DNSSEC Mechanisms

- New Resource Records
- Setting Up a Secure Zone
- Delegating Signing Authority
- Key Rollovers
- AD, CD, DO bits

Public Key Crypto (in one slide)

- Key pair: a secret (or private) key and a public key
- Simplified:
  - If you know the public key, you can decrypt data encrypted with the secret key
    - Usually an encrypted hash value over a published piece of information; the owner is the only person who can construct the secret. Hence this a signature
  - If you know the secret key, you can decrypt data encrypted with the public key
    - Usually an encrypted key for symmetric cipher
- PGP uses both, DNSSEC only uses signatures
- Algorithms: RSA, DSA, Elliptic curve, etc...

Public Key Issues

- Public keys need to be distributed.
- Private keys need to be kept private
- Both key distribution and secrecy are not trivial
- Public key cryptography is ‘slow’

The DNS is Not a PKI

- All key procedures are based on local policy
- A PKI is as strong as its weakest link
  - Certificate Authorities control this through SLAs
- The DNS does not have Certificate Revocation Lists
- If the domain is under one administrative control you might be able to enforce policy

Security Status of Data (RFC4035)

- Secure
  - Resolver is able to build a chain of signed DNSKEY and DS RRs from a trusted security anchor to the RRset
- Insecure
  - Resolver knows that it has no chain of signed DNSKEY and DS RRs from any trusted starting point to the RRset
- Bogus
  - Resolver believes that it ought to be able to establish a chain of trust but for which it is unable to do so
  - May indicate an attack but may also indicate a configuration error or some form of data corruption
- Indeterminate
  - Resolver is not able to determine whether the RRset should be signed

New Resource Records

RRs and RRSets

- Resource Record:
  - name TTL class type rdata

```
www.nlnetlabs.nl.    7200    IN  A   192.168.10.3
```

- RRset: RRs with same name, class and type:

```
www.nlnetlabs.nl.  7200    IN  A   192.168.10.3
                              A   10.0.0.3
                              A   172.25.215.2
```

- RRSets are signed, not the individual RRs

New Resource Records

- Three Public key crypto related RRs
  - RRSIG Signature over RRset made using private key
  - DNSKEY Public key, needed for verifying a RRSIG
  - DS Delegation Signer; 'Pointer' for building chains of authentication

- One RR for internal consistency
  - NSEC Indicates which name is the next one in the
  - zone and which typecodes are available for the current name
    - authenticated non-existence of data

DNSKEY RDATA

- 16 bits: FLAGS
- 8 bits: protocol
- 8 bits: algorithm
- N*32 bits: public key

Example:

```
nlnetlabs.nl. 3600 IN DNSKEY 256 3 5 (
AQOvhvXXU61Pr8sCwELcqqq1g4JJ
CALG4C9EtraBKVd+vGIF/unwigfLOA
O3nHp/cgGrG6gJYe8OWKYNgq3kDChN)
```

RRSIG RDATA

- 16 bits - type covered
- 8 bits - algorithm
- 8 bits - nr. labels covered
- 32 bits - original TTL

```
nlnetlabs.nl.  3600 IN       RRSIG      A  5  2  3600  (
    20050611144523       20050511144523  3112 nlnetlabs.nl.
        VJ+8ijXvbrTLeoAiEk/qMrdudRnYZM1VlqhN
        vhYuAcYKe2X/jqYfMfjfSUrmhPo+0/GOZjW
        66DJubZPmNSYXw== )
```

signature field

- 32 bit - signature expiration
- 32 bit - signature inception
- 16 bit - key tag
- signer’s name

Delegation Signer (DS)

- Delegation Signer (DS) RR indicates that:
  - delegated zone is digitally signed
  - indicated key is used for the delegated zone
- Parent is authorative for the DS of the child's zone
  - Not for the NS record delegating the child's zone!
  - DS **should not** be in the child's zone

DS RDATA

- 16 bits: key tag
- 8 bits: algorithm
- 8 bits: digest type
- 20 bytes: SHA-1 Digest

```
$ORIGIN nlnetlabs.nl.
lab.nlnetlabs.nl.   3600 IN   NS  ns.lab.nlnetlabs.nl
lab.nlnetlabs.nl.   3600 IN   DS  3112    5  1 (
                                  239af98b923c023371b52
                                  1g23b92da12f42162b1a9
                          )
```

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
- N*32 bit type bit map
- Used for authenticated denial-of-existence of data
  - authenticated non-existence of TYPEs and labels
- Example:

```
www.nlnetlabs.nl. 3600 IN NSEC nlnetlabs.nl. A RRSIG NSEC
```

NSEC Records

- NSEC RR provides proof of non-existence
- If the servers response is Name Error (NXDOMAIN):
  - One or more NSEC RRs indicate that the name or a wildcard expansion does not exist
- If the servers response is NOERROR:
  - And empty answer section
  - The NSEC proves that the QTYPE did not exist
- More than one NSEC may be required in response
  - Wildcards
- NSEC records are generated by tools
  - Tools also order the zone

NSEC Walk

- NSEC records allow for zone enumeration
- Providing privacy was not a requirement at the time
- Zone enumeration seems to be an deployment barrier

- NSEC-3 helps solved the problem

Other Keys in the DNS

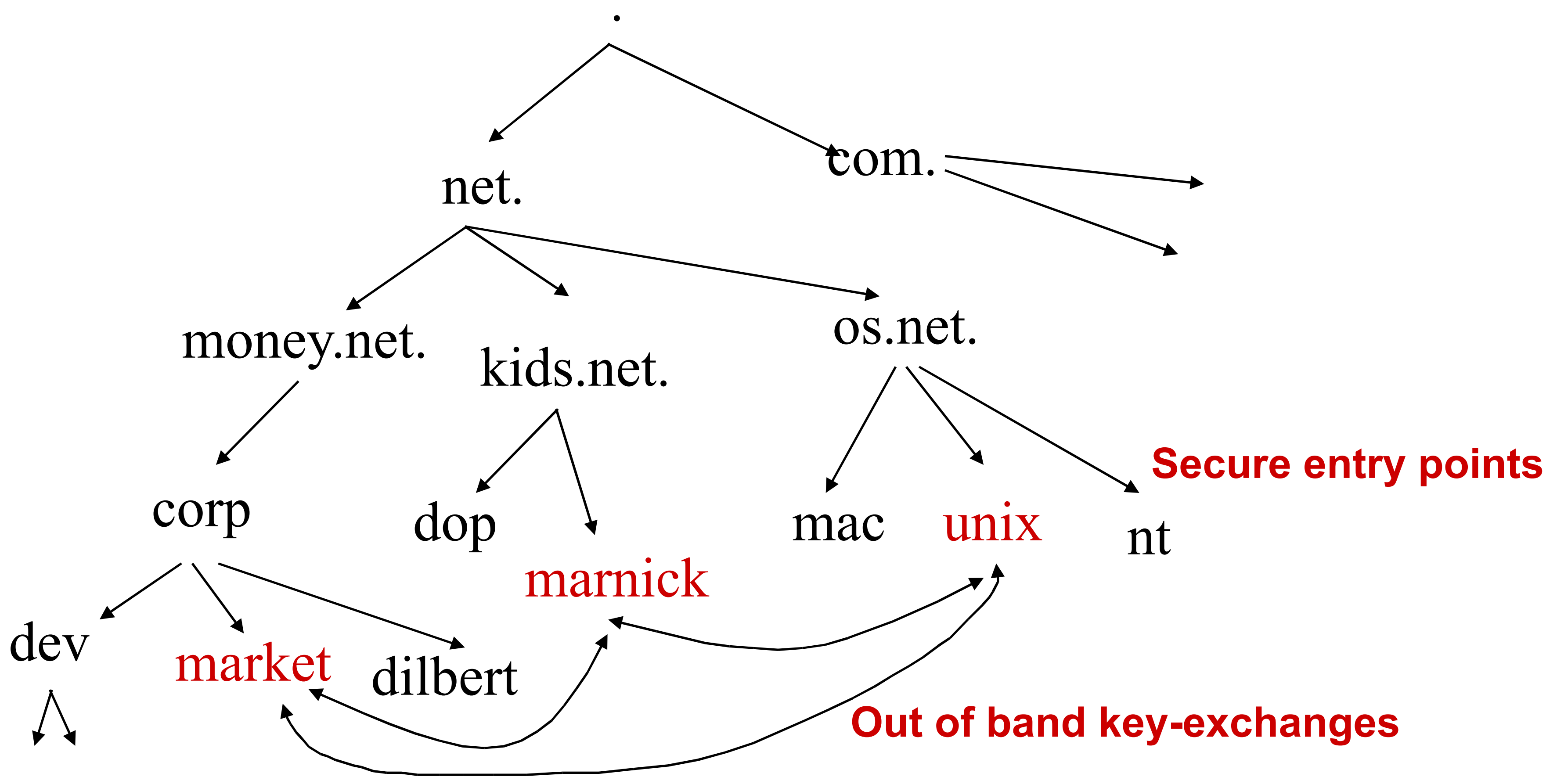
- DNSKEY RR can only be used for DNSSEC
  - Keys for other applications need to use other RR types
- CERT
  - For X.509 certificates
- Application keys under discussion/development
  - IPSECKEY
  - SSHFP

Delegating Signing Authority

Chains of Trust

Locally Secured Zones

- Key distribution does not scale!



Using the DNS to Distribute Keys

- Secured islands make key distribution problematic

- Distributing keys through DNS:
  - Use one trusted key to establish authenticity of other keys
  - Building chains of trust from the root down
  - Parents need to sign the keys of their children

- Only the root key needed in ideal world
  - Parents always delegate security to child

Key Problem

- Interaction with parent administratively expensive
  - Should only be done when needed
  - Bigger keys are better

- Signing zones should be fast
  - Memory restrictions
  - Space and time concerns
  - Smaller keys with short lifetimes are better

Key solution: KSK and ZSK

- RRsets are signed, not RRs
- DS points to specific key
  - Signature from that key over DNSKEY RRset transfers trust to all keys in DNSKEY RRset

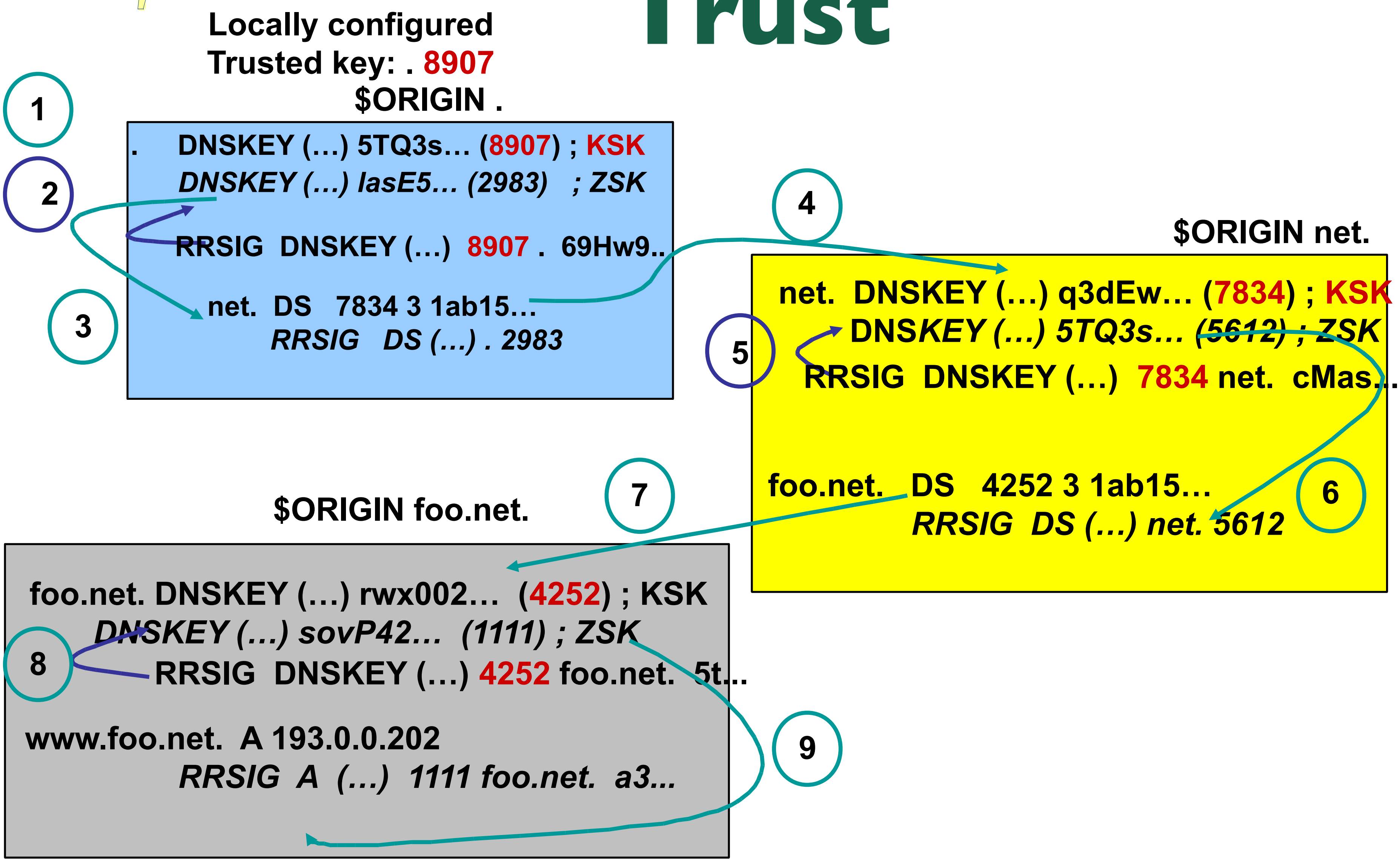
- Key that DS points to only signs DNSKEY RRset
  - Key Signing Key (KSK)
- Other keys in DNSKEY RRset sign entire zone
  - Zone Signing Key (ZSK)

Initial Key Exchange

- Child needs to:
  - Send key signing keyset to parent

- Parent needs to:
  - Check childs zone
    - for DNSKEY & RRSIGs
  - Verify if key can be trusted
  - Generate DS RR

Walking the Chain of Trust



Chain of Trust Verification, Summary

- Data in zone can be trusted if signed by a Zone-Signing-Key
- Zone-Signing-Keys can be trusted if signed by a Key-Signing-Key
- Key-Signing-Key can be trusted if pointed to by trusted DS record
- DS record can be trusted
  - if signed by the parents Zone-Signing-Key

or

  - DS or DNSKEY records can be trusted if exchanged out-of-band and locally stored (Secure entry point)

Key Rollovers

Private Keys

- You have to keep your private key secret
- Private key can be stolen
  - Put the key on stand alone machines or on bastion hosts behind firewalls and strong access control
- Private key reconstruction (crypto analysis)
  - Random number not random
  - Leakage of key material (DSA)
  - Brute force attacks

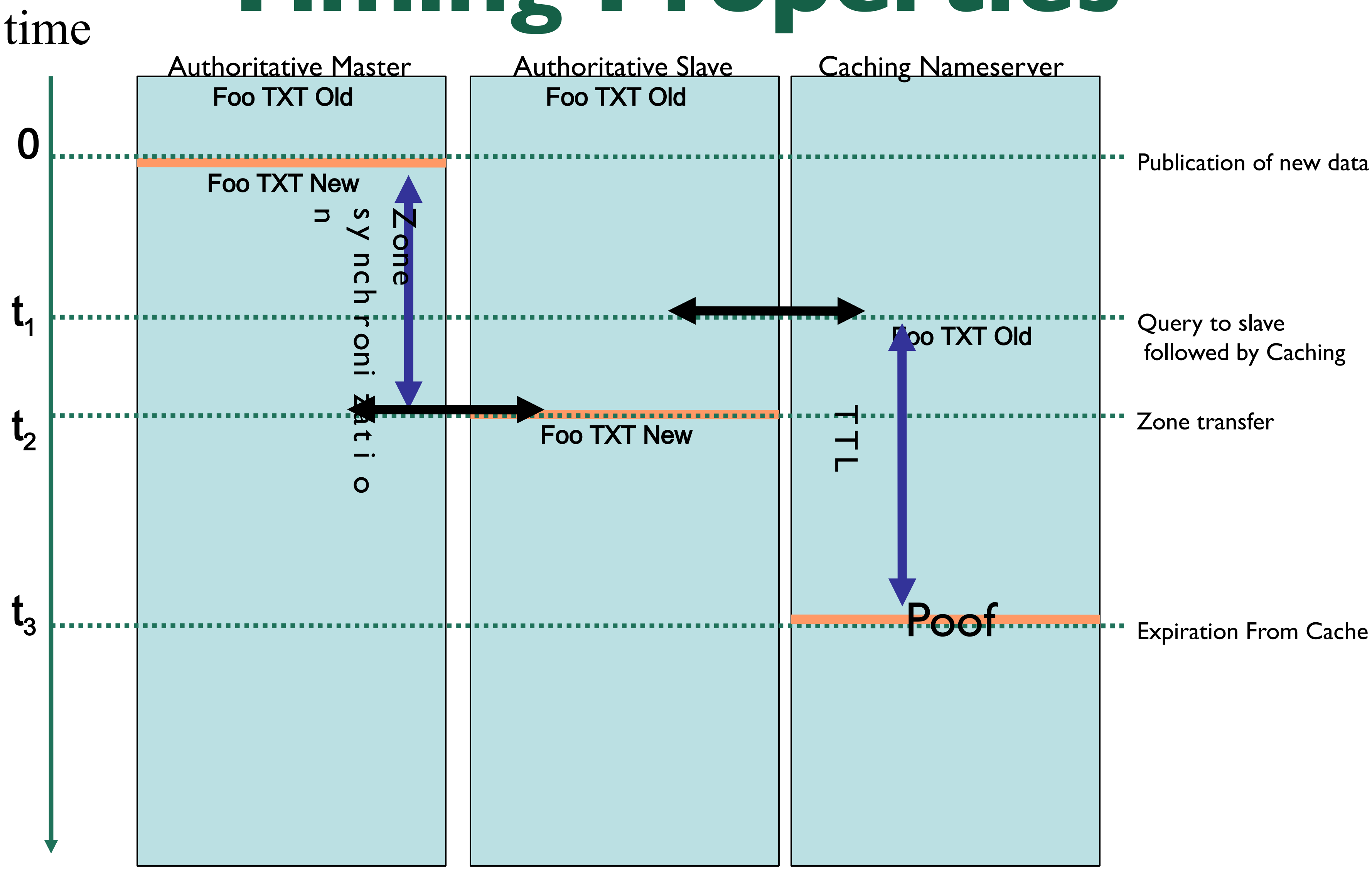
Key Rollovers

- Try to minimise impact
  - Short validity of signatures
  - Regular key rollover
- Remember: DNSKEYs do not have timestamps
  - the RRSIG over the DNSKEY has the timestamp
- Key rollover involves second party or parties:
  - State to be maintained during rollover
  - Operationally expensive

Timing of the Scheduled Key Rollover

- Don’t remove the old key while there are servers still handing out the old DS RR
- New DS needs to be distributed to the slaves
  - Max time set by the SOA expiration time
- Old DS needs to have expired from caches
  - Set by the TTL of the original DS RR
- You (or your tool) can check if the master and slave have picked up the change

Timing Properties



Unscheduled Rollover Problems

- Needs out of band communication
  - With parent and pre-configured resolvers
- The parent needs to establish your identity again
- How to protect child delegations?
  - Unsecured?
- There will be a period that the" stolen" key can be used to generate seemingly secure data
- Emergency procedure must be on the shelf

Key Rollover - Summary

- Generate new KSK
- Sign with old and new KSKs
- Wait for your servers + TTL of old DNSKEY RRset
- Inform resolvers of the new key
  - that have you as a trusted entry point
- Query for the parental DS and remember the TTL
- Upload the new KSK or DS to the parent
- Check if *all* parental servers have new DS
- Wait another TTL before removing the old key

D0 bit

- A state bit in the « header » section of DNS packets
  - Not used before DNSSEC (should be set to zero)
  - 1= "resolver" want DNSSEC RRs
  - 0= "resolver" does not want DNSSEC RRs

AD bit

- A state bit in the « header » section of DNS packets
  - Not used before DNSSEC(should be set to zero)
  - Only used in response from validators
- AD bit is not set by authoritative server, unless it has been configured to do so.
- AD = Authenticated data

Bit CD

- A state bit in the « header » section of DNS packets

  Not used before DNSSEC(should be set to zero)

- CD = Checking Disable
  - 1= validation disable
    - "resolver" accepts non verified data
  - 0= validation enabled
    - "resolver" want validated answers for signed data, but accepts answers for non signed data

“new” Developments

- NSEC3
  - RFC 5155
  - All RR names hashed
  - Hashed names are ordered
  - “opt-out” for unsecured delegations possibilities
- Automated Trust anchors rollover
  - RFC5011
- SHA1 to be deprecated
  - New hash for DS records
  - Overlap, no flag day

Some issues with DNSSEC

- Does not protect against denial of service attacks, but increases the risks
  - **Cryptographic load**
  - **Larger DNSSEC messages**
  - **RFC5358**
- Does not protect non signed RRs (non authoritative data at delegation point)
  - **NS and glue in parent zone**
  - **Zone transfer should be protected by other means**
- Add complexity to DNS, increasing the risks of bad configuration
  - **Nothing is for free :-)**
- How to distribute and roll trust anchor(s) ?
  - **RFC5011 ?**

Some issues DNSSEC(cont.d)

- NSEC offers zone-walk
  - **NSEC3**
- Certain firewalls/middle boxes do not support DNS message > 512 byte(edns0)
  - **Many are reconfigurable**
- Certain Firewalls/middle boxes have issues with AD, CD, DO bits in the DNS packet header
- Certain old stub resolvers may have issues with the AD bit
  - **Add the AD bit in request for signaling resolvers state ?**

Questions ??