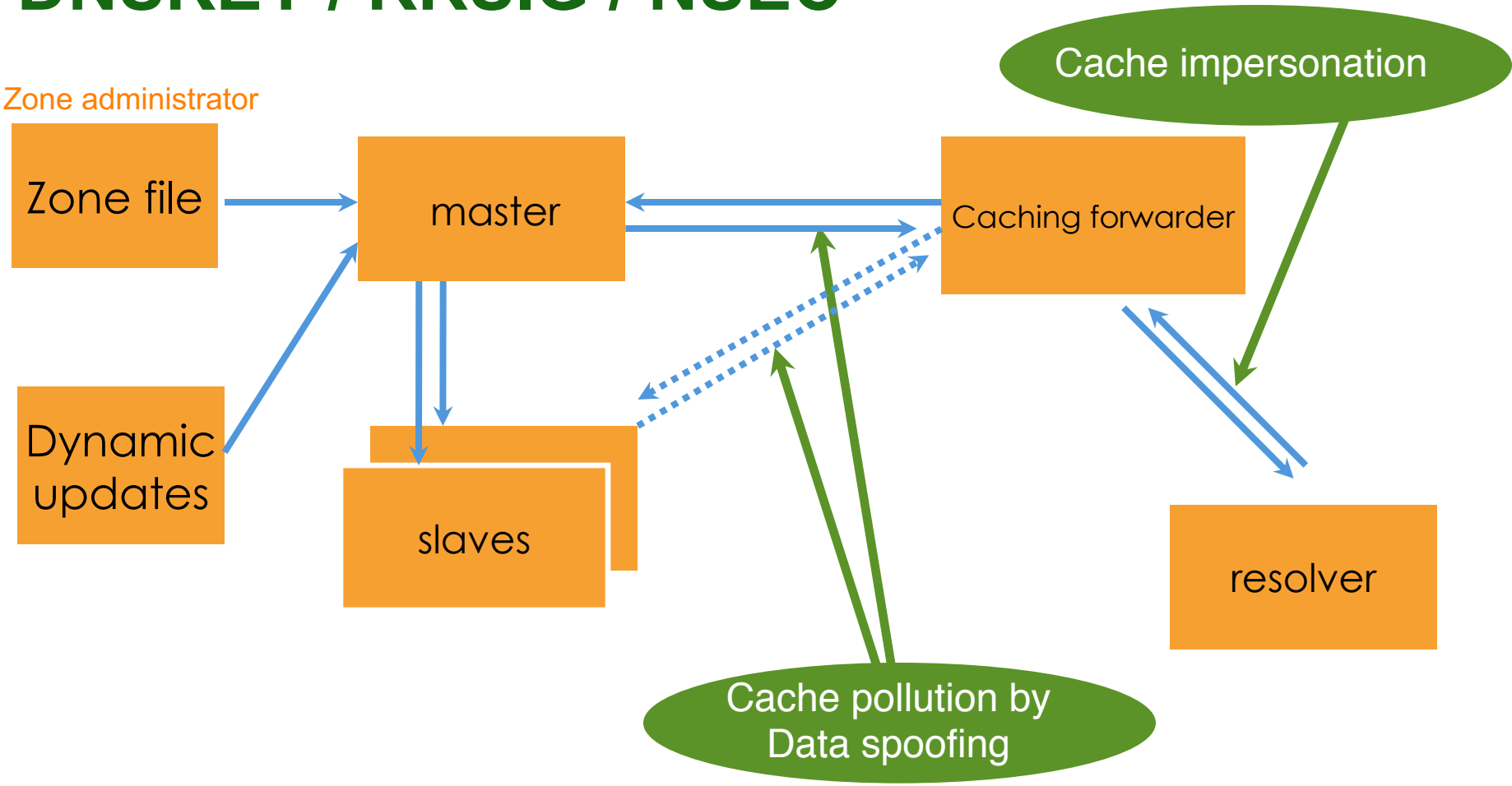
DNSSEC

Issue Date:

Revision:

APNIC

Vulnerabilities protected by DNSKEY / RRSIG / NSEC



What is DNSSEC?

- **DNS Sec**urity Extensions
- Protects the integrity of data in DNS by establishing a chain of trust
- A form of digitally signing the data to attest its validity
- Uses public key cryptography – each link in the chain has a public/private key pair
- Provides a mechanism to:
  - establish authenticity and integrity of data
  - delegate trust to third parties or parent zones

How DNSSEC Works

- Records are signed with private key to prove its authenticity and integrity
- The signatures are published in DNS
- Public key is also published so record signatures can be verified
- Child zones also sign their records with their private key
- Parent signs the hash of child zone's public key to prove authenticity

How DNSSEC Works

- Authoritative servers
  - Sign their zones
  - Answer queries with the record requested
  - Also send the digital signature corresponding to the record

- Validating Resolvers
  - Authenticates the responses from the server
  - Data that is not validated results to “SERVFAIL”

New Resource Records

Resource Record		Function
RRSIG	Resource Record Signature	Signature over RRset made using private key
DNSKEY	DNS Key	Public key needed for verifying a RRSIG
DS	Delegation Signer	Pointer for building chains of authentication
NSEC / NSEC3	Next Secure	indicates which name is the next one in the zone and which type codes are available for the current name

New Resource Records

- **RRsets** are signed with private key to prove its authenticity and integrity
- The signatures are published in DNS as **RRSIG**
- Public **DNSKEY** is also published so RRSIG can be verified
- Child zones also sign their records with their private key
- Parent signs the child zone's **DS record** to prove authenticity

RRs and RRsets

- Resource Record – each entry in the zonefile

```
www.example.net.  7200  IN  A 192.168.1.1
```

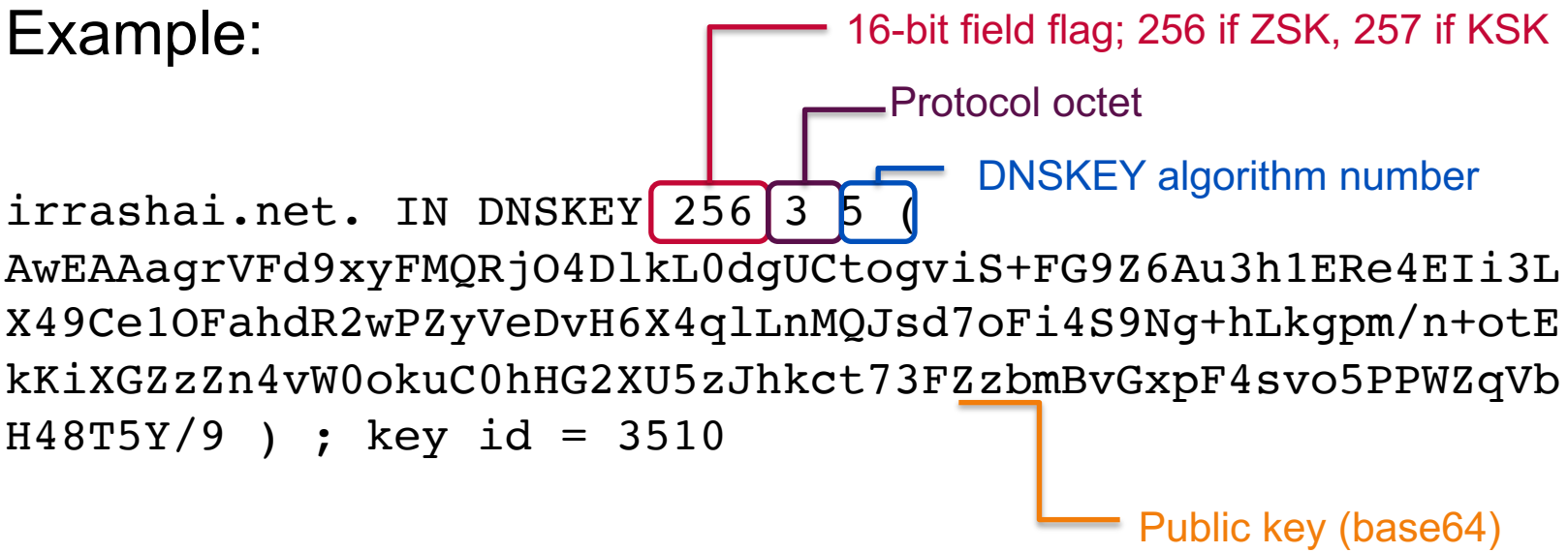
- RRset - RRs with same name, class and type

```
www.example.net. 7200 IN    A     192.168.1.1
web1.example.net. 7200 IN   A     10.0.0.1
web2.example.net. 7200 IN   A     172.16.0.20
```

In DNSSEC, RRsets are signed and not the individual RRs

DNSKEY

- Contains the zone's public key
- Uses public key cryptography to sign and authenticate DNS resource record sets (RRsets).
- Example:



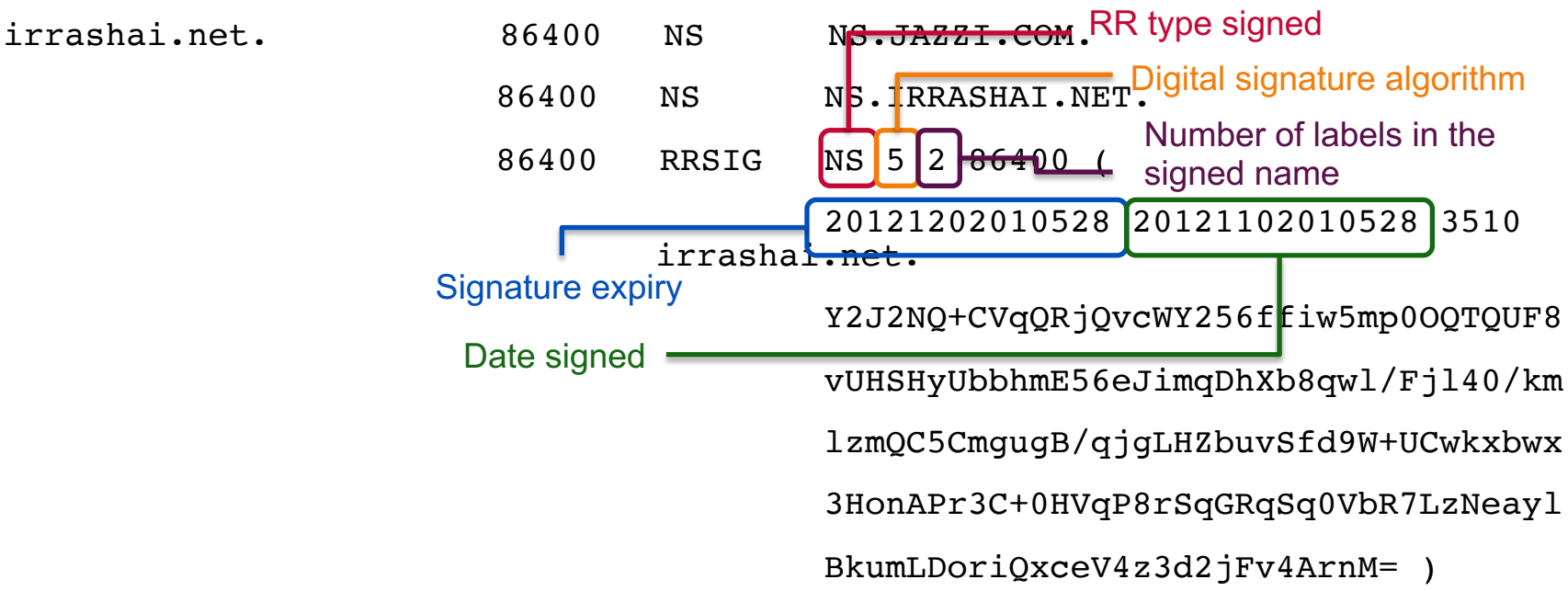
DNSKEY

- Also contains some timing metadata – as a comment in the key file

```
; This is a key-signing key, keyid 19996, for myzone.net.
; Created: 20121102020008 (Fri Nov  2 12:00:08 2012)
; Publish: 20121102020008 (Fri Nov  2 12:00:08 2012)
; Activate: 20121102020008 (Fri Nov  2 12:00:08 2012)
```

RRSIG

- The private part of the key-pair is used to sign the resource record set (Rrset)
- The digital signature per RRset is saved in an RRSIG record



NSEC Record

- **N**ext **Sec**ure
- Forms a chain of authoritative owner names in the zone
- Lists two separate things:
  - Next owner name (canonical ordering)
  - Set of RR types present at the NSEC RR's owner name
- Also proves the non-existence of a domain
- Each NSEC record also has a corresponding RRSIG

```
myzone.net.  NSEC blog.myzone.net. A NS SOA MX RRSIG NSEC DNSKEY
```

NSEC RDATA

- Points to the next domain name in the zone
  - also lists what are all the existing RRs for “name”
  - NSEC record for last name “wraps around” to first name in zone

- Used for authenticated denial-of-existence of data
  - authenticated non-existence of TYPEs and labels

NSEC Record – Example

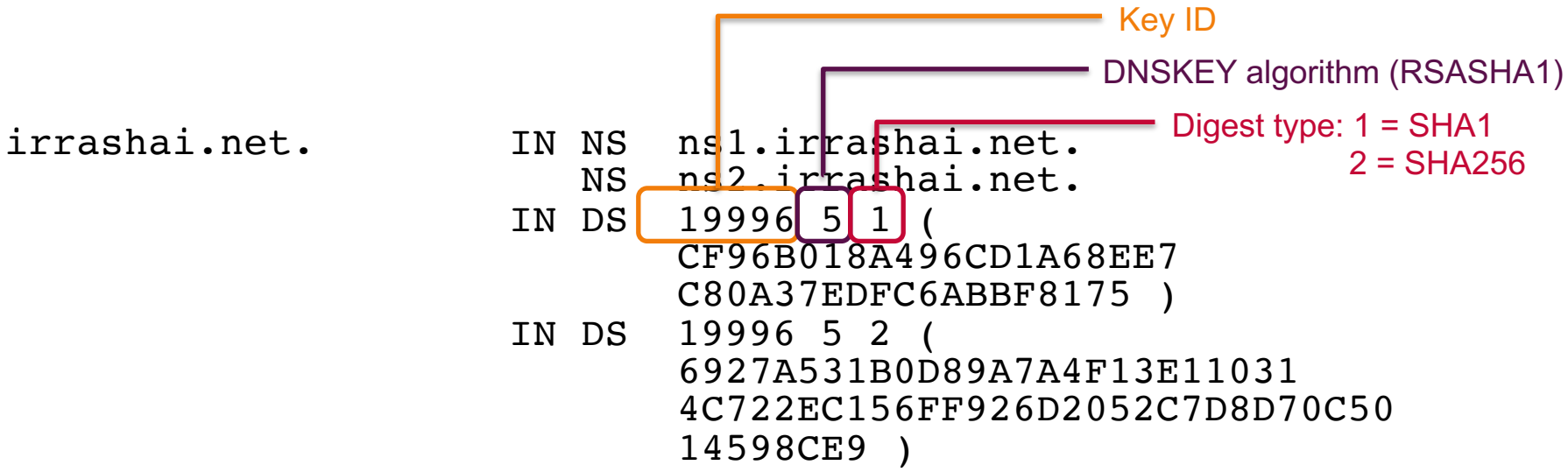
```
$ORIGIN example.net.
@ SOA        …
       NS     NS.example.net.
       DNSKEY …
       NSEC    mailbox.example.net. SOA NS NSEC DNSKEY        RRSIG

mailbox      A      192.168.10.2
                    NSEC  www.example.net.  A NSEC RRSIG
 WWW         A      192.168.10.3
                    TXT    Public webserver
                    NSEC  example.net. A NSEC RRSIG TXT
```

NSEC3

- NSEC allows an attacker to walk through the linked list to find all the records in the zone file. This is called zone walking.
- NSEC3 uses a hashing algorithm to list the next available domain in “hashed” format
- It is still possible for an attacker to do zone walking, although at a higher computation cost.

DS Record

- **D**elegation **S**igner
- Establishes authentication chains between DNS zones
- Must be added in the parent's zonefile
- In this example, irrashai.net has been delegated from .net. This record is added in the.net zone file



DS Record

- indicates that delegated zone is digitally signed
- Verifies that indicated key is used for the delegated zone
- Parent is authoritative for the DS of the child zone
  - Not for the NS record delegating the child zone
  - DS **should not** be added in the child zone

Chain of Trust

- Establishes a chain of trust from parent to child zone
- How?
  - Parent does not sign child zone
  - Parent only signs a pointer to the child zone (key) – DS RECORD
- The root is on top of the chain

Creation of keys

- In practice, we use two keypairs
  - one to sign the zones, another to sign the other key
- Using a single key or both keys is an operational choice (RFC allows both methods)
- If using a single key-pair:
  - Zones are digitally signed using the private key
  - Public key is published using DNSKEY RR
  - When key is updated, DS record must again be sent to parent zone
- To address this administrative load, two keypairs will be used

Types of Keys

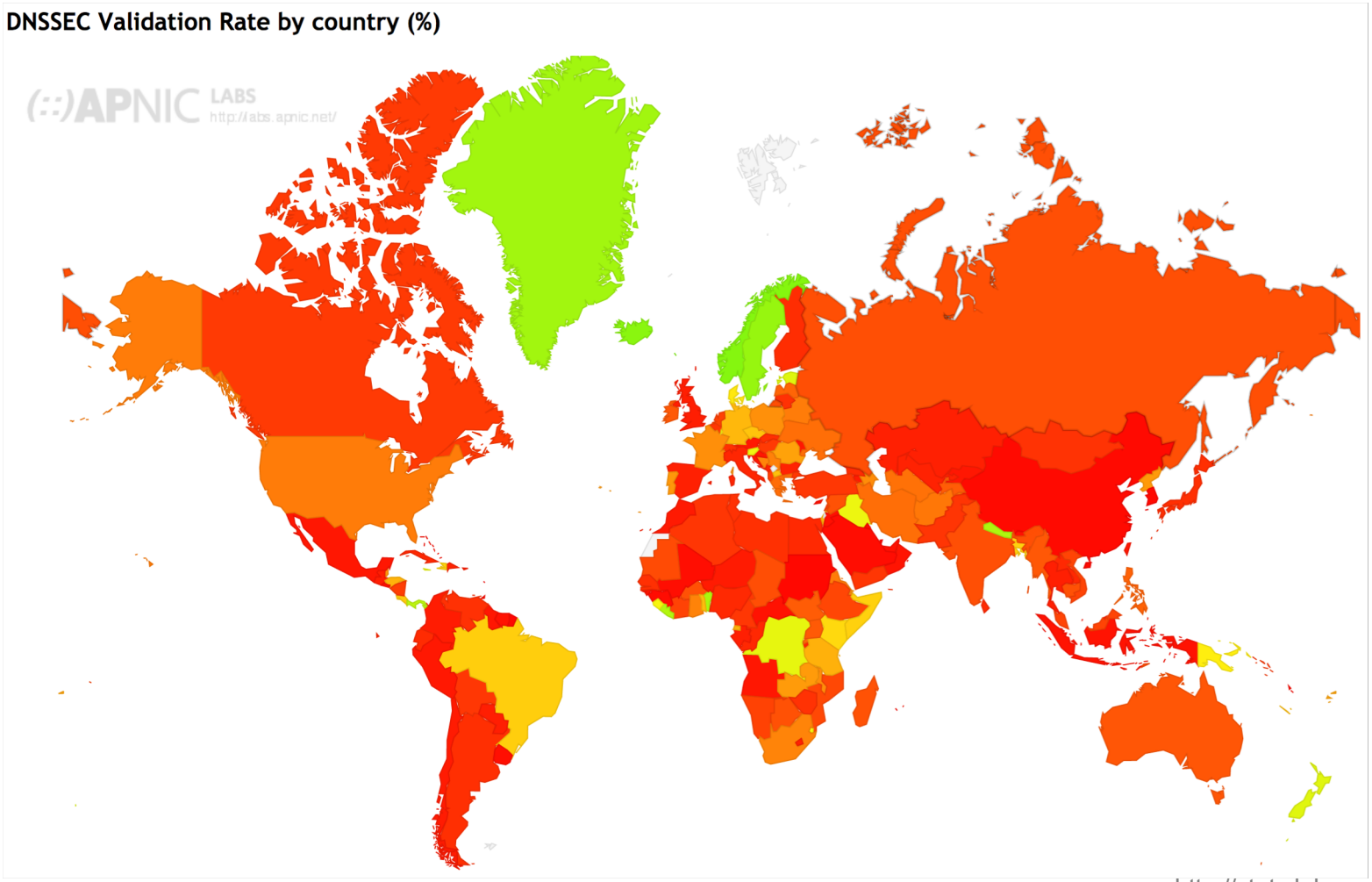
- Zone Signing Key (ZSK)
  - Signs the RRsets within the zone
  - Signed by the KSK
  - Uses flag 256

- Key Signing Key (KSK)
  - Signs the ZSK
  - Pointed to by the parent zone

Signature Expiration

- Keys do not expire
  - Still a good practice to generate new ones regularly for added security
- Signatures have validity period
  - By default set to 30 days
  - This info is added in the key metadata
- Expired signatures will not validate
  - Must re-sign the zones

DNSSEC Validation Rate



http://stats.labs.apnic.net/dnssec

DNSSEC in the Resolver

- Recursive servers that are dnssec-enabled can validate signed zones
- Enable DNSSEC validation

```
dnssec-validation yes;
```

- The AD bit in the message flag shows if validated

DNSSEC Validation

- Other options if you don't have a validating resolver
  - validator add-on for your web browser
    - ex: https://www.dnssec-validator.cz/
  - Online web tools
    - http://dnsviz.net/
    - http://dnssec-debugger.verisignlabs.com/
- Use an open DNSSEC-validating resolver
  - DNS-OARC's ODVR (link)
    - 149.20.64.20 (BIND9), 149.20.64.21 (Unbound)
  - Google Public DNS
    - 8.8.8.8 or 8.8.4.4

DNSSEC – Setting up a Secure Zone

- Enable DNSSEC in the configuration file (named.conf)
  - `dnssec-enable yes; dnssec-validation yes;`
- Create key pairs (KSK and ZSK)
  - `dnssec-keygen -a rsasha1 -b 1024 -n zone champika.net`
- Publish your public key
- Signing the zone
- Update the config file
  - Modify the zone statement, replace with the signed zone file
- Test with dig

Updating the DNS Configuration

- Enable DNSSEC in the configuration file (named.conf)

```
options {
        directory "…."
        dnssec-enable yes;
        dnssec-validation yes;
};
```

- Other options that can be added later

```
auto-dnssec { off | allow | maintain} ;
```

  - These options are used to automate the signing and key rollover

Generating Key Pairs

- Generate ZSK and KSK

```
dnssec-keygen -a rsasha1 -b 1024 -n zone <myzone>
```

Default values are RSASHA1 for algorithm, 1024 bits for ZSK and 2048 bits for KSK

The command above can be simplified as:

```
dnssec-keygen –f KSK <myzone>
```

This generates four files.

Note: There has to be at least one public/private key pair for each DNSSEC zone

Generating Key Pairs

- To create ZSK

```
dnssec-keygen -a rsasha1 -b 1024 -n zone
myzone.net
```

- To create KSK

```
dnssec-keygen -a rsasha1 -b 2048 -f KSK -n
zone myzone.net
```

Generating Key Pairs - Reverse

- To create ZSK

```
dnssec-keygen -a rsasha1 -b 1024 -n zone
100.168.192.in-addr.arpa
```

- To create KSK

```
dnssec-keygen -a rsasha1 -b 2048 -f KSK -n
zone 100.168.192.in-addr.arpa
```

Publishing the Public Key

- Using `$INCLUDE` you can call the public key (DNSKEY RR) inside the zone file

```
$INCLUDE /path/Kmyzone.net.+005+33633.key ; ZSK
$INCLUDE /path/Kmyzone.net.+005+00478.key ; KSK
```

- You can also manually enter the DNSKEY RR in the zone file

Signing the Zone

- Sign the zone using the secret keys:

```
dnssec-signzone –o <zonename> -N INCREMENT -f
<output-file> -k <KSKfile> <zonefile> <ZSKfile>
```

```
dnssec-signzone –o myzone.net db.myzone.net
Kmyzone.net.+005+33633
```

- Once you sign the zone a file with a .signed extension will be created
  - `db.myzone.net.signed`

Signing the Zone

- Note that only authoritative records are signed
  - NS records for the zone itself are signed
  - NS records used for delegations are not signed
  - DS records are signed
  - Glue records are not signed
- Notice the difference in file size
  - db.myzone.net vs. db.myzone.net.signed

Smart Signing

- Searches the key repository for any keys that will match the zone being signed

```
options {
     keys-directory { “path/to/keys”;
};
```

- Then the command for smart signing is

```
dnssec-signzone –S db.myzone.net
```

Publishing the Zone

- Reconfigure to load the signed zone. Edit named.conf and point to the signed zone.

```
zone “<myzone>” {
     type master;
     # file “db.myzone.net”;
     file “db.myzone.net.signed”;
};
```

Publishing the Zone – Reverse

- Reconfigure to load the signed zone. Edit named.conf and point to the signed zone.

```
zone “<myzone>” {
     type master;
     # file “db.192.168.100”;
     file “db.192.168.100.signed”;
};
```

Testing the Server

- Ask a dnssec-enabled server and see whether the answer is signed

```
dig @localhost www.apnic.net +dnssec
+multiline
```

Testing with Dig

`dig @localhost www.irrashai.net +dnssec (+multiline)`

```
; <<>> DiG 9.9.5-P1 <<>> @localhost www.irrashai.net +dnssec
; (2 servers found)
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 10871
;; flags: qr aa rd ra; QUERY: 1, ANSWER: 2, AUTHORITY: 2, ADDITIONAL: 3

;; OPT PSEUDOSECTION:
; EDNS: version: 0, flags: do; udp: 4096
;; QUESTION SECTION:
;www.irrashai.net.              IN      A

;; ANSWER SECTION:
www.irrashai.net.       864000  IN      A       192.168.100.100
www.irrashai.net.       864000  IN      RRSIG   A 5 3 864000 20150604031347 20150505031347 44727 irrashai.net. HBFfuooWXCIOyOuySO11/rSru5smi/E2mXAHR2tEP093IT8gMIPSQIL4 78XN3ecg3xQ1o
oeYTFjX6dgknE6Y4o179Ufba+zreHRP6sbBf852Btf4 wSExAZdOS9BmTEtDlhKXRDMnc0/9enqcfnku7IQqDYxudGBGfNmF5mnr gGY=

;; AUTHORITY SECTION:
irrashai.net.           864000  IN      NS      NS.IRRASHAI.NET.
irrashai.net.           864000  IN      RRSIG   NS 5 2 864000 20150604031347 20150505031347 44727 irrashai.net. 0BdYHJMLtvhhfbdwtcA4Z0Ja83L6iB51msJpurYzzffmiB5amq1V30YR vaFHqYM64Lmi
iXAePvq/mpdvutx6FiggNTyVb0HQ7+1ecHdNXO+AkGuF 2h4Go/rpjBpBN9a4Fexvuw7laO8CSykpfTNZ4hNaFagO/WmzbE9Pzm1K Vmg=

;; ADDITIONAL SECTION:
ns.irrashai.net.        864000  IN      A       192.168.100.8
ns.irrashai.net.        864000  IN      RRSIG   A 5 3 864000 20150604031347 20150505031347 44727 irrashai.net. MQQsnqWjMDJXI1VHNzXWywbRqDhYrEqxd3tMtx2Ua8ep+HYMfsJ/8/Im F9IfdPKm3TN+6
okecCionMixtzuvNLAs9FXY5q5V0lpSuC+oRe6Fulip i75uvARtYoLttB3zBHVzAIIlULzsDyrgagZZNrSS+EF12oeKNwOSYEir 64k=

;; Query time: 0 msec
;; SERVER: ::1#53(::1)
;; WHEN: Wed May 06 17:10:44 EST 2015
;; MSG SIZE  rcvd: 625
```

Testing with Dig – Reverse

```
dig @localhost -x 192.168.100.100 +dnssec
```

```
; <<>> DiG 9.9.5-P1 <<>> @localhost -x 192.168.100.100 +dnssec
; (2 servers found)
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 10393
;; flags: qr aa rd ra; QUERY: 1, ANSWER: 2, AUTHORITY: 2, ADDITIONAL: 3

;; OPT PSEUDOSECTION:
; EDNS: version: 0, flags: do; udp: 4096
;; QUESTION SECTION:
;100.100.168.192.in-addr.arpa.  IN      PTR

;; ANSWER SECTION:
100.100.168.192.in-addr.arpa. 864000 IN PTR     www.irrashai.net.
100.100.168.192.in-addr.arpa. 864000 IN RRSIG   PTR 5 6 864000 20150604031101 20150505031101 22107 100.168.192.in-addr.arpa. FyBAUv5Z8Z+8H8ZpbxZjAaFIpC9cJfzwY8Ojuol92wetwdzF0dyUV9v/
 XSwizzqGO9Pe3nchwRJNt7Of27xB52HgYOryyO/UudxF5TxN8Dp10rmj AbbR/9GrWIW9TOunBWfv17Pnxb1AMvTckncdogZeSghRV5QZ6rvmMtx2 yxk=

;; AUTHORITY SECTION:
100.168.192.in-addr.arpa. 864000 IN     NS      NS.IRRASHAI.NET.
100.168.192.in-addr.arpa. 864000 IN     RRSIG   NS 5 5 864000 20150604031101 20150505031101 22107 100.168.192.in-addr.arpa. mXv26lJVvtAZxM7Ni/DZwr7Vw/xZ5da8iflNRTm0zWe3huKiBkCoXnB0
TXmTNQKxfknfA1pLPrC4OZL4UyP00vAOwi5VYFZzwF/KA9xI9o8f59ng KbxWsbGtHLl3/e4Q8+lKSfVb4Al0cAF/m3yauQjYHGXzCHBO76w9nhk+ E7A=

;; ADDITIONAL SECTION:
ns.irrashai.net.        864000  IN      A       192.168.100.8
ns.irrashai.net.        864000  IN      RRSIG   A 5 3 864000 20150604031347 20150505031347 44727 irrashai.net. MQQsnqWjMDJXI1VHNzXWywbRqDhYrEqxd3tMtx2Ua8ep+HYMfsJ/8/Im F9IfdPKm3TN+6
okecCionMixtzuvNLAs9FXY5q5V0lpSuC+oRe6Fulip i75uvARtYoLttB3zBHVzAIIlULzsDyrgagZZNrSS+EF12oeKNwOSYEir 64k=

;; Query time: 0 msec
;; SERVER: ::1#53(::1)
;; WHEN: Wed May 06 17:08:58 EST 2015
;; MSG SIZE  rcvd: 675

[root@testserver master]# _
```

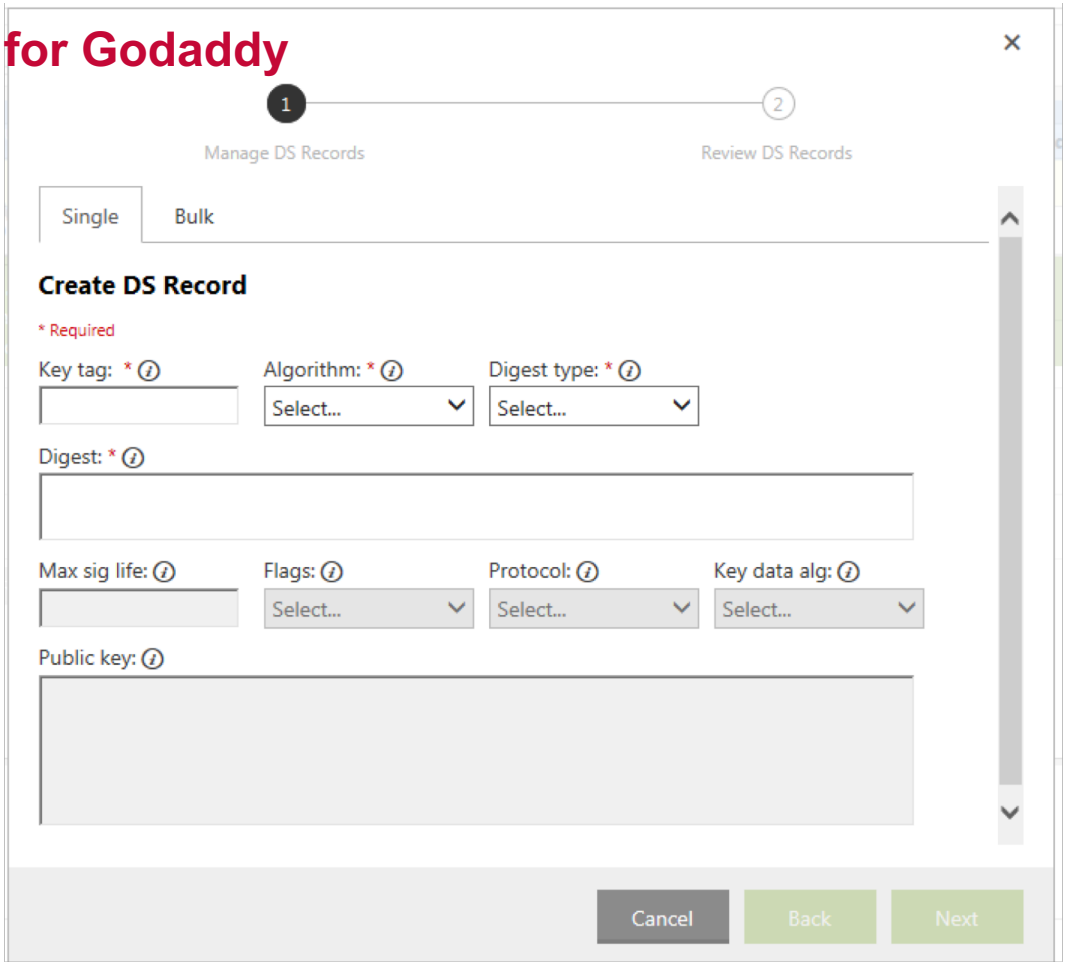
Pushing the DS record

- The DS record must be published by the parent zone.
- Contact the parent zone to communicate the KSK to them.

- There are proposals in the IETF DNSOP WG to address this:
  - Automating DNSSEC Delegation Trust Maintenance (link)
  - Child to Parent Synchronization in DNS (link)

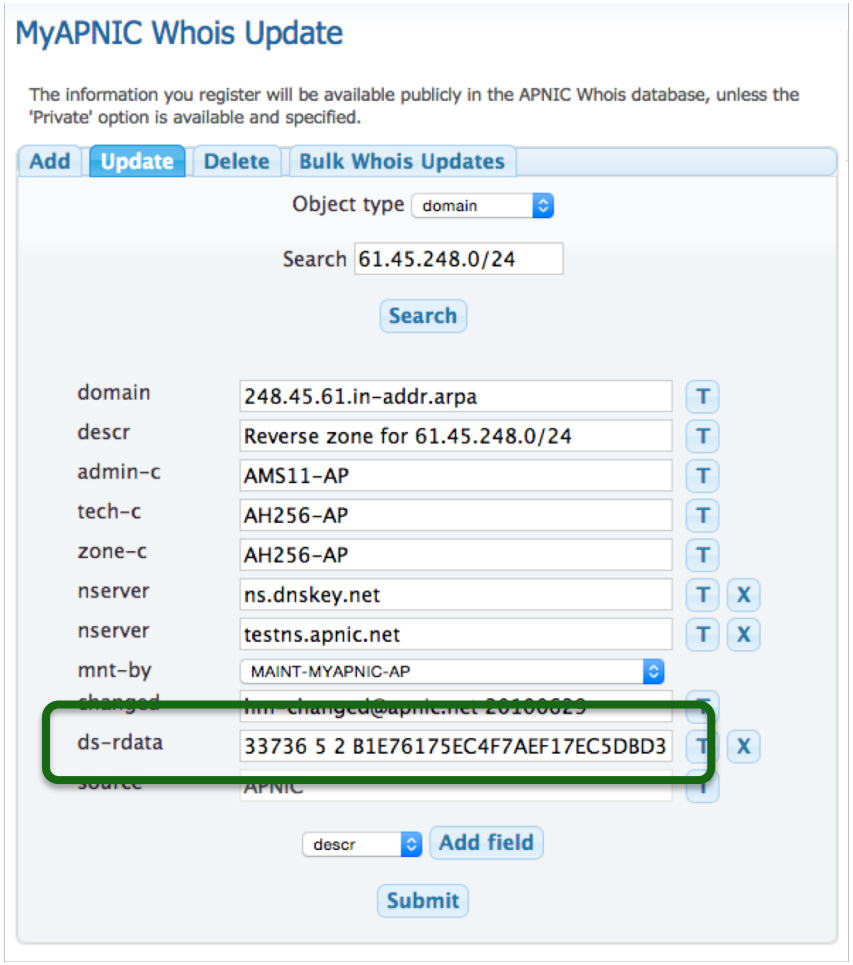
Pushing DS Records for Forward Zone

Example form for Godaddy



Pushing DS Record for Reverse Zone

Using MyAPNIC



DS record added in the domain object