DNSSEC Deployment a case study

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Presentation roadmap

- Overview of problem space
  - DNSSEC introduction
  - Architectural changes to allow for DNSSEC deployment
- Deployment tasks
  - Key maintenance
  - DNS infrastructure
  - Providing secure delegations

Why DNSSEC

- Good security is multi-leveled
  - Multiple defense rings in physical secured systems

Bourtange, source Wikipedia

Why DNSSEC

- Good security is multi-leveled
  - Multiple defense rings in physical secured systems
  - Multiple ‘layers’ in the networking world
- DNS infrastructure
  - Providing DNSSEC to raise the barrier for DNS based attacks
  - Provides a security ‘ring’ around many systems and applications

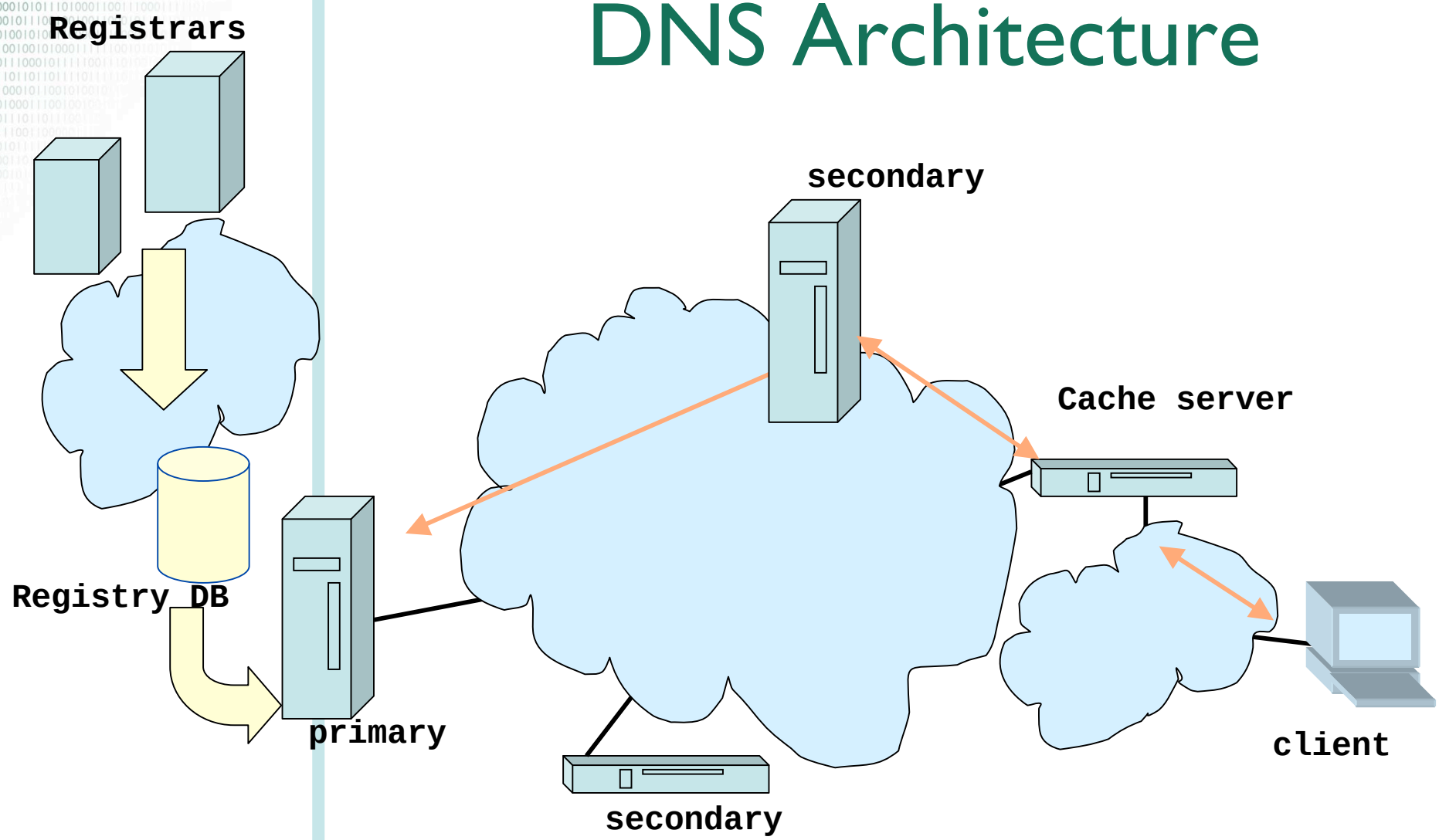
DNSSEC evangineer of the day

- NLnet Labs (www.NLnetLabs.nl)
  - Not for profit Open Source Software lab
    - NSD, open source nameserver
  - DNS and DNSSEC research
    - Protocol and software development
    - Deployment engineering
- Co-Chair of the IETF DNSEXT working group

The Problem

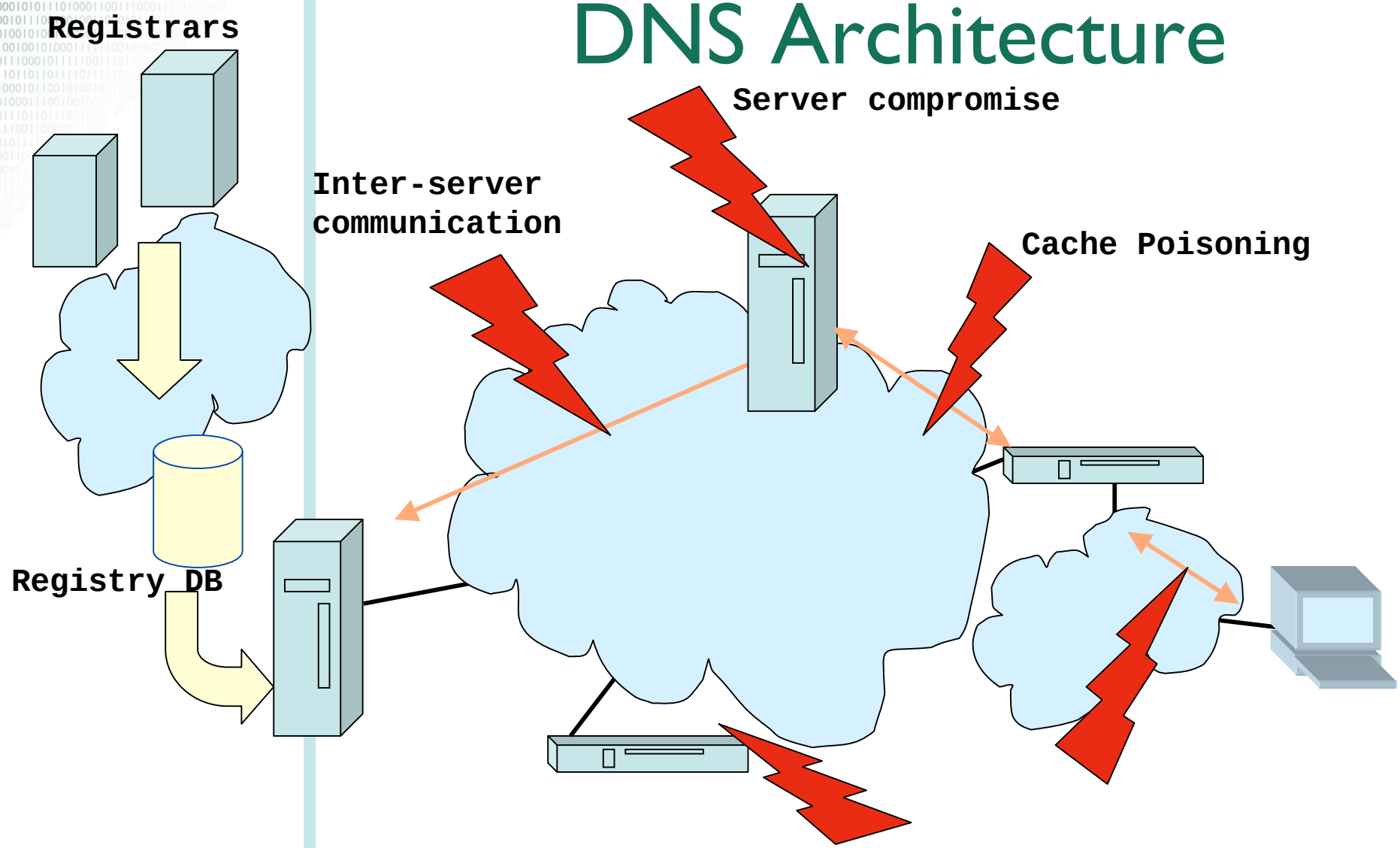
- DNS data published by the registry is being replaced on its path between the "server" and the "client".
- This can happen in multiple places in the DNS architecture
  - Some places are more vulnerable to attacks then others
  - Vulnerabilities in DNS software make attacks easier (and there will always be software vulnerabilities)

DNS Architecture



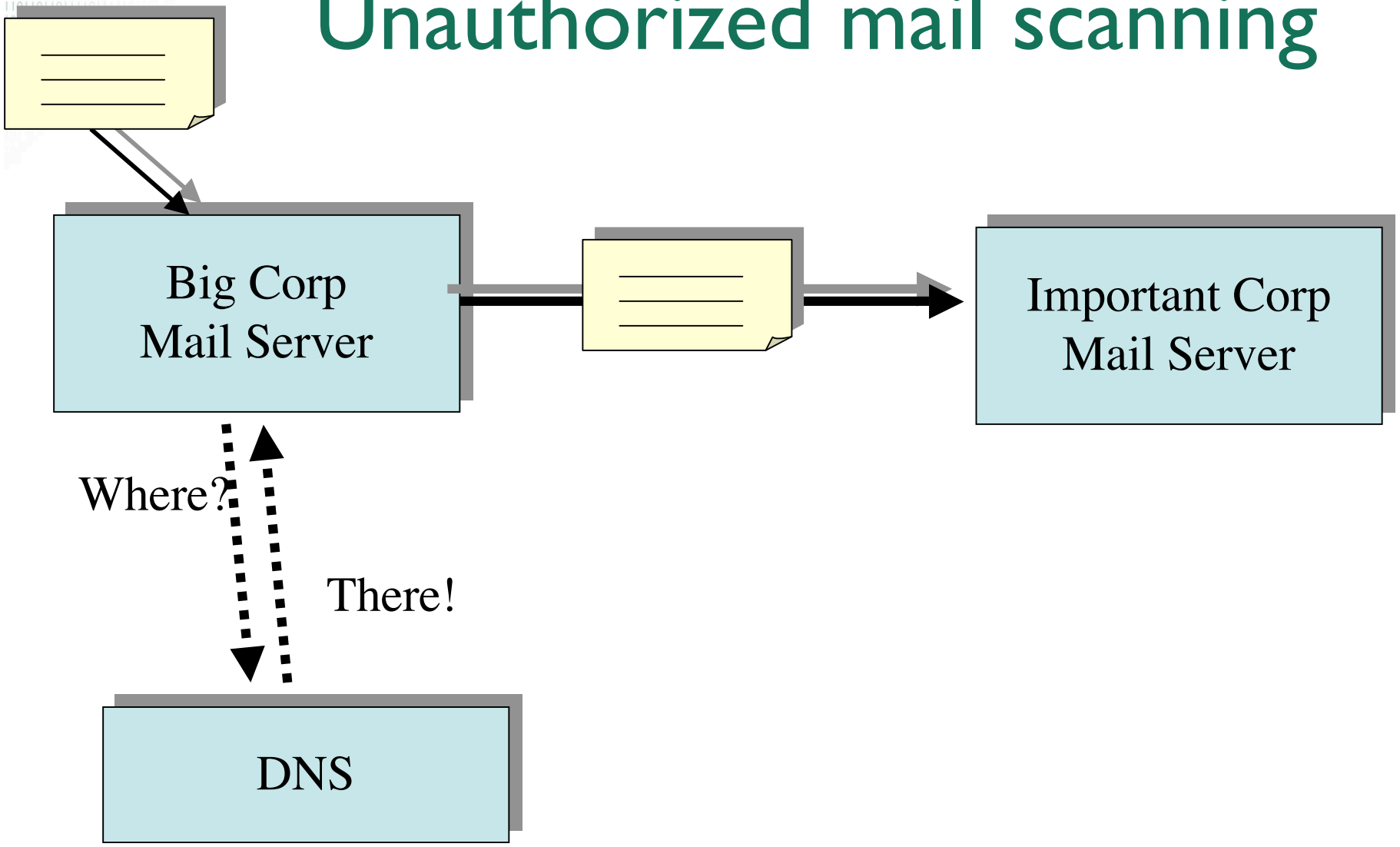
Provisioning DNS Protocol

DNS Architecture



Provisioning DNS Protocol

Example: Unauthorized mail scanning



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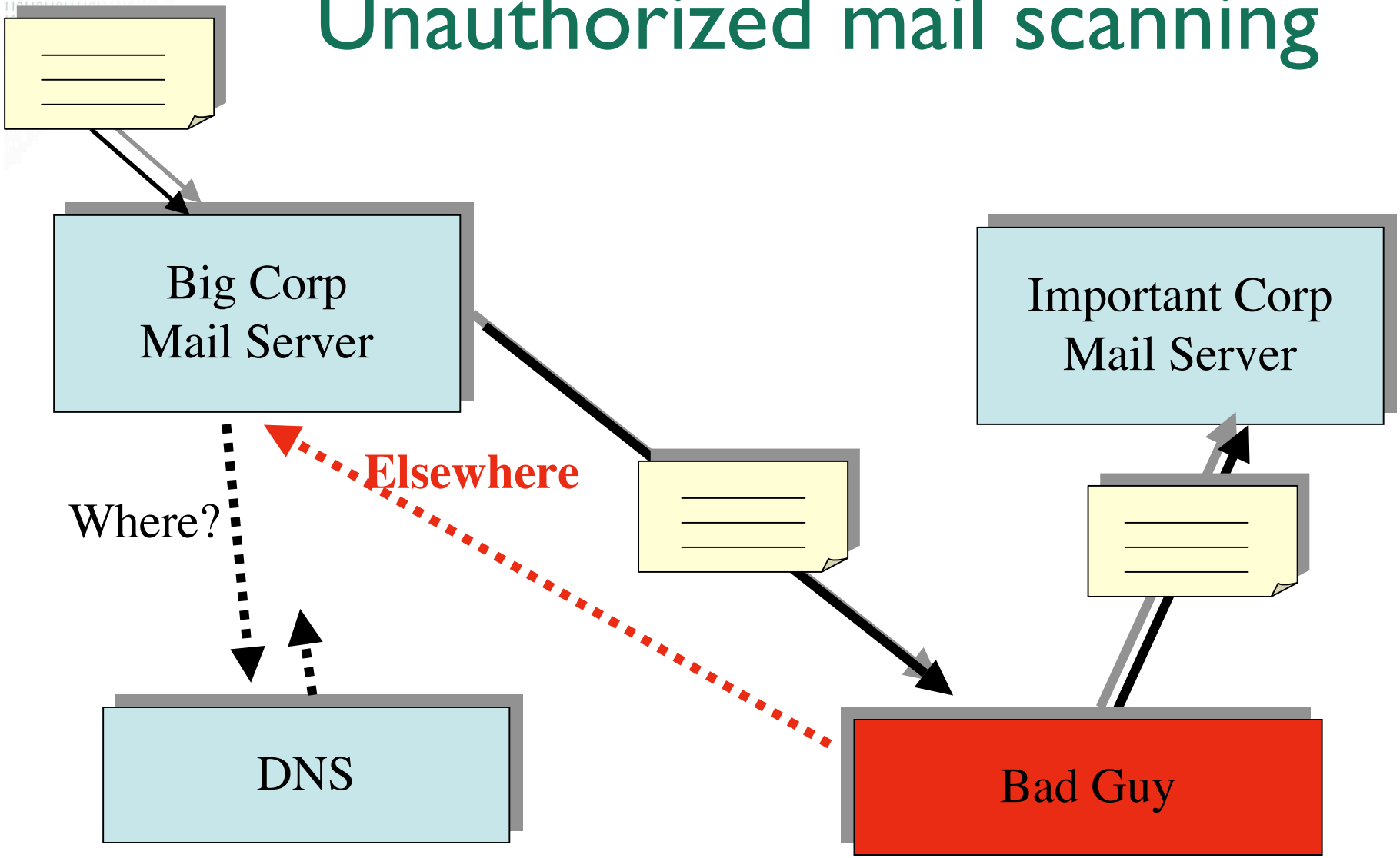

Targets…
Where do DNS and economics meet?

- SPF, DomainKey and family
  - Technologies that use the DNS to mitigate spam and phishing: $$$ value for the black hats
- Stock tickers, RSS feeds
  - Usually no source authentication but supplying false stock information via a stock ticker and via a news feed can have $$$ value
- ENUM
  - Mapping telephone numbers to services in the DNS

DNSSEC properties

- DNSSEC provides message authentication and integrity verification through cryptographic signatures
  - Authentic DNS source
  - No modifications between signing and validation
- It does not provide authorization
- It does not provide confidentiality

Metaphor

- Compare DNSSEC to a sealed transparent envelope.
- The seal is applied by whoever closes the envelope
- Anybody can read the message
- The seal is applied to the envelope, not to the message

```
nlnetlabs.nl.          86400 IN NS omval.tednet.nl.

nlnetlabs.nl.          86400 IN RRSIG NS 5 2 86400 20060131005003 (
                              20060101005003 43791 nlnetlabs.nl.
                              y9URn7lLgXdPh2MY/I/CRkmG5PZ2nJQxndGHwSB8OP15
                              […]
                              Qgl+b0Oj54b/65TyYVqPp3CLVt/q6L67SMK9orE= )

nlnetlabs.nl.          86400 IN DNSKEY 257 3 5 (
                              AQPzzTWMz8qSWIQlfRnPckx2BiVmkVN6LPupO3mbz7Fh
                              […]
                              9QP7y2bVw5zSbFCrefk8qCUBgfHm9bHzMG1UBYtEIQ==
                              ) ; key id = 43791

nlnetlabs.nl.          86400 IN RRSIG DNSKEY 5 2 86400 20060131005003 (
                              20060101005003 43791 nlnetlabs.nl.
                              6mEWVaFKLQrypCJb0wgzW56UC1SVGYW3z+KJVM/uANnA
                              […]
                              4cCBqAX/mE2N5nUZians0/IT1TzuqVS5h12R2jE= )

open.nlnetlabs.nl.     86400 IN RRSIG A 5 3 86400 20060131005003 (
                              20060101005003 43791 nlnetlabs.nl.
                              ZoZl6om+q5e4jrrDB64mMXpiloCQVe6NDu7KZbv7k9fg
                              […]
                              t+Xc4iQPI+HTPn5A18pjaEA9KAK7NFLTZHz5uV8= )

open.nlnetlabs.nl.     86400 IN RRSIG AAAA 5 3 86400 20060131005003 (
                              20060101005003 43791 nlnetlabs.nl.
                              […]
```

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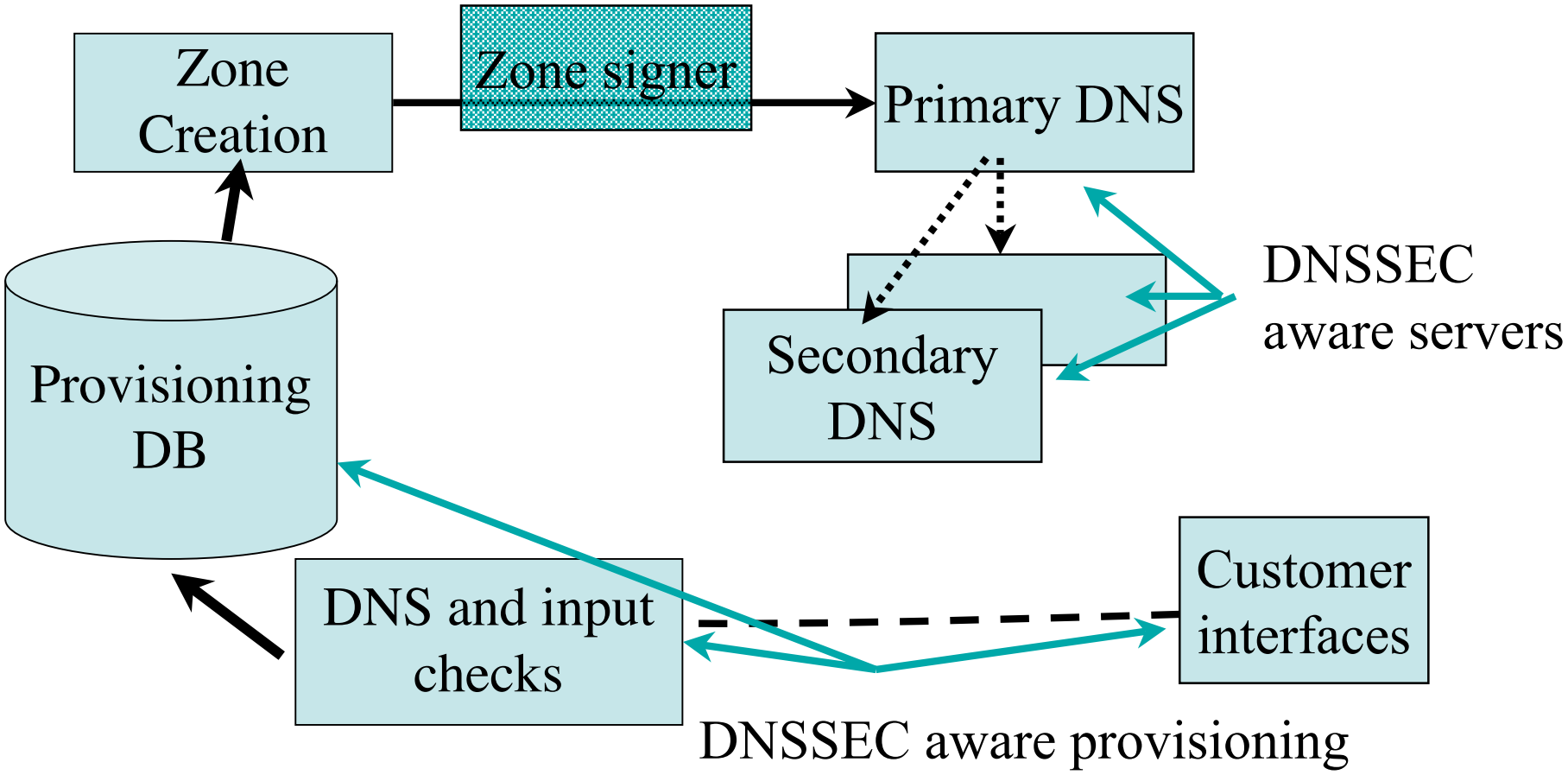
DNSSEC
Architecture modifications



DNSSEC deployment tasks

- Key maintenance policies and tools
  - Private Key use and protection
  - Public key distribution
- Zone signing and integration into the provisioning chain
- DNS server infrastructure
- Secure delegation registry changes
  - Interfacing with customers

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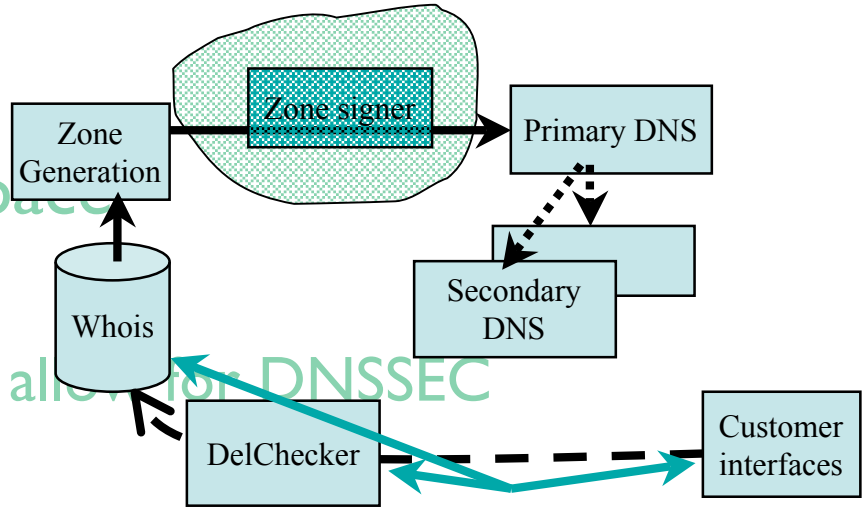


DNSSEC aware provisioning

Key Maintenance

- DNSSEC is based on public key cryptography
  - Data is signed using a private key
  - It is validated using a public key

Operational problems:

- Dissemination of the public key
- Private key has a '*best before*' date
  - Keys change, and the change has to disseminate

Public Key Dissemination

- In theory only one trust-anchor needed that of the root
  - How does the root key get to the end user?
  - How is it rolled?
- In absence of hierarchy there will be many trust-anchors
  - How do these get to the end-users?
  - How are these rolled?

- These are open questions, making early deployment difficult.

Public Key Dissemination at RIPE NCC

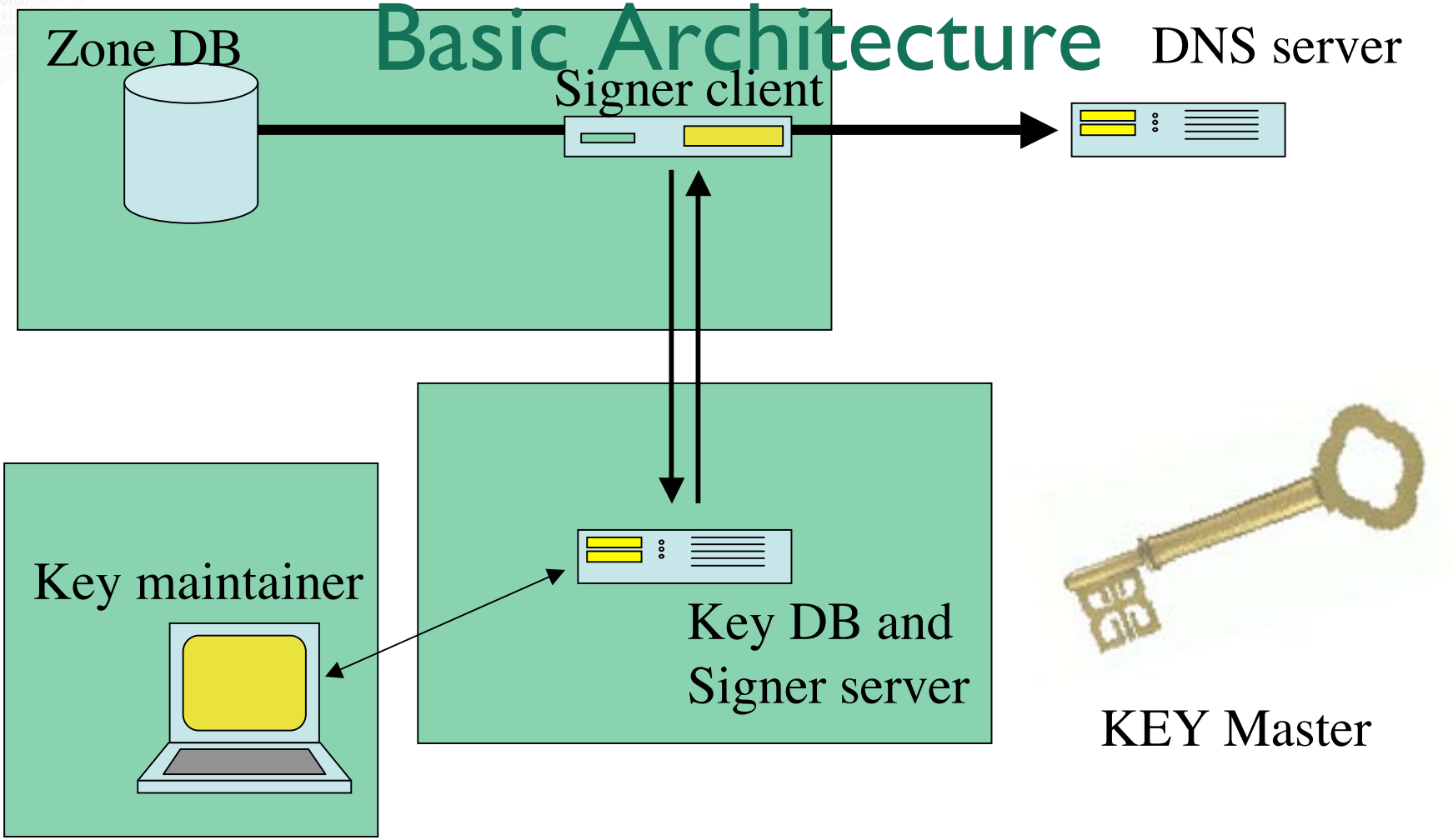
In absence of a signed parent zone and automatic rollover:

- Trust anchors are published on an "HTTPS" secured website
- Trust anchors are signed with the RIPE NCC public keys
- Trust anchor will be rolled twice a year (during early deployment)
- Announcements and publications are always signed by x.509 or PGP

Key Management

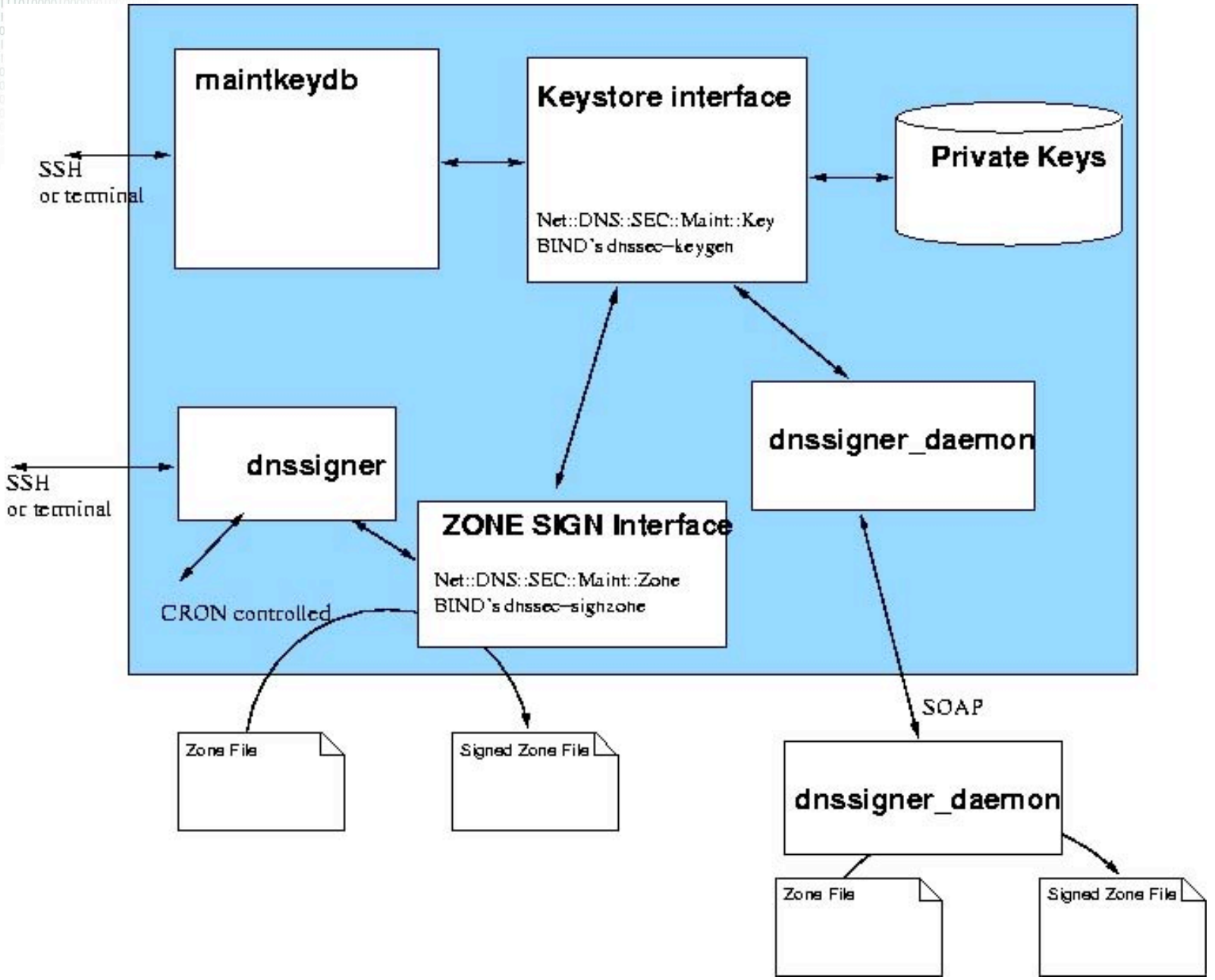
- There are many keys to maintain
  - Keys are used on a per zone basis
    - Key Signing Keys and Zone Signing Keys
  - During key rollovers there are multiple keys
    - In order to maintain consistency with cached DNS data [draft-ietf-dnsop-dnssec-operational-practices]
- Private keys need shielding

Private Key Maintenance
Basic Architecture



Maintaining Keys and Signing Zones

- The KeyDB maintains the private keys
  - It 'knows' rollover scenarios
  - UI that can create, delete, roll keys without access to the key material
  - Physically secured
- The signer ties the Key DB to a zone
  - Inserts the appropriate DNSKEYs
  - Signs the the zone with appropriate keys
- Strong authentication


maintkeydb
Keystore interface
Private Keys
SSH
or terminal
Net::DNS::SEC::Maint::Key
BIND's dnssec-keygen
dnssigner
dnssigner_daemon
SSH
or terminal
ZONE SIGN Interface
Net::DNS::SEC::Maint::Zone
BIND's dnssec-signzone
CRON controlled
SOAP
Zone File
Signed Zone File
dnssigner_daemon
Zone File
Signed Zone File

Private Key Maintenance
The software

- Perl front-end to the BIND dnssec-signzone and dnssec-keygen tools
- Key pairs are kept on disc in the "BIND format"
- Attribute files containing human readable information
  - One can always bail out and sign by hand.

- Works in the RIPE NCC environment, is a little rough edged but available via the www.ripe.net/disi

Example session

```
$ maintkeydb create KSK RSASHA1 2048 example.net
      Created 1 key for example.net
$ maintkeydb create ZSK RSASHA1 1024 example.net
      Created 2 keys for example.net
$ dnssigner example.net
      Output written to :example.net.signed

$ maintkeydb rollover zsk-stage1 RSASHA1 example.net
```

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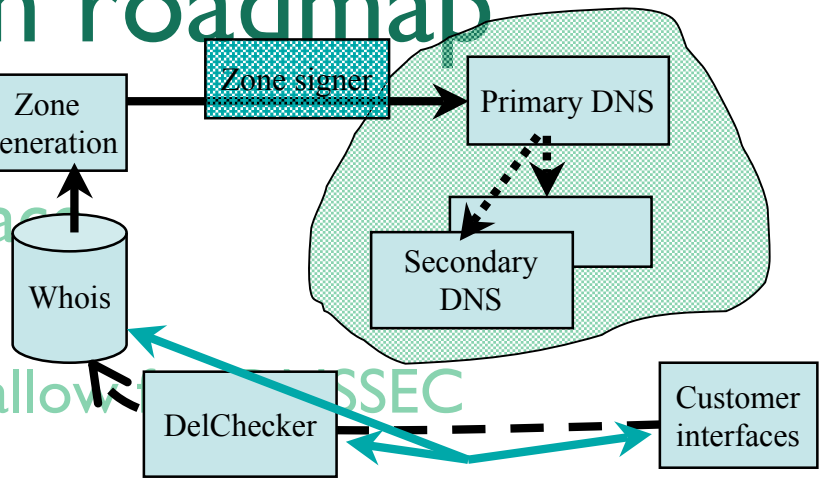


DNSSEC aware provisioning

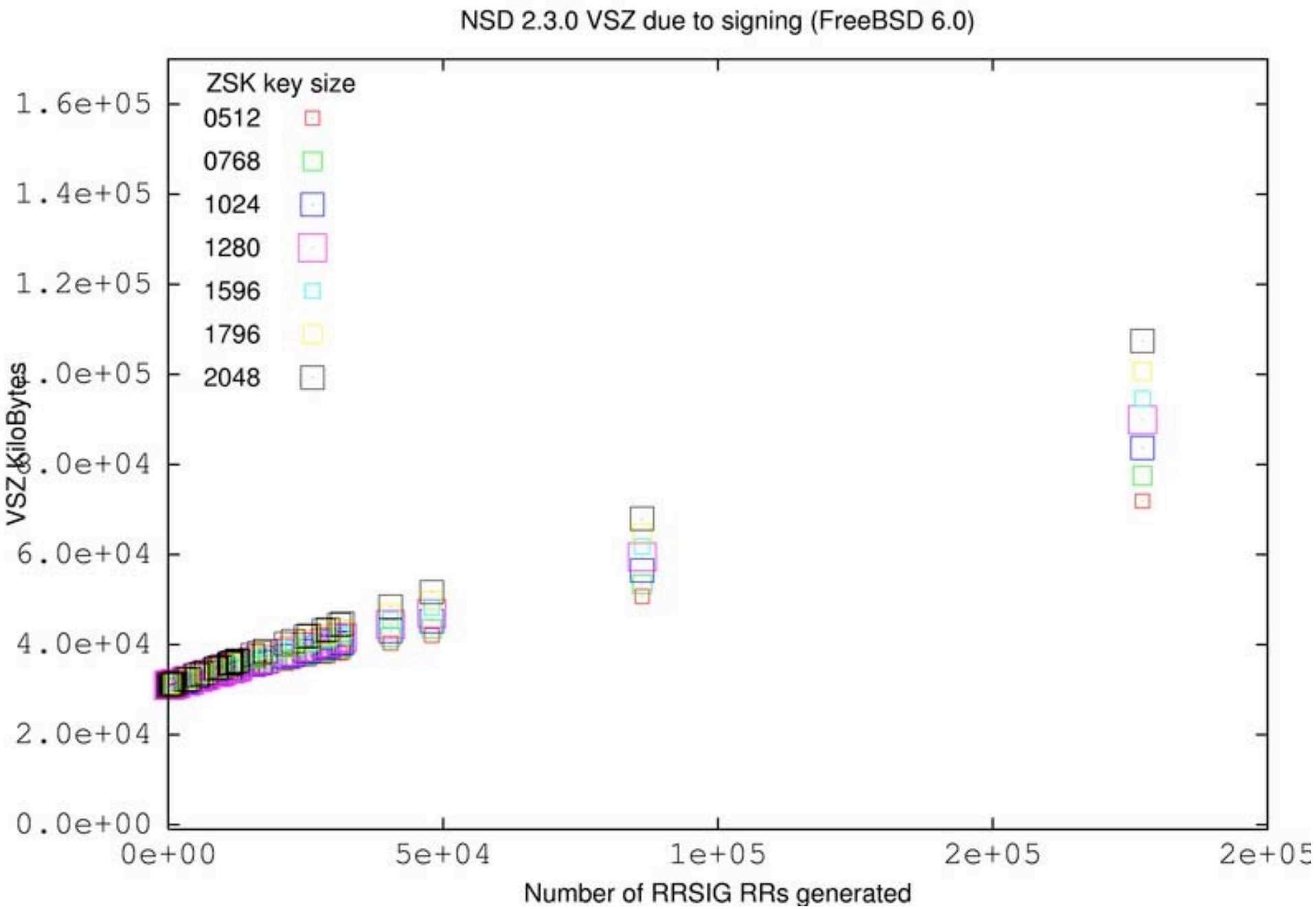
Infrastructure

- One needs primary and secondary servers to be DNSSEC protocol aware
- We had a number of concerns about memory CPU and network load
  - Research done and published as RIPE 352
  - What follows are the highlights of that paper

Question

What would be the immediate and initial effect on memory, CPU and bandwidth resources if we were to deploy DNSSEC on RIPE NCC's 'primary' name server?

- Measure through simulation.
- Published in RIPE352


NSD 2.3.0 VSZ due to signing (FreeBSD 6.0)
ZSK key size
0512
0768
1024
1280
1596
1796
2048
VSZ KiloBytes
1.6e+05
1.4e+05
1.2e+05
1.0e+05
8.0e+04
6.0e+04
4.0e+04
2.0e+04
0.0e+00
0e+00
5e+04
1e+05
2e+05
2e+05
Number of RRSIG RRs generated

Memory

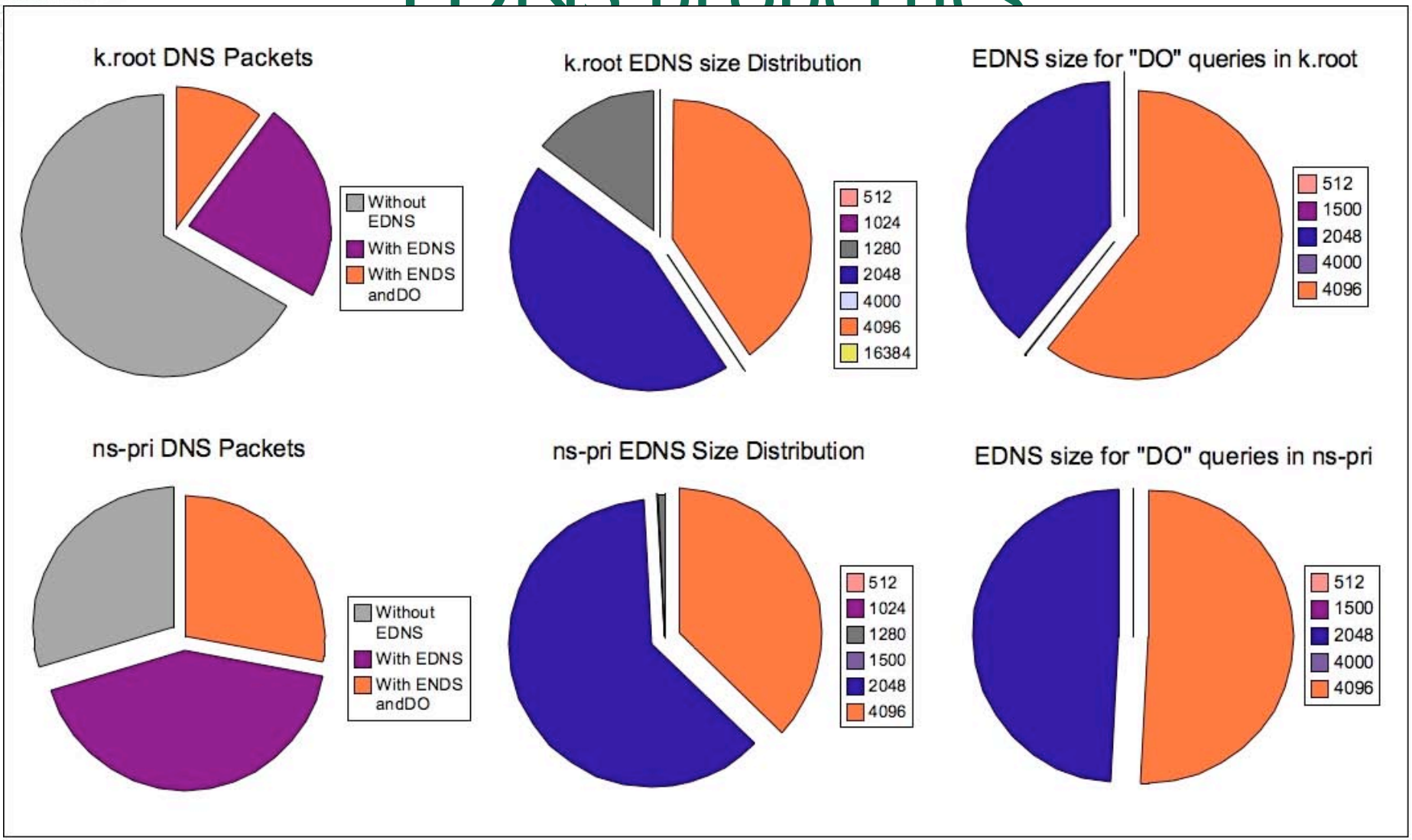
- On ns-pri.ripe.net factor 4 increase.
  - From ca. 30MB to 150MB
  - No problem for a 1GB of memory machine
- On k.root-servers.net
  - Increase by ca 150KB
  - Total footprint 4.4 MB
- Nothing to worry about
- Memory consumption on authoritative servers can be calculated in advance.
  - No surprises necessary

Serving the zones
Query Properties

- DNS clients set the "DO" flag and request for DNSSEC data.
  - Not to do their own validation but to cache the DNSSEC data for.
- EDNS size determines maximum packet size.

  (DNSSEC requires EDNS)
- EDNS/DO properties determine which fraction of the replies contain DNSSEC information

EDNS properties

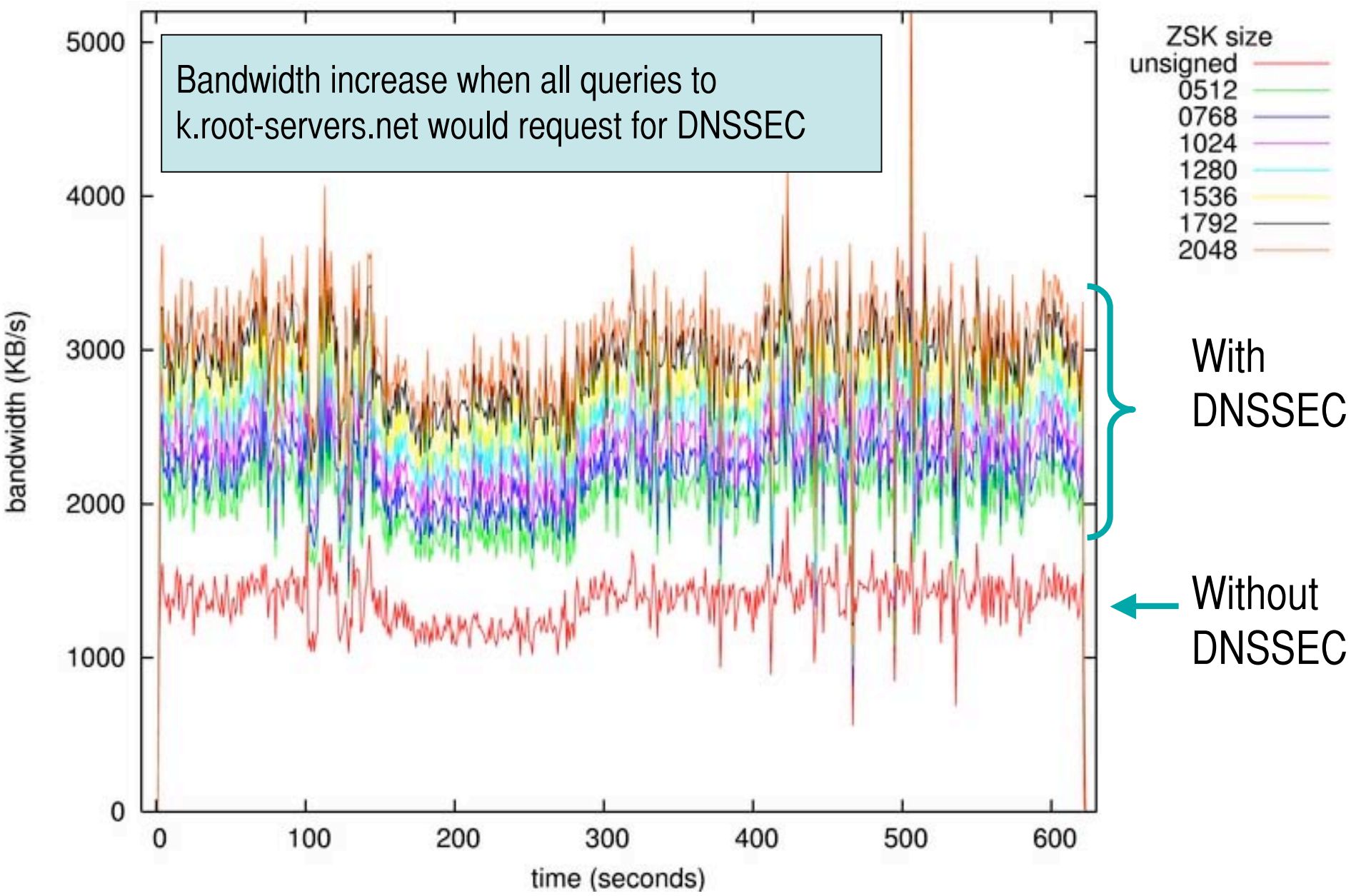


CPU

trace	server		ZSK size	WCPU
ns-pri	BIND 9.3.1	0000		ca 14%
ns-pri	BIND 9.3.1	2048		ca 18%
k.root	BIND 9.3.1	0000		ca 38%
k.root	BIND 9.3.1	2048		ca 42%
k.root	BIND 9.3.1	mod	2048	ca 50%
k.root	NSD 2.3.0		0000	ca 4%
k.root	NSD 2.3.0		2048	ca 4%
k.root	NSD 2.3.0	mod	2048	ca 5%

Bandwidth Factors

- fraction of queries with DO bit
  - Seen in difference between ns-pri and k.root result
  - Seen in difference between modified and unmodified servers
- Including DNSKEY RR in additional section.
  - Seen in difference between k.root traces from modified nsd and modified named
- Difference in answer patterns
  - Name Errors vs Positive answers
  - Difficult to asses from this data


Bandwidth increase when all queries to k.root-servers.net would request for DNSSEC
ZSK size
unsigned
0512
0768
1024
1280
1536
1792
2048
With DNSSEC
Without DNSSEC
bandwidth (KB/s)
time (seconds)
0
1000
2000
3000
4000
5000
0
100
200
300
400
500
600

Bandwidth Increase

- Significant for ns-pri.ripe.net
  - Well within provisioned specs.
- Insignificant for for k.root-servers.net
  - Upper bound well within provisioning specs

(Key size influences bandwidth but bandwidth should not influence your key size)

Conclusion of these measurements

- CPU, Memory and Bandwidth usage increase are not prohibitive for deployment of DNSSEC on k.root-servers.net and ns-pri.ripe.net

- Bandwidth increase is caused by many factors
  - Hard to predict but fraction of DO bits in the queries is an important factor
- CPU impact is small, Memory impact can be calculated
- Don't add DNSKEY RR set in additional

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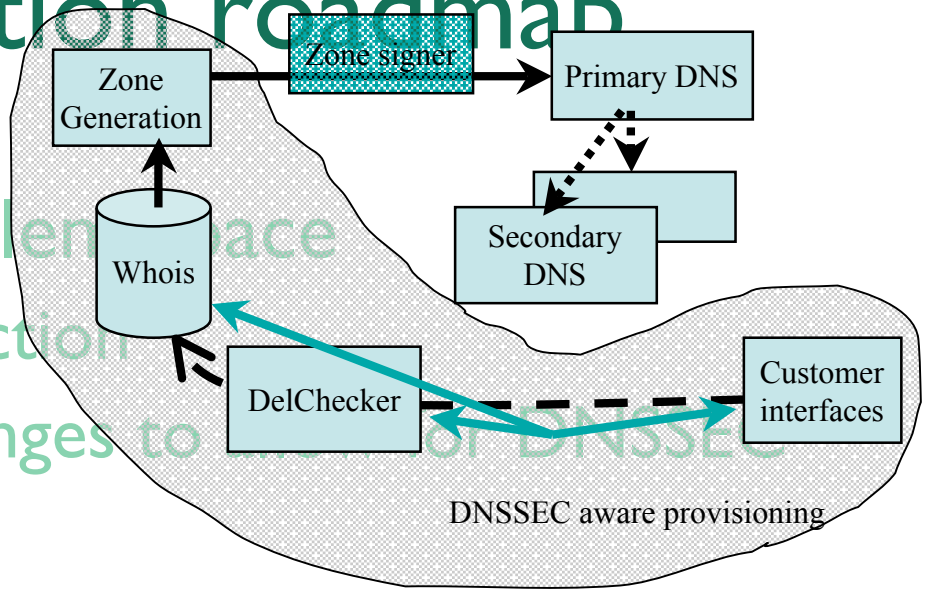


Parent-Child Key Exchange

- In the DNS the parent signs the "Delegations Signer" RR
  - A pointer to the next key in the chain of trust

```
$ORIGIN net.

kids NS   ns1.kids
     DS  (…) 1234
     RRSIG DS (…)net.

money NS   ns1.money
      DS   (…)
      RRSIG DS (…)net.
```

```
$ORIGIN kids.net.

@ NS   ns1
  RRSIG NS (…) kids.net.
  DNSKEY (…)  (1234)
  DNSKEY (…)  (3456)
  RRSIG dnskey … 1234 kids.net.
  RRSIG dnskey … 3456 kids.net.

beth  A  127.0.10.1
      RRSIG A (…) 3456 kids.net.
```

- DNSKEY or DS RR needs to be exchanged between parent and child

Underlying Ideas

- The DS exchange is the same process as the NS exchange
  - Same authentication/authorization model
  - Same vulnerabilities
  - More sensitive to mistakes
- Integrate the key exchange into existing interfaces
  - Customers are used to those
- Include checks on configuration errors
  - DNSSEC is picky
- Provide tools
  - To prevent errors and guide customers

How Did we Proceed

- The `ds-rdata:` attribute was added to the Domain object
- The zone generation tool:extract DS RRs from `ds-rdata:` attributes
- We introduced a filter, to block `ds-rdata:` for zones not yet signed
- Added a number of “DelChecker” checks

Intergration issue

- Thinking about DNSSEC made the NCC look at the provisioning system as a whole
  - Prompted a couple of modifications
  - Zone generation (generation of zone now from the Whois DB)
  - Authentication model (introduction of mnt-domain)
  - Possible replay attacks (countered by using timestamps of the strong auth. mechanisms)
- All these issues are NOT DNSSEC specific
- Addressed over the last 2 years

Introducing the Web Interface

- Eases registration of keys and the rollovers
  - Can also be used for “classic” delegations
- Restricts user somewhat
  - Fewer degrees of freedom mean fewer errors
  - One can always manually create the Domain object
- Version 1 to appear shortly
  - Demo in the hallway

Web Interface Examples

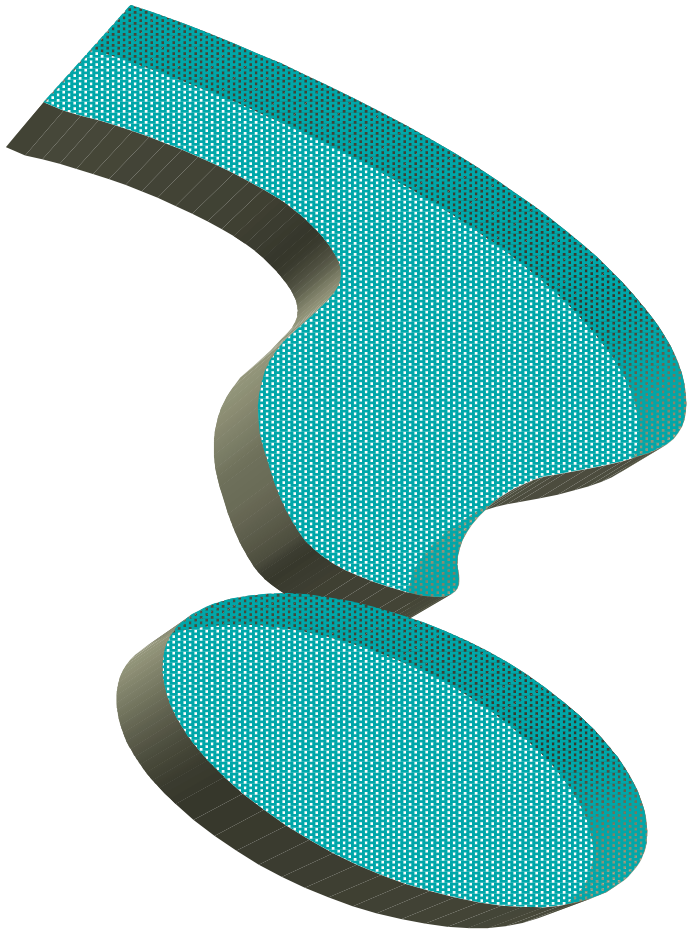
May the Demo Gods be with us.

We'll cheat.

NCC Roadmap

- RIPE NCC is signing its zones
  - Forward zones (ripe.net &c) are signed
  - Signatures are still being introduced in reverse zones (v4 and v6)
- Secure Delegations available for a number of /8 equivalent zones
- Policy and procedures available
  - www.ripe.net/reverse

QUESTIONS?



Acknowledgements: A number of these slides are based on earlier work at RIPE NCC.