLs
 - Manifest records

Repository View

```
./ba/03a5be-ddf6-4340-a1f9-1ad3f2c39ee6/1:
```

```
total 40
```

```
-rw-r--r--  1 143  143  1543 Jun 26  2009 ICcaIRKhGHJ-TgUZv8GRKqkidR4.roa
-rw-r--r--  1 143  143  1403 Jun 26  2009 cKxLCU94umS-qD4DOOkAK0M2US0.cer
-rw-r--r--  1 143  143   485 Jun 26  2009 dSmerM6uJGLWMMQTl2esy4xyUAA.crl
-rw-r--r--  1 143  143  1882 Jun 26  2009 dSmerM6uJGLWMMQTl2esy4xyUAA.mnf
-rw-r--r--  1 143  143  1542 Jun 26  2009 nB0gDFtWffKk4VWgln-12pdFtE8.roa
```

A Repository Directory containing an RFC3779
 Certificate, two ROAs, a CRL, and a manifest

Repository Use

- Pull down these files using a manifest-validating mechanism
- Validate the ROAs contained in the repository
- Communicate with the router marking routes “valid”, “invalid”, “unknown”
- Up to ISP to use local policy on how to route

Possible Flow

- RPKI Web interface -> Repository
- Repository aggregator -> Validator
- Validated entries -> Route Checking
- Route checking results -> local routing decisions (based on local policy)

How you can use ARIN's RPKI System?

- Hosted
- Hosted using ARIN's RESTful service
- Web Delegated (being deprecated)
- Delegated using Up/Down Protocol

Hosted RPKI

- Pros
 - Easier to use
 - ARIN managed
- Cons
 - No current support for downstream customers to manage their own space (yet)
 - Tedious through the IU if you have a large network
 - We hold your private key

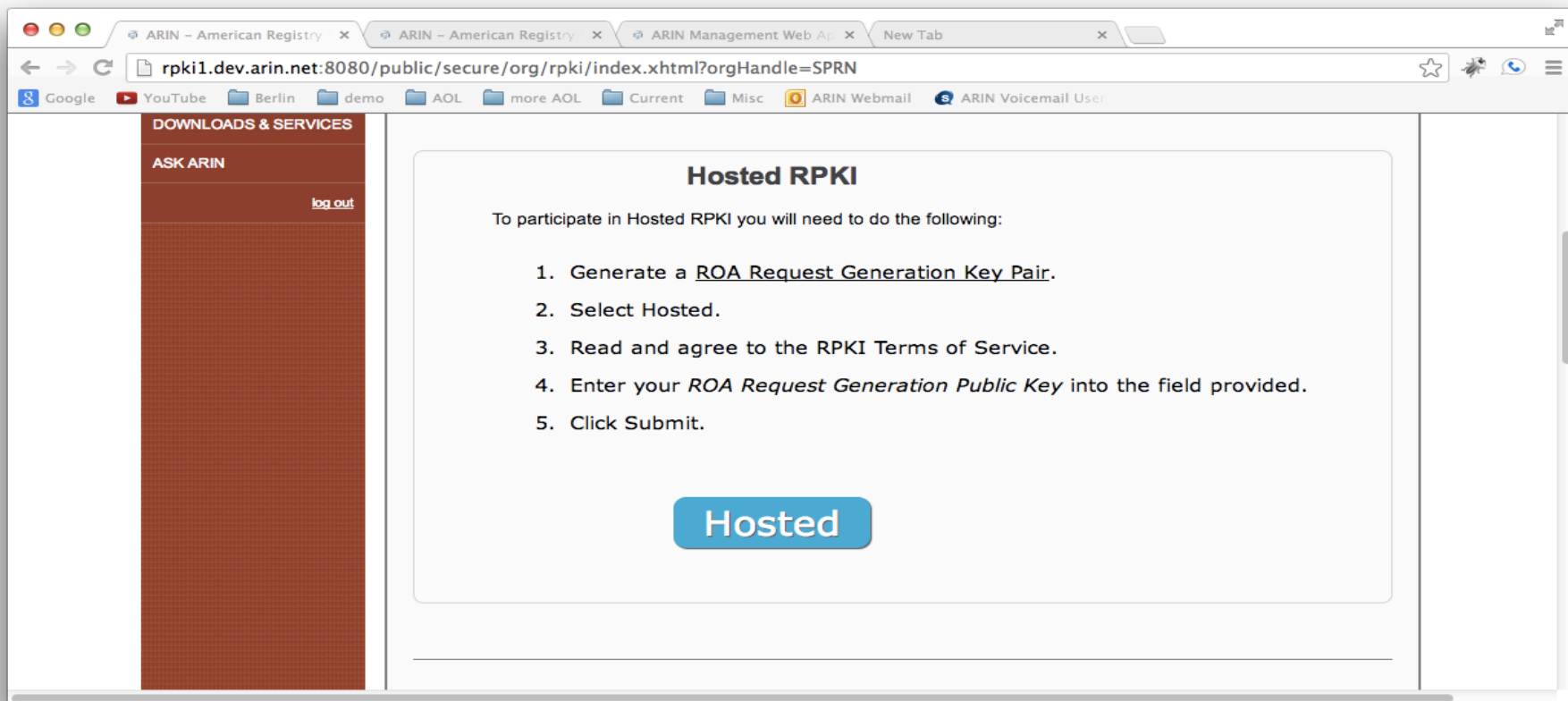
Hosted RPKI with RESTful Interface

- Pros
 - Easier to use
 - ARIN managed
 - Programmatic interface for large networks
- Cons
 - No current support for downstream customers to manage their own space (yet)
 - We hold your private key

Delegated RPKI with Up/Down

- Pros
 - Same as web delegated
 - Follows the IETF up/down protocol
- Cons
 - Extremely hard to setup
 - Need to operate your own RPKI environment

Hosted RPKI in ARIN Online



Hosted RPKI in ARIN Online

Organization Hosted RPKI Terms of Service



AGREEMENT

I agree to the ARIN Hosted RPKI Terms of Service

You must accept the Hosted RPKI Terms of Service in order to proceed.

[Access](#) a printable .pdf version of the Hosted RPKI Terms of Service.

Enter your initials

Continue

TERMS OF SERVICE

**AMERICAN REGISTRY FOR INTERNET NUMBERS, LTD.
RPKI TERMS OF SERVICE AGREEMENT**

YOU MUST READ AND ACCEPT THIS RPKI TERMS OF SERVICE AGREEMENT (THIS "AGREEMENT") BEFORE ACCESSING OR USING ANY RPKI SERVICES (AS DEFINED BELOW). IF YOU DO NOT AGREE TO THE TERMS OF THIS AGREEMENT, DO NOT ACCESS OR USE ANY RPKI SERVICES.

Hosted RPKI in ARIN Online

Enter your *ROA Request Generation Public Key* below.

ROA Request Generation Public Key:

Learn more about the [ROA Request Generation Key Pair](#). Or, just how to [create one and extract the public key](#).

```
-----BEGIN PUBLIC KEY-----  
MIIBIjANBgkqhkiG9w0BAQEFAAOCAQ8AMIIBCgKCAQEA vBhoSmbRQhbSpTIM2Pqn  
hWcHL/6SHORJGctuoMUS6tVamlqgdTZJw+8POFku+WIOlgUJOEw763rQVTsAq8WZ  
vs6px2FNr6CJftKAr3fg/T083vHYiMtYJnJbVPKJjdSQSylyUWleR2hYh/4LEOyK  
MPr3zAuDS2QOI6778OY/kpTEsCrwzp+dM4KtLGOQbyrkfSVIHgux5pCMzsQP/8nP  
son5vOikWtkuFNmg8pXgLfEdBR6MC0Y7eKaTeYM6EEJ7rhUCY69SUq+SFmuwYFsg  
7YNzRAErF9THpEWqOaOxaSu/4nwLVJ2oexksT6k4hsEWPadxJ0P3E0FHSb/YifOS  
fwIDAQAB  
-----END PUBLIC KEY-----|
```

Submit

Hosted RPKI in ARIN Online

Hosted Certificates



Information

Each resource certificate entry displays the number of Route Origin Authorizations (ROAs), IP addresses or ranges, and Autonomous System Numbers (ASNs) covered by that certificate, and the date of the certificate's last update. For a listing of data elements for a given resource certificate, select Details.

For more information about resource certificates, visit [ARIN's RPKI section](#).



ARIN

Updated: 03-20-2013

ROAs: 0

Nets: 20

ASNs: 10



Create Roa



View Resources



View Roas



View Details

Hosted RPKI in ARIN Online

Create a Route Origin Authorization (ROA) Request for SAMPLE-ORG

There are two ways to create and submit a ROA Request to ARIN:

Browser Signed ROA Request Complete the required fields below and digitally sign the ROA Request using the private key that corresponds with the public key you registered with ARIN.

Signed ROA Request. You must construct a precisely formatted text block containing your ROA Request information, and sign it using the private key that corresponds with the public key you registered with ARIN.

Browser Signed | Signed

* denotes optional field

ROA Name: ?

Origin AS: ?

Start Date: ?

End Date: ?

Prefix: / Max Length ^{*} ?

Private Key: No file chosen

This key will not be uploaded to ARIN.

Hosted RPKI in ARIN Online

Create a Route Origin Authorization (ROA) Request for SAMPLE-ORG


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Signed ROA Request. You must construct a precisely formatted text block containing your ROA Request information, and sign it using the private key that corresponds with the public key you registered with ARIN.


Browser Signed


Signed



 denotes optional field

ROA Name: 

Origin AS: 

Start Date: 

End Date: 

Prefix: / Max Length  

Private Key: Key Loaded

This key will not be uploaded to ARIN.

Hosted RPKI in ARIN Online

SUBMIT SIGNED ROUTE ORIGIN AUTHORIZATION

This information will not be saved until you click the **Submit** button below. Note that the signature is used by ARIN to ensure that the ROA Request was signed with your private key. Please verify that the information below is correct. Click **Submit** to send the request, or click **Back** to make changes.

ROA Name: **Test-ROA**

Origin AS: **23456**

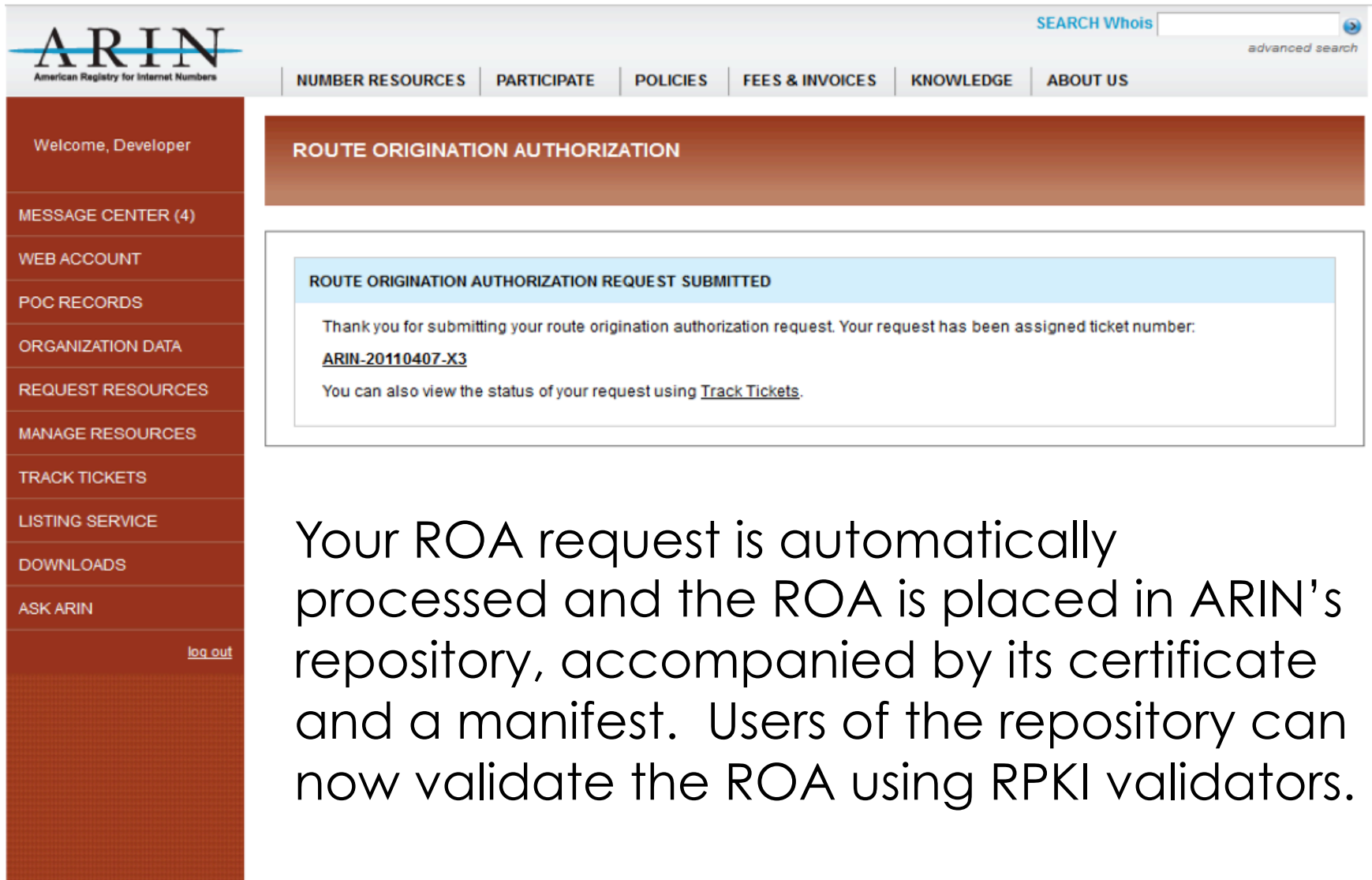
Validity Period: **03-20-2013 to 03-20-2023**

Resources: **70.182.32.0/24 max length 24**

Signature: **Hjnse52POzaVFupNDGqYXZVylmr78wSd4A1XEMUpj4vVmpJWWH
nKoZRupDvB2OBtwcJJEyx4KUWPgHUt8VhdCYroyuZGRxJkDtTe
q8c0FT2QQdjuD+GmwUWlvtnSD26VZdYUrXM6WniTVwL96UV6sK
bJGTx40GqD52tdJq6612QpC6K+Y+JEISgauVyy2htnAPI5r1Z
GY42Fb9c1CEoE8GmT/FWY+CX6UmKsxJ8LQ0NGR2XUeGKZyc2k5
gKiSCog976Vnltt88/z5jOm1GkYQoQvk6uyy+yYUKreC+GyNqP
YyPAvGAq61jYIDXMhDTSjWdGRiV2dNQ8zMmoDOgm9A==**

BACK

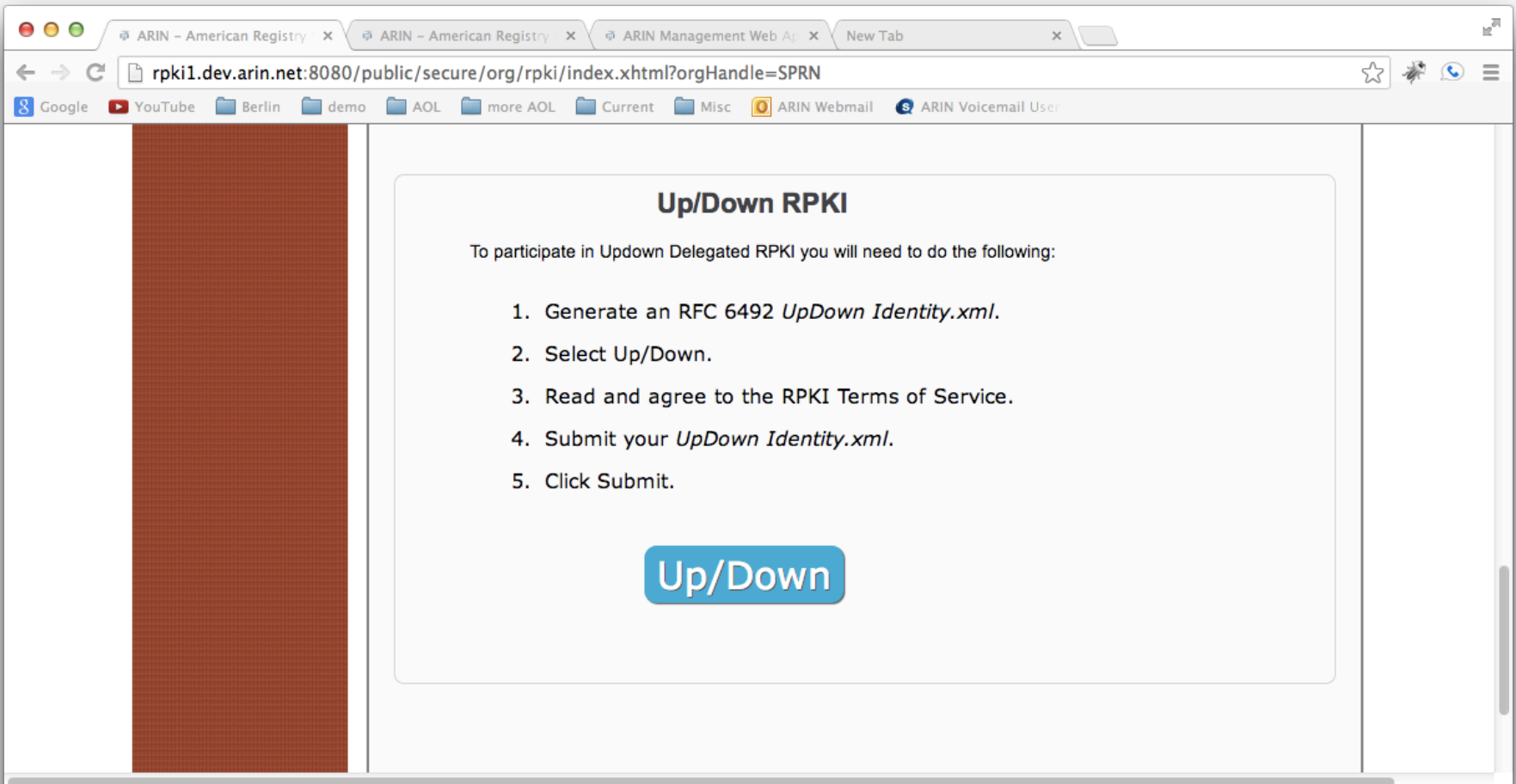
Submit Signed ROA Request



The screenshot shows the ARIN website interface. At the top left is the ARIN logo with the tagline "American Registry for Internet Numbers". To the right is a search bar labeled "SEARCH Whois" with a search button and a link to "advanced search". Below the logo is a navigation menu with links: "NUMBER RESOURCES", "PARTICIPATE", "POLICIES", "FEES & INVOICES", "KNOWLEDGE", and "ABOUT US". On the left side, there is a vertical sidebar menu with links: "Welcome, Developer", "MESSAGE CENTER (4)", "WEB ACCOUNT", "POC RECORDS", "ORGANIZATION DATA", "REQUEST RESOURCES", "MANAGE RESOURCES", "TRACK TICKETS", "LISTING SERVICE", "DOWNLOADS", "ASK ARIN", and a "log out" link. The main content area has a dark red header with the text "ROUTE ORIGINATION AUTHORIZATION". Below this is a light blue box with the heading "ROUTE ORIGINATION AUTHORIZATION REQUEST SUBMITTED". The text inside the box reads: "Thank you for submitting your route origination authorization request. Your request has been assigned ticket number: [ARIN-20110407-X3](#). You can also view the status of your request using [Track Tickets](#)."

Your ROA request is automatically processed and the ROA is placed in ARIN's repository, accompanied by its certificate and a manifest. Users of the repository can now validate the ROA using RPKI validators.

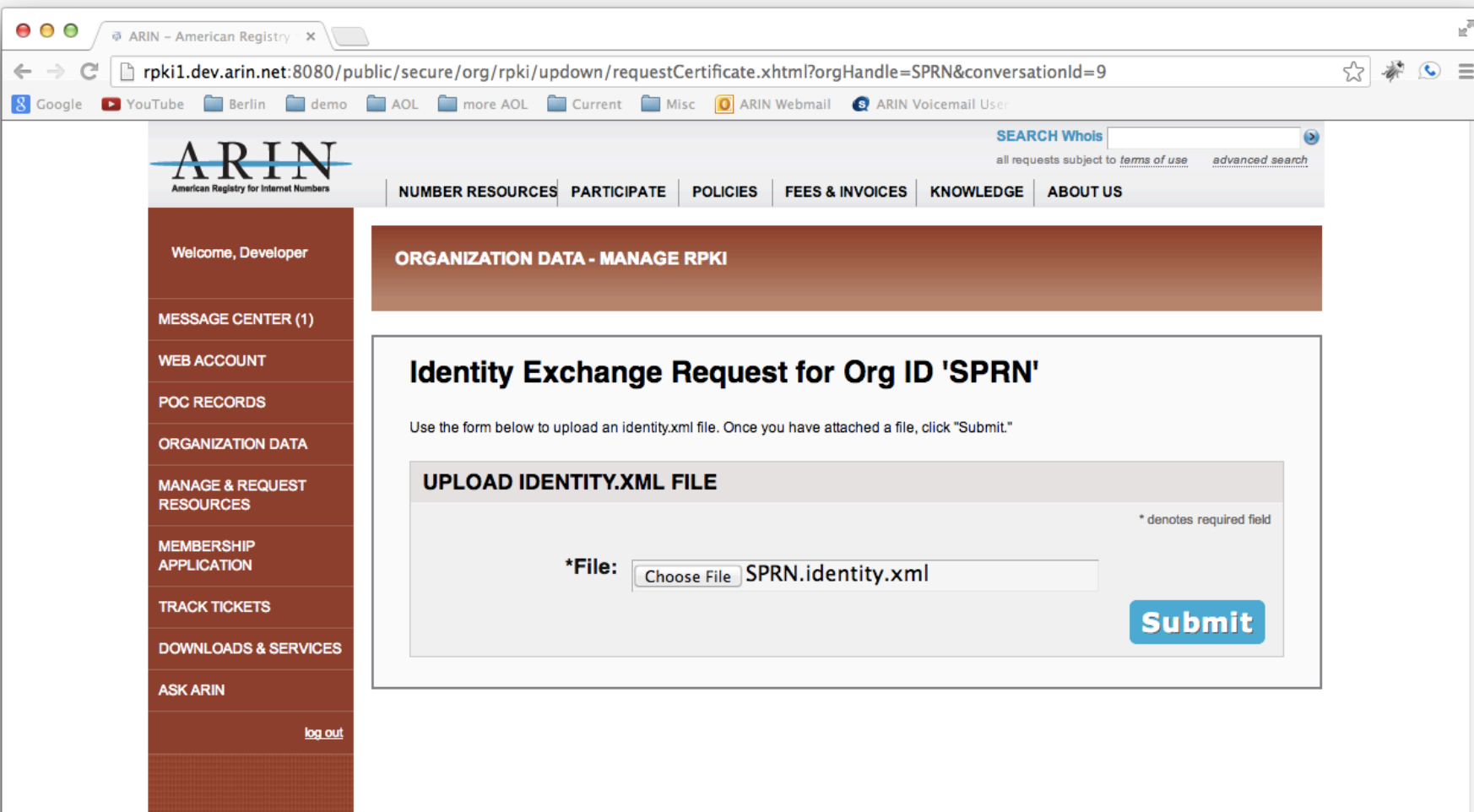
Delegated with Up/Down



The screenshot shows a web browser window with the following details:

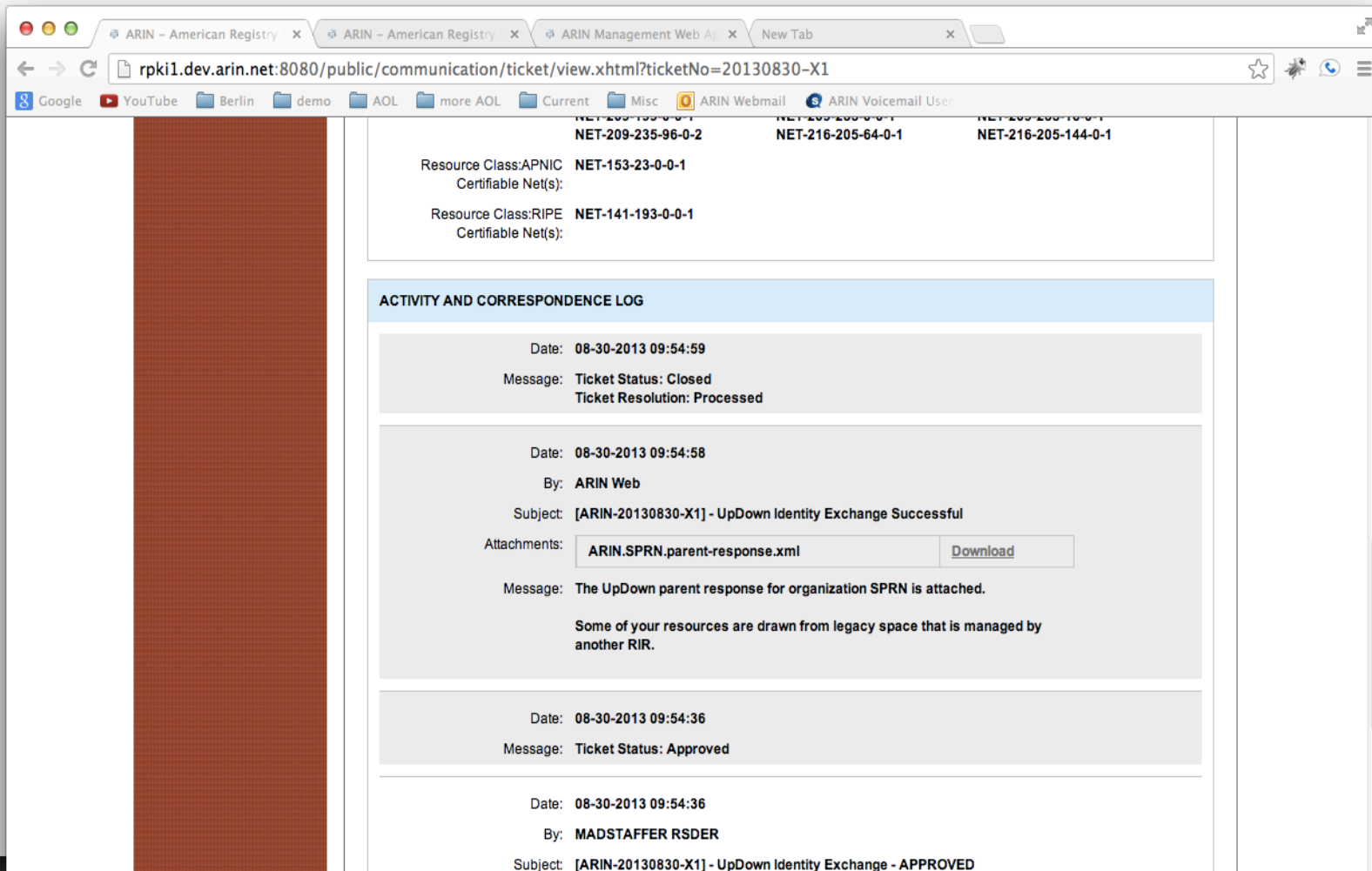
- Browser tabs: ARIN - American Registry, ARIN - American Registry, ARIN Management Web Ap, New Tab
- Address bar: `rpk1.dev.arin.net:8080/public/secure/org/rpki/index.xhtml?orgHandle=SPRN`
- Bookmarks: Google, YouTube, Berlin, demo, AOL, more AOL, Current, Misc, ARIN Webmail, ARIN Voicemail User
- Page Content:
 - Up/Down RPKI**
 - To participate in Updown Delegated RPKI you will need to do the following:
 - 1. Generate an RFC 6492 *UpDown Identity.xml*.
 - 2. Select Up/Down.
 - 3. Read and agree to the RPKI Terms of Service.
 - 4. Submit your *UpDown Identity.xml*.
 - 5. Click Submit.
- Buttons: A blue button labeled "Up/Down" is centered at the bottom of the content area.

Delegated with Up/Down



The screenshot shows a web browser window with the ARIN website. The address bar shows the URL: `rpki1.dev.arin.net:8080/public/secure/org/rpki/updown/requestCertificate.xhtml?orgHandle=SPRN&conversationId=9`. The page title is "ARIN - American Registry". The main content area is titled "ORGANIZATION DATA - MANAGE RPKI" and contains a form for "Identity Exchange Request for Org ID 'SPRN'". The form includes a "UPLOAD IDENTITY.XML FILE" section with a file input field containing "SPRN.identity.xml" and a "Submit" button. A sidebar on the left contains navigation links such as "Welcome, Developer", "MESSAGE CENTER (1)", "WEB ACCOUNT", "POC RECORDS", "ORGANIZATION DATA", "MANAGE & REQUEST RESOURCES", "MEMBERSHIP APPLICATION", "TRACK TICKETS", "DOWNLOADS & SERVICES", and "ASK ARIN".

Delegated with Up/Down



The screenshot shows a web browser window with the following details:

- Browser tabs: ARIN - American Registry, ARIN Management Web A, New Tab
- Address bar: `rpki1.dev.arin.net:8080/public/communication/ticket/view.xhtml?ticketNo=20130830-X1`
- Navigation bar: Google, YouTube, Berlin, demo, AOL, more AOL, Current, Misc, ARIN Webmail, ARIN Voicemail User
- Table of Resource Class: APNIC and RIPE with Certifiable Net(s) for various IP ranges.
- Section: **ACTIVITY AND CORRESPONDENCE LOG**
- Log entries:
 - Date: 08-30-2013 09:54:59, Message: Ticket Status: Closed, Ticket Resolution: Processed
 - Date: 08-30-2013 09:54:58, By: ARIN Web, Subject: [ARIN-20130830-X1] - UpDown Identity Exchange Successful, Attachments: ARIN.SPRN.parent-response.xml (Download button), Message: The UpDown parent response for organization SPRN is attached. Some of your resources are drawn from legacy space that is managed by another RIR.
 - Date: 08-30-2013 09:54:36, Message: Ticket Status: Approved
 - Date: 08-30-2013 09:54:36, By: MADSTAFFER RSDER, Subject: [ARIN-20130830-X1] - UpDown Identity Exchange - APPROVED

Delegated with Up/Down

- You have to do all the ROA creation
- Need to setup a CA
- Have a highly available repository
- Create a CPS

Updates within RPKI outside of ARIN

- The four other RIRs are in production with Hosted CA services
- ARIN and APNIC have delegated working for the public
- Major routing vendor support being tested
- Announcement of public domain routing code support

ARIN Status

- Hosted CA deployed 15 Sept 2012
- Web Delegated CA deployed 16 Feb 2013
- Delegated using “Up/Down” protocol deployed 7 Sept 2013
- RESTful interface deployed 1 Feb 2014

RPKI Usage

	Oct 2012	Apr 2013	Oct 2013	Apr 2014
RPA Signed	27	72	130	162
Certified Orgs		47	68	108
ROAs	19	60	106	162
Covered Resources	30	82	147	258
Web Delegated		0	0	0
Up/Down Delegated			0	0

Why is this important?

- Provides more credibility to identify resource holders
- Leads to better routing security

Q&A

