DNSSEC

The details

Presented by

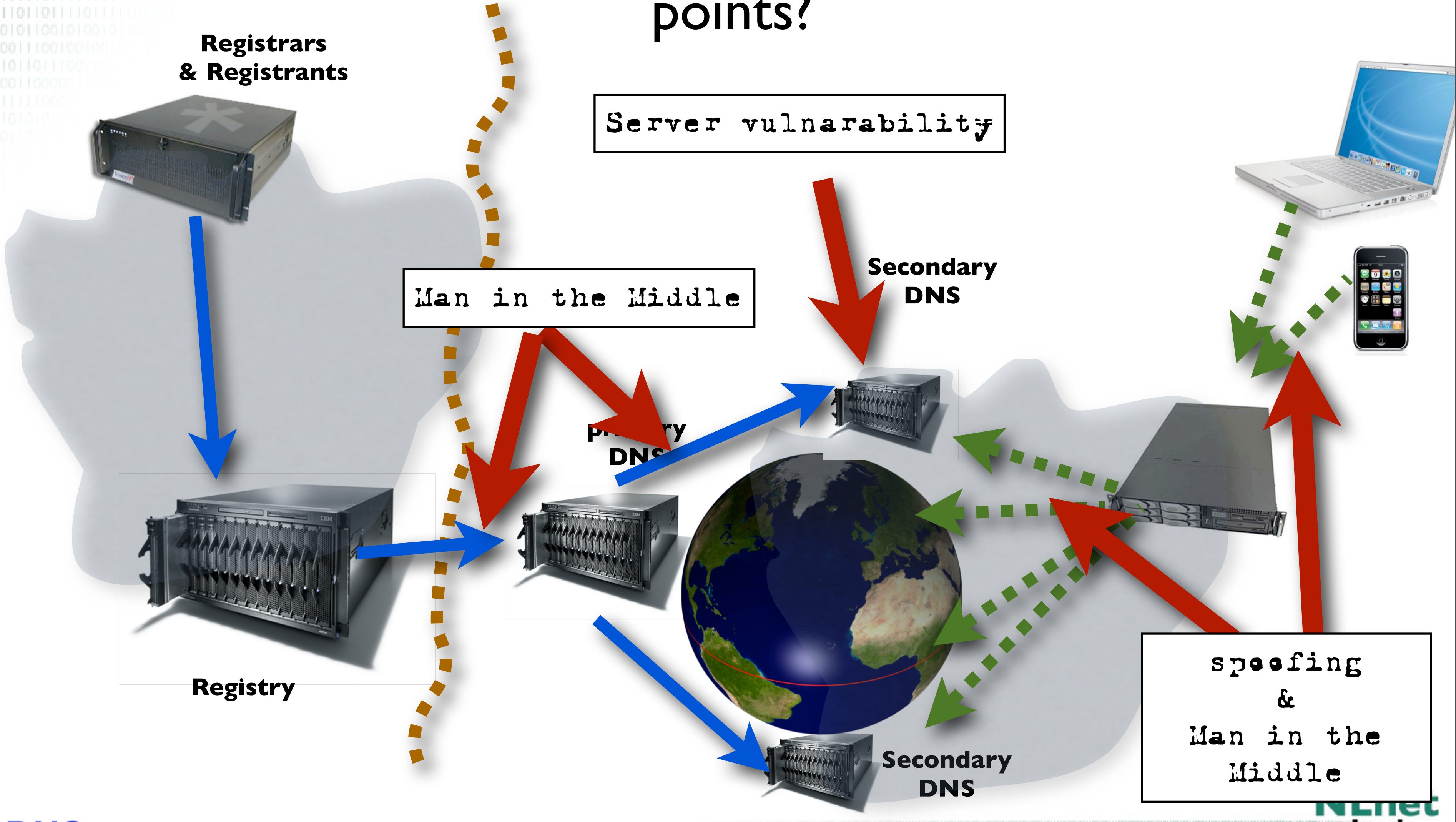
Olaf Kolkman (NLnet Labs)

DNSSEC Mechanisms

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

Data flow through the DNS

Where are the vulnerable points?



Registrars & Registrants

Server vulnerability

Man in the Middle

Secondary DNS

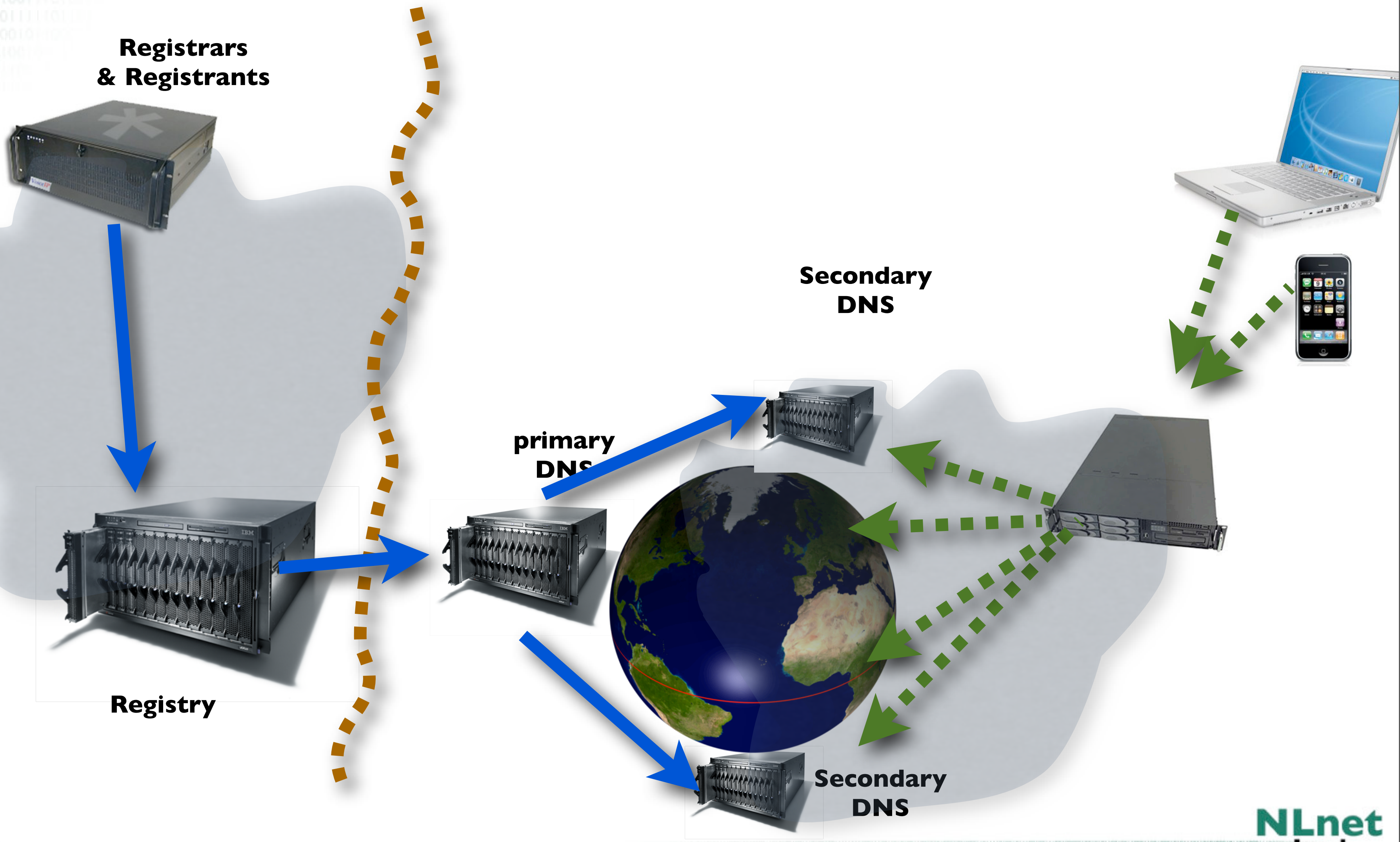
primary DNS

Registry

Secondary DNS

spoofing & Man in the Middle

Data flow through the DNS



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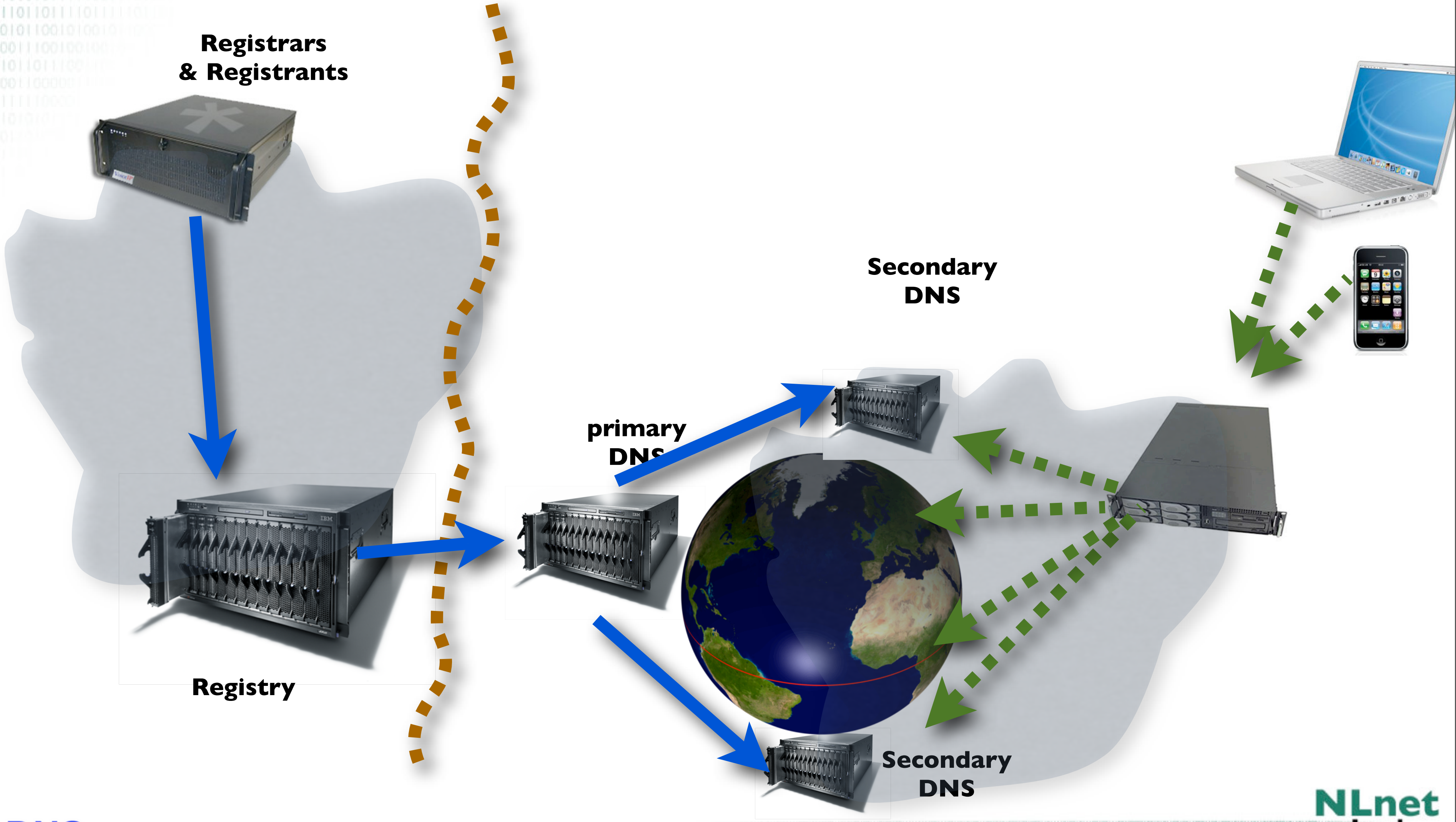
Data flow through the DNS



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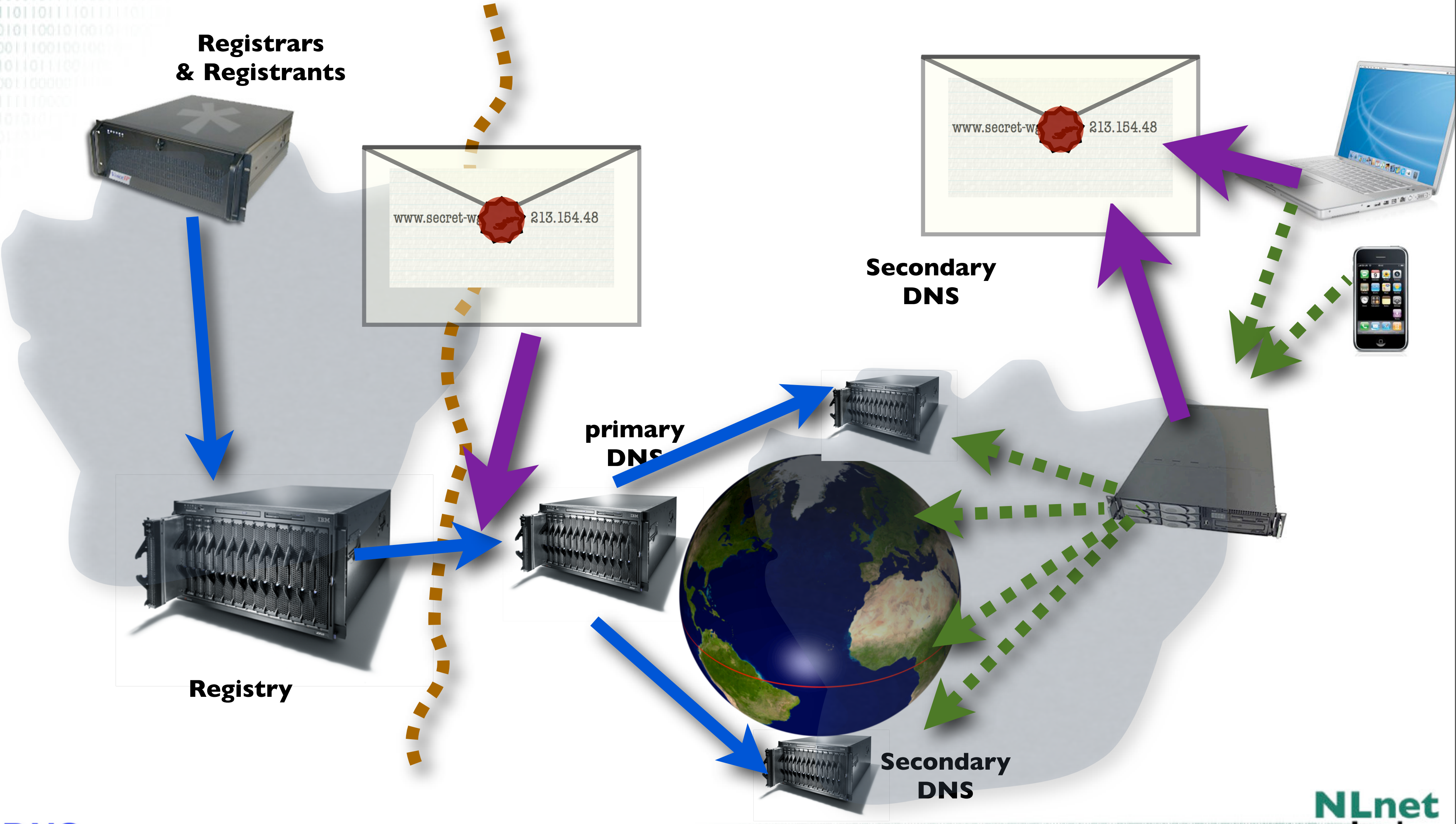
Data flow through the DNS
End to end security



DNSSEC

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The DNSSEC RRs

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 (
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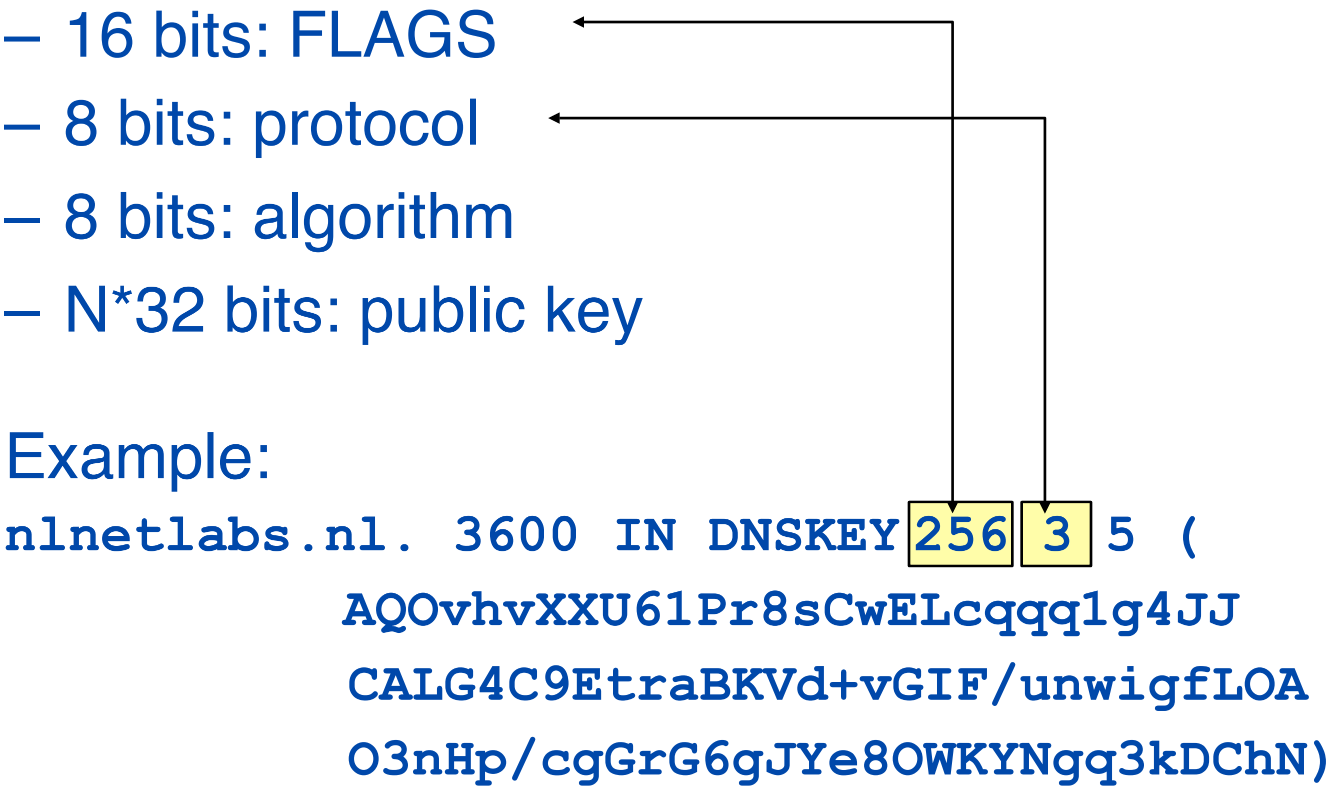

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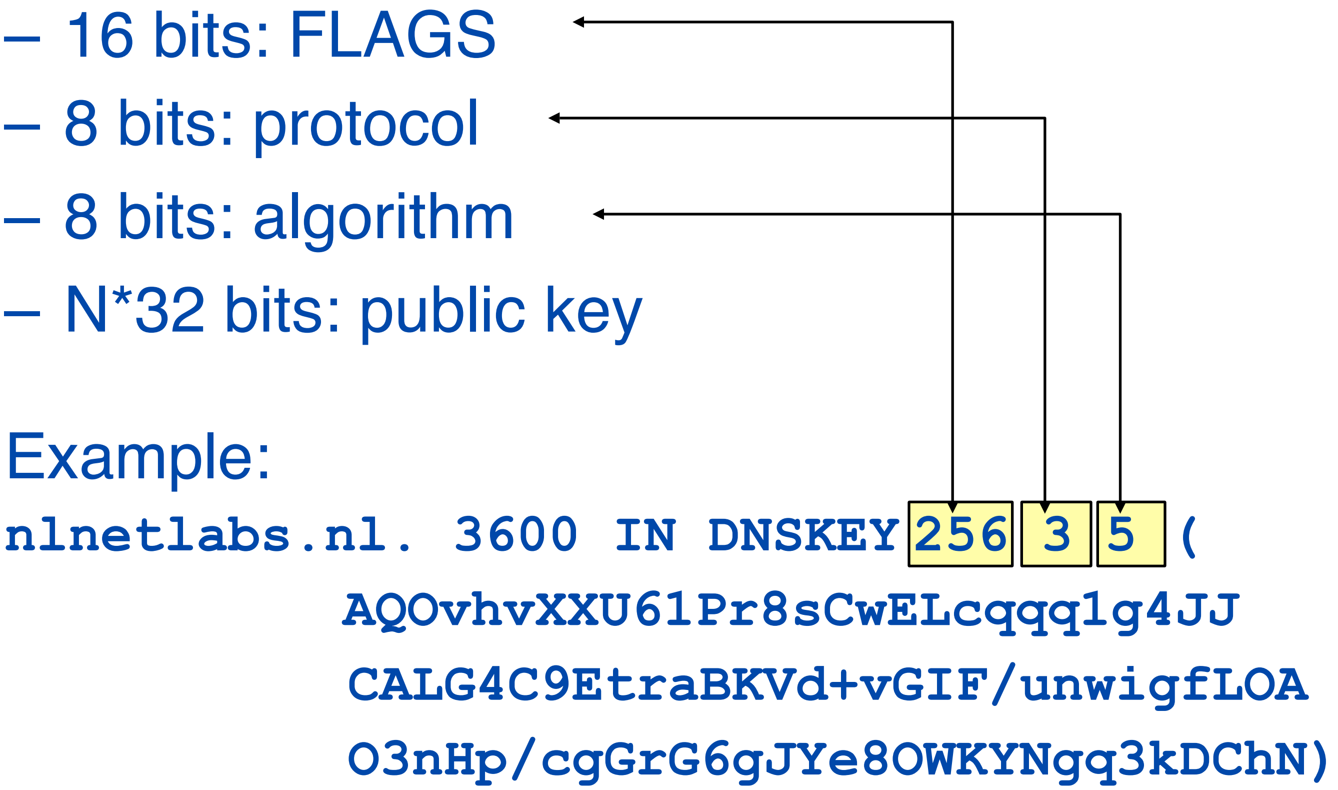

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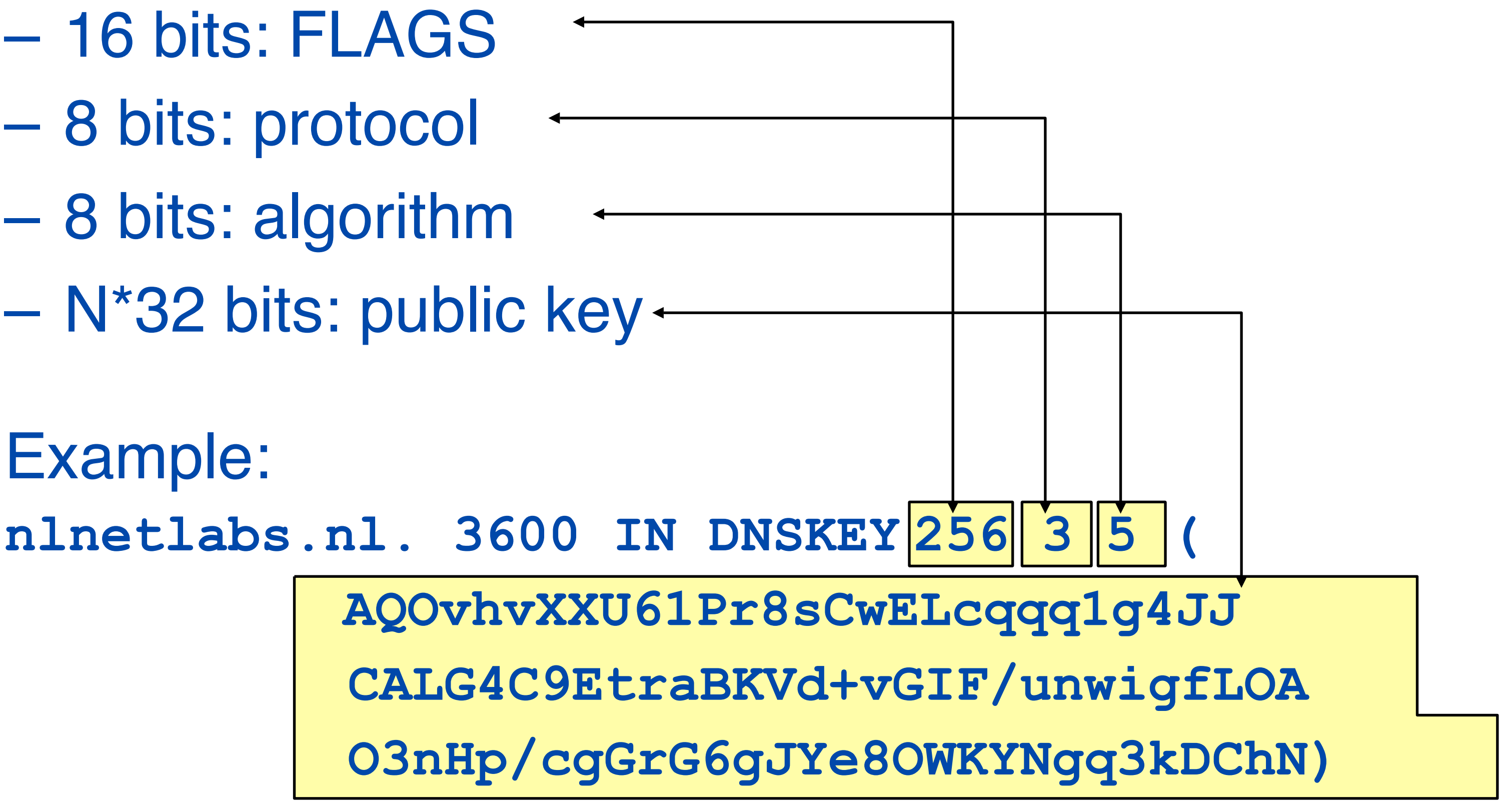

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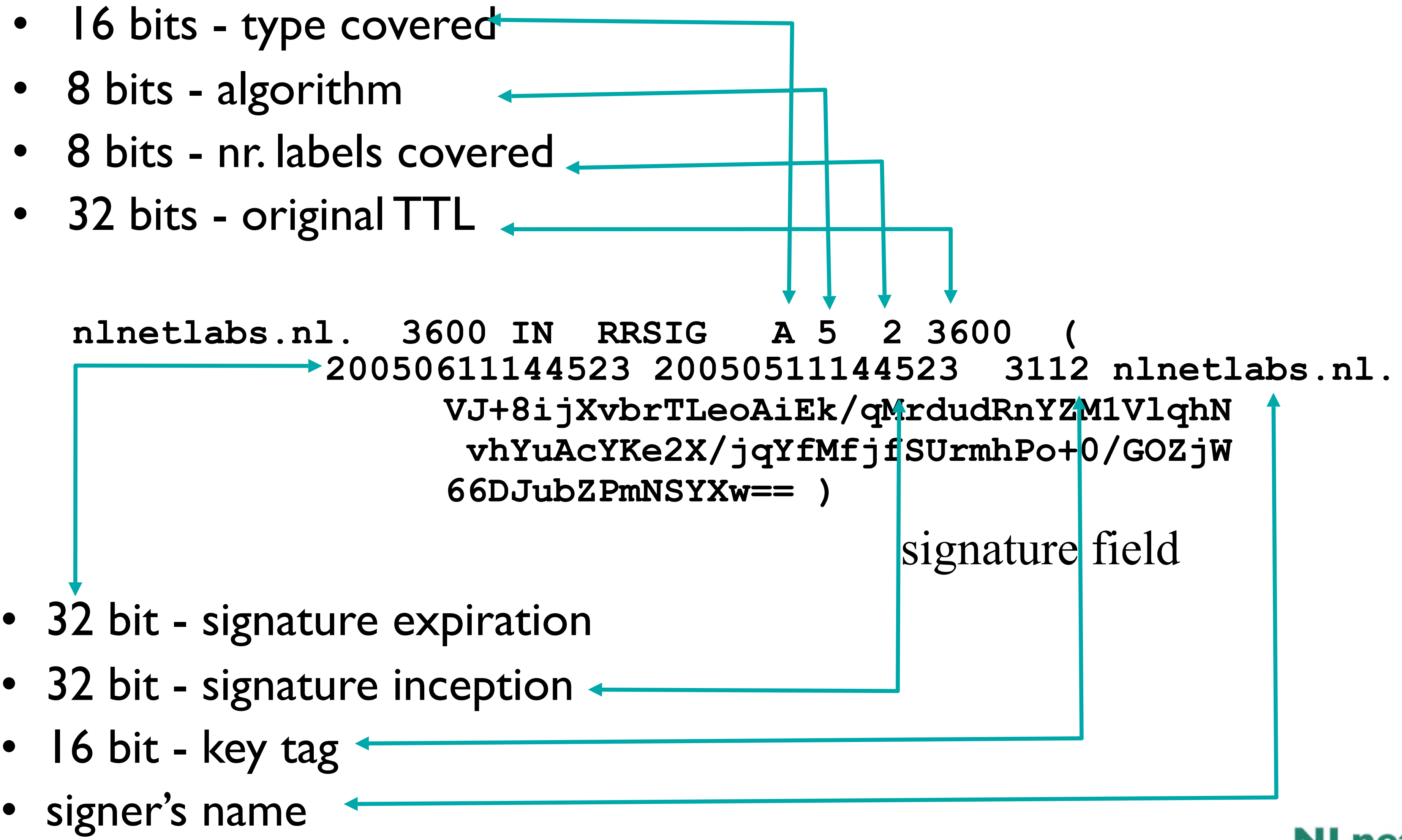
RRSIG RDATA



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signature field

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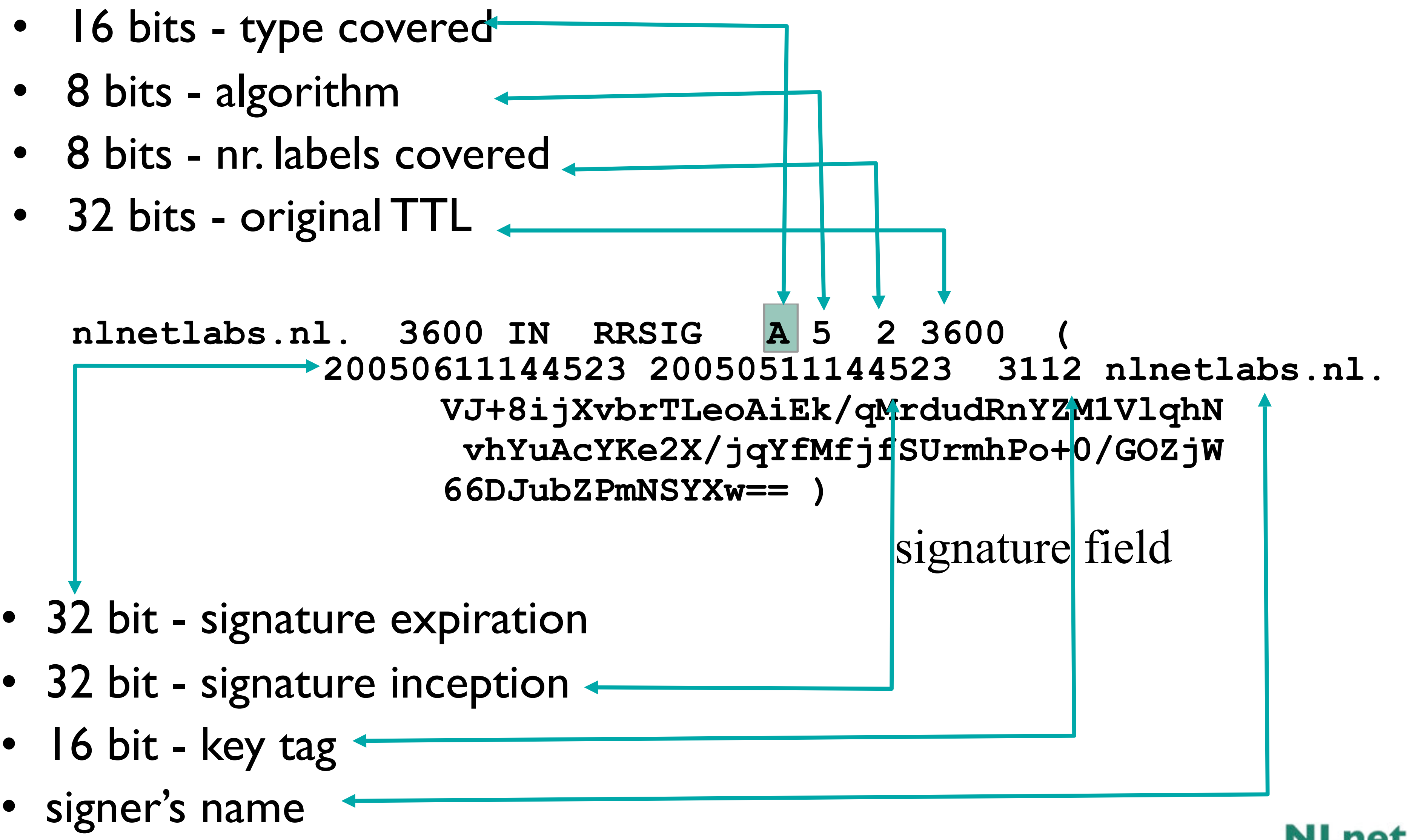
- 32 bit - signature inception
- 16 bit - key tag
- signer’s name

RRSIG RDATA



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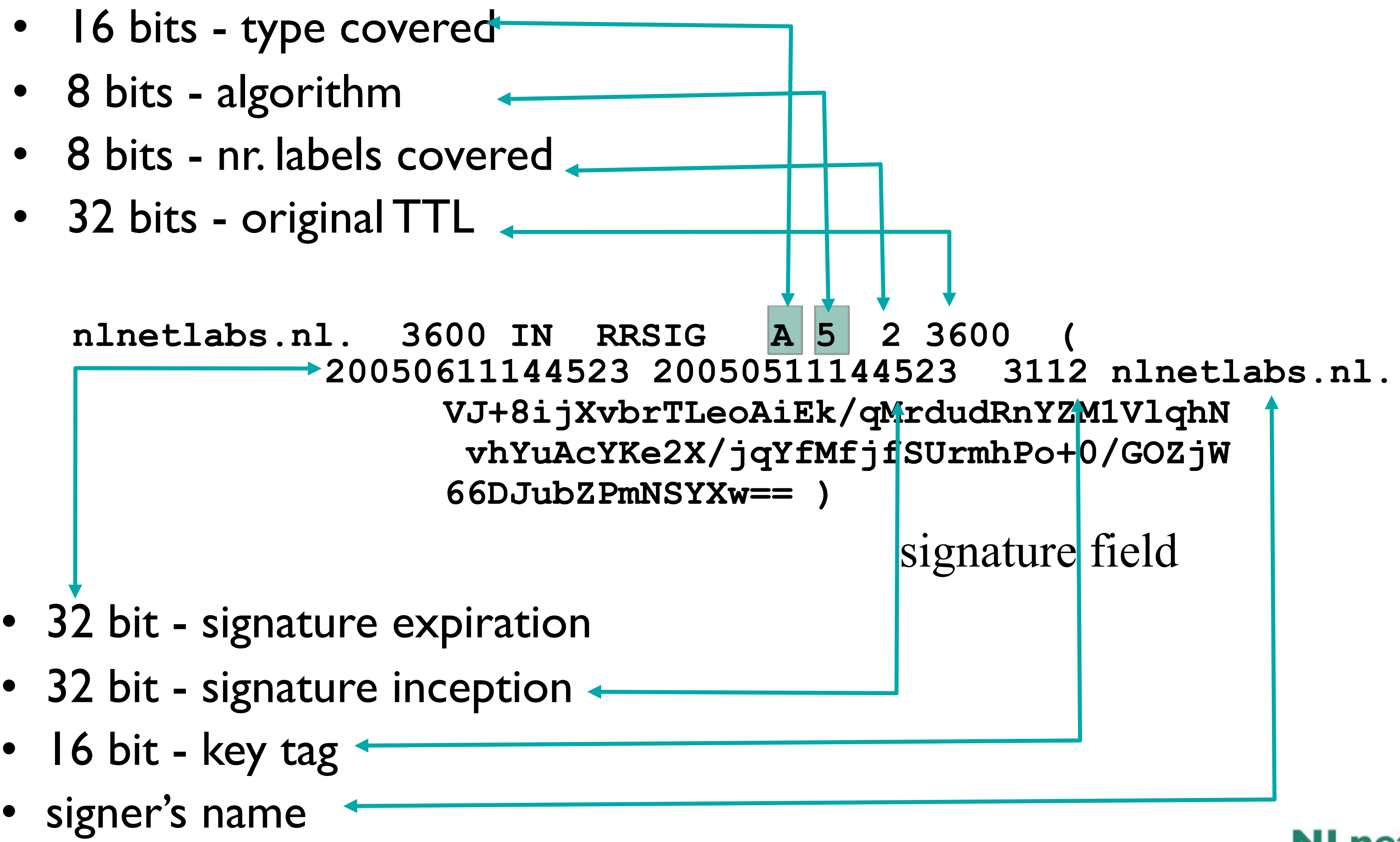

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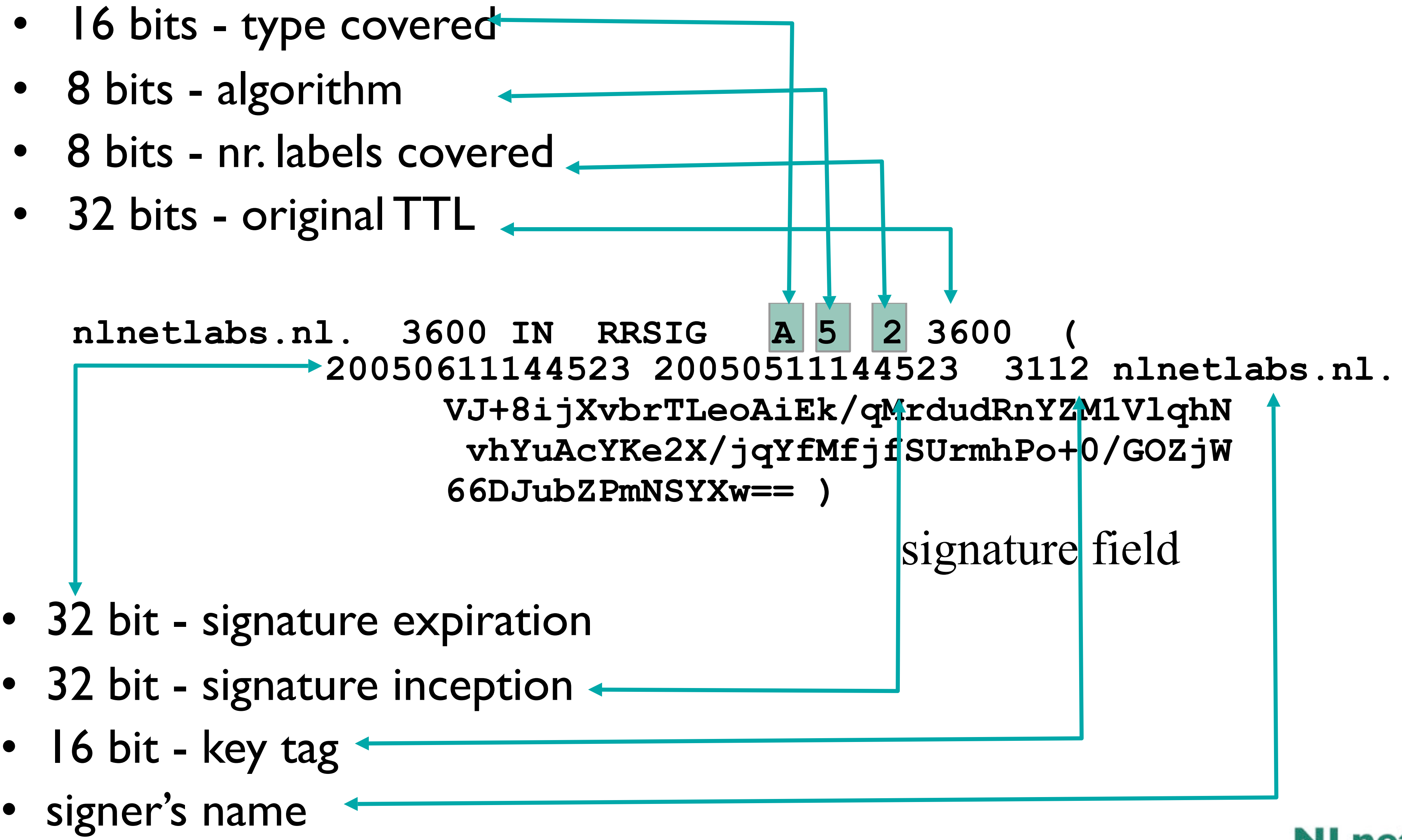

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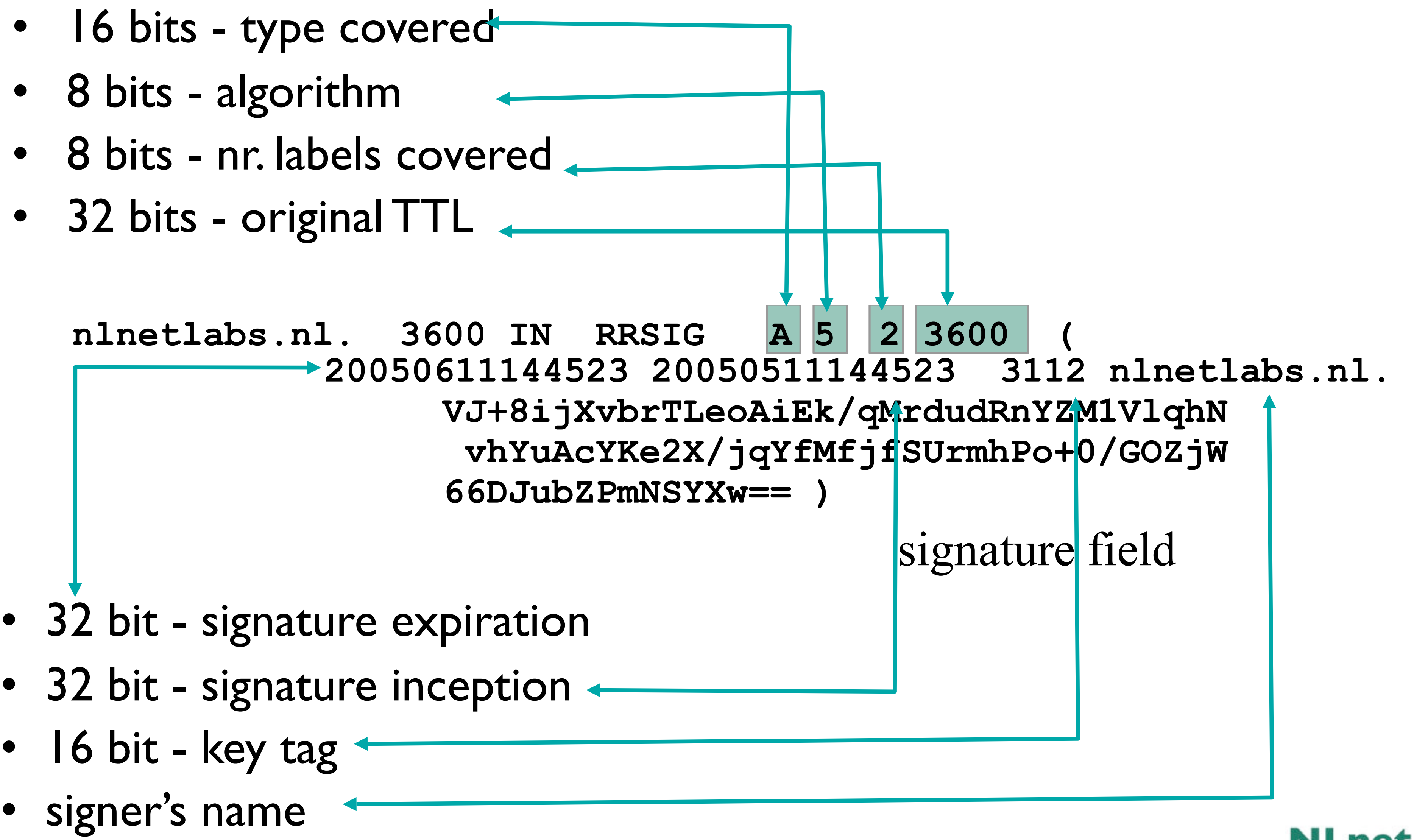

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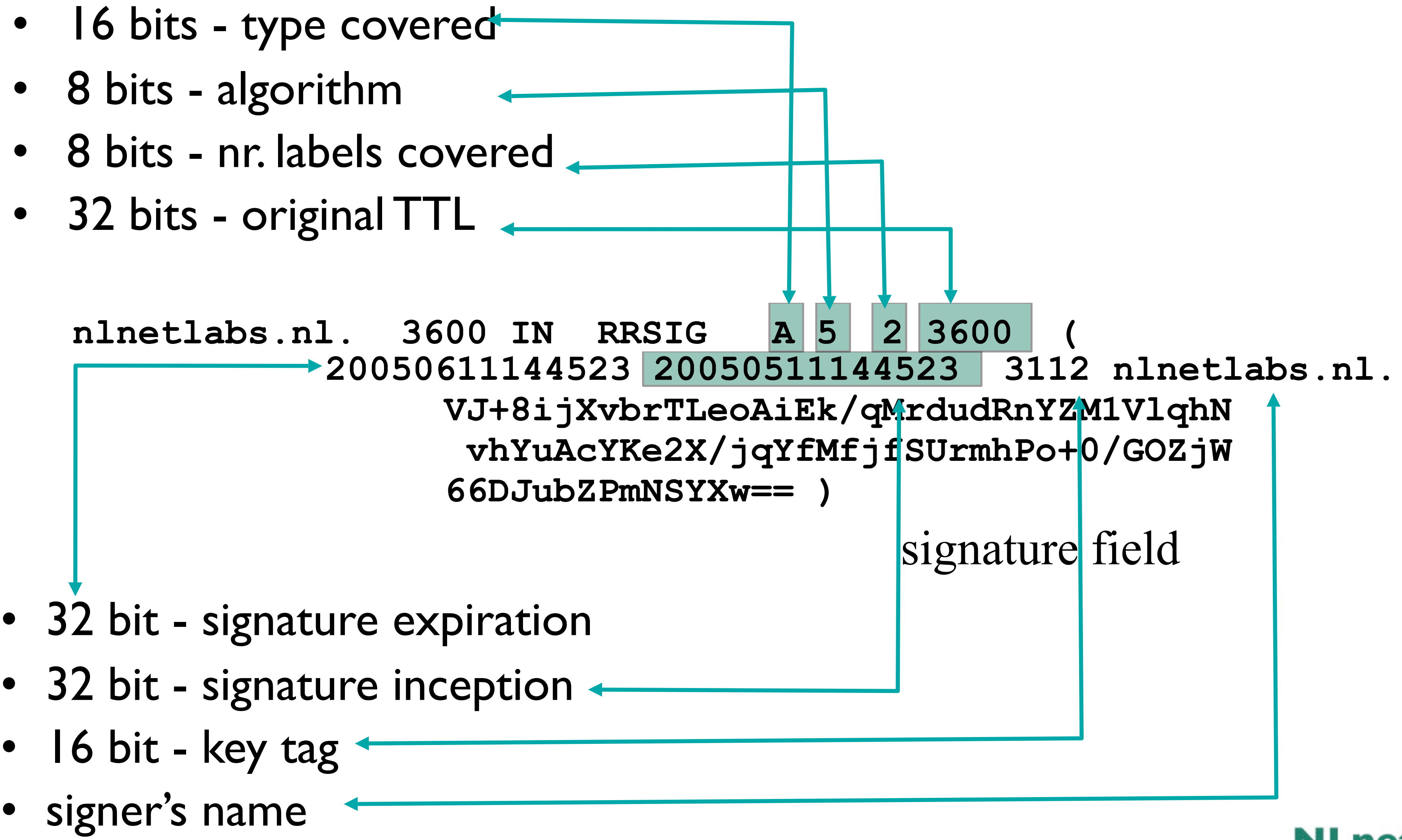

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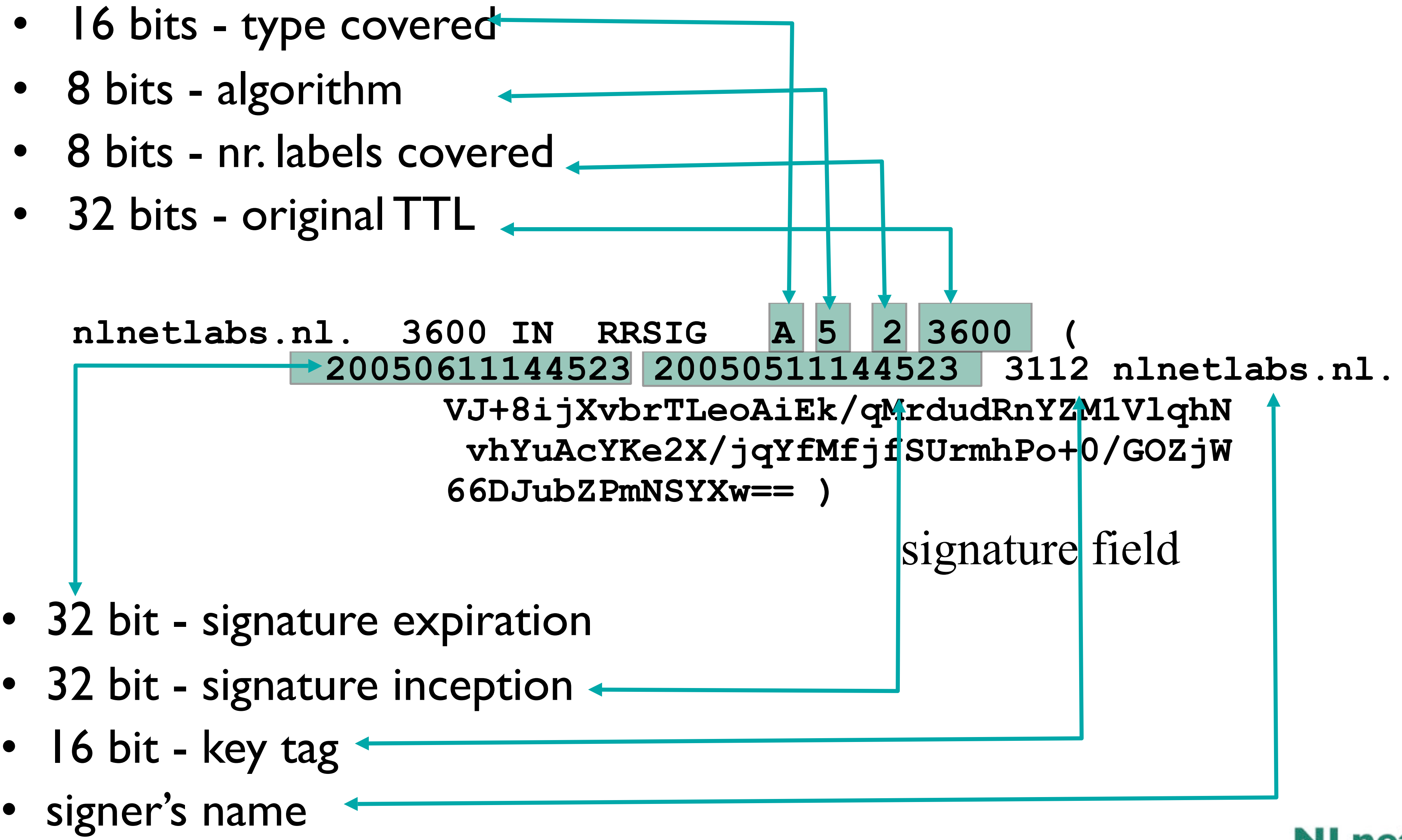

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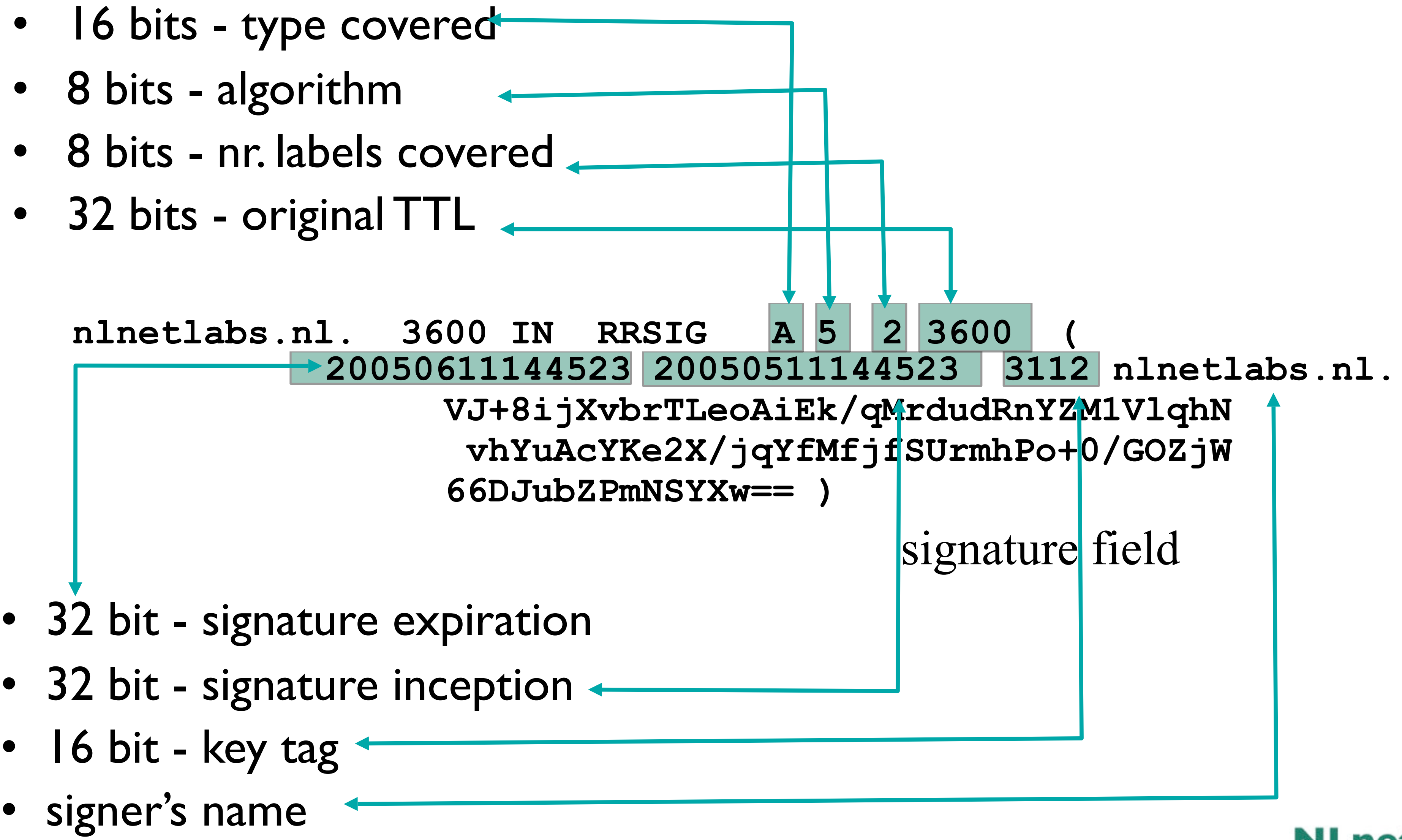

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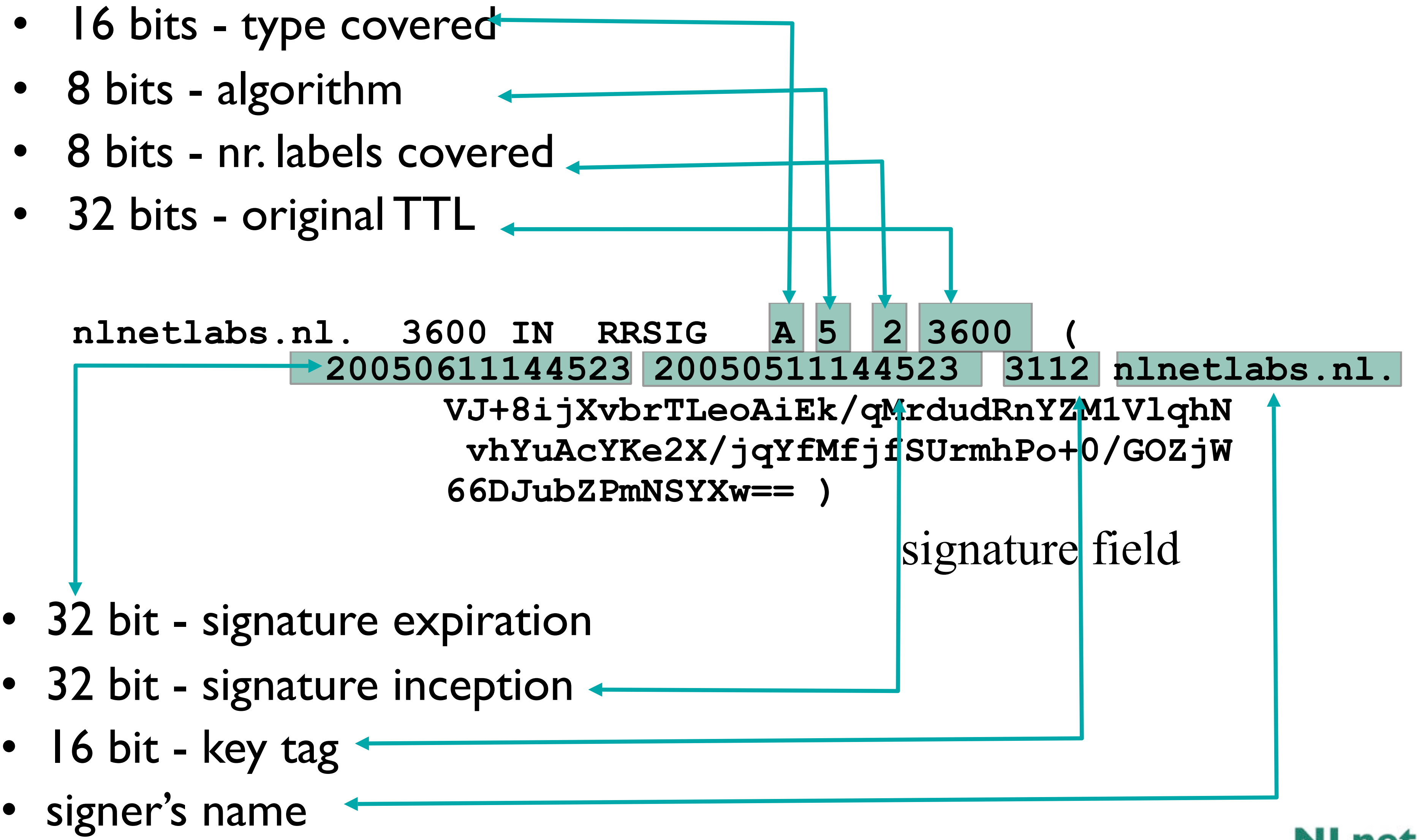

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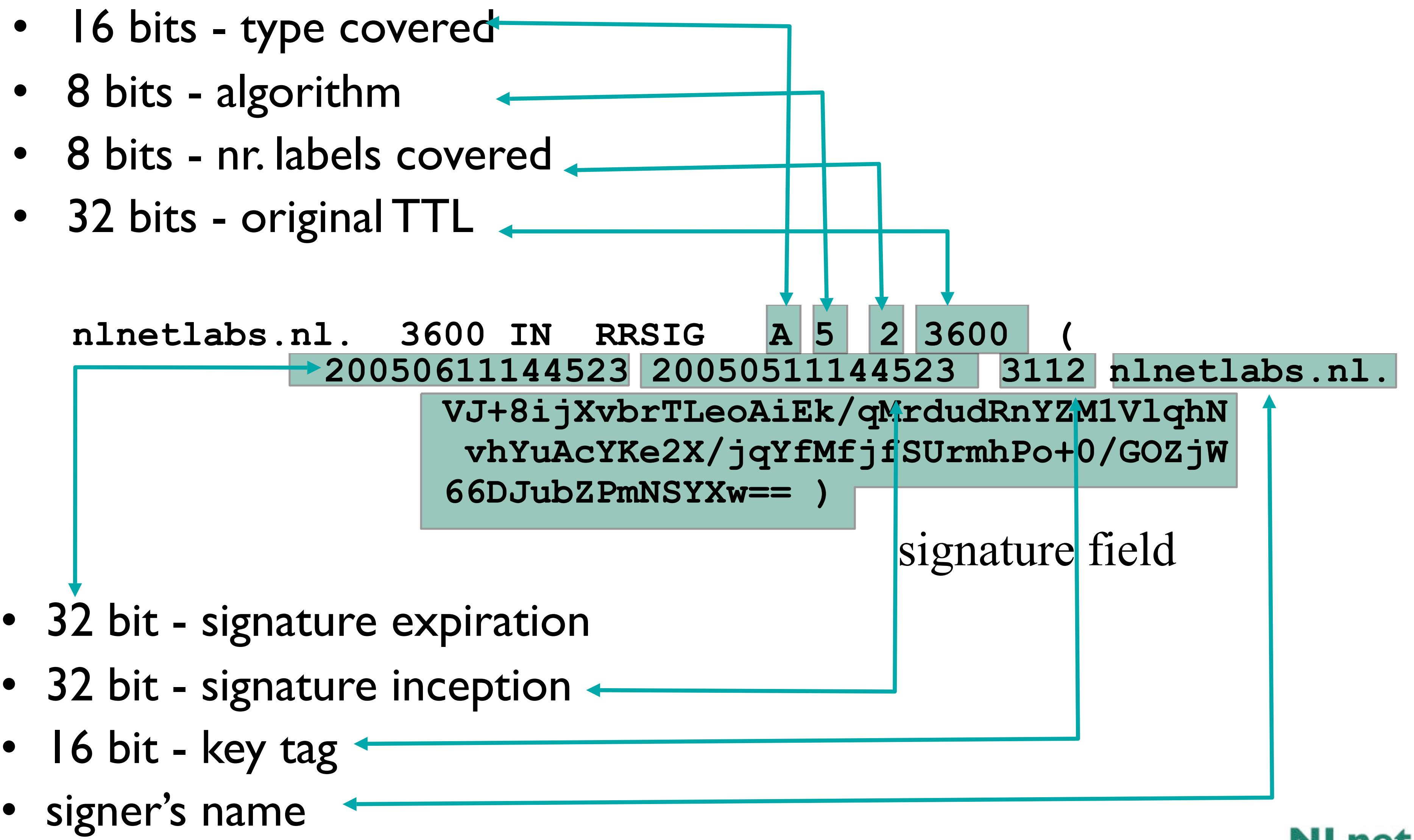

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Delegation Signer (DS)

- 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

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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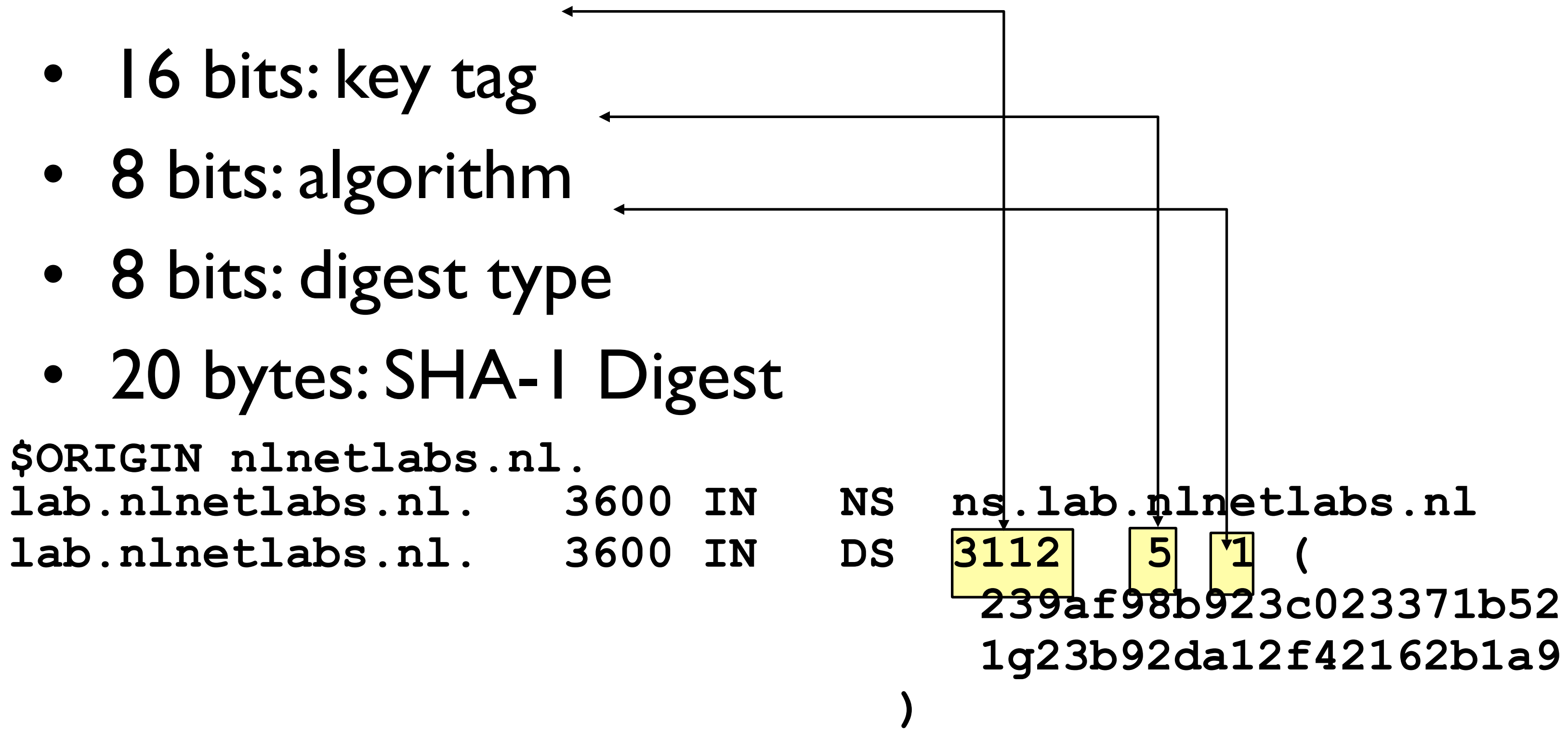

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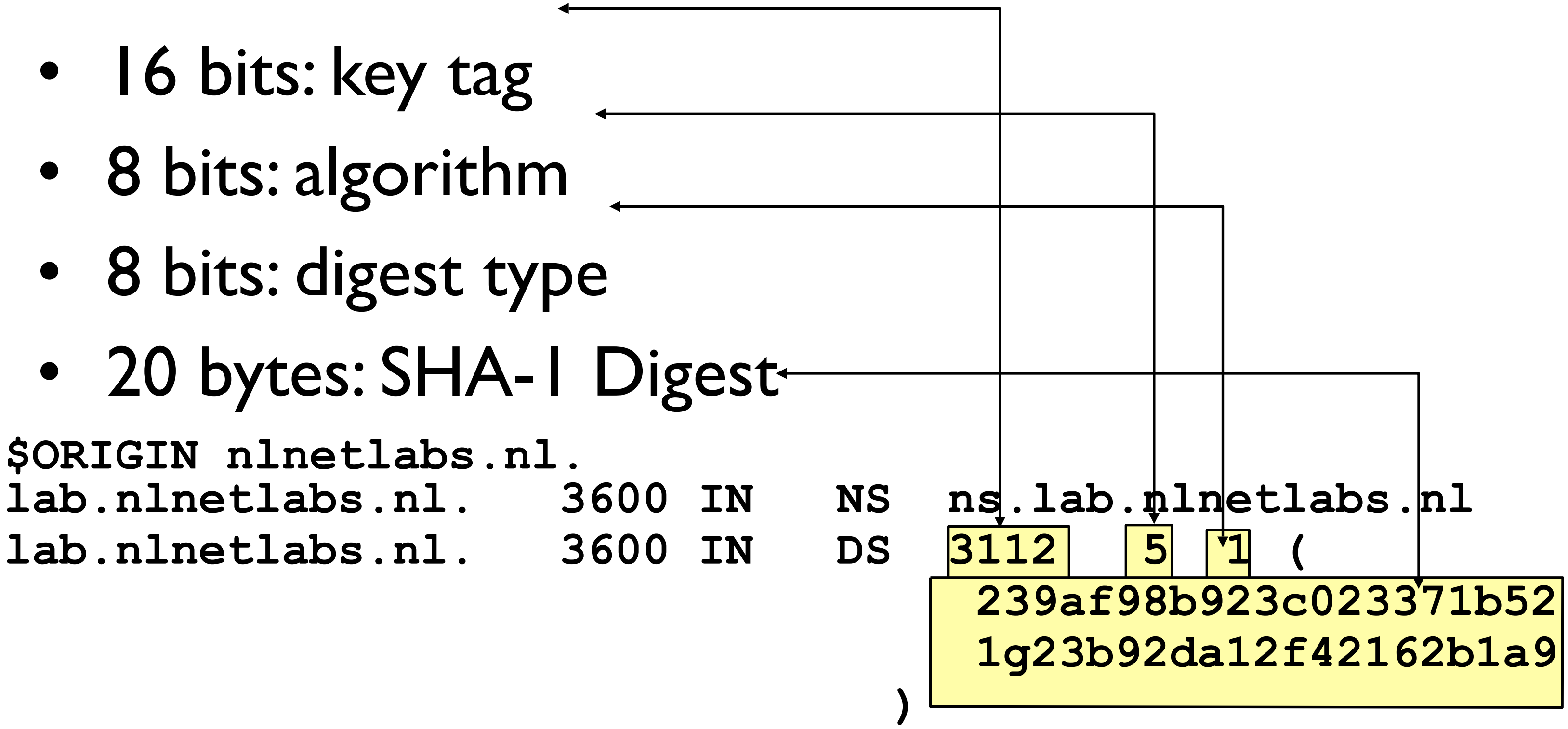

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```

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:

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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

NSEC Walk

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

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

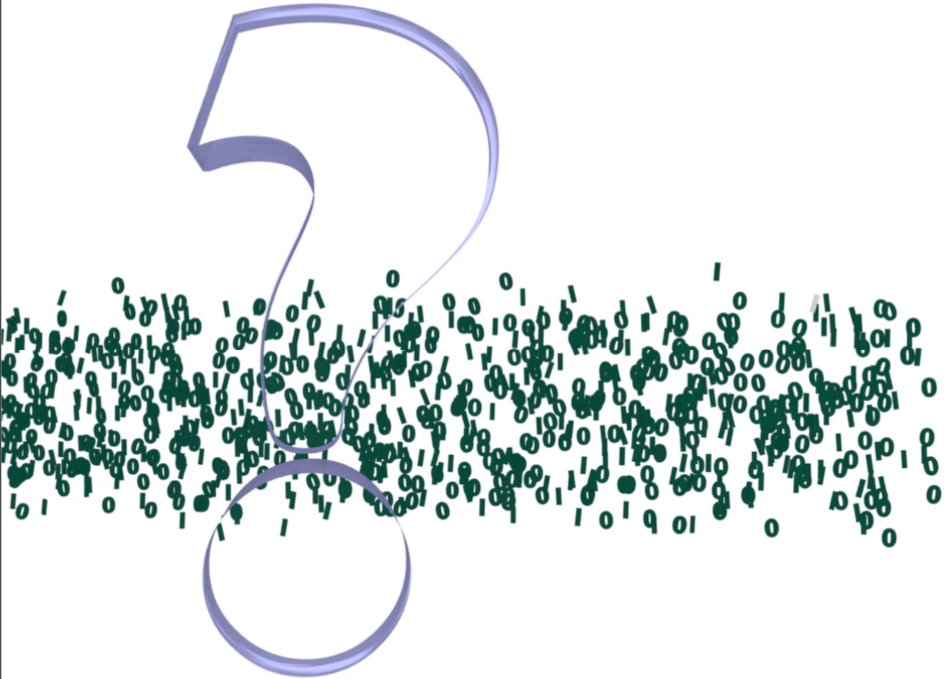
Current Developments

- SHA1 to be deprecated
  - New hash for DS records
  - Overlap, no flag day
- Introduction of SHA256

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

Summary and questions



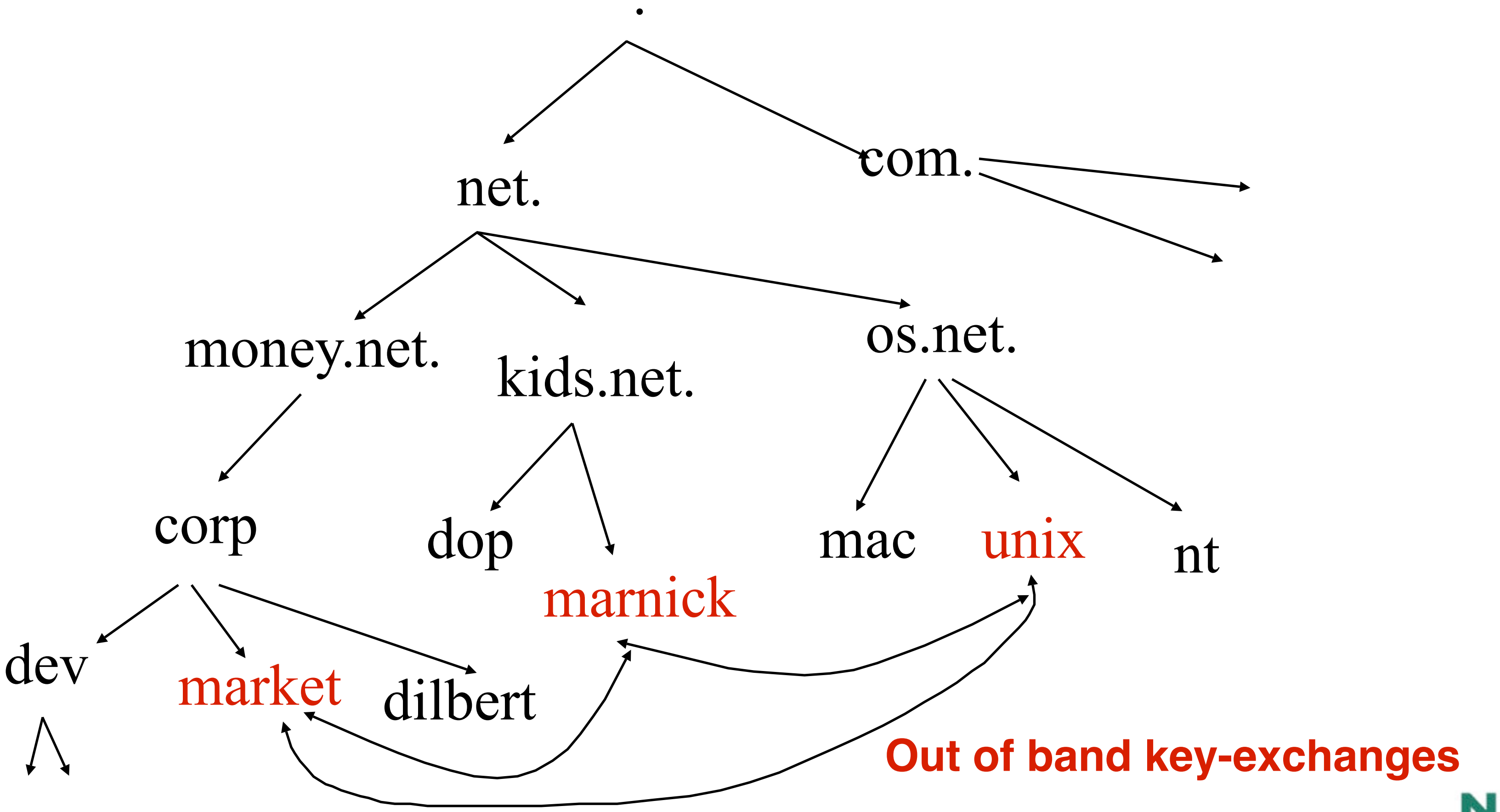
- You have seen the new RRs and learned what is their content

Delegating Signing Authority

Chains of Trust

Locally Secured Zones

- Key distribution does not scale!



Locally Secured Zones

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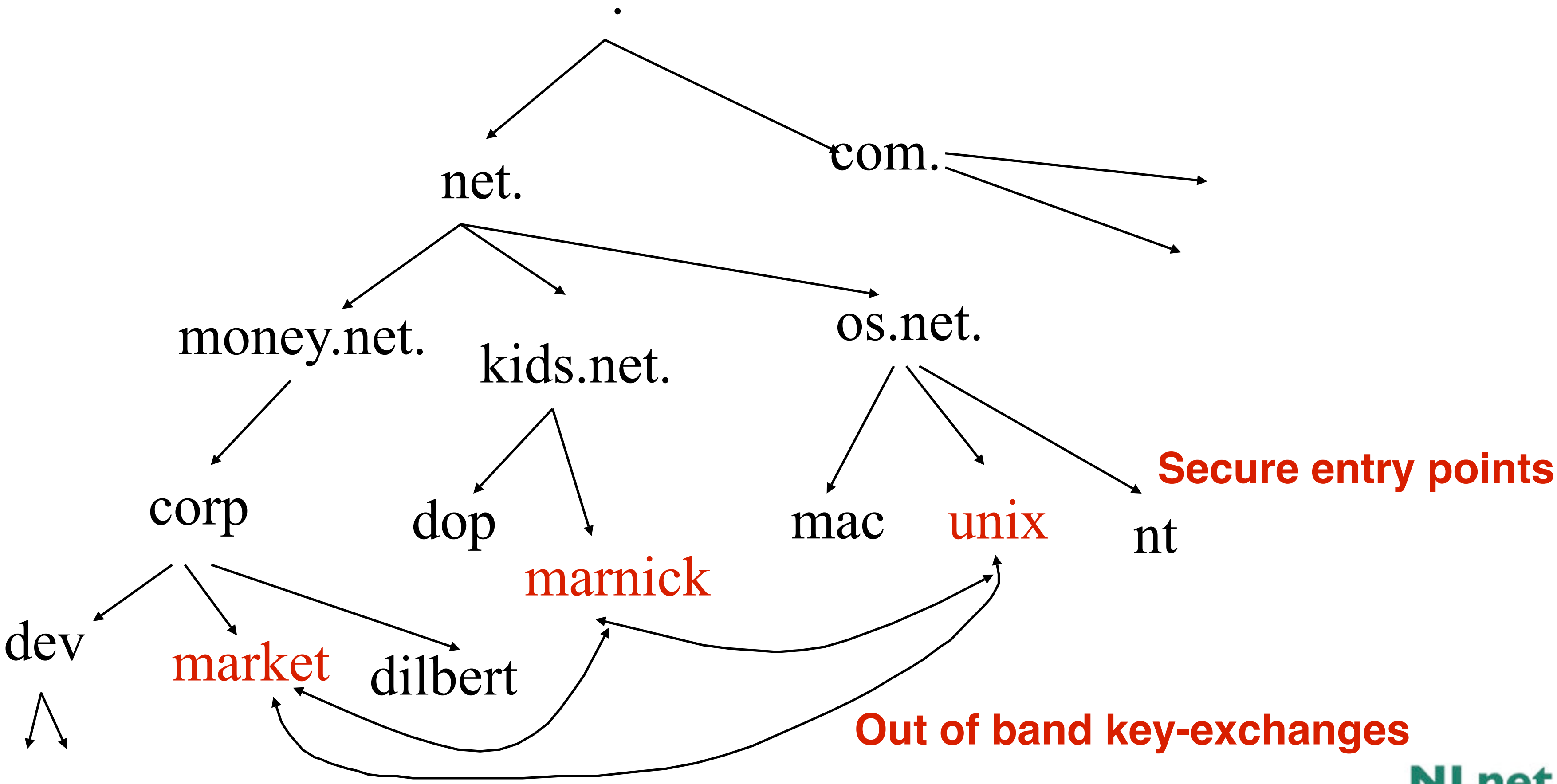


Using the DNS to Distribute Keys

- 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

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 Functions

- Large keys are more secure
  - Can be used longer ☺
  - Large signatures => large zonefiles ☹
  - Signing and verifying computationally expensive ☹

- Small keys are fast
  - Small signatures ☺
  - Signing and verifying less expensive ☺
  - Short lifetime ☹

Key solution: More Than One Key

- 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

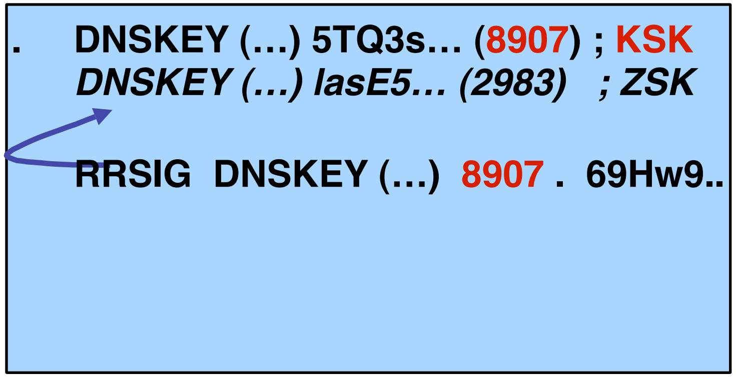
Walking the Chain of Trust

Locally configured
Trusted key: . 8907

1

2

$ORIGIN .



```
.     DNSKEY (…) 5TQ3s… (8907) ; KSK
      DNSKEY (…) lasE5… (2983)   ; ZSK

      RRSIG  DNSKEY (…)  8907 .  69Hw9..
```

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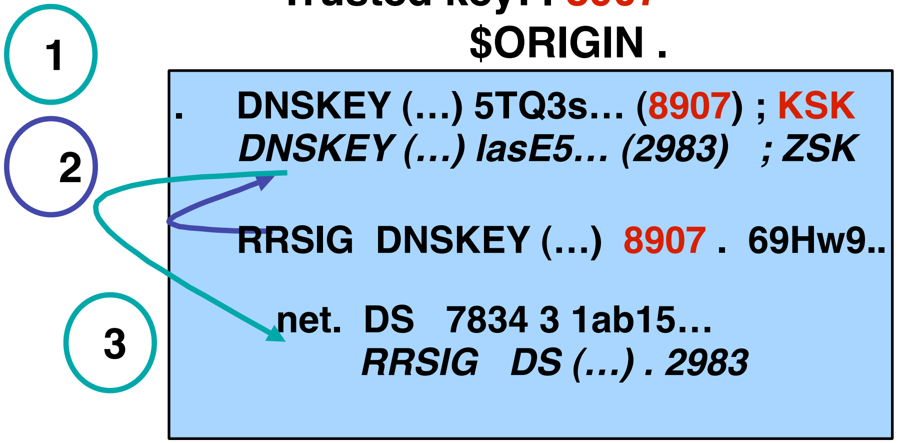
Trusted key: . 8907
$ORIGIN .



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RRSIG DNSKEY (…) 8907 . 69Hw9..

net. DS   7834 3 1ab15…
RRSIG   DS (…) . 2983

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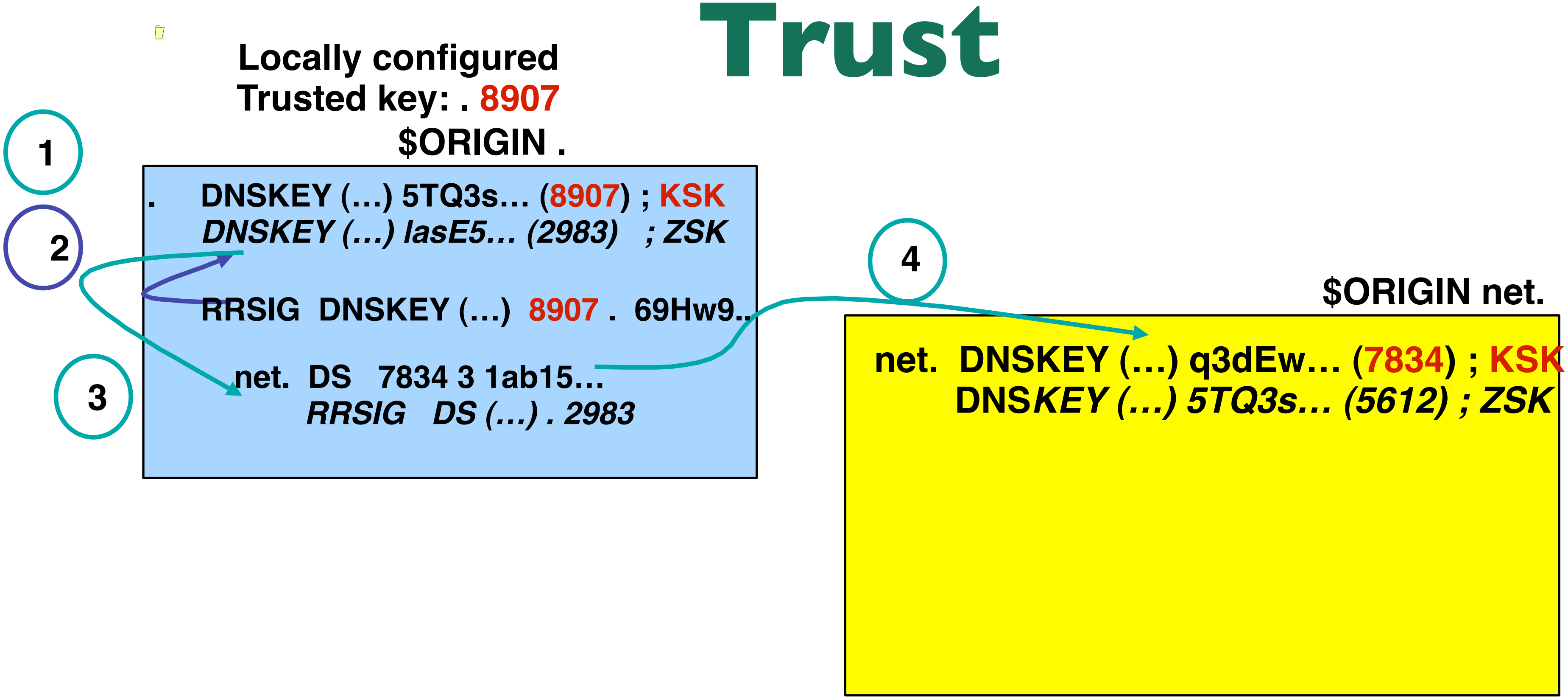

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$ORIGIN .

```
.    DNSKEY (…) 5TQ3s… (8907) ; KSK
     DNSKEY (…) lasE5… (2983)   ; ZSK

     RRSIG  DNSKEY (…)  8907 .  69Hw9..

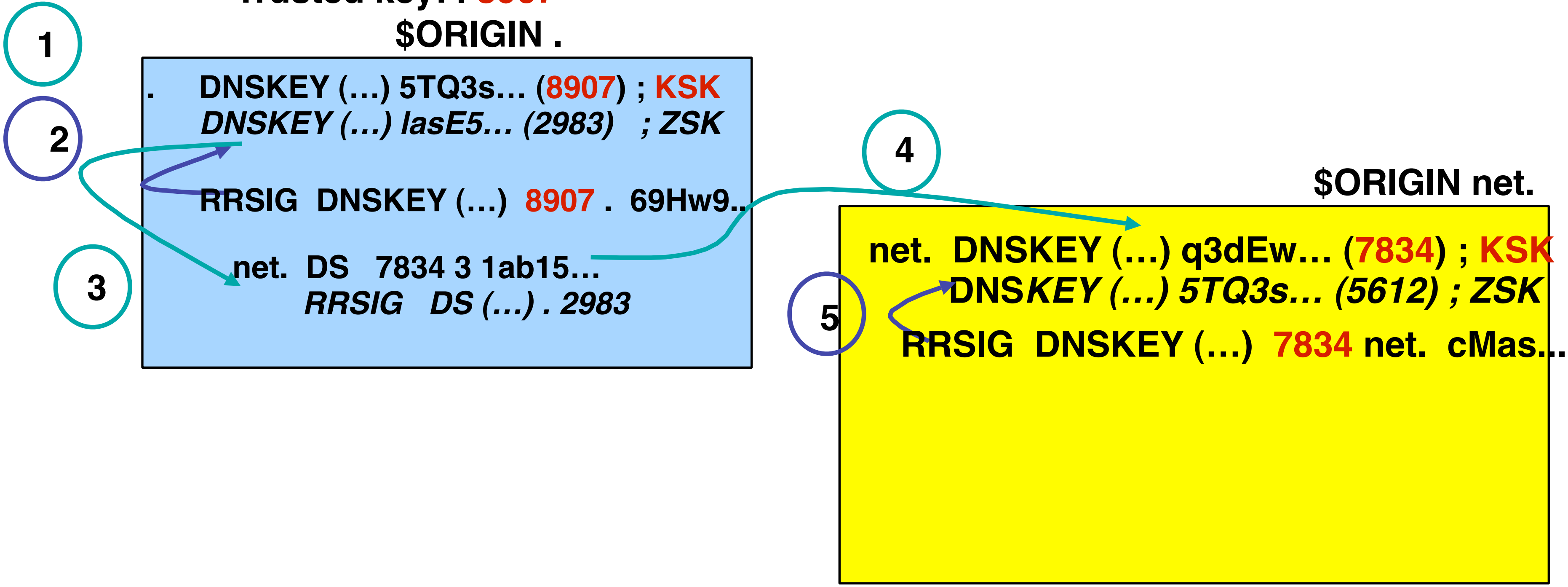
       net.  DS   7834 3 1ab15…
             RRSIG   DS (…) . 2983
```

$ORIGIN net.

```
net.  DNSKEY (…) q3dEw… (7834) ; KSK
      DNSKEY (…) 5TQ3s… (5612) ; ZSK
```

Walking the Chain of Trust

Locally configured
Trusted key: . 8907



$ORIGIN .

. DNSKEY (…) 5TQ3s… (8907) ; KSK
DNSKEY (…) lasE5… (2983) ; ZSK

RRSIG DNSKEY (…) 8907 . 69Hw9..

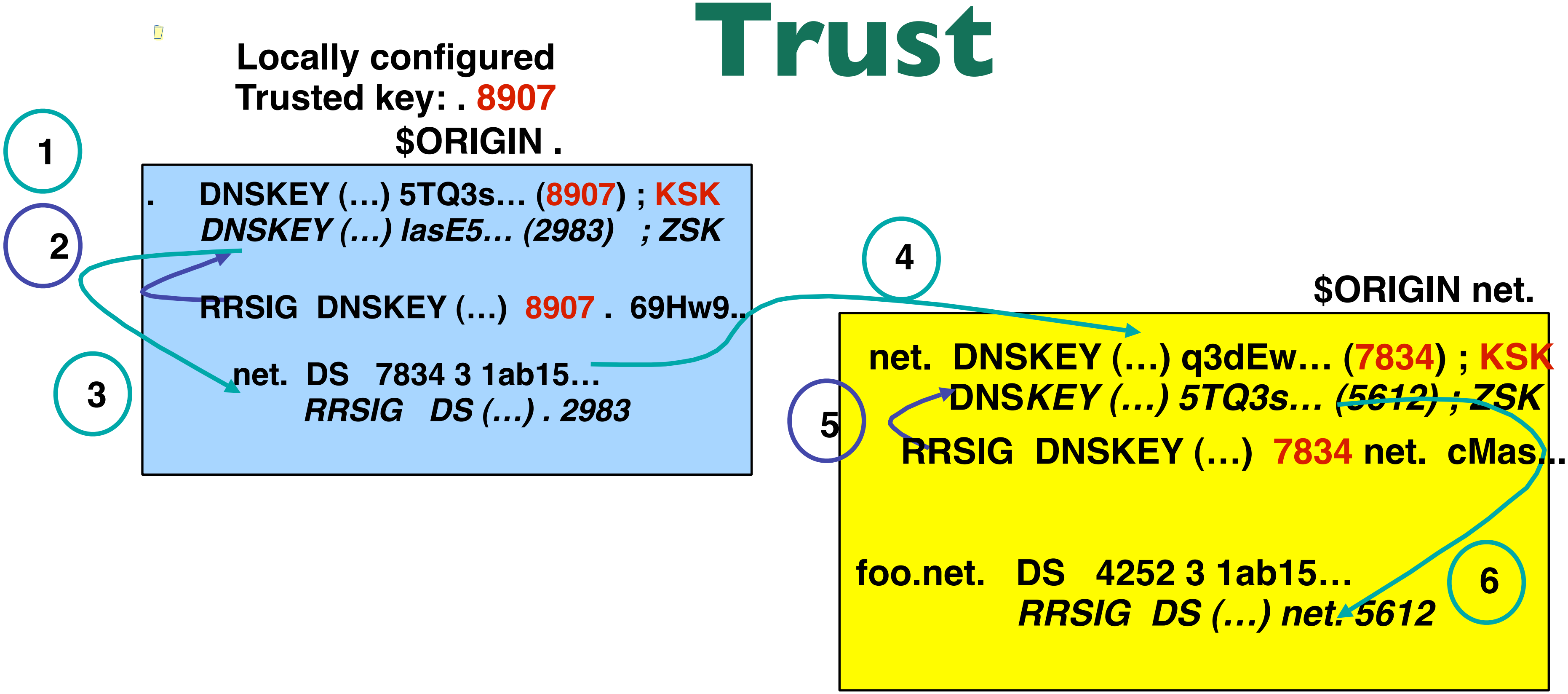
net. DS 7834 3 1ab15…
RRSIG DS (…) . 2983

$ORIGIN net.

net. DNSKEY (…) q3dEw… (7834) ; KSK
DNS*KEY (…) 5TQ3s… (5612) ; ZSK*

RRSIG DNSKEY (…) 7834 net. cMas...

Walking the Chain of Trust



Locally configured
Trusted key: . 8907
$ORIGIN .

```
.    DNSKEY (…) 5TQ3s… (8907) ; KSK
     DNSKEY (…) lasE5… (2983)   ; ZSK

     RRSIG  DNSKEY (…)  8907 .  69Hw9..

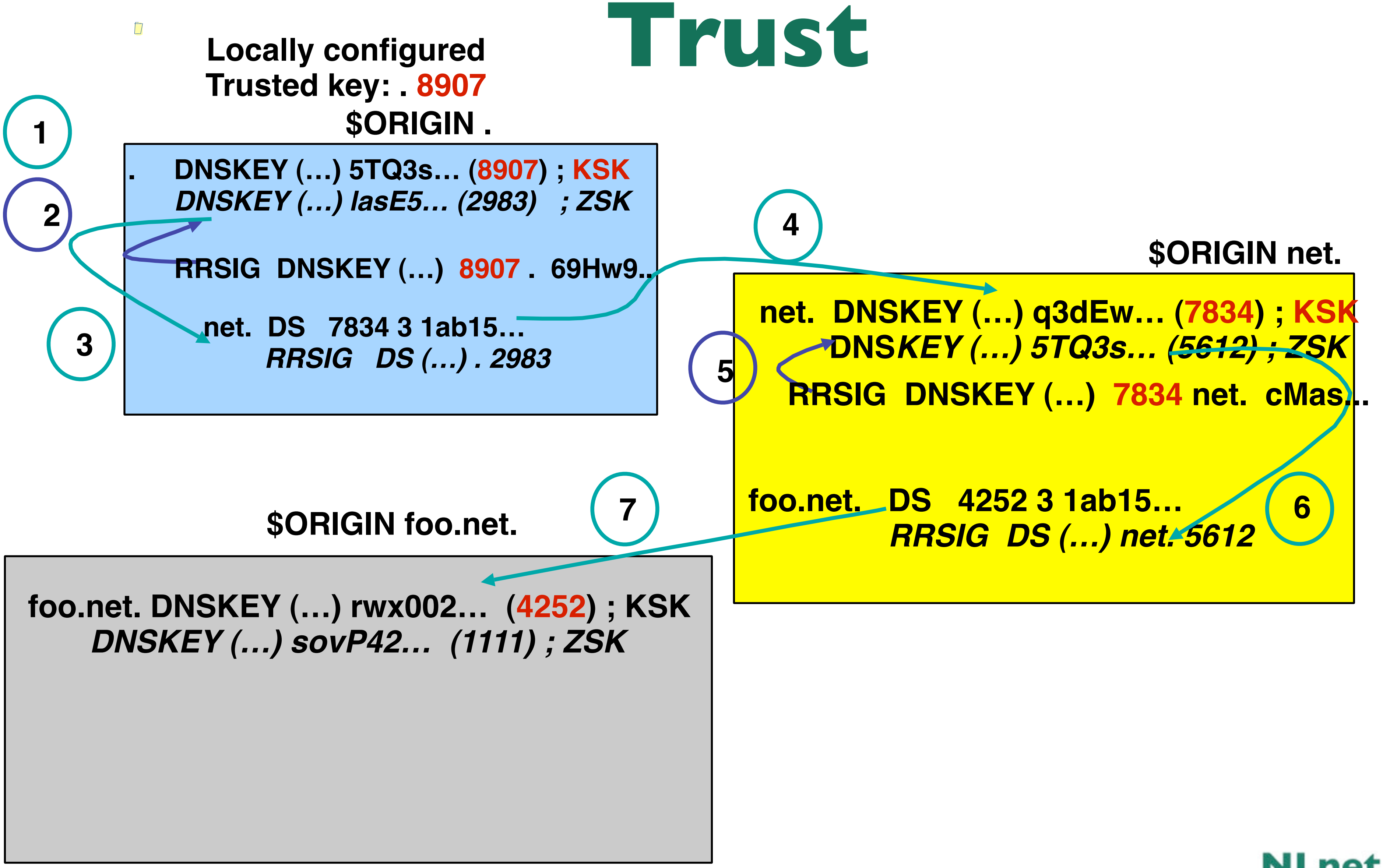
       net.  DS   7834 3 1ab15…
             RRSIG   DS (…) . 2983
```

$ORIGIN net.

```
net.  DNSKEY (…) q3dEw… (7834) ; KSK
      DNSKEY (…) 5TQ3s… (5612) ; ZSK
  RRSIG  DNSKEY (…)  7834 net.  cMas...

foo.net.   DS   4252 3 1ab15…
           RRSIG  DS (…) net. 5612
```

Walking the Chain of Trust



Locally configured
Trusted key: . 8907

$ORIGIN .

```
.    DNSKEY (…) 5TQ3s… (8907) ; KSK
     DNSKEY (…) lasE5… (2983)   ; ZSK

     RRSIG  DNSKEY (…)  8907 .  69Hw9..

        net.  DS   7834 3 1ab15…
              RRSIG   DS (…) . 2983
```

$ORIGIN net.

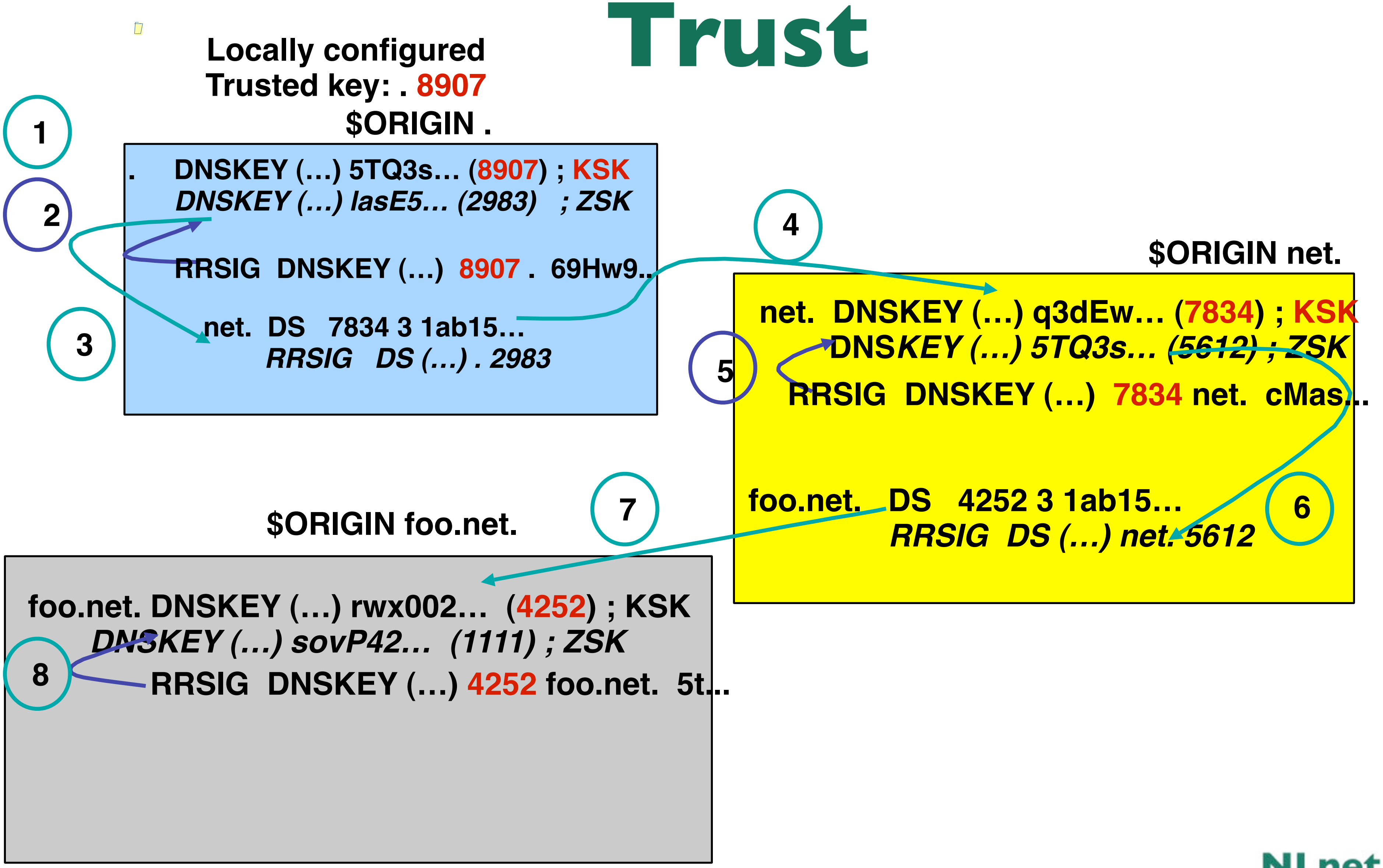
```
net.  DNSKEY (…) q3dEw… (7834) ; KSK
      DNSKEY (…) 5TQ3s… (5612) ; ZSK
   RRSIG  DNSKEY (…)  7834 net.  cMas...

foo.net.  DS   4252 3 1ab15…
          RRSIG  DS (…) net. 5612
```

$ORIGIN foo.net.

```
foo.net. DNSKEY (…) rwx002…  (4252) ; KSK
         DNSKEY (…) sovP42…  (1111) ; ZSK
```

Walking the Chain of Trust



Locally configured
Trusted key: . 8907

$ORIGIN .

```
.    DNSKEY (…) 5TQ3s… (8907) ; KSK
     DNSKEY (…) lasE5… (2983)   ; ZSK

     RRSIG  DNSKEY (…)  8907 .  69Hw9..

       net.  DS   7834 3 1ab15…
             RRSIG   DS (…) . 2983
```

$ORIGIN net.

```
net.  DNSKEY (…) q3dEw… (7834) ; KSK
      DNSKEY (…) 5TQ3s… (5612) ; ZSK
    RRSIG  DNSKEY (…)  7834 net.  cMas...

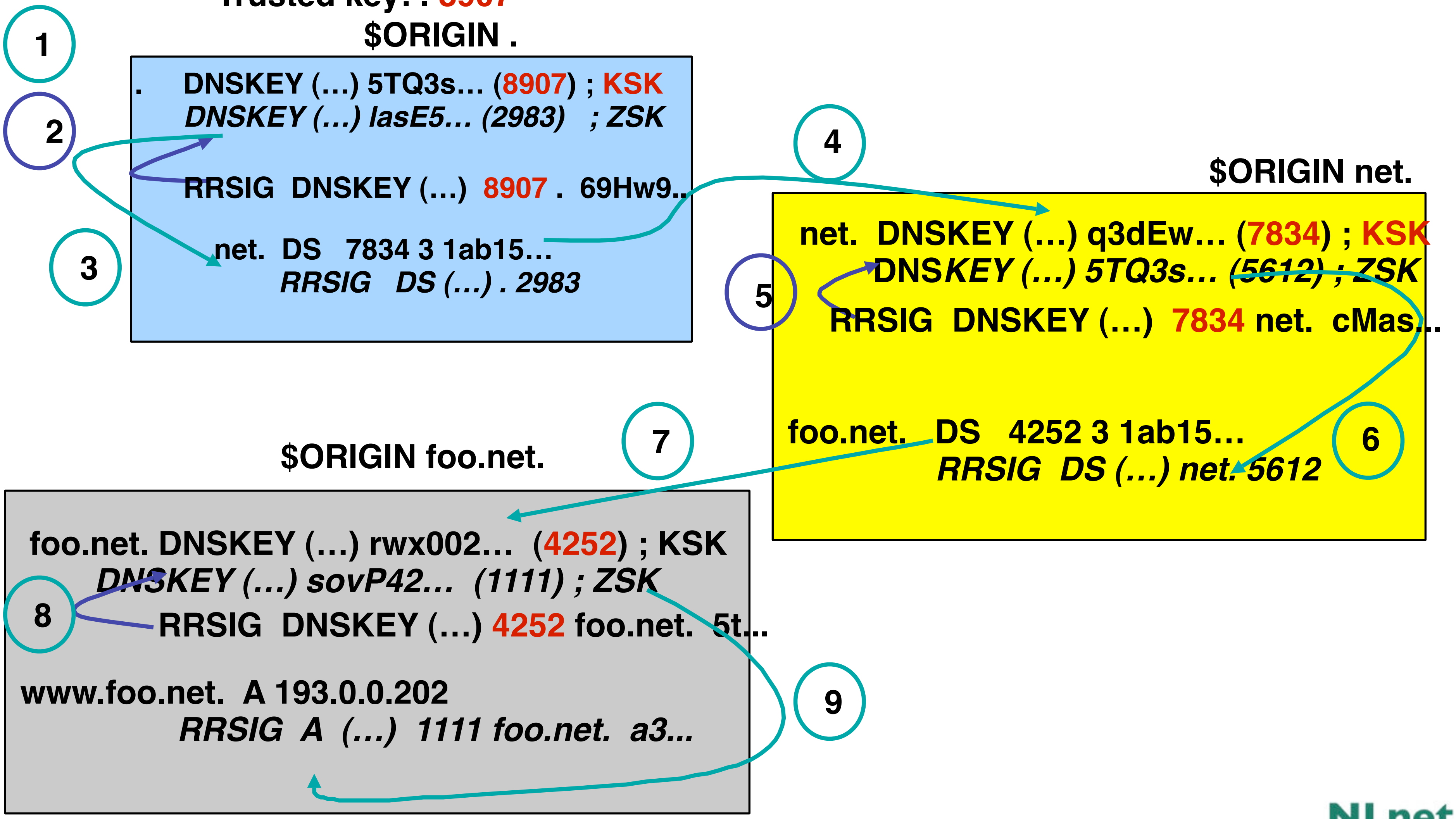
foo.net.  DS   4252 3 1ab15…
          RRSIG  DS (…) net. 5612
```

$ORIGIN foo.net.

```
foo.net. DNSKEY (…) rwx002…  (4252) ; KSK
         DNSKEY (…) sovP42…  (1111) ; ZSK
       RRSIG  DNSKEY (…) 4252 foo.net.  5t...
```

Walking the Chain of Trust

Locally configured
Trusted key: . 8907



$ORIGIN .

```
.    DNSKEY (…) 5TQ3s… (8907) ; KSK
     DNSKEY (…) lasE5… (2983)   ; ZSK

     RRSIG  DNSKEY (…)  8907 .  69Hw9..

        net.  DS   7834 3 1ab15…
              RRSIG   DS (…) . 2983
```

$ORIGIN net.

```
net.  DNSKEY (…) q3dEw… (7834) ; KSK
      DNSKEY (…) 5TQ3s… (5612) ; ZSK
    RRSIG  DNSKEY (…)  7834 net.  cMas...

foo.net.  DS   4252 3 1ab15…
          RRSIG  DS (…) net. 5612
```

$ORIGIN foo.net.

```
foo.net. DNSKEY (…) rwx002…  (4252) ; KSK
         DNSKEY (…) sovP42…  (1111) ; ZSK
         RRSIG  DNSKEY (…) 4252 foo.net.  5t...

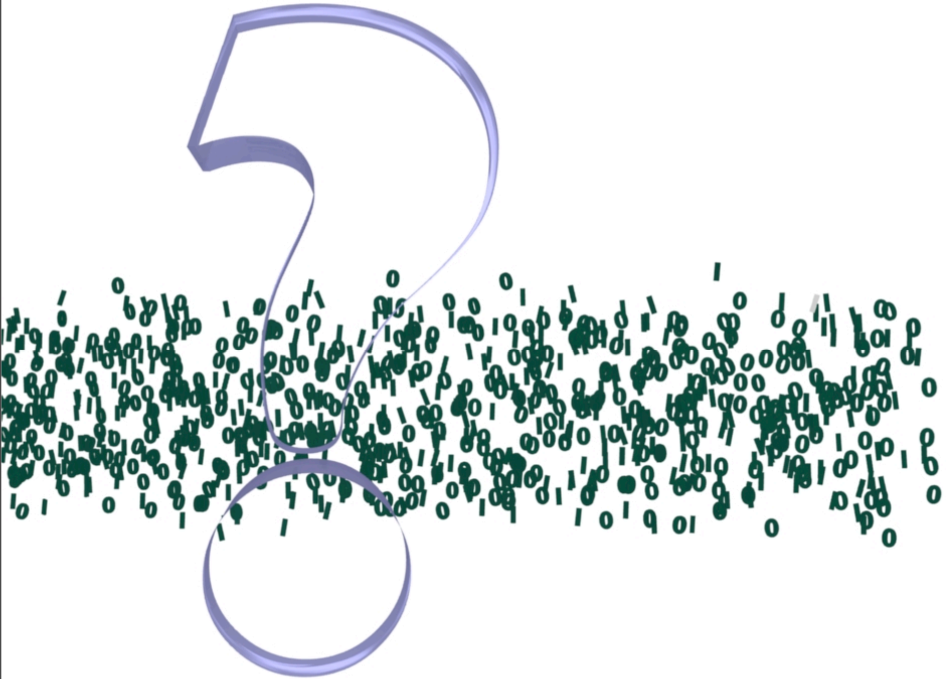
www.foo.net.  A 193.0.0.202
              RRSIG  A  (…)  1111 foo.net.  a3...
```

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

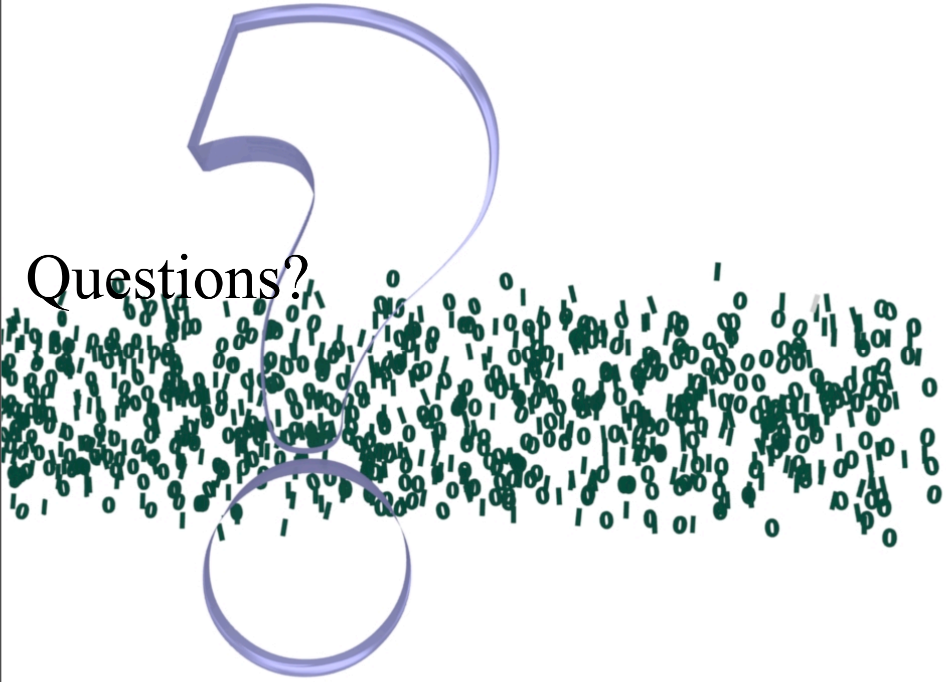
  or
  - DS or DNSKEY records can be trusted if exchanged out-of-band and locally stored (Secure entry point)

Summary



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

Summary

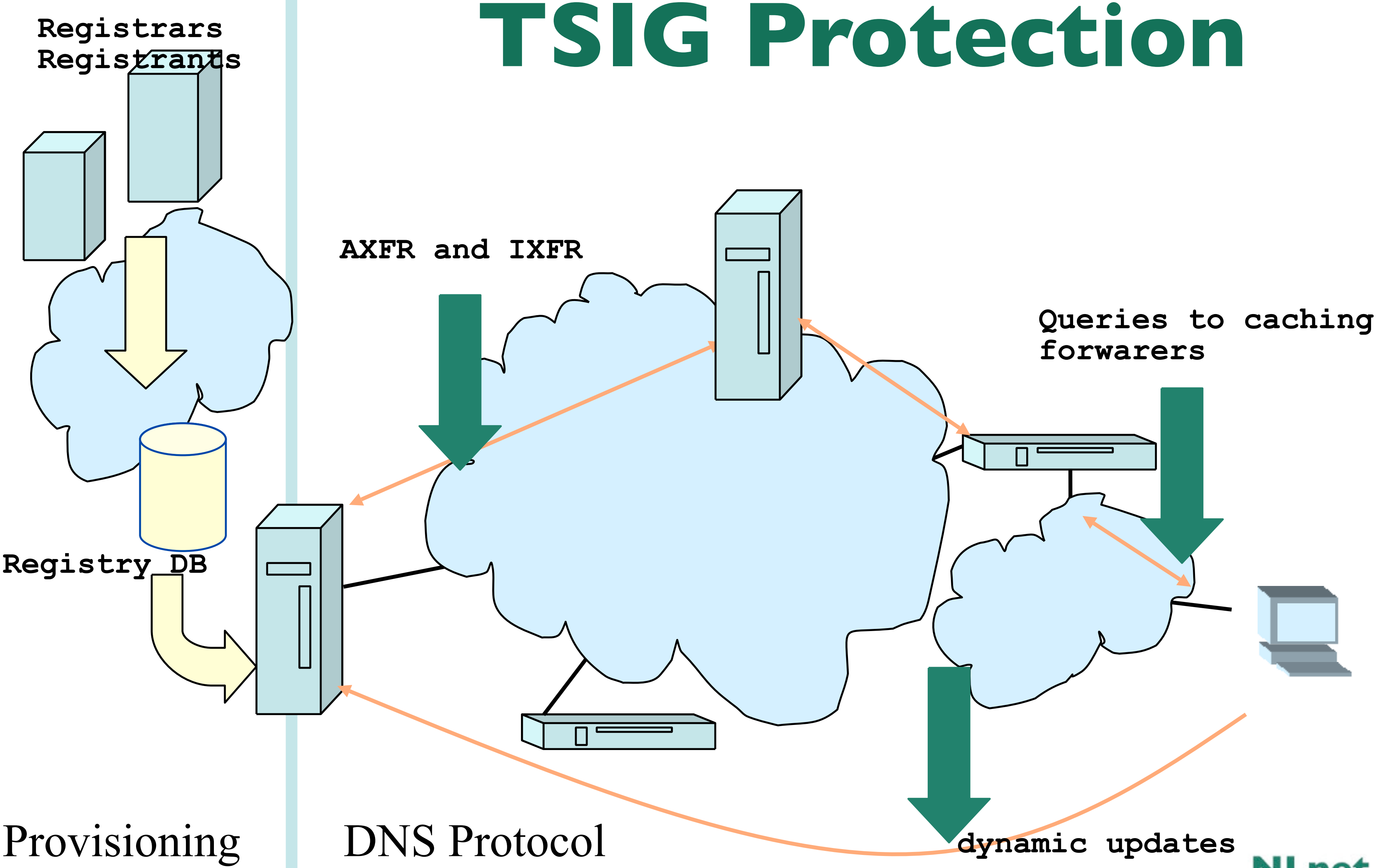


Questions?

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

Securing Host-Host Communication

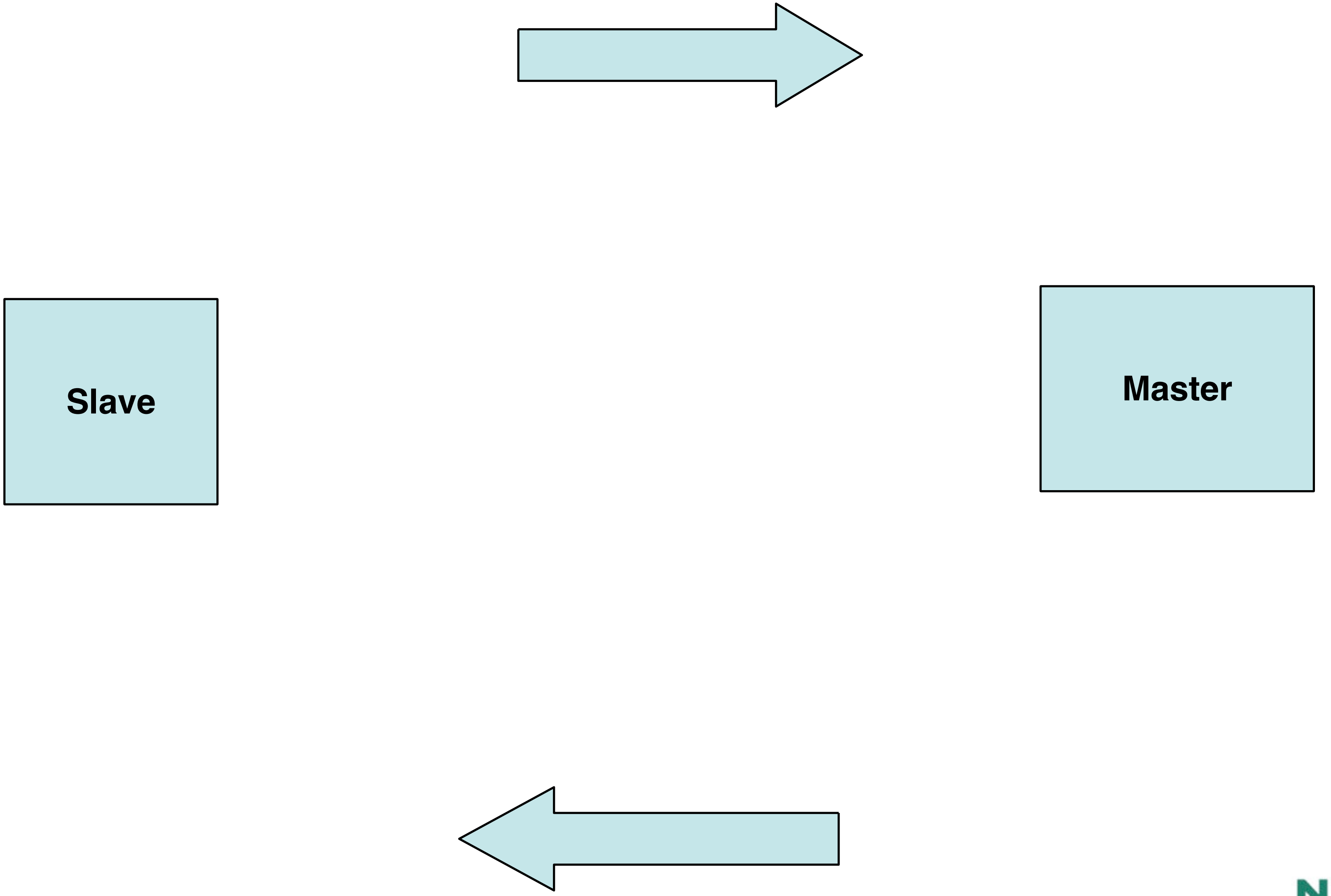
TSIG Protection



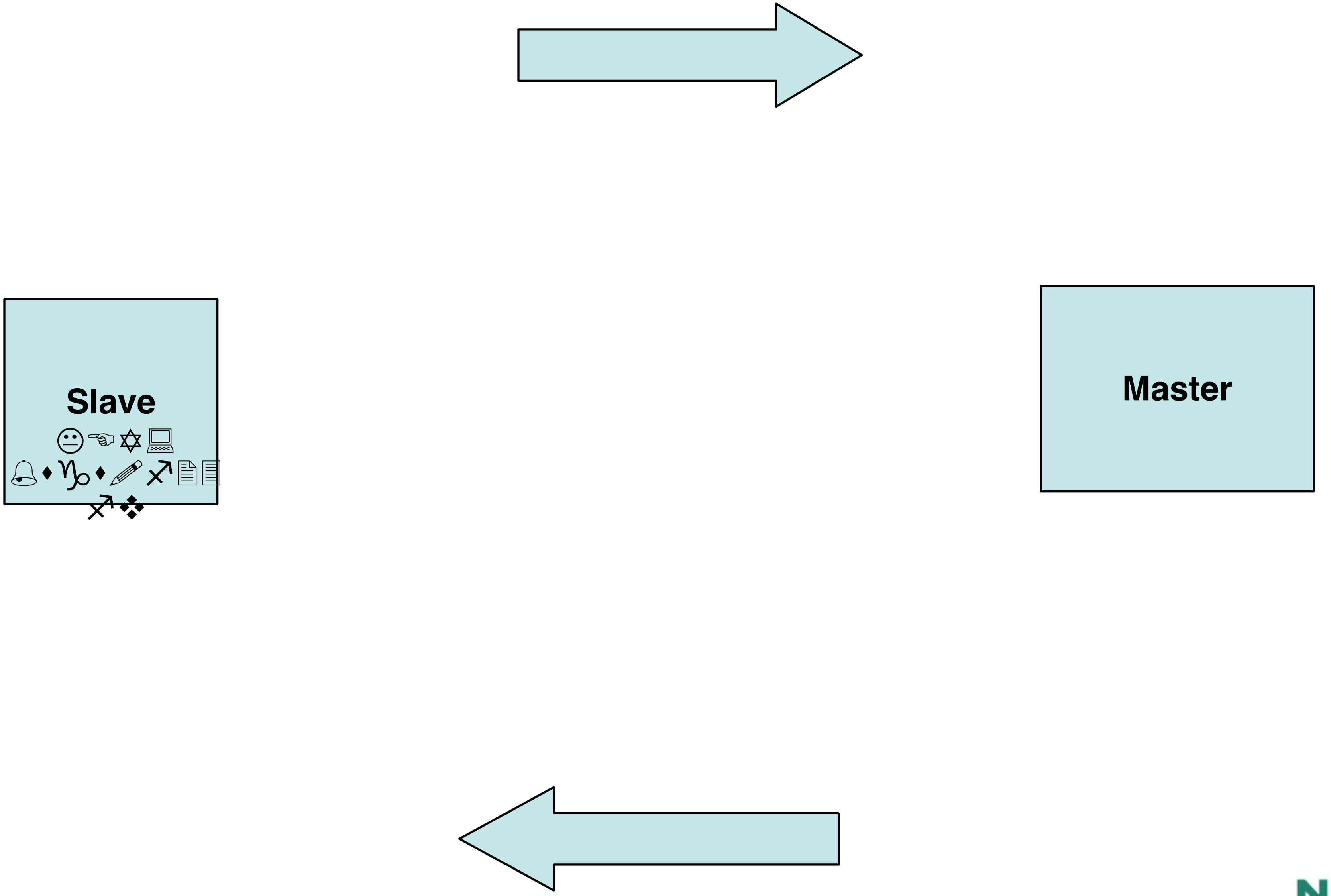
Transaction Signature: TSIG

- TSIG (RFC 2845)
  - Authorising dynamic updates and zone transfers
  - Authentication of caching forwarders
  - Independent from other features of DNSSEC
- One-way hash function
  - DNS question or answer and timestamp
- Traffic signed with "shared secret" key
- Used in configuration, **NOT** in zone file

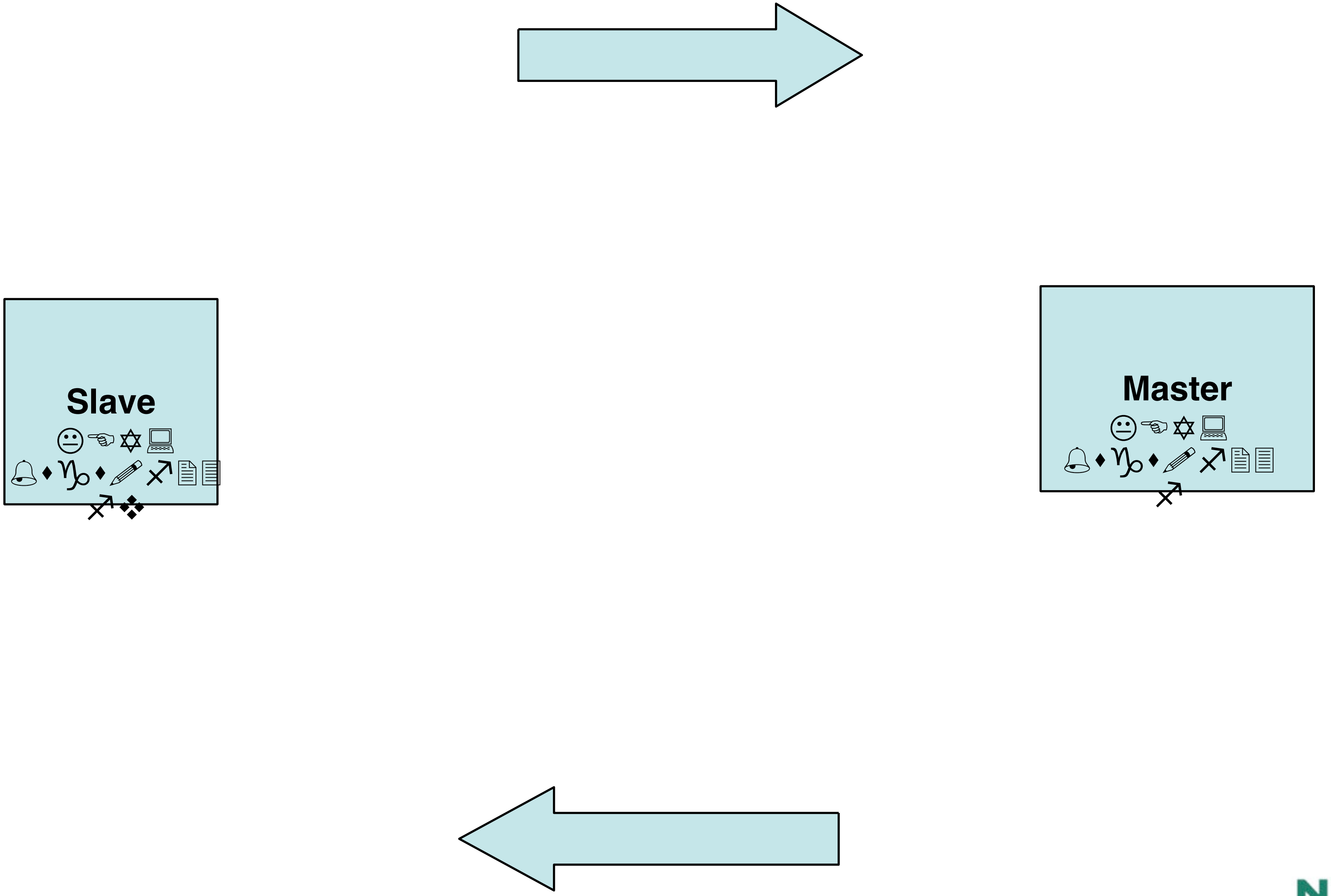
TSIG Example



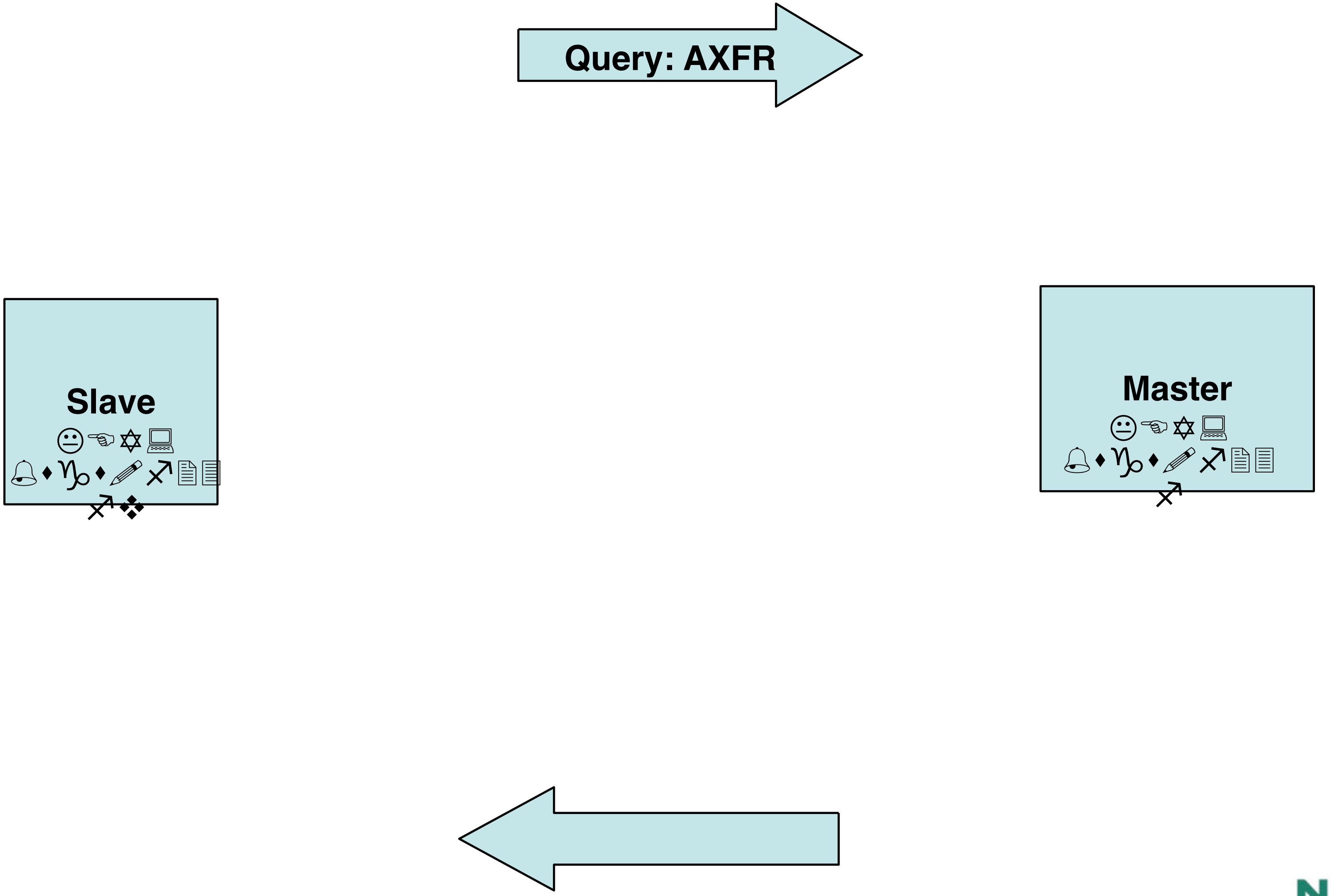
TSIG Example



TSIG Example



TSIG Example



Query: AXFR

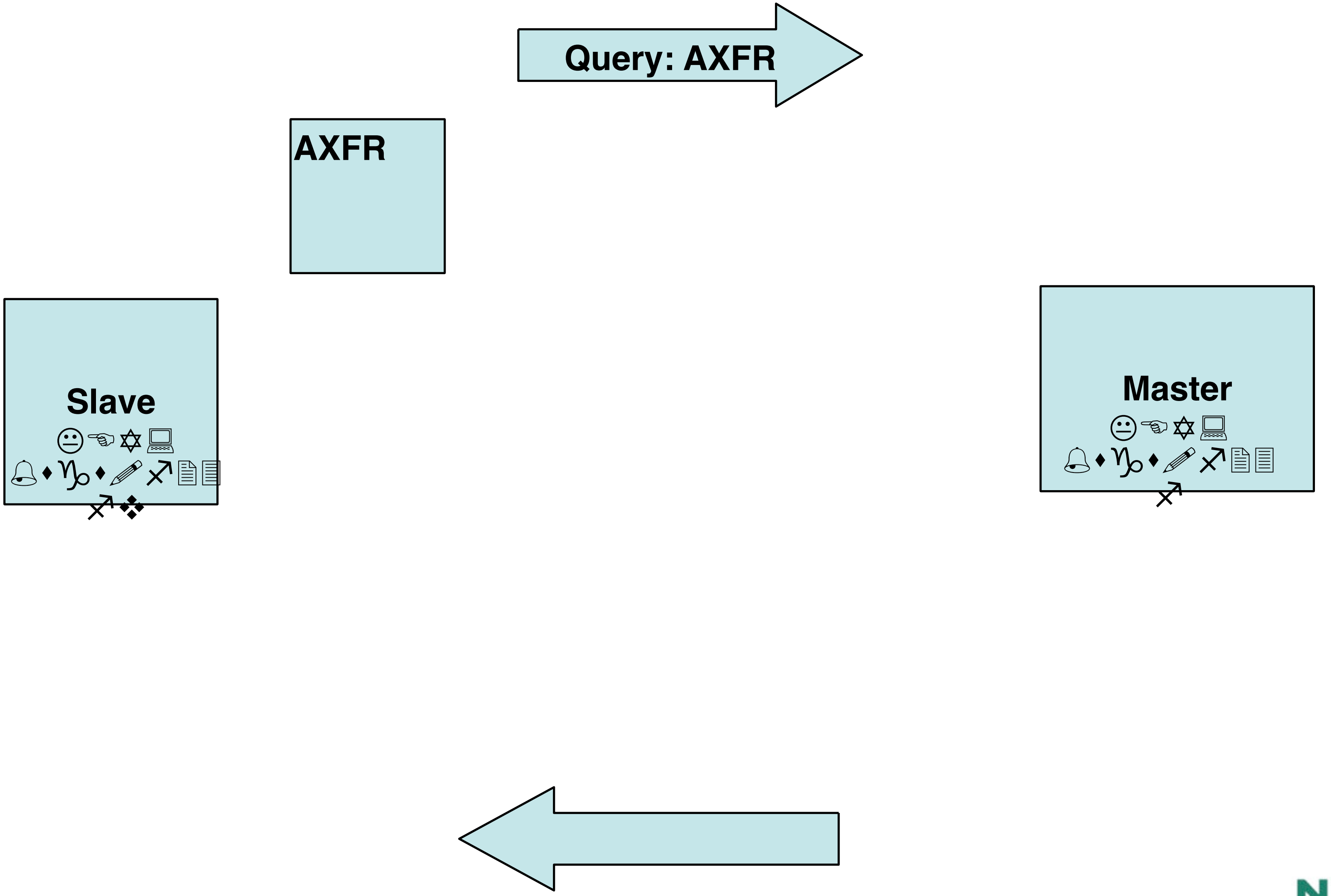
Slave

😐☜✡💻
🔔♦♑♦✏♐🗎🗏
♐❖

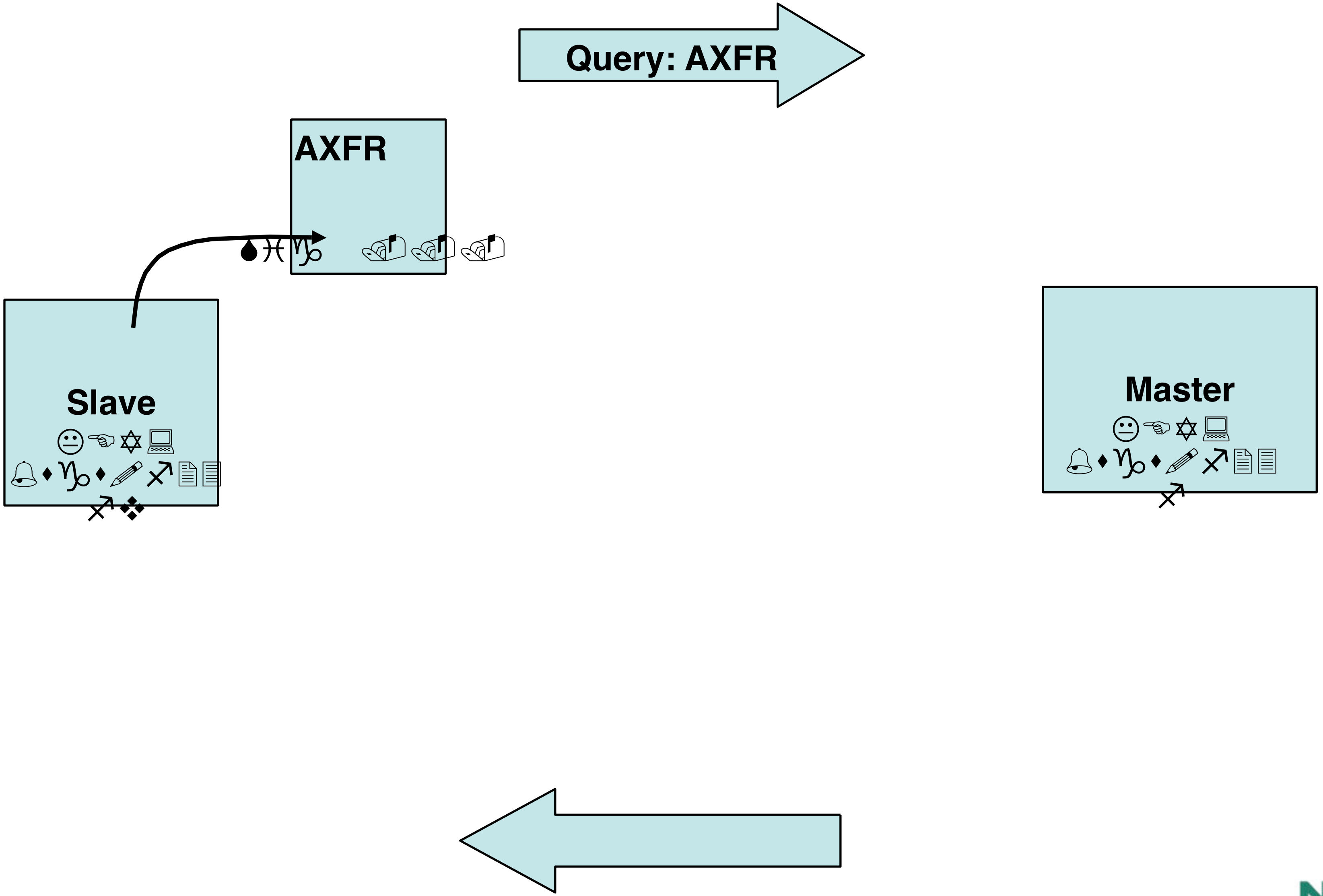
Master

😐☜✡💻
🔔♦♑♦✏♐🗎🗏
♐

TSIG Example



TSIG Example



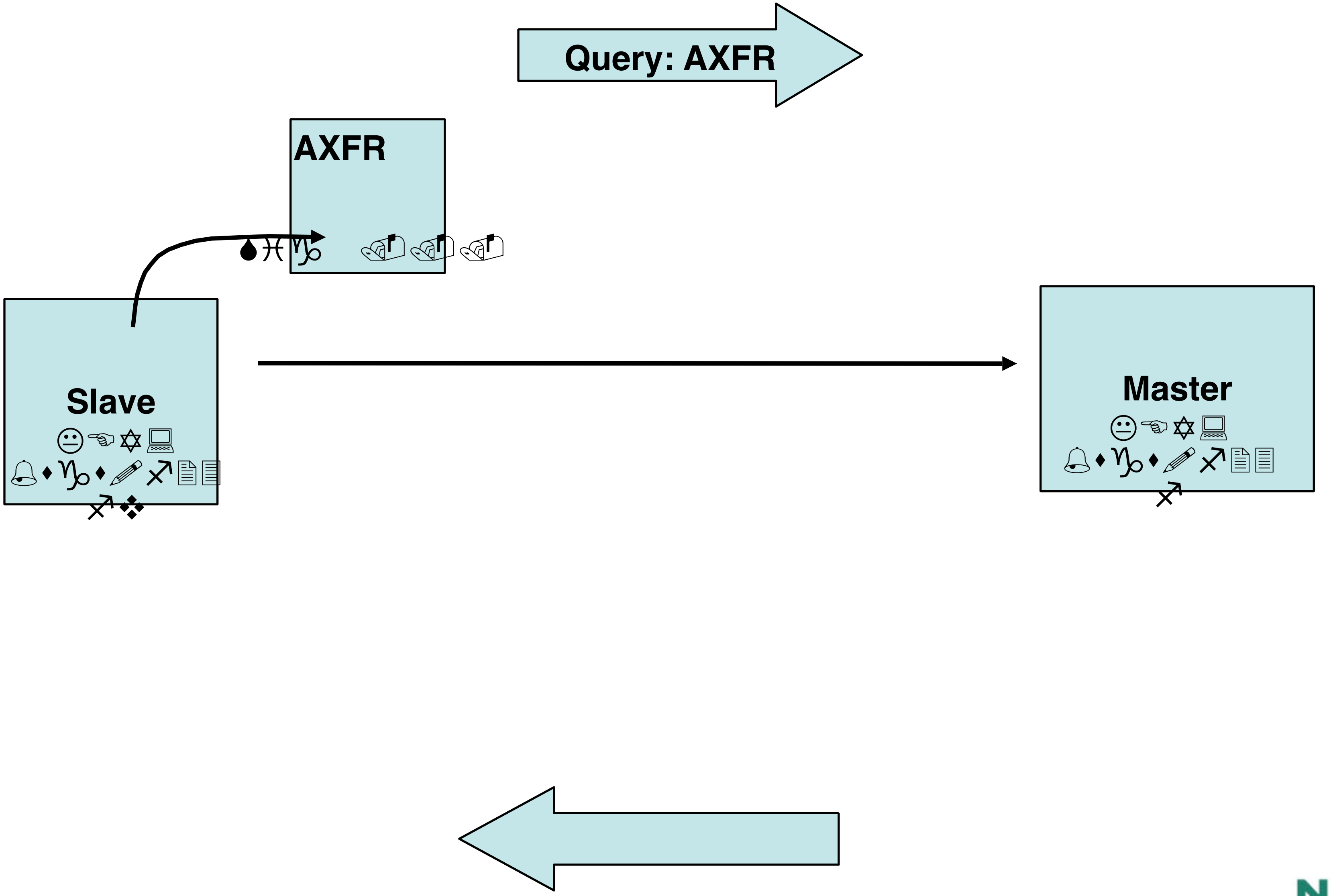
Query: AXFR

AXFR

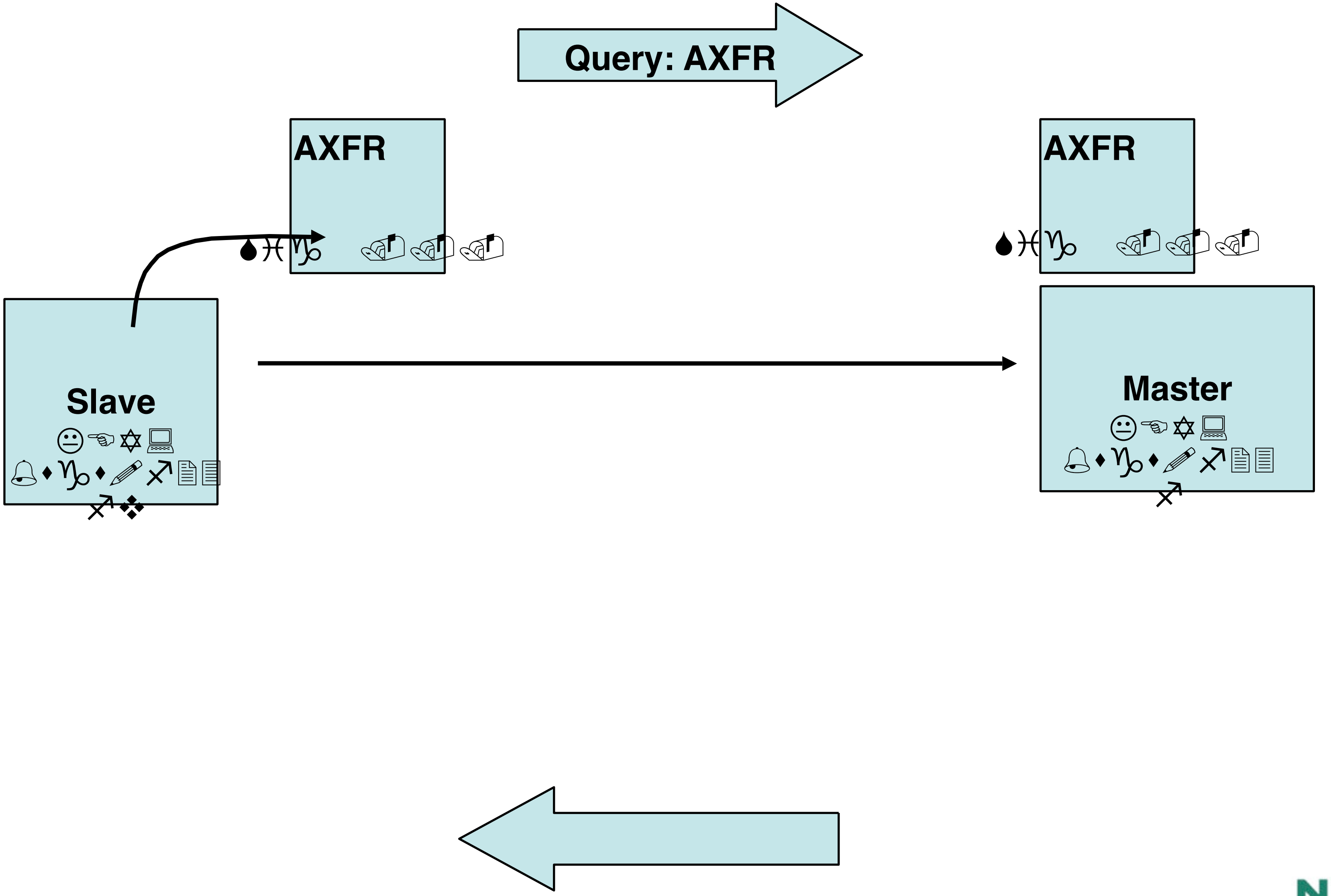
Slave

Master

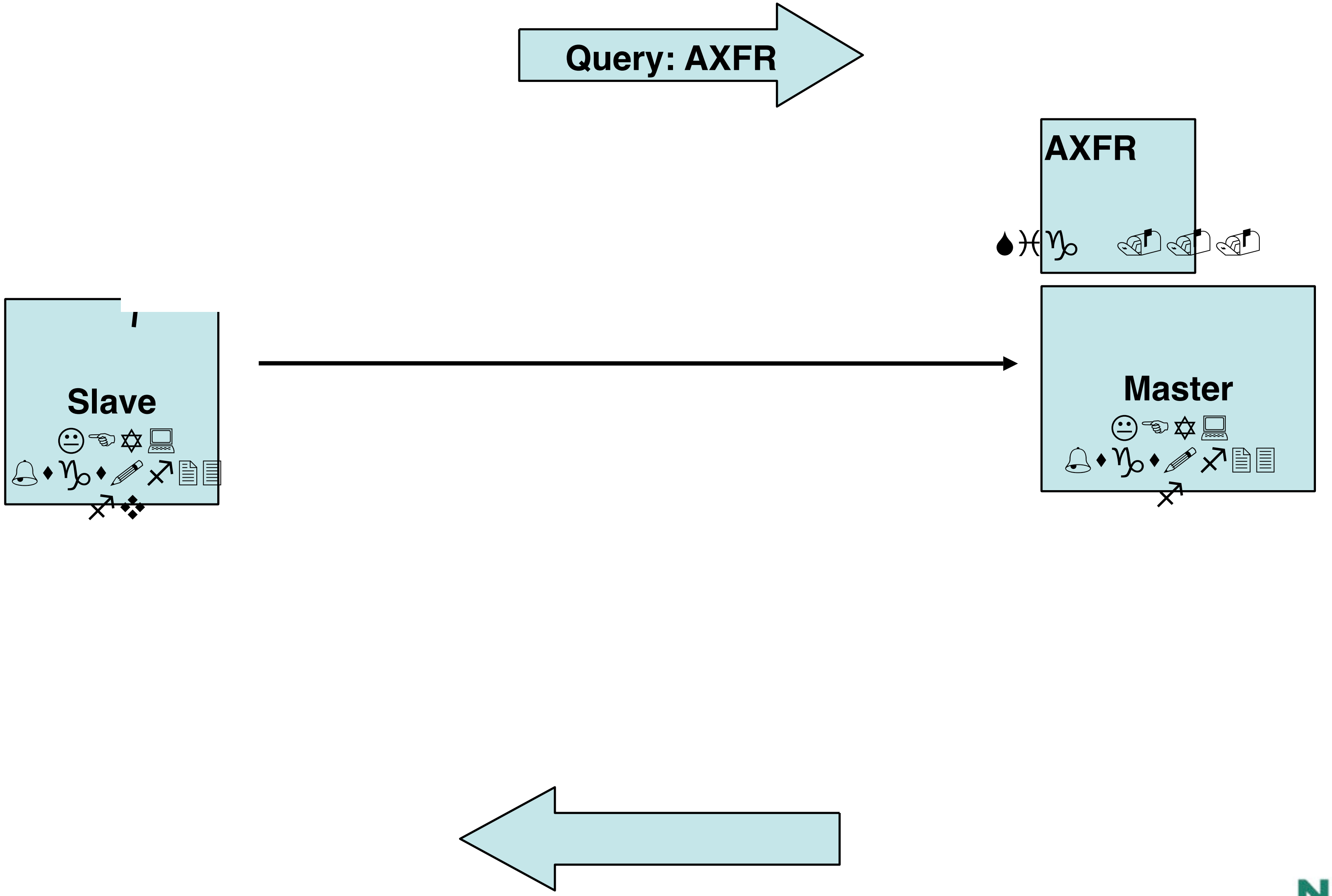
TSIG Example



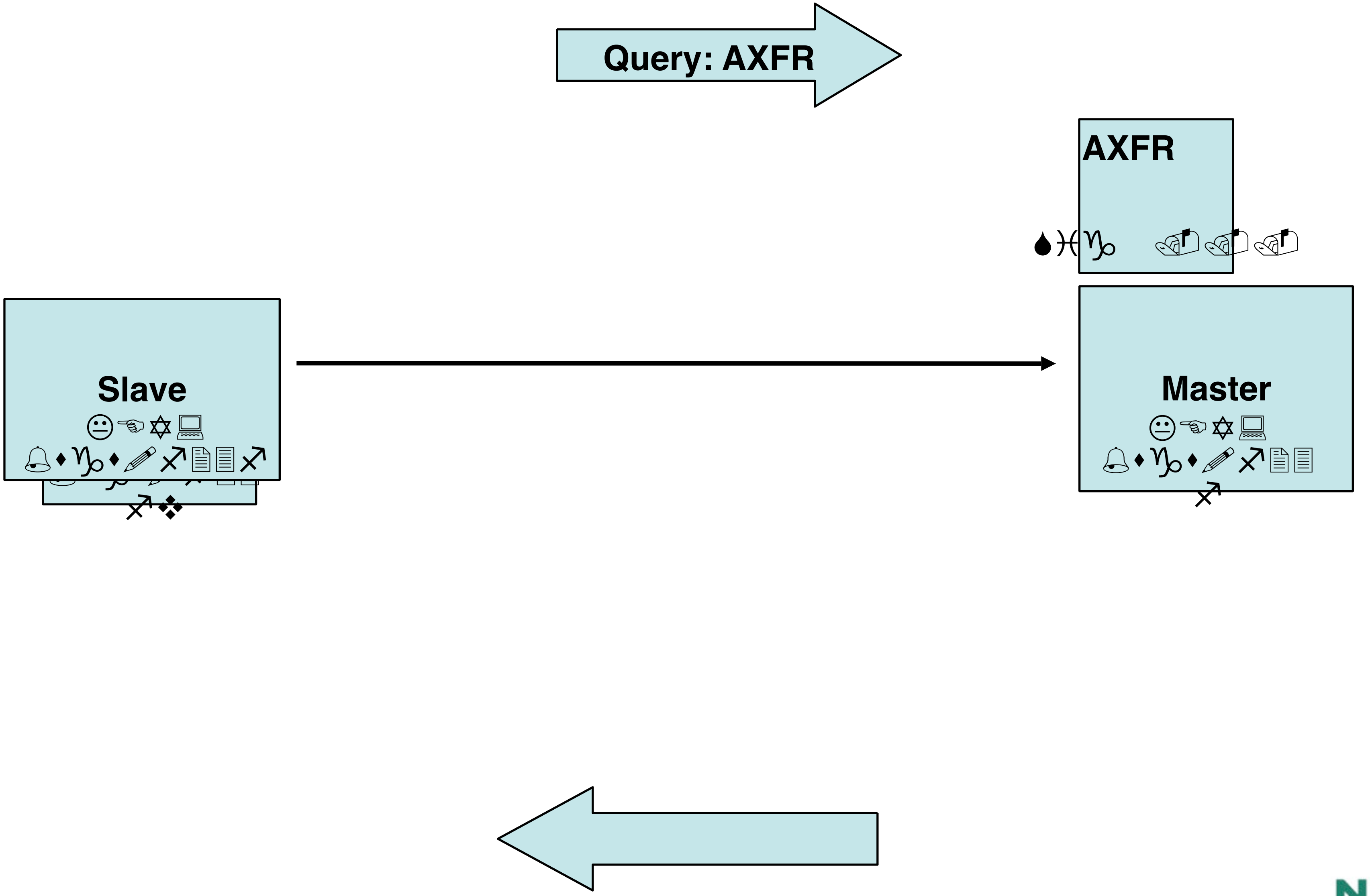
TSIG Example



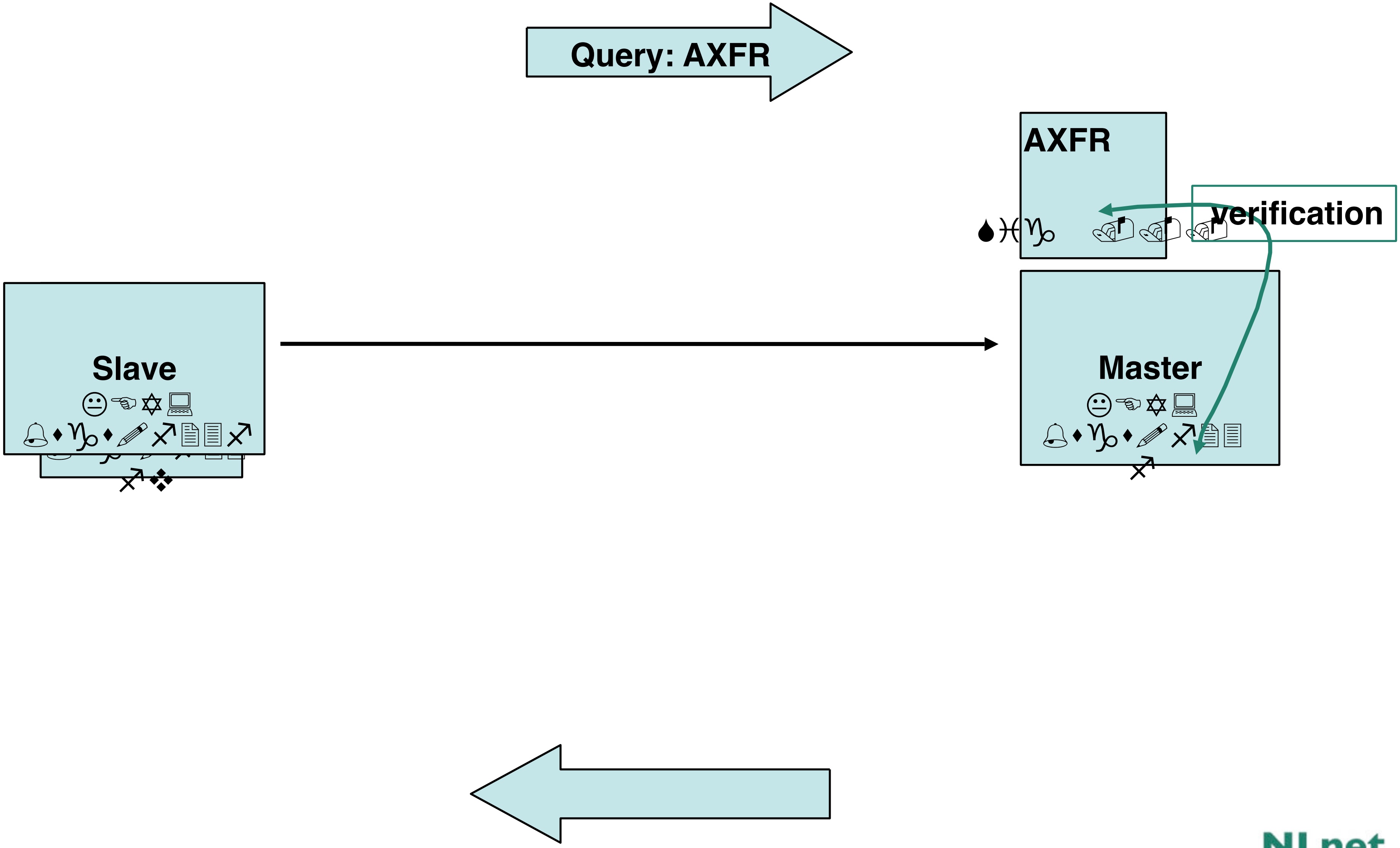
TSIG Example



TSIG Example



TSIG Example



Query: AXFR

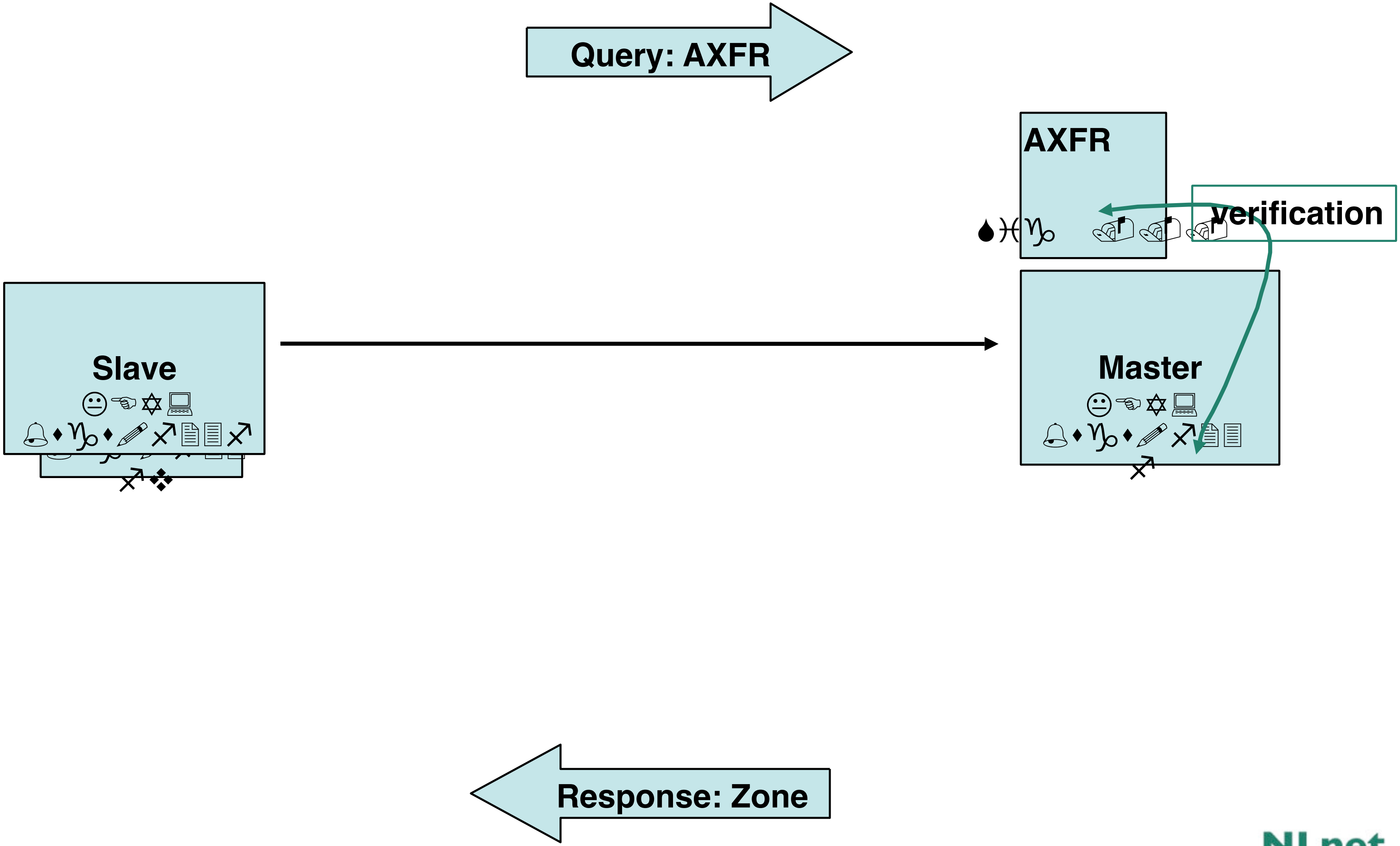
AXFR

verification

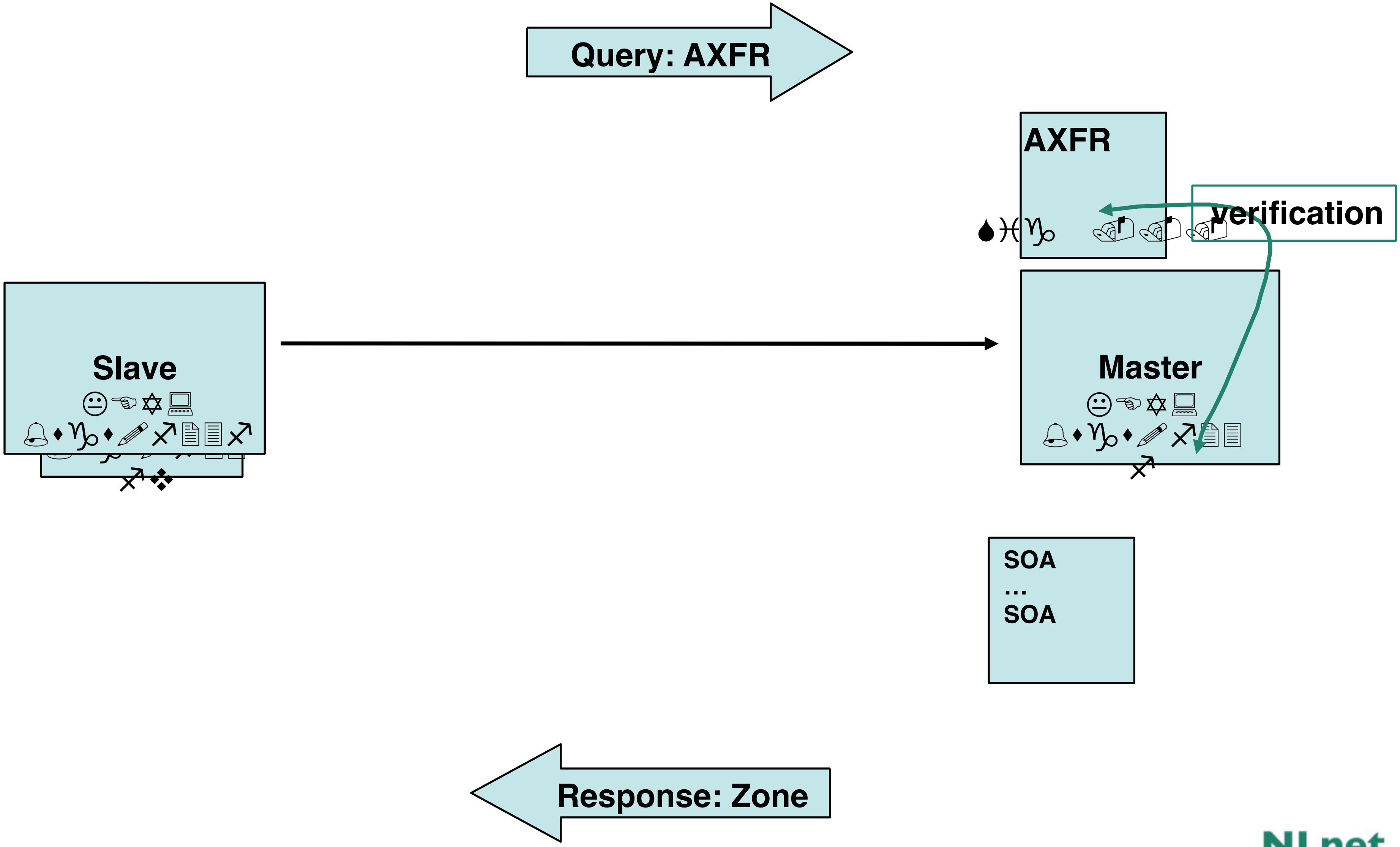
Slave

Master

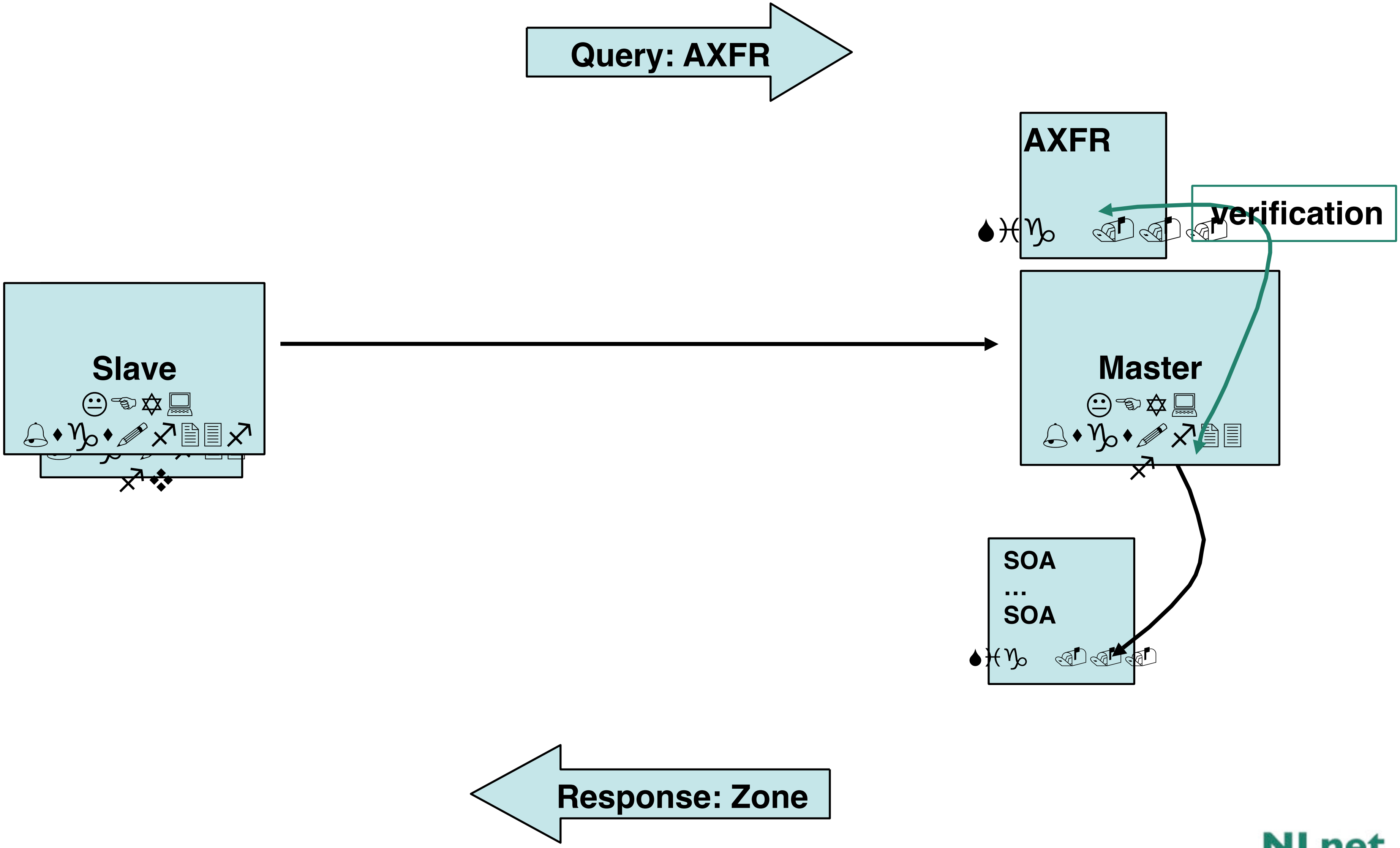
TSIG Example



TSIG Example



TSIG Example



Query: AXFR

AXFR

verification

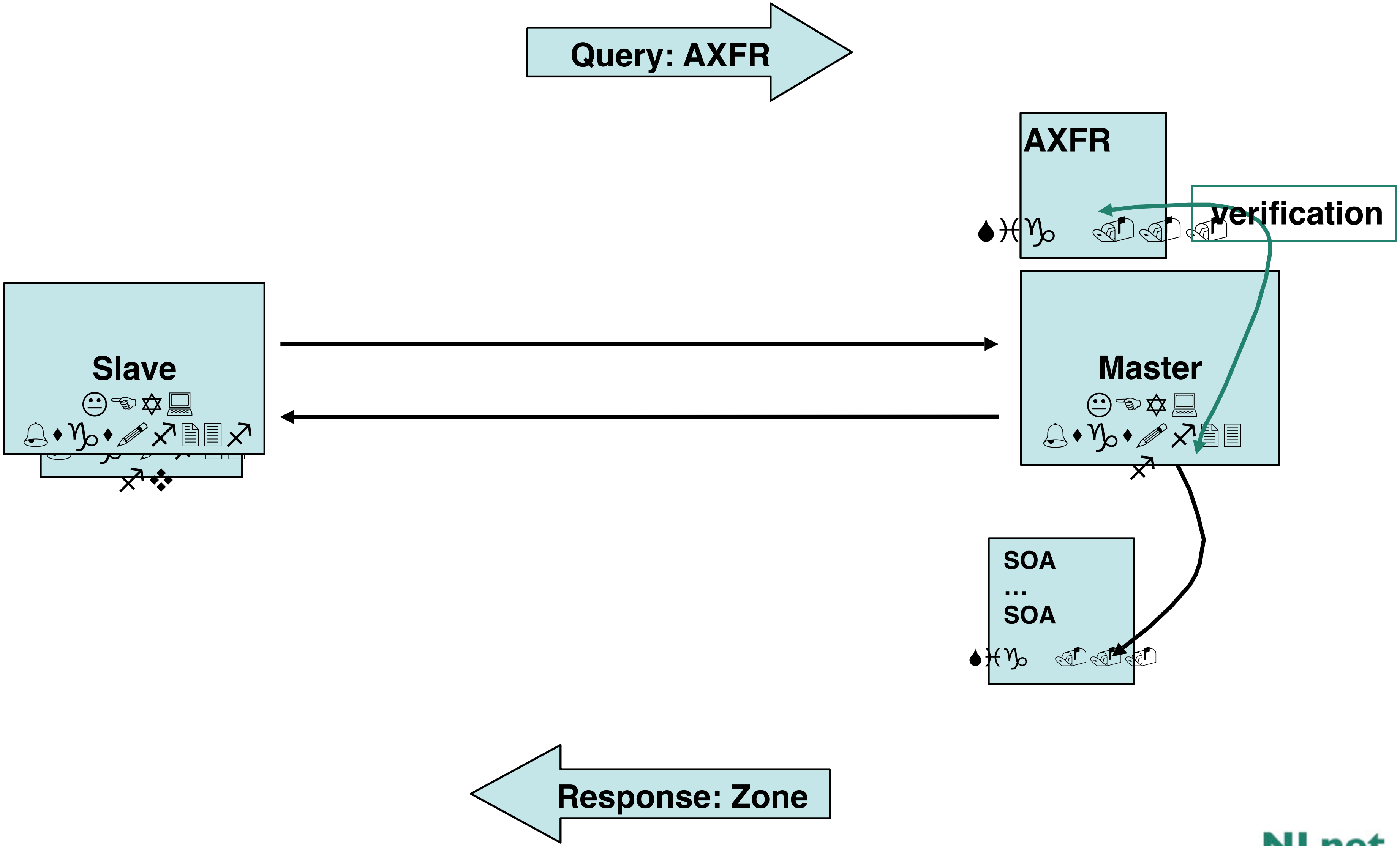
Slave

Master

SOA
...
SOA

Response: Zone

TSIG Example



Query: AXFR

AXFR

verification

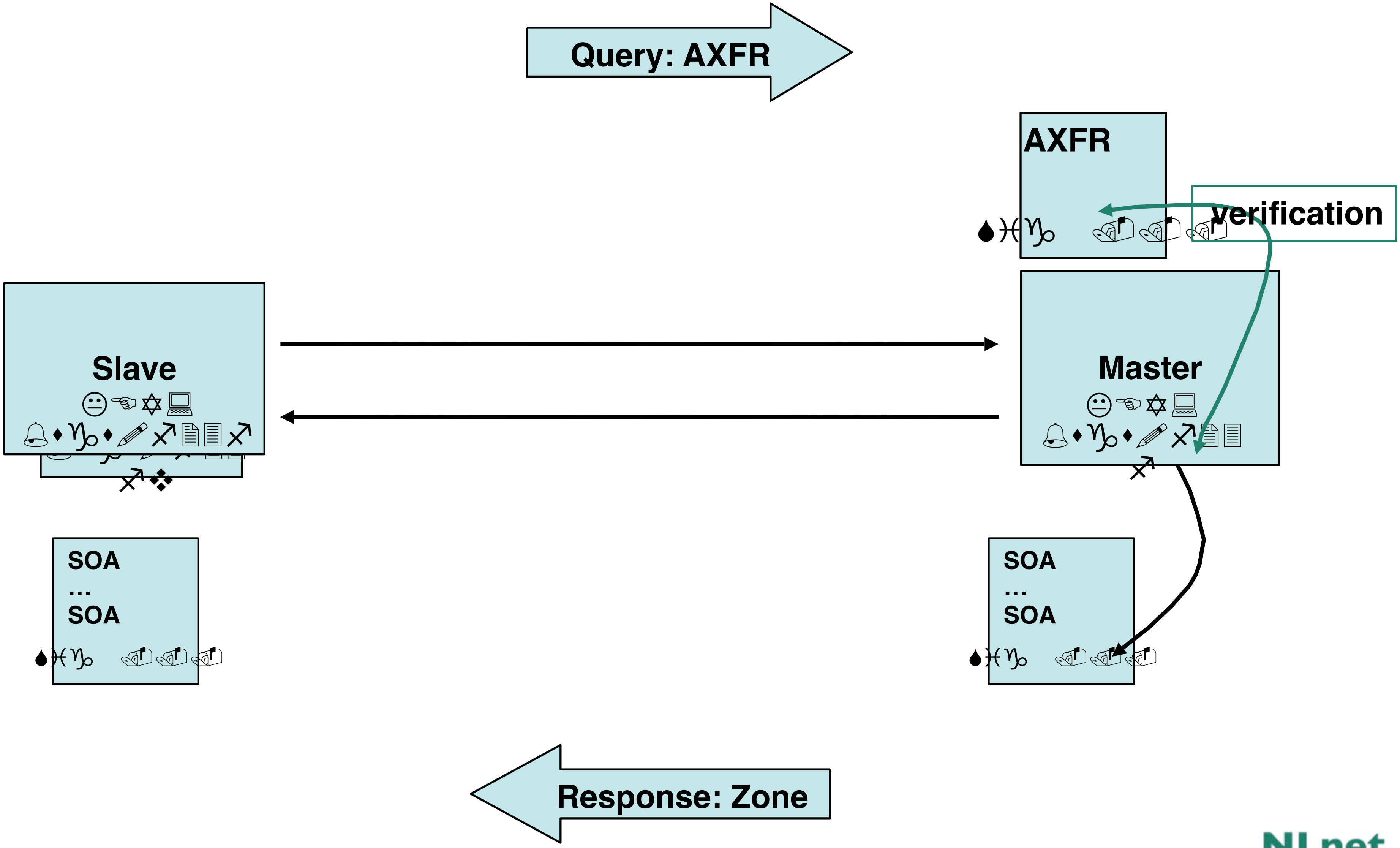
Slave

Master

SOA
…
SOA

Response: Zone

TSIG Example



Query: AXFR

AXFR

verification

Slave

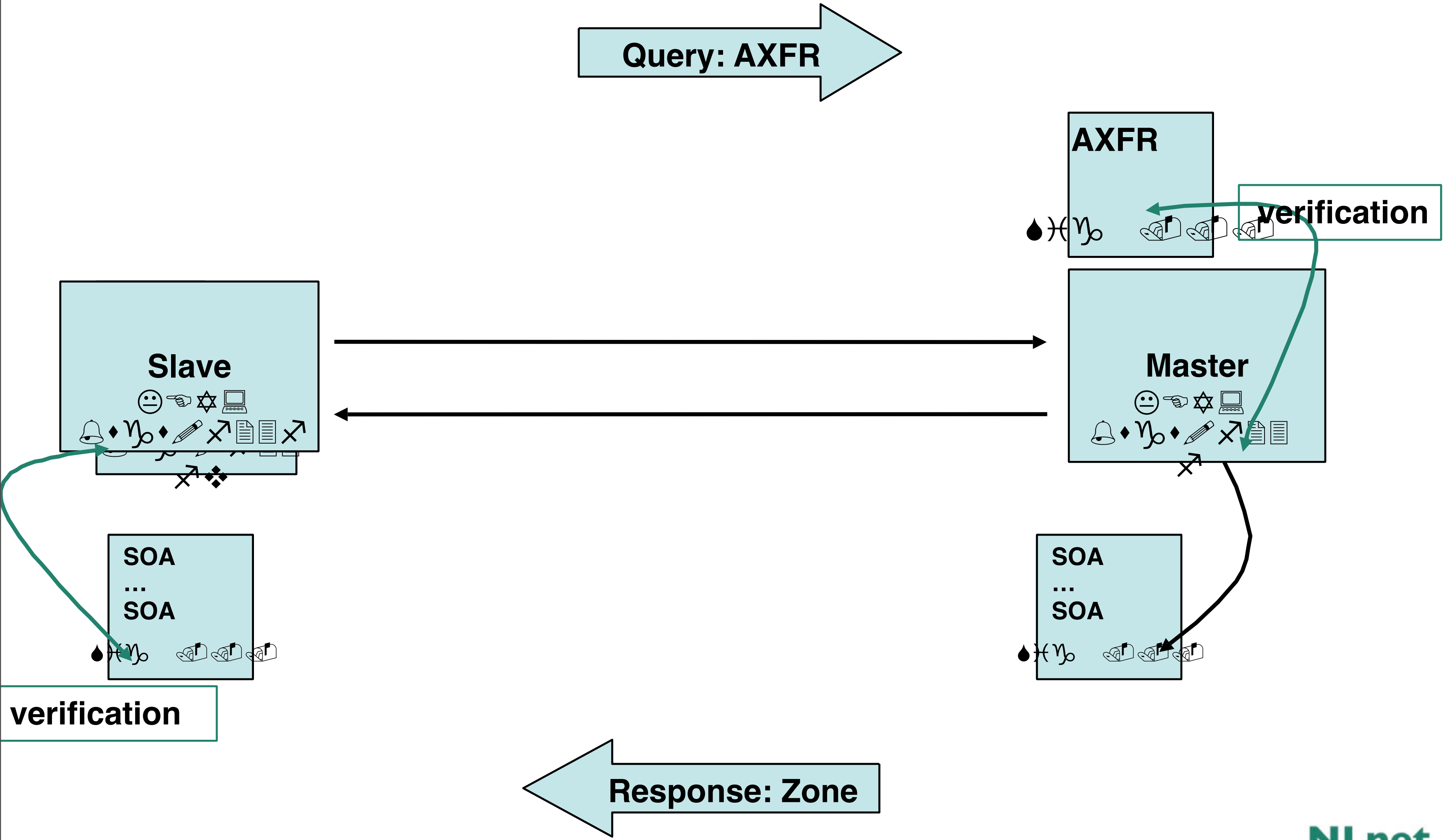
Master

SOA
…
SOA

SOA
…
SOA

Response: Zone

TSIG Example



Query: AXFR

AXFR

verification

Slave

Master

SOA
…
SOA

SOA
…
SOA

verification

Response: Zone

TSIG for Zone Transfers

1. Generate secret
2. Communicate secret
3. Configure servers
4. Test

Importance of the Time Stamp

- TSIG/SIG(0) signs a complete DNS request / response with time stamp
  - To prevent replay attacks
  - Currently hardcoded at five minutes

- Operational problems when comparing times
  - Make sure your local time zone is properly defined
  - `date -u` will give UTC time, easy to compare between the two systems
  - Use NTP synchronisation!

Authenticating Servers Using SIG(0)

- Alternatively, it is possible to use SIG(0)
  - Not yet widely used
  - Works well in dynamic update environment
- Public key algorithm
  - Authentication against a public key published in the DNS
- SIG(0) specified in RFC 2931

Cool Application

- Use TSIG-ed dynamic updates to configure configure your laptops name
- My laptop is know by the name of grover.secret-wg.org
  - http://ops.ietf.org/dns/dynupd/secure-ddns-howto.html
  - Mac OS users: there is a bonjour based tool.
    - www.dns-sd.org

Questions?

ASK

Questions?

ASK