signing the root saga

.se DNSSEC and IPV6 Workshop

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DNSSEC is …

- a PKI
- SSL for DNS without encryption

Recent Events

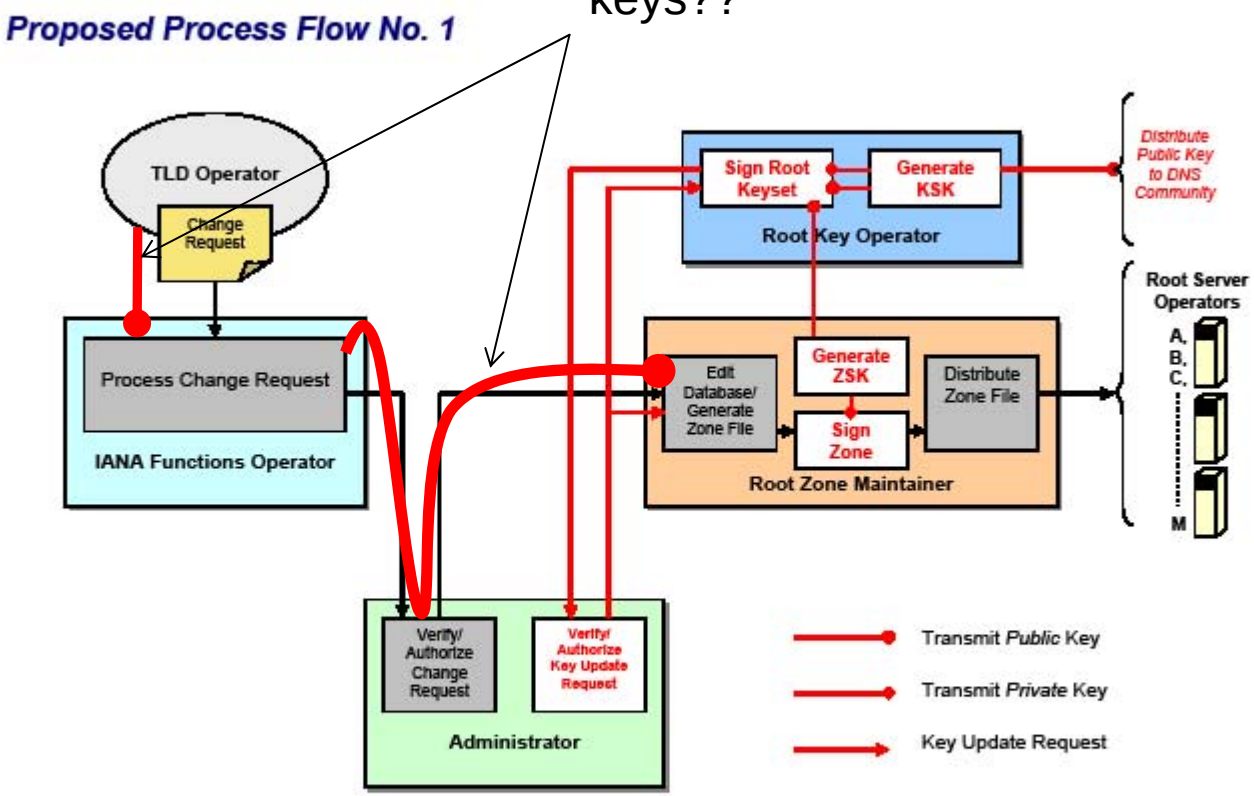
- Calls from the community to sign the root: RIPE, SE, ORG, UK, APNIC + press
- **.se** signs their zone. Leads the way and is an example for others to do so. (2/2007)
- BR, BG, PR, CZ, MUSEUM sign their zones. Upcoming: ORG, GOV, UK, CA, …
- So…in close cooperation with DNSSEC deployment and security experts (.SE, .UK, IETF) developed signing system for .arpa and root. Signed root publicly available at ns.iana.org (and anycast pch-test.iana.org) for well over a year (6/2007)
- Presentations describing system and seeking feedback at various fora: IETF, RIPE, ICANN, OARC, etc..
- DNSSEC and root zone management are part of ICANN Strategic Plan – primary part of IANA function and ICANN business
- DNSSEC @ ICANN paper published (7/24/2008)
- Interim-TAR (almost there), Root Zone Management system (ongoing)
- Dan Kaminsky! (8/5/2008)
- US Government mandates DNSSEC for its own .gov use (8/22)
- ICANN submits proposal to sign the root (9/2)
- NTIA response (9/9) (http://www.icann.org/correspondence/)
- VeriSign submits proposal (9/22)
- Market crashes (10/1), Industry meeting on DNSSEC in DC
- NTIA announces 45-day NOI on signing the root (10/9) - end 11/24
- Press http://blog.wired.com/27bstroke6/2008/10/who-should-sign.html

NTIA Notice of Inquiry

www.ntia.doc.gov/DNS/DNSSEC.html

- A good read! Overall a pretty fair and accurate treatment of the issue.
- Flow 4 is our proposal. Flow 5 is VeriSign's.
- Oddly absent throughout the text and flow diagrams are the processes of authenticating TLD keys and the transfer of those keys to the editing process. Elsewhere in the diagrams any transfer of keys between processes are both described in the text and specifically annotated in the diagrams.
- VeriSign and ICANN proposals published in their entirety
- Need your technical feedback

What about these keys??



proposals to sign the root

- ICANN
  - No restrictions on design
  - IANA vets TLD keys and immediately signs zone file
  - DNSSEC experts from community design final system, including KSK handling, for ICANN to implement
  - Community determines “who, how, where”
- VeriSign
  - Assumes IANA cannot create zone file
  - IANA vets TLD keys and transmits keys to VeriSign who signs zone file
  - M of N KSK handling by root server operators

trust

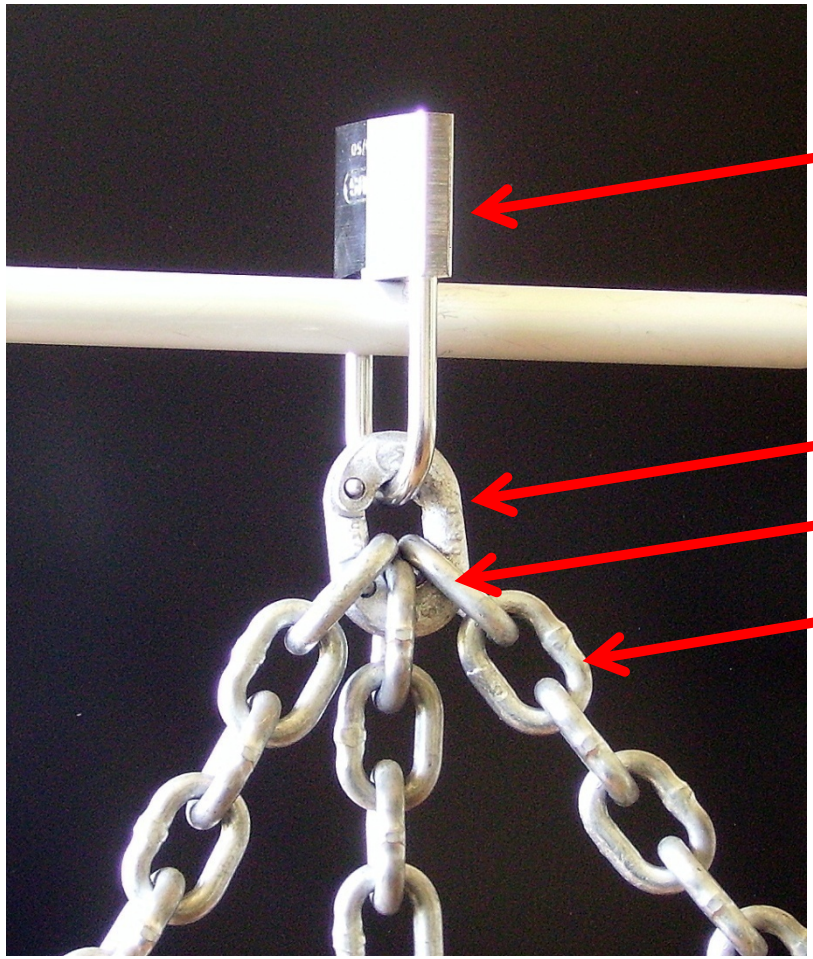
- Anyone can sign the root and generate keys
- A KSK has no value unless everyone agrees to trust and use it
- Classic cooperative definition for the Internet
- Community trust in:
  - how it is generated and protected
  - by whom and how it is used
  - how it is published and attested to
  - how auditing + reporting are performed
- In any case: ZSK signer can sign anything

part of a chain of trust / PKI

- PKI overlaid on DNS
- Treat it like one.
- A chain of trust
- Only as trustworthy as weakest link
- Pressure on root “link”
- A platform for innovation

  …..if done right

dnssec chain of trust



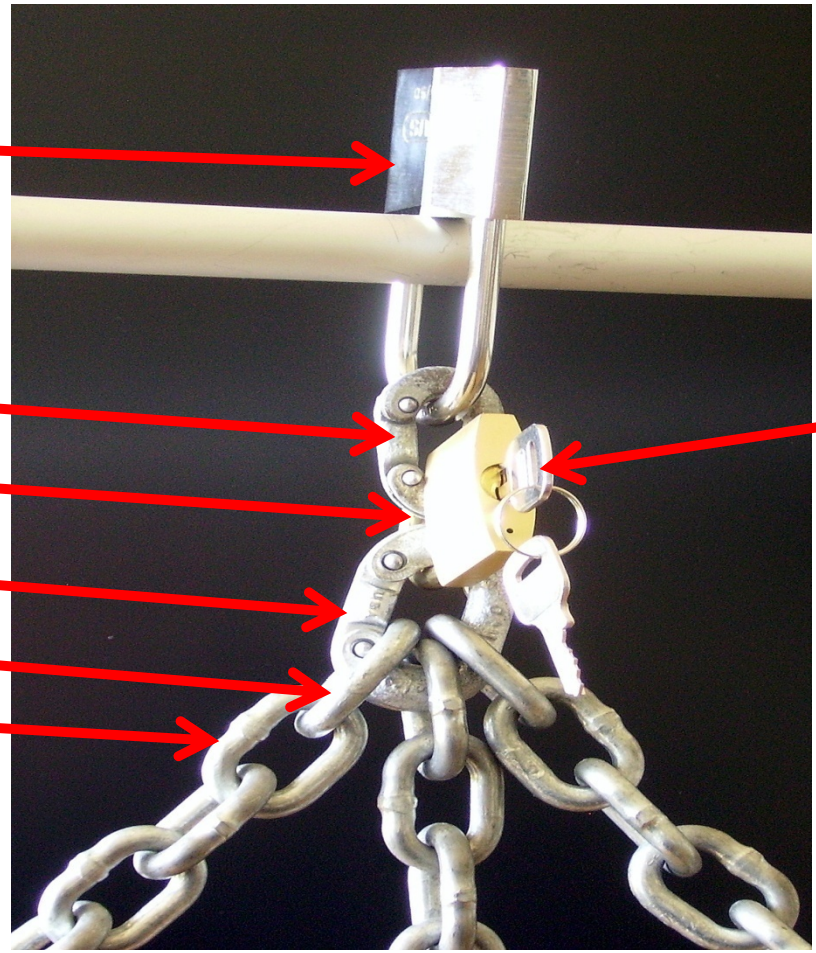
root trust anchor

vet+sign (IANA)

TLD

2nd level domain

an extra link in the chain



“key” questions

- Delicate balance of control vs security vs stability
- trade offs:
  - ZSK signer can always modify content
  - KSK signing ability and lifetime
  - ZSK lifetimes/length
  - compromise recovery
  - trust in ZSK and KSK generation
  - key backup, backup sites
  - broad multi-stakeholder participation (e.g. Key Ceremony)

➡ Requirement: Flexibility in processes and design as DNSSEC experience evolves

overall considerations

- Trust
- Accountability to the community
  - root zone management is IANA's primary job
  - committed: Part of Strategic Plan and Budget.
  - dnssec operations considered and envisioned for some time
- Transparency
  - system design help from experts in the Internet community which it would serve
  - roles: "Who and where" would be chosen by community
  - regular auditing and reporting to and by community
  - open source
- Timeliness
  - been operational over a year (June 2007)
  - preparedness efforts continue to serve if asked
  - dedicated funding and staff
- Reliability
  - multiple redundant systems at each site and backup/mirror sites
  - expertise from outside and in house (registry failover processes, sophisticated L-root operations)
- Flexibility
  - experts can re-arrange "the pieces" to meet changing requirements
  - native pkcs11 support designed in for HSM transitions
  - regular participation in a broad set of meetings and discussions IETF, ccTLD, dnssec-deployment, ICANN, per-TLD dns and dnssec meetings to understand changing requirements

elements of root signing

- Important elements of a root-signing solution are transparency, public consultation, broad stakeholder participation (e.g. key ceremony), flexibility, reliability, and trust;
- Solution has to balance various concerns, but must provide for a maximally secure technical solution and one that provides the trust promised by DNSSEC;
- An open, transparent and international participatory process will allow for root zone management to adapt to changing needs over time as DNSSEC is deployed throughout the Internet and as new lessons are learned.

Preservation of Trust

- Maintain trust from TLD operator to signed root. Any chain is only as strong as its weakest link.
- Increased confidence in DNS will depend more on this chain.
- Eliminate avenues for potential corruption during transmission between organizations.
- Keys (DS) should not have to go to another organization before being protected by signing.
- So the validator of changes signs the zone. A conclusion other DNSSEC deployers have come to.
- Will allow for timely and accurate TLD key replacement in the face of compromise
- Introduction of new gTLDs will stress this link

Transparency

- Open and transparent process for technical infrastructure design and signing oversight functions.
- KSK’s not under control of one organization.
- No security through obscurity: open source and designs
- Continuous collaboration with DNSSEC experts to evolve design as lessons are learned.
- Regular auditing and reports

Preparedness

- IANA's "business" is root zone management. DNSSEC is part of ICANN's Strategic Plan.
- IANA signed root was developed closely with DNSSEC experts. Publicly available for 15 months.
- Interim-TAR during the testing period (almost done)
- RZM would be modified to be ready to handle DS records incorporating technology and lessons from I-TAR
- Automation: signing, ZSK rollover (to avoid costly risk of service failures and errors), monitoring, notifications
- Kept the process and design simple
- Final design and ongoing modifications would be based on public consultation process with experts
- Plan on regular audits and reports on system operation and security

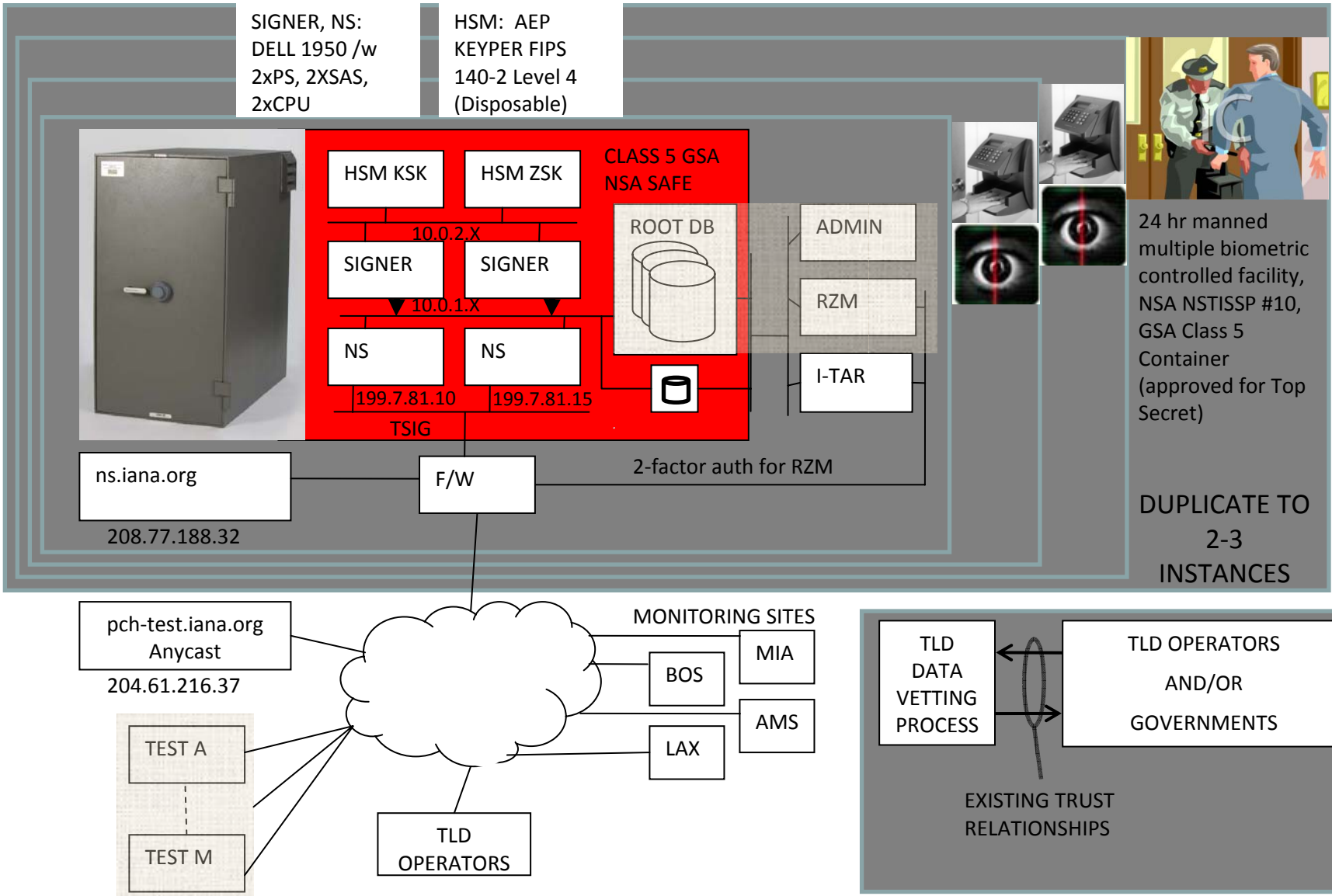
Key Ceremony

- Keys are not under the control of a single organization. IANA is key custodian only.
- Fresh key generation hardware each KSK gen. Dispose or recycle old.
- Community decides how, where, when, and who
- Any Interested stakeholders, auditors, publishers. Key has value only when witnessed and published by all.
- Filmed and broadcast
- Keys cannot be extracted, cloned or otherwise. Private key in FIPS 140-2 level 4 HSM (used by UN treaty org, etc). Key never leaves HSM. Tamper attempt destroys contents.
- Backup HSM's configured during Key Ceremony
- Community decides how, where, and who for backup and disaster recovery
- Other schemes using other equipment (e.g., M of N) supported via PKCS11 standard interface.

behind ns.iana.org

System status at:
https://ns.iana.org/dnssec/status.html

.arpa, in-addr.arpa, ip6.arpa, iris.arpa, urn.arpa, uri.arpa, .int, .se, .br, .bg, .pr, .cz, .museum, xn-"test".



Design Goals

- Maintainability – if its not easy, it will fail. Automation is “key”!
- Reliability – if there is a problem, no one will use it
- Security – it must look and be secure for people to trust it. Preserve the trust
- For .arpa, in-addr.arpa, ip6.arpa, iris.arpa, urn.arpa, uri.arp as well (as per IAB).

Maintainability – Only Two Scripts

- **zsign**: automatically run daily on multiple machines to pickup zone changes (based on SOA serial, new DS records, or expiring signatures); reload hidden master; check key status; update status web page; and email notifications.
- **kgen**: automatically run daily to introduce new keys and generate signed key bundles if needed. Generates or uses pre-generated (attested to) keys.

Maintainability – Overlapping Keys, Rollover Script

- Multiple overlapping keys (effectivity periods) to simplify rollovers.
- ZSK - three (3), old-active-new, overlapping ZSKs /w staggered effectivity periods. Use currently “active” key to sign records
- KSK - two (2) overlapping KSKs /w staggered effectivity periods. Use both to sign “key bundle” of five (5) keys
- Key introduction and rollover automated

```
64000K++++++++++++++++++++++++++++++++|++++++++++++++++++++++++++++++++++++++
24000K------------------------+++++++++|++++++++++++++++++++++++++++++++++++++
24001----------------ppppppppp+++++++++|++rrrr--------------------------------
08000Z------------------------pppppppp+|+++++++++rrrrr------------------------
92000---------------------------------p|pppppp++++++++++++rrrr----------------

keyindex file:
dn  type alg tag    publish date   start date     end date       remove date
root KSK 005 64000  19750101000000 19750101000000 19761231235959 19761231235959
root KSK 005 24000  19760101000000 19760101000000 19771231235959 19771231235959
root ZSK 005 24001  19751201000000 19760101000000 19760215000000 19760229235959
root ZSK 005 08000  19760101000000 19760201000000 19760315000000 19760331235959
root ZSK 005 92000  19760201000000 19760301000000 19760415000000 19760430235959
```

Maintainability – Compromised Key, Replacement Script

- For bad ZSK (old, active, new keys)
  - old – replace key with newly introduced “old” key.
  - active – use old key to sign and introduce a replacement. Phase out bad key.
  - new – replace key with “new” key.
  - Normally done in one-step. Two-steps if “close” to a transition to account for DNS propagation delays.
- For bad KSK (2 keys)
  - One - replace key with new KSK (from pre-generated keys) with the same effectivity period and immediately publish.
  - Both – introduce two new keys and phase out bad keys (tbd: may want to exercise rfc5011 revoke bit).
- Process automated with **badkey** script

Reliability – Dual Signers

- Design: Two (2) commodity hardware based SIGNERs, per site, periodically executing **zsign** to make sure the zone gets signed by one of them.
- Redundant hardware
- Backup sites (tbd)

Security – HSM

- To protect against internal as well as external attacks, generation, and signing is performed inside the HSM.
- Do this using modified BIND tools with native PKCS11 support
- FIPS 140-2 Level 4 devices (used by UN treaty org, credit card companies, military, etc)
- Top secret certified IPS GSA class 5 container
- 24 hour guarded, multiple biometric access controlled facility

Security – Key Lifetimes

- New ZSK 1024 bit every month to frustrate key guessing
- New KSK 2048 bit every year to frustrate key guessing
- Two KSKs always valid to support orderly replacement of old or compromised KSK
- Three published ZSKs to support orderly replacement and promotion of old or compromised ZSK
- 6 day (short) ZSK signature validity period to limit replay attacks while providing some time to recover from severe signing equipment failure
- 1.5 month key bundle KSK signature validity period to constrain compromised ZSK effects while not requiring daily manual resigning with KSK

Software

All software and modifications will be available as open source

SIGNERs

- kgen, badkey, and support programs
- pkcs11-backup, pkcs11-changepin, pkcs11-encrypt, pkcs11-random
- pkcs11 modified BIND tools: dnssec-signzone and dnssec-keygen
- zsign and support programs

Misc

- upsite – DNSSEC status web page generator

Add a Trust Anchor

Top-level domain operators who have used DNSSEC to sign their zones are invited to list their trust anchors in IANA's Interim Trust Anchor Repository. To successfully list a trust anchor, both the administrative and technical contacts for a domain must consent to the listing (as listed in IANA's root zone database). Matching DNSKEYs are also required to be in the secure domain's zone, however this does not need to be done straight away.

Applicant

Please provide the DNSSEC-signed domain to be listed in the repository. You may also provide and email address so that we may communicate to you the status of your request, as well as ask for any additional information.

Secured Domain
The interim trust anchor repository is limited to top-level domains such as "COM" and "SE".

Contact Email (optional)
This email address will be informed of updates to this request.

Trust Anchor Details

The trust anchor itself is comprised of the attributes of a Delegation Signer (DS) key. These components are derived from the key that is used to sign the zone.

Key Tag
The key tag of the trust anchor to be listed.

Key Digest
The complete key digest of the trust anchor to be listed.

Key Algorithm RSA/SHA-1
The encryption algorithm used to compute the key.

Digest Type SHA-1
The hash digest algorithm used to compute the trust anchor.

Listing Details

These periods are used to determine how and when the trust anchor is listed in the repository. Typically keys are only used for discrete periods of time, with multiple keys overlapping in validility. These times will help plan the listing of the keys in the repository. Dates can be entered in a number of formats, such as **YYYY-MM-DD** or **YYYY-MM-DD HH:MM:SS**.

Effectivity Period From
Until
The period the key will be valid for.

Listing Period From
Until
The period to list the key in the trust anchor repository.

Listing Password (optional)
Protects this listing from revocation from those who do not know this password.

Review Form

Please review the material supplied above. Once you are happy with the supplied data submit the form and the details will be verified.

Submit — Submit these details for verification.

Cancel — Cancel the listing process.

(DEMO) DNSSEC STATUS

HSM | Signer-A | Signer-B | NS

To test using this demo (nameserver ns.iana.org) refer to the sample BIND configuration file here

Note: This data, including the signed zones, are purely for test purposes and are not to be used in any production capacity. We do not guarantee their availability, and they may not otherwise function from time-to-time.

ZONE (serial)	STATE / LAST UPDATED	VALIDITY PERIODS (keyid)	EFFECTIVITY PERIODS (keyid)	TRUST ANCHORS
root (2008092440)	Ok 2008-SEP-24 16:25:49	2008-SEP-02 2008-OCT-15 (04183 KSK) 2008-SEP-02 2008-OCT-15 (34291 KSK) 2008-SEP-24 2008-SEP-30 (46716 ZSK)	2007-JAN-01 2008-DEC-31 (04183 KSK) 2008-JAN-01 2009-DEC-31 (34291 KSK) 2008-SEP-01 2008-OCT-15 (46716 ZSK)	-----BEGIN PGP SIGNED MESSAGE----- Hash: SHA1 $ORIGIN . @ 1 IN DNSKEY 257 3 5 (AwEAAbWMiPoQlFp+snq84lbEPx2kPgessP9l ieS+jeabIsxi9tE9MCbEeCrRqPtKTlp50l+C 0cvapYFAsg8VhyDIMlTpyw8KHTgh267GciKf VkxRRZy68ndKRHC/bq8zqD4cYxVdJofTbIAm bxdX80dYwtJ7ZFS7Bl4aSSQ/ly/8stX+l3oA PgSbcIhjCMKzH0loR9npD6gGJpUud5zoyGl+ GkVvuD7XPQpzmq08KAyMz7/Nh2MmJHzfWp4L glqT4cdCT/S8YTdE46I9+vDGlhknHIyEyI5m P9kZWXZa58wWbv9ZBTzN0PNPWQHfPWp045wU AqrRagTbRs7sWw/fpKgC5I0=) ; key id = 4183 1 IN DNSKEY 257 3 5 (AwEAAff8EiNa/S3wovNzPUmuBqelpSjnNoen cXDNMpmjTgngGMPct+8KDKxM6FwvPSRxl5gN RyRQfzSPU0WshDNkBV2TMtVpzqn/dsurbmTo ixRzLyLK2Kd2adg5o5yS/gaTgCo0HVBmIruS N3FVI2ugCWJBFLkFGHLvMJ0BTSYVqWGwQIzp EPKCbKN+L9nrLcvJRCWG59Yq6BUsSEK1zSK3 jMhYQs6y5IiCGAVol+3VyjN93/lXkeUG6u7d lQsyiY9fxfeUvmn004y0TjAgjZqdwKZB0K9M A7qcALG3Tw2TXEdQsn9aY3DzNii3YEBidzER mY7n4hIUrilr59MnuNJq2x0=) ; key id = 34291

Done ns.iana.org

its your root

- Help us design it
- Help us test it
- Make it a trusted platform for innovation
- If you want a signed root, keep your foot on the gas pedal

I did nothing. Thanks should go to:

.se !!!

Patrik Fältström, Jakob Schlyter, Olaf Kolkman, Roy Arends, John Dickinson, Steve Crocker, David Soltero (.pr), David Conrad, Don Davis, David Miller, Doug Maughan, and so many others …Thank you for listening

Questions ?