DNSSEC

Domain Name System Security Extensions

NANOG 67
14 June 2016

DNSSEC Introduction

How much trust do we put in the Internet?

13.5% of all purchases were done over the internet in 2010, according to BCG, and this is projected to rise to 23% by 2016.

[**UK** - http://www.bbc.com/news/business-17405016]

How much of that trust relies on DNS?

If DNS were to become unreliable or untrustworthy, what would the result be?

DNSSEC Introduction

In the simplest terms:

DNSSEC provides digital signatures that allow validating clients to prove that DNS data was not modified in transit

DNSSEC Introduction

Sources of DNS data generate signatures for data that they are authoritative for

Recursive servers check the signatures for correctness and signal to their clients the results of those checks

- If data is provably good, the AD (Authenticated Data) bit may be set in response headers

- If queried data is unable to be validated, yet is signaled to be signed, SERVFAIL responses are generated

Background Knowledge

Before delving into DNSSEC

- **DNS resolution mechanics**
  - **The Delegation Chain**
- Some Cryptography Fundamentals
  - Digital Signatures

DNS Resolution

Resolution is the process of obtaining ***answers*** from the DNS database in response to queries

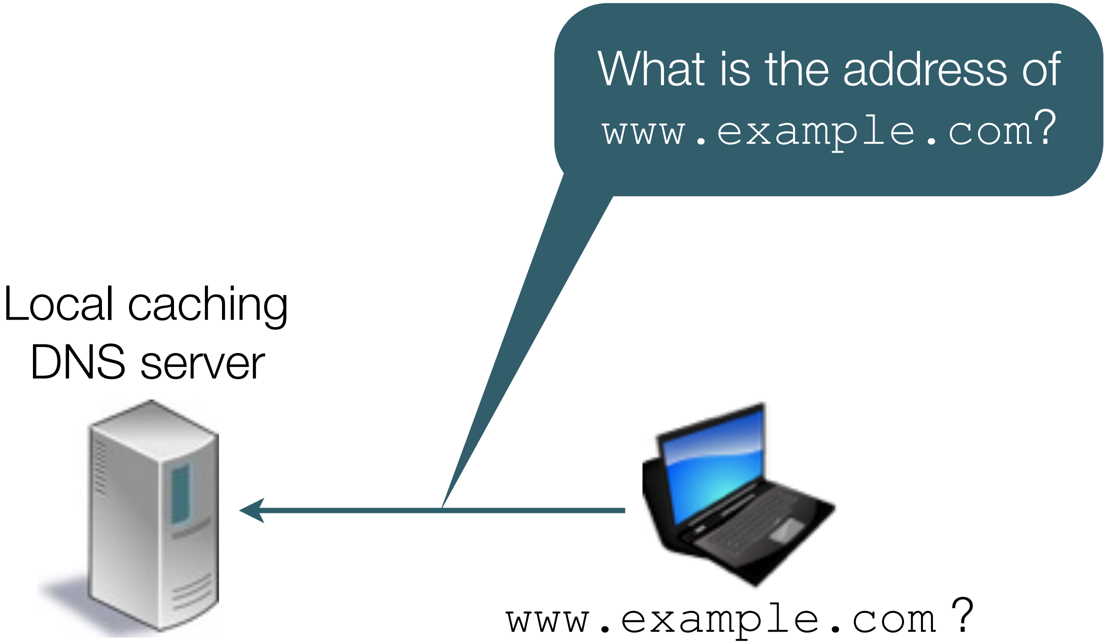
- Answers
  - are provided by **authoritative** servers
  - are cached by both **recursive** servers and **clients**

DNS Resolution

Resolution is the process of obtaining answers from the DNS database in response to ***queries***

- Queries
  - originate within applications
  - are handled on clients by **stub** resolvers
  - are sent to and processed by **recursive** servers

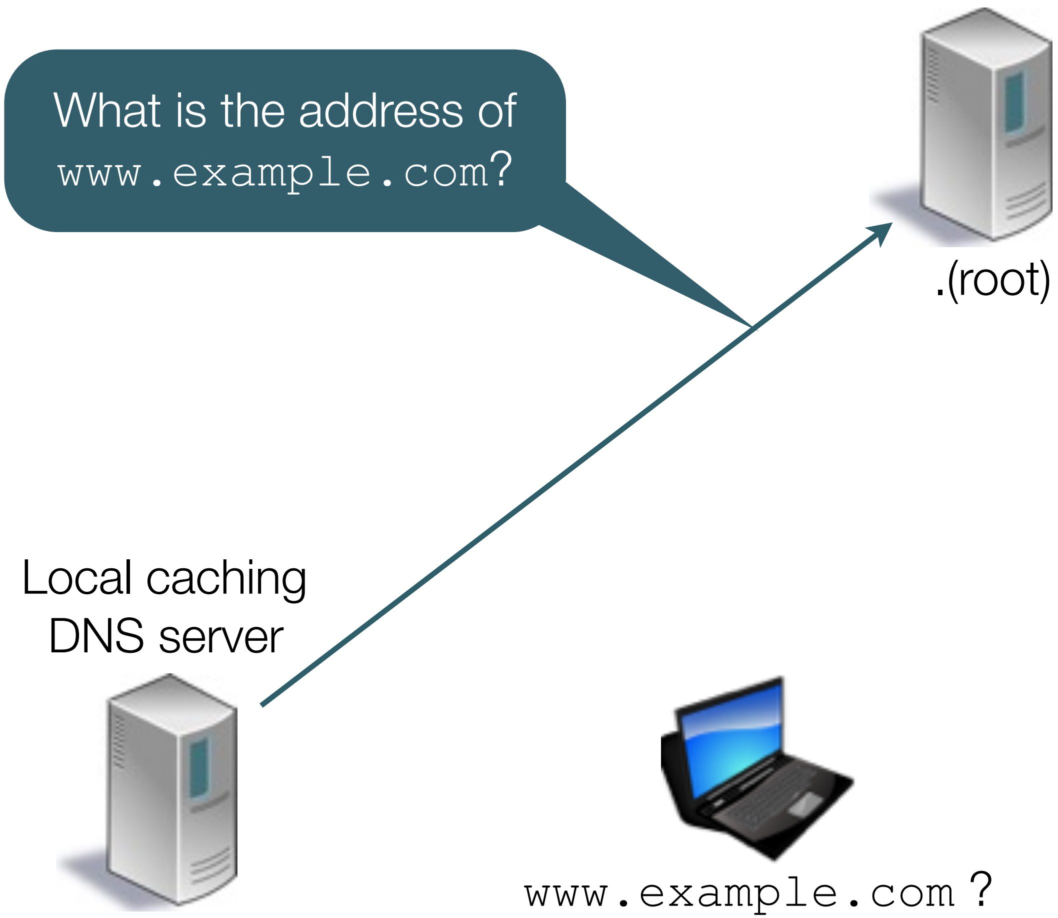
DNS Resolution



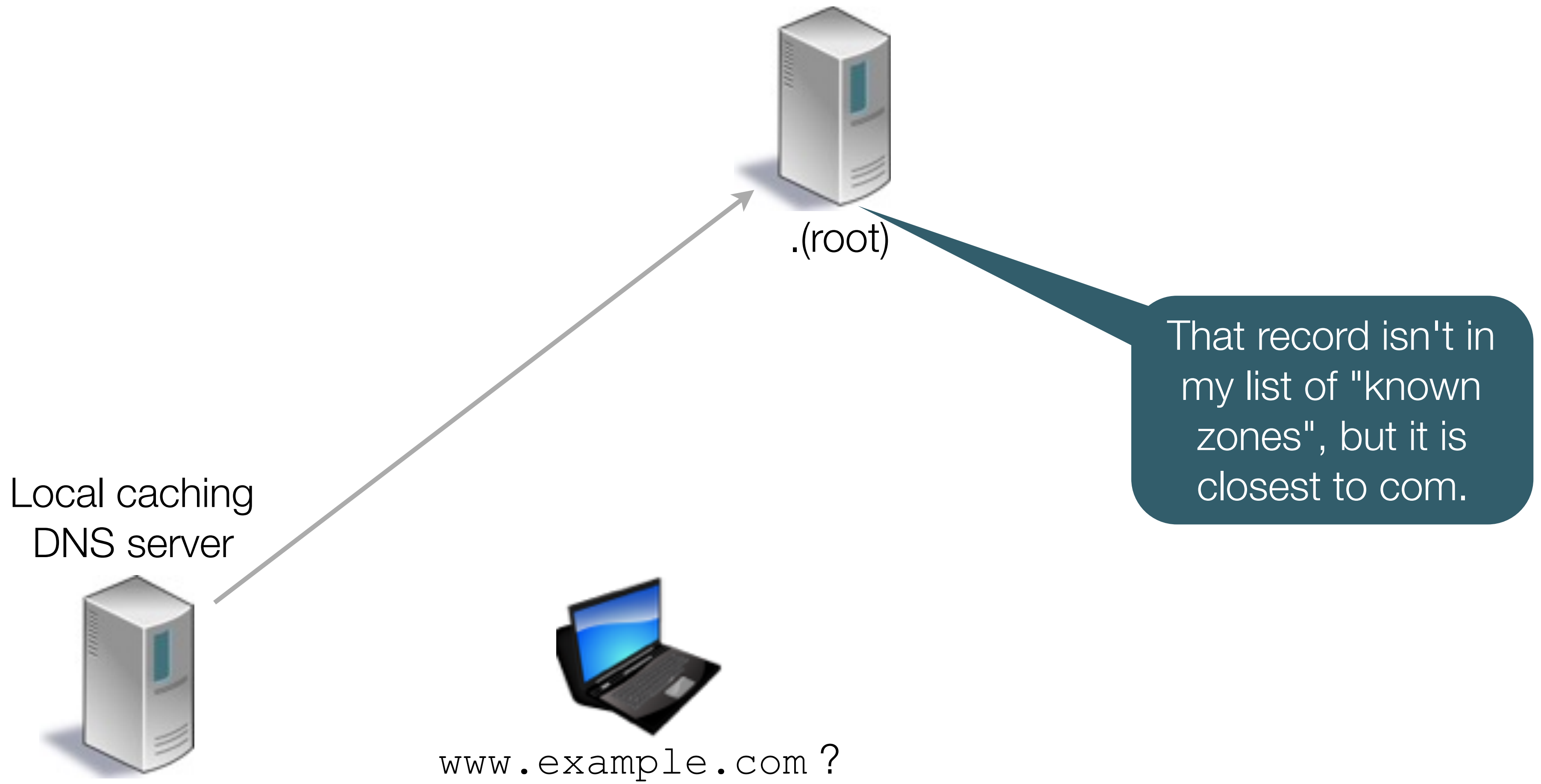
DNS Resolution

At this point, the local server knows nothing except the addresses of the root servers from "root hints"

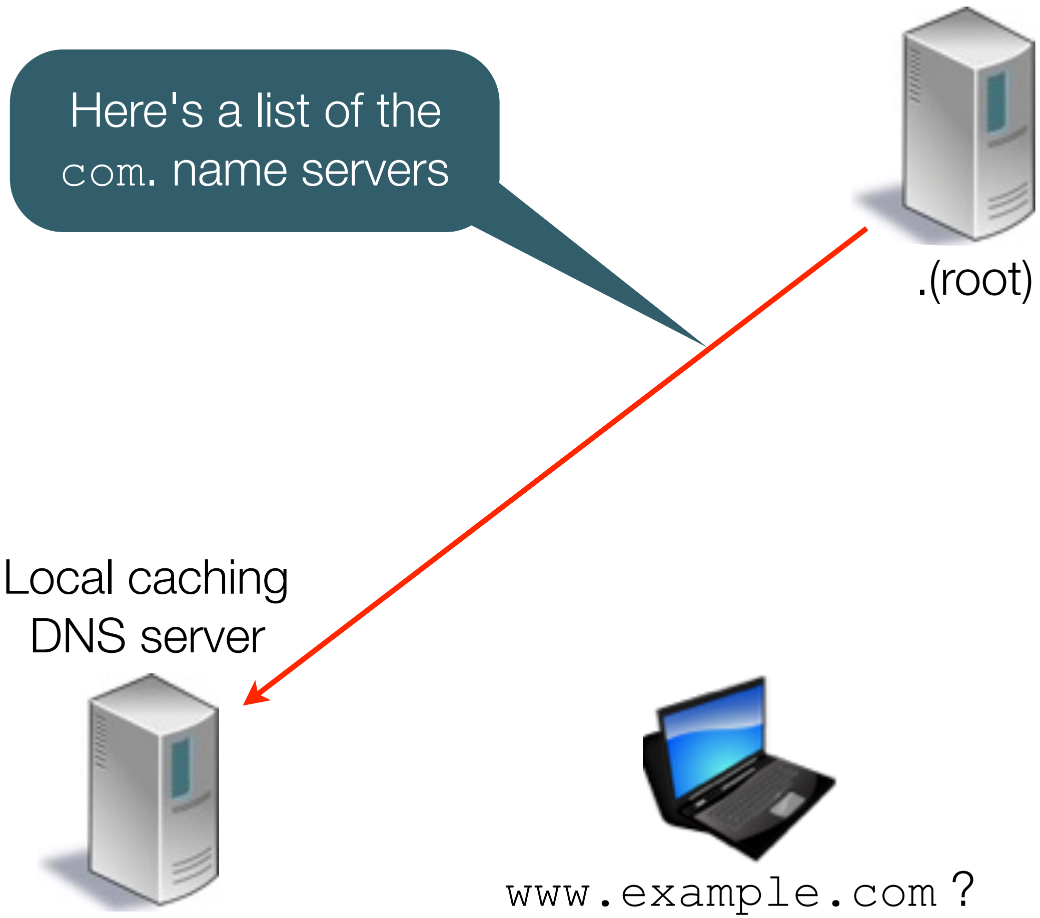
DNS Resolution



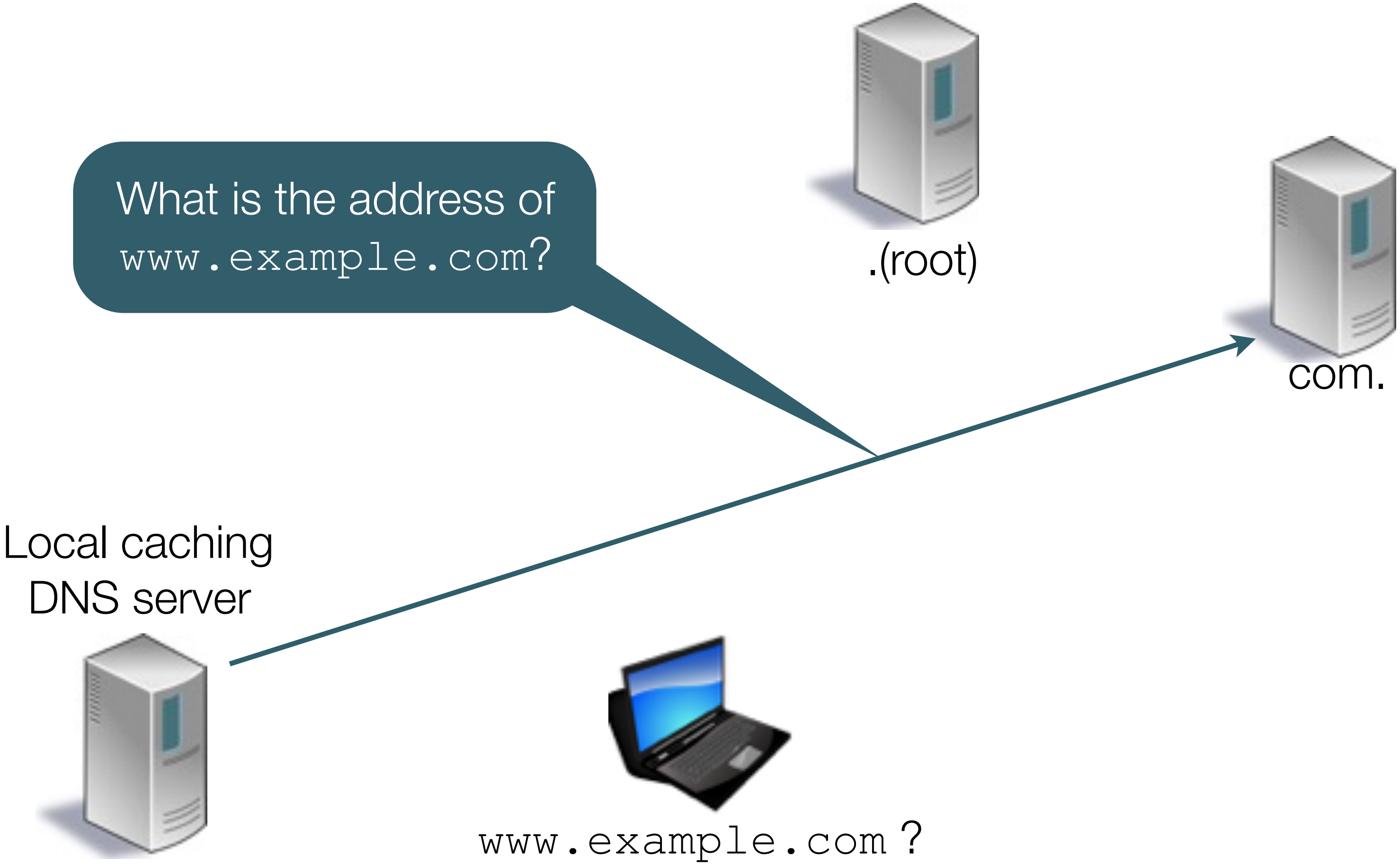
DNS Resolution



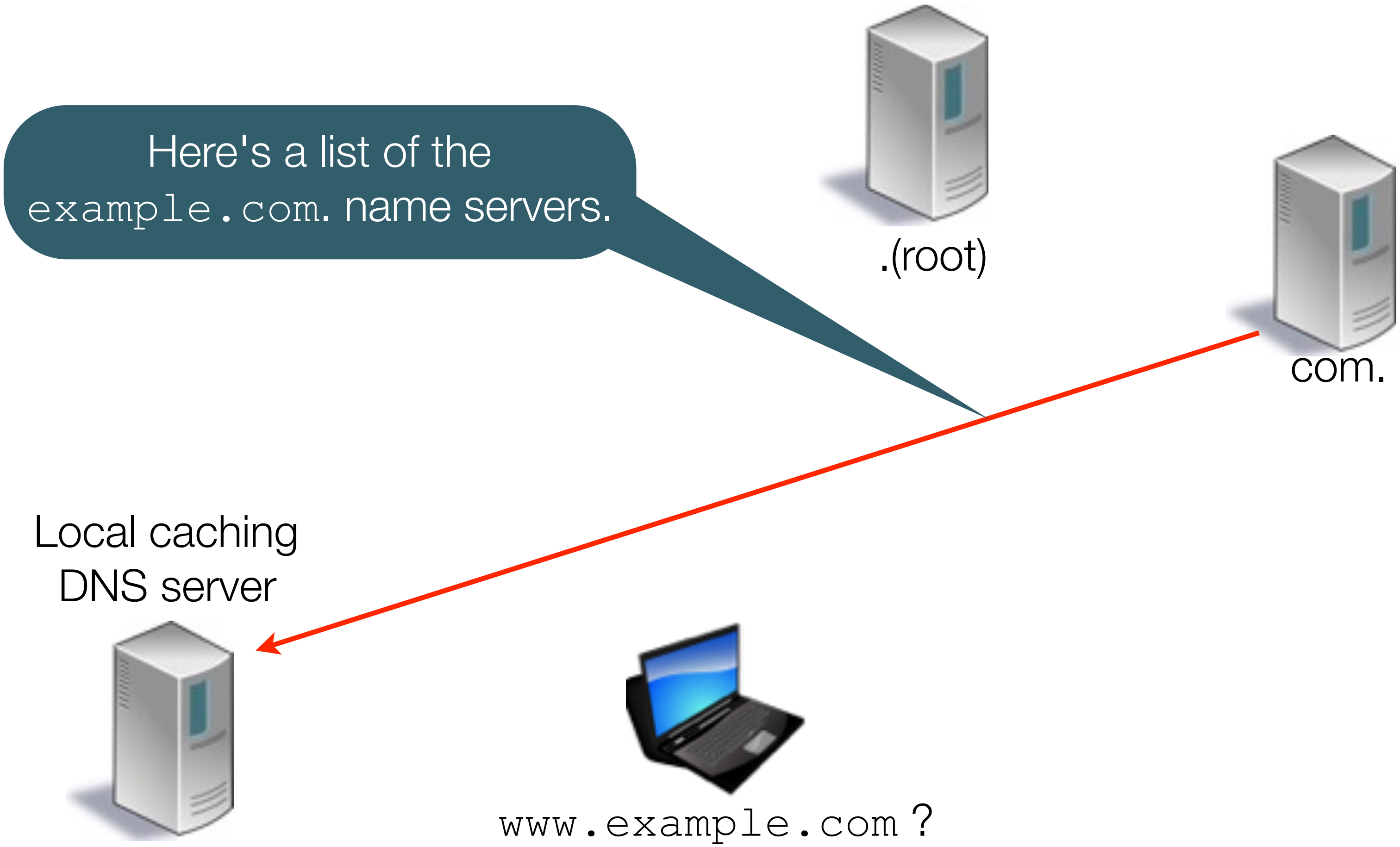
DNS Resolution



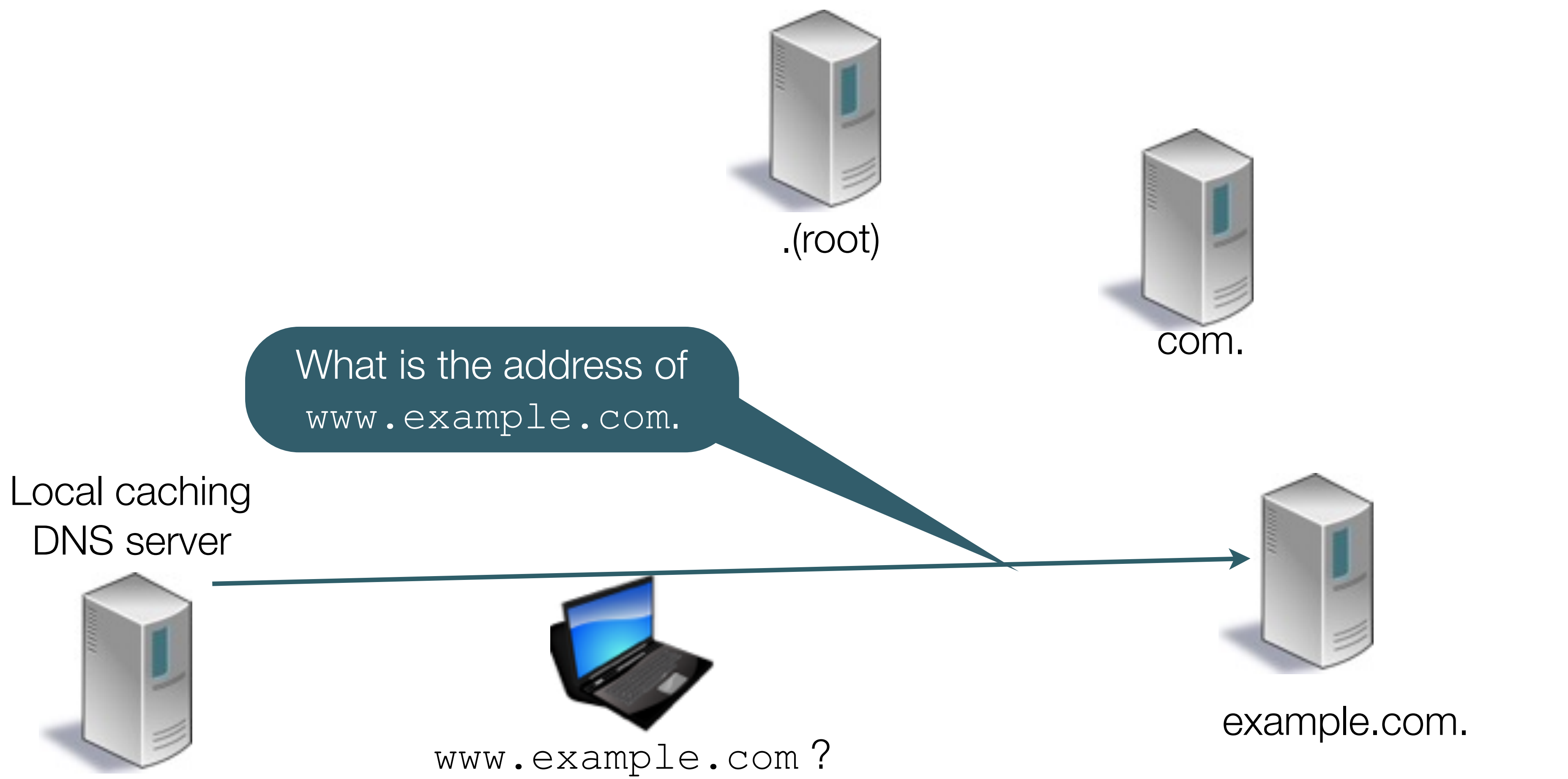
DNS Resolution



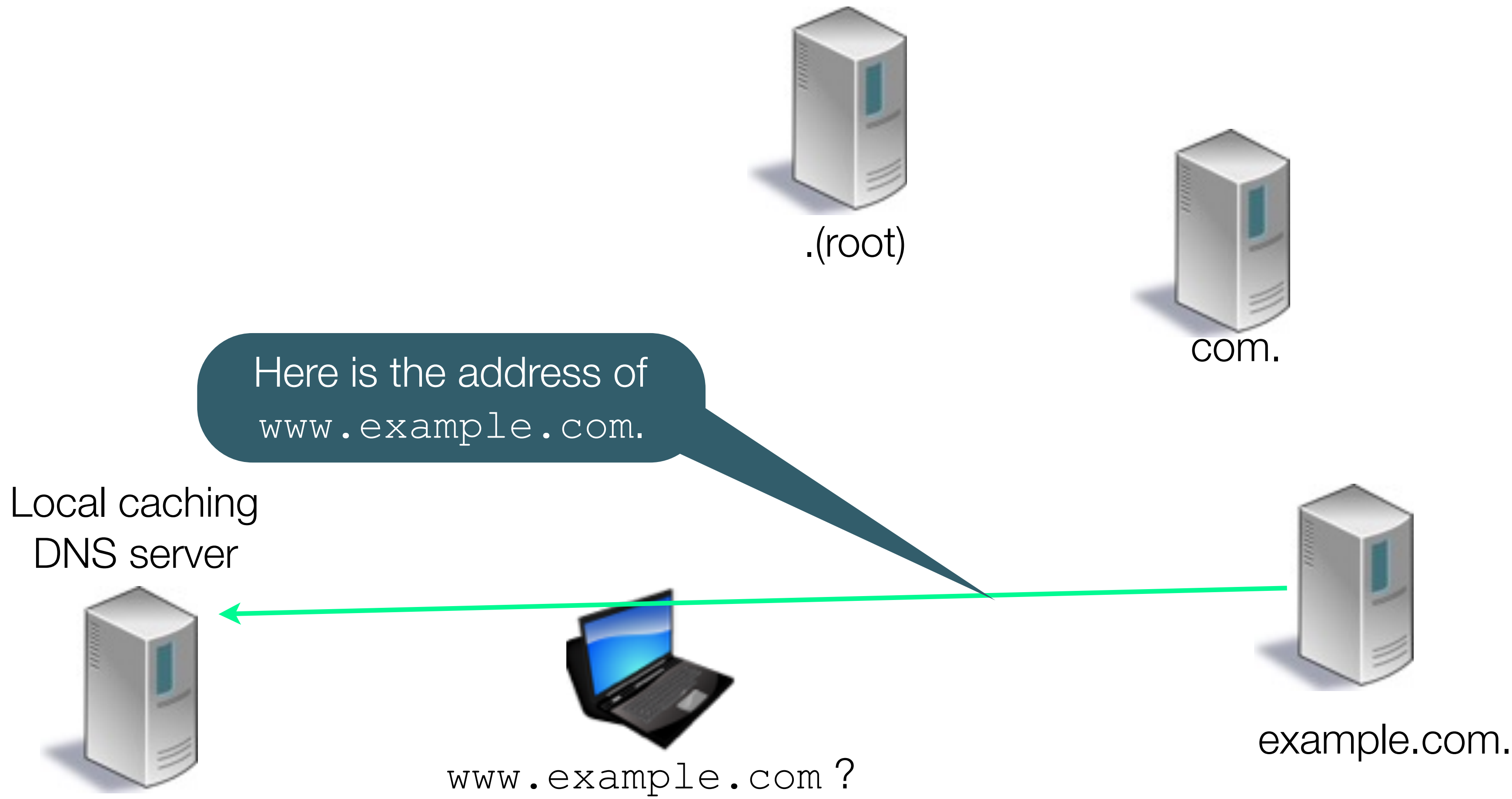
DNS Resolution



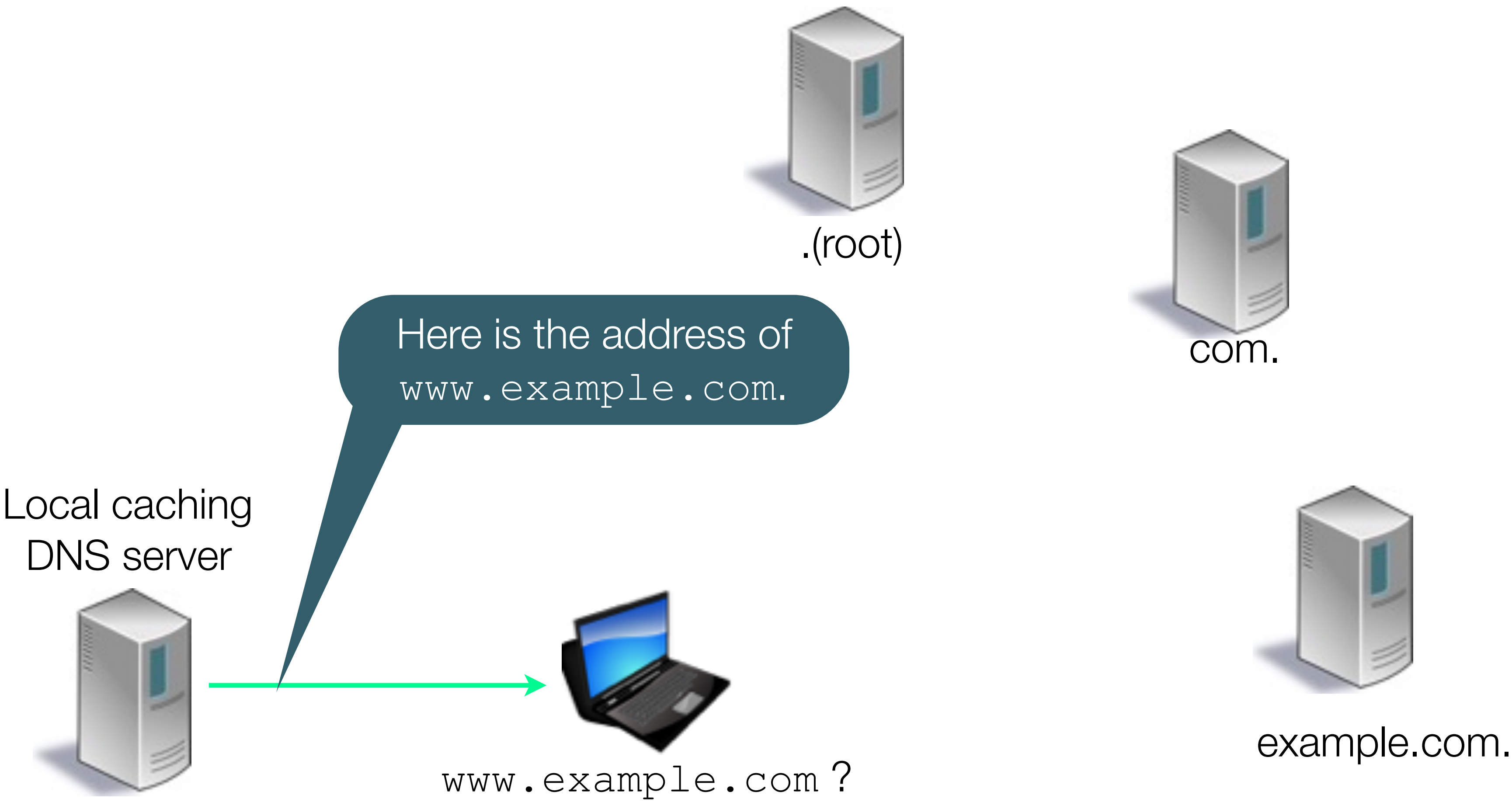
DNS Resolution



DNS Resolution



DNS Resolution



DNS Data Flow Vulnerabilities

Cache Poisoning

- What if someone were able to insert data into a server's cache
- That information would be returned to clients instead of "real" data

DNS Data Flow Vulnerabilities

Servers can send irrelevant information in the Additional Section

By definition, the additional section should contain answers to questions that have yet to be asked

DNS Data Flow Vulnerabilities

Header

www.isc.org. A ? — Question

www.isc.org. IN A 204.152.184.88 — Answer

Authority

www.bank.com. IN A 204.152.184.88 — Additional

DNS Data Flow Vulnerabilities

Cache Poisoning

- DNS uses UDP by default
- Sender can fabricate anything in the packet
  - including source address

DNS Data Flow Vulnerabilities

If I know a question that is about to be asked

I can flood responses containing my data, but a legitimate source

Background Knowledge

Before delving into DNSSEC

- DNS resolution mechanics
  - The Delegation Chain
- **Some Cryptography Fundamentals**
  - **Digital Signatures**

Cryptographic Fundamentals

Cryptography has four purposes:

Confidentiality	Keeping data secret
Integrity	Is it "as sent"?
Authenticity	Did it come from the right place?
Non-Repudiation	Don’t tell me you didn’t say that.

Cryptographic Fundamentals

DNSSEC uses cryptography for two purposes:

Confidentiality	Keeping data secret
Integrity	**Is it "as sent"?**
Authenticity	**Did it come from the right place?**
Non-Repudiation	Don’t tell me you didn’t say that.

Cryptography for DNS admins

To provide Authenticity and Integrity, we use:

- Asymmetric Cryptography
  - Digital Signatures

Asymmetric Cryptography

Keypairs – Public and Private Key Portions

Data encrypted with one piece of a key can be decrypted or checked for integrity with the other

It is unlikely that a person holding the public key will be able to reverse engineer the private key

Asymmetric Cryptography

Data that can be decrypted is guaranteed to have been unaltered since encryption

Integrity

Since the data was decrypted with a public portion of a known key pair, the private portion must have been the one to encrypt the data

Authenticity

Digital Signatures

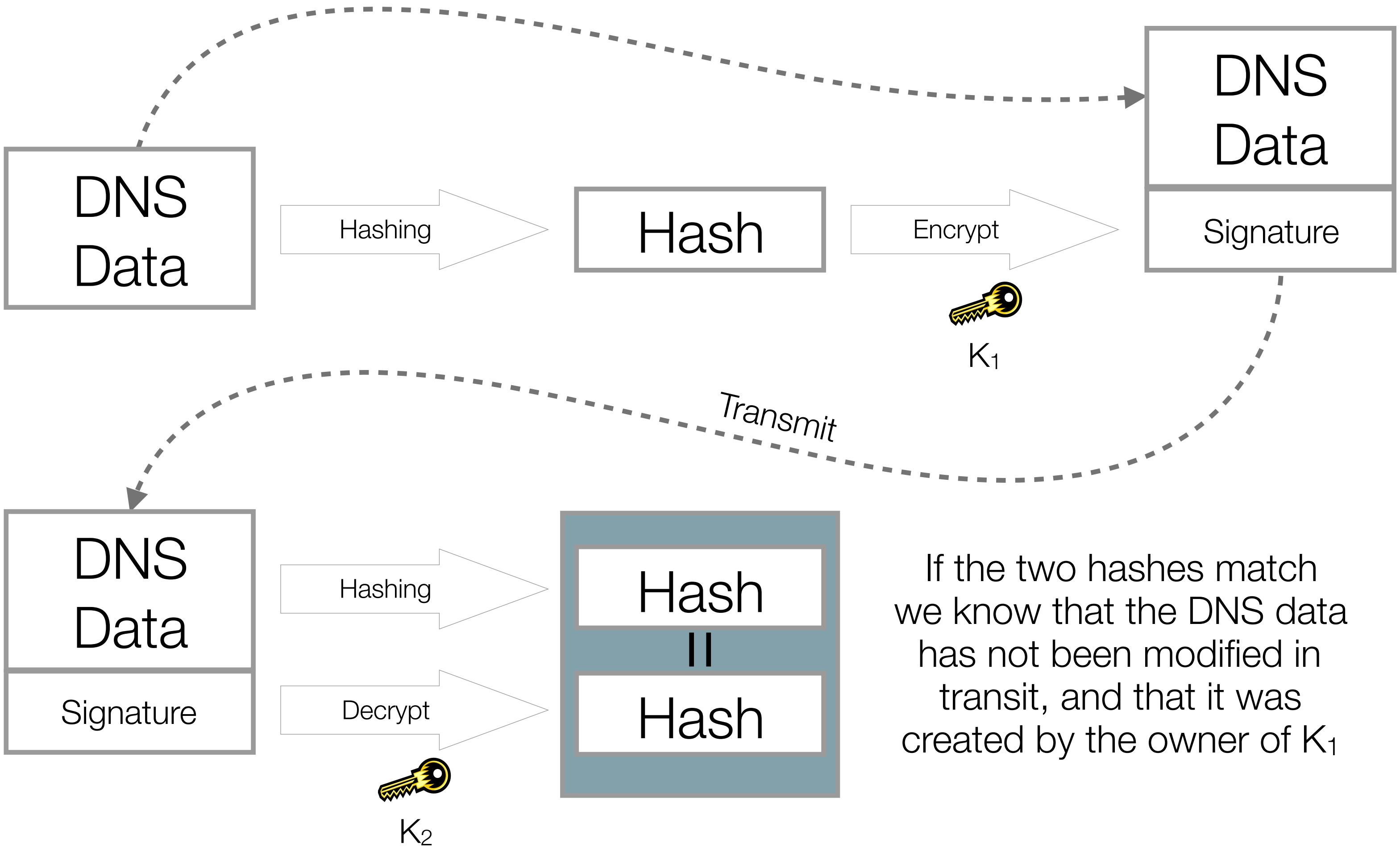
Since we don't care about encrypting the entire content of the message...

- Create a hash of the data to be sent, encrypt the hash with our private key and transmit it with the message

- Anyone holding public key can authenticate and confirm integrity of the message

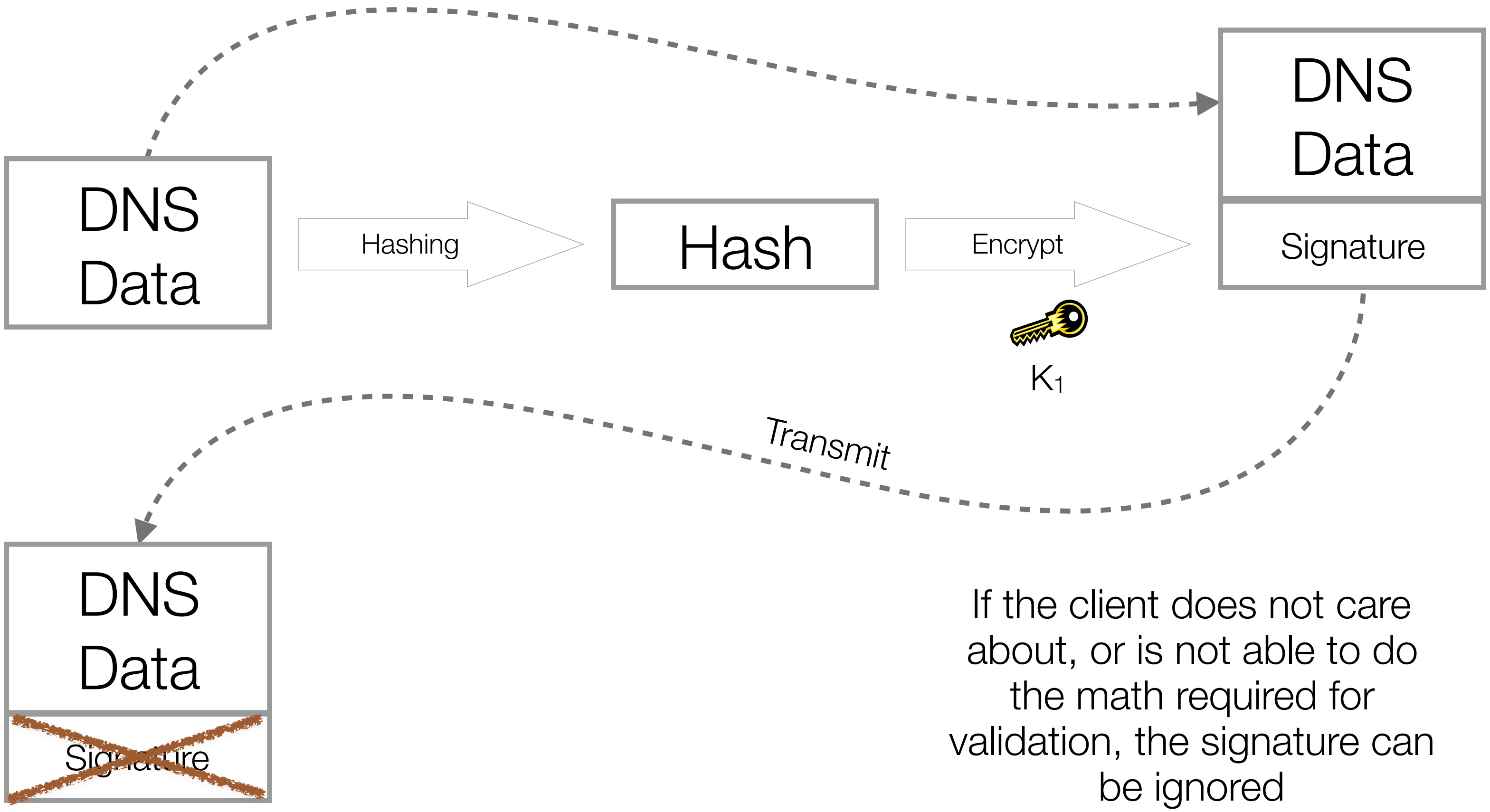
  - Anyone without the public key can still see the data

Digital Signatures in DNSSEC



If the two hashes match we know that the DNS data has not been modified in transit, and that it was created by the owner of K_1

Digital Signatures for those that don't care



If the client does not care about, or is not able to do the math required for validation, the signature can be ignored

Deploying DNSSEC Zone

Administrative Decisions

Administrative Decisions about DNSSEC

There are decisions that need to be made prior to deployment:

What algorithm will be used?

What bit-length for keying material?

NSEC or NSEC3 for proof of non-existence?

Two keys per zone? Yes, a Key-Signing Key (**KSK**) & a Zone-Signing Key (**ZSK**).

What Algorithm Should Be Used?

Choice of algorithm depends on a number of criteria:

- Interoperability with "legacy" systems
  - Requires use of RSASHA1 algorithm
- Legality issues
  - GOST vs. RSA
- Wide spread ability to validate chosen algorithm

ALG#	Name	Mnemonic
1	RSA/MD5	Deprecated
3	DSA/SHA1	DSA
5	**RSA/SHA-1**	**RSASHA1**
6	DSA-NSEC3-SHA1	NSEC3DSA
7	RSASHA1-NSEC3-SHA1	NSEC3RSASHA1
8	**RSA/SHA-256**	**RSASHA256**
10	RSA/SHA-512	RSASHA512
12	GOST R 34.10-2001	ECCGOST
13	ECDSA Curve P-256 w/ SHA-256	ECDSAP256SHA256
14	ECDSA Curve P-384 with SHA-384	ECDSAP384SHA384

Key Bit Length

The choice of bit-length for keying material is based on the algorithm being used and the purpose of the key

- Algorithm requirements
  - RSA keys must be between 512 and 2048 bits
  - DSA keys must be between 512 and 1024 bits and an exact multiple of 64
- NIST recommends 1024 bit ZSK and 2048 bit KSK

NSEC vs. NSEC3 denial of existence

The NSEC method of proof-of-nonexistence allows "zone walking", as it proves negative responses by enumerating positive responses

NSEC3 disallows "zone walking", but it requires additional processing on both authoritative servers providing negative responses and on recursive servers doing validation

- If you disallow zone transfers, you will want to deploy NSEC3

DS Resource Records - Talking to our Parent…

To create chains of trust "in-protocol," the Key Signing Key of a zone is hashed and that hash is placed into the parent

This record is known as the Delegation Signing (DS) record

The DS record in the parent creates a secure linkage that an external attacker would have to overcome to forge keying material in the child

Deploying DNSSEC Zones

Technical Decisions

```
DNSSEC Trust tree:
www.dnslab.org. (A)
|---dnslab.org. (DNSKEY keytag: 7308 alg
    |---dnslab.org. (DNSKEY keytag: 9247
    |---dnslab.org. (DS keytag: 9247 dig
        |---org. (DNSKEY keytag: 24209 a
            |---org. (DNSKEY keytag: 979
            |---org. (DNSKEY keytag: 213
            |---org. (DS keytag: 21366 d
            |   |---. (DNSKEY keytag: 33
            |       |---. (DNSKEY keytag
            |---org. (DS keytag: 21366 d
                |---. (DNSKEY keytag: 33
                    |---. (DNSKEY keytag
;; Chase successful
```

Preparing for DNSSEC Deployment

There are a number of methods of deploying DNSSEC into existing zones:

- Manual zone signing (In 2016, DDT - Don’t Do That!)
- Automatic zone signing of dynamic zones
- Automatic in-line signing "on-box"
- Automatic in-line signing "bump-in-the-wire"

Manual Zone Signing

Only do this if you are running BIND older than 9.9

- BIND 9.7 ("DNSSEC for Humans") made life easier
  - Key rollover is painful when done manually
- Manual insertion and deletion of keying material from zone files is fraught with danger
- Requires manual signing and re-signing of zones upon zone changes and signature expiration

Automatic Zone Signing of Dynamic Zones

BIND 9.7 and newer provide automation of zone signing of dynamic zones

- Keying material contains timing "meta-data" that can allow automation of key rollover

- Making a zone dynamic is significantly easier in recent versions of BIND

Dynamic zones are not always appropriate or allowed

Automatic In-Line Signing

BIND 9.9 introduced In-Line signing

- Signing of zones without knowledge of / changes to existing processes and procedures

On-Box in-line signing DNSSEC signs zones in memory on the same system on which they are mastered

Bump In The Wire signing provides signing on an intermediate system

- Use this where existing infrastructure can't be modified

Deploying DNSSEC Zones

Abbreviated Technical Steps

DNSSEC Signing - The Short List

Generate keys for zone

Insert public portions of keys Into zone

Sign zone with appropriate keys

Publish signed zone

DS in the parent zone

Validate!

Signing a Zone

```
#!/bin/bash
if [[ -z "$1" ]]; then
     exit
fi

echo Generating initial key for $1
ZONE=$1

echo Creating ZSK
dnssec-keygen -K /etc/namedb/keys -a rsasha256 -b 1024 $ZONE

echo Creating KSK
dnssec-keygen -K /etc/namedb/keys -a rsasha256 -b 2048 -f ksk $ZONE

SALT=`printf "%04x" $RANDOM $RANDOM`
echo Informing BIND that the zone $ZONE is to be
echo NSEC3 signed - salt is $SALT

rndc signing -nsec3param 1 1 10 $SALT $ZONE
rndc sign $ZONE
```

Insert Public Keying Material into Zone

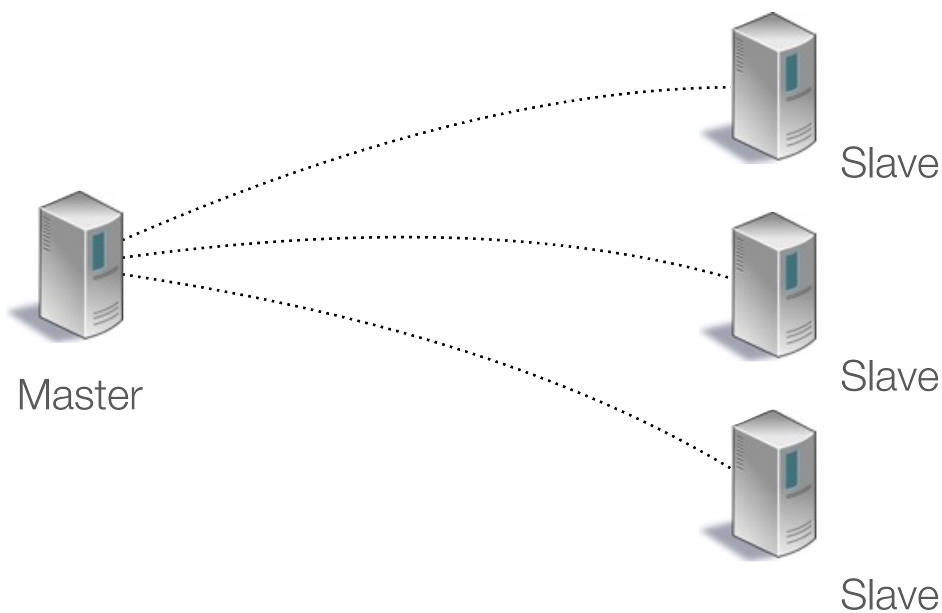
If using in-line signing, inserting keying material into the zone is automatic

```
zone "dnslab.org" {
        type master;
        file "master/dnslab.org";
        inline-signing yes;
        auto-dnssec maintain;
};
```

In-line signing keeps a separate copy of the zone in memory and adds records to that zone, not modifying the zone on disk

"Bump In The Wire" In-Line Signing

If there is a reason that your provisioning infrastructure can't be touched, consider “bump in the wire” in-line signing…



"Bump In The Wire" In-Line Signing

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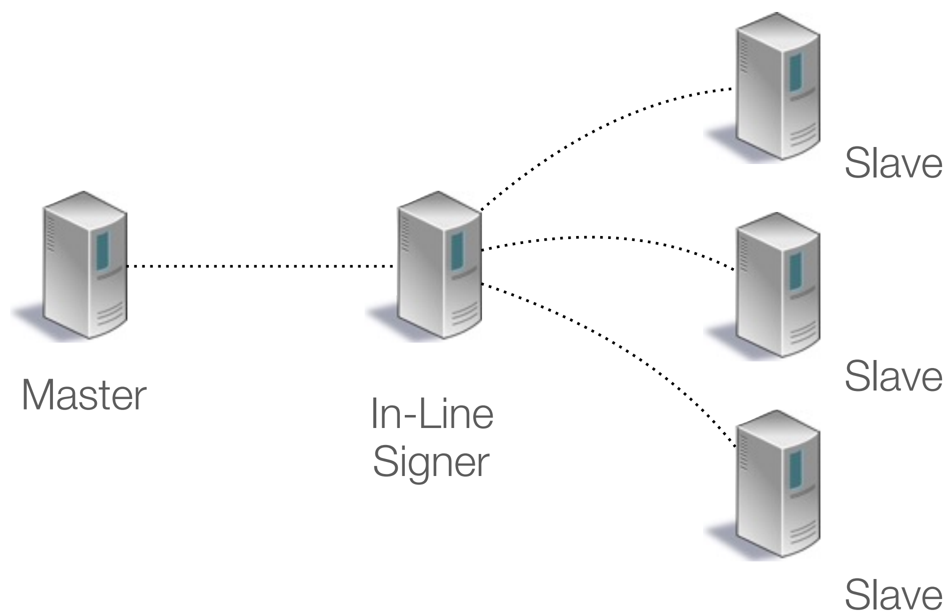
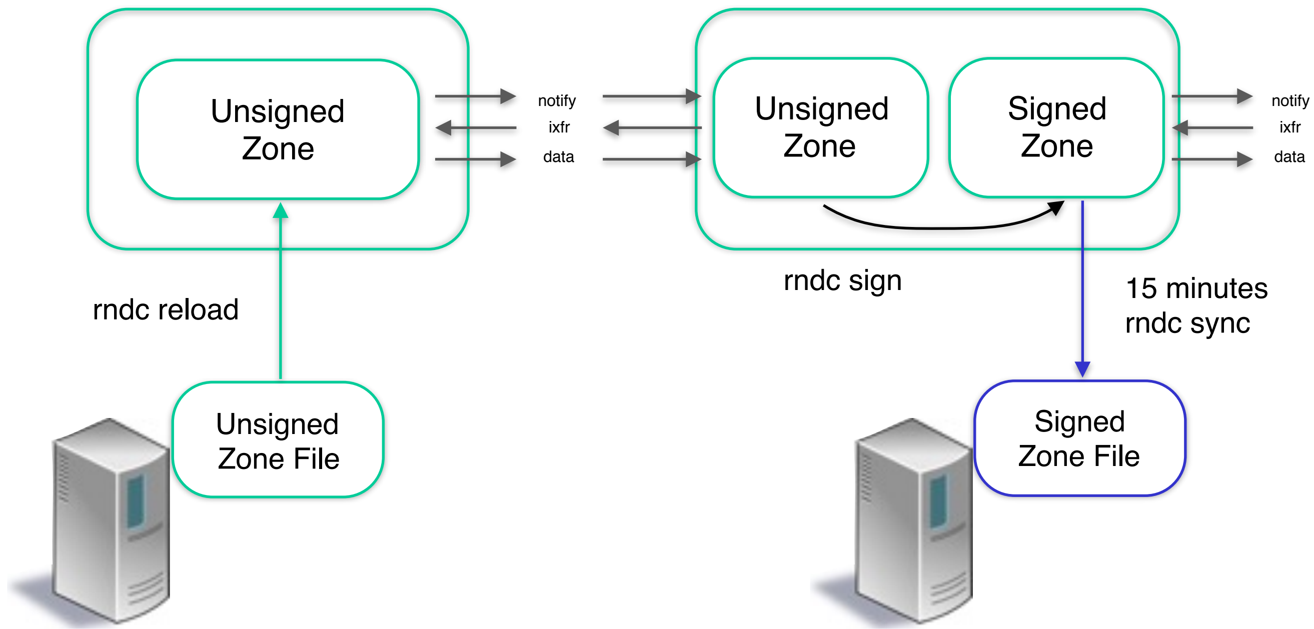


"Bump In The Wire" In-Line Signing



"Bump In The Wire" In-Line Signing

```
zone "dnslab.org" {
        type slave;
            masters { true-master; };
            also-notify { list-of-slaves; };
        file "slave/dnslab.org";
        inline-signing yes;
        auto-dnssec maintain;
};
```

The master must be modified to only send notifies and allow zone transfers from the signing server

The slave servers must be modified to accept notifies and perform zone transfers from the signing server

"Bump In The Wire" In-Line Signing

In-line signing, automatically inserts keying material into the zone

```
dnssec-keygen -K ./keys -a rsasha512 -b 1024 dnslab.org
dnssec-keygen -K ./keys -a rsasha512 -b 2048 -f ksk dnslab.org
rndc signing -nsec3param 1 1 10 bad5a170
rndc retransfer dnslab.org
rndc sign dnslab.org
```

Enabling DNSSEC Validation

```
DNSSEC Trust tree:
www.dnslab.org. (A)
|---dnslab.org. (DNSKEY keytag: 7308 alg
    |---dnslab.org. (DNSKEY keytag: 9247
    |---dnslab.org. (DS keytag: 9247 dig
        |---org. (DNSKEY keytag: 24209 a
            |---org. (DNSKEY keytag: 979
            |---org. (DNSKEY keytag: 213
            |---org. (DS keytag: 21366 d
            |   |---. (DNSKEY keytag: 33
            |       |---. (DNSKEY keytag
            |---org. (DS keytag: 21366 d
                |---. (DNSKEY keytag: 33
                    |---. (DNSKEY keytag
;; Chase successful
```

Validating DNSSEC

Authoritative Servers (master/slave) never do validation nor provide signaling of validation to clients

- If a DNS response has the AA (authoritative answer) bit set, it will never have the AD (authenticated data) bit set

It is the job of the recursive (validating) server to do the work required to prove data is unmodified

Validating DNSSEC

To validate DNSSEC, a recursive server must be able to track back to a trust anchor

Even if there is no trust anchor in place, a server may return signature data to the client in case the client can do validation itself

- DNSSEC data (RRSIGS) are returned if the DO bit is set in the EDNS0 header
- The AD bit is returned if validation to a trust anchor succeeded

Validating DNSSEC

BIND uses trust anchors from "trusted-keys" statements:

```
trusted-keys {
     "."  257 3 8 "AwEAA[...]ihz0=";
};
```

But what happens if the key changes? RFC-5011!

```
managed-keys {
 "." initial-key 257 3 8 "AwE[..]ihz0=";
};
```

Validating DNSSEC

RFC-5011 covers the problem of validating servers having to be reconfigured when trust-anchor material changes

- If a trust anchor KSK RRSET adds a new key and that key remains published in the zone for 30 days, that key may be considered as a trust anchor for the zone
- If the REVOKE bit is then set in the old KSK, the new KSK should be employed as the new trust-anchor for the zone

The Root KSK will be rolled! Use managed-keys!

```
options {
     dnssec-enable yes;
     dnssec-validation yes;
};
managed-keys {
     "." initial-key [.....];
};
```

Deep Diving DNSSEC

```
DNSSEC Trust tree:
www.dnslab.org. (A)
|---dnslab.org. (DNSKEY keytag: 7308 alg
    |---dnslab.org. (DNSKEY keytag: 9247
    |---dnslab.org. (DS keytag: 9247 dig
        |---org. (DNSKEY keytag: 24209 a
            |---org. (DNSKEY keytag: 979
            |---org. (DNSKEY keytag: 213
            |---org. (DS keytag: 21366 d
            |   |---. (DNSKEY keytag: 33
            |       |---. (DNSKEY keytag
            |---org. (DS keytag: 21366 d
                |---. (DNSKEY keytag: 33
                    |---. (DNSKEY keytag
;; Chase successful
```

DNSSEC Changes to DNS

To provide security to DNS, a number of new resource record types were introduced:

DNSKEY - Public portion of cryptographic key

RRSIG - Resource Record Signature

NSEC / NSEC3 - Proof of non-existance

NSEC3PARAM - NSEC3 parameter hint

DS - Delegation Signer

DNSKEY Resource Records

The DNSKEY Resource Record provides the public portion of the key used to create signatures

- Key type (ZSK or KSK)
- Algorithm used
- Key tag
- Keying material

DNSKEY Resource Records

Label

TTL

Class

```
dnslab.org.     3600 IN DNSKEY 256 3 8 (
                AwEAAavBUcpNl+jBynAU3DCtX4gmKDCayF23sI0Yn434
                LgLABSpfA8cPtW1SX3ukBRYPM0N5YerJec1xjPr+6e7O
                Ec+R2f+NvLzfChxorgQa2cOijDlqBUuSDlz+5kA+Mr4+
                INHpmjGZFQzRTy1kPZI9/HaW/U8o9sUL7D2vA8kxS2Hl
                ) ; ZSK; alg = RSASHA256; key id = 7308
```

DNSKEY Resource Records

Type Flags Protocol

```
dnslab.org.        3600 IN DNSKEY 256 3 8 (
                   AwEAAavBUcpNl+jBynAU3DCtX4gmKDCayF23sI0Yn434
                   LgLABSpfA8cPtW1SX3ukBRYPM0N5YerJec1xjPr+6e7O
                   Ec+R2f+NvLzfChxorgQa2cOijDlqBUuSDlz+5kA+Mr4+
                   INHpmjGZFQzRTy1kPZI9/HaW/U8o9sUL7D2vA8kxS2Hl
                   ) ; ZSK; alg = RSASHA256; key id = 7308
```

Flags: 256 for ZSK
257 for KSK

Protocol is always 3 for DNSSEC

DNSKEY Resource Records

Algorithm

```
dnslab.org.       3600 IN DNSKEY 256 3 8 (
                  AwEAAavBUcpNl+jBynAU3DCtX4gmKDCayF23sI0Yn434
                  LgLABSpfA8cPtW1SX3ukBRYPM0N5YerJec1xjPr+6e7O
                  Ec+R2f+NvLzfChxorgQa2cOijDlqBUuSDlz+5kA+Mr4+
                  INHpmjGZFQzRTy1kPZI9/HaW/U8o9sUL7D2vA8kxS2Hl
                  ) ; ZSK; alg = RSASHA256; key id = 7308
```

Key Material

Algorithm is determined during key generation

DNSKEY Resource Records

```
dnslab.org.      3600 IN DNSKEY 256 3 8 (
                 AwEAAavBUcpNl+jBynAU3DCtX4gmKDCayF23sI0Yn434
                 LgLABSpfA8cPtW1SX3ukBRYPM0N5YerJec1xjPr+6e7O
                 Ec+R2f+NvLzfChxorgQa2cOijDlqBUuSDlz+5kA+Mr4+
                 INHpmjGZFQzRTy1kPZI9/HaW/U8o9sUL7D2vA8kxS2Hl
                 ) ; ZSK; alg = RSASHA256; key id = 7308
```

Comments

Comments are created by specifying `+multi` on `dig` command line

RRSIG Resource Records

RRSIG Resource Records provide signatures across a resource record set

- Algorithm used
- Number of labels covered
- Original TTL
- Key Tag and Key Origin
- Digital Signature

RRSIG Resource Records

TTL

Label

Class

```
www.dnslab.org.     11 IN RRSIG A 8 3 30 (
                    20140324123008 20140222115153 7308 dnslab.org.
                    CteKosqUJRLer5p6py+d9L3I1djQwzTruiSOYeOc1Qkp
                    SvvP3cJKWsNbNgcrGh3Uz+Ms0V1+4AdUbNSgwR4rhsKG
                    mSxrc4H0uuM/8uLAWKuAIYJnqOTD45ASc3FnttPIKdED
                    Y1R2pvIn+jIvuxQ4w7z44/ZvF/ETayHk9GRagaE= )
```

RRSIG Resource Records

Type

Covered RRSET type

```
www.dnslab.org.      11 IN RRSIG A 8 3 30 (
                        20140324123008 20140222115153 7308 dnslab.org.
                        CteKosqUJRLer5p6py+d9L3I1djQwzTruiSOYeOc1Qkp
                        SvvP3cJKWsNbNgcrGh3Uz+Ms0V1+4AdUbNSgwR4rhsKG
                        mSxrc4H0uuM/8uLAWKuAIYJnqOTD45ASc3FnttPIKdED
                        Y1R2pvIn+jIvuxQ4w7z44/ZvF/ETayHk9GRagaE= )
```

Covered Type shows the RRSET that this signature validates

RRSIG Resource Records

Algorithm

```
www.dnslab.org.     11 IN RRSIG A 8 3 30 (
                20140324123008 20140222115153 7308 dnslab.org.
                CteKosqUJRLer5p6py+d9L3I1djQwzTruiSOYeOc1Qkp
                SvvP3cJKWsNbNgcrGh3Uz+Ms0V1+4AdUbNSgwR4rhsKG
                mSxrc4H0uuM/8uLAWKuAIYJnqOTD45ASc3FnttPIKdED
                Y1R2pvIn+jIvuxQ4w7z44/ZvF/ETayHk9GRagaE= )
```

Algorithm provides the alg# that was used to produce the signature

RRSIG Resource Records

Depth of labels covered

```
www.dnslab.org.     11 IN RRSIG A 8 3 30 (
                    20140324123008 20140222115153 7308 dnslab.org.
                    CteKosqUJRLer5p6py+d9L3I1djQwzTruiSOYeOc1Qkp
                    SvvP3cJKWsNbNgcrGh3Uz+Ms0V1+4AdUbNSgwR4rhsKG
                    mSxrc4H0uuM/8uLAWKuAIYJnqOTD45ASc3FnttPIKdED
                    Y1R2pvIn+jIvuxQ4w7z44/ZvF/ETayHk9GRagaE= )
```

Depth tells the number of labels in the name that is signed (used in wildcard validation)

RRSIG Resource Records

Original TTL of the covered RRSET

```
www.dnslab.org.      11 IN RRSIG A 8 3 30 (
                    20140324123008 20140222115153 7308 dnslab.org.
                    CteKosqUJRLer5p6py+d9L3I1djQwzTruiSOYeOc1Qkp
                    SvvP3cJKWsNbNgcrGh3Uz+Ms0V1+4AdUbNSgwR4rhsKG
                    mSxrc4H0uuM/8uLAWKuAIYJnqOTD45ASc3FnttPIKdED
                    Y1R2pvIn+jIvuxQ4w7z44/ZvF/ETayHk9GRagaE= )
```

Original TTL allows validation of data where the TTL in cache does not match authoritative data

RRSIG Resource Records

Expiration and
Inception Dates

```
www.dnslab.org.      11 IN RRSIG A 8 3 30 (
                20140324123008 20140222115153 7308 dnslab.org.
                CteKosqUJRLer5p6py+d9L3I1djQwzTruiSOYeOc1Qkp
                SvvP3cJKWsNbNgcrGh3Uz+Ms0V1+4AdUbNSgwR4rhsKG
                mSxrc4H0uuM/8uLAWKuAIYJnqOTD45ASc3FnttPIKdED
                Y1R2pvIn+jIvuxQ4w7z44/ZvF/ETayHk9GRagaE= )
```

Expiration and **Inception Dates** prevent replay attacks using signatures for changed data

RRSIG Resource Records

Key ID

Key Label

```
www.dnslab.org.       11 IN RRSIG A 8 3 30 (
                      20140324123008 20140222115153 7308 dnslab.org.
                      CteKosqUJRLer5p6py+d9L3I1djQwzTruiSOYeOc1Qkp
                      SvvP3cJKWsNbNgcrGh3Uz+Ms0V1+4AdUbNSgwR4rhsKG
                      mSxrc4H0uuM/8uLAWKuAIYJnqOTD45ASc3FnttPIKdED
                      Y1R2pvIn+jIvuxQ4w7z44/ZvF/ETayHk9GRagaE= )
```

Key ID and **Key Label** provide information about the key used to create (and validate) the signature

RRSIG Resource Records

Signature

```
www.dnslab.org.     11 IN RRSIG A 8 3 30 (
                20140324123008 20140222115153 7308 dnslab.org.
                CteKosqUJRLer5p6py+d9L3I1djQwzTruiSOYeOc1Qkp
                SvvP3cJKWsNbNgcrGh3Uz+Ms0V1+4AdUbNSgwR4rhsKG
                mSxrc4H0uuM/8uLAWKuAIYJnqOTD45ASc3FnttPIKdED
                Y1R2pvIn+jIvuxQ4w7z44/ZvF/ETayHk9GRagaE= )
```

RRSIG Resource Records

Here is a resource record and
its associated signature:

```
www.dnslab.org.      11 IN A 50.19.120.198
www.dnslab.org.      11 IN RRSIG A 8 3 30 (
                  20140324123008 20140222115153 7308 dnslab.org.
                  CteKosqUJRLer5p6py+d9L3I1djQwzTruiSOYeOc1Qkp
                  SvvP3cJKWsNbNgcrGh3Uz+Ms0V1+4AdUbNSgwR4rhsKG
                  mSxrc4H0uuM/8uLAWKuAIYJnqOTD45ASc3FnttPIKdED
                  Y1R2pvIn+jIvuxQ4w7z44/ZvF/ETayHk9GRagaE= )
```

DS Resource Records

To create chains of trust "in-protocol," the Key Signing Key of a zone is hashed and that hash is placed into the parent

This record is known as the Delegation Signing (DS) record

The DS record in the parent creates a secure linkage that an external attacker would have to overcome to forge keying material in the child

DS Resource Records

The DS record contains:

- The key tag of the key in the child
- The algorithm number of the key
- The hashing algorithm number used to create the DS

1	**SHA-1**	**2**	**SHA-256**
3	GOST R 34.11-94	4	SHA-384

- The hash of the key

DS Records

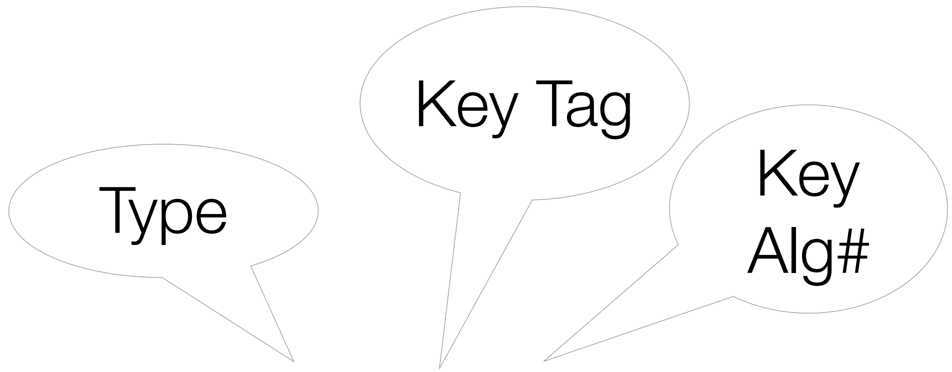
TTL

Label

Class

```
dnslab.org.        86400 IN DS 9247 8 2 (
                   F788167DCF705C97D0CB1FD61F7B8EA807E61D8077FA
                   2F50660B871FF9D8DE24 )
```

DS Records




```
dnslab.org.     86400 IN DS 9247 8 2 (
                F788167DCF705C97D0CB1FD61F7B8EA807E61D8077FA
                2F50660B871FF9D8DE24 )
```

DS Records

Hash Alg

```
dnslab.org.     86400 IN DS 9247 8 2 (
                F788167DCF705C97D0CB1FD61F7B8EA807E61D8077FA
                2F50660B871FF9D8DE24 )
```

Hash

DS Records

```
dnslab.org.        86394 IN DS 9247 8 2 (
                   F788167DCF705C97D0CB1FD61F7B8EA807E61D8077FA
                   2F50660B871FF9D8DE24 )
dnslab.org.        86394 IN RRSIG DS 7 2 86400 (
                   20140318154949 20140225144949 24209 org.
                   VWhUKxm+ig+yA/gV5kpEKB/Tb91R7b8dZTjpBtt4ZJFN
                   AI7OVFT6wlEL9TlZGYsOX8bYB5VQhK6ZOMATIodIS/gG
                   hQKGtC8sJG3I4ktuU/nMnyK/0FBCLnUpcGfk+A0E2ECj
                   GLOLu6N/0cst9UH01+1oh30hMoMQVfpL9UOse+c= )
```

DS record lives in the parent and is signed with parent ZSK

DS Records

Parent:

```
dnslab.org.        86400 IN DS 9247 8 2 (
                   F788167DCF705C97D0CB1FD61F7B8EA807E61D8077FA
                   2F50660B871FF9D8DE24 )
```

Child:

```
dnslab.org.        3600 IN DNSKEY 257 3 8 (
                   AwEAAaHaqpWsLOXTNKdaYa9kQcK/HTaYYsT05rKzPHsY
                   [...]
                   BFlYBHoDZ6HHf5RmSYWUSXr3YYCpf9DwYnqT6Rc=
                   ) ; KSK; alg = RSASHA256; key id = 9247
```

DNSSEC in the real world

DNSSEC in the real world

Sandia National Labs & Verisign provide a web page that performs DNSSEC chain testing

http://www.dnsviz.net

DNSSEC in the real world - what about the clients?

run your own validating resolver… NLNetLab's dnssec-trigger

do validation in the browser… cz.nic's DNSSEC Validator for Chrome

More Real-World… Key Rollover Schedule

There is not “one answer” as to how often you should roll your keys.

NIST recommends:

KSK should be rolled once a year

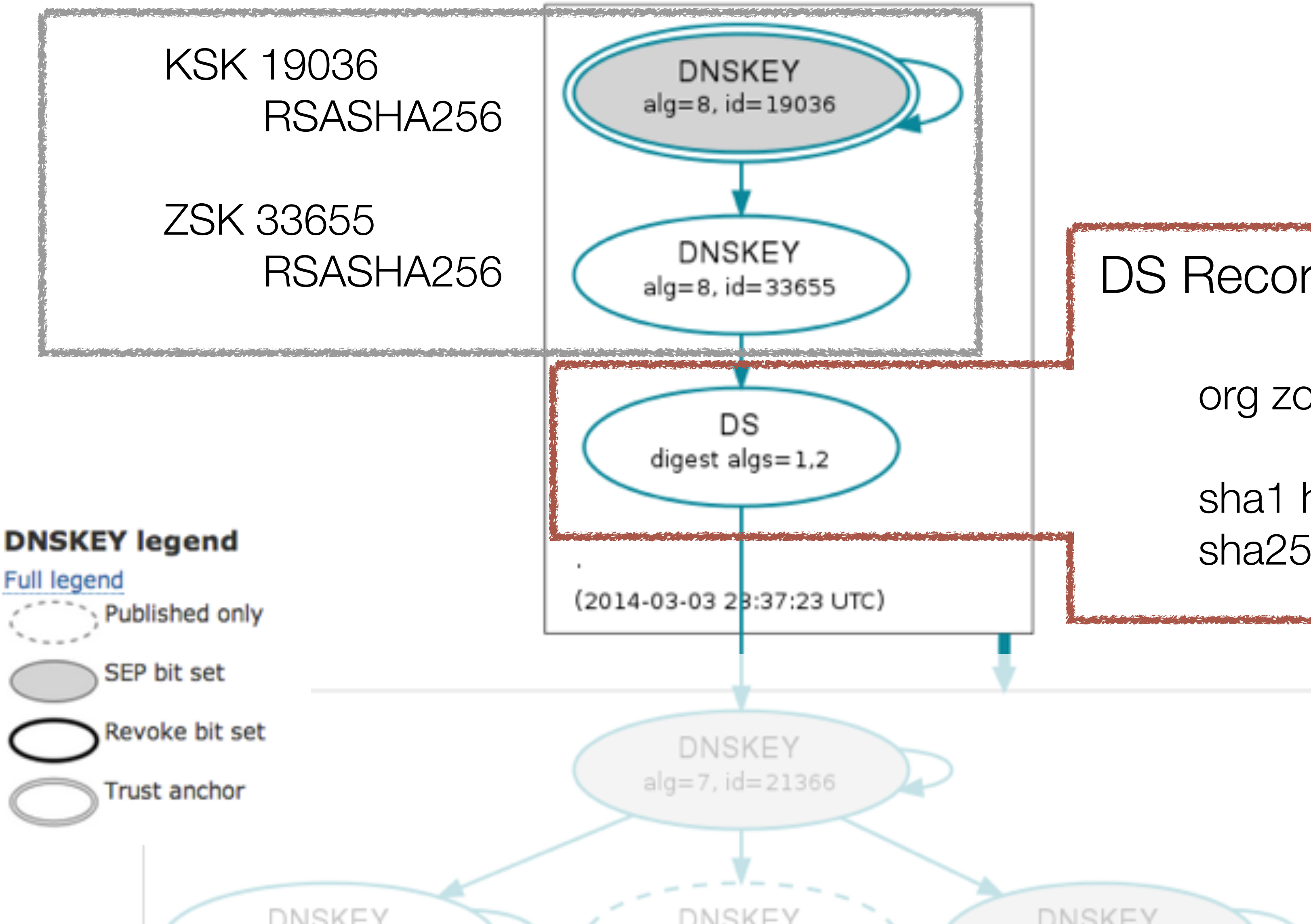
ZSK should be rolled every 3 months

NIST
National Institute of
Standards and Technology
U.S. Department of Commerce

Root Zone

KSK 19036
RSASHA256

ZSK 33655
RSASHA256

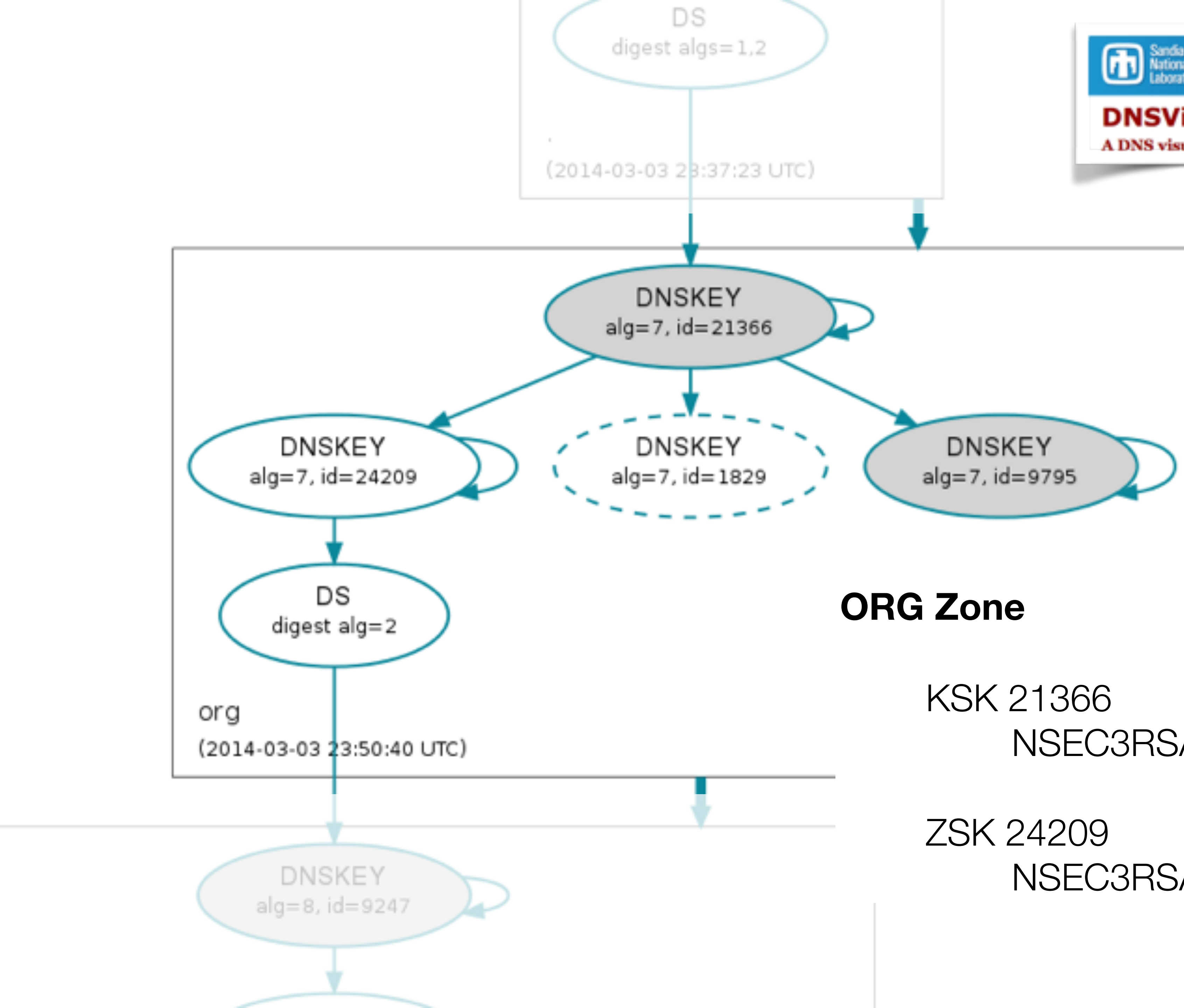


DS Record

org zone

sha1 hash &
sha256 hash

Sandia National Laboratories
DNSViz
A DNS visualization tool



ORG Zone

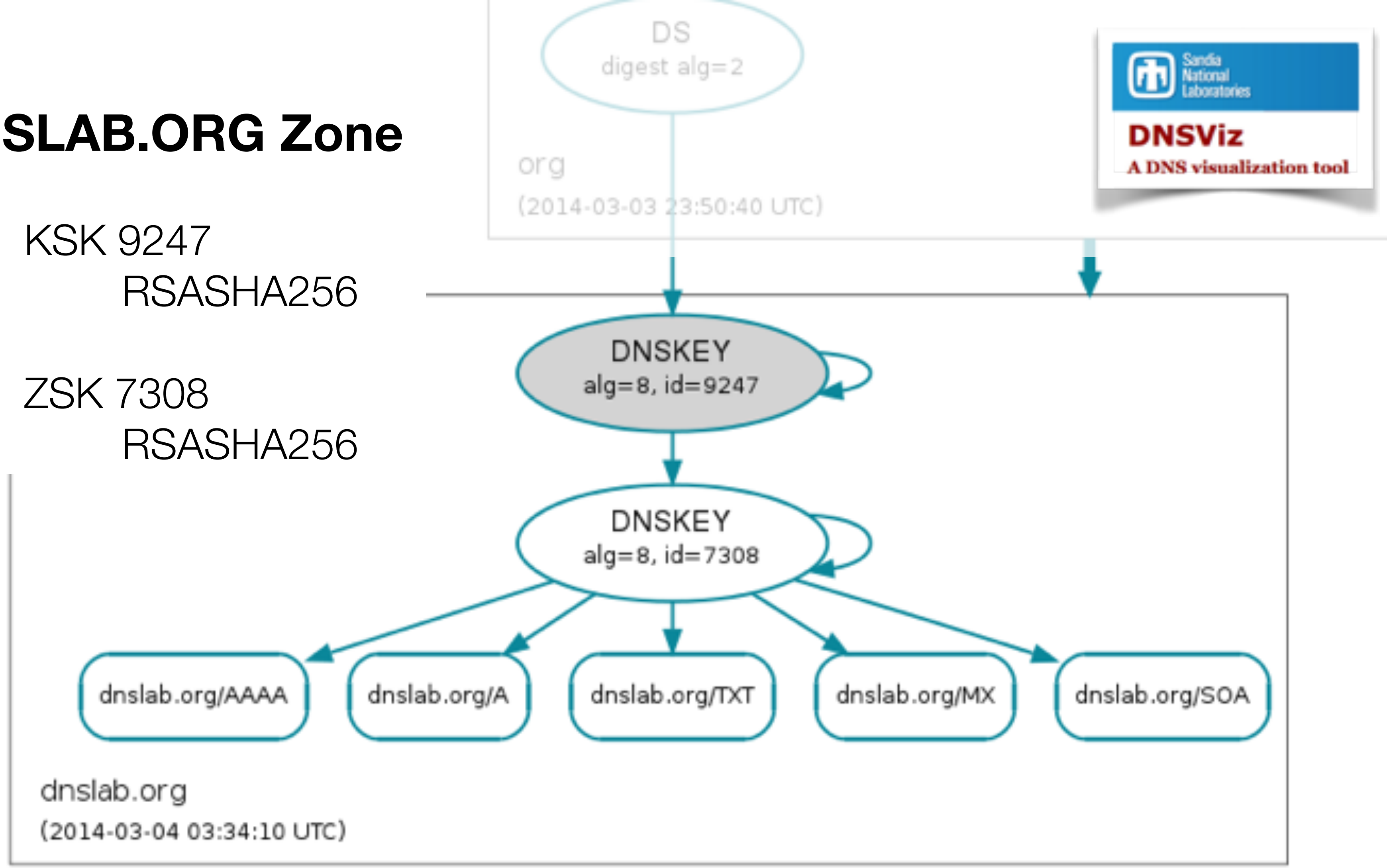
KSK 21366
NSEC3RSASHA1

ZSK 24209
NSEC3RSASHA1

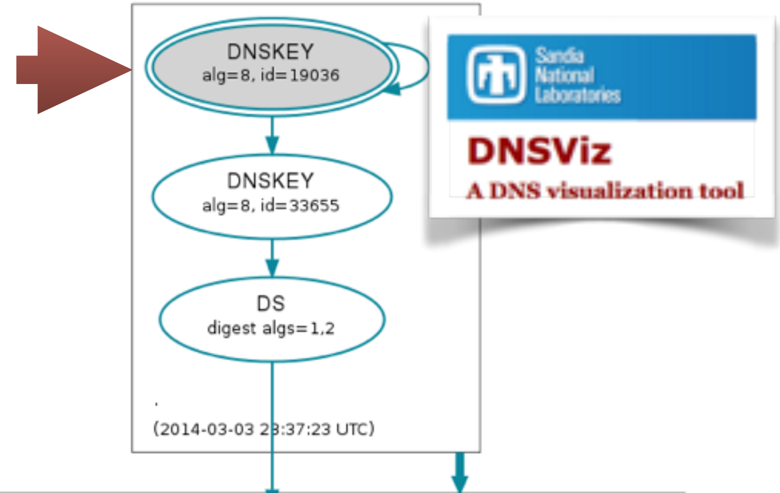
DNSLAB.ORG Zone

KSK 9247
RSASHA256

ZSK 7308
RSASHA256

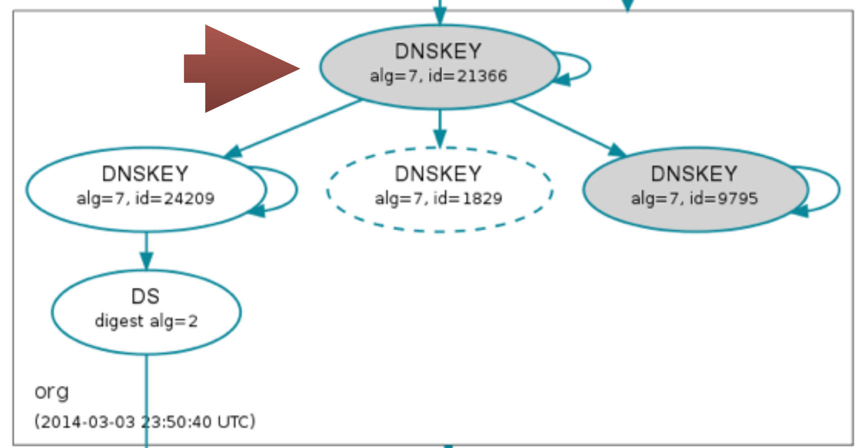


With a trust anchor for the root...



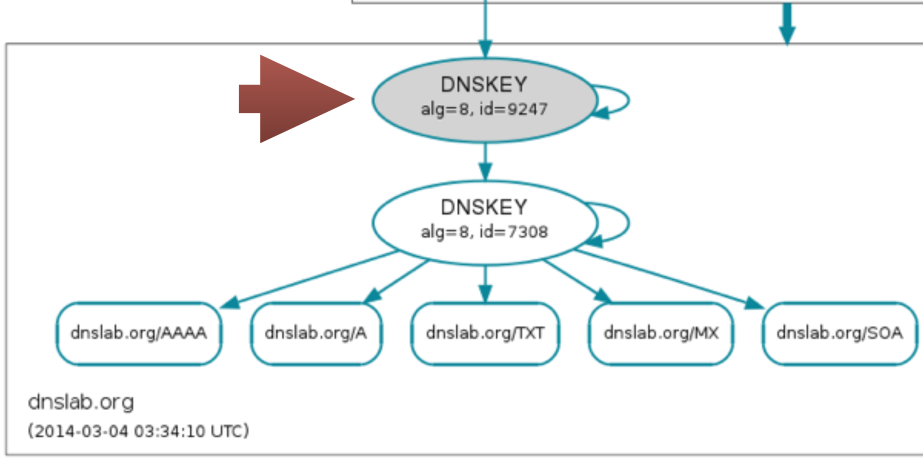
We trust . (root) KSK
We trust . (root) ZSK
We trust `org` DS

We trust `org` KSK
We trust `org` ZSK
We trust `dnslab.org` DS



We trust `dnslab.org` KSK
We trust `dnslab.org` ZSK
We trust `dnslab.org` RRsets

Or we can have a trust anchor for any KSK



```
DNSSEC Trust tree:
www.dnslab.org. (A)
|---dnslab.org. (DNSKEY keytag: 7308 alg
    |---dnslab.org. (DNSKEY keytag: 9247
    |---dnslab.org. (DS keytag: 9247 dig
        |---org. (DNSKEY keytag: 24209 a
            |---org. (DNSKEY keytag: 979
            |---org. (DNSKEY keytag: 213
            |---org. (DS keytag: 21366 d
            |   |---. (DNSKEY keytag: 33
            |       |---. (DNSKEY keytag
            |---org. (DS keytag: 21366 d
                |---. (DNSKEY keytag: 33
                    |---. (DNSKEY keytag
;; Chase successful
```

Key Rollover

Key Rollover

Key Rollover is by far the most terrifying part of DNSSEC

If rollover is done incorrectly, the zone affected "goes dark" and is unavailable to clients of validating servers

Having a zone "go insecure" is also not a good idea

- This could easily be a "career ending" move

So....

- Let's get to it

Key Rollover

The difficulty with key rollover is caused (mostly) by the "loose coherence" in the DNS caused by caching

- At no point can a signature exist for which the public portion of the key is not available

- At no point can the DS in the parent not match an active KSK in the child

Taking the TTL into account (and not rushing anything), rollover is actually very easy

Key Rollover

Remember:

- KSK signs <u>only</u> the DNSKEY RRset in a zone
- ZSK signs <u>all authoritative</u> RRsets in the zone
  - Everything except delegation NS records and glue

Initial signing of a zone causes it to expand anywhere up to 10x in size

- When we roll keys, we don't want to double it again

Key Rollover

For KSK, we don't mind creating "double signatures" since doubling one signature is inconsequential

For ZSK, we don't want to create "double signatures" since doubling signatures on every RRSet in the zone will cause an unnecessary "ballooning" of the zone

There are two mechanisms for rolling keys:

KSK ---> Double Signing

ZSK ---> Pre-publication

ZSK Rollover -- Pre-Publication

1. Generate a new ZSK
2. Publish both keys, use only the old one for signing
3. Wait at least propagation time + TTL of the DNSKEY RR
4. Use new key for zone signing; leave old one published
5. Wait at least propagation time + maximum TTL of the old zone
6. Remove old key & re-sign

KSK Rollover -- Double Signature

1. Generate new KSK

2. Publish both old and new KSK, using both keys for signing

3. Send new DS record to the parent

4. Wait until the DS is propagated + TTL of the old DS

5. Remove the old key & re-sign

Key Rollover Schedule

There is not "one answer" as to how often you should roll your keys.

NIST recommends:

KSK should be rolled once a year

ZSK should be rolled every 3 months

National Institute of Standards and Technology
U.S. Department of Commerce