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Deploying IPv6 in the Enterprise

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A Few Points on IPv6 Deployment

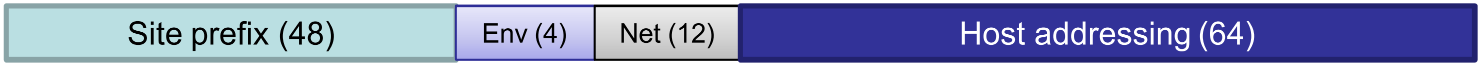
- Enterprises will typically be working in an existing IPv4 architecture
- Many enterprises will need to largely work with existing IP address configuration management processes
  - Automatic configuration
  - Managed IP addresses allocation
- IPv6 is not expected to be deployed everywhere at once in an enterprise

Outline

- Addressing
- Architecture
- Host/application observations
- DNSViz – testing DNS consistency with IPv6

*Addressing and architectural guidelines are based on actual deployment at Sandia, though they are generally consistent with Best Current Operational Practices.

IPv6 Addressing



Site prefix (48)

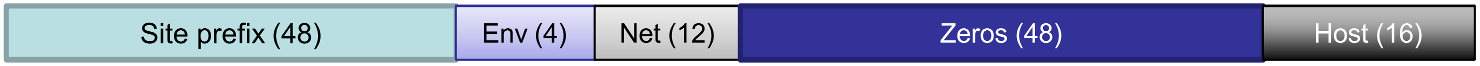
Env (4)

Net (12)

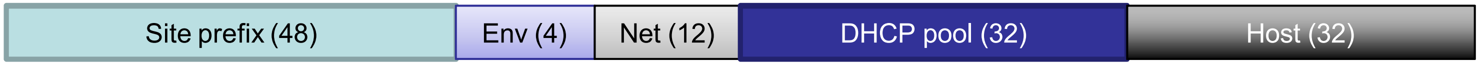
Host addressing (64)

- 52-bit network environments
  - 4-bit environment identifier
- 64-bit prefixes – all non-PTP subnets
  - 12-bit network identifier
  - Based on VLAN value
- 126-bit prefixes – PTP subnets
  - Last network in an environment (all network bits set) reserved for PTP addressing within that environment
  - PTP subnets assigned sequentially from reserved network (skip first)
  - PTP prefix length – 126 vs. 127 vs. 64
    - Determined by both network availability and hardware limitations

IPv6 Host Addressing


Site prefix (48)
Env (4)
Net (12)
Zeros (48)
Host (16)

- Fixed addressing
  - 64-bit host identifier uses decimal-encoded value of IPv4 last octet, padded by zeroes, for facilitated identification
    - 192.0.2.**13** => 2001:db8:1234:abcd::**13**


Site prefix (48)
Env (4)
Net (12)
DHCP pool (32)
Host (32)

- Dynamic addressing
  - 96-bit prefix from each subnet network used for dynamic pool
    - 32 bits for non-temporary address assignment
    - Doesn’t conflict with static addressing scheme

Address Configuration

- Manual host configuration
  - Fixed addressing only
  - Servers
- Automatic configuration
  - DHCPv6 (no SLAAC)
    - Supports both fixed addressing (pre-assigned addresses) and dynamic addressing (from /96 pools)
    - Enterprise host/IP management
    - IPv6 DNS server advertisement
    - DDNS updates (to forward/reverse DNS zones) via DHCP server

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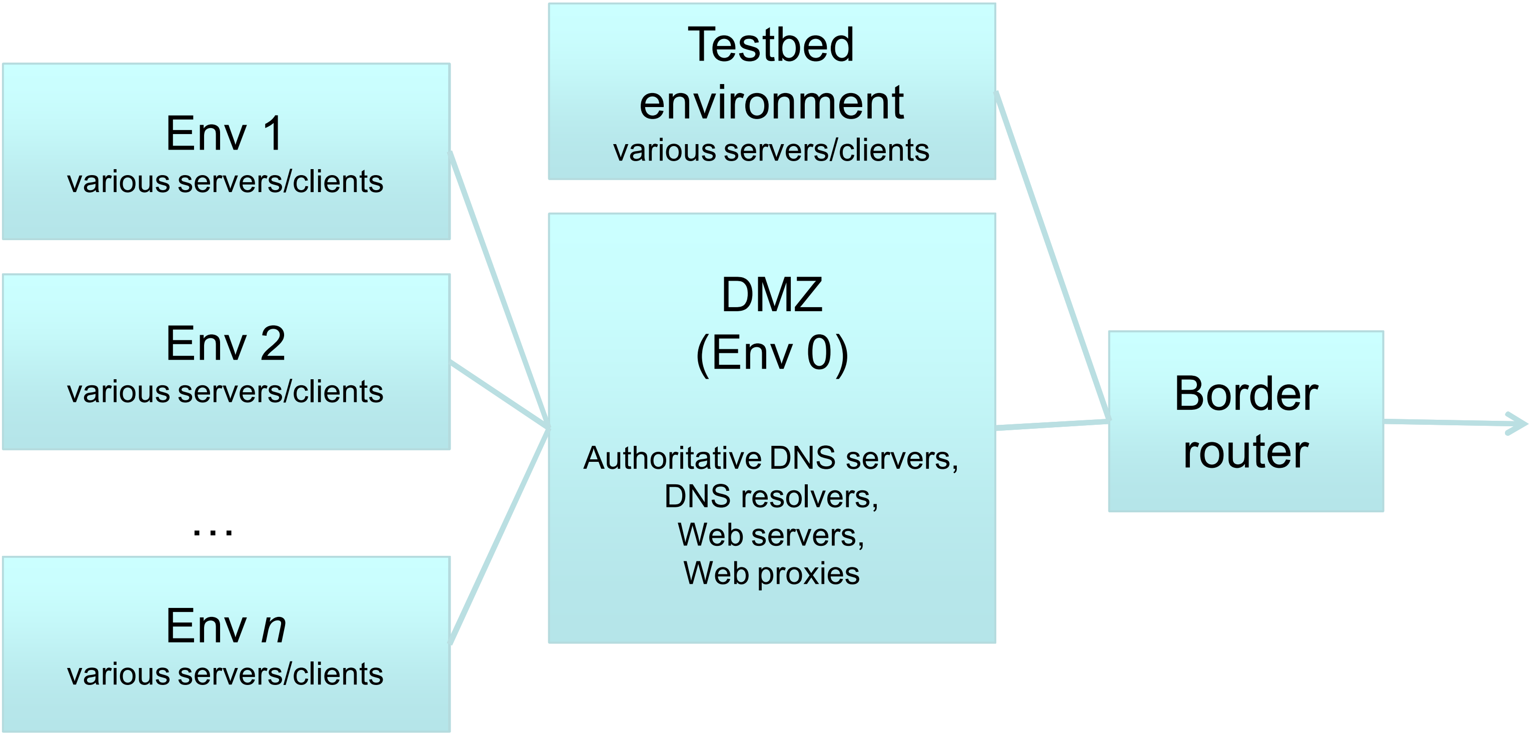
Architecture



Env 1
various servers/clients

Env 2
various servers/clients

…

Env *n*
various servers/clients

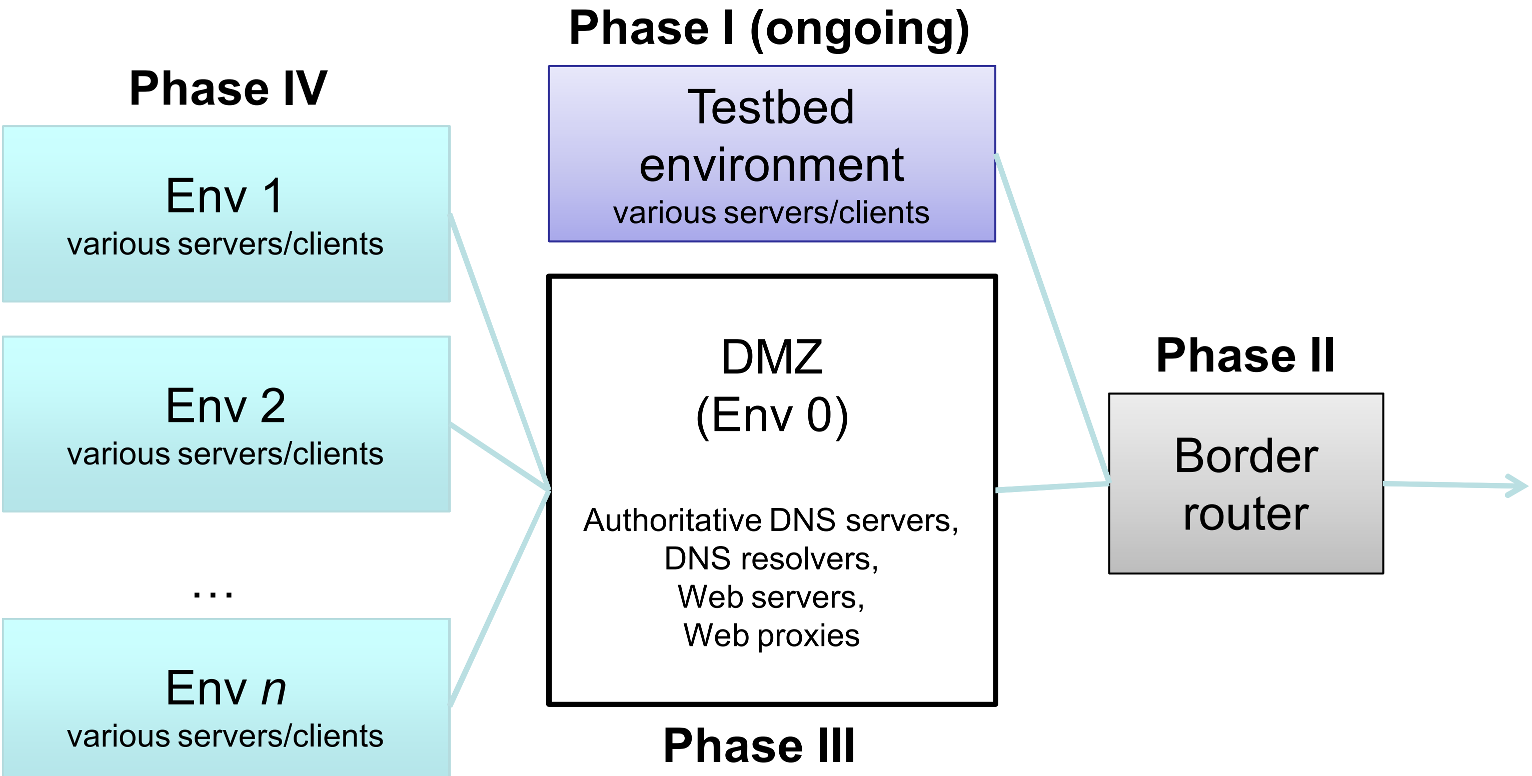
Testbed environment
various servers/clients

DMZ
(Env 0)

Authoritative DNS servers,
DNS resolvers,
Web servers,
Web proxies

Border router

Deployment Plan



Phase I (ongoing)

Testbed environment
various servers/clients

Phase IV

Env 1
various servers/clients

Env 2
various servers/clients

…

Env *n*
various servers/clients

DMZ
(Env 0)

Authoritative DNS servers,
DNS resolvers,
Web servers,
Web proxies

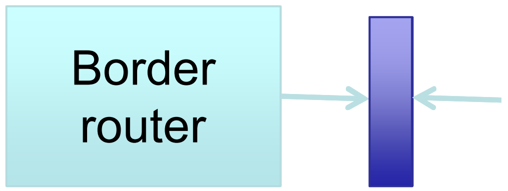
Phase III

Phase II

Border router

IPv6 Security

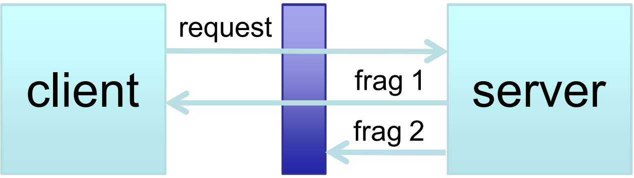
- Usual stuff blocked at the border:
  - Protocol 41
  - Teredo
  - Unnecessary ICMPv6
  - Reserved IPv6 addresses
  - Obsolete IPv6 addresses

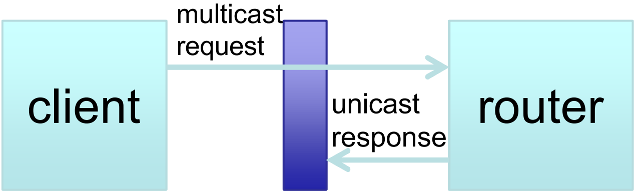


Firewall Woes

- Application-level Gateway (ALG)
  - Some implementations have problems handling fragmented packets
- RHEL5
  - Linux kernel 2.6.18 doesn't filter properly; unable to re-assemble packet fragments
- RHEL6 (and RHEL5?)
  - Default firewall rules don't allow return DHCPv6 responses

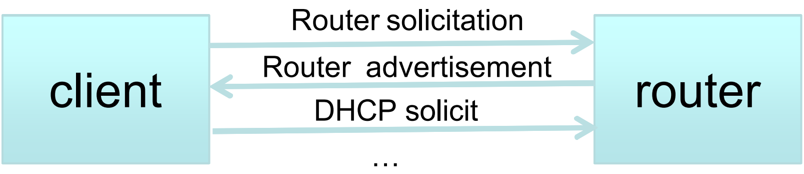
- Fragmentation
  - Mostly affects DNS/DNSSEC
  - Use large DNS responses to test IPv6 connectivity





DHCPv6 RA Configuration

- Router Advertisements (RAs) for DHCPv6
  - Managed (**M**) address configuration bit **set**
    - Indicates that addresses are available via DHCPv6
  - Autonomous (**A**) address-configuration bit **cleared** from prefix
    - Indicates that prefix cannot be used for stateless address configuration
- Results from initial testing
  - WinXP doesn’t support DHCPv6
  - Mac OS X pre-Lion doesn’t support DHCPv6
  - Tested OSes respect cleared A-bit on prefix (i.e., don’t use SLAAC)



Challenges with ISC dhcp for DHCPv6

- Features not yet fully developed as for IPv4
- “host” statements use DHCP Unique Identifier (DUID), rather than MAC address
  - IPAM must have client DIUDs to populate hosts for dhcpd6.conf
  - ISC dhcp 4.2 includes retrofit that allows old-style MACs for dhcpd6.conf hosts
  - RHEL6 ships with ISC dhcp 4.1, but backported functionality
- “pool” statements unusable within subnet6
  - Unable to allow/deny clients, based on existence of “host” statement
- DDNS
  - updates can’t update both A and AAAA records
    - Current update algorithm doesn’t allow updating AAAA when A already exists for name
    - Reverse doesn’t get updated either
    - Work-arounds exist, but aren’t clean
  - Only Windows 7 clients are sending FQDN option (with default settings)

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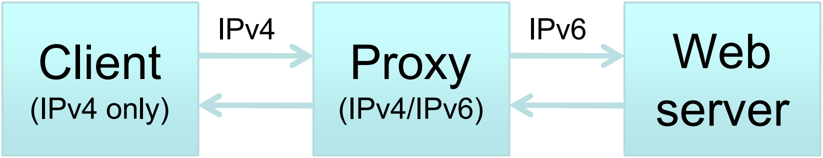
Major OSes

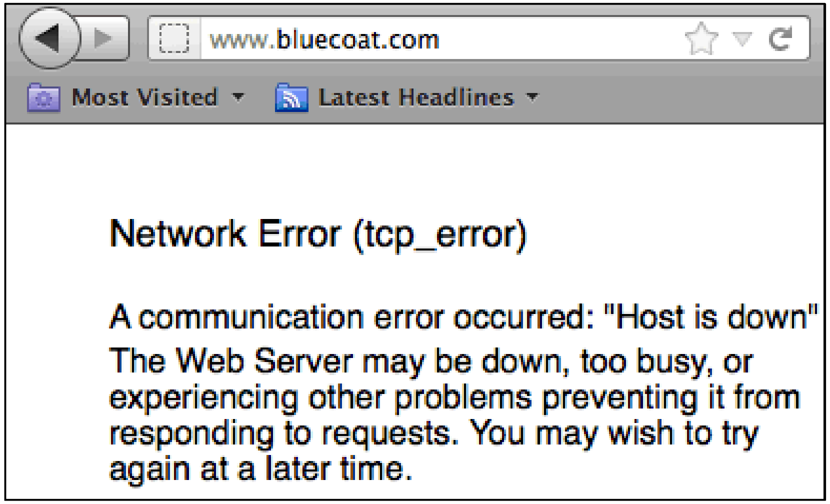
- Windows 7
  - DHCPv6 works as expected, out of box
- Mac OS X Lion
  - DHCPv6 works as expected, out of box
  - Uses IPv4 DNS servers **before** IPv6 servers
- RHEL6 (NetworkManager)
  - IPv6 must be explicitly enabled on network interface (default: “ignore”)
  - DHCPv6 works as expected
  - Uses IPv4 DNS servers **before** IPv6 servers
- Ubuntu 11.10 (NetworkManager)
  - IPv6 must be explicitly enabled on network interface (default: “ignore”)
  - DHCPv6 requires “priming” – change from “Automatic” to “Automatic, DHCP Only” and back
  - Uses IPv4 DNS servers **before** IPv6 servers

Other IPv6 Applications

- BlueCoat Secure Gateway (Web proxy)
  - Allows IPv4-only client to access IPv6 Web servers
  - Doesn’t fail over to IPv4 in the case of IPv6 connectivity issues
    - Works well for identifying others’ IPv6 issues
    - Requires manually whitelisting troubled domains
  - Loses its own IPv6 route with bounce of physical interface!
- World IPv6 Day
  - June 8, 2011 – 10% HTTP traffic used IPv6
  - Oct 5, 2011 – 3.6% HTTP traffic used IPv6



```
$ dig +short www.bluecoat.com aaaa
2001:418:9804:111::9
$ curl -I6 http://www.bluecoat.com/
curl: (7) couldn't connect to host
$ curl -I4 http://www.bluecoat.com/
HTTP/1.1 200 OK
```



Network Error (tcp_error)

A communication error occurred: "Host is down"
The Web Server may be down, too busy, or experiencing other problems preventing it from responding to requests. You may wish to try again at a later time.

Other Challenges

- No mechanism for inserting AAAA glue into .gov
- Monitoring
  - Our current monitoring tools don’t fully support IPv6
  - We’re setting up Nagios to supplement existing toolset
- Current corporate protection suite for Windows 7 doesn’t support IPv6

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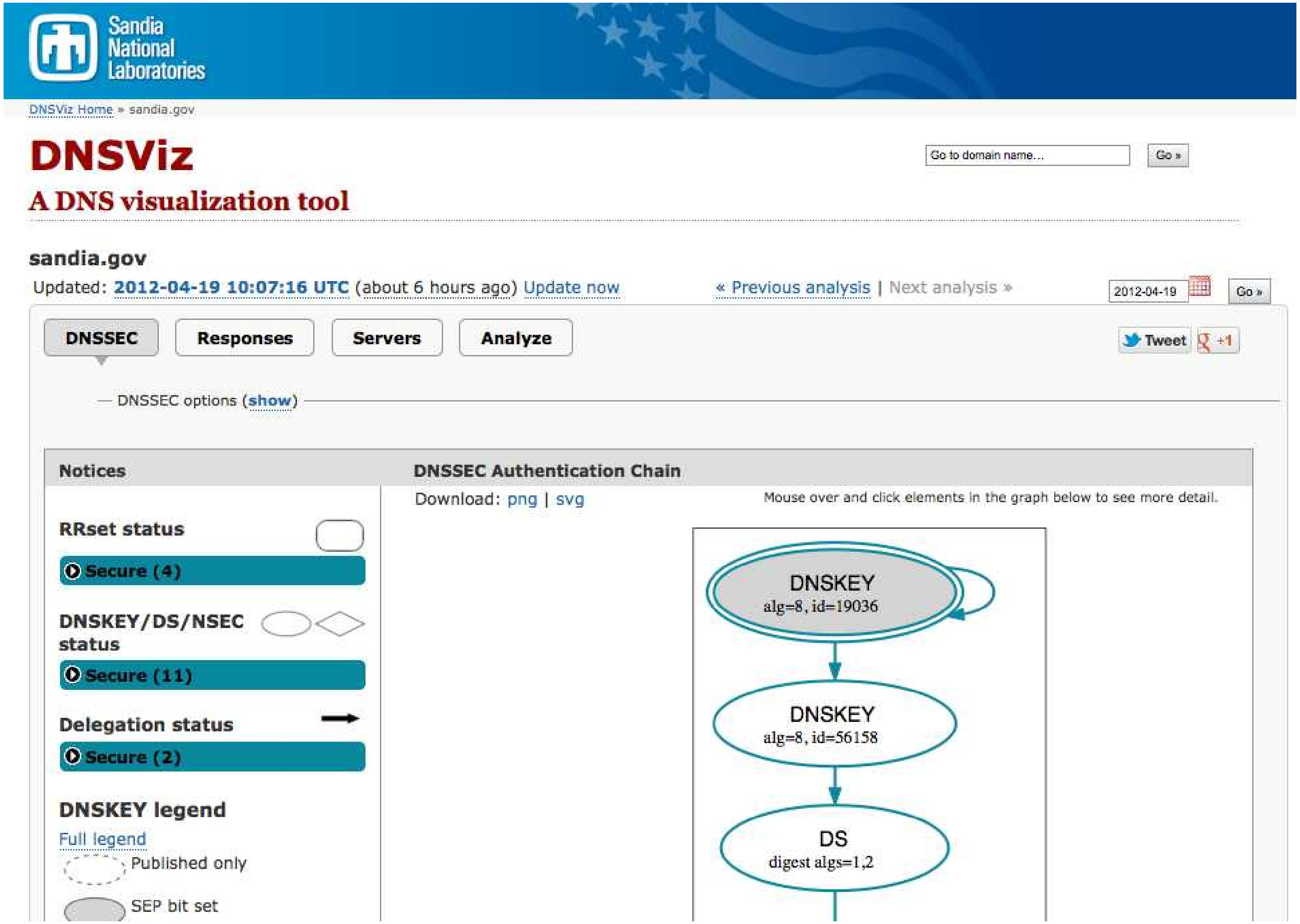
DNS Visualization – and IPv6

http://dnsviz.net/



DNSViz Home » sandia.gov

DNSViz

A DNS visualization tool

Go to domain name... Go »

sandia.gov

Updated: 2012-04-19 10:07:16 UTC (about 6 hours ago) Update now

« Previous analysis | Next analysis »

2012-04-19 Go »

DNSSEC | Responses | Servers | Analyze

Tweet +1

— DNSSEC options (show)

Notices

RRset status

Secure (4)

DNSKEY/DS/NSEC status

Secure (11)

Delegation status

Secure (2)

DNSKEY legend

Full legend

Published only

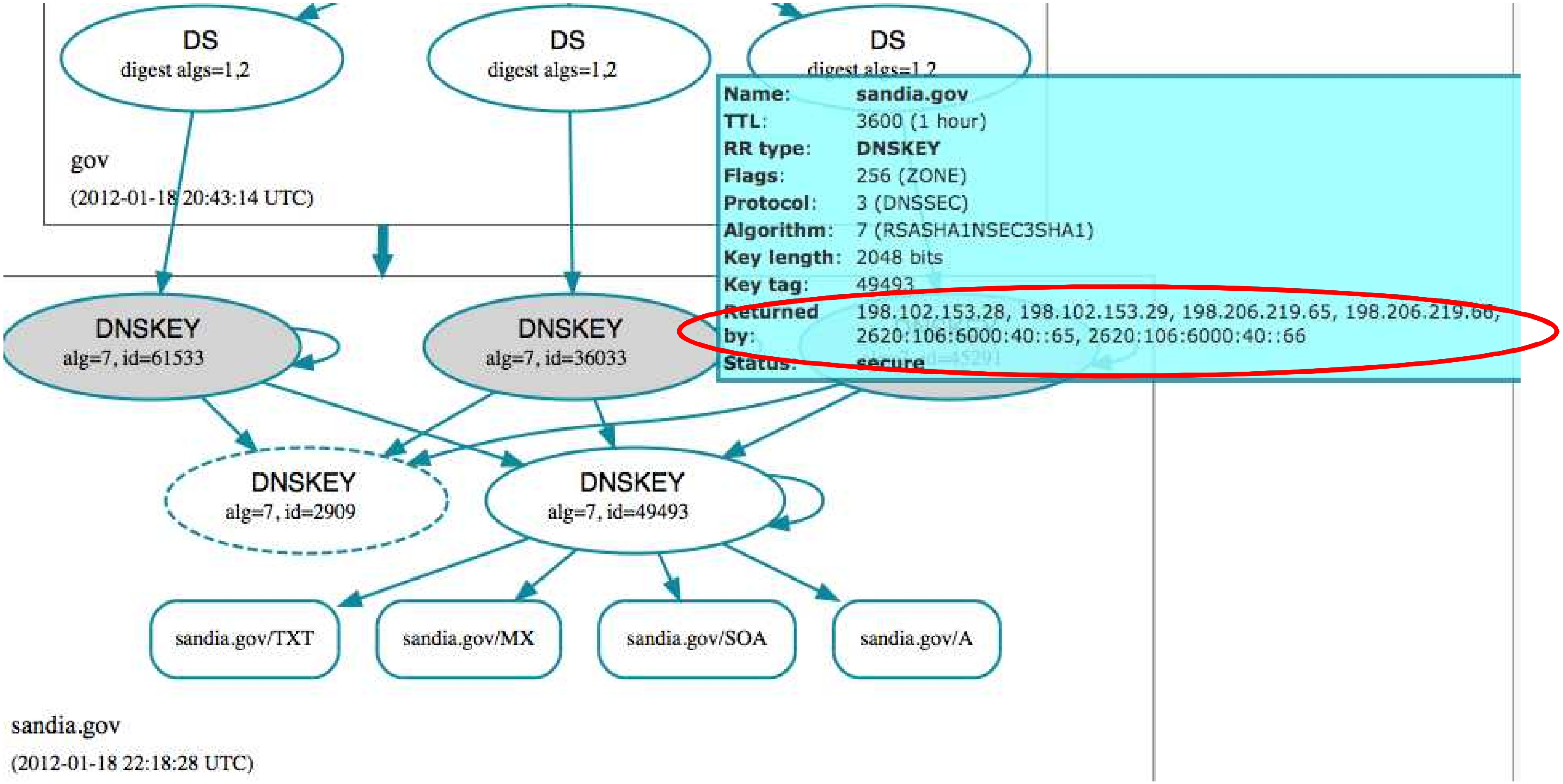
SEP bit set

DNSSEC Authentication Chain

Download: png | svg

Mouse over and click elements in the graph below to see more detail.

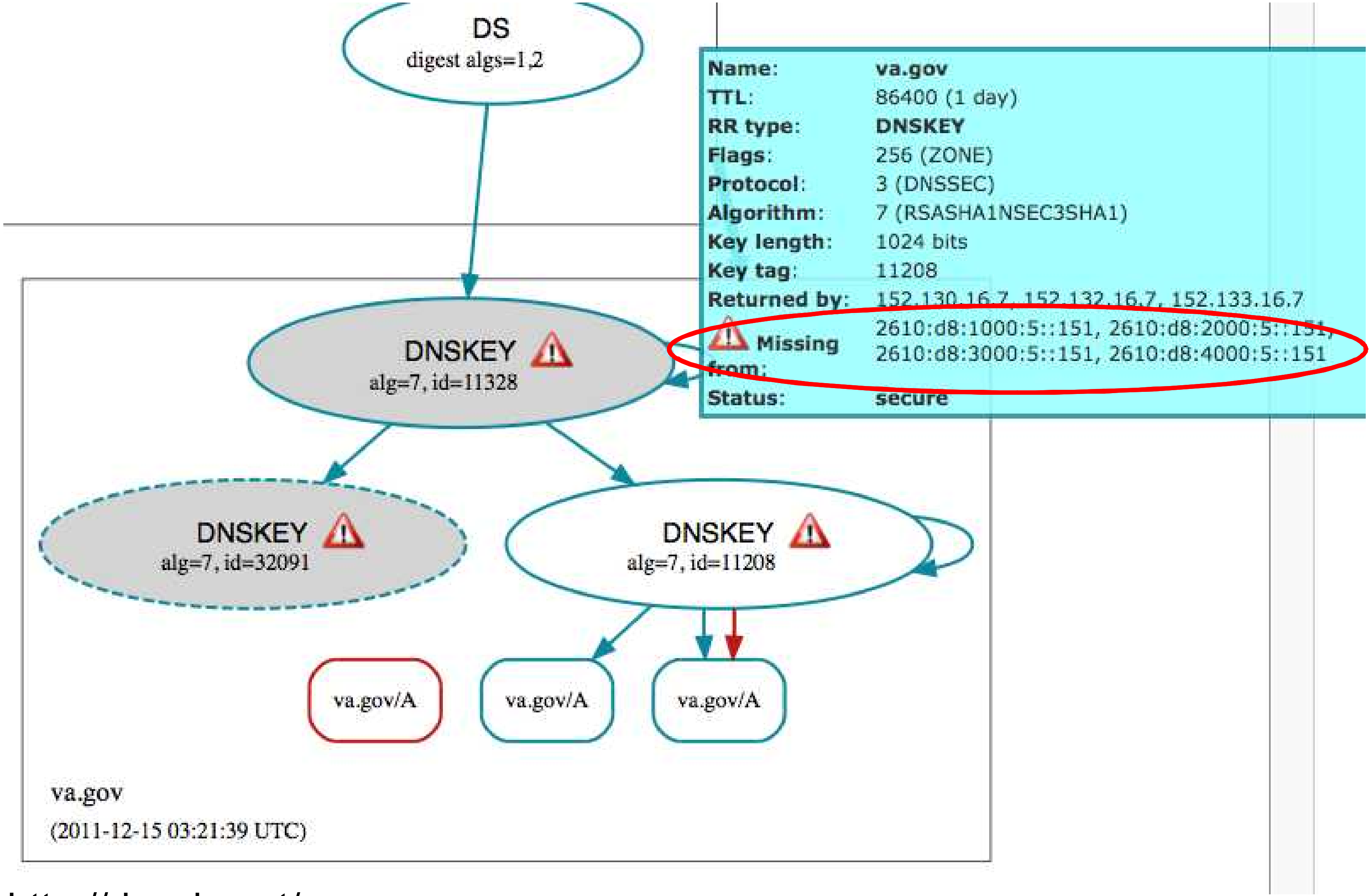
DNS Consistency with IPv6



Name: **sandia.gov**
TTL: 3600 (1 hour)
RR type: **DNSKEY**
Flags: 256 (ZONE)
Protocol: 3 (DNSSEC)
Algorithm: 7 (RSASHA1NSEC3SHA1)
Key length: 2048 bits
Key tag: 49493
Returned by: 198.102.153.28, 198.102.153.29, 198.206.219.65, 198.206.219.66, 2620:106:6000:40::65, 2620:106:6000:40::66
Status: **secure**

http://dnsviz.net/

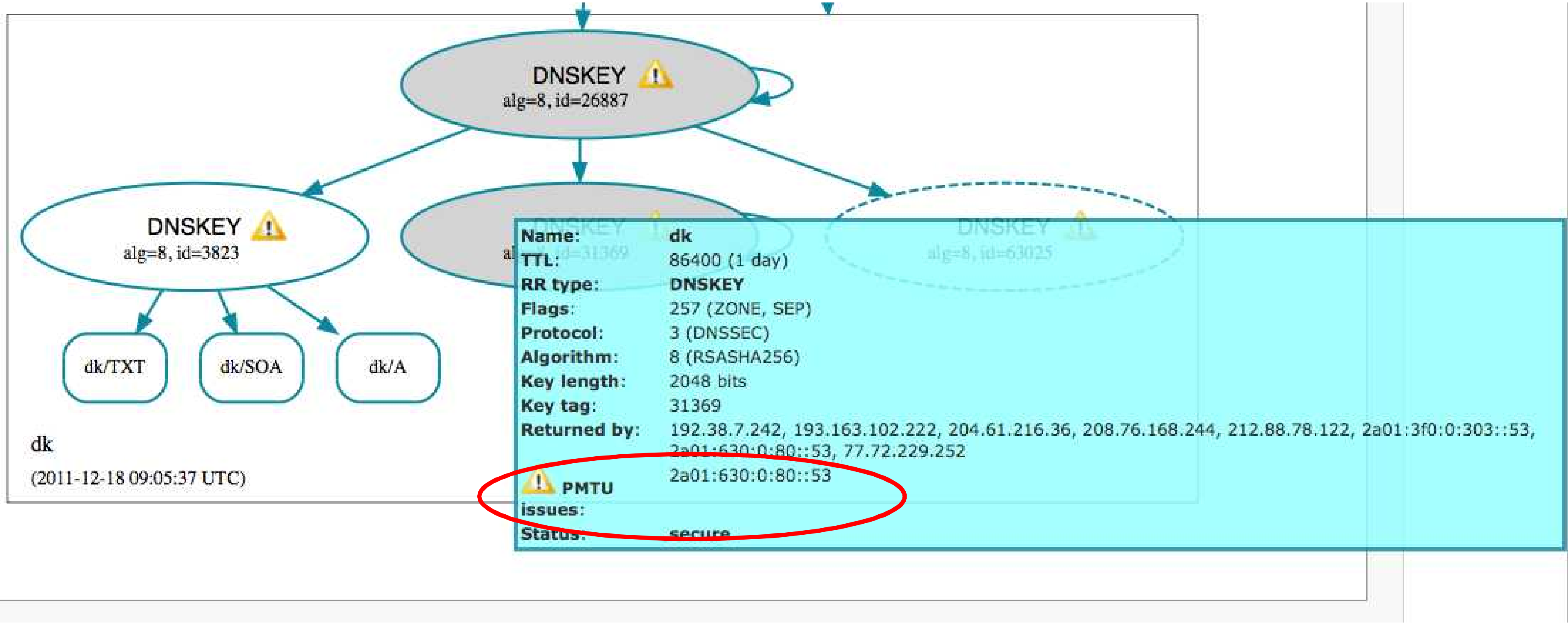
DNS(SEC) Consistency with IPv6



Name:	**va.gov**
TTL:	86400 (1 day)
RR type:	**DNSKEY**
Flags:	256 (ZONE)
Protocol:	3 (DNSSEC)
Algorithm:	7 (RSASHA1NSEC3SHA1)
Key length:	1024 bits
Key tag:	11208
Returned by:	152.130.16.7, 152.132.16.7, 152.133.16.7
⚠ **Missing from:**	2610:d8:1000:5::151, 2610:d8:2000:5::151, 2610:d8:3000:5::151, 2610:d8:4000:5::151
Status:	**secure**

http://dnsviz.net/

DNS Consistency with IPv6 – PMTU issues



Name:	**dk**
TTL:	86400 (1 day)
RR type:	**DNSKEY**
Flags:	257 (ZONE, SEP)
Protocol:	3 (DNSSEC)
Algorithm:	8 (RSASHA256)
Key length:	2048 bits
Key tag:	31369
Returned by:	192.38.7.242, 193.163.102.222, 204.61.216.36, 208.76.168.244, 212.88.78.122, 2a01:3f0:0:303::53, 2a01:630:0:80::53, 77.72.229.252
⚠ **PMTU issues:**	2a01:630:0:80::53
Status:	secure

http://dnsviz.net/

Questions?