DNSSEC Implementation
Module 1

LACTLD Workshop
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Overview

• Design Considerations
• Demo Implementation
• DNSSEC Practices Statement
• Demo
• Outputs
  – Demo Implementation
  – Demo DNSSEC Practice Statement
  – Demo Key Ceremony Scripts
DNSSEC Update
DNSSEC Update

• < 1% DNSSEC still needs to deployed on more domain names.
• 72/310 top level domain (e.g., .com) have DNSSEC deployed. Internal ICANN-only site:
• 81% of domain names can have DNSSEC deployed on them.
Jeff Moss, told the Black Hat Technical Security conference in Las Vegas that now is the time for corporations and organizations to embrace DNSSEC.

If you only call us after the house is on fire, you have very few options, Moss told the conference in emphasizing the need for business to prioritize online security, including adoption of DNSSEC.

If you don’t have a corporate policy or strategy to sign your zone, you should, said Moss, who is the founder of the Black Hat conference. You're not only going to be helping your own organization, you're going to be helping the rest of the Internet.

Basic HowTo

• For Companies:
  – Sign your corporate domain names
  – Turn on validation on their DNS resolvers

• For Users:
  – Ask ISP to turn on validation on their DNS resolvers.
    (ISP in US with >18M has turned on validation)

• For ccTLDs
  – Do Yourself / Outsource / Somewhere in between

• More Registrars need to support DNSSEC
Game changing Internet Core Infrastructure Upgrade

• “More has happened here today than meets the eye. An infrastructure has been created for a hierarchical security system, which can be purposed and re-purposed in a number of different ways. ..” – Vint Cerf
Opportunity

• Looks like we now have a global, secure database for “free”!
• A globally trusted Public Key Infrastructure
• Enabler for global security applications
• An authentication platform for identification
  – Identifying the threat is a key obstacle for cyber security efforts.
• Cross-organizational and trans-national
• .. A global platform for innovation
Sources of Trust on the Internet

CA Certificate roots ~1482

Content security
Commercial SSL
Certificates for
Web and e-mail

Yet to be discovered
security innovations
and enhancements

DNSSEC root - 1

Content security
“Free SSL”
certificates for
Web and e-mail
and “trust agility”

Network security
IPSECKEY RFC4025

VoIP securing SIP

Domain Names

Cross-organizational and
trans-national
identity and
authentication

E-mail security
DKIM RFC4871

Login security
SSHFP RFC4255

Domain Names
One effort: DANE in IETF

• Free SSL Certificates
  – Currently ~4M out of 255M sites use SSL. Y-not all?
• Improved security for existing and high security (EV) Certificates
  – Extra protection around recent CA mistakes
• Secure e-mail - S/MIME
  – Mature but unused due to difficult PKI deployment.
• Timeframe? ~2 years

https://www.eff.org/observatory
Opportunity for Indigenous Certification Authorities

• CAs located in only 52 countries

• Even then, some countries are not using their own CAs.

• Synergy: Reduced barriers, Alignment with TLD and national interests, DNSSEC operations
Achieving full potential

• Someday critical industries will come to rely on DNSSEC (or not )-:
• Need to focus on weak links in the chain of trust
  Registrant → Registrar → Registry → Root
• This will require secure IT practices and transparency
• ...and greater awareness for the consumer
Design Considerations
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

Reliability
Reliability

• Availability: Absolute time matters / Signatures expire: can not set and forget.

raiz. 135957  IN  RRSIG  DNSKEY 8 0 172800
20110913235959  20110830000000 19036 raiz.
mTOLwTC+jfhKi7P5V/zcLYLwjFUvOqTXGujYQVzeMCJdR1VdlYLxGUmM ..

• Complexity: Key management: DNSSEC > DNS
Reliability

• Ensuring Availability
  – Automate
  – Monitor
  – Backup Sites

• Taming Complexity
  – Step-by-step checklists
  – Rely on documented processes - not specialists
Reliability - Automation

• Pre-gen key material and rollover schedules
  – Pre-gen KSK signed DNSKEY RRsets
• Scripts
  – cronjob dnssec-signzone execution
  – check zone before publication
Reliability - Monitor

• Early Warning systems
  – Impending RRsig expiration
  – SOA serial sync between NS
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
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..
    – USHER HEBCA, Dartmouth
  • 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

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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 Key Material and Key Distribution services. These include, among others, issuing, managing, changing and distributing the Root Zone Keys in accordance with the specific requirements of the IANA Assigned Names and Numbers. This work has been prepared for the Internet Assigned Numbers Authority (IANA) by VeriSign, Inc., to be used in soliciting comments related to the "Key Maintenance for the Internet's Root" project. The comments will be reviewed by an appropriate IETF working group and will be considered for inclusion in the final document and/or publication in RFCs.

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91 Pages and tree of other documents!
Documentation - .SE

22 pages, Creative Commons License!
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
  – 3\textsuperscript{rd} party auditor $$
  – ISO 27000 $$ etc..
  – Internal
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
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 - 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 (e.g., 8 characters and mixed)
  – 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
- KSK/ZSK Splitting
- Effectivity (rollover) Period
- Number and Scheduling of keys
- Validity Period
- Crypto Hardware
Crypto - Algorithms / Key Length

• Factors in selection
  – Cryptanalysis
  – Regulations
  – Network limitations
Crypto - Key Length

- Cryptanalysis from NIST: 2048 bit RSA SHA256

<table>
<thead>
<tr>
<th>Year</th>
<th>Min. Bit Strength</th>
<th>Algorithm Suites</th>
<th>Key Sizes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Now-&gt;2010</td>
<td>80</td>
<td>DSA/SHA-1, RSA/SHA-1</td>
<td>Both: 1024 bits</td>
</tr>
<tr>
<td>2010-&gt;2029</td>
<td>112</td>
<td>DSA/SHA-256, RSA/SHA-256</td>
<td>Both: 2048 bits</td>
</tr>
<tr>
<td>2030 and Beyond</td>
<td>128</td>
<td>DSA/SHA-256, RSA/SHA-256</td>
<td>Both: 3072 bits</td>
</tr>
</tbody>
</table>

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 available yet
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 - KSK/ZSK Split

- Any reasonable sized zone will change frequently enough to warrant the ZSK to be on-line
- Manage compromise risk of on-line ZSK for frequently changing zone
- Flexibility in handling interaction with parent zone
- Not difficult to implement
Crypto – KSK Rollover

• Key length sets upper limit on effectivity (rollover) period
• Earlier cryptanalysis suggests 2048 bit key is good till 2030 so upper limit is ~20 years
• Other factors:
  – Practice emergency rollover
  – HSM operational considerations
  – Trusted employee turnover
  – Hard to roll if Trust Anchor. Easy if not.
  – Automated TA update - RFC5011
Crypto - KSK Rollover (cont)

• Only roll when compromised.
• Counter argument is to need to exercise emergency rollover for compromise recovery
• No widespread agreement
• If the KSK is not used as a Trust Anchor and decision is to do rollovers, not so difficult.
  – RFC4641bis suggests ~ 1 year effectivity period since year time-span is easily planned and communicated.
Crypto – ZSK Rollover

• ZSK more frequently accessed: operational considerations
• ZSK compromise less severe since under zone owner control but rollover should happen soon.
• If online, exposed to various threats: keep off-net and roll.
Number and Schedule of Keys

- 1, 2, or 3 published (DNSKEY) keys for KSK and/or ZSK
  - UDP fragmentation on DNSKEY RRset + RRSIGs
  - Note: DNSKEY RRset does not need to be signed by ZSK

- Pre-publish KSK
  - more work for parent w/ extra steps;
  - can't pre-verify new DS;
  - doesn't work for combined alg rollover

- Double sign for KSK
  - only DNSKEYs signed so doesn't make zone too big

- Generally pre-publish for ZSK. Double sign for KSK.
- For root we use 1 KSK and 1 ZSK. Pre-publish new ZSK during ZSK rollover and double sign with both KSKs during KSK rollover.
Number and Schedule of Keys (cont)

- Example (root)
Crypto - Signature Validity Period

• Short to minimize replay attack - quickly recover from compromise
  – Max validity period < how long willing to tolerate replay attack
• Long to limit operational risks from equipment failure
  – Min validity period > operational failure recovery time.
• Validity periods overlap to deal with clock skew
• Other Guidelines
  – Avoid expiration in cache: Max TTL < validity period/N where N > 2
  – Secondaries do not serve expired signatures: SOA expiration < validity period
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/Ncpher nshield (~500 RSA 1024/sec) ~$15000
- 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

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 ~$20)
  - Oberthur ~$5-$15
  - AthenaSC IDProtect ~$35
  - Feitian ~$5-10

- **Token**
  - Aladdin/SafeNet USB e-Token ~$50
  - SDencrypter micro HSM www.go-trust.com

- **Open source PKCS11 Drivers available**
  - OpenSC

- **Has RNG**
- **Slow ~0.5-10 1024 RSA signatures per second**
Crypto - Random Number Generator

- `rand()`
- Netscape: Date+PIDs
- LavaRand
- System Entropy /dev/random
- Quantum Mechanical "$\$
- Standards based (FIPS, NIST 800-90 DRBG)
- Coming soon: Intel atomic

```c
int getRandomNumber()
{
    return 4; // chosen by fair dice roll.
    // guaranteed to be random.
}
```
Crypto - FIPS 140-2 Level 4 HSM

Root, .FR, ...
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
Crypto - But this is also “level 3”
Crypto - Other Hardware (cont)

• Two-Factor
  – RSA SecureID
  – Vasco “footballs” ~$5
  – NagraID cards ~$30

• Good for registrant-registrar authentication
Miscellaneous
Tools and Software

• BIND
  • BIND 9.8.x dynamic zone signing
  • dig [+sigchase]
  • dnssec-signzone, dnssec-dsfromkey, dnssec-dsfromkey

• LDNS
  — ldns-*

• OpenDNSSEC

• PKCS11
  — Some tools
  — But Not so hard. Plenty of examples out there.

• Test Tools
  — [http://dnsviz.net](http://dnsviz.net)
  — TLDMon - [https://www.dns-oarc.net/oarc/services/tldmon](https://www.dns-oarc.net/oarc/services/tldmon)
  — DNSMON - [http://dnsmon.ripe.net/dns-servmon/](http://dnsmon.ripe.net/dns-servmon/)
Parental policies

• Initial key exchange
  • Out of band check even if dnskey available
  • Accept DS at minimum
  • Verify matching DNSKEY (root does this)
  • Awaiting simplifying protocols that update DS in band between parent and child using established crypto relationship (non-TA only)
• Avoid security lameness – no matching DNSKEY for DS: “bogus”
  • Child’s careful removal of KSK DNSKEY material
  • Advice to child not to remove the KSK before the parent has a DS record for the new KSK in place (otherwise attacker’s zone valid while yours is not)
• Changing DNS operators
  • Cooperative (double KSK signed + ZSK pre-pub) - publish your policies. Reasonable TTLs 😊
  • Non-cooperative – 10year TTL+validity period for DNSKEY 😞 Solution: ask registry to remove DS
  • Proper contractual relationships between all parties is only solution.
Demo Implementation
Demo Implementation

• Key lengths – KSK:2048 RSA  ZSK:1024 RSA
• Rollover – KSK:as needed  ZSK:51 days
• RSASHA256 NSEC3
• Physical – HSM inside Safe inside Rack inside Cage inside Commercial Data Center
• Logical – Separation of roles: cage access, safe combination, HSM 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
Off-Net Signer

DATA CENTER

CAGE

RACK

Flash Drive

KSK signed DNSKEYs

Encrypted ZSKs

zonefile

signer

firewall

hidden master

nameserver

nameserver

nameserver
Write DNSSEC Practice Statement