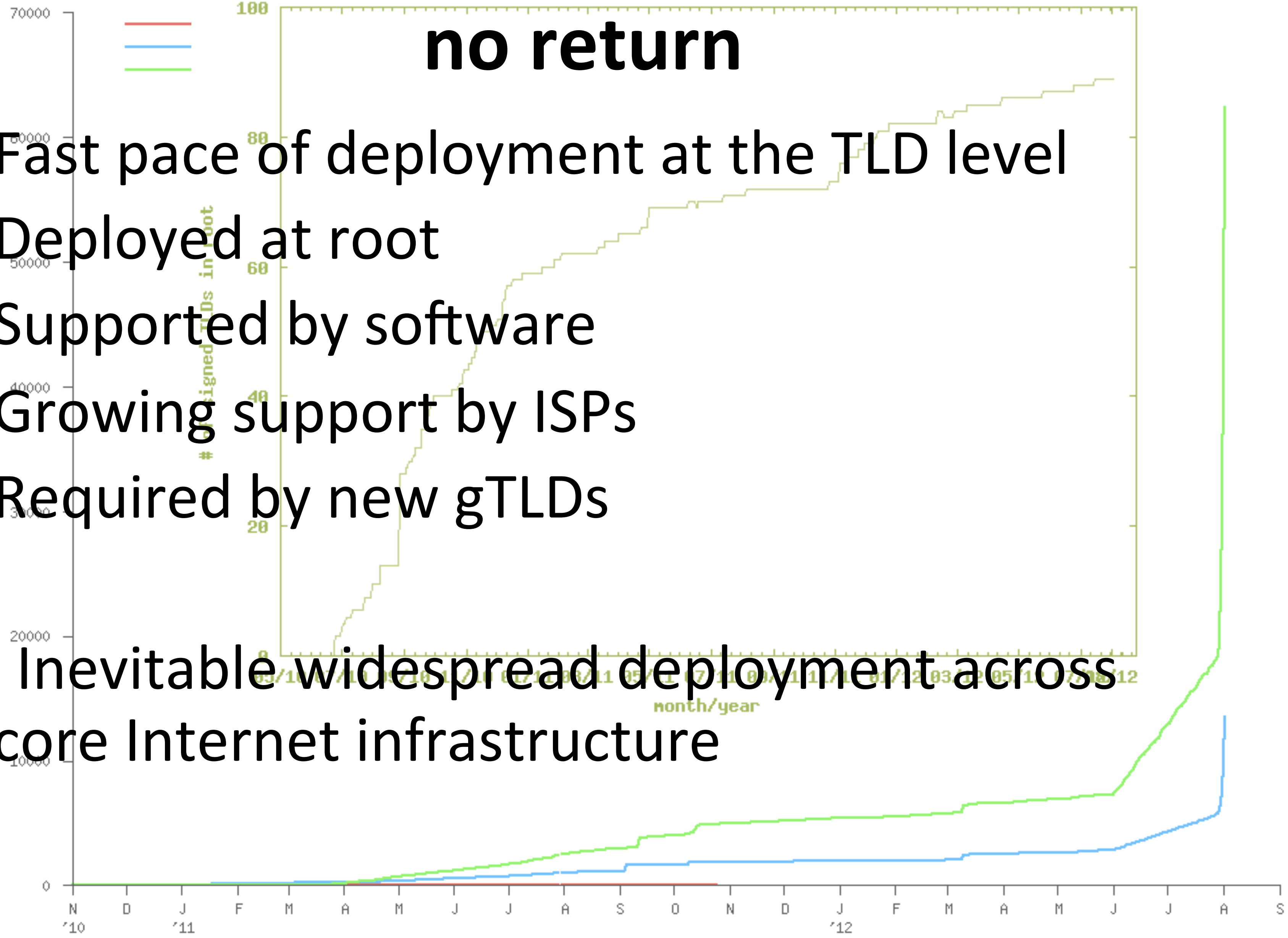
DNSSEC Implementation Considerations and Risk Analysis

ICANN Meeting
Singapore
18 March 2014
richard.lamb@icann.org

DNSSEC: We have passed the point of no return



- Fast pace of deployment at the TLD level
- Deployed at root
- Supported by software
- Growing support by ISPs
- Required by new gTLDs

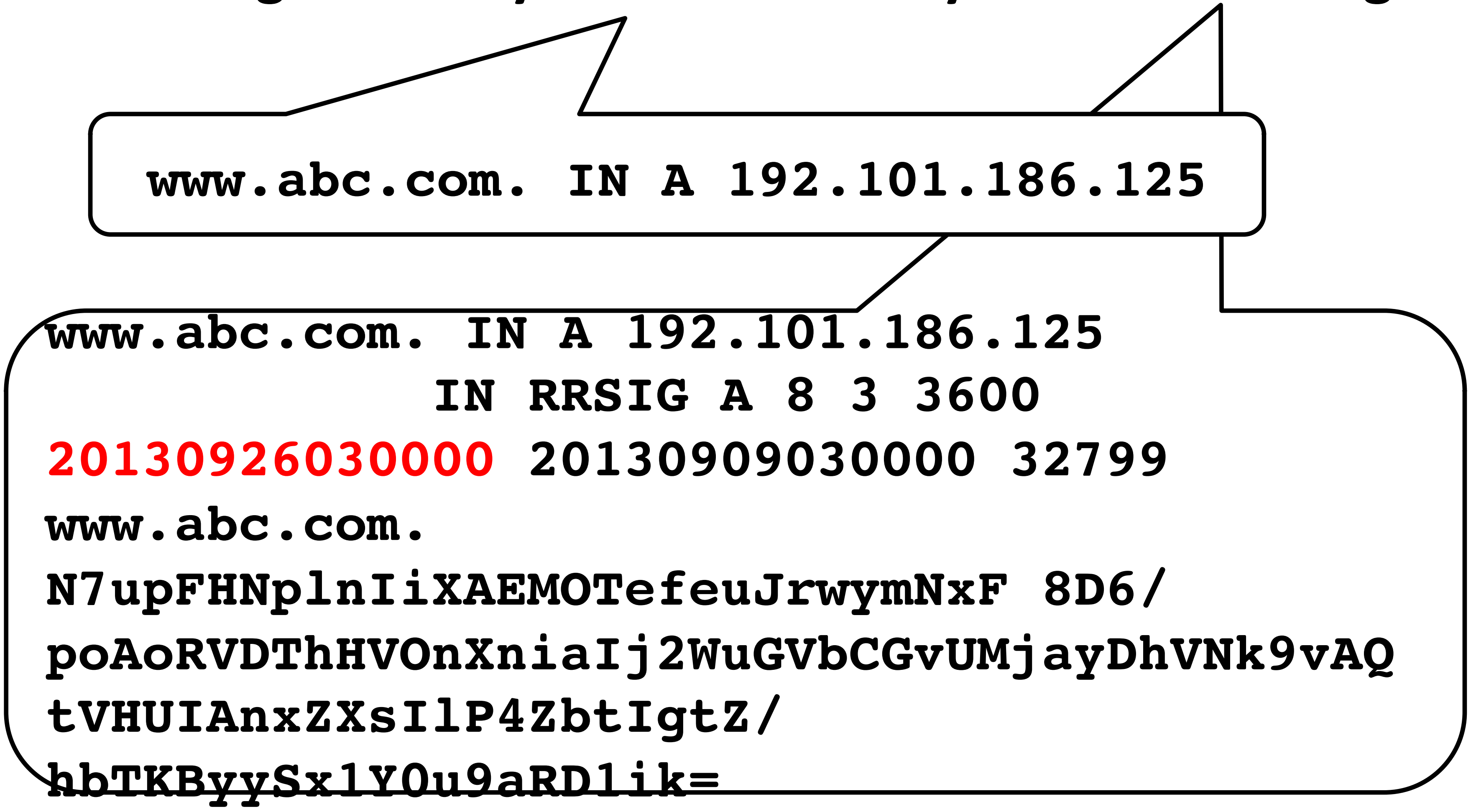
→ Inevitable widespread deployment across core Internet infrastructure

Design Considerations

How do I sign a zone?

That’s it

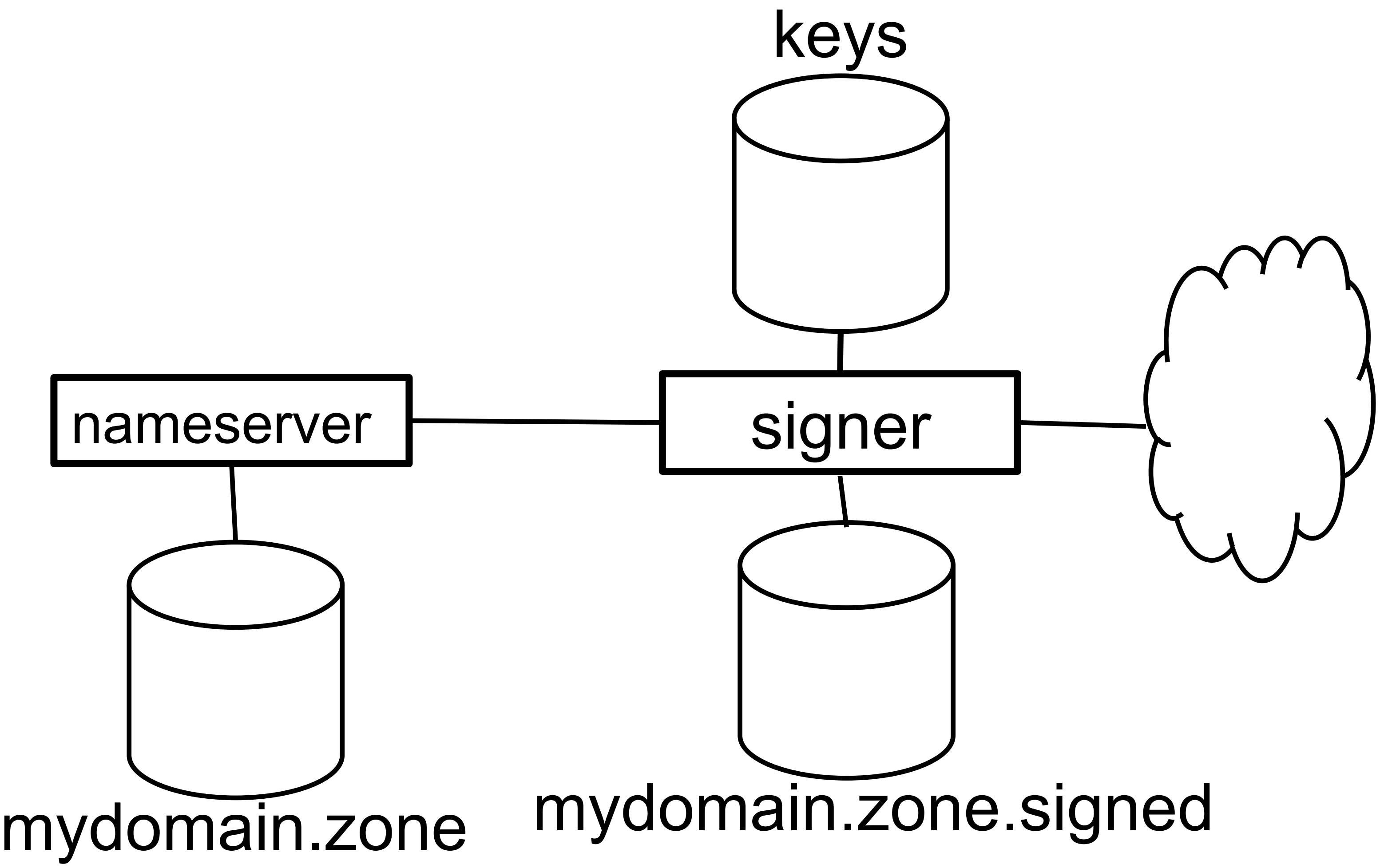
dnssec-signzone mydomain.zone mydomain.zone.signed



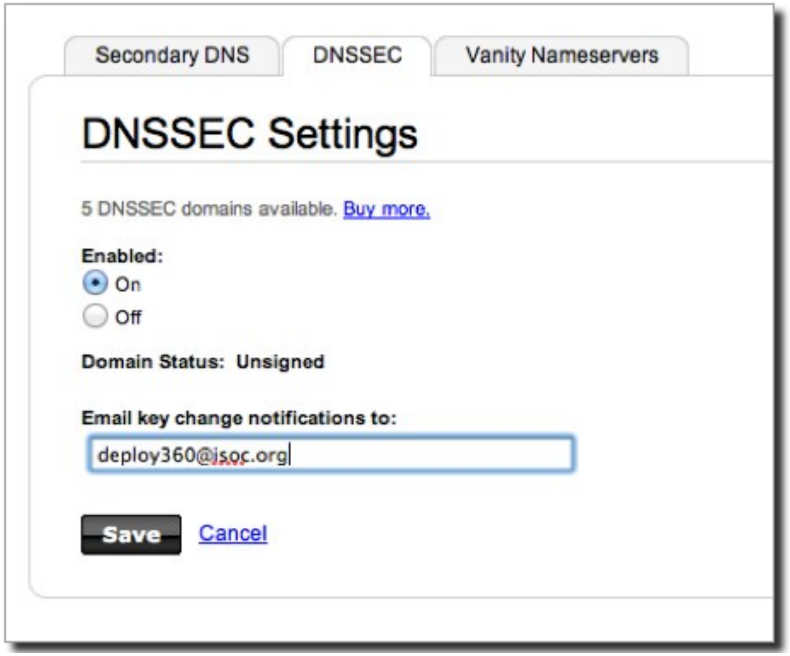
```
www.abc.com. IN A 192.101.186.125
```

```
www.abc.com. IN A 192.101.186.125
            IN RRSIG A 8 3 3600
20130926030000 20130909030000 32799
www.abc.com.
N7upFHNplnIiXAEMOTefeuJrwymNxF 8D6/
poAoRVDThHVOnXniaIj2WuGVbCGvUMjayDhVNk9vAQ
tVHUIAnxZXsIlP4ZbtIgtZ/
hbTKByySx1YOu9aRD1ik=
```

One way to do this



or…another



DNSSEC Settings

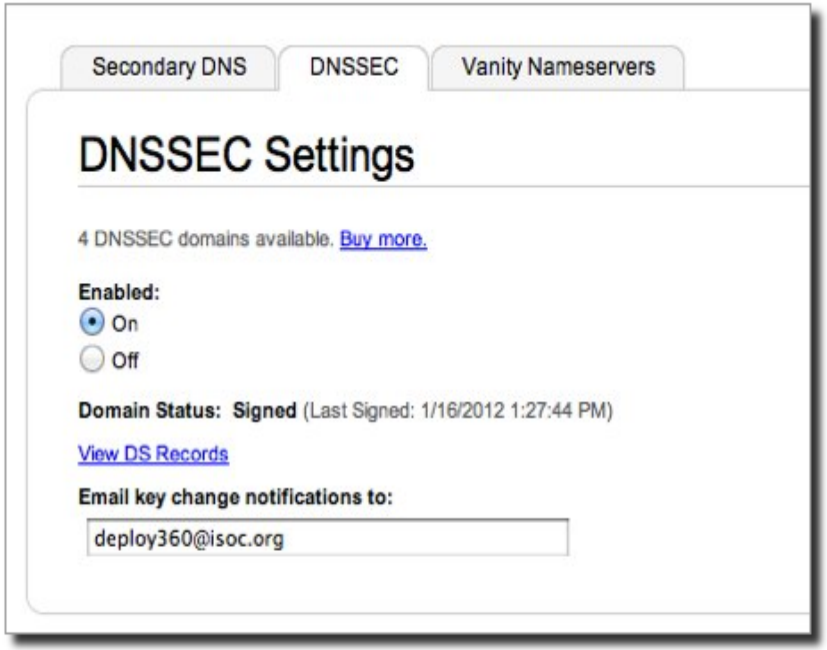
5 DNSSEC domains available. Buy more.

Enabled:
● On
○ Off

Domain Status: Unsigned

Email key change notifications to:

deploy360@isoc.org



DNSSEC Settings

4 DNSSEC domains available. Buy more.

Enabled:
● On
○ Off

Domain Status: Signed (Last Signed: 1/16/2012 1:27:44 PM)

Email key change notifications to:

deploy360@isoc.org

http://www.internetsociety.org/deploy360/resources/how-to-sign-your-domain-with-dnssec-using-godaddy-com/

It’s a question of risk / trust,

but is does not have to be expensive

Goals

- Reliable
- Trusted
- Cost Effective (for you)

Cost Effectiveness

Cost Effectiveness

- Risk Assessment
- Cost Benefit Analysis

Business Benefits and Motivation

(from “The Costs of DNSSEC Deployment” ENISA report)

- Become a reliable source of trust and boost market share and/or reputation of zones;
- Lead by example and stimulate parties further down in the chain to adopt DNSSEC;
- Earn recognition in the DNS community and share knowledge with TLD’s and others;
- Provide assurance to end-user that domain name services are reliable and trustworthy;
- Look forward to increasing adoption rate when revenue is an important driver. Deploying DNSSEC can be profitable;

Risk Assessment

- Identify your risks
  - Reputational
    - Competition
    - Loss of contract
  - Legal / Financial
    - Who is the relying party?
    - SLA
    - Law suits
- Build your risk profile
  - Determine your acceptable level of risk

Vulnerabilities

- False expectations
- Key compromise
- Signer compromise
- Zone file compromise

Cost Benefit Analysis

Setting reasonable expectations means it doesn’t have to be expensive

From ENISA Report

- "….organizations considering implementing DNSSEC can greatly benefit from the work performed by the pioneers and early adopters."
- Few above 266240 Euros: Big Spenders: DNSSEC as an excuse to upgrade all infrastructure; embrace increased responsibility and trust through better governance.
- Most below 36059 Euros: Big Savers: reuse existing infrastructure. Do minimum.

Anticipated Capital and Operating Expense

- Being a trust anchor requires mature business processes, especially in key management;
- Investment cost also depends on strategic positioning towards DNSSEC: leaders pay the bill, followers can limit their investment;
- Financial cost might not outweigh the financial benefits. Prepare to write off the financial investment over 3 to 5 years, needed to gear up end-user equipment with DNSSEC.

Other Cost Analysis

- People
  - Swedebank – half a FTE
  - Occasional shared duties for others
- Facilities
  - Datacenter space
  - Safe ~ $100 - $14000
- Crypto Equip ~ $5-$40000
- Bandwidth ~ 4 x

http://www.internetdagarna.se/arkiv/2008/www.internetdagarna.se/images/stories/doc/22_Kjell_Rydger_DNSSEC_from_a_bank_perspective_2008-10-20.pdf

Trusted

Trust

- Transparent
- Secure

Transparency

Transparency

- The power of truth
  - Transparency floats all boats here
- Say what you do
- Do what you say
- Prove it

Say what you do

- Setting expectations
- Document what you do and how you do it
- Maintain up to date documentation
- Define Organization Roles and responsibilities
- Describe Services, facilities, system, processes, parameters

Learn from CA successes (and mistakes)

- The good:
  - The people
  - The mindset
  - The practices
  - The legal framework
  - The audit against international accounting and technical standards
- The bad:
  - Diluted trust with a race to the bottom (>1400 CA's)
  - DigiNotar
    - Weak and inconsistent polices and controls
    - Lack of compromise notification (non-transparent)
    - Audits don't solve everything (ETSI audit)

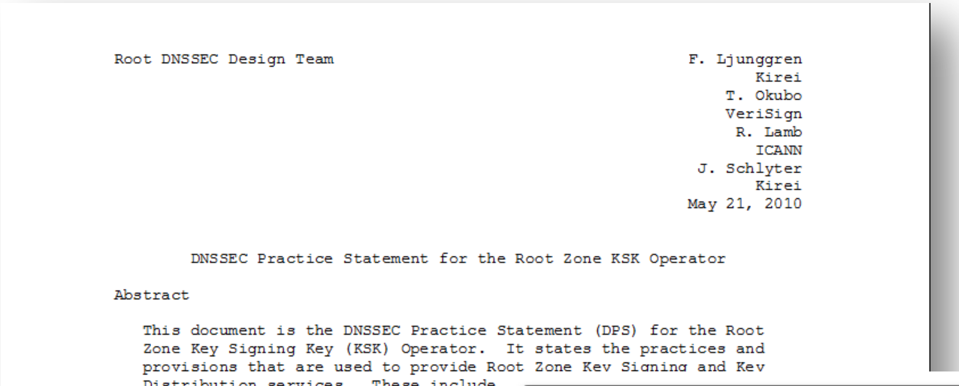
Say What You Do - Learn from Existing Trust Services

- Borrow many practices from SSL Certification Authorities (CA)
  - Published Certificate Practices Statements (CPS)
    - VeriSign, GoDaddy, etc..
  - Documented Policy and Practices (e.g., key management ceremony, audit materials, emergency procedures, contingency planning, lost facilities, etc…)

Say What You Do - DNSSEC Practices Statement

- DNSSEC Policy/Practices Statement (DPS)
  - Drawn from SSL CA CPS
  - Provides a level of assurance and transparency to the stakeholders relying on the security of the operations.
  - Regular re-assessment
  - Management signoff
    - Formalize - Policy Management Authority (PMA)

Documentation - Root



Root DNSSEC Design Team   F. Ljunggren
                                                                    Kirei
                                                                T. Okubo
                                                                VeriSign
                                                                 R. Lamb
                                                                   ICANN
                                                            J. Schlyter
                                                                   Kirei
                                                            May 21, 2010

DNSSEC Practice Statement for the Root Zone KSK Operator

Abstract

This document is the DNSSEC Practice Statement (DPS) for the Root Zone Key Signing Key (KSK) Operator. It states the practices and provisions that are used to provide Root Zone Kev Signing and Kev Distribution services. These include, issuing, managing, changing and distrib with the specific requirements of the U

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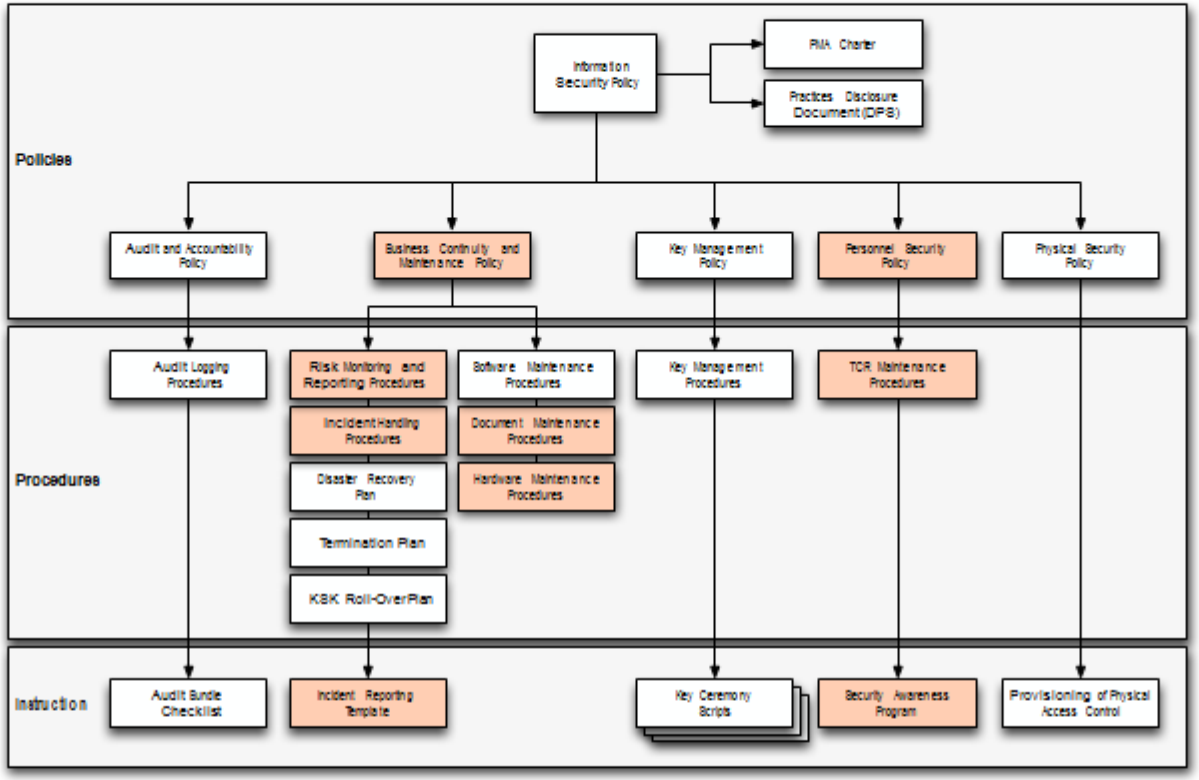
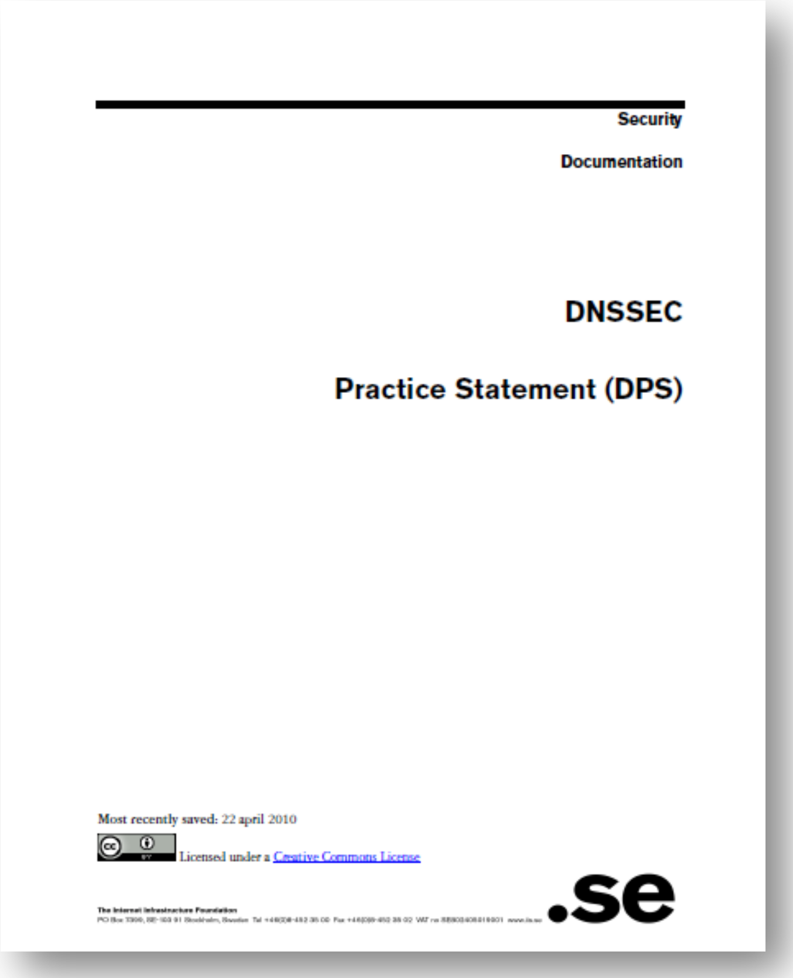
Root DPS

91 Pages and tree of other documents!



Information Security Policy
PMA Charter
Practices Disclosure Document (DPS)
Policies
Audit and Accountability Policy
Business Continuity and Maintenance Policy
Key Management Policy
Personnel Security Policy
Physical Security Policy
Procedures
Audit Logging Procedures
Risk Monitoring and Reporting Procedures
Software Maintenance Procedures
Key Management Procedures
TCR Maintenance Procedures
Incident Handling Procedures
Document Maintenance Procedures
Disaster Recovery Plan
Hardware Maintenance Procedures
Termination Plan
KSK Roll-Over Plan
Instruction
Audit Bundle Checklist
Incident Reporting Template
Key Ceremony Scripts
Security Awareness Program
Provisioning of Physical Access Control

Documentation - .SE



Security

Documentation

DNSSEC

Practice Statement (DPS)

Most recently saved: 22 april 2010

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The Internet Infrastructure Foundation
PO Box 7399, SE-103 91 Stockholm, Sweden Tel +46(0)8-452 35 00 Fax +46(0)8-452 35 02 VAT no [illegible] www.iis.se

.se

22 pages, Creative Commons License!

.SE DPS

Do what you say

- Follow documented procedures / checklists
- Maintain logs, records and reports of each action, including incidents.
- Critical operations at Key Ceremonies
  - Video
  - Logged
  - Witnessed

Key Ceremony

A filmed and audited process carefully scripted for maximum transparency at which cryptographic key material is generated or used.

Prove it

- Audits
  - –3rd party auditor $$
  - –ISO 27000 $$ etc..
  - –Internal

SysTrust

Prove it - Audit Material

- Key Ceremony Scripts
- Access Control System logs
- Facility, Room, Safe logs
- Video
- Annual Inventory
- Logs from other Compensating Controls
- Incident Reports

Prove it

- Stakeholder Involvement
  - Publish updated material and reports
  - Participation, e.g. External Witnesses from
    - local Internet community
    - Government
  - Listen to Feedback

Prove it

- Be Responsible
  - Executive Level Involvement
    - In policies via Policy Management Authority
    - Key Ceremony participation

Security

Building in security

- Getting the machinery for DNSSEC is easy (BIND, NSD/Unbound, OpenDNSSEC, etc..).

- Finding good security practices to run it is not.

Security

- Physical
- Logical
- Crypto

Physical

- – Environmental
- – Tiers
- – Access Control
- – Intrusion Detection
- – Disaster Recovery

Physical - Environmental

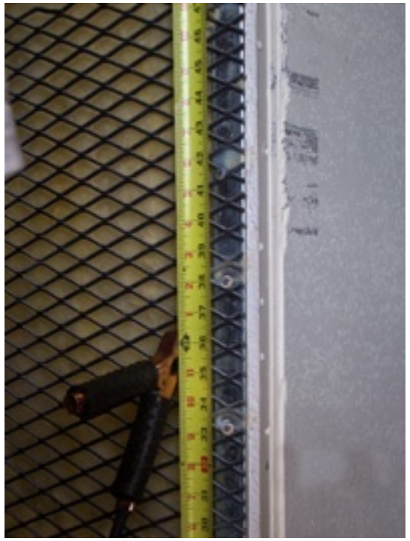
- Based on your risk profile
- Suitable
  - Power
  - Air Conditioning
- Protection from
  - Flooding
  - Fire
  - Earthquake

Physical - Tiers

- Each tier should be successively harder to penetrate than the last
  - Facility
  - Cage/Room
  - Rack
  - Safe
  - System
- Think of concentric boxes

Physical - Tier Construction

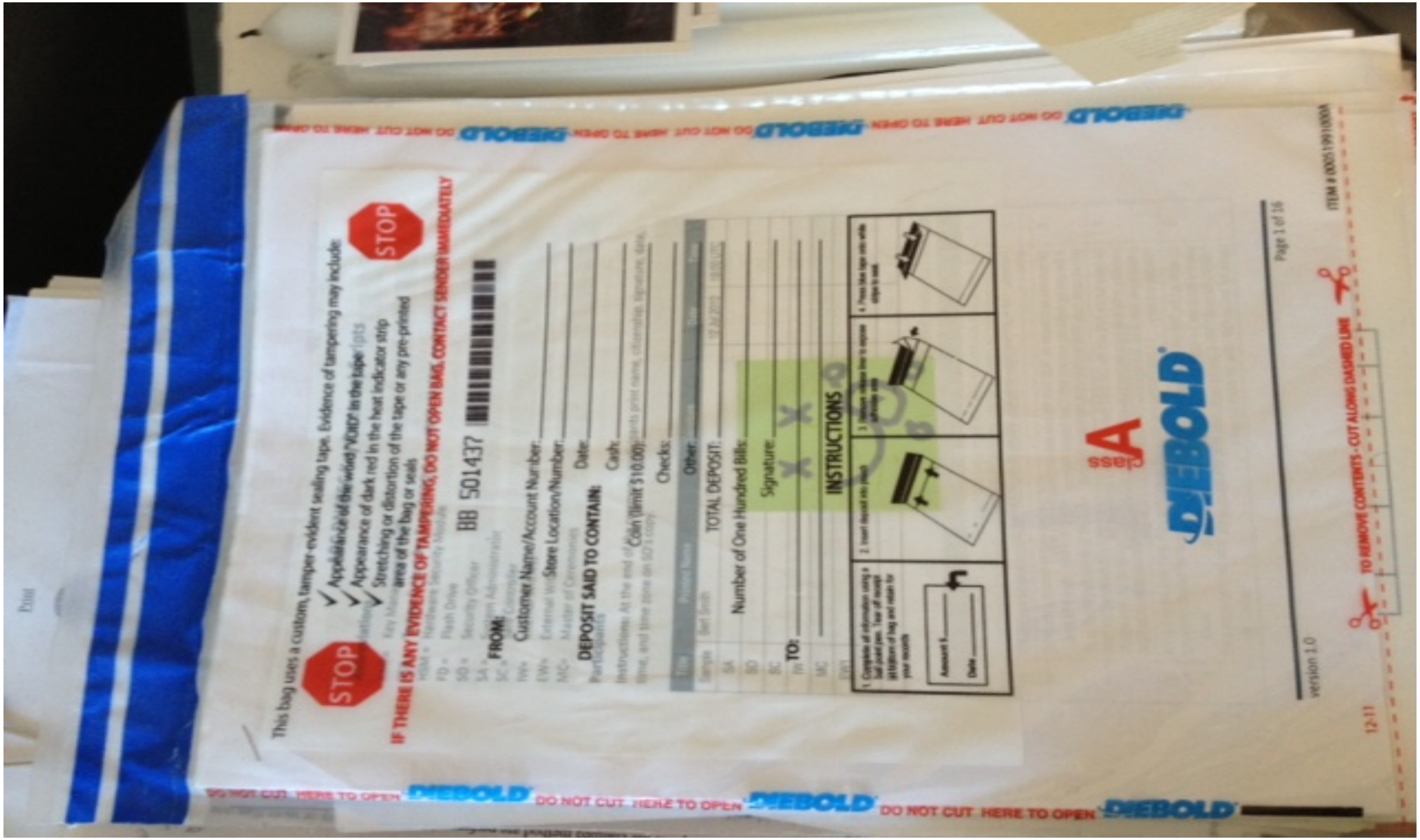
- Base on your risk profile and regulations
- Facility design and physical security on
  - Other experience
  - DCID 6/9
  - NIST 800-53 and related documents
  - Safe / container standards



Physical – Safe Tier

Physical – Safe Tier

Physical – Tamper Evident Packaging



This bag uses a custom, tamper-evident sealing tape. Evidence of tampering may include:

- ✓ Appearance of the word "VOID" in the tape
- ✓ Appearance of dark red in the heat indicator strip
- ✓ Stretching or distortion of the tape or any pre-printed area of the bag or seals

STOP STOP

IF THERE IS ANY EVIDENCE OF TAMPERING, DO NOT OPEN BAG. CONTACT SENDER IMMEDIATELY

BB 501437

FROM:

Customer Name/Account Number: ______

Store Location/Number: ______

Date: ______

DEPOSIT SAID TO CONTAIN:

Cash: ______

Coin (limit $10.00): ______

Checks: ______

Other: ______

TOTAL DEPOSIT: ______

Number of One Hundred Bills: ______

Signature: ______

TO: ______

INSTRUCTIONS

1. Complete all information using a ball point pen. Tear off receipt at bottom of bag and retain for your records
   Amount $ ______
   Date ______
2. Insert deposit into pouch
3. Remove release liner to expose adhesive area
4. Press blue tape onto white stripe to seal.

class A

DIEBOLD

Page 1 of 16

version 1.0

ITEM # 00051991000A

12-11

TO REMOVE CONTENTS - CUT ALONG DASHED LINE

DIEBOLD DO NOT CUT HERE TO OPEN

Physical - Access Control

- Base on your risk profile
- Access Control System
  - Logs of entry/exit
  - Dual occupancy / Anti-passback
  - Allow Emergency Access
- High Security: Control physical access to system independent of physical access controls for the facility

Physical - Intrusion Detection

- Intrusion Detection System
  - Sensors
  - Motion
  - Camera
- Tamper Evident Safes and Packaging
- Tamper Proof Equipment

Physical - Disaster Recovery

- Multiple sites
  - Mirror
  - Backup
- Geographical and Vendor diversity

Logical

- Authentication (passwords, PINs)
- Multi-Party controls

Logical - Authentication

- Procedural:
  - REAL passwords
  - Forced regular updates
  - Out-of-band checks
- Hardware:
  - Two-factor authentication
  - Smart cards (cryptographic)

Logical - Multi-Party Control

- Split Control / Separation of Duties
  - E.g., Security Officer and System Admin and Safe Controller
- M-of-N
  - Built in equipment (e.g. HSM)
  - Procedural: Split PIN
  - Bolt-On: Split key (Shamir, e.g. ssss.c)

Crypto

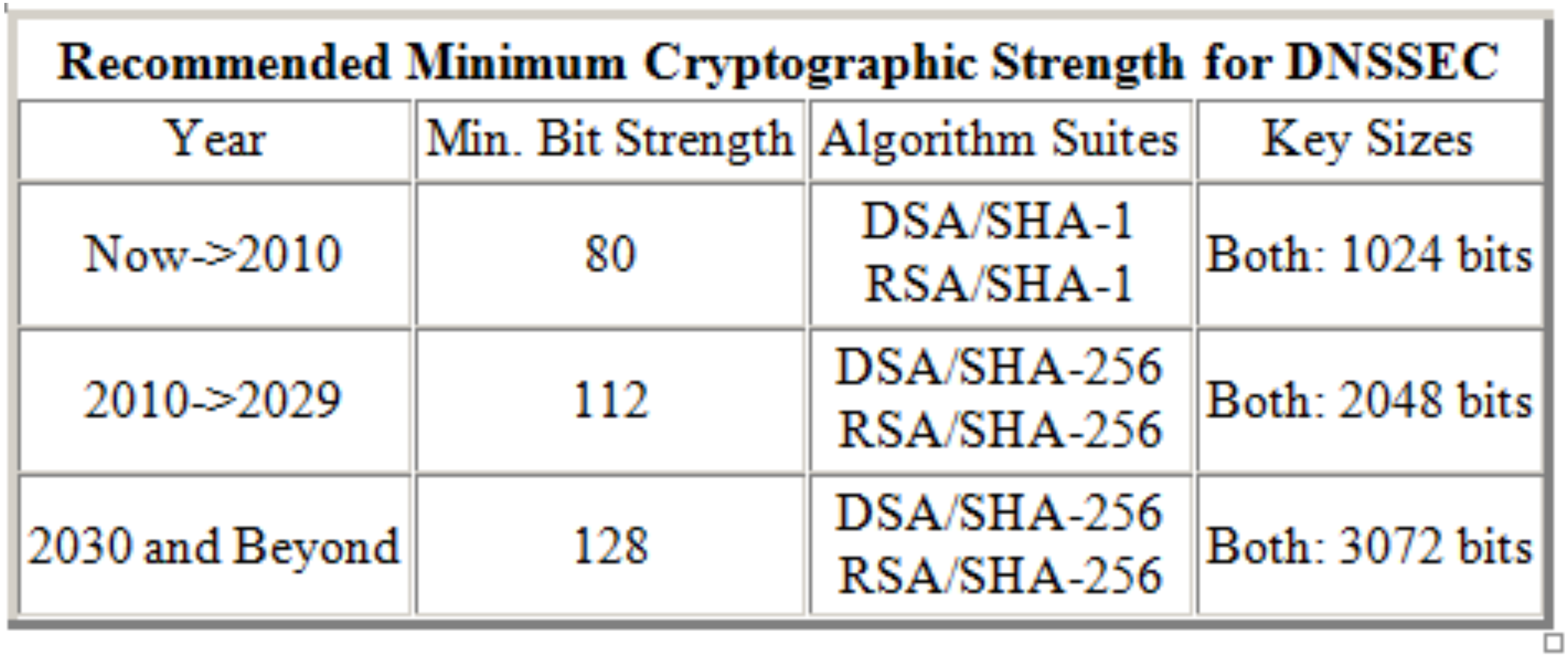
- Algorithms / Key Length
- Crypto Hardware

Crypto - Algorithms / Key Length

- Factors in selection
  - Cryptanalysis
  - Regulations
  - Network limitations

Crypto - Key Length

- Cryptanalysis from NIST: *2048 bit RSA SHA256*



Recommended Minimum Cryptographic Strength for DNSSEC			
Year	Min. Bit Strength	Algorithm Suites	Key Sizes
Now->2010	80	DSA/SHA-1 RSA/SHA-1	Both: 1024 bits
2010->2029	112	DSA/SHA-256 RSA/SHA-256	Both: 2048 bits
2030 and Beyond	128	DSA/SHA-256 RSA/SHA-256	Both: 3072 bits

http://csrc.nist.gov/publications/nistpubs/800-57/sp800-57_PART3_key-management_Dec2009.pdf

Crypto - Algorithms

- Local regulations may determine algorithm
  - GOST
  - DSA
- Network limitations
  - Fragmentation means shorter key length is better
  - ZSK may be shorter since it gets rolled often
  - Elliptical is ideal – but not commonplace

Crypto - Algorithms

- NSEC3 if required
  - Protects against zone walking
  - Avoid if not needed – adds overhead for small zones
  - Non-disclosure agreement?
  - Regulatory requirement?
  - Useful if zone is large, not trivially guessable (only "www" and "mail") or structured (ip6.arpa), and not expected to have many signed delegations ("opt-out" avoids recalculation).

Crypto - Hardware

- Satisfy your stakeholders
  - Doesn't need to be certified to be secure (e.g., off-line PC)
  - Can use transparent process and procedures to instill trust
  - But most Registries use or plan to use HSM. Maybe CYA?
- AT LEAST USE A GOOD Random Number Generator (RNG)!
- Use common standards avoid vendor lock-in.
  - Note: KSK rollover may be ~10 years.
- Remember you must have a way to backup keys!

Crypto - Hardware Security Module (HSM)

- FIPS 140-2 Level 3
  - Sun SCA6000 (~30000 RSA 1024/sec) ~$10000 (was $1000!!)
  - Thales/Ncipher nshield (~500 RSA 1024/sec) ~$15000
  - Ultimaco
- FIPS 140-2 Level 4
  - AEP Keyper (~1200 RSA 1024/sec) ~$15000
  - IBM 4765 (~1000 RSA 1024/sec) ~$9000
- Recognized by your national certification authority
  - Kryptus (Brazil) ~ $2500

Study:

http://www.opendnssec.org/wp-content/uploads/2011/01/A-Review-of-Hardware-Security-Modules-Fall-2010.pdf

Crypto - PKCS11

- A common interface for HSM and smartcards
  - C_Sign()
  - C_GeneratePair()
- Avoids vendor lock-in - somewhat
- Vendor Supplied Drivers (mostly Linux, Windows) and some open source

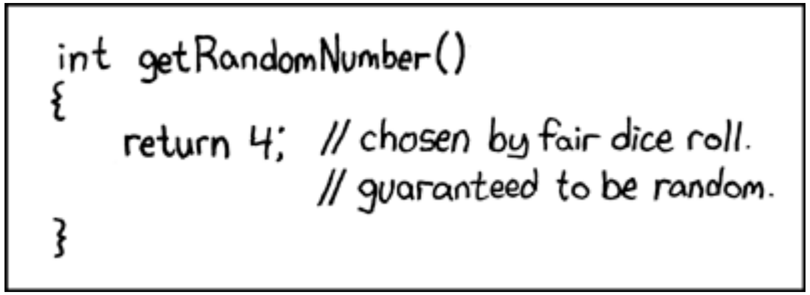
Crypto - Smartcards / Tokens

- Smartcards (PKI) (card reader ~$12)
  - AthenaSC IDProtect ~$30
  - Feitian ~$5-10
  - Aventra ~$11
- TPM
  - Built into many PCs
- Token
  - Aladdin/SafeNet USB e-Token ~$50
- Open source PKCS11 Drivers available
  - OpenSC
- Has RNG
- Slow ~0.5-10 1024 RSA signatures per second

Crypto -Random Number Generator

X rand()

X Netscape: Date+PIDs



```
int getRandomNumber()
{
    return 4;  // chosen by fair dice roll.
               // guaranteed to be random.
}
```

✓ LavaRand

? System Entropy into /dev/random (FBSD=c
+entropy/Linux=entropy?)

✓ H/W, Quantum Mechanical (laser) $

✓ Standards based (FIPS, NIST 800-90 DRBG)

✓ Built into CPU chips

Crypto - FIPS 140-2 Level 4 HSM

Root, .FR, .CA …

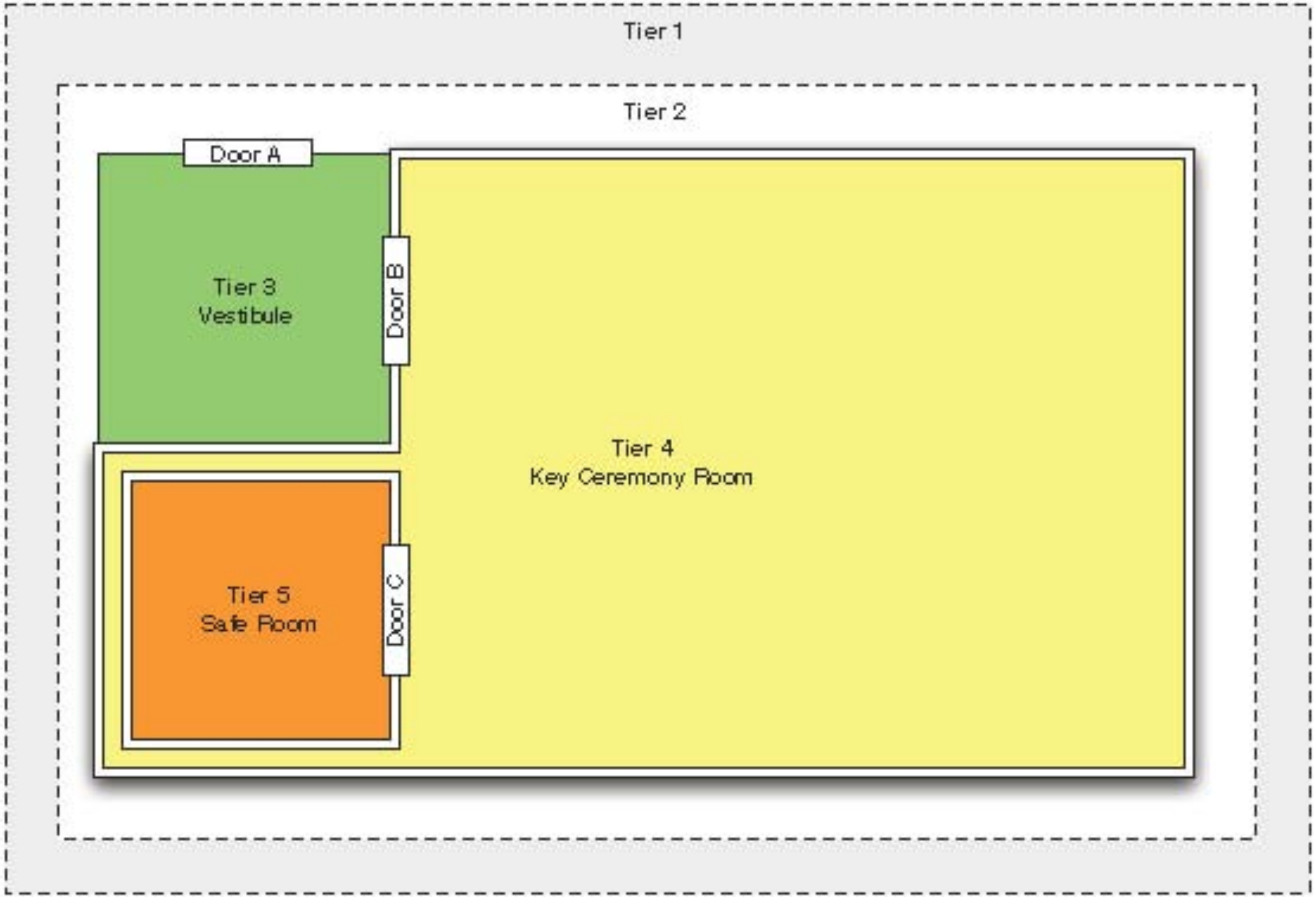
Crypto – FIPS Level 3 HSM

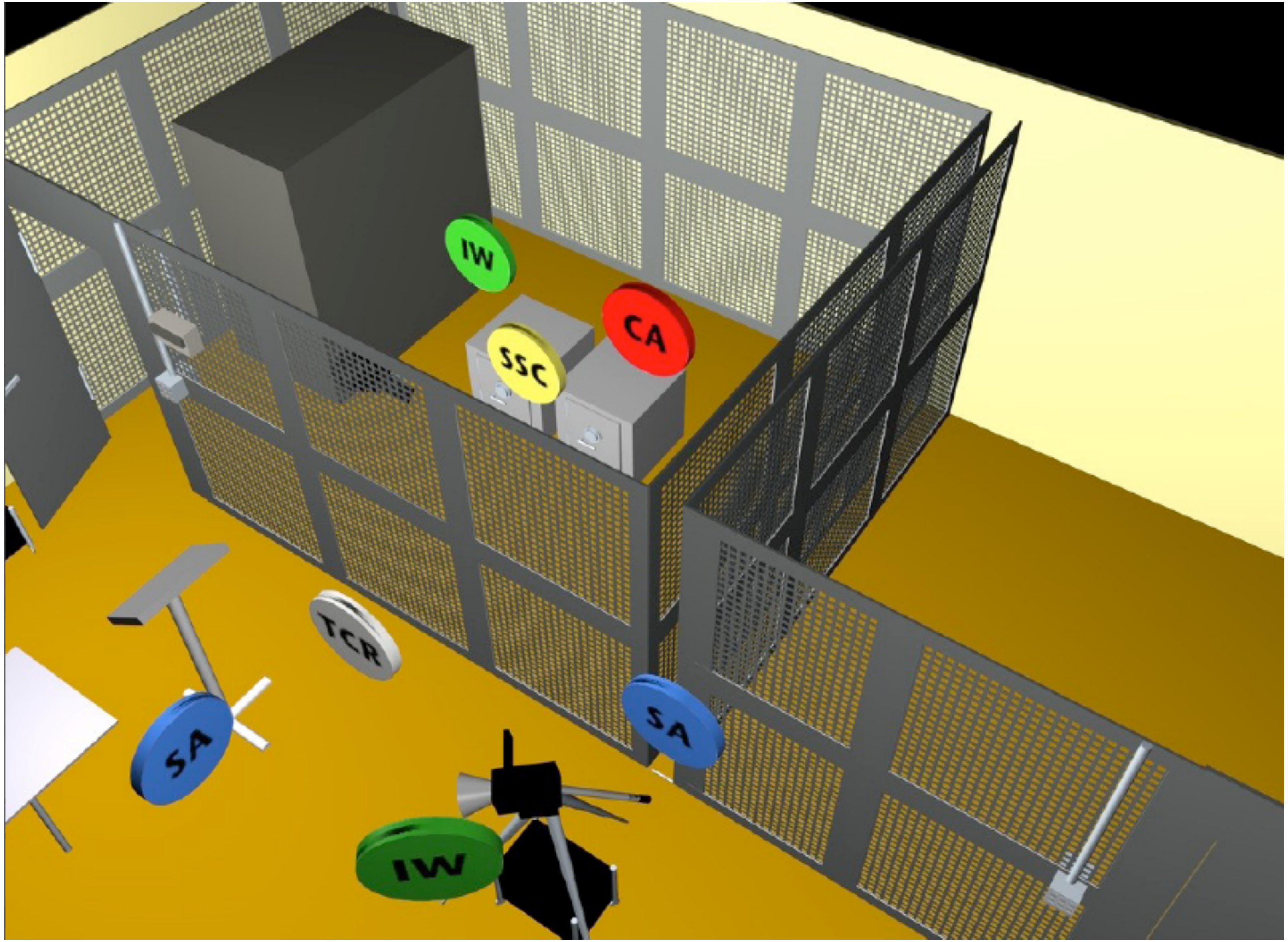
- But FIPS 140-2 Level 3 is also common
- Many TLDs using Level 3 .com , .se, .uk, .com, etc… $10K-$40K

An implementation can be thi$

SysTrust

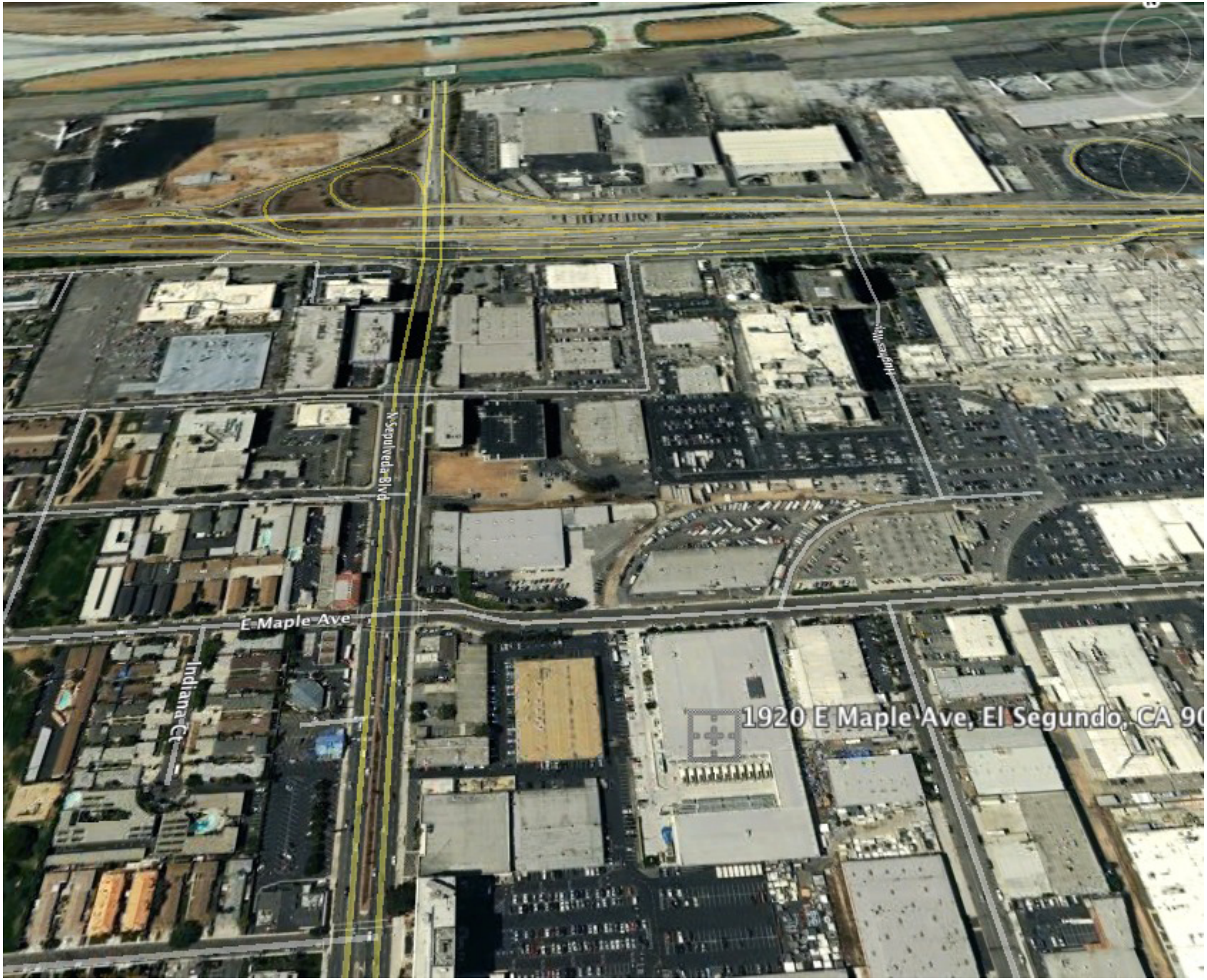
Physical Security




IW
CA
SSC
TCR
SA
SA
IW

http://www.flickr.com/photos/kjd/sets/72157624302045698/

17:29 13:29 10:29
JUN-16-2010 JUN-16-2010 JUN-16-2010
RICTED
AREA
AUTHORIZED PERSONNEL ONLY
LG
SAFE 2
SAFE 1
ICANN
SAMSUNG


N Sepulveda Blvd
Hughes Way
E Maple Ave
Indiana Ct
1920 E Maple Ave, El Segundo, CA 90

January 27, 2010

NOTICE
ALL EMPLOYEES AND VISITORS MUST WEAR IDENTIFICATION BADGES
NOTICE
UNAUTHORIZED PERSONS NOT PERMITTED BEYOND THIS POINT
NOTICE
NO FOOD OR DRINK BEYOND THIS POINT
NOTICE
ICANN
SEASTRON 3066
SAFE 2
SAFE 1
One World. One Internet. Everyone Connected.
19036

```
Starting: keygen (at Wed Jun 16 21:28:00 2010 UTC)
Use HSM /opt/dnssec/aep.hsmconfig?
Activate HSM prior to accepting in the affirmative!! (y/N): y

HSM /opt/dnssec/aep.hsmconfig activated.
[debug] setenv KEYPER_LIBRARY_PATH=/opt/dnssec
[debug] setenv PKCS11_LIBRARY_PATH=/opt/Keyper/PKCS11Provider/pkcs11.GCC4
.0.2.so.4.07
Found 1 slots on HSM /opt/Keyper/PKCS11Provider/pkcs11.GCC4.0.2.so.4.07
HSM slot 0 included
Loaded /opt/Keyper/PKCS11Provider/pkcs11.GCC4.0.2.so.4.07 Slot=0
HSM Information:
    Label:             ICANNKSK
    ManufacturerID:    AEP Networks
    Model:             Keyper Pro 0405
    Serial:            K6002013

Generating 2048 bit RSA keypair...
```

…or this

FIPS 140-2 Valic

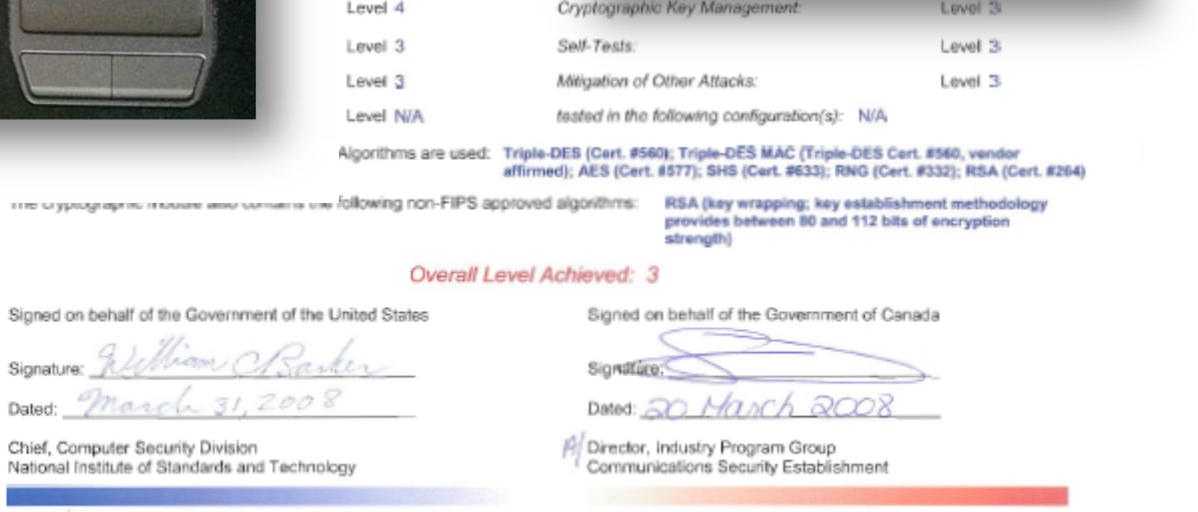
The Communications Security Establishment of the Government of Canada

ive levels of security: Level 1, L
d environments in which cryptog
ign and implementation of a cry
ict identified as:

Athena IDProtect by Athen
AT90SC25672RCT Revision D; F

ting accredited laboratory:

+



Level 3 C

Level 3 F

Level 4 Cryptographic Key Management: Level 3

Level 3 Self-Tests: Level 3

Level 3 Mitigation of Other Attacks: Level 3

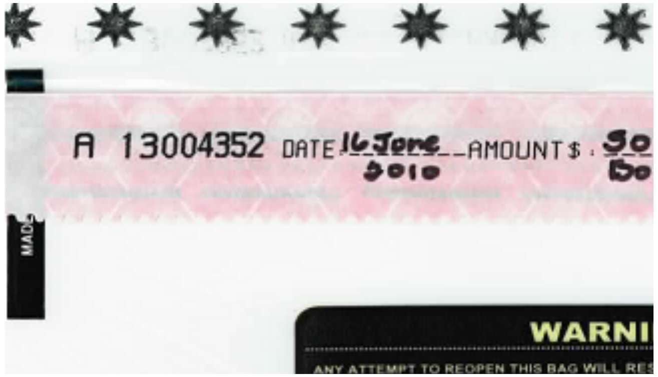
Level N/A tested in the following configuration(s): N/A

Algorithms are used: Triple-DES (Cert. #560); Triple-DES MAC (Triple-DES Cert. #560, vendor affirmed); AES (Cert. #577); SHS (Cert. #633); RNG (Cert. #332); RSA (Cert. #264)

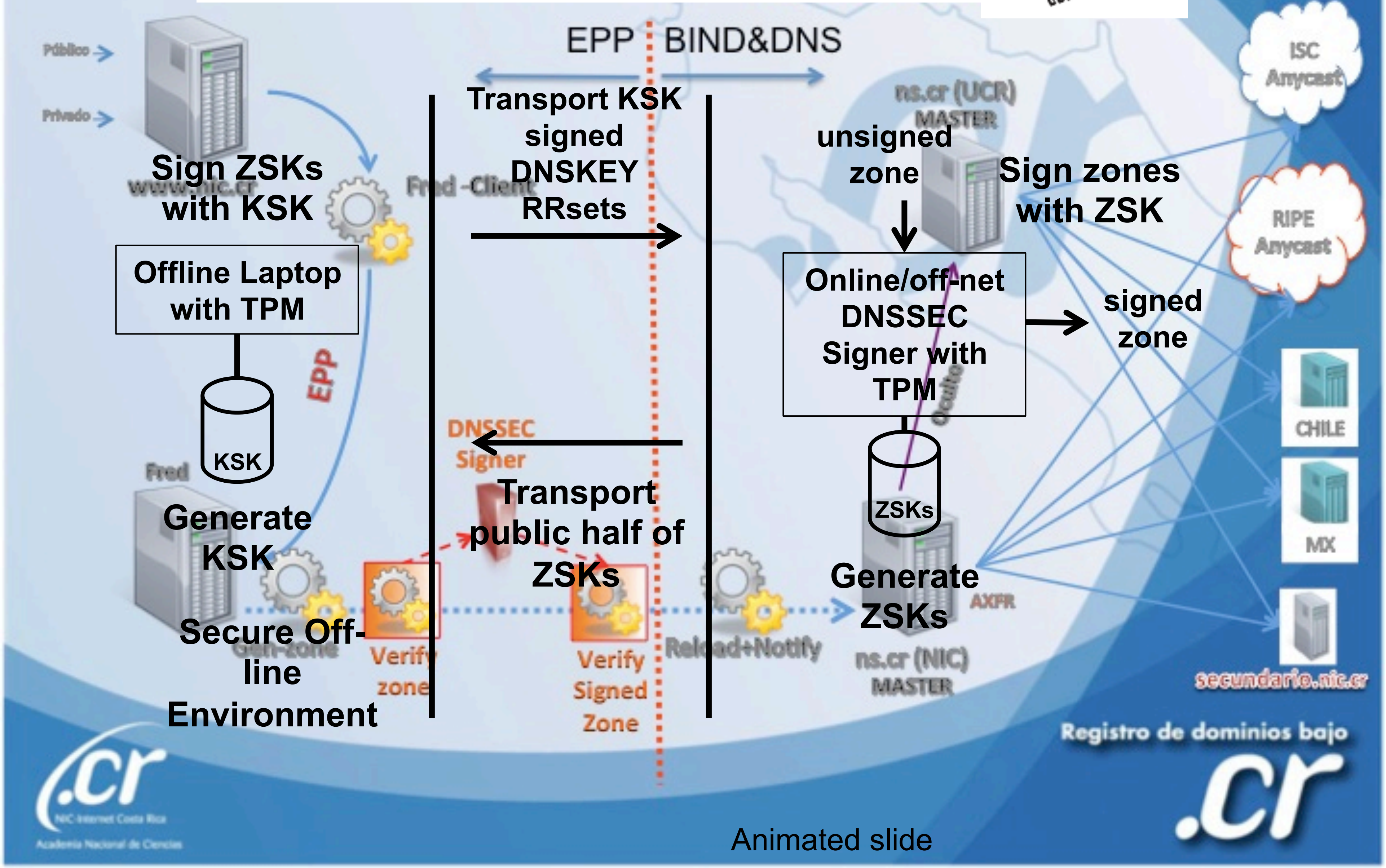
The cryptographic module also contains the following non-FIPS approved algorithms: RSA (key wrapping; key establishment methodology provides between 80 and 112 bits of encryption strength)

Overall Level Achieved: 3

Signed on behalf of the Government of the United States	Signed on behalf of the Government of Canada
Signature: William C Barker	Signature:
Dated: March 31, 2008	Dated: 20 March 2008
Chief, Computer Security Division National Institute of Standards and Technology	A/ Director, Industry Program Group Communications Security Establishment


A 13004352 DATE 16 June 2010 AMOUNT $ 50 00
MADE
WARNI
ANY ATTEMPT TO REOPEN THIS BAG WILL RES

..or this (from .cr)



EPP | BIND&DNS

Sign ZSKs with KSK

Offline Laptop with TPM

KSK

Generate KSK

Secure Off-line Environment

Transport KSK signed DNSKEY RRsets

Transport public half of ZSKs

unsigned zone

Sign zones with ZSK

Online/off-net DNSSEC Signer with TPM

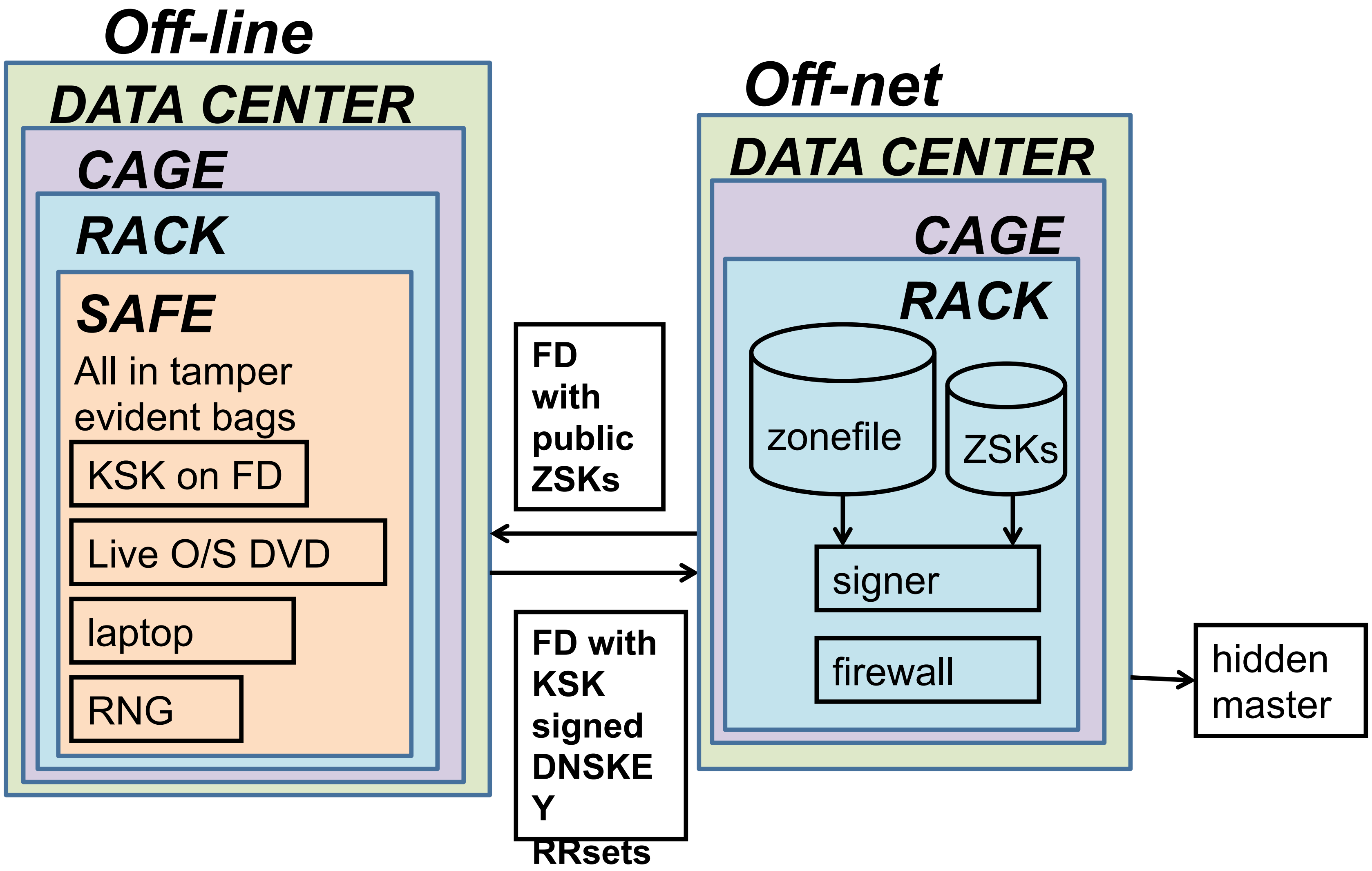
signed zone

ZSKs

Generate ZSKs

Animated slide

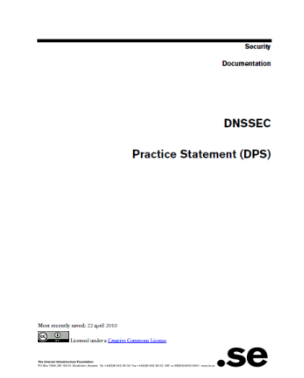
…or even this



Off-line
DATA CENTER
CAGE
RACK
SAFE
All in tamper evident bags
KSK on FD
Live O/S DVD
laptop
RNG
FD with public ZSKs
FD with KSK signed DNSKEY RRsets
Off-net
DATA CENTER
CAGE
RACK
zonefile
ZSKs
signer
firewall
hidden master

But all must have:

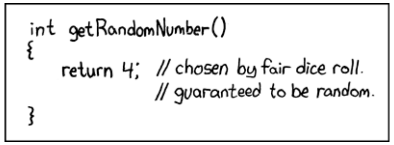
- Published practice statement
  - Overview of operations
  - Setting expectations
    - Normal
    - Emergency
  - Limiting liability
- Documented procedures
- Multi person access requirements
- Audit logs
- Monitoring (e.g., for signature expiry)
- Good Random Number Generators



Security
Documentation

DNSSEC
Practice Statement (DPS)

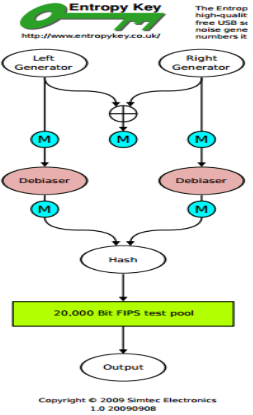
.se



```
int getRandomNumber()
{
    return 4;  // chosen by fair dice roll.
               // guaranteed to be random.
}
```

Intel RdRand

DRBGs
FIPS 140

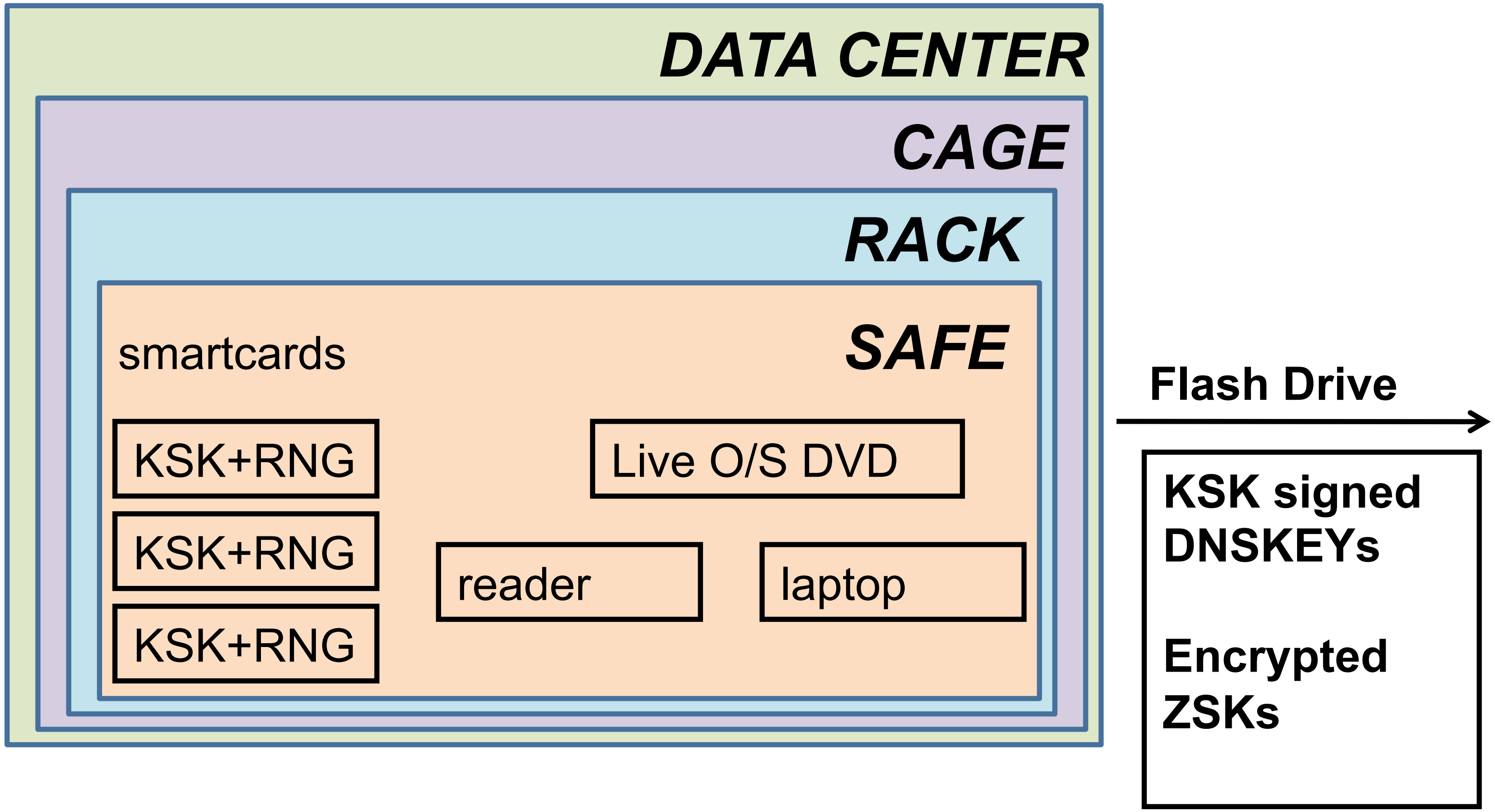


Useful IETF RFCs:
DNSSEC Operational Practices http://tools.ietf.org/html/draft-ietf-dnsop-rfc4641bis
A Framework for DNSSEC Policies and DNSSEC Practice Statements http://tools.ietf.org/html/draft-ietf-dnsop-dnssec-dps-framework

Demo Implementation

- Key lengths – KSK:2048 RSA ZSK:1024 RSA
- Rollover – KSK:as needed ZSK:90 days
- RSASHA256 NSEC3
- Physical – HSM/smartcards inside Safe inside Rack inside Cage inside Commercial Data Center
- Logical – Separation of roles: cage access, safe combination, HSM/smartcard activation across three roles
- Crypto – use FIPS certified smartcards as HSM and RNG
  - Generate KSK and ZSK offline using RNG
  - KSK use off-line
  - ZSK use off-net

Off-Line Key generator and KSK Signer



DATA CENTER

CAGE

RACK

SAFE

smartcards

KSK+RNG

KSK+RNG

KSK+RNG

Live O/S DVD

reader

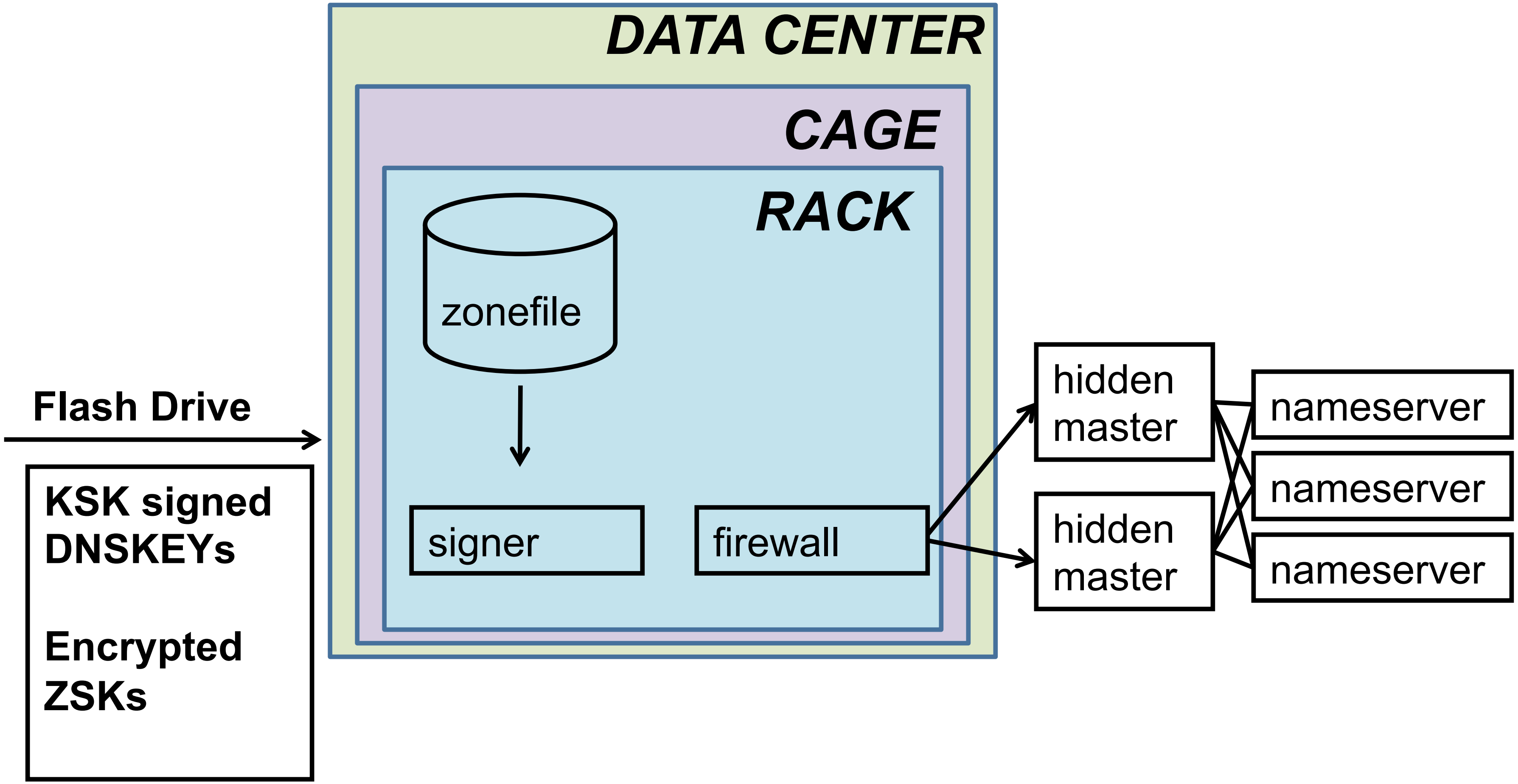
laptop

Flash Drive

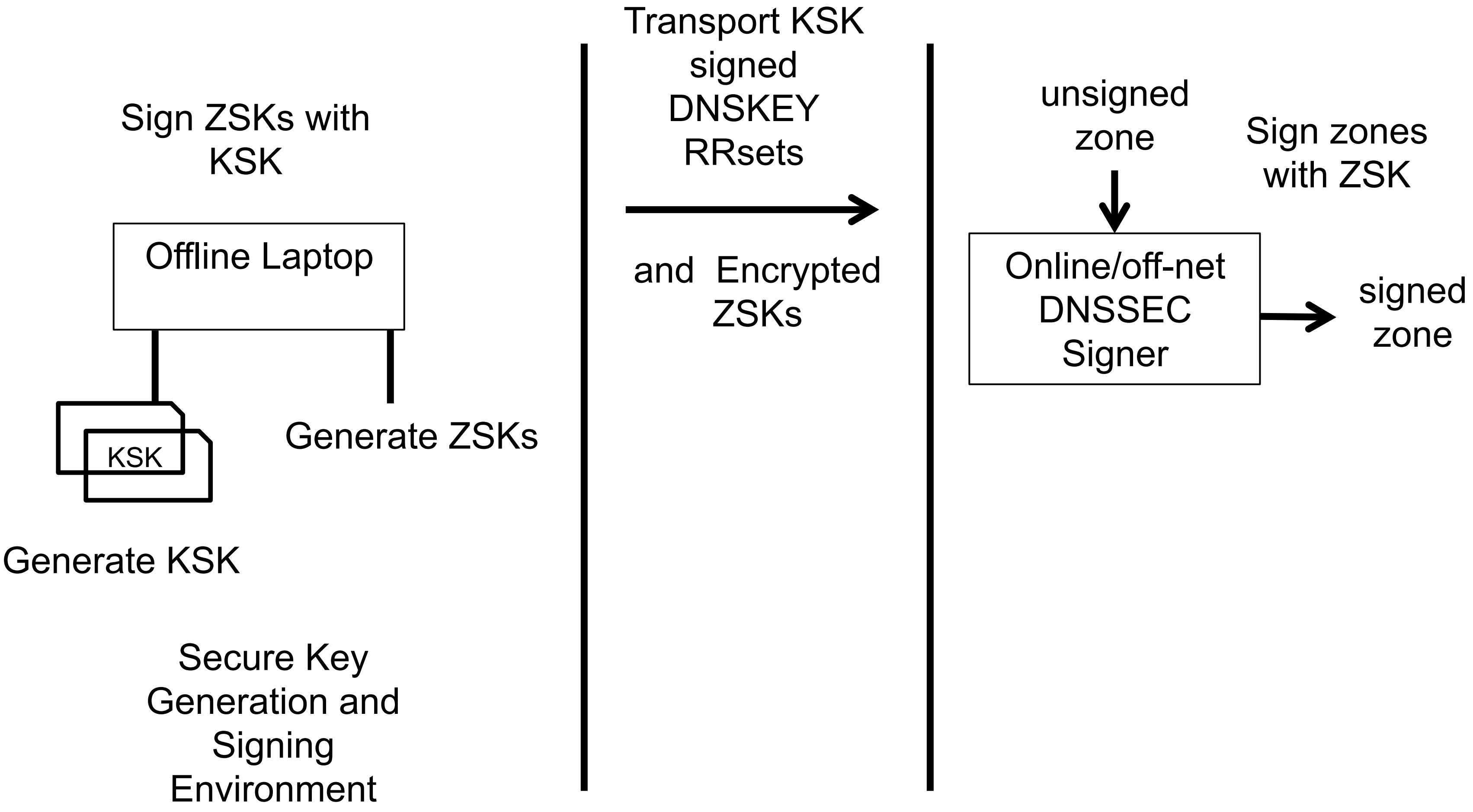
KSK signed DNSKEYs

Encrypted ZSKs

Off-Net Signer



Key Management



Sign ZSKs with KSK

Offline Laptop

KSK

Generate KSK

Generate ZSKs

Secure Key Generation and Signing Environment

Transport KSK signed DNSKEY RRsets

and Encrypted ZSKs

unsigned zone

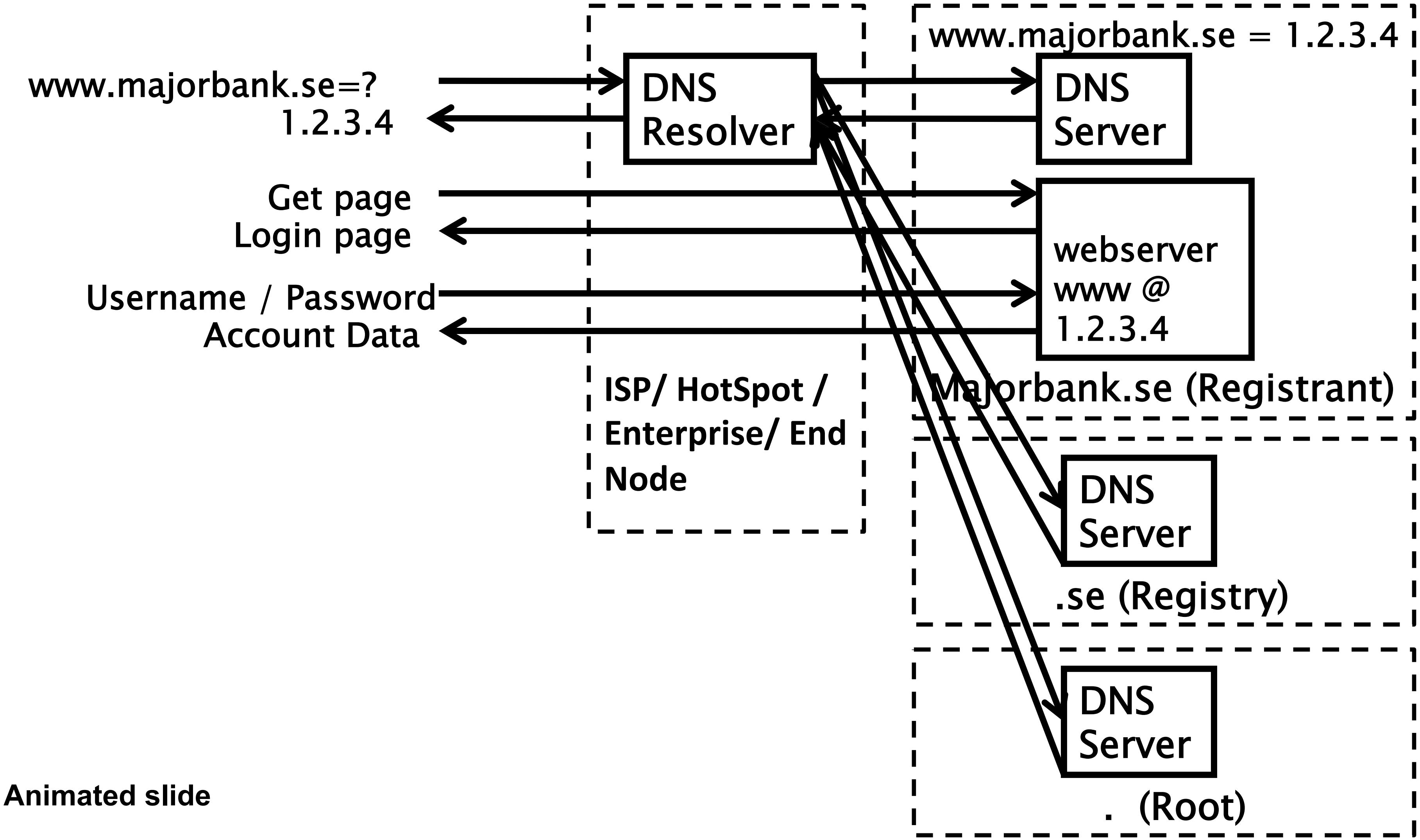
Sign zones with ZSK

Online/off-net DNSSEC Signer

signed zone

Animated slide

DNS+DNSSEC



Animated slide

Simple Key Management Scripts

Keeping things signed

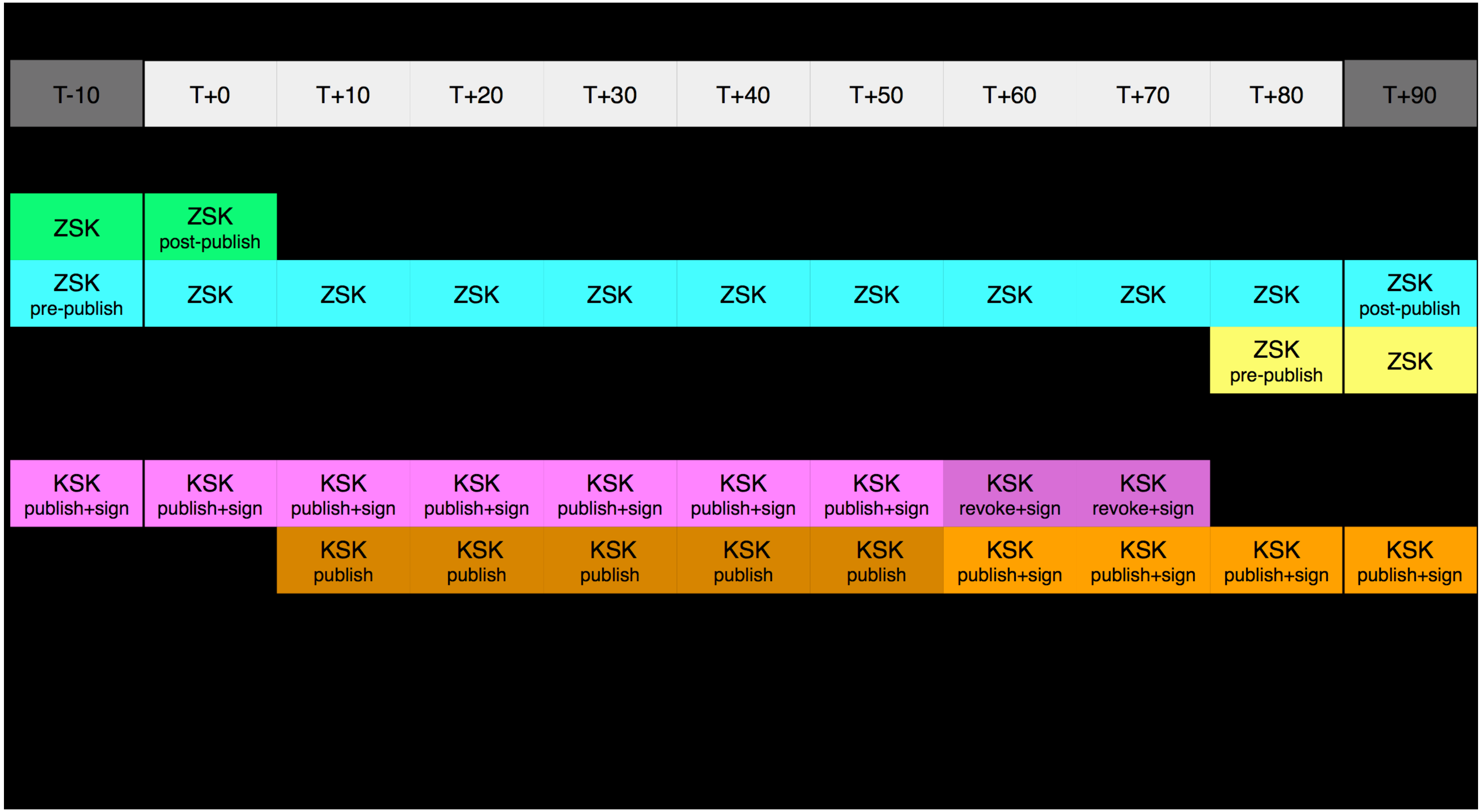
- If the signatures are going to expire soon, sign the zone
- Define “soon”
- Also sign if a record has changed
- That’s it!

```
while(1) {
  t = time
  if(exp - t) < 5 days {
     inc = t
     exp = t + 10 days
     touch infile
  }
  if new infile {
    cat infile keys > zonefile
    increment zonefile SOA serial
    signzone -s inc -e exp zonefile
                      zsk-current ksk
    rndc reload
  }
  sleep 1 second
}
```

Rolling keys

- Mind the cache – DNS resolvers have memory
- Publish the new ZSK before signing with it
  - Put the new ZSK in the DNSKEY RRset along with old ZSK and wait until everyone see its
- Sign the zone with the new ZSK until you want to change it
- But do not un-Publish the old ZSK until no one may need it

Key Rollover Schedule - Root



T-10	T+0	T+10	T+20	T+30	T+40	T+50	T+60	T+70	T+80	T+90
ZSK	ZSK post-publish									
ZSK pre-publish	ZSK	ZSK	ZSK	ZSK	ZSK	ZSK	ZSK	ZSK	ZSK	ZSK post-publish
									ZSK pre-publish	ZSK
KSK publish+sign	KSK publish+sign	KSK publish+sign	KSK publish+sign	KSK publish+sign	KSK publish+sign	KSK publish+sign	KSK revoke+sign	KSK revoke+sign		
		KSK publish	KSK publish	KSK publish	KSK publish	KSK publish	KSK publish+sign	KSK publish+sign	KSK publish+sign	KSK publish+sign

https://www.iana.org/dnssec

```
generate zsk-new
cat zsk-new zsk-current ksk > keys
touch infile
sleep >2xTTL
copy zsk-new zsk-current
touch infile
sleep >2xTTL
cat zsk-current ksk > keys
touch infile
sleep >2xTTL
```