

Hands-On DNSSEC with DNSViz

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The logo for Brigham Young University (BYU), consisting of the letters 'BYU' in a bold, blue, serif font.

Preparation

- Demo and exercises available at:
 - <http://dnsviz.net/demo/>
- Includes links to the following:
 - VirtualBox software
 - VirtualBox demo image
 - Tutorial exercises

Objectives

- Understand the basics of DNS and DNSSEC
- Become familiar with DNS server and analysis tools
 - DiG
 - BIND
 - DNSViz
- Learn how tools might be used to routinely analyze/monitor your DNS health

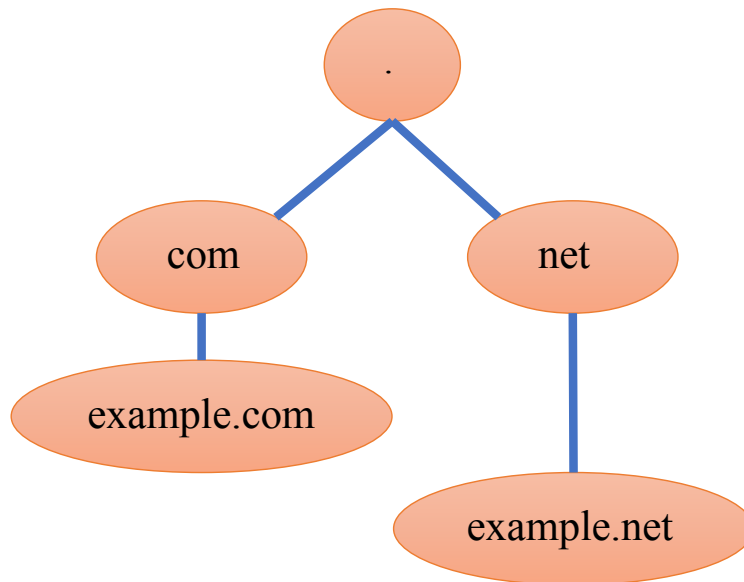
Caveats

- The exercises range from novice-level to advanced.
- Many of the exercises are more to facilitate understanding than efficiency.
- The exercises are meant for learning DNS/DNSSEC and related tools, but do not cover all details for proper DNS/DNSSEC maintenance.

DNS Overview

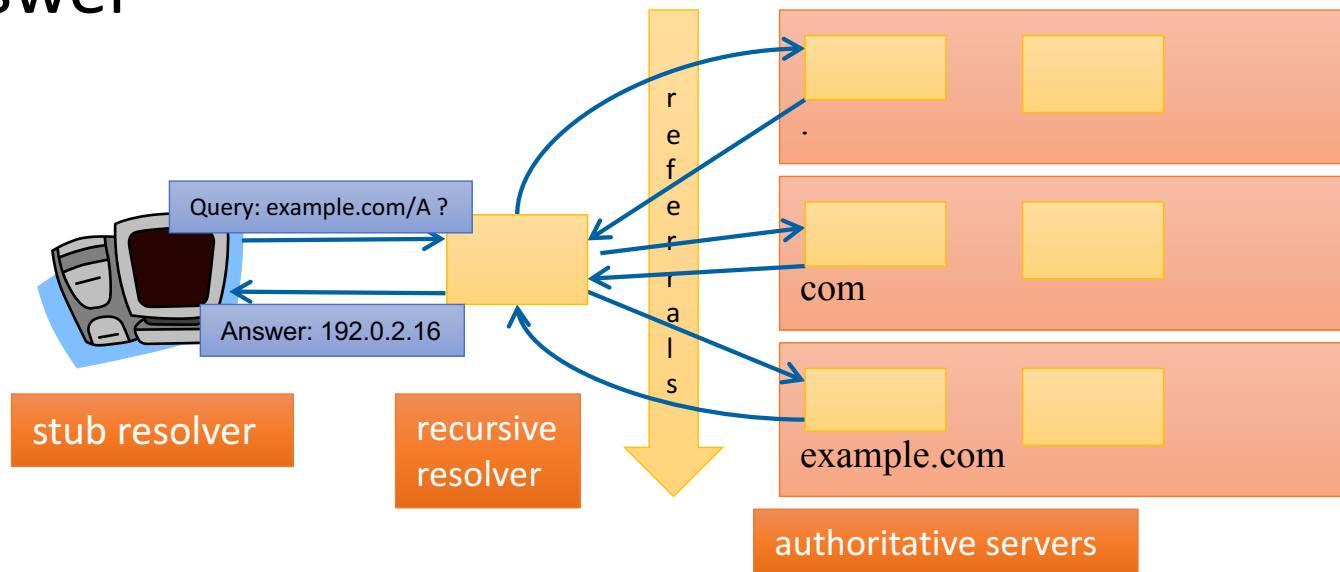
DNS Namespace

- Namespace is organized hierarchically
- DNS **root** is top of namespace
- **Zones** are autonomously managed pieces of DNS namespace
- Subdomain namespace is delegated to child zones



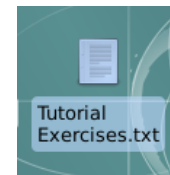
DNS Name Resolution

- **Resolvers** query **authoritative servers**
- Queries begin at root zone, resolvers follow downward referrals
- Resolver stops when it receives authoritative answer



Virtual Environment Initialization

- Unzip dnsviz-demo-v4.zip
- Open dnsviz-demo-v4/dnsviz-demo-v4.vbox
- “Start” VM
- Enlarge screen
- Double-click “Tutorial Exercises” file
- (Exercises 0.1 – 0.2)
 - Open “Terminal Emulator”
 - Change to “demo” directory



```
$ cd demo
```


Query DNS Servers (1.1 – 1.5)

```
$ dig @a.root-servers.net example.com
```



query a specific server
(rather than querying your
configured resolver)



no record type specified,
so default type "A"
(address) is used

```
$ dig @a.gtld-servers.net example.com
```

```
$ dig @a.iana-servers.net example.com
```

```
$ dig example.com
```



no server is explicitly
designated, so query goes
to local resolver

```
$ dig @a.iana-servers.net foobar.example.com
```

Query a Root Server

```
Terminal - dnsviz@dnsviz-demo: ~/demo
File Edit View Terminal Tabs Help
dnsviz@dnsviz-demo:~/demo$ dig @a.root-servers.net example.com

; <<>> DiG 9.9.5-9-Debian <<>> @a.root-servers.net example.com
; (2 servers found)
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 1649
;; flags: qr rd; QUERY: 1, ANSWER: 0, AUTHORITY: 13, ADDITIONAL: 16
;; WARNING: recursion requested but not available

;; OPT PSEUDOSECTION:
; EDNS: version: 0, flags:; udp: 4096
;; QUESTION SECTION:
;example.com.                IN      A

;; AUTHORITY SECTION:
com.          172800  IN      NS      m.gtld-servers.net.
com.          172800  IN      NS      l.gtld-servers.net.
com.          172800  IN      NS      k.gtld-servers.net.
com.          172800  IN      NS      j.gtld-servers.net.
com.          172800  IN      NS      i.gtld-servers.net.
com.          172800  IN      NS      h.gtld-servers.net.
com.          172800  IN      NS      g.gtld-servers.net.
com.          172800  IN      NS      f.gtld-servers.net.
com.          172800  IN      NS      e.gtld-servers.net.
com.          172800  IN      NS      d.gtld-servers.net.
com.          172800  IN      NS      c.gtld-servers.net.
com.          172800  IN      NS      b.gtld-servers.net.
com.          172800  IN      NS      a.gtld-servers.net.

;; ADDITIONAL SECTION:
m.gtld-servers.net. 172800  IN      A      192.55.83.30
l.gtld-servers.net. 172800  IN      A      192.41.162.30
```

Query a TLD Server

```
Terminal - dnsviz@dnsviz-demo: ~/demo
File Edit View Terminal Tabs Help
dnsviz@dnsviz-demo:~/demo$ dig @a.gtld-servers.net example.com

; <<>> DiG 9.9.5-9-Debian <<>> @a.gtld-servers.net example.com
; (2 servers found)
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 64763
;; flags: qr rd; QUERY: 1, ANSWER: 0, AUTHORITY: 2, ADDITIONAL: 5
;; WARNING: recursion requested but not available

;; OPT PSEUDOSECTION:
; EDNS: version: 0, flags:; udp: 4096
;; QUESTION SECTION:
;example.com.                IN      A

;; AUTHORITY SECTION:
example.com.                172800 IN      NS      a.iana-servers.net.
example.com.                172800 IN      NS      b.iana-servers.net.

;; ADDITIONAL SECTION:
a.iana-servers.net.        172800 IN      A       199.43.132.53
a.iana-servers.net.        172800 IN      AAAA    2001:500:8c::53
b.iana-servers.net.        172800 IN      A       199.43.133.53
b.iana-servers.net.        172800 IN      AAAA    2001:500:8d::53

;; Query time: 91 msec
;; SERVER: 192.5.6.30#53(192.5.6.30)
;; WHEN: Thu Apr 30 21:27:16 EDT 2015
;; MSG SIZE rcvd: 176
```

Query an SLD Server

```
Terminal - dnsviz@dnsviz-demo: ~/demo
File Edit View Terminal Tabs Help
dnsviz@dnsviz-demo:~/demo$ dig @a.iana-servers.net example.com

; <<>> DiG 9.9.5-9-Debian <<>> @a.iana-servers.net example.com
; (2 servers found)
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 44304
;; flags: qr aa rd; QUERY: 1, ANSWER: 1, AUTHORITY: 2, ADDITIONAL: 1
;; WARNING: recursion requested but not available

;; OPT PSEUDOSECTION:
; EDNS: version: 0, flags:; udp: 4096
;; QUESTION SECTION:
;example.com.                IN      A

;; ANSWER SECTION:
example.com.                86400   IN      A      93.184.216.34

;; AUTHORITY SECTION:
example.com.                172800  IN      NS     b.iana-servers.net.
example.com.                172800  IN      NS     a.iana-servers.net.

;; Query time: 17 msec
;; SERVER: 199.43.132.53#53(199.43.132.53)
;; WHEN: Thu Apr 30 21:29:30 EDT 2015
;; MSG SIZE rcvd: 104
```

Query Local Recursive Resolver

```
Terminal - dnsviz@dnsviz-demo: ~/demo
File Edit View Terminal Tabs Help
dnsviz@dnsviz-demo:~/demo$ dig example.com

; <<>> DiG 9.9.5-9-Debian <<>> example.com
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 15182
;; flags: qr rd ra ad; QUERY: 1, ANSWER: 1, AUTHORITY: 2, ADDITIONAL: 5

;; OPT PSEUDOSECTION:
; EDNS: version: 0, flags:; udp: 4096
;; QUESTION SECTION:
;example.com.                IN      A

;; ANSWER SECTION:
example.com.                68734   IN      A      93.184.216.34

;; AUTHORITY SECTION:
example.com.                155133  IN      NS     b.iana-servers.net.
example.com.                155133  IN      NS     a.iana-servers.net.

;; ADDITIONAL SECTION:
a.iana-servers.net.        1768    IN      A      199.43.132.53
a.iana-servers.net.        1768    IN      AAAA   2001:500:8c::53
b.iana-servers.net.        155133  IN      A      199.43.133.53
b.iana-servers.net.        155133  IN      AAAA   2001:500:8d::53

;; Query time: 1 msec
;; SERVER: 127.0.0.1#53(127.0.0.1)
;; WHEN: Thu Apr 30 21:30:02 EDT 2015
;; MSG SIZE rcvd: 192
```

Query for a Non-existent Name

```
Terminal - dnsviz@dnsviz-demo: ~/demo
File Edit View Terminal Tabs Help
dnsviz@dnsviz-demo:~/demo$ dig @a.iana-servers.net foobar.example.com

; <<>> DiG 9.9.5-9-Debian <<>> @a.iana-servers.net foobar.example.com
; (2 servers found)
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NXDOMAIN, id: 36564
;; flags: qr aa rd; QUERY: 1, ANSWER: 0, AUTHORITY: 1, ADDITIONAL: 1
;; WARNING: recursion requested but not available

;; OPT PSEUDOSECTION:
; EDNS: version: 0, flags:; udp: 4096
;; QUESTION SECTION:
;foobar.example.com.          IN      A

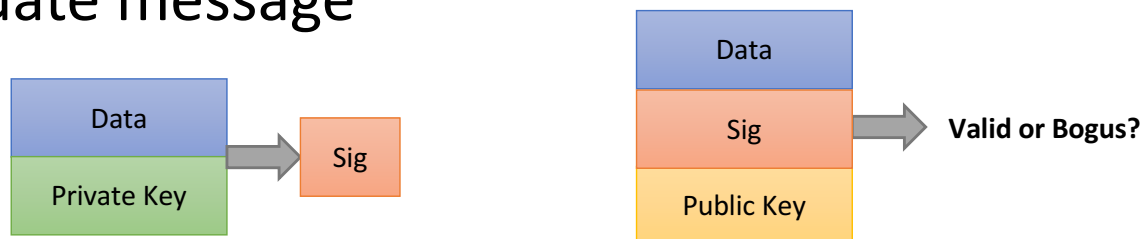
;; AUTHORITY SECTION:
example.com.                  3600    IN      SOA     sns.dns.icann.org. noc.d
0 3600 1209600 3600

;; Query time: 12 msec
;; SERVER: 199.43.132.53#53(199.43.132.53)
;; WHEN: Thu Apr 30 21:30:41 EDT 2015
;; MSG SIZE rcvd: 104
```

DNSSEC Overview

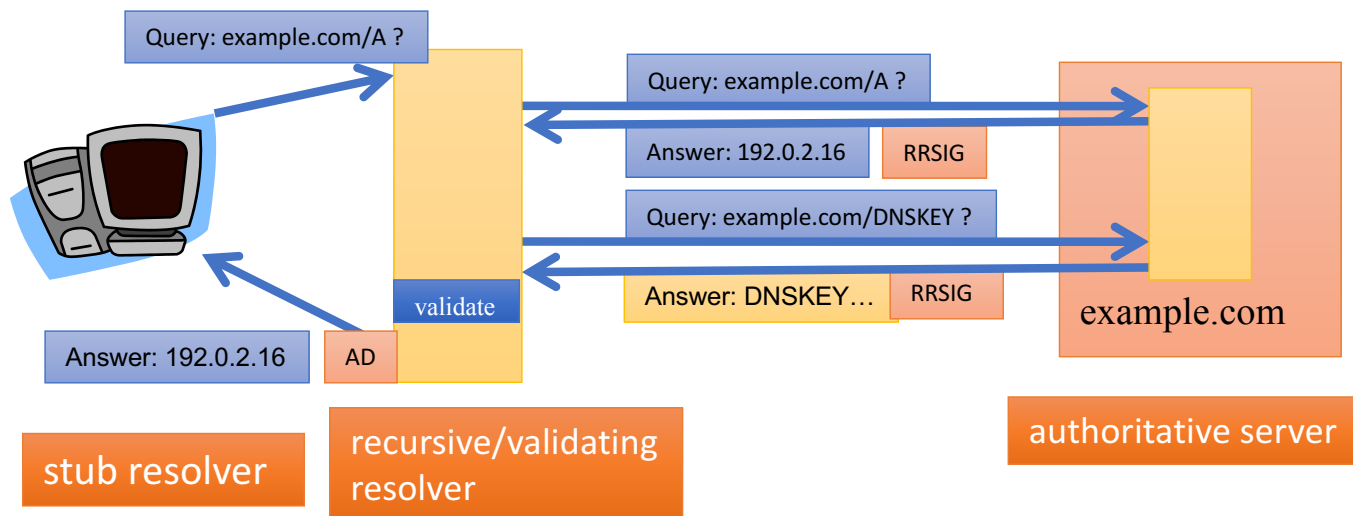
Public Key Cryptography

- Keys
 - **Public** Key – advertised to everyone
 - **Private** Key – kept hidden
- Signatures
 - Made by private key
 - Validated with public key
- Validation
 - Consumer uses public key, message, and signature to validate message



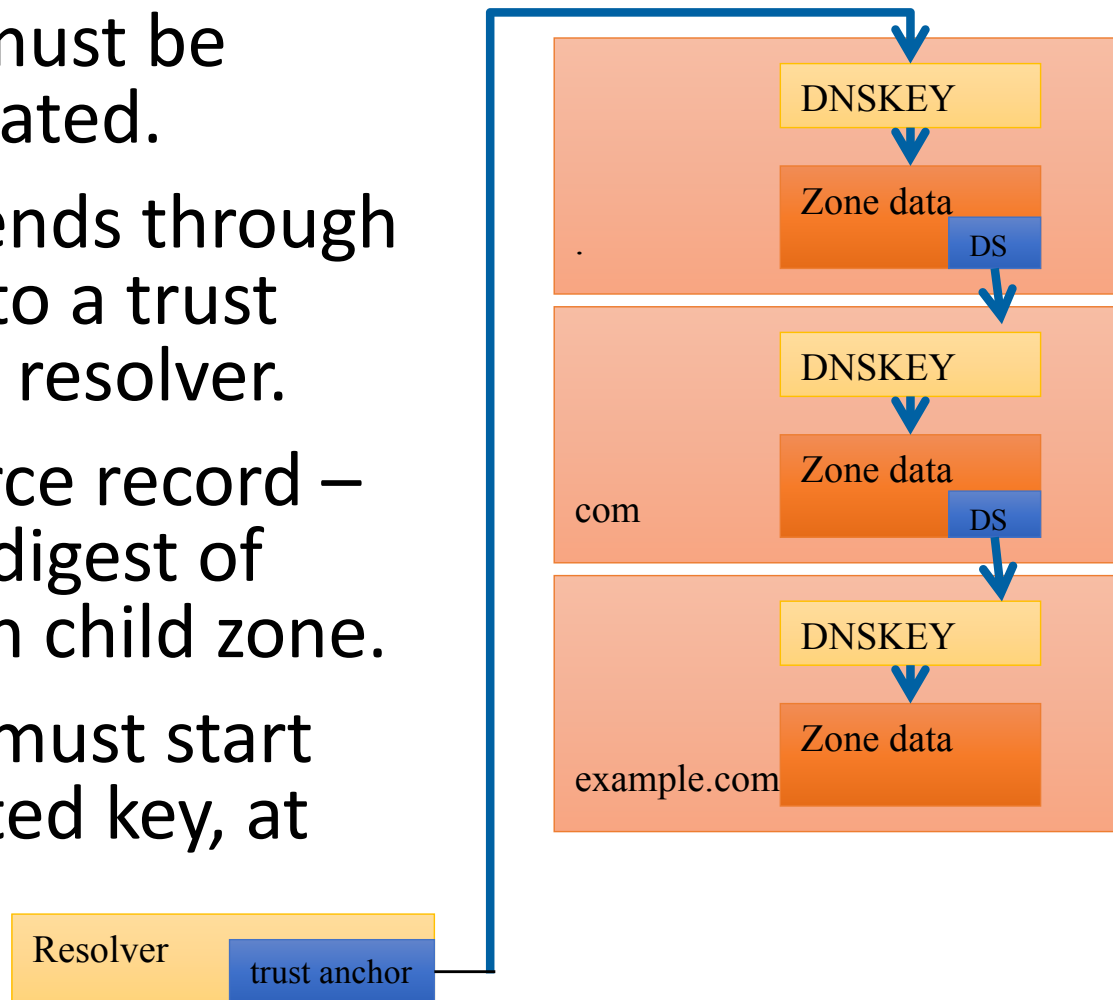
DNS Security Extensions (DNSSEC)

- DNS data signed with private keys
- Signatures (RRSIGs) and public keys (DNSKEYs) published in zone data
- Resolver response
 - If authentic: Authenticated data (AD) bit is set
 - If bogus: SERVFAIL message is returned



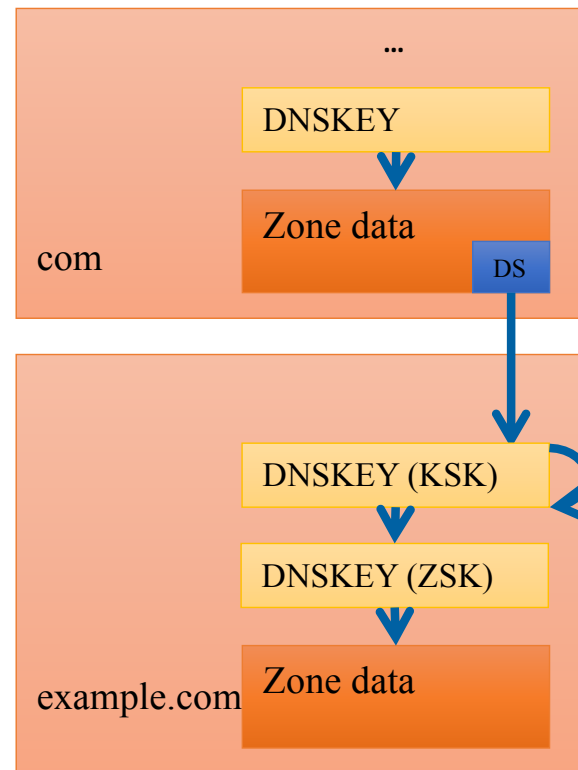
DNSSEC Chain of Trust

- DNSKEY must be authenticated.
- Trust extends through ancestry to a trust anchor at resolver.
- DS resource record – provides digest of DNSKEY in child zone.
- Resolver must start with trusted key, at root.



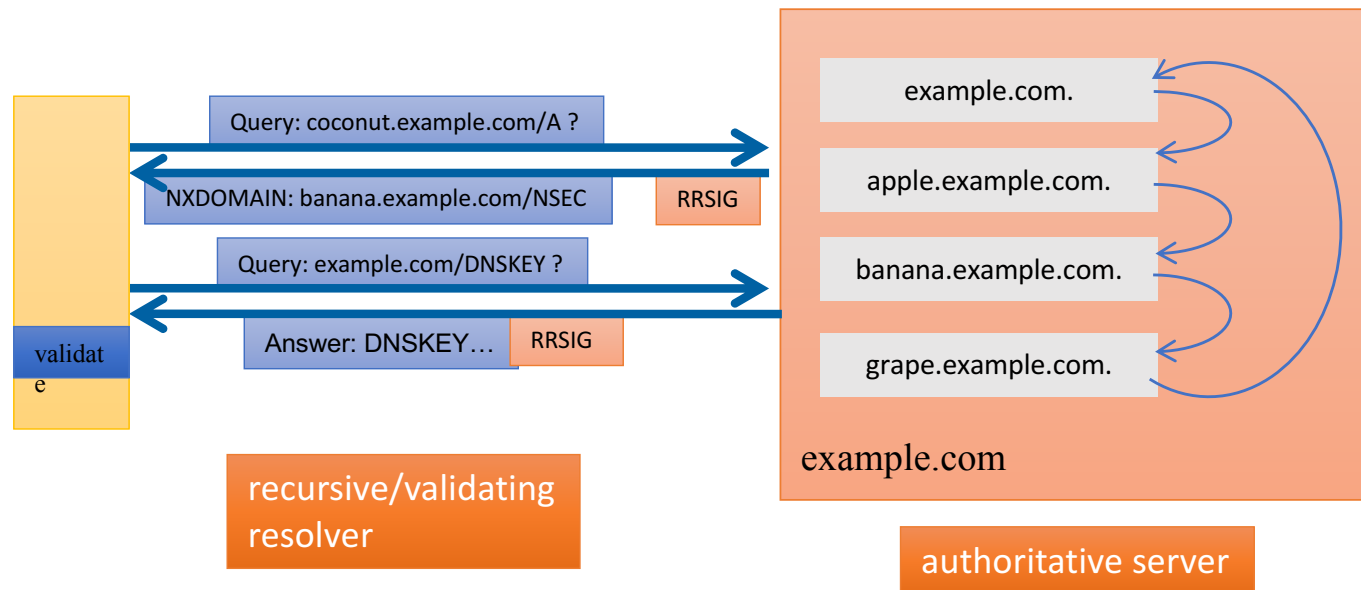
Key Roles – KSK/ZSK

- DNSKEY RRset usually has multiple keys, often with split roles.
- KSK (Key signing key)
 - Signs (only) the DNSKEY RRset.
 - Corresponds to DS records in parent, providing “secure entry point” into zone.
- ZSK (Zone signing key)
 - Signs the rest of the zone.



Authenticated Denial of Existence

- How do you prove something doesn't exist?
- “Chain” of names of zone formed using NSEC records.
- NSEC records form comprehensive chain of names (and their record types) in zone in canonical ordering.
- Server uses NSEC records to prove non-existence.



Query for DNSSEC Records (2.1 – 2.5)

```
$ dig +dnssec +multi @a.iana-servers.net example.com
```

include DNSSEC records
in response (e.g., RRSIG)

present response in multi-line
format with comments (for
readability)

query for records of type "DNSKEY"
(DNSSEC public key) instead of the
default, "A" (address)

```
$ dig +dnssec +multi @a.iana-servers.net example.com DNSKEY
```

```
$ dig +dnssec +multi @a.gtld-servers.net example.com DS
```

query a "parent" server because
we're seeking a DS record

```
$ dig +dnssec +multi example.com
```

```
$ dig +dnssec +multi @a.iana-servers.net  
foobar.example.com
```

Query for DNSSEC Records (RRSIGs)

```
Terminal - dnsviz@dnsviz-demo: ~/demo
File Edit View Terminal Tabs Help
dnsviz@dnsviz-demo:~/demo$ dig +dnssec +multi @a.iana-servers.net example.com

; <<<>> DiG 9.9.5-9+deb8u5-Debian <<<>> +dnssec +multi @a.iana-servers.net example.com
; (2 servers found)
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 19813
;; flags: qr aa rd; QUERY: 1, ANSWER: 2, AUTHORITY: 3, ADDITIONAL: 1
;; WARNING: recursion requested but not available

;; OPT PSEUDOSECTION:
; EDNS: version: 0, flags: do; udp: 4096
;; QUESTION SECTION:
;example.com.                IN A

;; ANSWER SECTION:
example.com.                86400 IN A 93.184.216.34
example.com.                86400 IN RRSIG A 8 2 86400 (
                             20160212201614 20160122081757 2718 example.com.
                             Wlw09+oa0EQEUdQpdF+oeJNsGYwK8vmLL3u4gtGHP9Jc
                             GLNWxmF6+ggbTDxA0E8Z0pxe/FgWpiC9AA0WsmPuQw66
                             XMXyoo+M8m5gtY6uzQWIZrYFoKiaSp4UDsxd/gNWmi3f
                             yaUs0ms1JMCdAJZY0cJQCXH+bDx3xBpXc250UC1XkRk= )

;; AUTHORITY SECTION:
example.com.                86400 IN NS b.iana-servers.net.
example.com.                86400 IN NS a.iana-servers.net.
example.com.                86400 IN RRSIG NS 8 2 86400 (
                             20160213061624 20160122221757 2718 example.com.
                             uMmGfrbwm0n69CDW9jhoRF82gvCG5gMi9RSaY0W8mvCz
                             0BceCe7T4AgzBY6JRn3s49IjwI1hGfHqYxDIX5hA5hQt
                             30136 4813 01 05 01551WY4 BB6G6L13B 563
```

Query for DNSSEC Records (DNSKEY)

```
Terminal - dnsviz@dnsviz-demo: ~/demo
File Edit View Terminal Tabs Help
;; OPT PSEUDOSECTION:
; EDNS: version: 0, flags: do; udp: 4096
;; QUESTION SECTION:
;example.com.          IN DNSKEY

;; ANSWER SECTION:
example.com.          3600 IN DNSKEY 257 3 8 (
    AwEAABoFAXl+Lkt0UMglZizKEC1AxUu8zlj65KYatR5w
    BWMrh18TYzK/ig6Y1t5YTWC068bynorpNu9fqNFALX7b
    VL9/gybA0v0EhF+dgXmoUfRX7ksMGgBvtfa2/Y9a3klX
    NLqkTszIQ4PEMVCjtryl19Be9/PkFeC9ITjgMR0sQhmB
    39eyMYnal+f3bUxKk4fq7cuEU0dbRpue4H/N6jPucXW0
    wiMAkTJhghqgy+o9FfIp+tR/emKao94/wpVXDcPf5B18
    j7xz2SVTTxiuqCzCMtsxnkZHcoh1j4g+Y1B8zIMIVrE
    M+pZGhh/Yuf4RwCBgaYCi9hpiMwVvS4WBzx0/LU=
    ) ; KSK; alg = RSASHA256; key id = 31406
example.com.          3600 IN DNSKEY 256 3 8 (
    AwEAAbuOm42PJ0/VW6UDgJtNgXSANaKG/ygkdKHAvD74
    MxF7oaq03H/iZrqcgf33BNAZ8YZd76yL9Q3c6mxC18/c
    HEHHUVPAYlqRyJhscNwjLn3IZUf1IDTj8Tx7+NrtAM2u
    xpN7RrxQRlqa9vnGwXtqJtPzAzmdN5nP3FR4coLd+oly
    M//t
    ) ; ZSK; alg = RSASHA256; key id = 2718
example.com.          3600 IN RRSIG DNSKEY 8 2 3600 (
    20160203090718 20160113121757 31406 example.com.
    pQ6/bRnuyW08hYYRguR+7RF/XvBSQw0K7Lep/7TzZEpY
    P0wzimsgIO/p3ard+K5u1kXx7fxUQgmAesg5a93DJYGr
    lMmjEmpx846SFKjp9d4ALEC409RNz4Pk5m0bx4bkUWZV
    hNR1jImcImabsrwxhYPqjHfqXUJcWcfi0Y60Aba/FdWi
    Fut1v8VubxcSxqXt1JzuySj1c1mX0LoXXEXoCVF3KhnU
    R0hSUIgXHaCRB16Tc4P4fl+E/Keo0lqNIq1KI51MQr6p
    T8tMreD+dt5W9nzlMm8N7VdDYi8n1B7GBDaUqsIe00LV
    xEZUwiE1hKue6nEgVtvJLsqdykzZnD4RmA== )
```

Query for DNSSEC Records (DS)

```
Terminal - dnsviz@dnsviz-demo: ~/demo
File Edit View Terminal Tabs Help
; <<<>> DiG 9.9.5-9+deb8u5-Debian <<<>> +dnssec +multi @a.gtld-servers.net example.co
m DS
; (2 servers found)
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 37017
;; flags: qr aa rd; QUERY: 1, ANSWER: 7, AUTHORITY: 14, ADDITIONAL: 16
;; WARNING: recursion requested but not available

;; OPT PSEUDOSECTION:
; EDNS: version: 0, flags: do; udp: 4096
;; QUESTION SECTION:
;example.com.          IN DS

;; ANSWER SECTION:
example.com.          86400 IN DS 31589 8 1 (
                      3490A6806D47F17A34C29E2CE80E8A999FFBE4BE )
example.com.          86400 IN DS 31589 8 2 (
                      CDE0D742D6998AA554A92D890F8184C698CFAC8A26FA
                      59875A990C03E576343C )
example.com.          86400 IN DS 43547 8 1 (
                      B6225AB2CC613E0DCA7962BDC2342EA4F1B56083 )
example.com.          86400 IN DS 43547 8 2 (
                      615A64233543F66F44D68933625B17497C89A70E858E
                      D76A2145997EDF96A918 )
example.com.          86400 IN DS 31406 8 1 (
                      189968811E6EBA862DD6C209F75623D8D9ED9142 )
example.com.          86400 IN DS 31406 8 2 (
                      F78CF3344F72137235098ECBBD08947C2C9001C7F6A0
                      85A17F518B5D8F6B916D )
example.com.          86400 IN RRSIG DS 8 2 86400 (
                      20160130053119 20160123042119 28259 com.
                      EretipsIc/dRjJSD5Jy5u0blsAna+0S27dz8W0uEX/Gv
                      VgEIw8cbCFd9uZ2jqArED38Rqt7Yd+jL/zfXD7Cvsubs
```


Query for DNSSEC Records

```
Terminal - dnsviz@dnsviz-demo: ~/demo
File Edit View Terminal Tabs Help
dnsviz@dnsviz-demo:~/demo$ dig +dnssec +multi example.com

; <<>> DiG 9.9.5-9+deb8u5-Debian <<>> +dnssec +multi example.com
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 44311
;; flags: qr rd ra ad; QUERY: 1, ANSWER: 2, AUTHORITY: 3, ADDITIONAL: 3

;; OPT PSEUDOSECTION:
; EDNS: version: 0, flags: do; udp: 4096
;; QUESTION SECTION:
;example.com.                IN A

;; ANSWER SECTION:
example.com.                 83916 IN A 93.184.216.34
example.com.                 83916 IN RRSIG A 8 2 86400 (
                             20160212201614 20160122081757 2718 example.com.
                             Wlw09+oa0EQEUdQpdF+oeJNsGYwK8vmLL3u4gtGHP9Jc
                             GLNWxmF6+ggbTDxA0E8Z0pxe/FgWpiC9AA0WsmPuQw66
                             XMXYoo+M8m5gtY6uzQWIzrYFoKiaSp4UDsxd/gNWmi3f
                             yaUs0ms1JMCdAJZY0cJQCXH+bDx3xBpXc250UC1XkRk= )

;; AUTHORITY SECTION:
example.com.                 83916 IN NS a.iana-servers.net.
example.com.                 83916 IN NS b.iana-servers.net.
example.com.                 83916 IN RRSIG NS 8 2 86400 (
                             20160213061624 20160122221757 2718 example.com.
                             uMmGfrbwm0n69CDW9jhoRF82gvCG5gMi9RSaY0W8mvCz
                             0BceCe7T4AgzBY6JRn3s49IjwI1hGfHqYxDIX5hA5hQt
                             J8hl6cz48ily0bmc9Ee9k65WNY4sBB9CPCbV1Pyc5f3w
                             9LkX5ftRVhFYxfkoqCyY/oQvGsbH8fIvRMMIleHj6WY= )
```

Query For DNSSEC Records (NSEC)

```
Terminal - dnsviz@dnsviz-demo: ~/demo
File Edit View Terminal Tabs Help
; (2 servers found)
;; global options: +cmd
;; Got answer:
;; ->HEADER<<- opcode: QUERY, status: NXDOMAIN, id: 30072
;; flags: qr aa rd; QUERY: 1, ANSWER: 0, AUTHORITY: 4, ADDITIONAL: 1
;; WARNING: recursion requested but not available

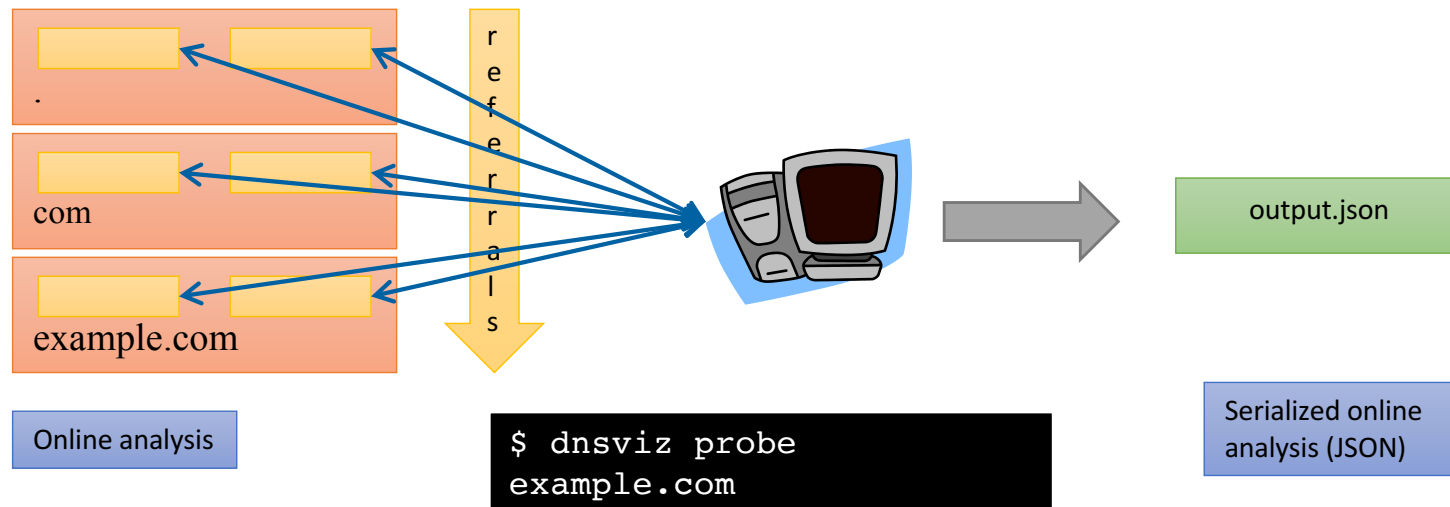
;; OPT PSEUDOSECTION:
; EDNS: version: 0, flags: do; udp: 4096
;; QUESTION SECTION:
;foobar.example.com.      IN A

;; AUTHORITY SECTION:
example.com.              3600 IN SOA sns.dns.icann.org. noc.dns.icann.org. (
                          2015082496 ; serial
                          7200      ; refresh (2 hours)
                          3600      ; retry (1 hour)
                          1209600   ; expire (2 weeks)
                          3600      ; minimum (1 hour)
                          )
example.com.              3600 IN RRSIG SOA 8 2 3600 (
                          20160213015032 20160123081757 2718 example.com.
                          Ffpm4KlQJ8wDFZLYUrMPZfIGApdU1Tm5b8JfzYKFhves
                          BZp0zDs9iABwaxkG9n1qlnxl+6YE7QPtInTy9xbQHs0j
                          CxY9ETquysfmXS4FX+fr2B0v9C5H/nw4e0PfZ4mT9hXS
                          VKb4D24R4/+fhhA+SrFVY4/FpsTMv1zAy6e5LYXwzDA= )
example.com.              3600 IN NSEC www.example.com. A NS SOA TXT AAAA RRSIG NSEC
DNSKEY
example.com.              3600 IN RRSIG NSEC 8 2 3600 (
                          20160206053540 20160116141757 2718 example.com.
                          jqCR8lM7X+puGvuQogxaMudYHX30FaBnb8RY/AgRZpnk
                          KF0f8Qj5+fEushkaViW0BFG48p4B025I0nvc6l0j8eVk
                          Xl65mjIv0Gvhir3lpMPcIJNUz3uRkXv5Q5miegEyJmy
```

DNSViz

DNS Analysis Using DNSViz (`dnsviz probe` command line)

- Queries issued – IPv4/IPv6 UDP/TCP
 - Referral queries – to learn delegation NS records from parent
 - NS queries – to learn authoritative NS records
 - DNSKEY/DS queries – for building a DNSSEC chain
 - A/AAAA/TXT/MX/SOA queries
 - Diagnostic queries (special handling of errors, etc.)



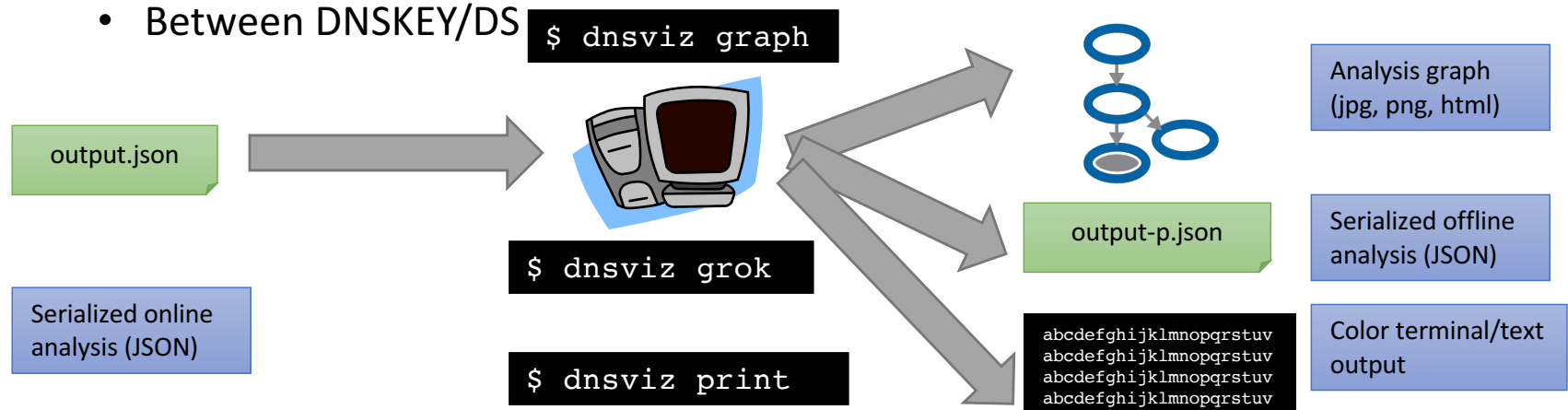
DNS Analysis Using DNSViz (`dnsviz grok/graph/print` command line)

- Responses analyzed (offline)

- Responsiveness
 - Query timeouts
 - Network errors
 - EDNS/fragmentation capabilities
- Consistency
 - Across servers
 - Between DNSKEY/RRSIG
 - Between DNSKEY/DS

- Correctness

- RRSIG
 - Expiration/inception dates
 - Cryptographic signature
- DS - Cryptographic hash
- Negative responses
 - NSEC proof correctness
 - SOA record correctness



Analyze Using `dnsviz probe`

(3.1 – 3.2)

Issue diagnostic queries to authoritative servers, rather than recursive servers



```
$ dnsviz probe -A -a . -p example.com > example.com.json
```



follow referrals from root (".") to analyze name



make the output "pretty" (for readability)



store analysis in file called "example.com.json"

```
$ medit example.com.json &
```

Analyze Using `dnsviz` `grok` (3.3 – 3.4)

read analysis from
"example.com.json"



```
$ dnsviz grok < example.com.json > example.com-p.json
```



store analysis in file called
"example.com-p.json"

```
$ medit example.com-p.json
```

Analyze Using `dnsviz` `grok` (3.5 – 3.6)

show only
information that is
of priority "info" or
higher



```
$ dnsviz grok -l info < example.com.json \  
> example.com-p1.json
```

```
$ medit example.com-p1.json
```


Analyze Using `dnsviz grok` (3.7)

show only
information that is
of priority "error" or
higher



display output (if
any) to screen,
instead of
redirecting to file



```
$ dnsviz grok -l error < example.com.json
```

Analyze Using dnsviz graph (3.8 – 3.11)

output interactive
HTML format



Don't use any
trust anchor



```
$ dnsviz graph -Thtml -t /dev/null < example.com.json \  
> example.com.html
```

```
$ firefox example.com.html &
```

```
$ dnsviz graph -Thtml < example.com.json \  
> example.com.html
```

```
$ firefox example.com.html &
```

Analyze Using `dnsviz print` (3.12 – 3.13)

Don't use any
trust anchor



```
$ dnsviz print -t /dev/null < example.com.json
```

```
$ dnsviz print < example.com.json
```



anchor trust
with root KSK

View dnsviz probe Output

```
example.com.json
{
  ".": {
    "type": "authoritative",
    "stub": false,
    "analysis_start": "2016-01-26 14:54:55 UTC",
    "analysis_end": "2016-01-26 14:54:58 UTC",
    "clients_ipv4": [
      "10.0.2.15"
    ],
    "clients_ipv6": [],
    "referral_rdtype": "NS",
    "explicit_delegation": false,
    "auth_ns_ip_mapping": {
      "a.root-servers.net.": [
        "198.41.0.4",
        "2001:503:ba3e::2:30"
      ],
      "b.root-servers.net.": [
        "192.228.79.201",
        "2001:500:84::b"
      ],
      "c.root-servers.net.": [
        "192.33.4.12",
        "2001:500:2::c"
      ],
      "d.root-servers.net.": [
        "199.7.91.13",
        "2001:500:2d::d"
      ],
      "e.root-servers.net.": [
        "192.203.230.10"
      ],
      "f.root-servers.net.": [
        "192.5.5.241",
        "2001:500:2f::f"
      ]
    }
  }
}
```

View dnsviz probe Output

```
example.com.json
]
},
"queries": [
  {
    "qname": ".",
    "qclass": "IN",
    "qtype": "NS",
    "options": {
      "flags": 0,
      "edns_version": 0,
      "edns_max_udp_payload": 4096,
      "edns_flags": 32768,
      "edns_options": [],
      "tcp": false
    }
  },
  "responses": {
    "192.5.5.241": {
      "10.0.2.15": {
        "message": "DPyEAAAABAA4AAAAZAAACAAEAAAIA",
        "msg_size": 913,
        "time_elapsed": 86,
        "history": []
      }
    },
    "192.33.4.12": {
      "10.0.2.15": {
        "message": "qw6EAAAABAA4AAAAZAAACAAEAAAIA",
        "msg_size": 913,
        "time_elapsed": 32,
        "history": []
      }
    },
    "192.36.148.17": {
      "10.0.2.15": {
        "message": "KIOEAAAABAA4AAAAZAAACAAEAAAIA"
      }
    }
  }
]
```

View dnsviz probe Output

```
example.com.json
}
}
}
},
"example.com.": {
  "type": "authoritative",
  "stub": false,
  "analysis_start": "2016-01-26 14:54:59 UTC",
  "analysis_end": "2016-01-26 14:55:01 UTC",
  "clients_ipv4": [
    "10.0.2.15"
  ],
  "clients_ipv6": [],
  "parent": "com.",
  "referral_rdtype": "NS",
  "explicit_delegation": false,
  "nxdomain_name": "rph3tzkbls.example.com.",
  "nxdomain_rdtype": "A",
  "nxrrset_name": "example.com.",
  "nxrrset_rdtype": "CNAME",
  "auth_ns_ip_mapping": {
    "a.iana-servers.net.": [
      "199.43.132.53",
      "2001:500:8c::53"
    ],
    "b.iana-servers.net.": [
      "199.43.133.53",
      "2001:500:8d::53"
    ]
  }
},
"queries": [
  {
    "qname": "example.com.",
    "qclass": "IN",
    "qtype": "A",
```

View dnsviz grok Output

```
example.com-p.json
{
  ".": {
    "status": "NOERROR",
    "queries": {
      "./IN/DNSKEY": {
        "answer": [
          {
            "id": "./IN/DNSKEY",
            "description": "RRset for ./DNSKEY",
            "name": ".",
            "ttl": 172800,
            "type": "DNSKEY",
            "rdata": [
              "256 3 8 AwEAAbr/RV0stAWYbmK0ldjShp4A0QG0 yY3",
              "257 3 8 AwEAAgAIKlVZrpC6Ia7gEzah0R+9W29 eux"
            ],
            "servers": [
              "192.5.5.241",
              "192.33.4.12",
              "192.36.148.17",
              "192.58.128.30",
              "192.112.36.4",
              "192.203.230.10",
              "192.228.79.201",
              "193.0.14.129",
              "198.41.0.4",
              "198.97.190.53",
              "199.7.83.42",
              "199.7.91.13",
              "202.12.27.33"
            ],
            "query_options": [
              "UDP_0_EDNS0_32768_4096"
            ],
            "rrsig": [

```

View dnsviz grok Output

```
example.com-p.json
}
},
"dnskey": [
  {
    "id": "8/19036",
    "description": "DNSKEY for . (algorithm 8 (RSA/)",
    "flags": 257,
    "protocol": 3,
    "algorithm": 8,
    "key": "AwEAAgAIKlVZrpC6Ia7gEzah0R+9W29euxhJhV",
    "ttl": 172800,
    "key_length": 2048,
    "key_tag": 19036,
    "servers": [
      "192.5.5.241",
      "192.33.4.12",
      "192.36.148.17",
      "192.58.128.30",
      "192.112.36.4",
      "192.203.230.10",
      "192.228.79.201",
      "193.0.14.129",
      "198.41.0.4",
      "198.97.190.53",
      "199.7.83.42",
      "199.7.91.13",
      "202.12.27.33"
    ],
    "query_options": [
      "UDP_0_EDNS0_32768_4096"
    ]
  },
  {
    "id": "8/54549",
    "description": "DNSKEY for . (algorithm 8 (RSA/)"
```


View dnsviz grok Output

```
example.com-p.json
},
  "rph3tzkbls.example.com./IN/A": {
    "nxdomain": [
      {
        "id": "rph3tzkbls.example.com./IN/A",
        "proof": [
          {
            "id": "NSEC",
            "description": "NSEC record(s) proving the non-existen",
            "nsec": [
              {
                "id": "example.com./IN/NSEC",
                "description": "RRset for example.com/NSEC",
                "name": "example.com.",
                "ttl": 3600,
                "type": "NSEC",
                "rdata": [
                  "www.example.com. A NS SOA TXT AAAA RRSIG"
                ],
                "servers": [
                  "199.43.132.53",
                  "199.43.133.53"
                ],
                "query_options": [
                  "UDP_0_EDNS0_32768_4096"
                ],
                "rrsig": [
                  {
                    "id": "example.com./8/2718",
                    "description": "RRSIG covering example",
                    "signer": "example.com.",
                    "algorithm": 8,
                    "key_tag": 2718,
                    "original_ttl": 3600,
                    "labels": 2,
                    "expiration": "2016-01-16 14:17:57 UTC"
                  }
                ]
              }
            ]
          }
        ]
      }
    ]
  }
}
```

View dnsviz grok Output

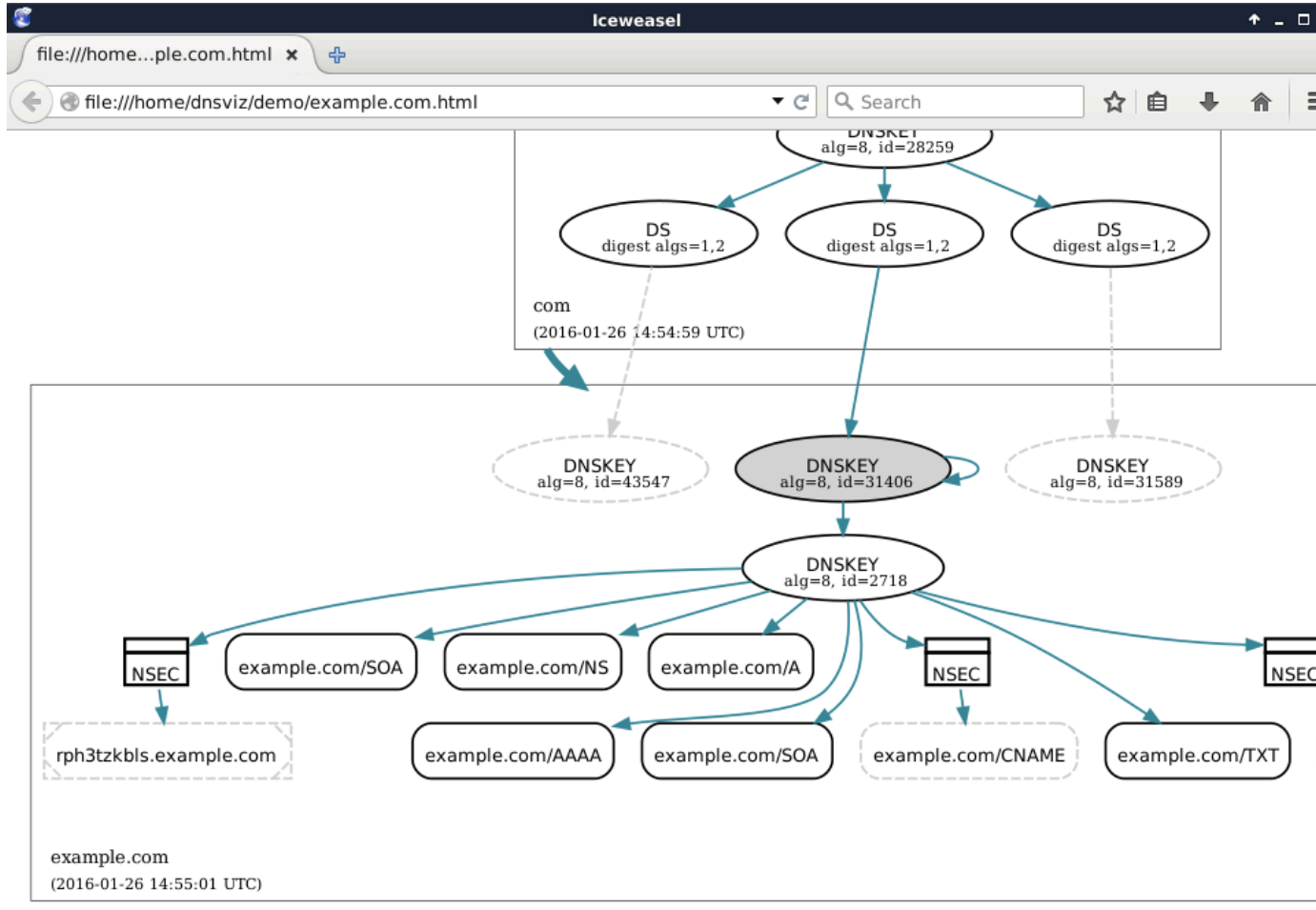
```
example.com-p1.json
{
  ".": {
    "status": "NOERROR",
    "queries": {
      "./IN/DNSKEY": {
        "answer": [
          {
            "id": "./IN/DNSKEY",
            "rrsig": [
              {
                "id": "./8/19036",
                "status": "VALID",
                "servers": [
                  "192.5.5.241",
                  "192.33.4.12",
                  "192.36.148.17",
                  "192.58.128.30",
                  "192.112.36.4",
                  "192.203.230.10",
                  "192.228.79.201",
                  "193.0.14.129",
                  "198.41.0.4",
                  "198.97.190.53",
                  "199.7.83.42",
                  "199.7.91.13",
                  "202.12.27.33"
                ],
                "query_options": [
                  "UDP_0_EDNS0_32768_4096"
                ]
              }
            ]
          }
        ],
        "servers": [
          "192.5.5.241",
          "192.33.4.12",
          "192.36.148.17",

```

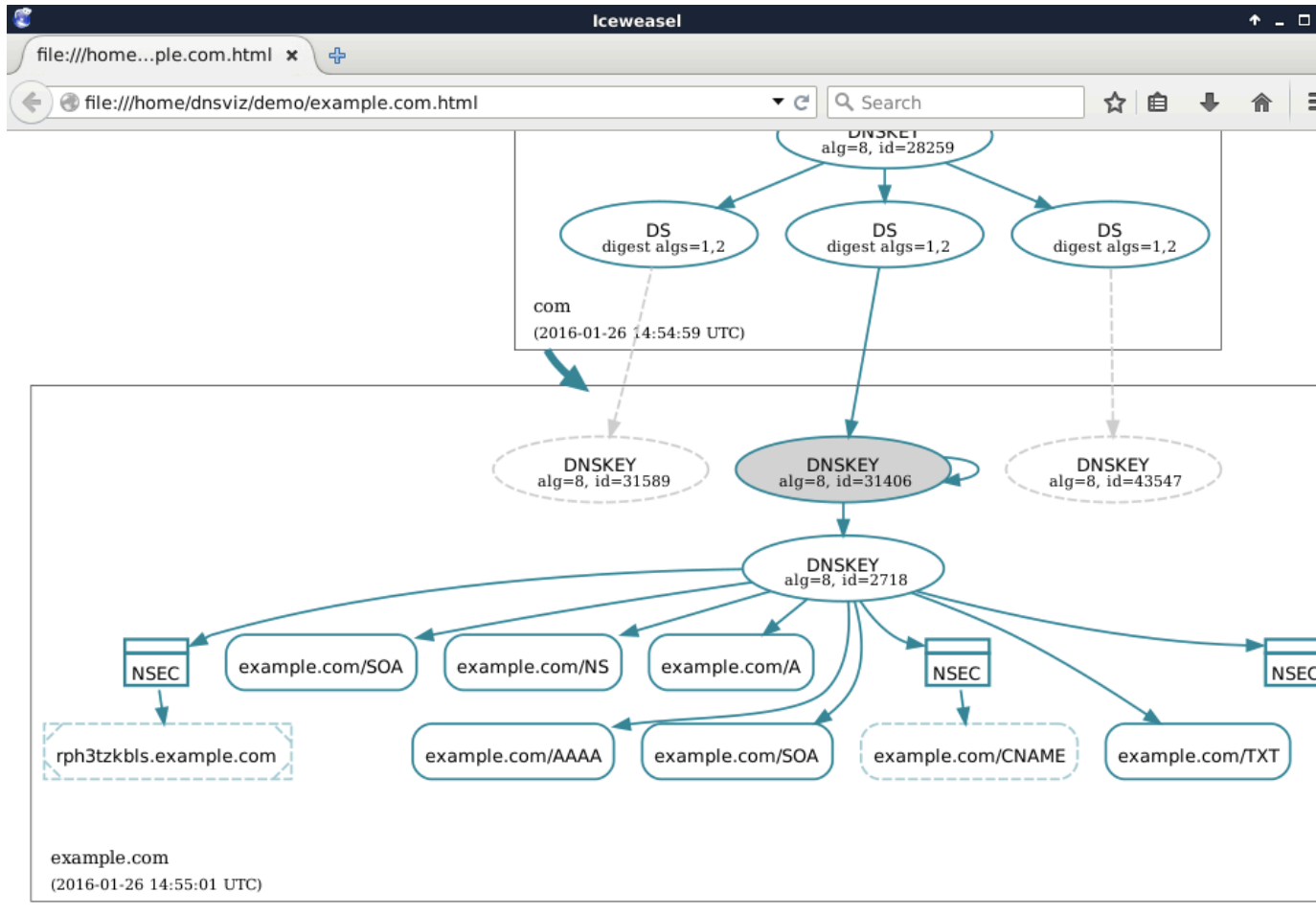
View dnsviz grok Output

```
example.com-p1.json
"UDP_0_EDNS0_32768_4096"
  ]
}
],
"delegation": {
  "ds": [
    {
      "id": "8/30909/2",
      "status": "VALID",
      "servers": [
        "192.5.5.241",
        "192.33.4.12",
        "192.36.148.17",
        "192.58.128.30",
        "192.112.36.4",
        "192.203.230.10",
        "192.228.79.201",
        "193.0.14.129",
        "198.41.0.4",
        "198.97.190.53",
        "199.7.83.42",
        "199.7.91.13",
        "202.12.27.33"
      ],
      "query_options": [
        "UDP_0_EDNS0_32768_4096"
      ]
    }
  ],
  "status": "SECURE"
},
"example.com.": {
  "status": "NOERROR",
  "queries": {
    "example.com./IN/A": {
```

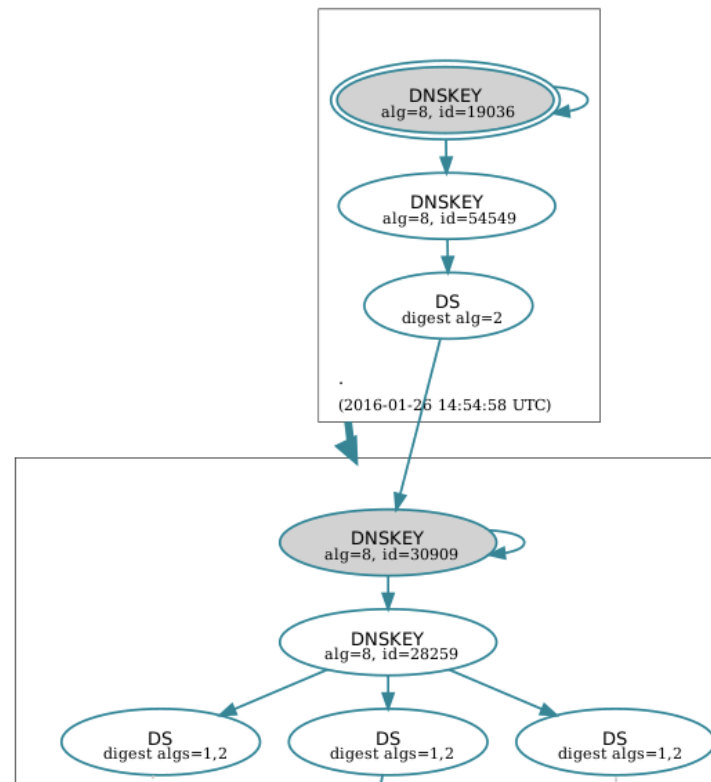
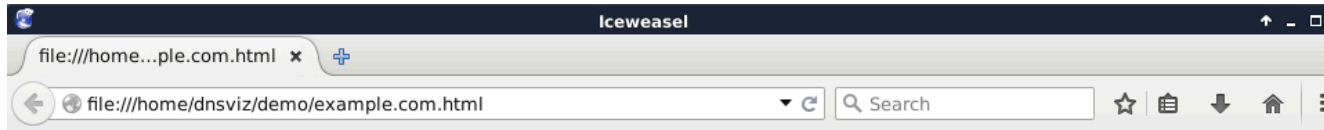
View dnsviz graph Output



View dnsviz graph Output



View dnsviz graph Output



View dnsviz print Output

```
Terminal - dnsviz@dnsviz-demo: ~/demo
File Edit View Terminal Tabs Help
dnsviz@dnsviz-demo:~/demo$ dnsviz print -t /dev/null < example.com.json
. [-]
[-] DNSKEY: 8/19036/257 [..], 8/54549/256 [..]
[-] RRSIG: ./8/19036 (2016-01-21 - 2016-02-04) [..]
com [-] [..]
[-] DS: 8/30909/2 [..]
[-] RRSIG: ./8/54549 (2016-01-27 - 2016-02-06) [..]
[-] DNSKEY: 8/28259/256 [..], 8/30909/257 [..]
[-] RRSIG: com/8/30909 (2016-01-18 - 2016-02-02) [..]
example.com [-] [..]
[-] DS: 8/31406/1 [..], 8/31406/2 [..], 8/31589/1 [-], 8/31589/2 [-], 8/43547/1 [-], 8/43547/2 [-]
[-] RRSIG: com/8/28259 (2016-01-27 - 2016-02-03) [..]
[-] DNSKEY: 8/31406/257 [..], 8/2718/256 [..]
[-] RRSIG: example.com/8/31406 (2016-01-13 - 2016-02-03) [..]
[-] A: 93.184.216.34
[-] RRSIG: example.com/8/2718 (2016-01-22 - 2016-02-12) [..]
[-] NS: b.iana-servers.net., a.iana-servers.net.
[-] RRSIG: example.com/8/2718 (2016-01-22 - 2016-02-13) [..]
[-] CNAME: NODATA
[-] SOA: sns.dns.icann.org. noc.dns.icann.org. 2015082496 7200 3600 1209600 3600
[-] RRSIG: example.com/8/2718 (2016-01-23 - 2016-02-13) [..]
[-] PROOF: [..]
[-] NSEC: example.com. www.example.com. A NS SOA TXT AAAA RRSIG NSEC DNSKEY
[-] RRSIG: example.com/8/2718 (2016-01-16 - 2016-02-06) [..]
[-] SOA: sns.dns.icann.org. noc.dns.icann.org. 2015082496 7200 3600 1209600 3600
[-] RRSIG: example.com/8/2718 (2016-01-23 - 2016-02-13) [..]
[-] MX: NODATA
[-] SOA: sns.dns.icann.org. noc.dns.icann.org. 2015082496 7200 3600 1209600 3600
[-] RRSIG: example.com/8/2718 (2016-01-23 - 2016-02-13) [..]
[-] PROOF: [..]
[-] NSEC: example.com. www.example.com. A NS SOA TXT AAAA RRSIG NSEC DNSKEY
[-] RRSIG: example.com/8/2718 (2016-01-16 - 2016-02-06) [..]
[-] TXT: "$Id: example.com 4415 2015-08-24 20:12:23Z davids $", "v=spf1 -all"
```

View dnsviz print Output

```
Terminal - dnsviz@dnsviz-demo: ~/demo
File Edit View Terminal Tabs Help
dnsviz@dnsviz-demo:~/demo$ dnsviz print < example.com.json
. [.]
[.] DNSKEY: 8/19036/257 [..], 8/54549/256 [.]
[.] RRSIG: ./8/19036 (2016-01-21 - 2016-02-04) [.]
com [.] [.]
[.] DS: 8/30909/2 [.]
[.] RRSIG: ./8/54549 (2016-01-27 - 2016-02-06) [.]
[.] DNSKEY: 8/28259/256 [..], 8/30909/257 [.]
[.] RRSIG: com/8/30909 (2016-01-18 - 2016-02-02) [.]
example.com [.] [.]
[.] DS: 8/31406/1 [..], 8/31406/2 [..], 8/31589/1 [-], 8/31589/2 [-], 8/43547/1 [-], 8/43547/2 [-]
[.] RRSIG: com/8/28259 (2016-01-27 - 2016-02-03) [.]
[.] DNSKEY: 8/31406/257 [..], 8/2718/256 [.]
[.] RRSIG: example.com/8/31406 (2016-01-13 - 2016-02-03) [.]
[.] A: 93.184.216.34
[.] RRSIG: example.com/8/2718 (2016-01-22 - 2016-02-12) [.]
[.] NS: b.iana-servers.net., a.iana-servers.net.
[.] RRSIG: example.com/8/2718 (2016-01-22 - 2016-02-13) [.]
[.] CNAME: NODATA
[.] SOA: sns.dns.icann.org. noc.dns.icann.org. 2015082496 7200 3600 1209600 3600
[.] RRSIG: example.com/8/2718 (2016-01-23 - 2016-02-13) [.]
[.] PROOF: [.]
[.] NSEC: example.com. www.example.com. A NS SOA TXT AAAA RRSIG NSEC DNSKEY
[.] RRSIG: example.com/8/2718 (2016-01-16 - 2016-02-06) [.]
[.] SOA: sns.dns.icann.org. noc.dns.icann.org. 2015082496 7200 3600 1209600 3600
[.] RRSIG: example.com/8/2718 (2016-01-23 - 2016-02-13) [.]
[.] MX: NODATA
[.] SOA: sns.dns.icann.org. noc.dns.icann.org. 2015082496 7200 3600 1209600 3600
[.] RRSIG: example.com/8/2718 (2016-01-23 - 2016-02-13) [.]
[.] PROOF: [.]
[.] NSEC: example.com. www.example.com. A NS SOA TXT AAAA RRSIG NSEC DNSKEY
[.] RRSIG: example.com/8/2718 (2016-01-16 - 2016-02-06) [.]
[.] TXT: "$Id: example.com 4415 2015-08-24 20:12:23Z davids $" "v=spf1 -all"
```


Signing a DNS Zone

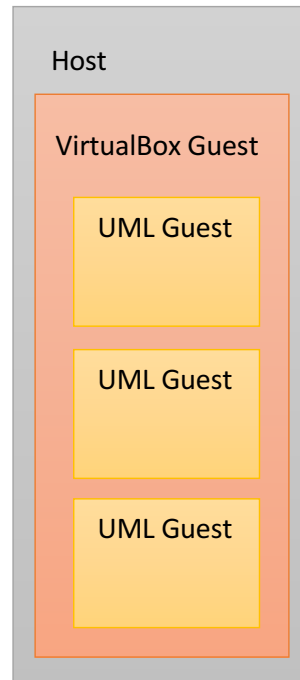
Setup Virtual DNS Environment (4.1 – 4.2)

```
$ ./start_all
```

(Wait for all three
consoles to come up)

Change directory for all
three consoles: root,
tld1, sld1

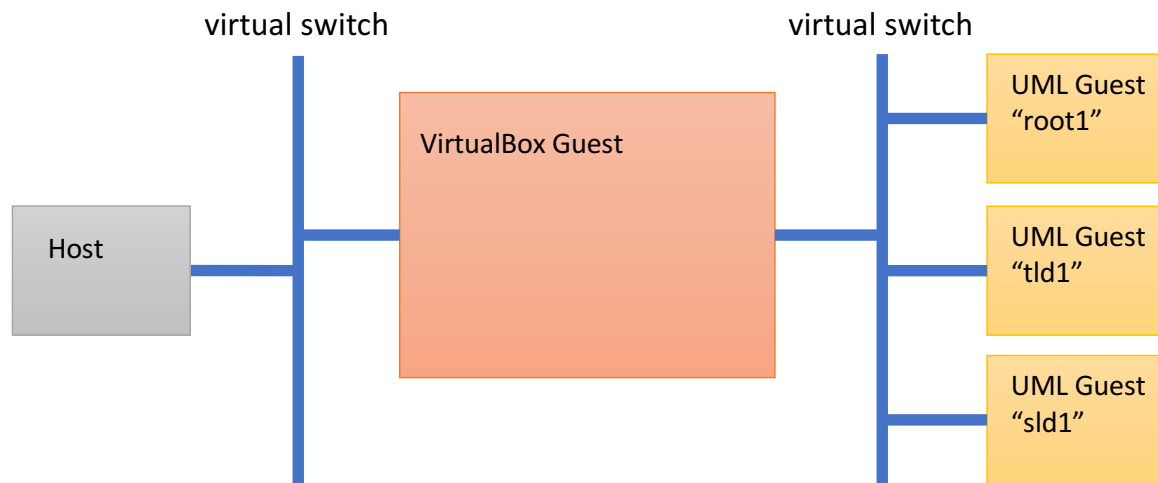
```
$ cd /etc/bind
```



Setup Virtual DNS Environment (4.3)


```
$ ./dns_change_root local
```

(point DNS root hints and trusted keys to internal root server)




Analyze example.com in Local Environment (4.4 – 4.6)

Pipe results directly to
dnsviz graph,
rather than redirecting
to file



```
$ dnsviz probe -A -a . -p example.com | dnsviz graph -Thtml -O
```



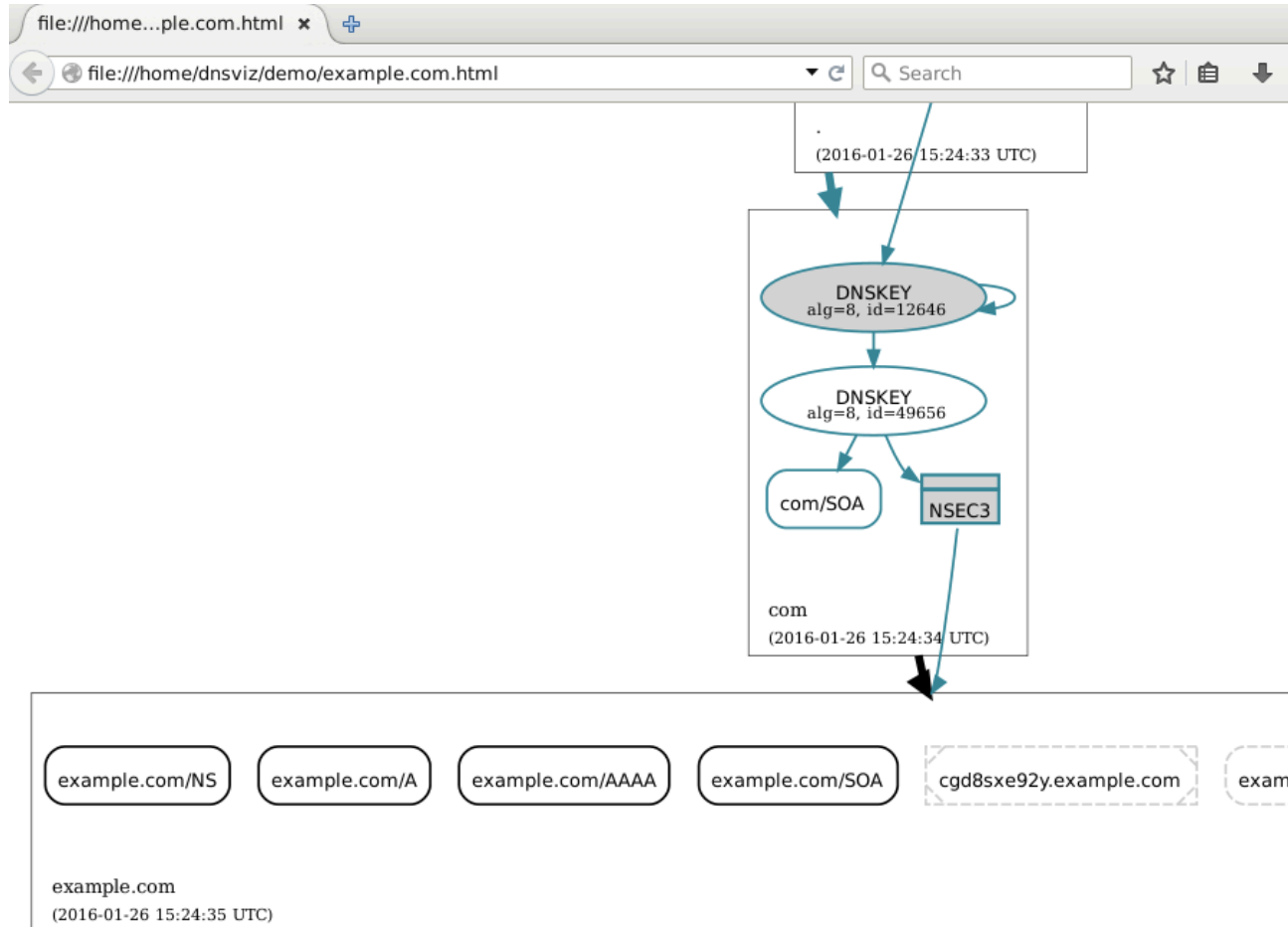
Output analysis to file
named
"example.com.html"

```
$ ./dnsviz_analyze example.com
```

(script included for simplification)

```
$ firefox example.com.html &
```

View dnsviz graph Output



Add Records to example.com Zone (5.1 – 5.4)

- Add A records for names “a”, “c”, and “e” (on **sld1**)

(hint: see existing record for “www”)

```
# nano zones/db.example.com
```

or

```
# vi zones/db.example.com
```

- Check zone

```
# named-checkzone example.com zones/db.example.com
```

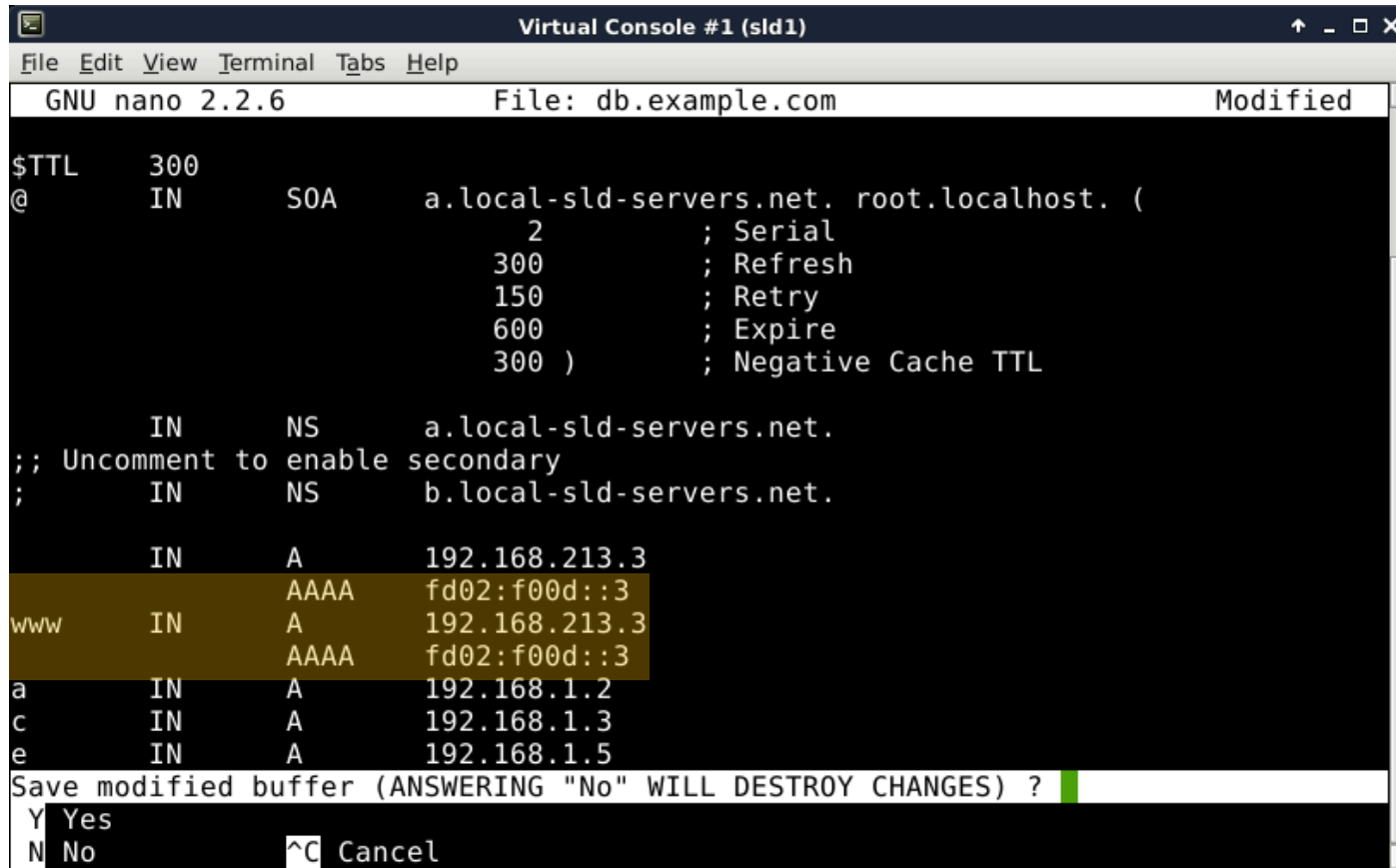
- Reload zone

```
# service bind9 reload
```

- Check that record shows up (query from VirtualBox guest)

```
$ dig @sld1 a.example.com
```

Add Records to example.com Zone



```
Virtual Console #1 (sld1)
File Edit View Terminal Tabs Help
GNU nano 2.2.6 File: db.example.com Modified
$TTL 300
@ IN SOA a.local-sld-servers.net. root.localhost. (
    2 ; Serial
    300 ; Refresh
    150 ; Retry
    600 ; Expire
    300 ) ; Negative Cache TTL

    IN NS a.local-sld-servers.net.
;; Uncomment to enable secondary
; IN NS b.local-sld-servers.net.

    IN A 192.168.213.3
www IN AAAA fd02:f00d::3
    IN A 192.168.213.3
a IN A 192.168.1.2
c IN A 192.168.1.3
e IN A 192.168.1.5
Save modified buffer (ANSWERING "No" WILL DESTROY CHANGES) ?
Y Yes
N No ^C Cancel
```

Add Records to example.com Zone

```
Terminal - dnsviz@dnsviz-demo: ~/demo
File Edit View Terminal Tabs Help
dnsviz@dnsviz-demo:~/demo$ dig @sld1 a.example.com

; <<>> DiG 9.9.5-9-Debian <<>> @sld1 a.example.com
; (2 servers found)
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 13020
;; flags: qr aa rd; QUERY: 1, ANSWER: 1, AUTHORITY: 1, ADDITIONAL: 1
;; WARNING: recursion requested but not available

;; OPT PSEUDOSECTION:
; EDNS: version: 0, flags:; udp: 4096
;; QUESTION SECTION:
;a.example.com.                IN      A

;; ANSWER SECTION:
a.example.com.                 300    IN      A      192.168.1.2

;; AUTHORITY SECTION:
example.com.                   300    IN      NS     a.local-sld-servers.net.

;; Query time: 0 msec
;; SERVER: fd02:f00d::25#53(fd02:f00d::25)
;; WHEN: Fri May 01 08:43:23 EDT 2015
;; MSG SIZE rcvd: 95
```


Create DNSSEC Keys for example.com Zone (6.1 – 6.3)

(on sld1)

Set the "SEP"
bit for this
DNSKEY

Use algorithm
RSASHA256
for signing


Create a
2048-bit key



```
# KSK=`dnssec-keygen -n ZONE -f KSK -a RSASHA256 -b 2048 \  
-r /dev/urandom example.com`
```

No "SEP" bit
here

Create a
1024-bit key



```
# ZSK=`dnssec-keygen -n ZONE -a RSASHA256 -b 1024 \  
-r /dev/urandom example.com`
```

```
# ls $KSK* $ZSK*
```

Add DNSKEY Records to example.com Zone (6.4 – 6.9)

- Look at DNSKEY records (on **sld1**):

```
# cat $KSK.key $ZSK.key
```

- Add DNSKEY records to zone

```
# cat $KSK.key $ZSK.key >> zones/db.example.com
```

- Reload zone

```
# service bind9 reload
```

-
- Re-analyze

```
$ ./dnsviz_analyze example.com
```

```
$ firefox example.com.html &
```

```
$ dig +noall +comment +ad example.com
```

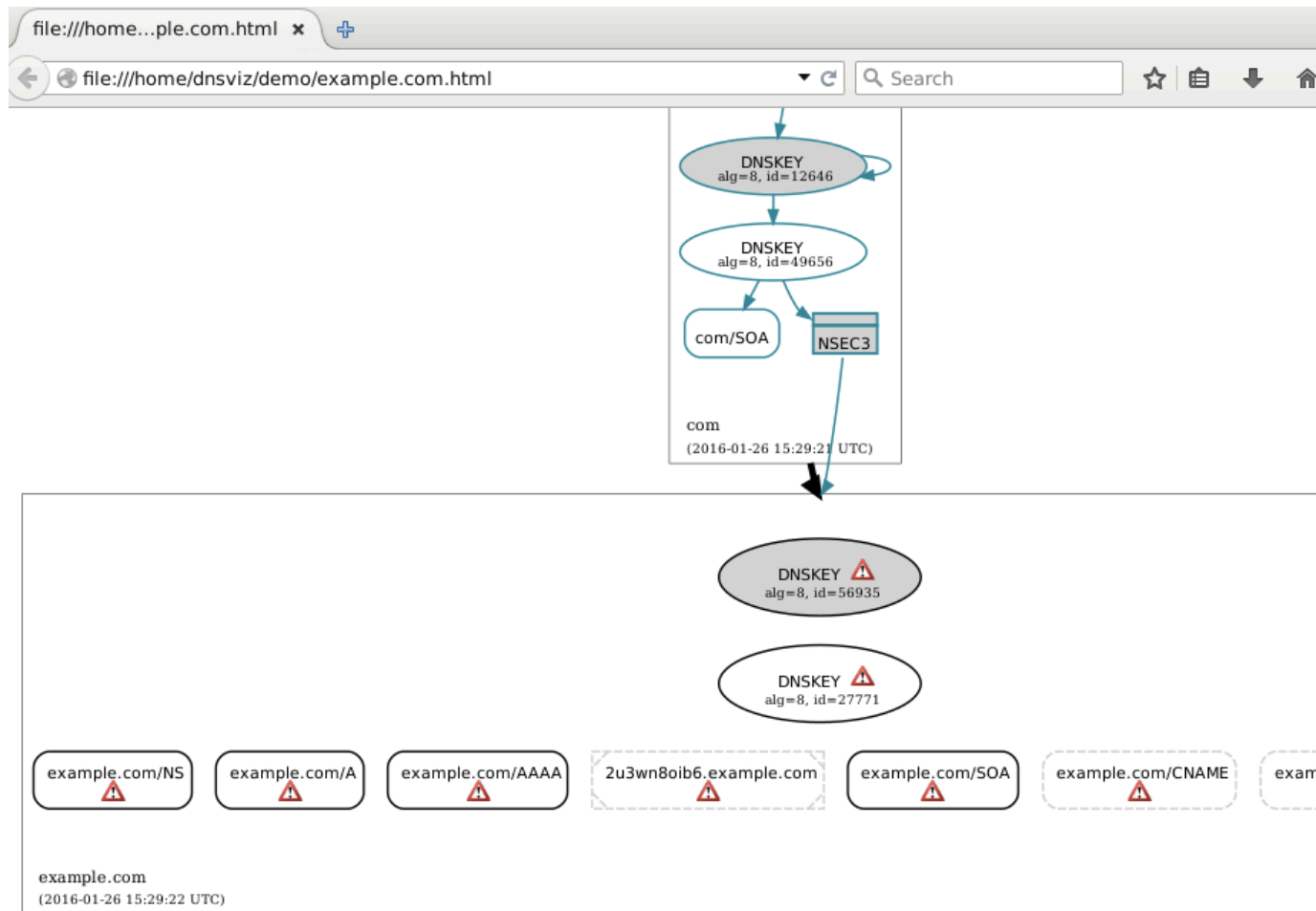
Create DNSSEC keys for example.com Zone

```
Virtual Console #1 (sld1)
File Edit View Terminal Tabs Help
root@sld1:/etc/bind# KSK=`dnssec-keygen -n ZONE -f KSK -a RSASHA256 -b 2048 \
> -r /dev/urandom example.com`
Generating key pair.....+++ ...+++
root@sld1:/etc/bind# ZSK=`dnssec-keygen -n ZONE -a RSASHA256 -b 1024 -r /dev/urandom example.com`
Generating key pair.....+++++ .....+++++
root@sld1:/etc/bind# ls $KSK* $ZSK*
Kexample.com.+008+42499.key      Kexample.com.+008+56319.key
Kexample.com.+008+42499.private  Kexample.com.+008+56319.private
root@sld1:/etc/bind# █
```

Create DNSSEC keys for example.com Zone

```
Virtual Console #1 (sld1)
File Edit View Terminal Tabs Help
root@sld1:/etc/bind# cat $KSK.key $ZSK.key
; This is a key-signing key, keyid 42499, for example.com.
; Created: 20150501124519 (Fri May 1 08:45:19 2015)
; Publish: 20150501124519 (Fri May 1 08:45:19 2015)
; Activate: 20150501124519 (Fri May 1 08:45:19 2015)
example.com. IN DNSKEY 257 3 8 AwEAAckRTKcWx4aZHdBpdtjxZ3wGPgQS6x6DHwYfhuKYf9M5k
p0Ij5Z2 FtvvWFeHe4aXhXrorpKmZj5Z6rytJsY4eicuJiJ3Q67XV4Ht7SMRdZz 0M2S32lyQdZGsl0
YEAonI+H14y10QcuU2YblcPS+ovvwkeXMDBmqftNu J/Lusfd8/UmPRs9sBXMM4KTfU/MexgzmJCsmk
91MBrtSuEi/RQj+hr3 iK7pDctie+9rIrdlBn+Yey3ZgnqWJQEtwws2klZCdKkZ5fbCbsgouVQp UBh5
WpQI+4jEMaVtF1C6MYbALT3lGMjXi0aESoIyW30fTNxMdlTJb6jy flAE2mH4f0M=
; This is a zone-signing key, keyid 56319, for example.com.
; Created: 20150501124534 (Fri May 1 08:45:34 2015)
; Publish: 20150501124534 (Fri May 1 08:45:34 2015)
; Activate: 20150501124534 (Fri May 1 08:45:34 2015)
example.com. IN DNSKEY 256 3 8 AwEAAAdswNjmsquwbpUpoDk6YyG+lzNCHiMgn3Q0B4p1xPmab/
TXmTFWT 35Icz9RAk6eBmdYCoC0l+tdQ04v7WEsqW/M5MzMNPgxqvKKA5qvTGH1N 0h3tx/JpKBXK7Ax
P6m44NeVX0NVbbpZw3vPipcZi+swYxXlBne6prsZf dM00K4m3
root@sld1:/etc/bind#
```

View dnsviz graph Output: DNSKEYs with no RRSIGs



View dig Output: no AD bit

```
Terminal - dnsviz@dnsviz-demo: ~/demo
File Edit View Terminal Tabs Help
dnsviz@dnsviz-demo:~/demo$ dig +noall +comment +ad example.com
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 51191
;; flags: qr rd ra; QUERY: 1, ANSWER: 1, AUTHORITY: 0, ADDITIONAL: 1

;; OPT PSEUDOSECTION:
; EDNS: version: 0, flags;; udp: 4096
dnsviz@dnsviz-demo:~/demo$
```

Sign Records in example.com Zone (7.1 – 7.4)

- Sign zone (**sld1**)
 - Use pseudo-random entropy source (**not for production use**)
- ```
dnssec-signzone -r /dev/urandom \
-k $KSK -o example.com zones/db.example.com $ZSK
```
- ↑ Sign only DNSKEY records with this key
- ↑ Sign entire zone with this key

- Point named.conf to signed zone file

```
sed -i -e 's:/db.example.com:&.signed:' named.conf.local
```

- Reload zone

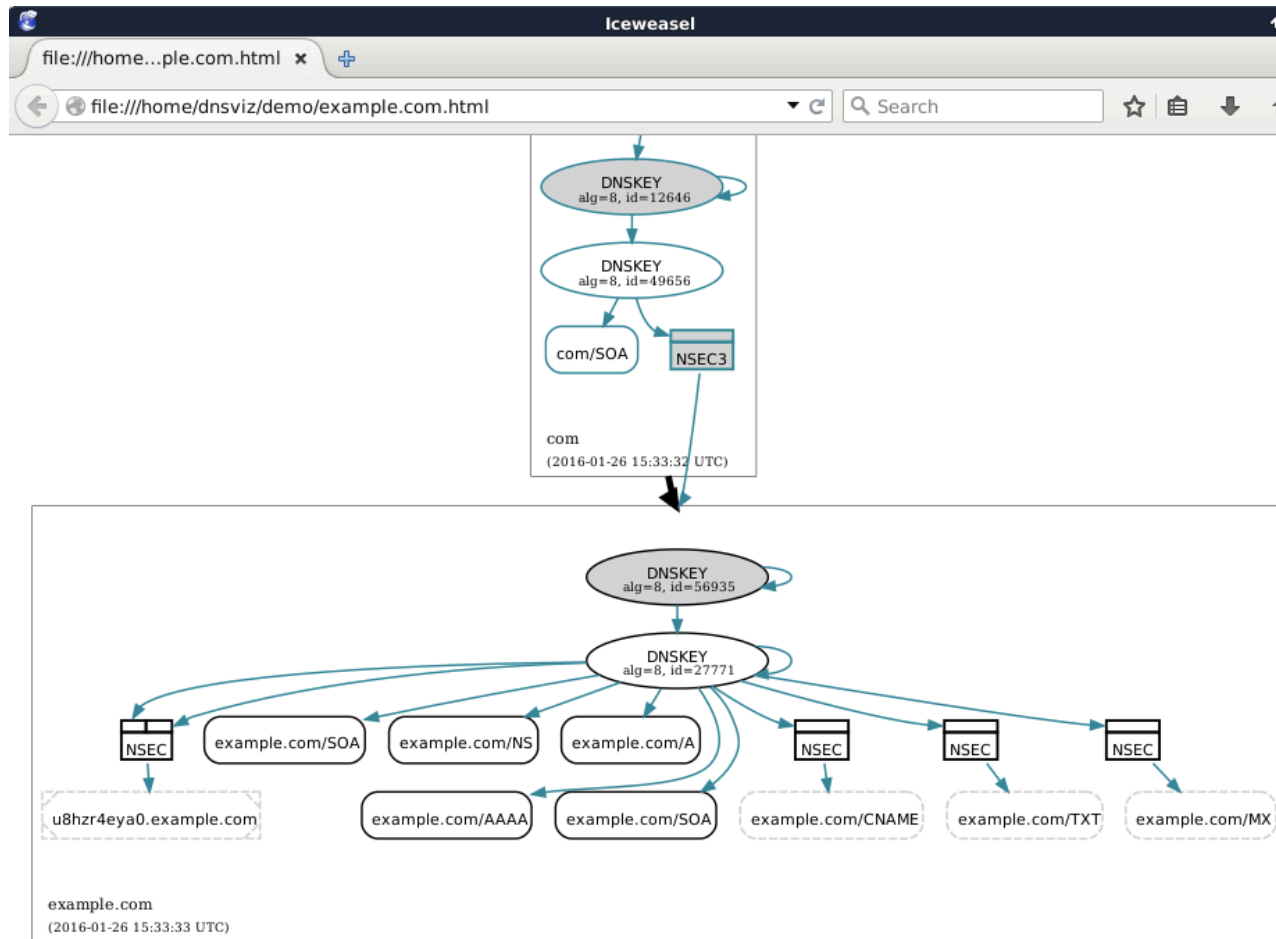
```
service bind9 reload
```

```
$./dnsviz_analyze example.com
```

```
$ firefox example.com.html &
```

```
$ dig +noall +comment +ad example.com
```

# View dnsviz graph Output: Signed example.com Zone





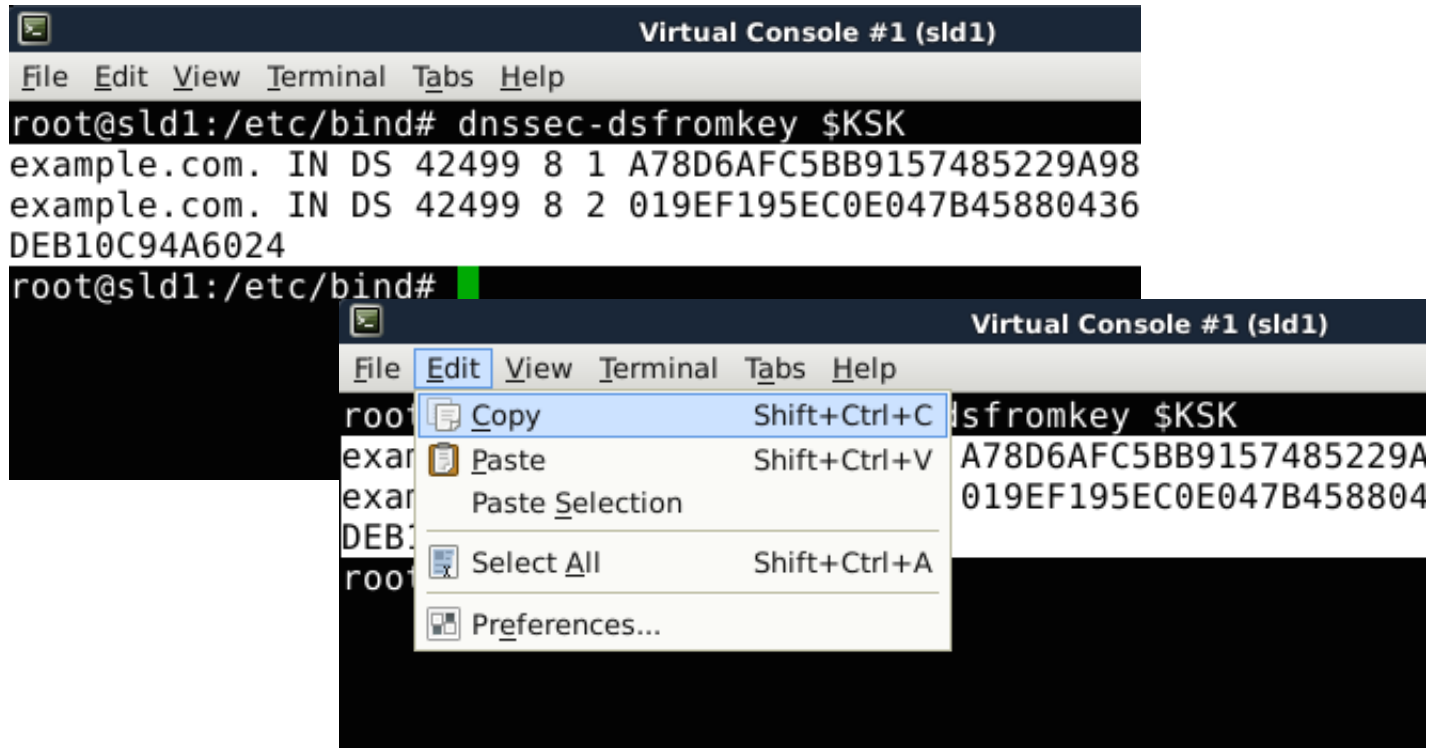
# View dig Output: no AD bit

```
Terminal - dnsviz@dnsviz-demo: ~/demo
File Edit View Terminal Tabs Help
dnsviz@dnsviz-demo:~/demo$ dig +noall +comment +ad example.com
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 51191
;; flags: qr rd ra; QUERY: 1, ANSWER: 1, AUTHORITY: 0, ADDITIONAL: 1

;; OPT PSEUDOSECTION:
; EDNS: version: 0, flags;; udp: 4096
dnsviz@dnsviz-demo:~/demo$
```

# Generate DS Records for example.com (8.1 – 8.2) (on sld1)

```
dnssec-dsfromkey $KSK
```



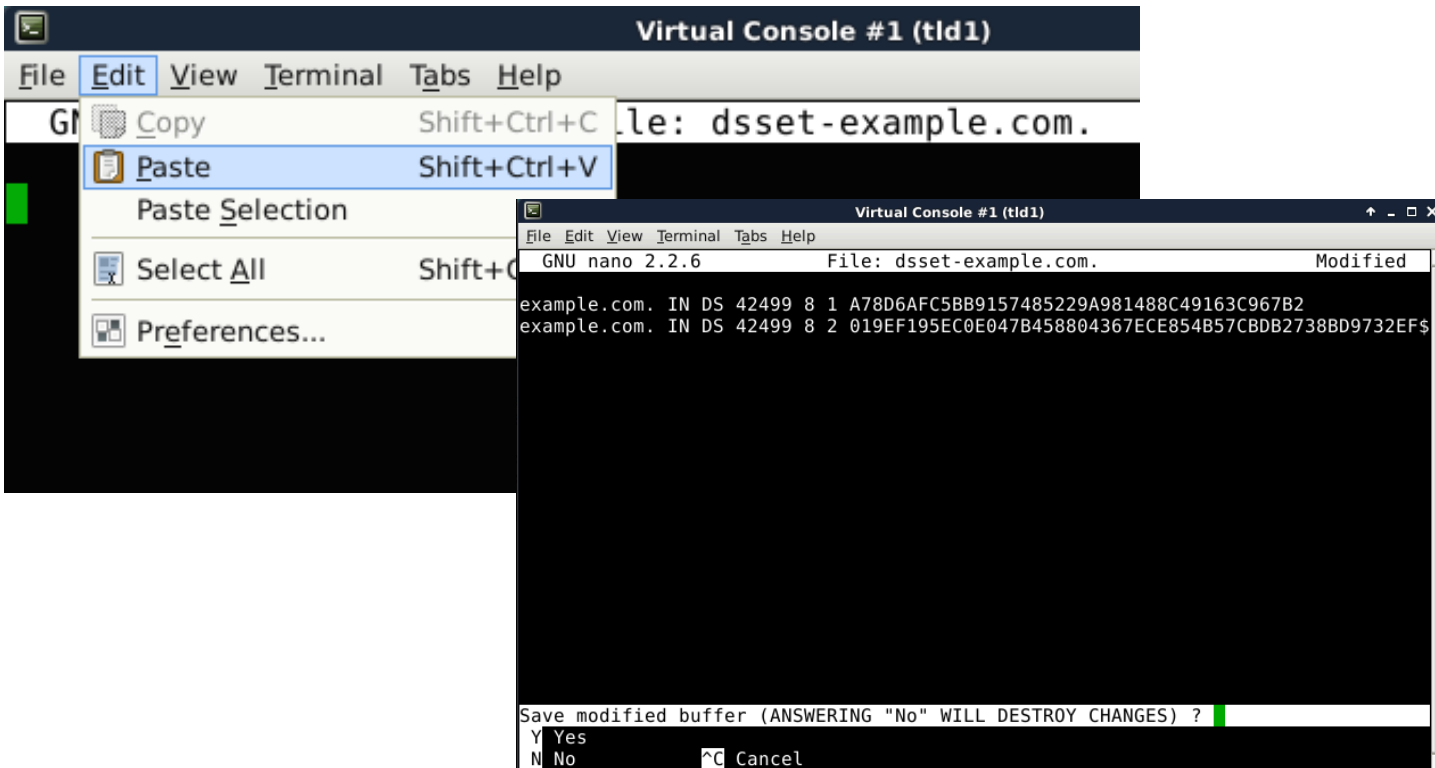
The image shows a terminal window titled "Virtual Console #1 (sld1)". The terminal output displays the command `dnssec-dsfromkey $KSK` and its results for the domain `example.com`. The output consists of two lines of DS records:

```
example.com. IN DS 42499 8 1 A78D6AFC5BB9157485229A98
example.com. IN DS 42499 8 2 019EF195EC0E047B45880436
DEB10C94A6024
```

The terminal prompt is `root@sld1:/etc/bind#`. A context menu is overlaid on the terminal, showing options: `Copy` (Shift+Ctrl+C), `Paste` (Shift+Ctrl+V), `Paste Selection`, `Select All` (Shift+Ctrl+A), and `Preferences...`. The menu is positioned over the second line of the output, highlighting the text `019EF195EC0E047B458804`.

# Add DS Records for example.com (8.3a – 8.3c) (on **tld1**)

```
nano zones/dsset-example.com.
```



# Sign Records in “example.com” Zone (8.4)

- Check DS consistency before they are deployed (preview)

```
$./dnsviz probe -A -a . \
-N example.com:a.local-sld-servers.net \
-D example.com:zones/dsset-example.com. \
-p example.com | dnsviz graph -Thtml -O
```

- 
- Re-analyze

```
$ firefox example.com.html &
```

# Sign Records in “example.com” Zone (8.5 – 8.6)

- Sign zone (on **tld1**)

```
./resign_tld
```

- 
- Re-analyze

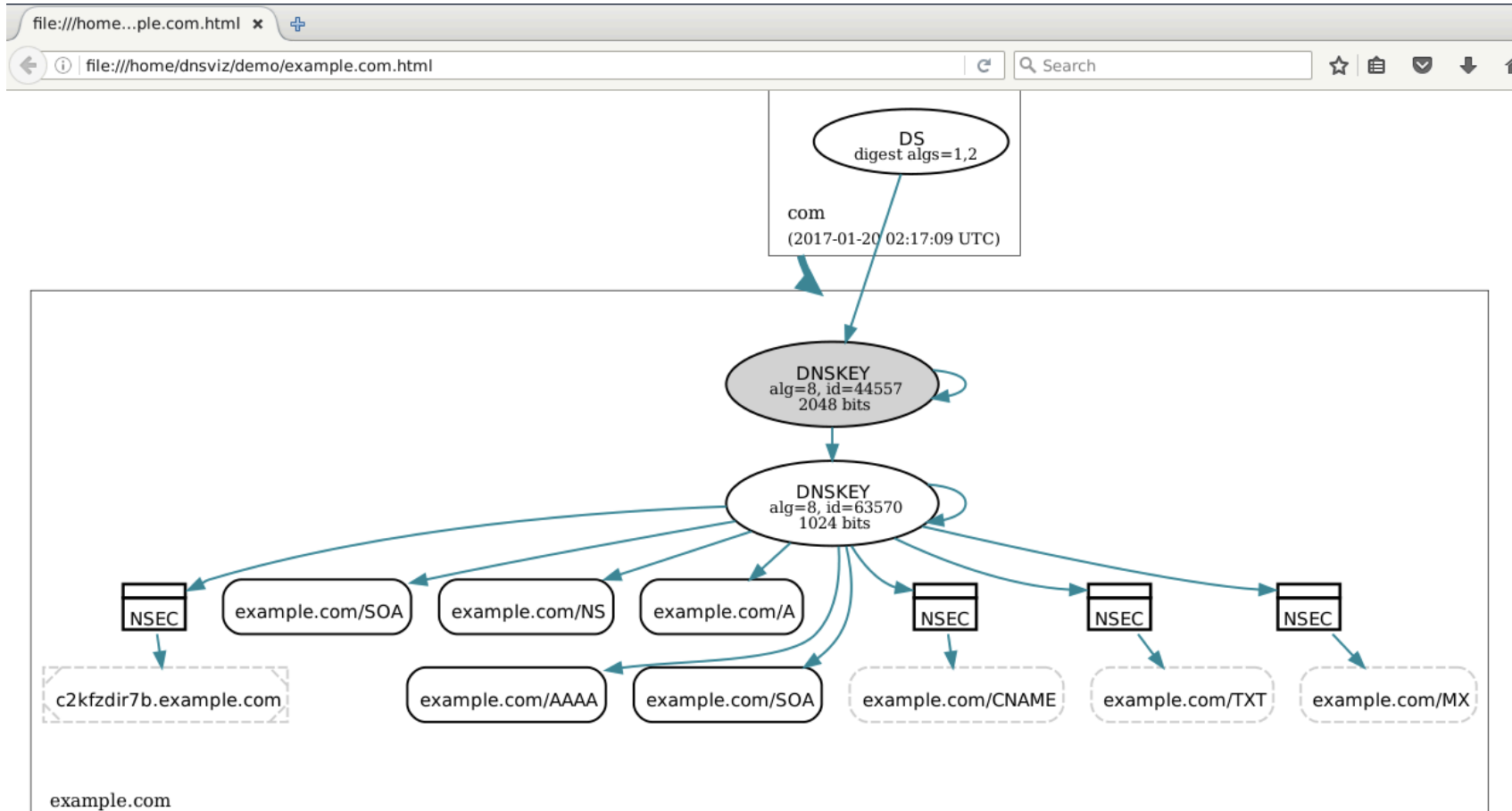
```
$./dnsviz_analyze example.com
```

```
$ firefox example.com.html &
```

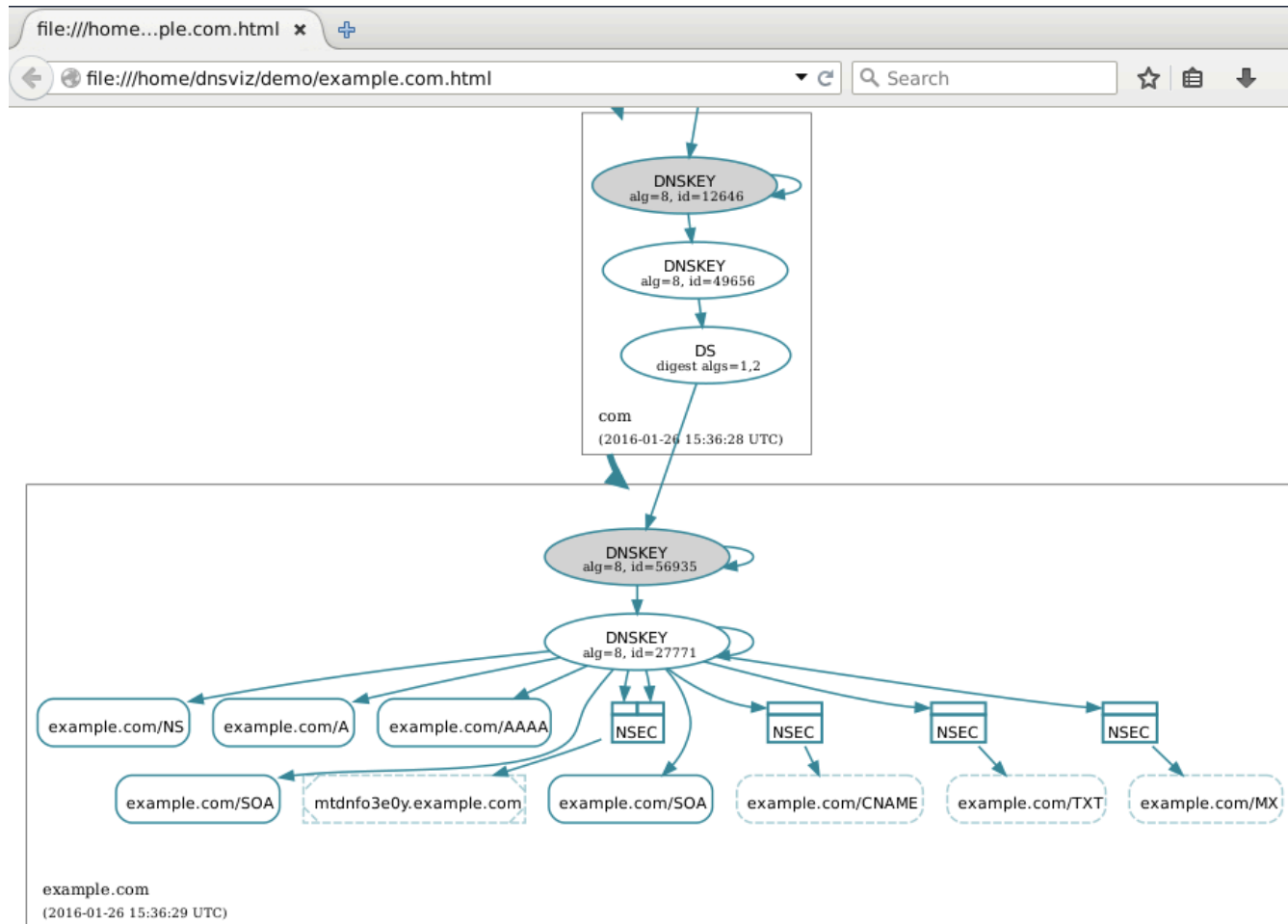
```
$ dig +noall +comment +ad example.com
```

# Preview dnsviz graph

## Output: Full Chain of Trust



# View dnsviz graph Output: Full Chain of Trust



# View dig Output: AD bit

```
Terminal - dnsviz@dnsviz-demo: ~/demo
File Edit View Terminal Tabs Help
dnsviz@dnsviz-demo:~/demo$ dig +noall +comment +ad example.com
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 50710
;; flags: qr rd ra ad; QUERY: 1, ANSWER: 1, AUTHORITY: 1, ADDITIONAL: 1
;; OPT PSEUDOSECTION:
; EDNS: version: 0, flags;; udp: 4096
dnsviz@dnsviz-demo:~/demo$
```



# Fun with DNSViz

# Use KSK to Only Sign DNSKEY RRset (9.1 – 9.3)

Don't sign zone  
data with KSK



```
dnssec-signzone -x -r /dev/urandom \
-k $KSK -o example.com zones/db.example.com $ZSK
```

```
service bind9 reload
```

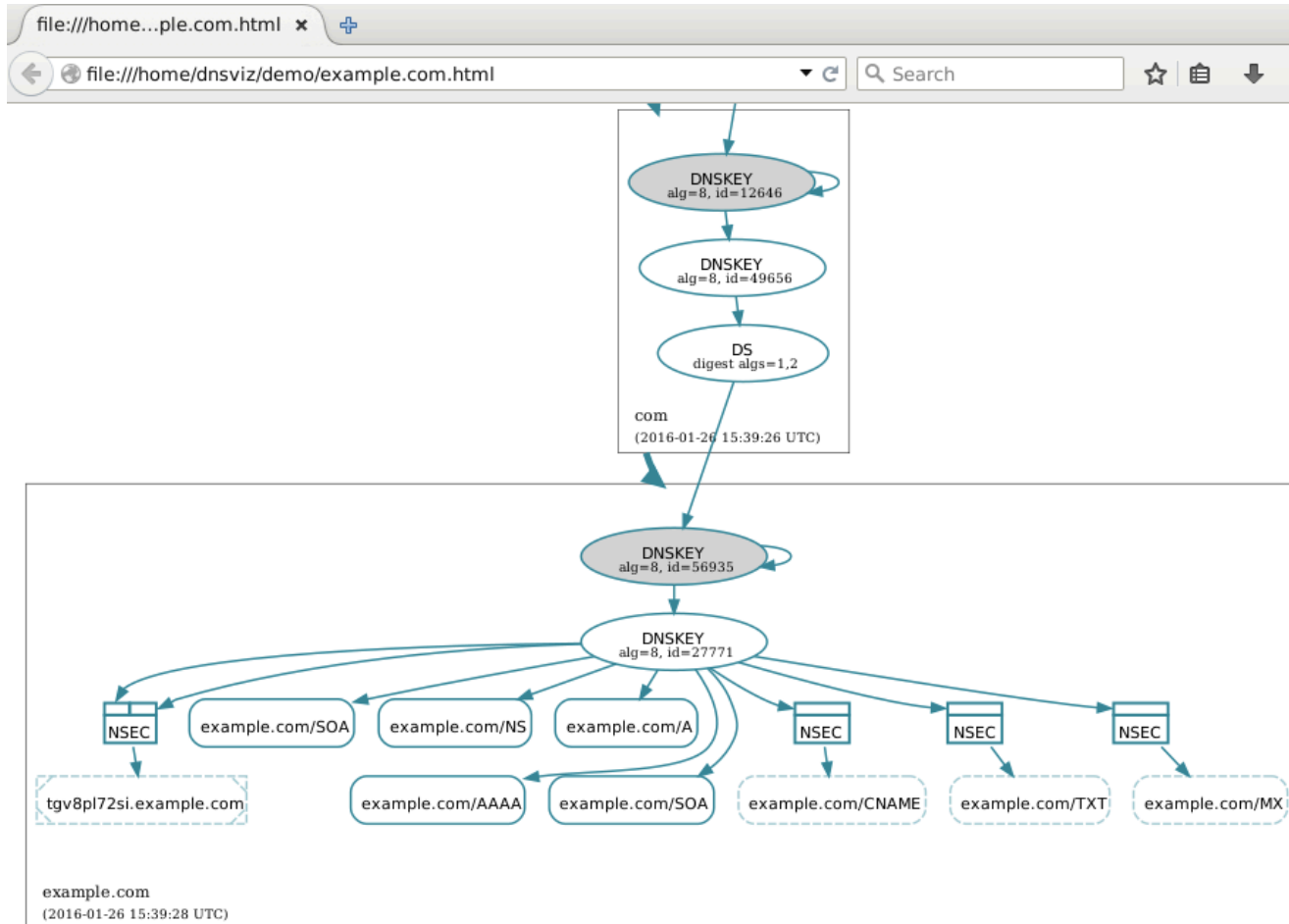
---

```
$./dnsviz_analyze example.com
```

```
$ firefox example.com.html &
```

```
$ dig +noall +comment +ad example.com
```

# View dnsviz graph Output: KSK-only



# View dig Output: AD bit

```
Terminal - dnsviz@dnsviz-demo: ~/demo
File Edit View Terminal Tabs Help
dnsviz@dnsviz-demo:~/demo$ dig +noall +comment +ad example.com
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 26165
;; flags: qr rd ra ad; QUERY: 1, ANSWER: 1, AUTHORITY: 1, ADDITIONAL: 1
;; OPT PSEUDOSECTION:
; EDNS: version: 0, flags:; udp: 4096
dnsviz@dnsviz-demo:~/demo$
```

# Add New KSK to example.com Zone (9.4 – 9.8)

- Generate new KSK:

```
NEWKSK=`dnssec-keygen -n ZONE -f KSK -a RSASHA256 -b 2048 \
-r /dev/urandom example.com`
```

```
cat $NEWKSK.key >> zones/db.example.com
```

```
dnssec-signzone -x -r /dev/urandom \
-k $KSK -o example.com zones/db.example.com $ZSK
```

- Reload zone

```
service bind9 reload
```

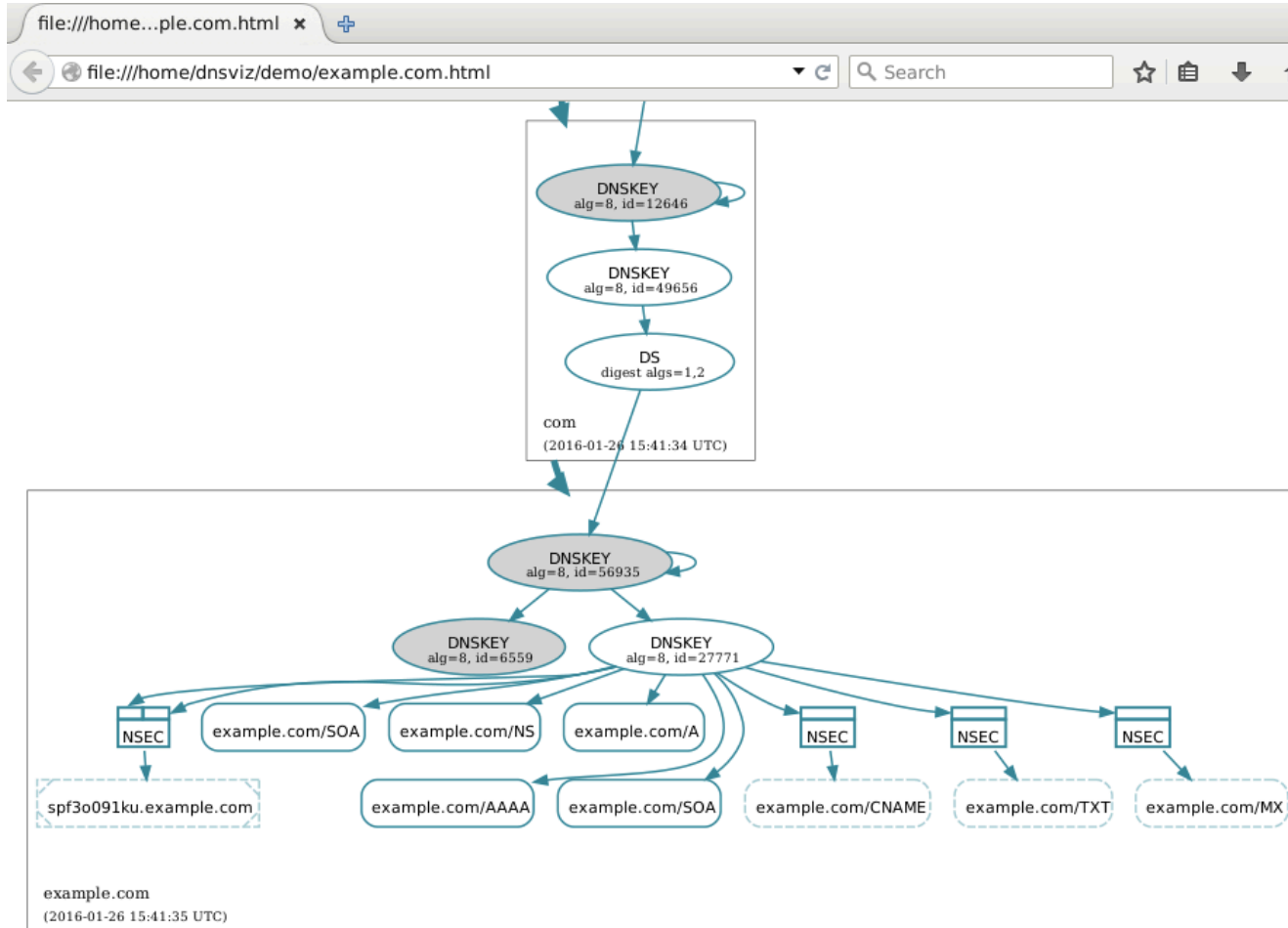
---

```
$./dnsviz_analyze example.com
```

```
$ firefox example.com.html &
```

```
$ dig +noall +comment +ad example.com
```

# View dnsviz graph Output: Standby KSK



# View dig Output: AD bit

```
Terminal - dnsviz@dnsviz-demo: ~/demo
File Edit View Terminal Tabs Help
dnsviz@dnsviz-demo:~/demo$ dig +noall +comment +ad example.com
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 26165
;; flags: qr rd ra ad; QUERY: 1, ANSWER: 1, AUTHORITY: 1, ADDITIONAL: 1

;; OPT PSEUDOSECTION:
; EDNS: version: 0, flags:; udp: 4096
dnsviz@dnsviz-demo:~/demo$
```

# Add New KSK to example.com Zone (9.9 – 9.11)

- Re-sign zone with two KSKs:

```
dnssec-signzone -x -r /dev/urandom \
-k $KSK -k $NEWKSK -o example.com zones/db.example.com $ZSK
```

- Reload zone

```
service bind9 reload
```

---

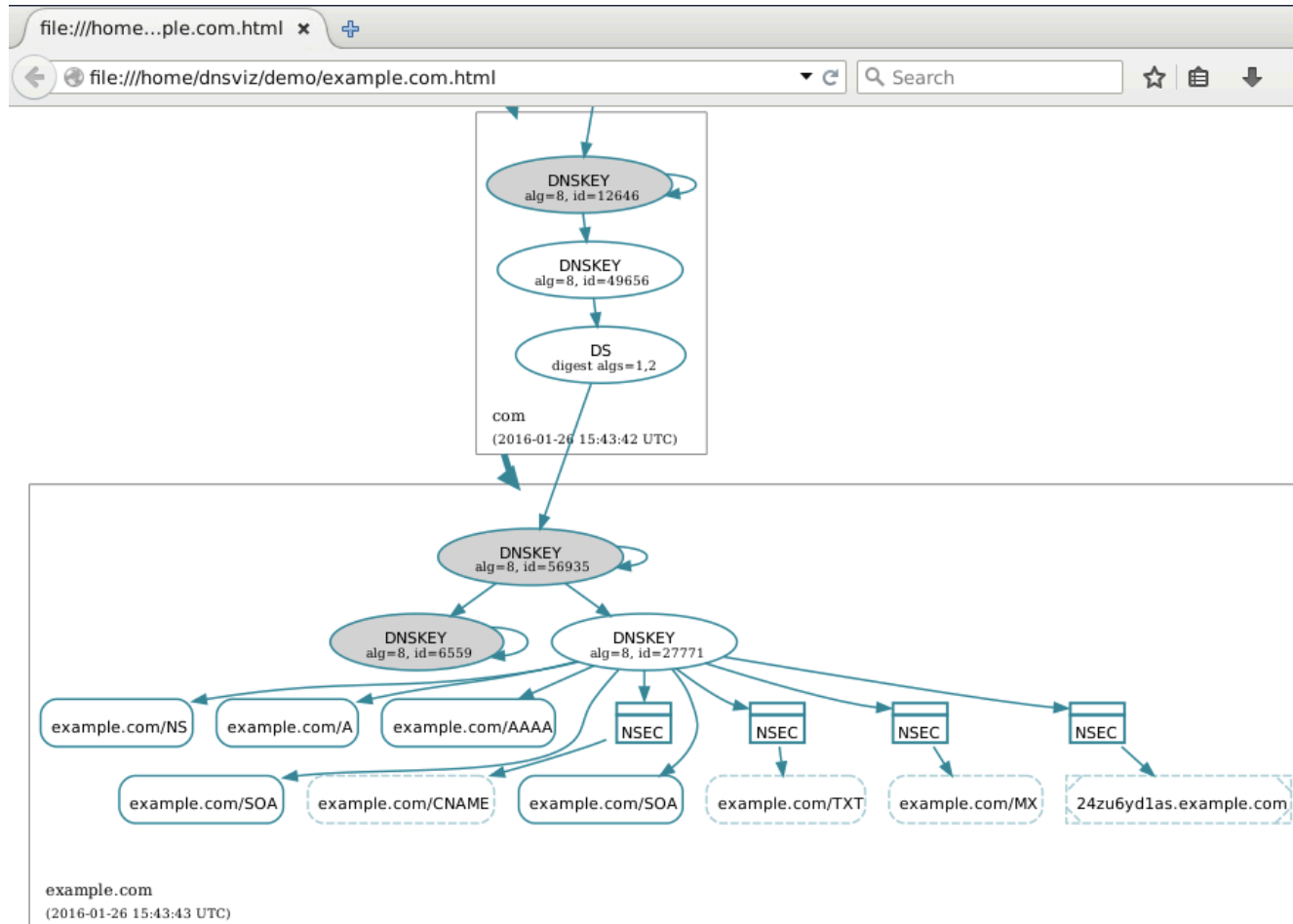
```
$./dnsviz_analyze example.com
```

```
$ firefox example.com.html &
```

```
$ dig +noall +comment +ad example.com
```



# View dnsviz graph Output: Multiple KSKs



# View dig Output: AD bit

```
Terminal - dnsviz@dnsviz-demo: ~/demo
File Edit View Terminal Tabs Help
dnsviz@dnsviz-demo:~/demo$ dig +noall +comment +ad example.com
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 26165
;; flags: qr rd ra ad; QUERY: 1, ANSWER: 1, AUTHORITY: 1, ADDITIONAL: 1
;; OPT PSEUDOSECTION:
; EDNS: version: 0, flags:; udp: 4096
dnsviz@dnsviz-demo:~/demo$
```

# Change KSK for example.com Zone (9.12 – 9.13)

- Sign with only the second KSK:

```
dnssec-signzone -x -r /dev/urandom \
-k $NEWKSK -o example.com zones/db.example.com $ZSK
```

---

```
$ dnsviz probe -A -a . -x example.com:zones/db.example.com.signed -p \
example.com | dnsviz graph -Thtml -O
```

```
$ firefox example.com.html &
```

# Change KSK for example.com Zone (9.14 – 9.15)

- Reload zone

```
service bind9 reload
```

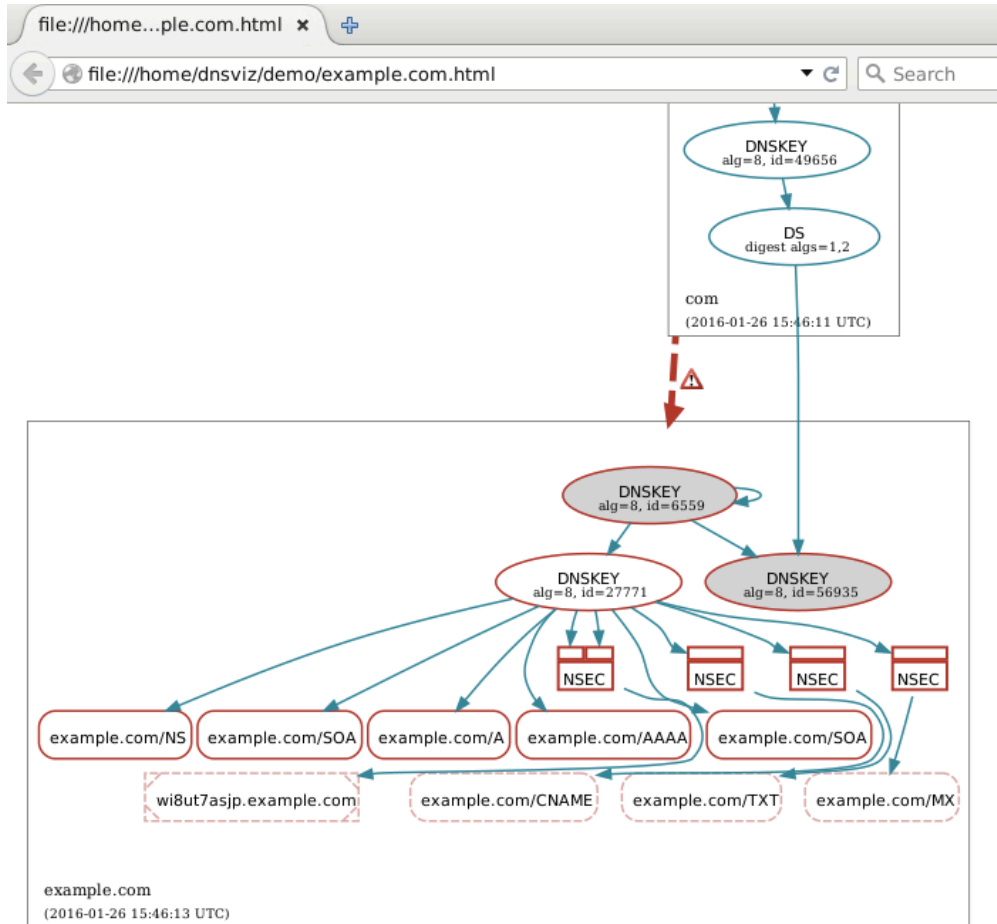
---

```
$./dnsviz_analyze example.com
```

```
$ firefox example.com.html &
```

```
$ dig +noall +comment +ad example.com
```

# View dnsviz graph Output: DS Mismatch



# View dig Output: SERVFAIL

```
Terminal - dnsviz@dnsviz-demo: ~/demo
File Edit View Terminal Tabs Help
dnsviz@dnsviz-demo:~/demo$ dig +noall +comment +ad example.com
;; Got answer:
;; ->HEADER<<- opcode: QUERY, status: SERVFAIL, id: 52392
;; flags: qr rd ra; QUERY: 1, ANSWER: 0, AUTHORITY: 0, ADDITIONAL: 1

;; OPT PSEUDOSECTION:
; EDNS: version: 0, flags;; udp: 4096
dnsviz@dnsviz-demo:~/demo$
```

# Tamper with Record Content (9.16 – 9.18)

- Change SOA record:

```
sed -i -e 's/root.localhost/root1.localhost/' \
zones/db.example.com.signed
```

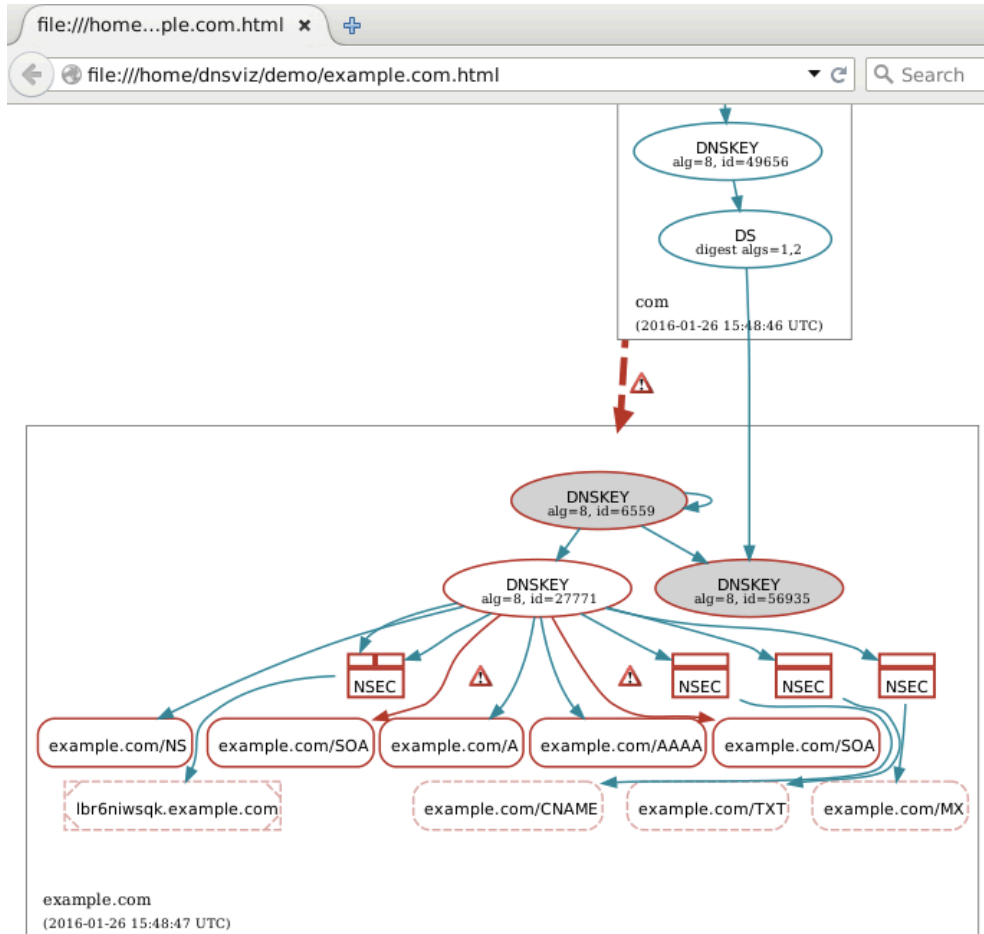
```
service bind9 reload
```

---

```
$./dnsviz_analyze example.com
```

```
$ firefox example.com.html &
```

# View dnsviz graph Output: Invalid Signatures





# Change RRSIG Expiration (9.19 – 9.22)

- Set the RRSIG expiration explicitly to 1 second from “now”

```
dnssec-signzone -x -e now+1 -r /dev/urandom \
-k $NEWKSK -o example.com zones/db.example.com $ZSK
```

- Manipulate (again) SOA record

```
sed -i -e 's/root.localhost/root1.localhost/' \
zones/db.example.com.signed
```

- Reload zone

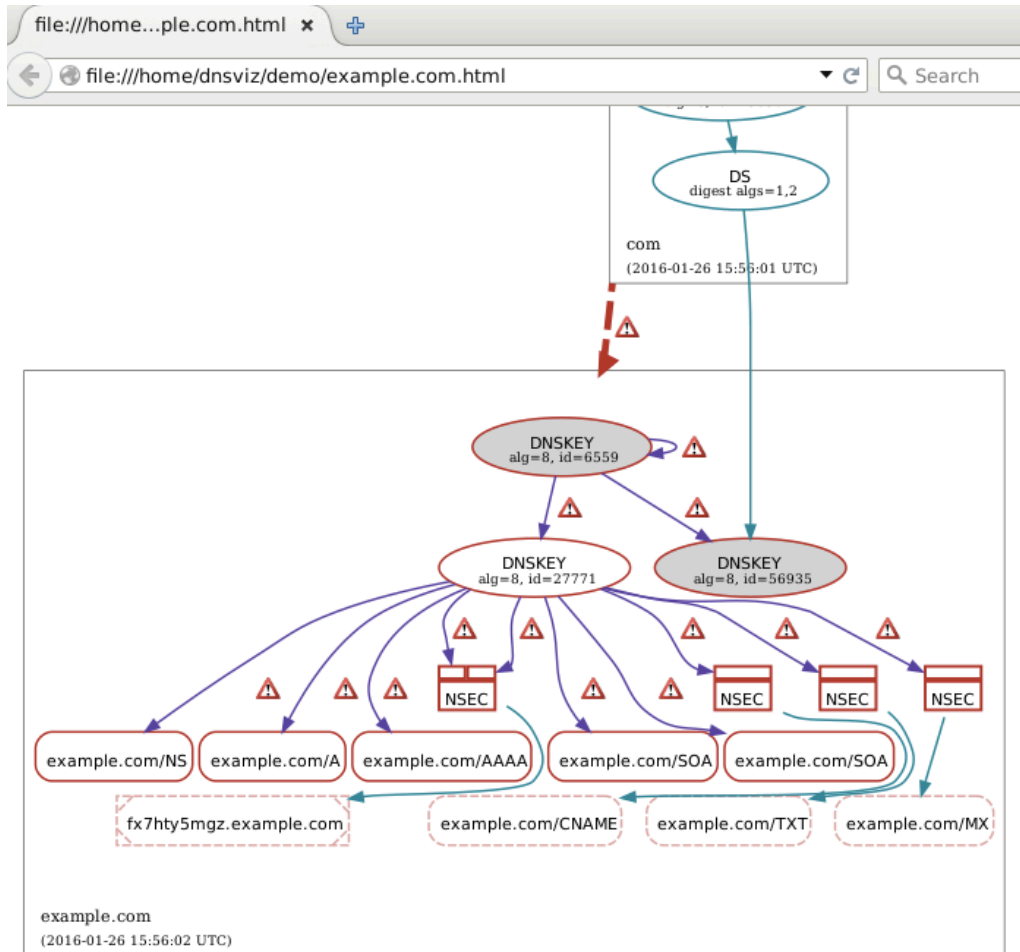
```
service bind9 reload
```

---

```
$./dnsviz_analyze example.com
```

```
$ firefox example.com.html &
```

# View dnsviz graph Output: Expired RRSIGs



# Remove RRSIGs (9.23 – 9.26)

- Remove RRSIG covering AAAA record (on **sld1**)

```
nano zones/db.example.com.signed
```

or

```
vi zones/db.example.com.signed
```

- Check zone

```
named-checkzone example.com zones/db.example.com.signed
```

- Reload zone

```
service bind9 reload
```

---

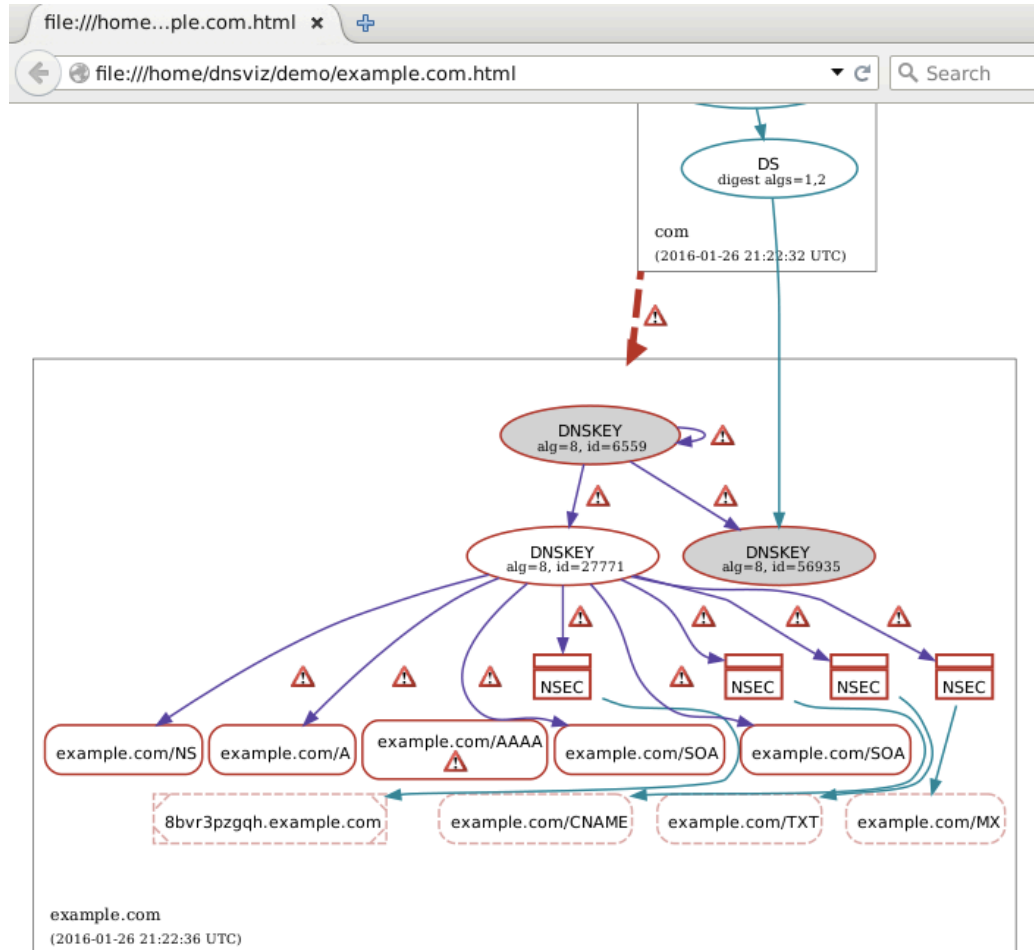
```
$./dnsviz_analyze example.com
```

```
$ firefox example.com.html &
```

# Remove RRSIG for AAAA Record from Zone

```
Virtual Console #1 (sld1)
File Edit View Terminal Tabs Help
GNU nano 2.2.6 File: db.example.com.signed Modified
UJ6S30+5I0ZeiP2QF+C3oMRae04s8ktGfXlN
5sqJHK7PNRT2hkzKfKB9nmCKCq0=)
60 AAAA fd02:f00d::3
60 NSEC a.example.com. A NS SOA AAAA RRSIG NSEC$
60 RRSIG NSEC 8 2 60 (
20160126200644 20160126190643 27771 exa$
TKWcAPykouqhKHHu9zro2SHXeRbz5Ybb7UQT
7ZHk+FiqnR6nZhox0ZyKyAeUeoJFVuqTG7+9
Hu+Id571QQ2e5uu3R+0BIsSlGy2s2rLdb2X2
K+YMPY5wqy2ED/r7t8j0aFhJ1i/gWuVCNsU4
sBl317iYnw2pBeaYAkLUIInIZzww=)
60 DNSKEY 256 3 8 (
AwEAAbH3j5TsiuNrHcGbg80PunX3K9VHcFkz
8Sj5GFLjHbNpiY5XkVS1G/jUV0EDf8detb/d
Bv8g0tLS9tbwGe6fFwT7TwTWP3sZyRMrASq
Pqci0Xk9QmxsEEz9Zv24ZGBRhp02bQ3vlbAB
Y2eV9XxgHQbemMWVu8811FoWv5F1ENU1
) ; ZSK; alg = RSASHA256; key id = 27771
60 DNSKEY 257 3 8 (
Save modified buffer (ANSWERING "No" WILL DESTROY CHANGES) ?
Y Yes
N No ^C Cancel
```

# View dnsviz graph Output: Missing RRSIGs



# Modify TCP Connectivity (9.27 – 9.28)

- Reject TCP connection requests

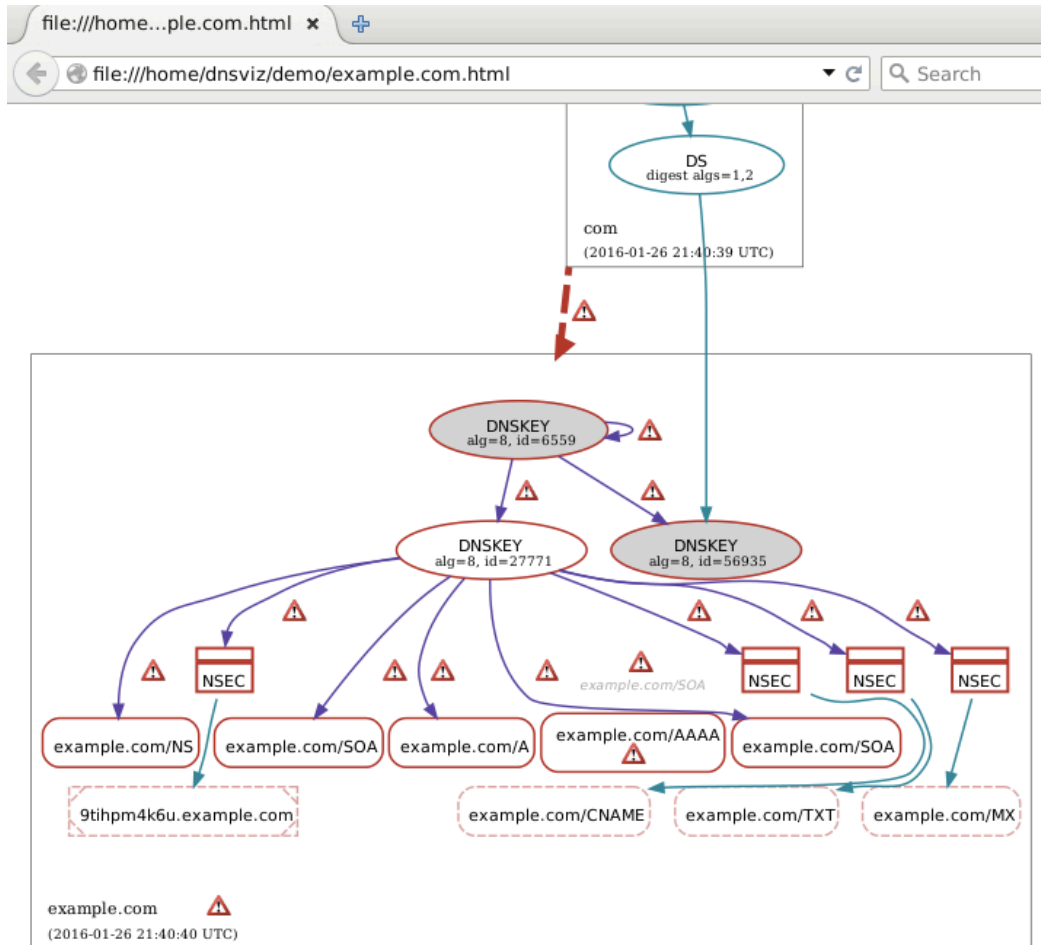
```
iptables -A INPUT -m state --state NEW -p tcp \
--dport 53 -j REJECT
```

---

```
$./dnsviz_analyze example.com
```

```
$ firefox example.com.html &
```

# View dnsviz graph Output: No TCP



# Modify Path MTU (9.29 – 9.30)

- Drop UDP responses with payloads larger than 512 bytes

```
iptables -A OUTPUT -p udp --sport 53 \
-m length --length 540:65535 -j DROP
```

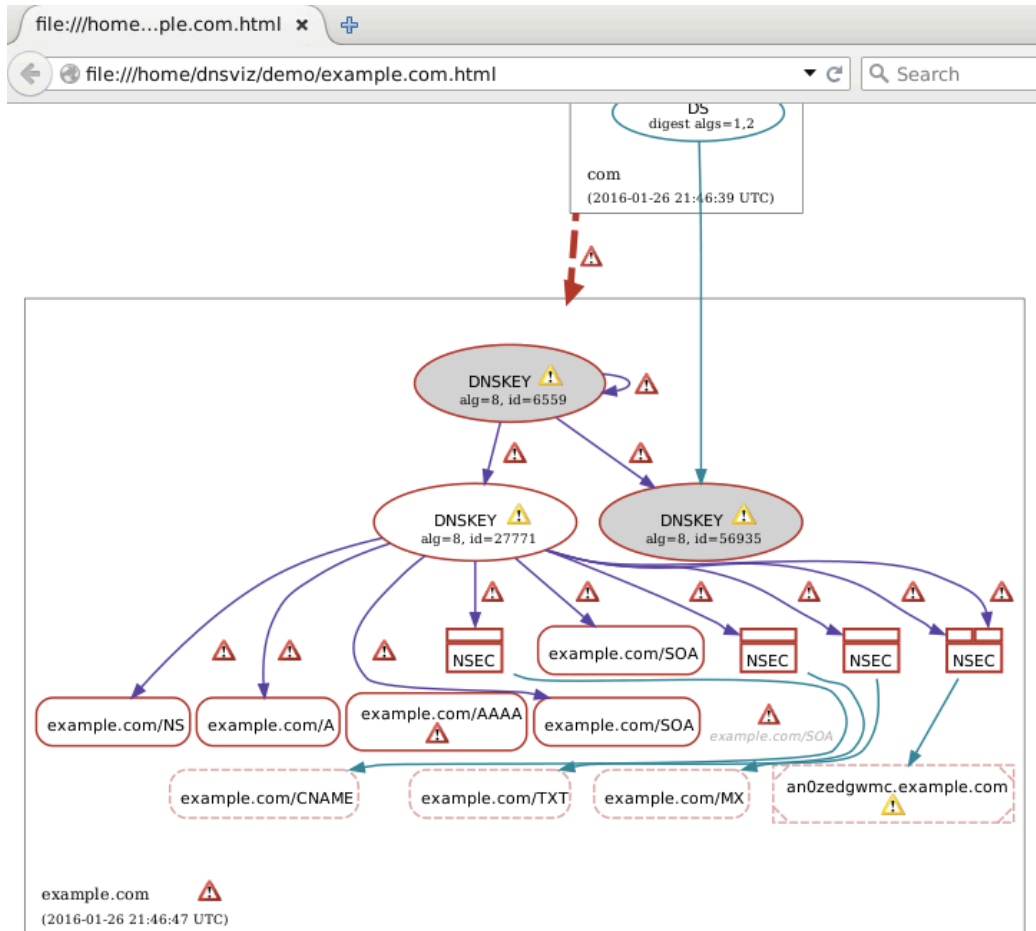
---

```
$./dnsviz_analyze example.com
```

```
$ firefox example.com.html &
```



# View dnsviz graph Output: Low PMTU



# Add Lame Delegation (9.31 – 9.33)

- Add second delegation NS record for example.com in com zone (on **tld1**)

```
nano zones/db.com
```

or

```
vi zones/db.com
```

- Sign com zone (on **tld1**)

```
./resign_tld
```

---

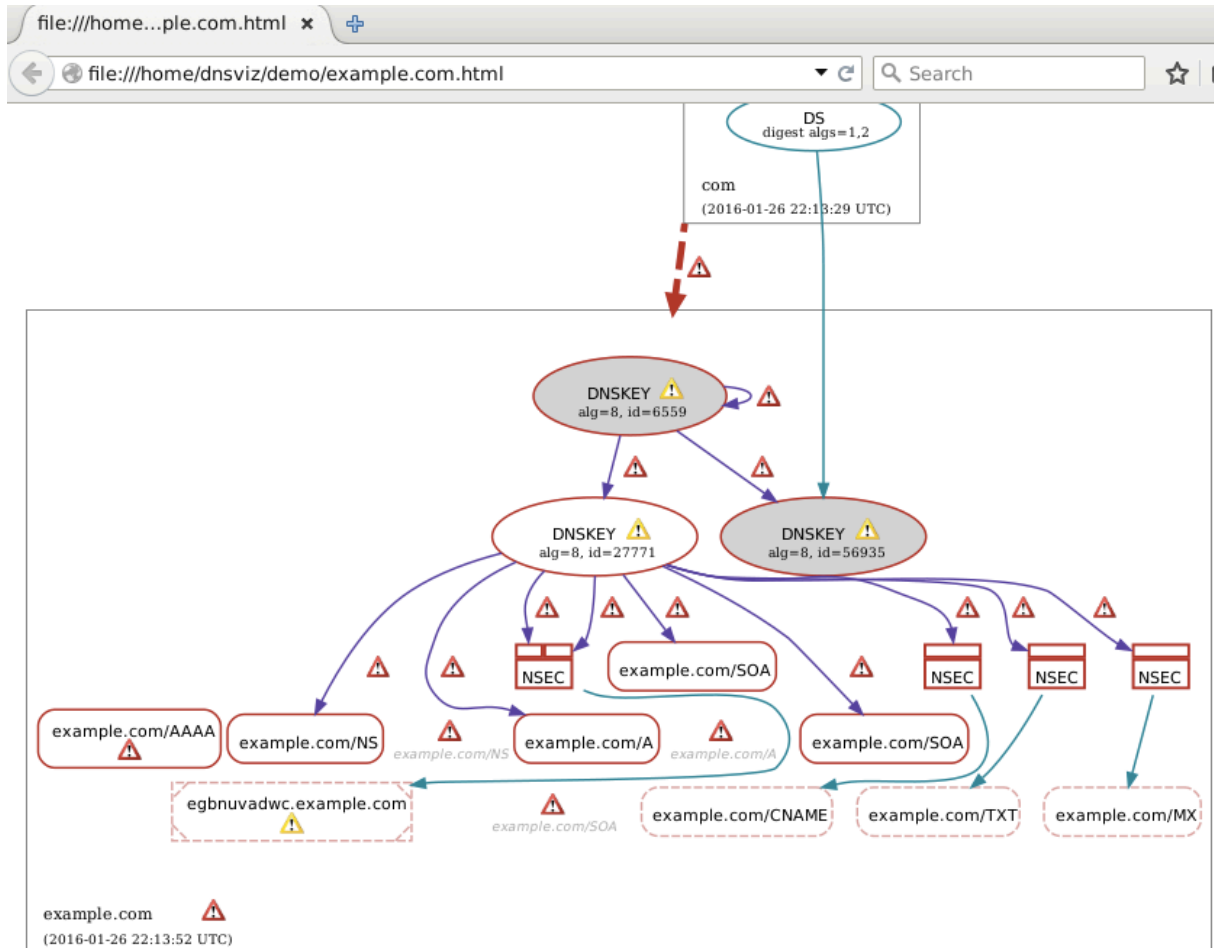
```
$./dnsviz_analyze example.com
```

```
$ firefox example.com.html &
```

# Add Second NS Record for example.com

```
Virtual Console #1 (tld1)
File Edit View Terminal Tabs Help
GNU nano 2.2.6 File: db.com Modified
; IN NS b.local-tld-servers.net.
example IN NS a.local-sld-servers.net.
foo IN NS a.local-sld-servers.net.
bar IN NS a.local-sld-servers.net.
;; Uncomment to enable secondary
example IN NS b.local-sld-servers.net.
;foo IN NS b.local-sld-servers.net.
;bar IN NS b.local-sld-servers.net.
; This is a key-signing key, keyid 12646, for com.
; Created: 20150428203212 (Tue Apr 28 16:32:12 2015)
; Publish: 20150428203212 (Tue Apr 28 16:32:12 2015)
; Activate: 20150428203212 (Tue Apr 28 16:32:12 2015)
com. IN DNSKEY 257 3 8 AwEAAZ7Gi0GFu0jNKWzKDtGluIemgsFm/bbjKCQDKPCh9cOMjSsxzGmuS
; This is a zone-signing key, keyid 49656, for com.
; Created: 20150428203229 (Tue Apr 28 16:32:29 2015)
; Publish: 20150428203229 (Tue Apr 28 16:32:29 2015)
; Activate: 20150428203229 (Tue Apr 28 16:32:29 2015)
com. IN DNSKEY 256 3 8 AwEAAAdTXkCiLQDDNu2Du2VCBqYLQ9AnqFgpXey18M03sj6UG6oaHT/Yhs
Save modified buffer (ANSWERING "No" WILL DESTROY CHANGES) ?
Y Yes
N No ^C Cancel
```

# View dnsviz graph Output: Lame Delegation



# Graph Only Select RRsets (9.34)

Only graph A and  
AAAA RRsets

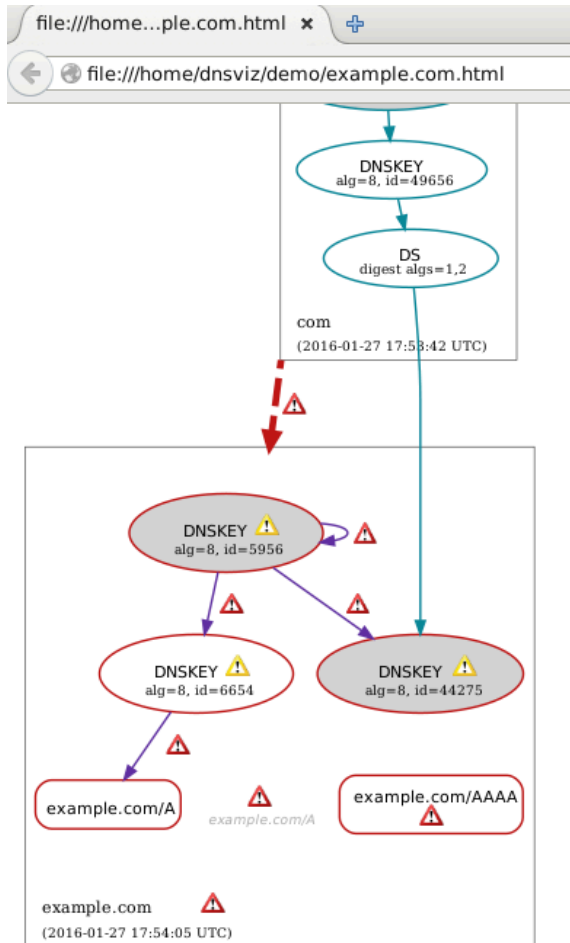


```
$ dnsviz graph -R A,AAAA -Thtml -O < example.com-working.json
```

---

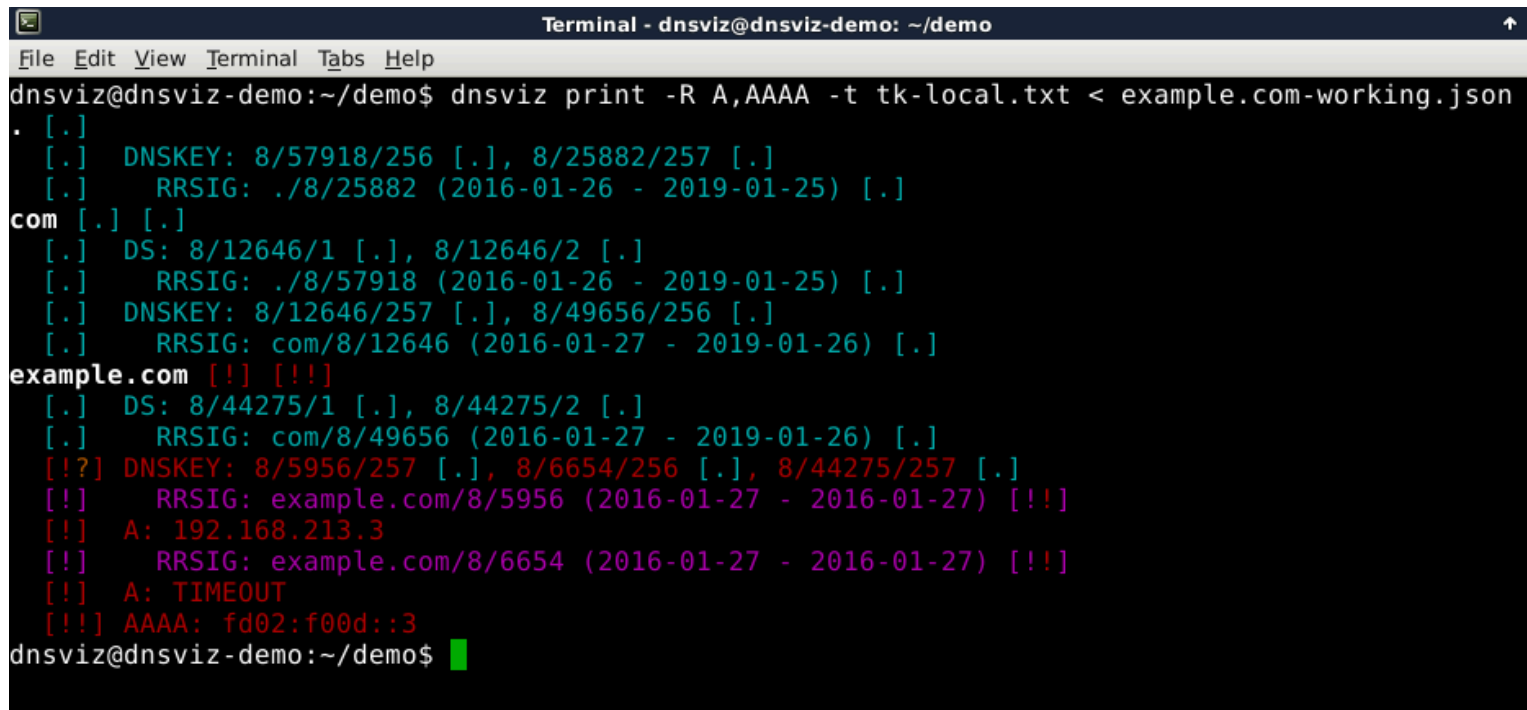
```
$ firefox example.com.html &
```

# View dnsviz graph Output: Select RRsets



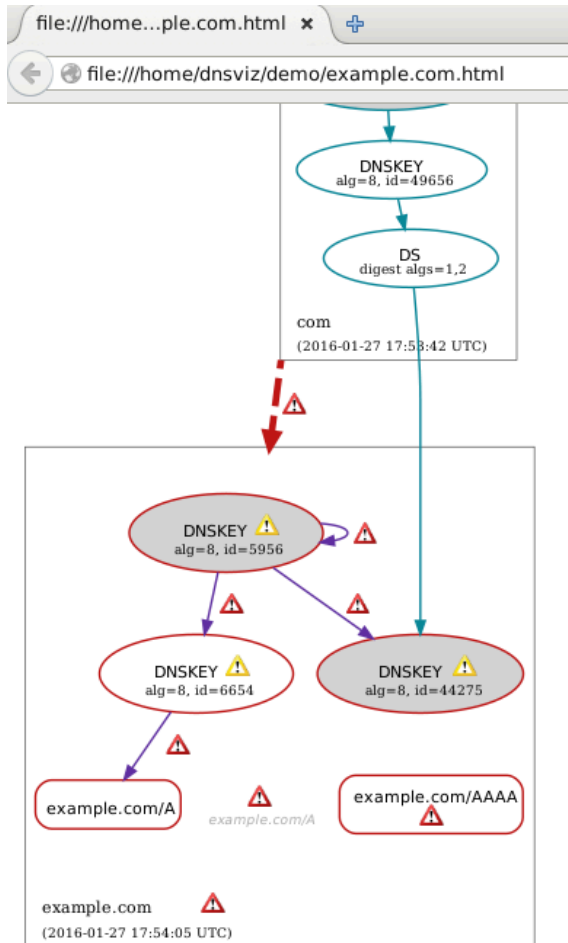
# Analyze with `dnsviz print` (9.35)

```
$ dnsviz print -R A,AAAA < example.com-working.json
```



```
Terminal - dnsviz@dnsviz-demo: ~/demo
File Edit View Terminal Tabs Help
dnsviz@dnsviz-demo:~/demo$ dnsviz print -R A,AAAA -t tk-local.txt < example.com-working.json
. [.]
[.] DNSKEY: 8/57918/256 [.] , 8/25882/257 [.]
[.] RRSIG: ./8/25882 (2016-01-26 - 2019-01-25) [.]
com [.] [.]
[.] DS: 8/12646/1 [.] , 8/12646/2 [.]
[.] RRSIG: ./8/57918 (2016-01-26 - 2019-01-25) [.]
[.] DNSKEY: 8/12646/257 [.] , 8/49656/256 [.]
[.] RRSIG: com/8/12646 (2016-01-27 - 2019-01-26) [.]
example.com [!] [!!!]
[.] DS: 8/44275/1 [.] , 8/44275/2 [.]
[.] RRSIG: com/8/49656 (2016-01-27 - 2019-01-26) [.]
[!?] DNSKEY: 8/5956/257 [.] , 8/6654/256 [.] , 8/44275/257 [.]
[!] RRSIG: example.com/8/5956 (2016-01-27 - 2016-01-27) [!!!]
[!] A: 192.168.213.3
[!] RRSIG: example.com/8/6654 (2016-01-27 - 2016-01-27) [!!!]
[!] A: TIMEOUT
[!!!] AAAA: fd02:f00d::3
dnsviz@dnsviz-demo:~/demo$
```

# View dnsviz graph Output: Select RRsets





# DNSViz Recursive Server Analysis

# Analyze example.com on Recursive Server (10.1)

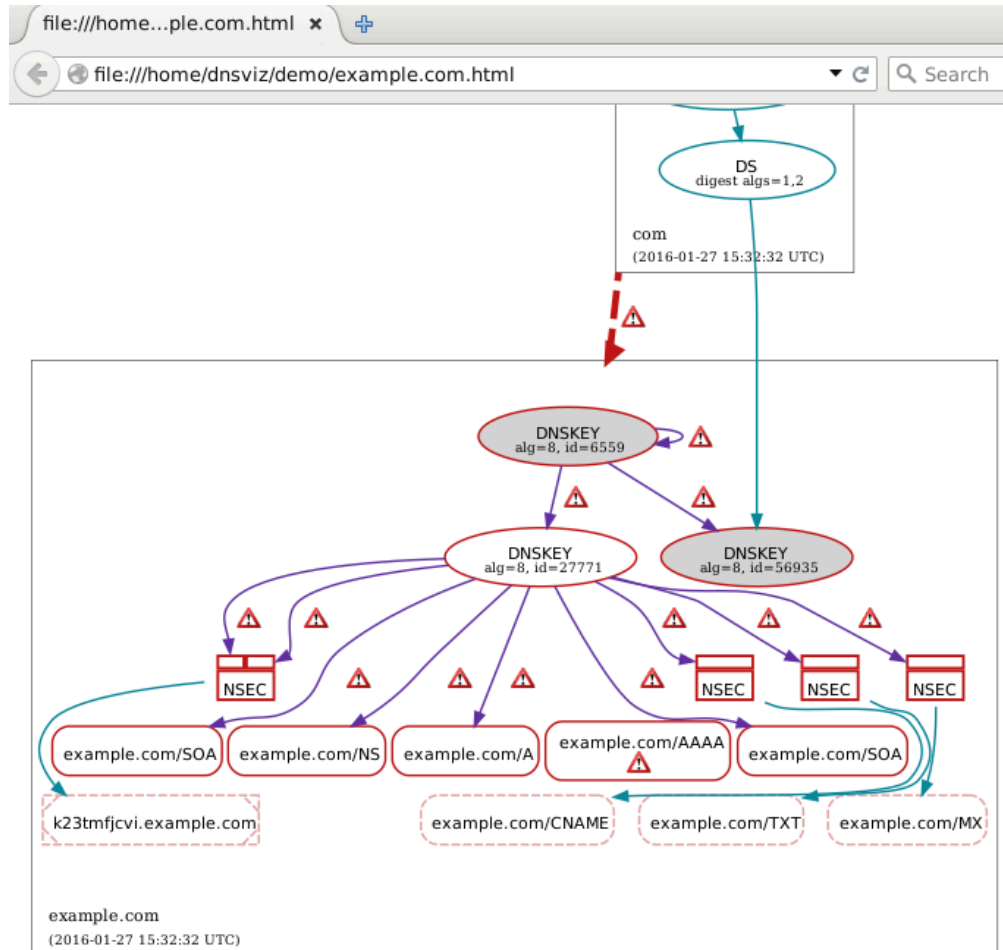
No "-A" option  
means query  
recursive servers



```
$ dnsviz probe example.com | dnsviz graph -Thtml -O
```

```
$ firefox example.com.html &
```

# View dnsviz graph Output: Recursive



# DNSViz Programmatic Analysis

# dnsviz probe Revisited (11.1)

```
$ medit example.com-working.json &
```

or

```
$ vi example.com-working.json
```

# View dnsviz probe Output: Diagnostic Query History

```
example.com-working.json
{
 "qname": "example.com.",
 "qclass": "IN",
 "qtype": "DNSKEY",
 "options": {
 "flags": 0,
 "edns_version": 0,
 "edns_max_udp_payload": 4096,
 "edns_flags": 32768,
 "edns_options": [],
 "tcp": false
 },
 "responses": {
 "192.168.213.26": {
 "192.168.213.1": {
 "message": "Xh6EAAAABAAQAAAABB2V4YW1wbGUDY29tAAAwAAHADAAwAAEAAAAA8A",
 "msg_size": 1039,
 "time_elapsed": 1,
 "history": [
 {
 "time_elapsed": 1000,
 "cause": "TIMEOUT",
 "action": "NO_CHANGE"
 },
 {
 "time_elapsed": 1000,
 "cause": "TIMEOUT",
 "action": "NO_CHANGE"
 },
 {
 "time_elapsed": 2000
 }
]
 }
 }
 }
}
```

# View dnsviz probe Output: Diagnostic Query History

```
example.com-working.json
message : XH0LCAAAADAAQAAAAADZV4T1W1W000T29CAAAWAAAHADAAWAAALAAAAAQAQGBAQHIAWLEAAAC
"msg_size": 1039,
"time_elapsed": 1,
"history": [
 {
 "time_elapsed": 1000,
 "cause": "TIMEOUT",
 "action": "NO_CHANGE"
 },
 {
 "time_elapsed": 1000,
 "cause": "TIMEOUT",
 "action": "NO_CHANGE"
 },
 {
 "time_elapsed": 2000,
 "cause": "TIMEOUT",
 "action": "NO_CHANGE"
 },
 {
 "time_elapsed": 4003,
 "cause": "TIMEOUT",
 "action": "CHANGE_UDP_MAX_PAYLOAD",
 "action_arg": 512
 },
 {
 "time_elapsed": 0,
 "cause": "TC",
 "cause_arg": 40,
 "action": "USE_TCP"
 },
 {

```

# dnsviz grok Revisited (10.3 – 10.4)

```
$ dnsviz grok -l warning -p < example.com-broken.json \
> example.com-working-p.json
```

```
$ medit example.com-working-p.json &
```

or

```
$ vi example.com-working-p.json
```



# View dnsviz grok Output: Errors, Warnings, Statuses

```
example.com-working-p.json
{
 "example.com./IN/A": {
 "answer": [
 {
 "id": "example.com./IN/A",
 "rrsig": [
 {
 "id": "example.com./8/6654",
 "status": "EXPIRED",
 "errors": [
 {
 "description": "The Signature Expiration field of the RRSIG RR (201",
 "code": "EXPIRATION_IN_PAST"
 }
]
 }
]
 }
]
 },
 "error": [
 {
 "description": "No response was received from the server over UDP (tried 8 times).",
 "code": "TIMEOUT",
 "servers": [
 "192.168.213.27",
 "fd02:f00d:18::27"
],
 "query_options": [
 "UDP_0_NOEDNS"
]
 }
]
}
```

# View dnsviz grok Output: Errors, Warnings, Statuses

```
example.com-working-p.json
{
 "example.com./IN/SOA": {
 "answer": [
 {
 "id": "example.com./IN/SOA",
 "rrsig": [
 {
 "id": "example.com./8/6654",
 "status": "EXPIRED",
 "errors": [
 {
 "description": "The Signature Expiration field of the RRSIG RR (2016-01-01 00:00:00) has expired.",
 "code": "EXPIRATION_IN_PAST"
 },
 {
 "description": "The cryptographic signature of the RRSIG RR does not match the data it covers.",
 "code": "SIGNATURE_INVALID"
 }
]
 }
]
 }
],
 "error": [
 {
 "description": "The TCP connection was refused (ECONNREFUSED).",
 "code": "NETWORK_ERROR",
 "servers": [
 "fd02:f00d:18::26"
],
 "query_options": [
 "TCP 0 EDNS0 32768 4096"
]
 }
]
 }
}
```

# View dnsviz grok Output: Errors, Warnings, Statuses

```
example.com-working-p.json
},
"delegation": {
 "status": "BOGUS",
 "errors": [
 {
 "description": "No valid RRSIGs made by a key corresponding to a DS RR were found covering the zone",
 "code": "NO_SEP",
 "servers": [
 "192.168.213.26",
 "fd02:f00d:18::26"
],
 "query_options": [
 "TCP_0_EDNS0_32768_1038",
 "UDP_0_EDNS0_32768_4096"
]
 },
 {
 "description": "The DS RRset for the zone included algorithm 8 (RSASHA256), but no DS RRset was found covering the zone",
 "code": "MISSING_SEP_FOR_ALG",
 "servers": [
 "192.168.213.26",
 "fd02:f00d:18::26"
],
 "query_options": [
 "TCP_0_EDNS0_32768_1038",
 "UDP_0_EDNS0_32768_4096"
]
 }
]
}
}
```

# Monitoring with DNSViz

- Sample script uses combination of dnsviz get and dnsviz graph, e.g., for use with cron

```
#!/bin/sh
name=$1
date=`date +%Y%m%d%H%M%S`
probe_out=/tmp/$name-probe-$date.json
grok_out=/tmp/$name-grok-$date.json
graph_out=/tmp/$name-graph-$date.png

dnsviz probe -A -d 0 -p $name > $probe_out
dnsviz grok -l warning -p $name < $probe_out > $grok_out
if (($(stat -c %s $grok_out) > 0)); then
 dnsviz graph -Tpng -o $graph_out $name $name < $probe_out
 gzip $probe_out
 cat $grok_out | \
 mutt -s "Problems with $name" -a $graph_out $grok_out.gz -- \
 joe@example.com
fi

rm $probe_out* $grok_out $graph_out
```

# Summary

- Understanding and analyzing DNS and DNSSEC can be complex.
- DiG, BIND, DNSViz, and other tools can aid in understanding, troubleshooting, and monitoring.
- Maintain and monitor your DNS zones!

# Further Information on DNSViz

- Source: <https://github.com/dnsviz/dnsviz> (License: GPLv2)
- Online version: <http://dnsviz.net/>
- Mailing list:  
<https://groups.google.com/d/forum/dnsviz-users>