The details

Presented by

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DNSSEC Mechanisms

- New Resource Records
- Setting Up a Secure Zone
- Delegating Signing Authority

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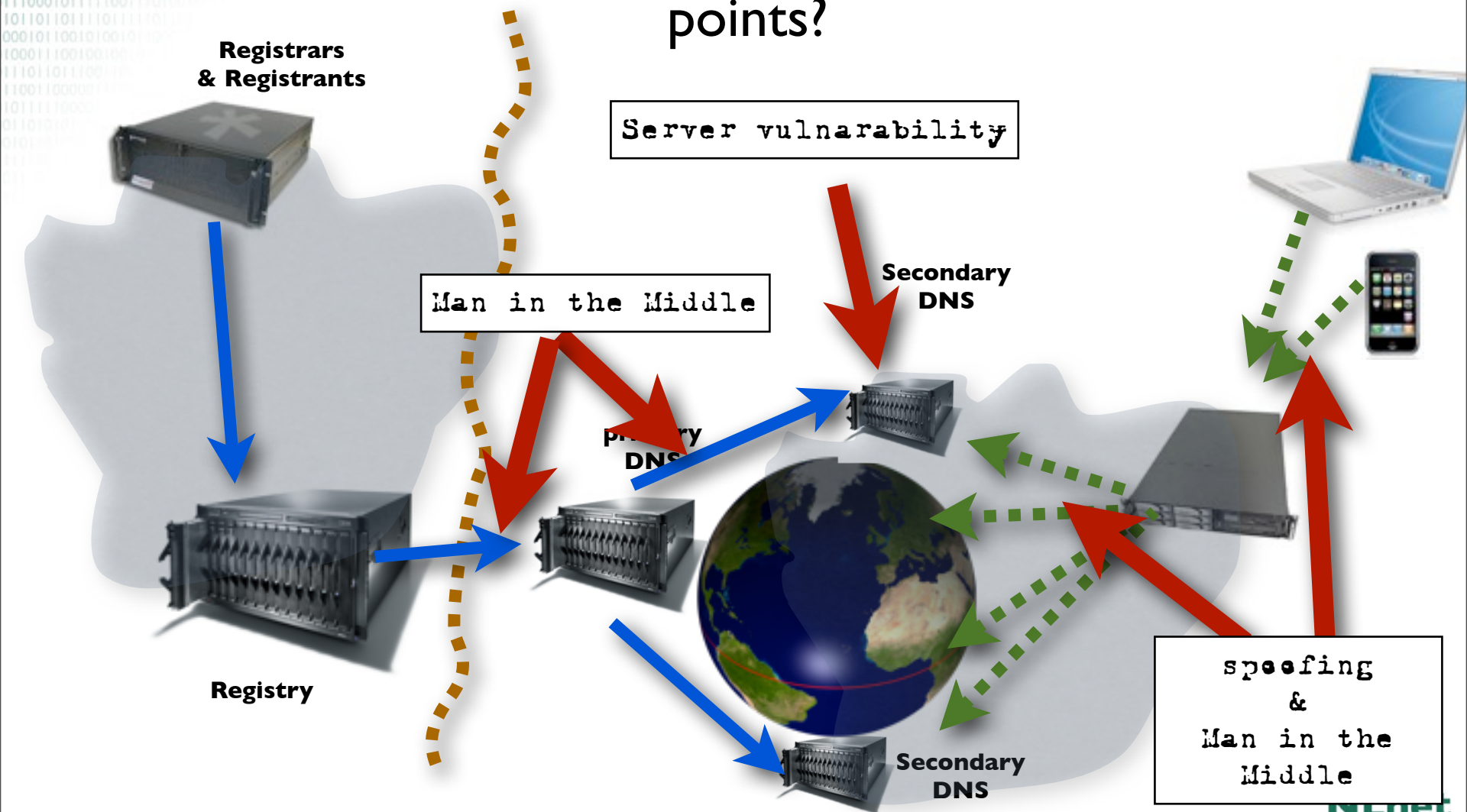
Data flow through the DNS

Where are the vulnerable points?



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DNSSEC protects all these end-to-end

- As an aside:
  There is a protection mechanism against the man in the middle: TSIG
  - Provides hob-by-hop security
  - TSIG is operationally deployed today
  - Based on shared secret: not scalable

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What does DNSSEC provide

- provides message authentication and integrity verification through cryptographic signatures
  - You know who provided the signature
  - No modifications between signing and validation
- It does not provide authorization
- It does not provide confidentiality
- It does not provide protection against DDOS

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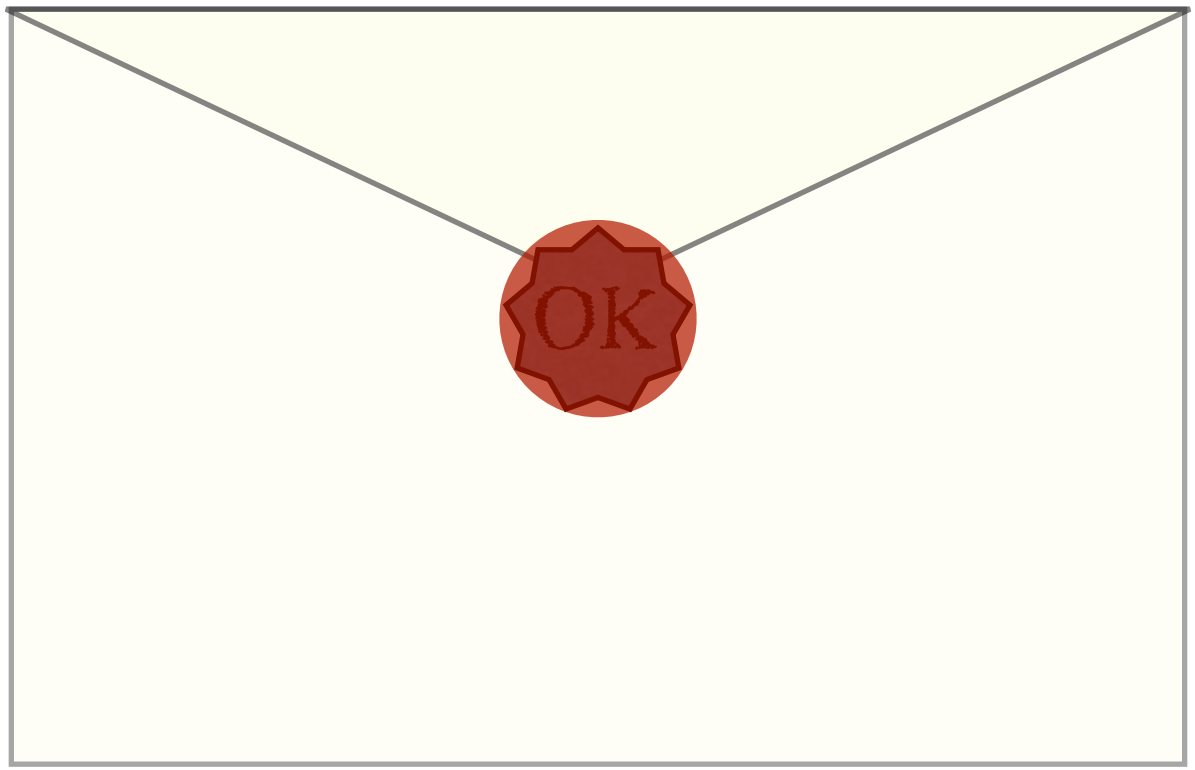
Metaphor



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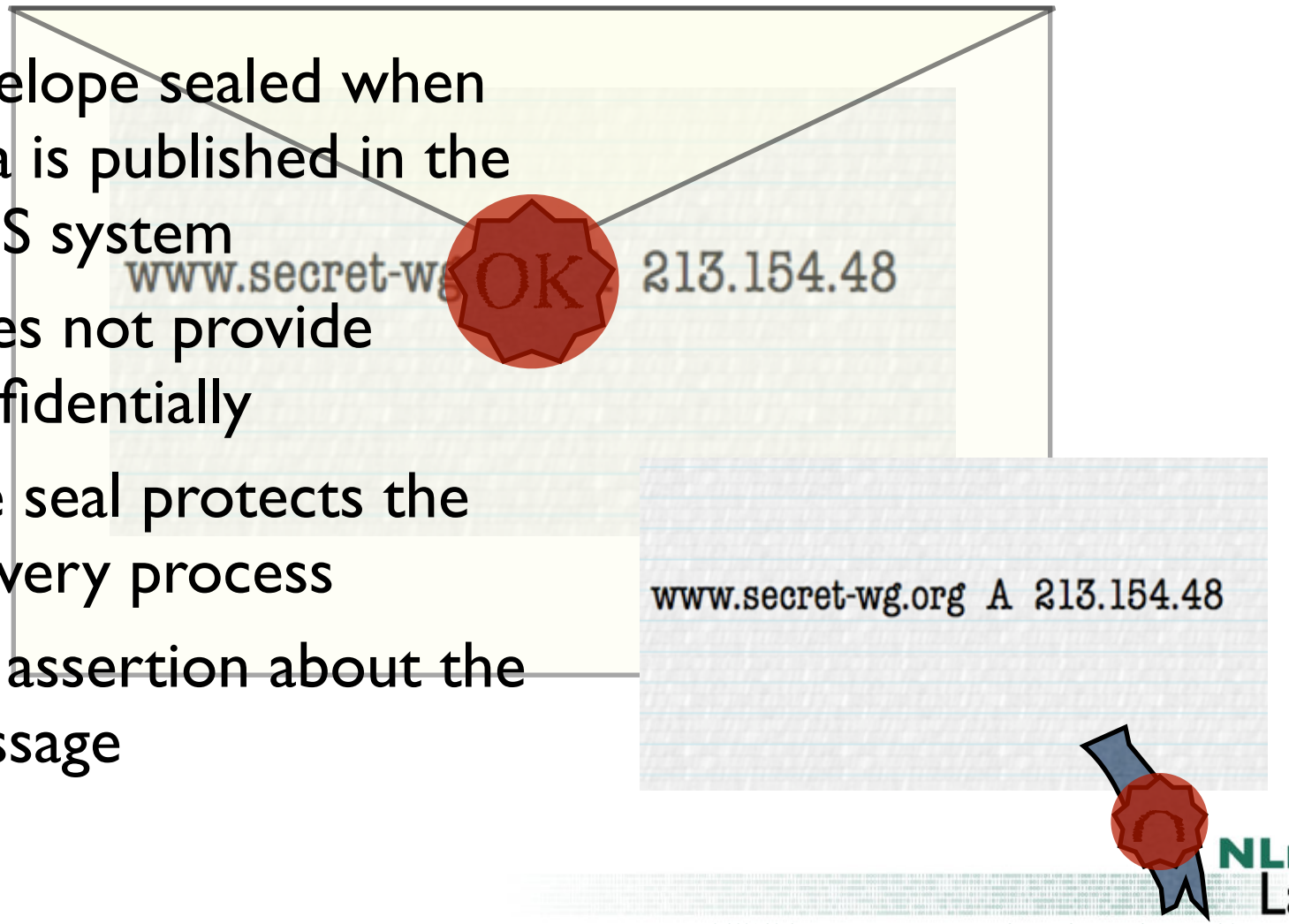
Metaphor

- Envelope sealed when data is published in the DNS system
- Does not provide confidentially
- The seal protects the delivery process
- No assertion about the message



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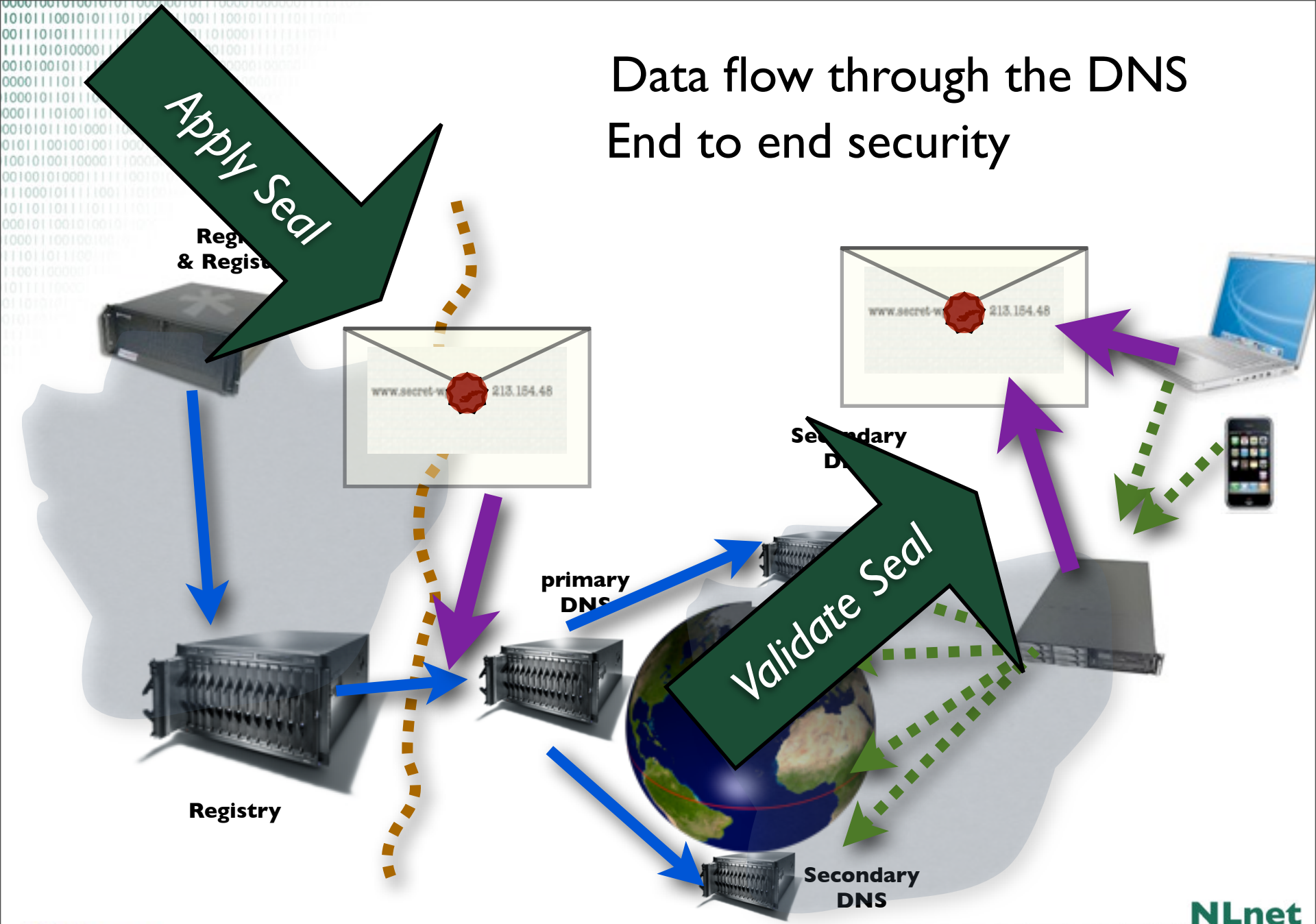
Data flow through the DNS
End to end security



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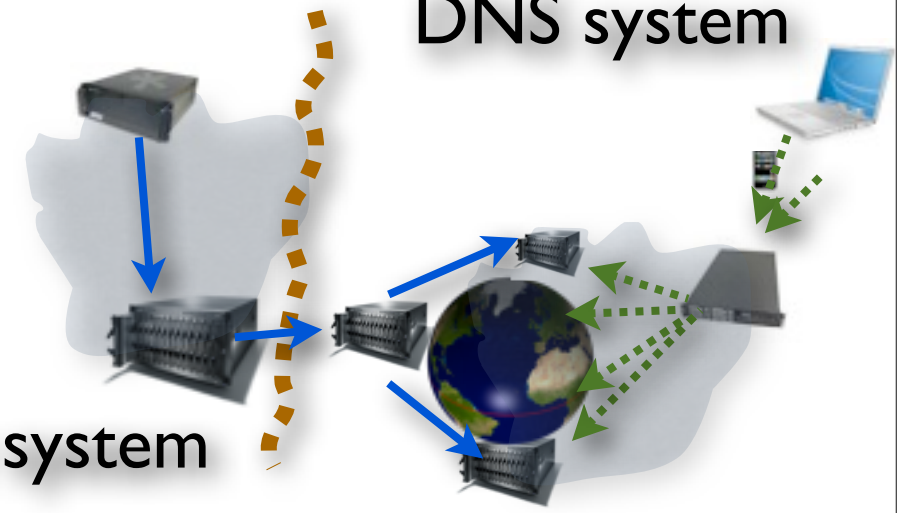
Trust and Confidence



- DNSSEC enables confidence in the DNS
- It does not change the trust we put in the Registry/Registrar procedures
  - Although introduction of DNSSEC may improve some of the procedures

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The mechanism used

- Using public key cryptographic algorithms signatures are applied over the DNS data
- By comparing the signatures with public keys the integrity and authenticity of the data can be established.

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Public key cryptography in a nutshell

- Two large numbers and an encryption and decryption algorithm
- If one of the numbers (the private key) and a message are used for encryption
- The other number (public key) and the decryption algorithm can be used to retrieve the original message

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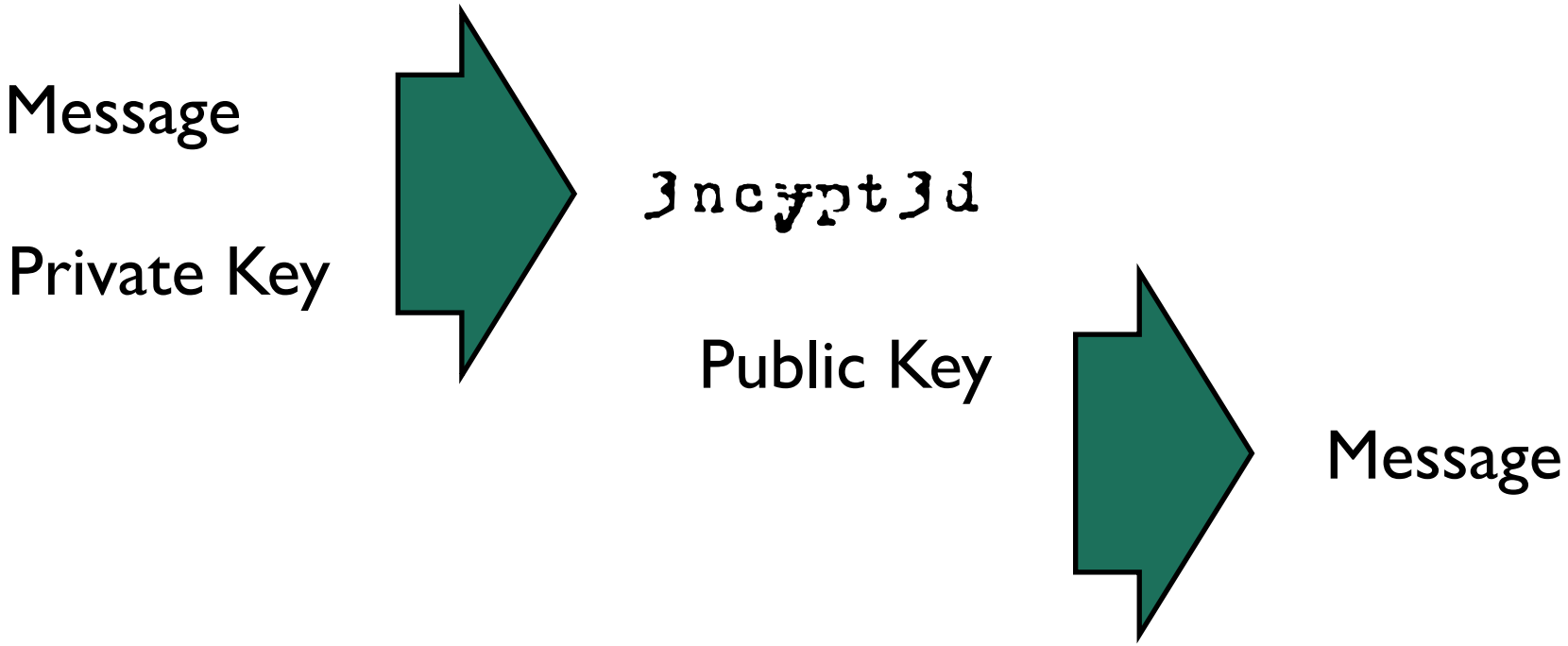

Decription only with matching key:
If you can decrypt with a public key you may assert the message was signed with corresponding private key

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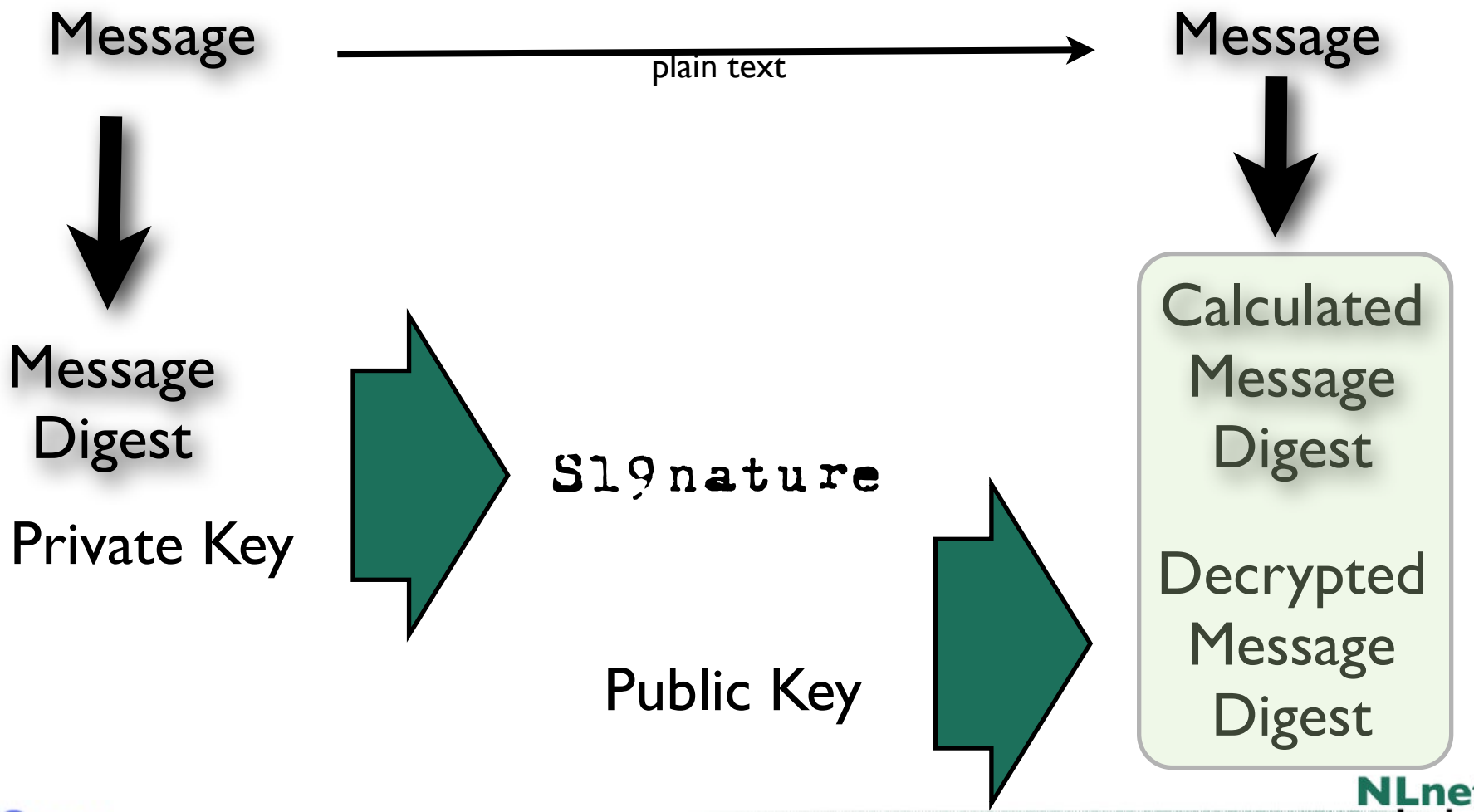
Use that for signatures



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In Practice

- Key generation and signing is done by tools
- Validating and signing entity need to communicate which algorithms for hashing and public key cryptography is needed: e.g. RSASHA1, RSASHA256 or DSA

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Holy Trinity

- Private Key: kept private and stored locally
- Public Keys: Published in the DNS as a DNSKEY Resource Record
- Signatures: Published in the DNS as a RRSIG Resource Record

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Signing is done per Zone

- Each zone has one or more key-pairs for signing
- If you have the public keys from a zone you can validate signatures made with the corresponding private keys
- However, signing a complete zone does not scale

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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 the atomic data units in the DNS
- RRsets are signed, not the individual RRs

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DNSKEY RDATA

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

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

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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== )
```

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

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Validate Public Keys

- Make sure you get them from the appropriate entity and configure them as trust-anchors
- If you validate against the wrong public key there is a problem again
- For DNSSEC: key distribution through the DNS
  - Ideally only one key needed: that of the root of the DNS hierarchy (more on that later)

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Delegating Signing Authority

Chains of Trust

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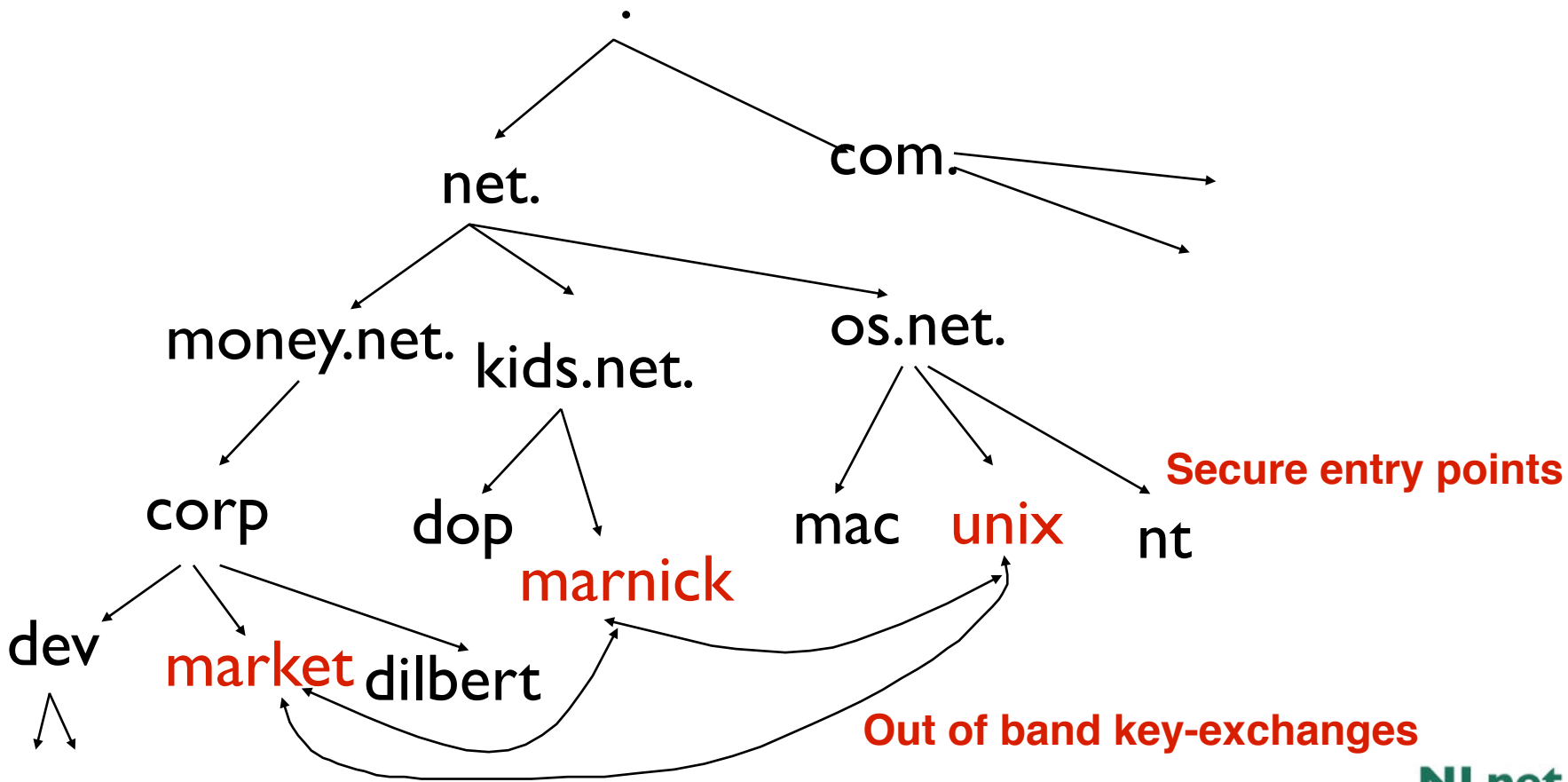
Validating against configured keys

- Key distribution does not scale!



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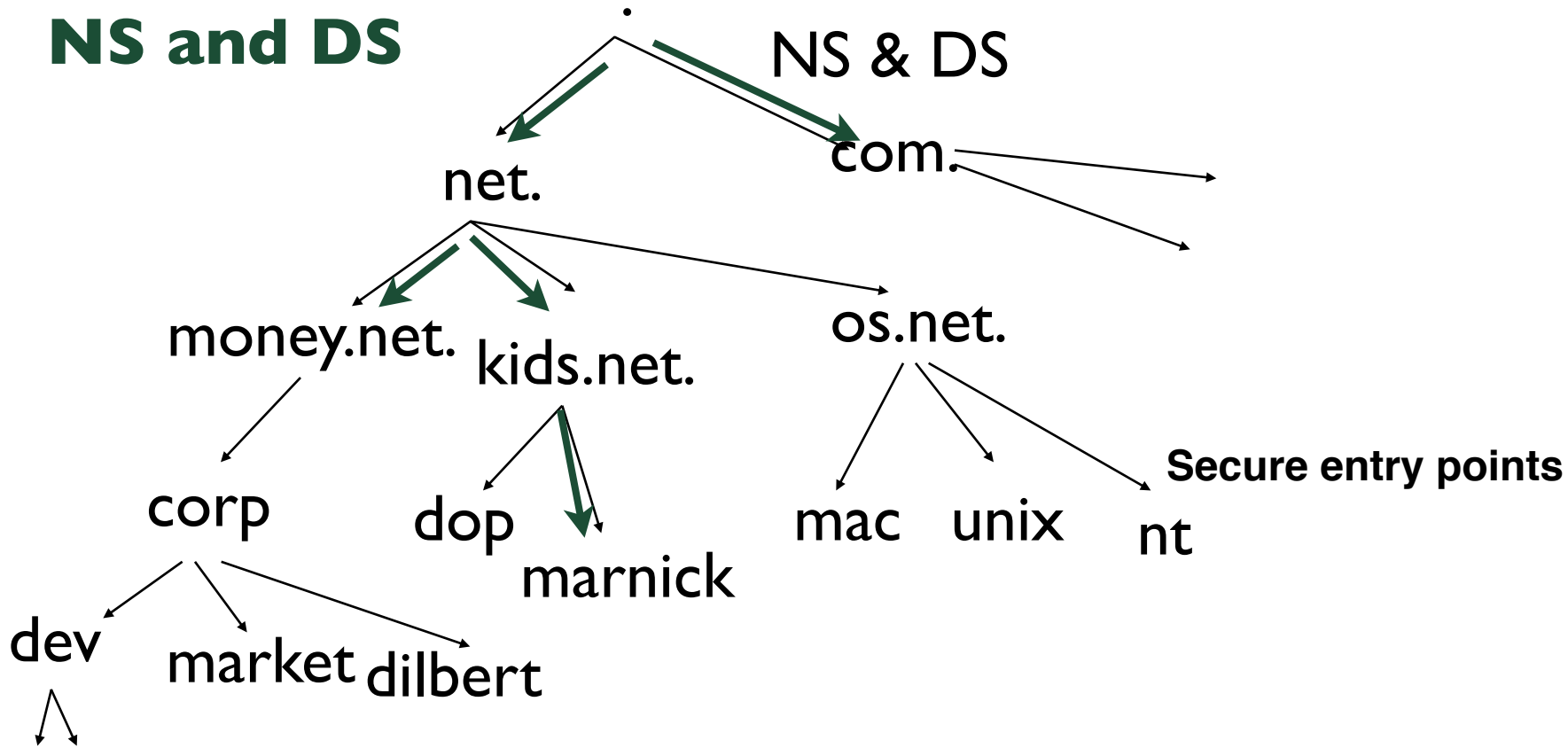
Locally Secured Zones

- Delegate Signing Security



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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

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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

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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 )
```

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Key Problem

- Interaction with parent administratively expensive
  - Should only be done when needed
  - You might want to lock these in hardware
- Signing zones should be fast
  - Memory restrictions
  - Space and time concerns
  - Operational exposure higher

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More Than One Key: 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)

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The Important Considerations

- KSK and ZSK have different 'shielding' properties: KSK on smartcard, ZSK on disk
- ZSK needs 'daily' or permanent use.
- KSK less frequent
- ZSK change needs no involvement with 3rd parties
- KSK may need uncontrolled cooperation from 3rd parties

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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

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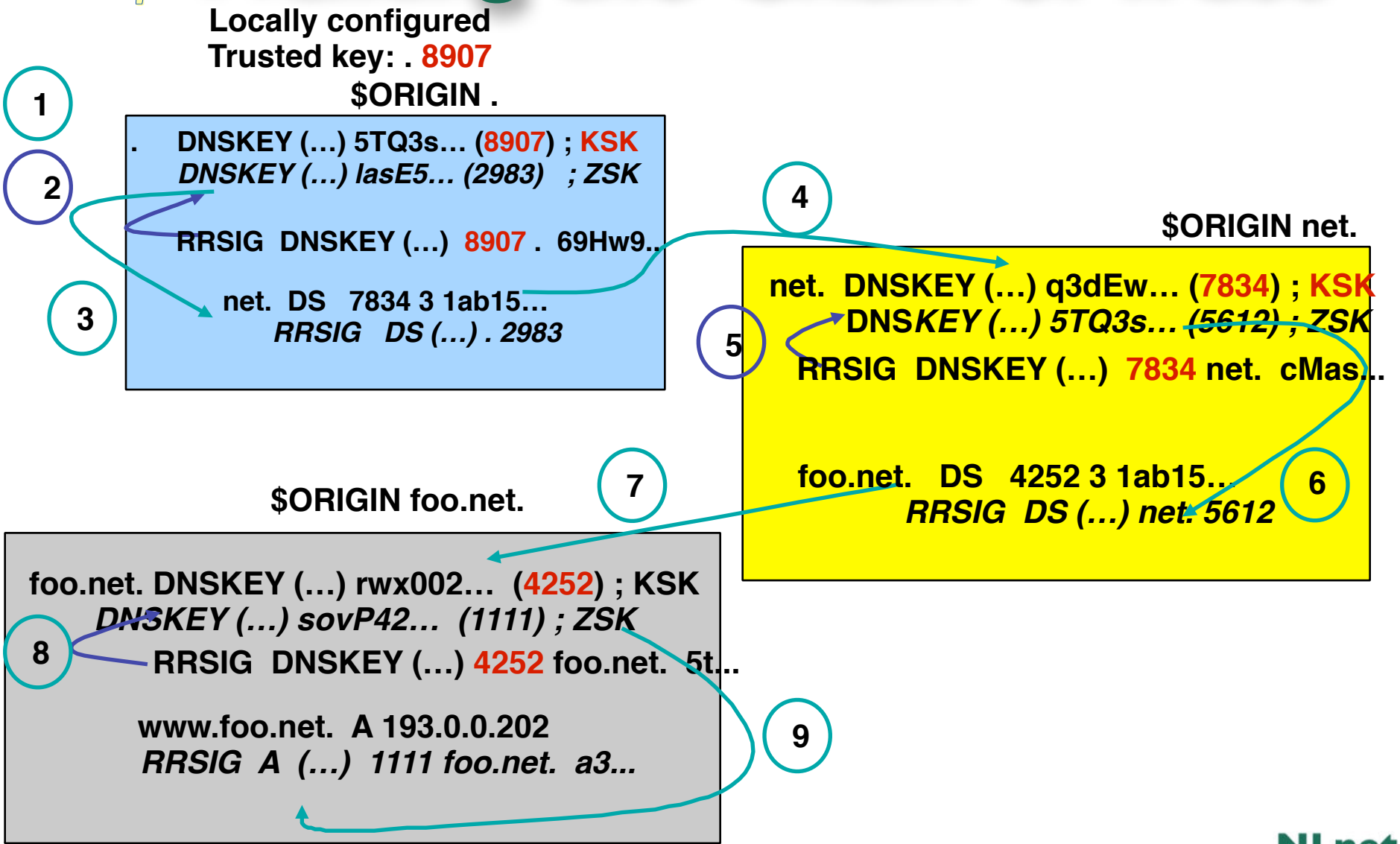
Walking the Chain of Trust



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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)

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Where are we

- DNSKEY
- RRSIG
- DS

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Offline Signing and Denial of Existence

- Problems with on-the-fly signing
  - Private key needs to be stored on an Internet facing system
  - Performance, signing is a CPU expensive operation
- How does one provide a proof that the answer to a question does not exist?

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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
```

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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

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NSEC Walk

- NSEC records allow for zone enumeration
- Providing privacy was not a requirement at the time
- Zone enumeration is a deployment barrier

- Solution has been developed: NSEC3
  - RFC 5155
  - Complicated piece of protocol work
  - Hard to troubleshoot
  - Only to be used over Delegation Centric Zones

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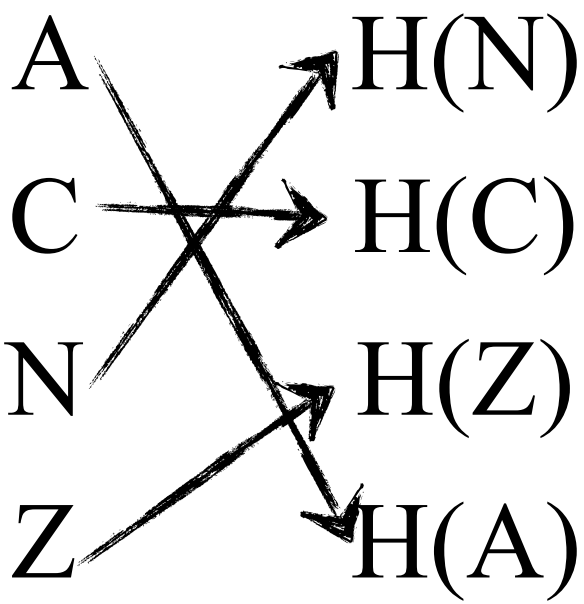
NSEC3



- Creates a linked list of the hashed names
- Non-existence proof of the hash proofs non-existence of original
- Dictionary attack barriers:
  - Salt
  - Iterations

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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 and NSEC3: Indicates which name is the next one in the zone and which typecodes are available for the current name
    - authenticated non-existence of data

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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
    - SSHFPSummary for now
  - DANE!!!

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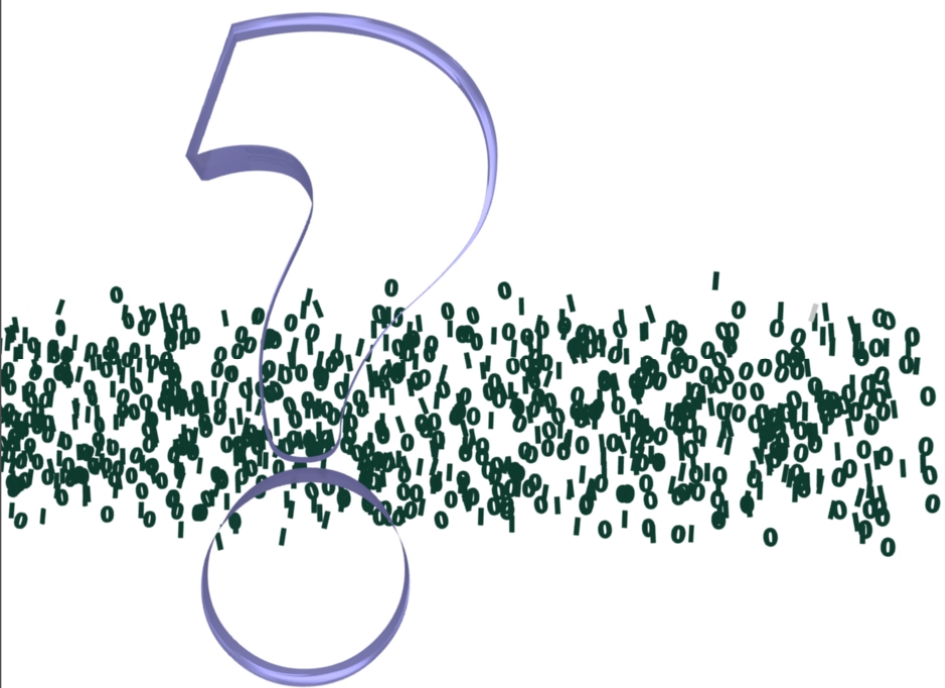
Summary and

- You have seen the new RRs and learned what is their content



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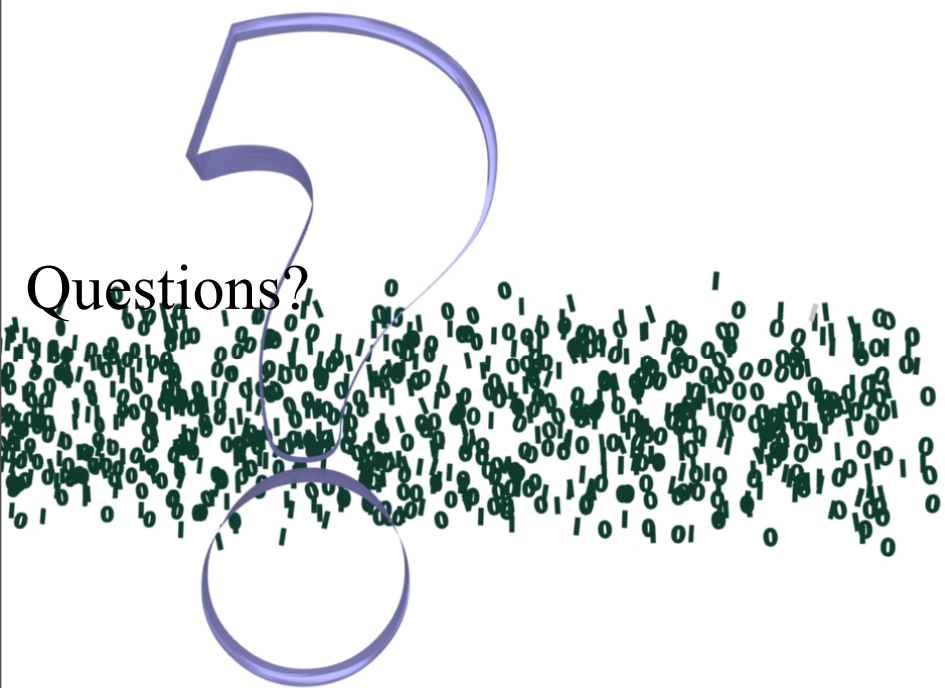
Summary

- Scaling problem: secure islands
- Zone signing key, key signing key
- Chain of trust



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Questions?

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