Ch 6: DNSSEC and Beyond

Updated 11-22-16

DNSSEC

Objectives of DNSSEC

- Data origin authentication
  - Assurance that the requested data came from the genuine source
- Data integrity
  - Assurance that the data have not been altered

Development of DNSSEC

- Record signatures use public-key cryptography to verify authenticity of DNS records
- RFC 2065 (1997): SIG and KEY records
- RFC 2535 (1999): NXT record – denial of existence of a record
- 2003: DS (Delegation Signer) record
  - Allows secure delegation to child zones
  - SIG, KEY, NXT evolved to RRSIG, DNSKEY, NSEC

Development of DNSSEC

- RFC 3757 (2004)
  – Zone-Signing Key (ZSK)
  – Key-Signing-Key (KSK)
  – Secure Entry Point (SEP)
    - A flag used to identify a KSK
- 2005
  – NSEC replaced by NSEC3

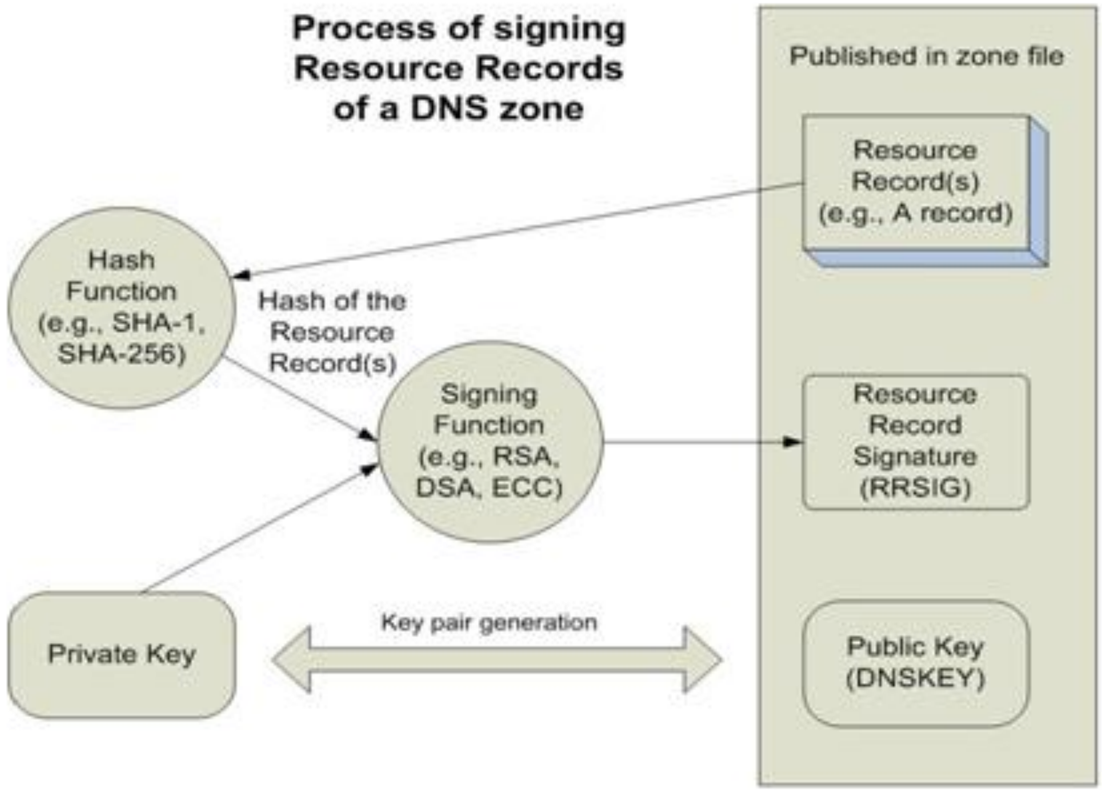


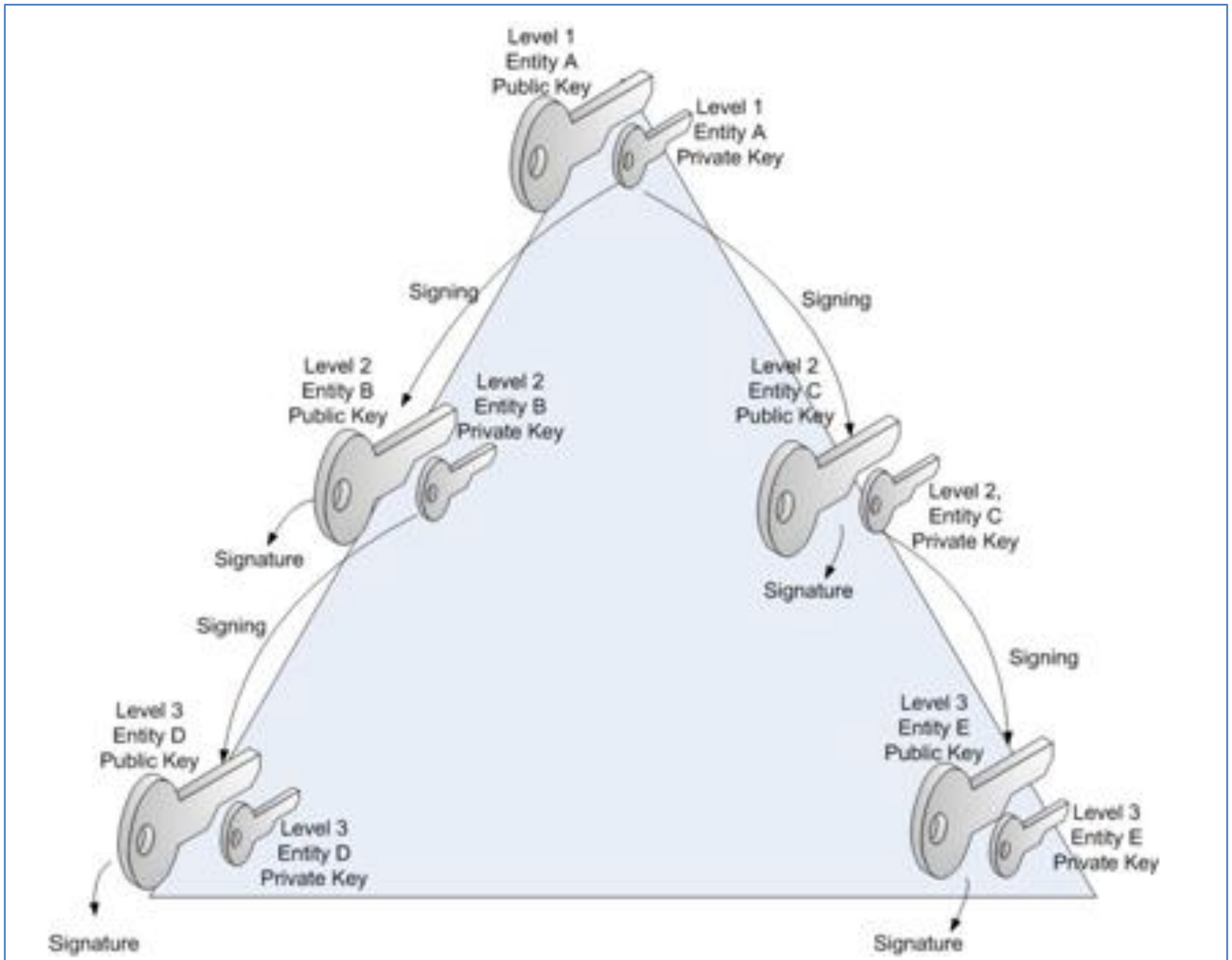
Figure 53: The process of signing the resource records of a DNS zone. Using a public key cryptography algorithm, we first generate a key pair, consisting of a private and a public key. A set of records (RR set) are passed through a hash function (such as SHA1 or SHA-256). The private key is then used to sign the hash of the selected resource records using an algorithm such as RSA, DSA or Elliptic Curve. The resource records, along with their corresponding signature and public key are published in the zone file.

Man-in-the-Middle Attack

- Attacker generates two “false” key pairs
- Attacker intercepts the genuine keys and send false keys out
- Client trusts the Attacker's data

• Trusted third party prevents this attack
  - The root of DNS

Hierarchical Chain of Trust



The Delegation Signer (DS) Record

- Links in the chain of trust
- DS record contains a hash of a zone's public key
- To make performance better, the zone key may be separated into
  - Zone Signing Key (ZSK) and
  - Key Signing Key (KSK)

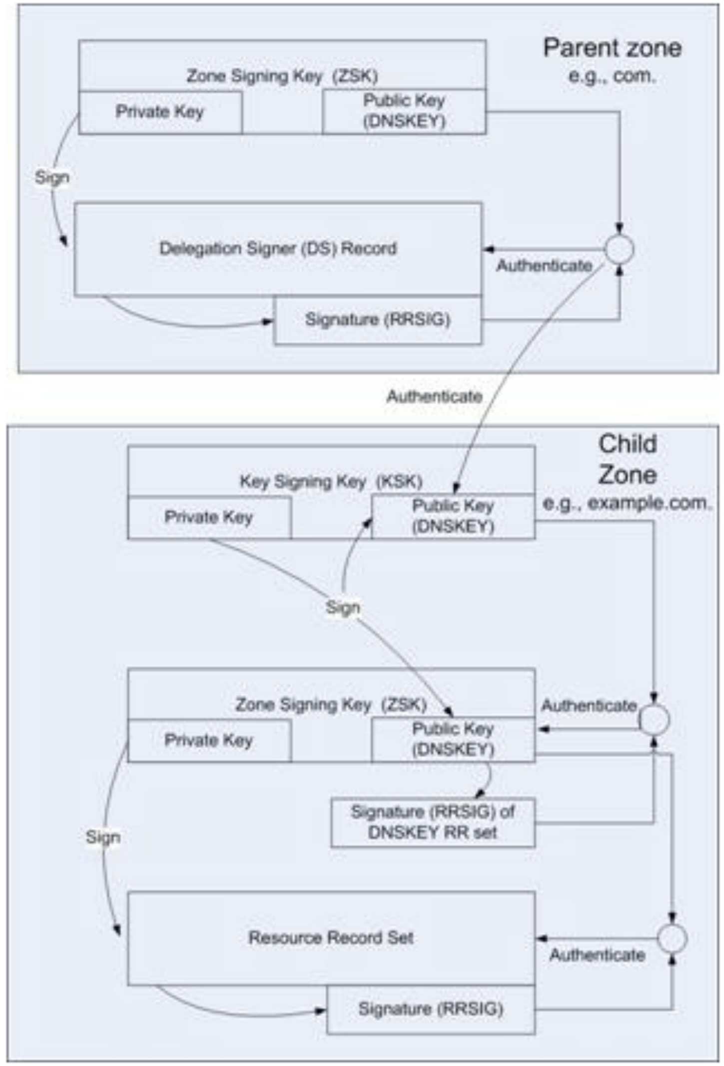


Figure 56: Delegation Signer (DS) records are used to establish a chain of trust in DNSSEC between a parent and a child

Authenticated Denial of Existence NSEC and NSEC3 Records

- Sort all domain names in zone in alphabetical order
  - a.example.com with A, AAAA, RRSIG
  - c.example.com
- NSEC Record
  - **a.example.com** TTL IN NSEC **c.example.com** A AAAA RRSIG
  - Nothing between **a.example.com** and **c.example.com**
- This record proves there is no b.example.com

Example

```
~ $dig a.b.c.d.us. +dnssec
```

```
us.                    21599    IN       NSEC     0-.us. NS SOA RRSIG NSEC DNSKEY
```

- Proves there is no *.us

```
CZZH.us.               21599    IN       NSEC     D-.us. NS RRSIG NSEC
```

- Proves there is no d.us

NSEC Information Disclosure

- Easy to find all domains in a zone
- Like a zone transfer
- dig *.se +dnssec
  - Reveals first valid hostname
- Dig for valid hostname* to find next one
- NSEC3 fixes this problem

NSEC3 Hostnames are Hashed and Salted

- Can be hashed many times

Algorithm and Salt in Record

The presentation format[45] of the record also contains a hash algorithm identifier (e.g., SHA1 etc.), a flags field, the number of hashing iterations executed, and the salt used to seed the hash:

```
<Hashed_owner_name.zonename> <TTL> <CLASS> NSEC3 <Algorithm ID> <Flags> <Iterations> <Salt> <Next_hashed_owner_name> <List of Types at the original owner name>
```

```
Sams-MacBook-Air-2:~ sambowne$ dig a.b.cia.mil +dnssec

; <<>> DiG 9.8.3-P1 <<>> a.b.cia.mil +dnssec
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NXDOMAIN, id: 2162
;; flags: qr rd ra ad; QUERY: 1, ANSWER: 0, AUTHORITY: 8, ADDITIONAL: 1

;; OPT PSEUDOSECTION:
; EDNS: version: 0, flags: do; udp: 512
;; QUESTION SECTION:
;a.b.cia.mil.                   IN      A

;; AUTHORITY SECTION:
mil.                    1800    IN      SOA     CON1.NIPR.mil. DISA\.COLUMBUS\.NS\.MBX\.HOSTMASTER-DOD-NIC.
MAIL.mil. 2013120901 3600 900 1209600 10800
mil.                    1800    IN      RRSIG   SOA 8 1 21600 20131216182101 20131209182101 51921 mil. VtXu
YT/snP5dafjC1MH8raTXLXLm/LJ6EnEOCFSB3DVZMm3UwHKnqG2X gPONA7eZi385SYovdC+5nQVTYoHzX4m6h4LvMeTESo8k4Md05AgDIN
ov AlWzC3PXh3SsV9jCc2uhr26JRr2BrHabNv51NZu5GhAXn83VSxvdhGzH P4I0Anc=
UN6A0HU9UVDKVNUE9L1QMK82DKNP6QHG.mil. 10800 IN NSEC3 1 0 10 EAAA UQ3DUC8QJRQ7B1FSFE0J3ANEN2R0V4LL NS SOA RR
SIG DNSKEY NSEC3PARAM
UN6A0HU9UVDKVNUE9L1QMK82DKNP6QHG.mil. 10800 IN RRSIG NSEC3 8 2 10800 20131216182101 20131209182101 51921 mi
l. YfFhajnoMf1Fwo+pcYfqbKH5n/jg01w+hCSfaIoafAzOPVEjjGRR5Mke A2p+SBgS9qCZQkuIuoSFIv/U+lyxG801337Es01G/uSJUPl
qCWPoKl98 BpFXqrNWIFZivSeswNYbE2aK4CPzZhb8hqNMp9u+nvO5y6p0HkGHKEpT RyK/woc=
LRIPSTTJ7TOQATH6L9LRPPTS94KLSK4A.mil. 10800 IN NSEC3 1 0 10 EAAA LSJHCKOHBN8GRT54OMJ6PS9KD39BE5D5 NS
LRIPSTTJ7TOQATH6L9LRPPTS94KLSK4A.mil. 10800 IN RRSIG NSEC3 8 2 10800 20131216182101 20131209182101 51921 mi
l. lmbtgVTY5yWyxDf3RMi85OLWQYUSNEK9WIT9jKtVMynR1EImGwMZalkd FVX9D+iXm/NLJhZjD7CTdNW68mNP0L7vWuvKkbLf2U9qJKI
REpcVpQKf 3efnCdt/Gx8UvcYmIHZgoCNJM74FbM2DXHUCVbwk6YYIPR4M3sXclJaB 2FhKGsc=
QNI13VV1NPF2E3K6GFMA7K5SQ8T08RQ9.mil. 10800 IN NSEC3 1 0 10 EAAA R5I410NG3VBPRU3H05V9UB2NC0UN9HT1 NS DS RRS
IG
QNI13VV1NPF2E3K6GFMA7K5SQ8T08RQ9.mil. 10800 IN RRSIG NSEC3 8 2 10800 20131216182101 20131209182101 51921 mi
l. LfFnJMzthb1/ePjNhX18Bk/rkjcx3vUimIT6iCUaA7N4tZvG3nrTLXu6 a9TYL9JQ9SlSlzmdUpnfxsHjqx1RdN3w7tcFcnLfgphzKko
EbLt8tiiq +fN5ljAFjHKwBGcl1q8lwzBnDhSQC/QTZw+kLJD/27L79za74MXUj1Le GViJSs4=

;; Query time: 154 msec
;; SERVER: 8.8.8.8#53(8.8.8.8)
;; WHEN: Tue Dec 10 08:43:49 2013
;; MSG SIZE  rcvd: 1034
```

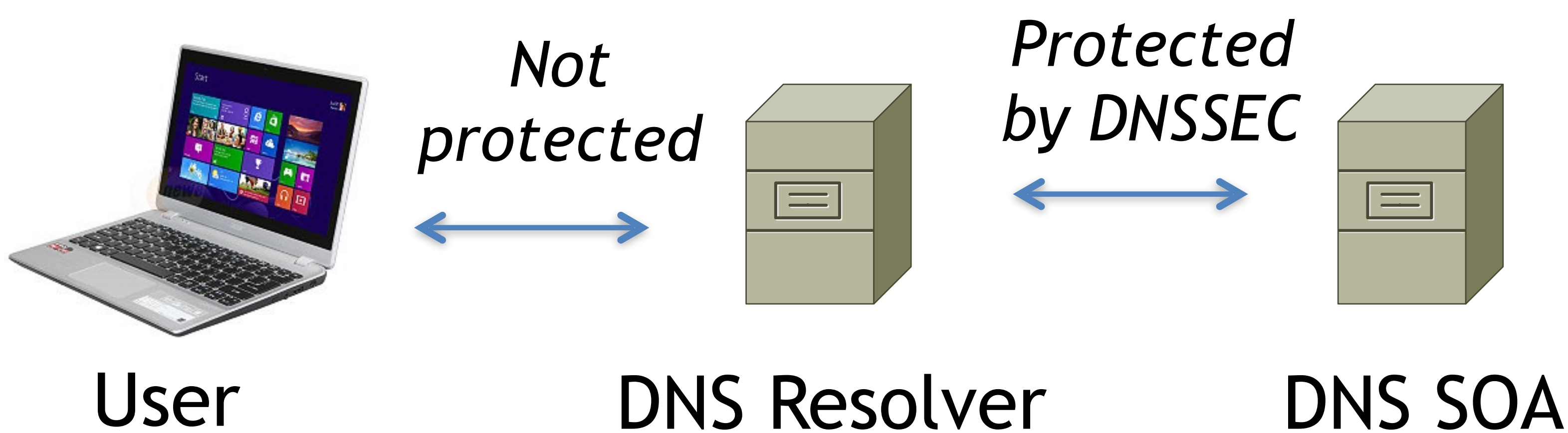
Making a Validating Resolver

- See Proj 7x

Weaknesses of DNSSEC

Lack of Protection Between User Devices and Resolvers

- Attacker in the middle has enough info to perfectly forge responses
  - Unless DNSSEC is enforced in the client's browser



Lack of Protection of Glue Records

- DNSSEC only protects Resource Records if they are authoritative in the zone
- Glue records are resource records that facilitate a resolution that is delegated from a parent zone to a child zone
- They are owned by the child zone but appear in the parent zone
- So they are non-authoritative
- Not protected by DNSSEC

Key Changes Don't Propagate

- Keys can
  - Roll over
  - Be Revoked
  - Signatures can expire
- These events do not propagate down the DNS tree

NSEC3 Denial of Service

- If a zone is insecurely delegated to another zone
- And it includes NSEC3 records
- A MITM can block resolution of a domain
- Or delegate the resolution to another server and change the A record
- Enabling spoofing, cookie-stealing, etc.

Re-Addressing Replay Attack

- If a server moves to a new hosting provider
- The old IP address can be used until the signatures expire
- Because there's no way to push signature expiration from authoritative servers to resolvers

NSEC3 Still Allows Zone Walking

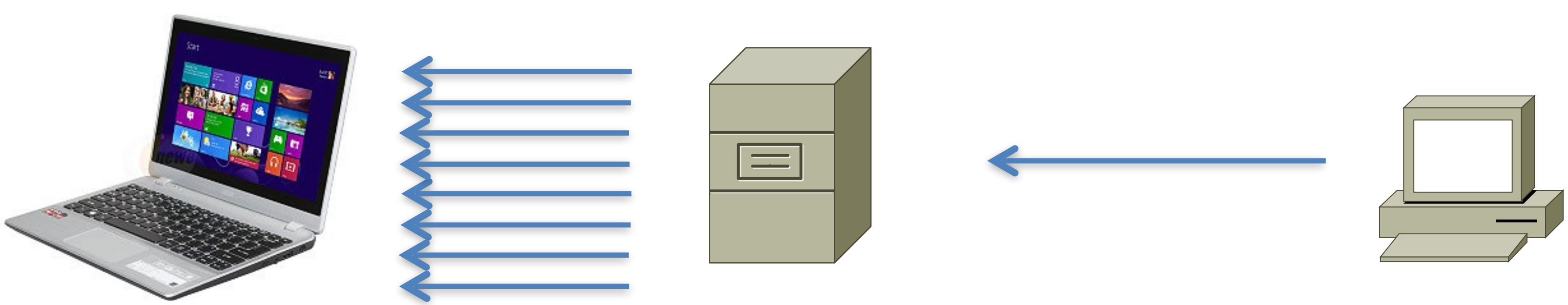
- An offline dictionary attack can be used to guess the hashes
- It's the same as cracking password hashes

No Protection of DNS or Lower Layer Header Data

- The AD flag is part of the DNS header
  - Authenticated Data flag, indicating that the response data was verified by DNSSEC
  - Can't be trusted, because
- Can be changed by a MITM
- DNSSEC won't detect that

DNSSEC Data Inflate Zone Files and DNS Packet Sizes

- Small requests lead to large responses
- UDP allows spoofing the source IP address



Target Open DNS Resolver Attacker

DNSSEC Increases Computational Requirements on Validators and Servers

- Verifying signatures
- Calculating hashes for NSEC3 records

DNSCurve

Encrypted Packets

- Operates at layer 2 (Data Link)
- Uses Elliptic Curve Cryptography
- Each request and response packet is encrypted in its entirety
  - DNSSEC doesn't encrypt any data, it just signs it
- ECC keys are 256 bits long
- Calculation is much faster than RSA

DNSCurve Limitations

- Not yet an IETF standard
- Does not provide end-to-end security
  - Just from endpoint to resolver
- Name-server names need to be longer to include a Base-32 encoded 53-byte public key
  - Makes responses even larger
- DNS Queries may exceed 255 bytes, which will be dropped by old middleware
- Key compromise requires renaming the server
  - And manual update of NS record in the parent zone