PCH DPS

Packet Clearing House
DNSSEC Practice Statement

Most recently updated: 25 June 2014

This document states the Domain Name System Security Extensions policies and practices in effect in Packet Clearing House's operations in its role as DNSSEC Zone Operator on behalf of domain registries. It describes the practices and provisions that PCH employs in providing key-management and zone-signing services.

DNSSEC Policy Management Authority
Packet Clearing House
572-B Ruger Street, Box 29920
The Presidio of San Francisco
San Francisco, California 94129-0920 USA
+1 415 831 3100
https://pch.net/dnssec
dnssec-pma@pch.net

Contents

1 Introduction

This document (this “DPS”) is PCH’s statement of security practices that are applied to its Domain Name System Security Extensions (DNSSEC) operations. At the time of its last revision, this DPS conforms with Internet Engineering Task Force Request For Comment 6841, *A Framework for DNSSEC Policies and DNSSEC Practice Statements*, of January 2013, and inherits by reference all terms defined in Section 2 of that document. This document may also use terms defined in Section 1.1 of NLnet Labs Document 2013-002 Version 1.0, *DNSSEC Infrastructure Audit Framework*. This DPS is one of several documents relevant to PCH’s DNSSEC operations. Other relevant documents include PCH’s baseline security standard, PCH’s information security policy, PCH’s data breach policy, PCH’s business contingency plan, and PCH’s Memorandum of Understanding, as well as ancillary security and operational documents that supplement the DPS by providing more detailed requirements, such as the Key Ceremony Reference Guide, which presents detailed key management operational procedures, and the Key Ceremony Scripts, which detail the specific actions taken during each key ceremony. In some instances, where the specifics are not germane to the purpose of the DPS, the DPS refers to these ancillary documents for specific detailed practices implementing PCH policies. All of these documents are published under a Creative Commons Attribution-ShareAlike license, pursuant to Section 2.1 of this document. In some cases, these documents may be referenced in this DPS. In some cases, PCH may have a Service Agreement or other agreement containing terms and conditions applicable to PCH’s DNSSEC operations that applies bilaterally between PCH and a countersignatory and is private, at the countersigner’s request.

1.1 Overview

DNSSEC is a set of records and protocol modifications that provide authentication of the signer of Domain Name System (DNS) data, verification of integrity of the DNS data against modification and authenticated denial of existence of DNS records. DNS data secured with DNSSEC are cryptographically signed and incorporate asymmetric cryptography in the DNS hierarchy, whereby trust follows the same hierarchy as the DNS tree, meaning that trust originates at the root of the DNS and is delegated through the same parties as the control of a domain. DNSSEC does not enhance the availability of DNS data, nor does it provide any form of confidentiality.

1.2 Document name and identification

Document title: Packet Clearing House DNSSEC Practice Statement
Created: 3 March 2011 by Richard Lamb, DNSSEC Program Manager, ICANN, seconded to PCH
Reviewed: 22 March 2011 by Michael Lee, Partner, Intellectual Property, McDermott Will & Emery
Updated: 14 April 2011 by Bill Woodcock, Executive Director, PCH
Updated: 24 June 2011 by Bill Woodcock, Executive Director, PCH
Updated: 14 January 2014 by Bill Woodcock, Executive Director, PCH
Reviewed: 4 April 2014 by Olaf Kolkman, Director, NLnet Labs
Reviewed: 7 April 2014 by Stéphane Bortzmeyer, Systems Architect, AFNIC
Updated: 9 April 2014 by Robert Martin-Legène, DNS Program Manager, PCH
Reviewed: 25 April 2014 by Roy Arends, Research Director, Nominet
Updated: 25 June 2014 by Bill Woodcock, Executive Director, PCH

1.3 Community and applicability

Roles and delegation of responsibility and liability are as follows:

1.3.1 Registry

Each Registry bears responsibility for its respective domain and administers subdomain names that identify child zones subsidiary to its own zone. This means that the Registry manages all data that are related to a domain name. The Registry is also responsible for the publication of trust anchors (TA) and the registration and maintenance of delegation signer (DS) resource records in the parent zone above it.

PCH in its role as DNSSEC Zone Operator (DZO) is responsible for generating key pairs and protecting the confidentiality of the private component of the Key-Signing Keys (KSKs) and Zone-Signing Keys (ZSKs). PCH is also responsible for securely signing all authoritative DNS resource records in the Registry's zone.

1.3.2 Registrars

Registrars are responsible for the administration and management of subdomain names on behalf of Registrants. The Registrar handles the registration, maintenance, and management of a Registrant's subdomain name and is accredited by the relevant parent Registry. The Registrar is responsible for securely identifying the Registrant of a subdomain. The Registrar is responsible for adding, removing, or updating specified Delegation Signer (DS) records for each subdomain at the request of its Registrant.

1.3.3 Registrants

A Registrant is the physical or legal entity that enjoys beneficial control over a subdomain name. Registrants are responsible for generating and protecting their own keys and registering and maintaining their DS records through the Registrar. Registrants are responsible for issuing an emergency key rollover if keys are suspected of being compromised or have been lost.

1.3.4 Relying party

A Relying Party is an entity that relies on a signed response from the DNS, such as a security-aware validating resolver or other application that performs validation of DNSSEC signatures. The relying party is advised to properly configure and update trust anchors using the method described in RFC 5011 or otherwise as appropriate. Relying parties may also inform themselves of any relevant DNSSEC-related events in the Registry's domain via communications directly between Registry and Relying Party.

1.3.5 Applicability

Each Registrant is responsible for determining the relevant level of security for its domain. This DPS is exclusively applicable to PCH DNSSEC operations and describes the procedures and security controls and practices applicable when managing and employing keys and signatures for PCH's signing of a client Registry's zone.

With the support of this DPS, each relying party may evaluate its own environment and its associated threats and vulnerabilities to determine the level of trust it may assign to DNSSEC in its environment and the level of risk it is willing to accept.

1.4 Specification administration

This DPS may be updated from time to time by the PCH DNSSEC Policy Management Authority (PMA), including, without limitation, revisions that reflect modifications in systems or procedures that affect the content of this DPS or PCH DNSSEC operations. The PMA is responsible for the management of the DPS and should be considered the point of contact for all matters related to the DPS.

1.4.1 Specification administration organization

Packet Clearing House
572-B Ruger Street, Box 29920
The Presidio of San Francisco
San Francisco, California 94129-0920 USA

1.4.2 Contact information

DNSSEC Policy Management Authority
Packet Clearing House
572-B Ruger Street, Box 29920
The Presidio of San Francisco
San Francisco, California 94129-0920 USA

+1 415 831 3100 main voice
+1 415 831 3101 fax
https://pch.net/dnssec
dnssec-pma@pch.net

1.4.3 Specification change procedures

Amendments to this DPS are made by the PCH DNSSEC PMA. Amendments are either made in the form of amendments to the existing document or published in a new version of the document. This DPS and any amendments to it are published at https://pch.net/dnssec. Only the most recent version of this DPS and any amendments to it, as published by PCH, is applicable. PCH reserves the right to amend or restate the DPS and any amendments to it from time to time without prior notification. Any changes are effective immediately upon publication by PCH. The decision to designate amendments as material or non-material is within the PMA's sole discretion.

2 Publication and Repositories

2.1 Publication site

PCH publishes DNSSEC-relevant information on PCH's website at https://pch.net/dnssec. The electronic version of this DPS at this specific address is the official version. Notifications relevant to PCH DNSSEC operations are distributed by PGP-signed email originating from dnssec-announce@pch.net.

2.2 Publication of key-signing keys

Each Registry is responsible for timely publication of its KSKs in the form of a DNSKEY and DS in the manner of its choosing. Timeliness is specifically relevant in the case of emergency KSK rollover in accordance with section 4.5.3.

Each Registry must make all possible effort to ensure that the Registry of their parent zone includes and signs their DS record in the parent zone.

The public part of the Registry's KSK may be signed with its official PGP key. PCH may publish copies or links to this information, but the Registry's site remains the authoritative source for such information.

2.3 Access control

Information concerning DNSSEC published at https://pch.net/dnssec is available to the general public.

3 Operational Requirements

3.1 Meaning of domain names

A domain name is a unique identifier that is often associated with services such as web hosting or email. As DZO, PCH exercises no control and asserts no policy over the meaning, content, or form of the domain names contained within the zones it operates.

3.2 Activation of DNSSEC for child zone

DNSSEC is activated for a zone by having at least one DS record for that zone published in the parent zone, which establishes a chain of trust from the root of the DNS to the child zone. As DZO, PCH presumes that DS records contained in zones provided to it by Registries are correct and does not perform any specific controls. Registries incorporate DS records into unsigned zones supplied to PCH just as they do NS and other resource records.

3.3 Identification and authentication of child zone manager

It is the responsibility of the Registrar to securely identify and authenticate the Registrant through a suitable mechanism and in compliance with the contract between Registry and Registrar. PCH performs no controls over the identity or authenticity of Registrants, nor over the mechanism used to establish those.

3.4 Registration of delegation signer resource records

DS records may be generated by or on behalf of Registrants and passed from Registrant to Registrar to Registry in any manner defined by the policies and procedures of the relevant entities. PCH accepts those DS records as resource records embedded within the unsigned zones supplied to PCH by Registries.

3.5 Method to prove possession of private key

PCH does not perform any controls with the aim of validating the Registrant as the holder of a private key. The Registry and Registrar are collectively responsible for conducting the controls that are required or deemed necessary.

3.6 Removal of Delegation Signer record

A DS record is deregistered via a deletion request passed from the Registrant to the Registrar to the Registry. The Registry is responsible for removing the corresponding DS record from the zone prior to passing the zone as a whole to PCH. Deregistration of all DS records associated with a child zone removes the possibility of generic Relying Parties depending on the DNSSEC security mechanism for that child zone.

4 Facility, Management, and Operational Controls

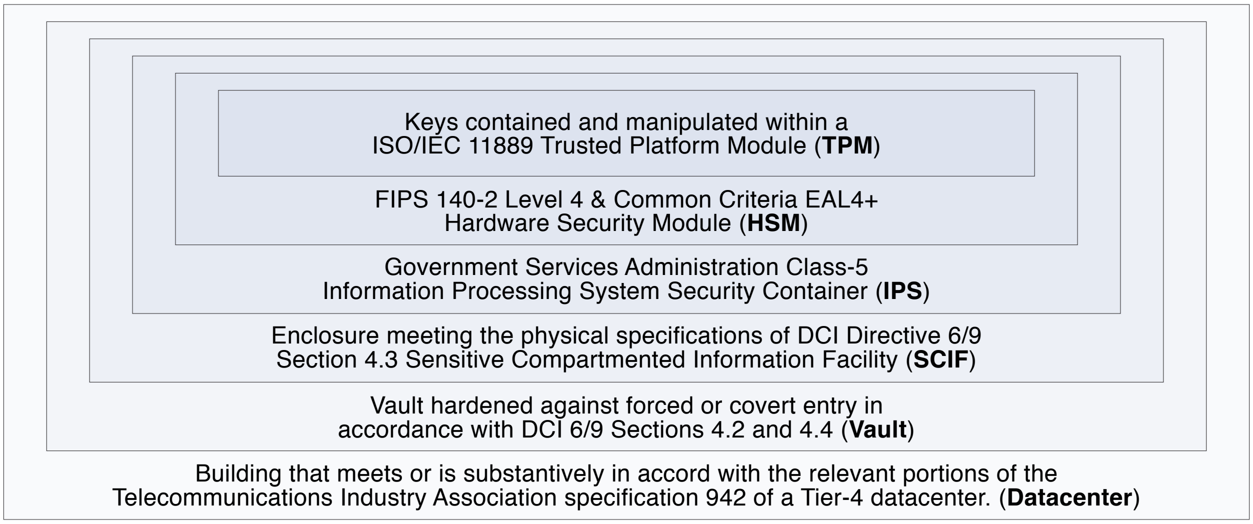
4.1 Physical controls

PCH implements physical security controls to meet the requirements specified in this DPS.

4.1.1 Site location and construction

PCH has established two fully operational and geographically dispersed online zone-signing facilities, in Zurich, Switzerland, and San Jose, United States, 9365 kilometers apart. Both facilities contain a complete set of PCH's DNSSEC zone-signing systems. PCH has furthermore established two fully operational and geographically dispersed offline key-signing facilities, in Singapore and San Jose, United States, 13,594 kilometers apart. Both facilities contain a complete set of PCH's critical DNSSEC key-signing systems. In addition, the Singapore site is equipped to act as a fallback zone-signing facility in the event that zone-signing operations at both Zurich and San Jose are disabled. Online sites contain continuously powered and enabled HSMs that are attached to the network so that they may perform zone-signing functions; offline sites contain HSMs that hold key signing keys, are normally powered off, are physically isolated from the network, and are periodically used solely for the purpose of generating zone signing keys. All system components are protected within a physical perimeter with an access control and alarm system operated by PCH.

In each facility, all cryptographic key material is housed solely within an ISO/IEC 11889 Trusted Platform Module (TPM). The TPM is an integral component of a FIPS 140-2 Level 4 and Common Criteria EAL4+ Hardware Security Module (HSM). The HSM, in turn, is protected within a GSA Class-5 IPS Security Container (IPS). The IPS, in turn, is contained within an enclosure meeting the physical specifications of a DCI Directive 6/9 Section 4.3 Sensitive Compartmented Information Facility (SCIF). The SCIF, in turn, is enclosed within a vault that has been hardened against forced or covert entry in accordance with DCI 6/9 Sections 4.2 and 4.4, and the interior of which is under constant video recording and other monitoring. This vault, in turn, is housed within a building that meets or is substantively in accord with the relevant portions of the Telecommunications Industry Association specification 942 of a Tier-4 datacenter. In addition, the Zurich facility meets the requirements of FEMA TR-87 *Standards for Fallout Shelters* and the Swiss Federal Office for Civil Protection *TWK 1994 - Technische Weisung für die Konstruktion und Bemessung von Schutzbauten* ("Technical Directive for the construction and design of nuclear protection structures") and its subsidiary documents.



Keys contained and manipulated within a ISO/IEC 11889 Trusted Platform Module (**TPM**)

FIPS 140-2 Level 4 & Common Criteria EAL4+ Hardware Security Module (**HSM**)

Government Services Administration Class-5 Information Processing System Security Container (**IPS**)

Enclosure meeting the physical specifications of DCI Directive 6/9 Section 4.3 Sensitive Compartmented Information Facility (**SCIF**)

Vault hardened against forced or covert entry in accordance with DCI 6/9 Sections 4.2 and 4.4 (**Vault**)

Building that meets or is substantively in accord with the relevant portions of the Telecommunications Industry Association specification 942 of a Tier-4 datacenter. (**Datacenter**)

Together, the TPM, HSM, IPS, SCIF, Vault, and datacenter comprise six concentric layers of physical security, each successively harder to compromise than the last, to provide tamper resistance and tamper evidence protecting the key material and zone-signing process at each location.

Construction of a third ZSK signing facility is planned for Montevideo, Uruguay, in CY2014.

4.1.2 Physical access

Physical access to the protected environment is limited to authorized personnel. Specifically, each HSM requires at least three of PCH's seven Crypto Officers (COs) to operate. The IPS Security Container may be opened only by one of PCH's two Security Controllers (SCs). The SCIF requires one of PCH's two SCs to open. The hardened room requires a Facility Operator (FO) to enter, and entry to the datacenter is also controlled by the FO. At all stages, entry and exit are logged and the environment is continuously monitored. In addition, entry and exit to the vault, SCIF, and IPS are witnessed and notarized. In addition, entry and exit to the SCIF and IPS are recorded on three points-of-view of video. All of these documents and recordings are published on PCH's web site as per section 2.1 and 4.4.

4.1.3 Power and air conditioning

Power is provided to the operational facilities from multiple sources. In the event of utility power outages, power is provided by PCH-controlled batteries until the datacenter's backup power systems have begun to generate electricity. The backup power systems are engineered to supply electricity indefinitely, provided fuel deliveries are maintained.

4.1.4 Water and fire

Each datacenter facility implements flood protection and detection mechanisms, and PCH operates separate water detection within each SCIF. Each datacenter facility is equipped with fire detection and extinguishing systems. The facilities are equipped with automatic extinguishers with dry extinguishing and fireproof floors. Each room constitutes an independent fire cell. In all cases, the purpose of notification is to enable mitigation of the threat. In zone-signing facilities, DNSSEC operations continue regardless of impending disaster, until operations cease of their own accord, at which point continued operation is dependent upon the other redundant zone-signing facilities. In key-signing facilities, replacement hardware and supplies are brought to the facility on the occasion of the next key ceremony.

4.1.5 Media storage

PCH's guidelines for information classification define the requirements imposed for the storage of sensitive data.

4.1.6 Waste disposal

Disposed storage media and other material that may contain sensitive information are destroyed in a secure manner by PCH's SCs.

4.1.7 Transport of Hardware Signing Modules

HSMs containing the Storage Master Key are transported by hand by an SC, in a locked container, and are never out of the immediate presence and visual scrutiny of the SC. The locked container is treated in the same manner as an IPS safe, and any opening of the container as, for example, for airport security screening, shall be documented on an accompanying safe log. Any other incident or irregularity encountered while in transport is documented in a permanent event log.

4.1.8 Offsite storage of Hardware Signing Modules

HSMs containing the Storage Master Key may from time to time be stored in secured third-party facilities geographically and administratively separated from PCH's facilities as, for example, when PCH facilities are undergoing construction or renovation. When such storage is necessary, the facilities will be bank safe-deposit boxes or the equivalent. Physical access to the storage facility is limited to authorized personnel. Safe logs will be maintained for such facilities in the same manner as for safes physically under PCH's sole control.

4.2 Procedural controls for key-signing operations

4.2.1 Trusted roles

Trusted roles are held by persons who are able to affect the zone file's content, delivery of trust anchors, or generation or use of private keys. The trusted roles are:

- Crypto Officers (CO), who hold smartcard credentials to authorize HSM operations
- Security Controllers (SC), who control physical access to the SCIF, IPS, and HSM

4.2.2 Identification and authentication for each role

Only people who have agreed to responsibilities defined by PCH may hold a trusted role. Before a person receives his or her credentials for system access and upon each exercise of that access a valid form of identification must be presented. Refer to Section 4.3.2.

4.2.3 Tasks requiring separation of duties

The trusted roles in Section 4.2.1 may not be held simultaneously by one and the same person. The separation of duties is enforced by the COs not having exclusive physical access to the operational facilities and the SCs not having access to the activation material of the HSM.

4.2.4 Other authorized persons

Other authorized people may include but are not limited to:

- Ceremony Administrator (CA), executes the key ceremony script
- External Witness (EW), provides an authoritative notarized transcript of each key ceremony
- Facility Operator (FO), controls physical access to the datacenter and vault
- Systems Administrator (SA), facilitates audio and video logging of each key ceremony
- Registry Representatives (R), witness key ceremonies on behalf of relevant Registries
- Witnesses (W), whose presence may be authorized in the key-signing facility

4.2.5 Number of persons required per task

There must be a minimum of three COs and one SC. Under normal circumstances, there are seven COs and two SCs.

HSM activation requires the cooperation of three COs with their assigned credentials and one SC.

Key generation requires the cooperation of three COs with their assigned credentials and one SC.

The control of encrypted key material require the cooperation of three or five COs with their assigned credentials, depending on the specific operation, and one SC.

HSM management functions require the cooperation of five COs with their assigned credentials and one SC.

None of the aforementioned operations may be performed in the presence of unauthorized people.

4.3 Personnel controls

4.3.1 Qualifications, experience, and clearance requirements

Candidates seeking to assume any of the trusted roles must present proof of the requisite background and qualifications to PCH's Human Resources function.

4.3.2 Background check procedures

Background checks are conducted by PCH's Human Resources function. The control of backgrounds and qualifications may include, but is not limited to, reviewing

- Candidate's resume
- Previous employments
- References (unclassified and others)
- Documentation confirming the relevant and completed education
- Financial position through a credit check

Candidates are not qualified for any of the trusted roles if these controls reveal any discrepancies that indicate unsuitability as determined by PCH.

4.3.3 Training requirements

PCH provides the relevant and requisite training regarding procedures, administration, and technical systems associated with each trusted role. Training includes

- PCH operations
- Role's scope, areas of responsibility, and authority
- Concept of structural separation of roles and access
- Basic technical proficiency in DNS and DNSSEC
- Basic knowledge of information security
- Administration, procedures, and checklists
- Procedures for incident management
- Procedures for crisis management

The trusted role holder's knowledge is evaluated by PCH's Human Resources function.

4.3.4 Retraining frequency and requirements

People holding trusted roles are subject to continuous evaluation and may be required to undertake supplementary training periodically or in the event of major changes, as determined by PCH.

4.3.5 Availability

A key qualification for the critical roles of Crypto Officer and Security Controller is availability. COs and SCs must make themselves available for scheduled and unscheduled key ceremonies in San Jose or Singapore several times each year. PCH will endeavor to schedule key ceremonies at times that maximize the number of available COs and SCs in order to maximize the probability of a successful key ceremony.

4.3.6 Job rotation frequency and sequence

Specific operational responsibilities are rotated on occasion, at PCH's sole discretion, among the people who hold trusted roles. PCH may replace any trusted person at any time.

4.3.7 Sanctions for unauthorized actions

Sanctions resulting from unauthorized actions are determined by PCH and may include termination and damage liability.

4.3.8 Contracting personnel requirements

PCH may at its discretion use contractors or volunteers as well as employees. Such parties are bound by the same responsibility agreements and are subject to the same requirements as employees under this DPS, including but not limited to the same background checks and training.

4.3.9 Documentation supplied to personnel

PCH IT operations supply the documentation necessary for all personnel to perform their work task in a secure and satisfactory manner.

4.4 Audit logging procedures

Information regarding the activities that take place and the operational status and security state of the system are automatically and continuously collected. This log information is used in monitoring the performance, availability, and correct operation of the system, for statistical purposes, and for investigation of suspected violations of PCH's policies, procedures, or regulations.

In addition to automatically collected sensor and process-status information, logs also include journals, checklists, photographs, video and audio recordings, and other documents that may be required to reconstruct a complete picture of the state of the system or a timeline of events. The ultimate goal of logging is to enable investigating auditors to completely understand and attribute any failures that may occur, after the fact. To that end, log information identifies individuals, components, and processes and provides as much information as possible about what occurred, when, and for what purpose.

4.4.1 Types of events recorded

The following events are included in logging:

- All activities that involve an HSM, such as key generation, key activation, signing, and exporting keys
- Remote access to systems, successful and unsuccessful
- Privileged operations
- Entry to a facility or access to equipment
- Sensor input that indicates activity or a change of state, including monitoring and surveillance recordings

Sensor input that indicates inactivity or continuity of state may be published in real time but may, at PCH's discretion, be elided from the long-term archive.

4.4.2 Frequency of processing log

Logs are continuously analyzed through automated and manual controls. Specific controls are conducted on processes including key generation, system reboots, and detected anomalies. Logs are examined after each key ceremony for significant security and operational events. In addition, PCH reviews its audit logs for suspicious or unusual activity in response to alerts generated on the basis of irregularities and incidents within the DNSSEC systems and their security environment. Audit log processing consists of a review of logs and documentation for all significant events within a context of interest. Audit log reviews include a verification that the log has not been tampered with and an investigation of any alerts or irregularities in the logs. Actions taken on the basis of audit log reviews are also documented.

4.4.3 Retention period for audit log information

Log information is archived for not less than ten years.

4.4.4 Protection of audit log

All electronic log information is stored in at least two PCH facilities. Logging collection and storage systems are protected against unauthorized access and manipulation of information. Any log data deemed by PCH to be too sensitive for publication may be redacted or protected against unauthorized access, but generally log data are published for public inspection as they become available.

4.4.5 Audit log backup procedures

As it is collected and as network connectivity permits, electronic log information is continuously transferred to at least one separate and secure online location and periodically backed up to two offline long-term archives. All paper log information is periodically scanned and electronically transferred to the online location and periodically backed up to the long-term archives. The offline long-term archives are in fire- and intrusion-resistant safes in separate locations.

4.4.6 Audit collection system

Electronic log information is handled external to the key-generating system. In the event that network connectivity between any logging facility and the online archive is interrupted, each logging facility has sufficient capacity to independently buffer at least seven days of its own activity at normal rates of collection, and this buffer is immediately transferred to the archive upon reestablishment of network connectivity. Manual logs are recorded on paper, scanned, and periodically entered into the collection system. Original paper documents are archived in one of the offline long-term archives.

4.4.7 Notification to event-causing subject

Notification is hereby given that logging is taking place. No notice is required to be given to any individual, organization, device, or application causing or appearing in a log event, nor does any such party have any special entitlement to view logs that are not otherwise public.

4.4.8 Vulnerability assessments

Events in the audit process are logged, in part, to monitor system vulnerabilities. Periodic vulnerability assessments are performed manually as part of the audit log review process. PCH may at its discretion share security-related information with relevant parties in order to improve the security of the DNSSEC signing process or Internet security environment.

4.5 Compromise and disaster recovery

4.5.1 Incident and compromise handling procedures

All real and perceived security events that cause or could compromise the integrity of the DNSSEC system or cause disruption of or defects in the service are defined as incidents.

Incidents are handled in accordance with PCH’s incident-handling procedures. The incident-handling procedure includes investigating the cause of the incident, identifying any effects of the incident, mitigating or correcting any ongoing effects, and evaluating measures to prevent the incident from recurring.

In the event that any private key is reasonably suspected of compromise or misuse, that key is immediately rolled pursuant to the procedures described in Section 4.5.3.

4.5.2 Corrupted computing resources, software, or data

In the event of corruption, the incident management procedures are initiated and appropriate measures taken as defined in this DPS.

4.5.3 Private key compromise procedures

In the event that any private key is reasonably suspected of compromise, a controlled key rollover is performed as follows:

- If a ZSK is suspected of being compromised, it is immediately removed from production and no longer used. A new ZSK is deployed immediately. The old key is removed from the key set as soon as its signatures have expired. Provided it is not the last facility in operation, operations at the zone signing facility where the incident is suspected to have occurred are suspended pending review. The incident is announced using the mechanisms defined in Section 2.
- If a KSK is suspected of being compromised, a new key is generated and put into immediate use, in parallel with the old key. The appropriate Registry is notified, and a coordinated communication plan is instituted, including requesting the IANA to publish the additional DS record corresponding to the new KSK. The old KSK remains in place and is used to sign key sets until such time as it can be considered sufficiently safe to remove. During the time preceding the rollover, the key set remains static and any scheduled ZSK rollover is postponed until the KSK rollover is complete. A KSK rollover in progress is announced using the mechanisms defined in Section 2 in addition to Registry communications.
- If the public or private key material of the KSK becomes unavailable for use without suspicion of compromise, a new KSK is generated with a new corresponding DS record. The Registry is notified, and a coordinated communication plan is instituted, including a request to the IANA to publish the additional DS record corresponding with the new KSK, even though the DS still does not point to a KSK which can be seen in the Key Set. The TTL of the old DS in the root zone specifies when the change in the root zone DS RRset has propagated. After propagation has been ensured, the Key Set at the zone apex will be updated to contain only the new KSK and the existing ZSK. The old KSK is removed. After waiting for an additional period of time equal to the maximum of the TTL of the Key Set and the TTL of the RRSIG which was signed by the old KSK, the DS in the root zone which points to the old KSK is removed. The event is announced using the mechanisms defined in Section 2. During the time preceding the rollover, regular ZSK rollovers may be needed, because the expiration date of signatures on the old Key Set cannot be modified. However, since RRSIGs were pregenerated in a key ceremony for regular key rollovers and do not require subsequent access to the KSK, it may still be possible to roll the ZSK as per schedule. It is important that signing with the new KSK follows the same schedule as was used with the old KSK for the ZSKs in use during this KSK roll. During the entire KSK rollover, zone data will continuously be signed if the ZSK is available.

4.5.4 Private key misuse procedures

In the event that inauthentic data is suspected of having been signed with a private key, signing of the affected zone or zones is halted, the authorized parties of the responsible Registry are contacted, and an investigation conforming with the requirements of section 4.5.1 is conducted to determine whether the failure was on PCH's side or the Registry's side.

4.5.5 Business continuity and IT disaster recovery capabilities

The PCH contingency plan ensures that operation-critical production can be relocated between the two online zone-signing facilities within four hours. The facilities are equivalent in terms of physical and logistical protection. Information is replicated between the facilities. Spare components and supplies are stored onsite at each facility.

The contingency plan and routines are tested regularly. The completed tests and trials are recorded and subsequently evaluated.

The contingency plan includes

- Who decides on the activation of an emergency recovery procedure
- How and where the crisis management is to convene
- Activation of backup operations
- Appointment of a Task Manager
- Criteria for restoring normal operations

4.5.6 Entity termination

If the Registry discontinues DNSSEC for its zone for any reason and returns to an unsigned position, this is to take place in an orderly manner (by removing DS records from IANA), with the full cooperation of PCH. If operations are to be transferred to another DNSSEC Zone Operator, PCH cooperates fully with the transition with the goal of ensuring continuity of service for Relying Parties.

5 Technical Security Controls

5.1 Key pair generation and installation

5.1.1 Key pair generation

Key generation takes place in a hardware security module (HSM) that is operated by trained and specifically appointed personnel in trusted roles.

Key generation takes place when necessary and must be performed by at least two people working in unison. Separate from the requirement that three COs cooperate to enable the HSM and an SC manage physical access, a minimum of two people must be present during the entire operation.

The entire key-generation procedure is logged, part of which is done electronically and part of which is done manually on paper by the External Witness (EW).

5.1.2 Public key delivery

The public component of each generated KSK is exported from the signing system and verified by the Ceremony Administrator (CA). The CA is responsible for communicating the public component of the KSK in a secure manner to the Registry and ensuring that the keys published in Section 2.2 are the same as those that are generated.

5.1.3 Public key parameters and quality control

Key parameters are regulated by PCH’s key-signing policies. Quality control includes checking the key length.

5.1.4 Key usage purposes

Keys generated for DNSSEC are never used for any purpose other than the signing of DNS zone data, nor are they used outside the signing system.

5.2 Private key protection and cryptographic module engineering controls

All KSK and ZSK cryptographic operations are performed within an HSM, and private keys are never exposed in clear-text outside an HSM. Instead, when they must be transported between HSMs they are exported in “wrapped” form, encrypted with the symmetric Storage Master Key.

5.2.1 Cryptographic module standards and controls

The system uses HSMs that conform to the requirements of FIPS 140-2 level 4 for KSK and ZSK operations.

5.2.2 Private key (M-of-N) multiperson control

PCH applies multiperson control for HSM activation. Multiple COs are required to activate the HSM in a three-of-seven scheme, which in turn requires physical access that can be provided only by one or more SCs.

5.2.3 Private key protection between HSMs

The Storage Master Key (SMK) is a symmetric shared key possessed by all HSMs in the system. The SMK is used to secure the contents of the HSM, to enable induction of a new HSM into the system (in case of equipment failure or expansion of the system, for example), and to protect private keys while in transit between HSMs. An exported copy of the SMK is split across seven smartcards held by COs in a five-of-seven scheme. SMK smartcards are stored as detailed in section 5.4.2.

5.2.4 Private key storage on key-signing HSMs

As a routine part of each key ceremony, KSK and ZSK key-pairs, including their private keys, are deleted from key-signing HSMs as soon as they've been successfully exported. They are not stored within key-signing HSMs.

5.2.5 Private key storage on zone-signing HSMs

Zone-Signing private keys are stored on zone-signing HSMs only as necessary to facilitate signing. ZSK private keys are deleted from zone-signing HSMs upon expiry. At least one, and no more than two, future ZSKs are held within each zone-signing HSM for each zone signed by that HSM. No keys are held within a zone-signing HSM that are not related to zones signed by that HSM.

5.2.6 Private key transfer to or from Hardware Signing Modules

During the construction of the signing system, a joint Storage Master Key was transferred via SMK smartcards to initialize HSMs. Transfer of KSK and ZSK material between HSMs is done via encrypted export to transportable flash memory, as described in Section 5.2.8, which can be decrypted only within HSMs that posses the shared SMK. Zone-signing HSMs do not allow further export of keys.

5.2.7 Method of destroying private key

Private keys are not destroyed. After their useful life, they are removed from the signing system.

5.2.8 Private key export

KSKs and ZSKs are exported in encrypted form, protected by the SMK, to flash memory securely stored in tamper-evident packaging inside safes at each key-signing facility.

5.2.9 Private key archival

Private keys that are no longer used are not archived in any form other than backup copies.

5.2.10 Private key escrow

PCH does not utilize key escrow.

5.3 Other aspects of key pair management

5.3.1 Public key archival

Public keys are archived in accordance with the archiving of other information relevant to traceability in the system, such as log data.

5.3.2 Key usage periods

Keys become invalid as they are taken out of production. Old keys are not reused.

5.4 Activation data

Activation data are in the form of a smartcard and PIN possessed by each CO that are used to activate the HSM.

5.4.1 Activation data generation and installation

CO smartcards are generated during the initialization of the HSMs during the initialization key ceremony.

5.4.2 Activation data protection

Each CO is responsible for protecting his or her smartcard. All smartcards are currently held in tamper-evident bags. At such times as is convenient during future key ceremonies, all smartcards will be transferred to FIPS 201-compliant rigid clear holders, which in turn will contained within tamper-evident bags. All smartcards are subject to inventory management requirements. On the suspicion of compromise, the CO must immediately notify PCH and PCH will replace all COs smartcards at the next key ceremony. PCH's DNSSEC contingency plan states the conditions under which this will occur. All decommissioned smartcards are physically destroyed by an SC in the presence of witnesses.

5.5 Computer security controls

All critical components of PCH's systems are placed in the organization's secure facilities in accordance with Section 4.1. Access to the server's operating system is limited to individuals who require access for their work. All access is logged and is traceable at the individual level.

5.6 Network security controls

PCH has logically partitioned networks that are divided into various security zones with secured communications between. Logging is conducted behind the firewalls. All sensitive information that is transferred over the communications network is protected by strong encryption.

5.7 Time-stamping

PCH retrieves time that is traceable to timeservers from the United States National Institute of Standards and Technology. Time stamps are recorded in UTC and are standardized for all log information and validity time for signatures.

5.8 Life cycle technical controls

5.8.1 System development controls

All source code is stored in a version-control system. The source code archive is regularly backed up, and copies are stored separately in a fire- and intrusion-resistant safe.

PCH's development model is based on industry standards and includes

- Fully functional specification and documented security requirements
- Documented architectural design based on a natural modularization of the system
- Continuous minimization of complexity
- Systematic and automated testing and regression tests
- Issuing distinct software versions
- Constant quality follow-ups of detected defects

5.8.2 Security management controls

Authorization registers are maintained. PCH conducts regular security audits of the system. PCH prepares and maintains a system security plan that is based on recurring risk analyses.

5.8.3 Life cycle security controls

The signer system is designed to require a minimum of maintenance. Updates critical to the security and operations of the signer system are applied after formal testing and approval. The origin of all software and firmware is securely authenticated by available means.

Critical hardware components of the signer system are procured directly from the manufacturer and transported in tamper-evident bags to their destination in the secure facility. All hardware is decommissioned within its specified life expectancy.

6 Zone Signing

6.1 Key lengths and algorithms

Key lengths and algorithms are to be of sufficient strength for their designated purpose during each key's useful life.

Algorithms shall be standardized by the IETF, available to the public, and resource-efficient for all parties involved.

The RSA algorithm with a key length of 4096 bits is used for newly-generated KSKs, and 2048 bits for newly-generated ZSKs.

6.2 Authenticated denial of existence

PCH uses NSEC3 records as specified by RFC 5155 and may sort zones prior to signing, in order to maximize NSEC3 efficiency. Zone content order does not affect the functionality of the DNS.

6.3 Signature format

Signatures are generated using an RSA operation over a cryptographic hash function using SHA256.

6.4 Signature lifetime and resigning frequency

Resource Record sets (RRsets) other than key sets are signed with ZSKs with a validity period depending on zone SOA refresh and expiration parameters, but of no less than seven days. Propagation delay is the SOA refresh plus SOA retry, or three times the TTL of the DNSKEY, whichever is greater. Signature sets for DNSKEYs are replaced as often as the propagation delay allows, but no more frequently than every ten days. To allow for zones to continue to validate in case of a problem, other zone data signature expiration times are set to match the SOA expiration time, with seven days as a minimum, plus the signature lifetime of the DNSKEY RRSIGs. The ZSK is rolled after three zone data signature lifetimes, but no more frequently than every three months.

6.5 Zone-Signing key rollover

ZSK rollover varies depending on zone (e.g., SOA and TTL values) but occurs at least once every six months.

6.6 Key-Signing key rollover

KSK rollover is carried out as needed.

6.7 Verification of zone-signing key set

To ensure signatures and the validity period of keys, security controls are conducted against the DNSKEY prior to publishing zone information on the Internet. This is done by verifying the DNSKEY KSK signature and ZSK signature on the apex NS RRset.

6.8 Verification of resource records

PCH verifies that all resource records are valid in accordance with the current standards prior to distribution.

6.9 Time-To-Live of resource records

DNSKEY TTL is set to 3600 seconds for all zones. TTL for other records is set by Registry in the unsigned zone file provided to PCH. RRSIG inherits TTL from the RRset that it signs.

6.10 Check on completeness of signed data

PCH verifies that all records present in the unsigned zone also appear in the signed zone.

6.11 Start Of Authority parameters and Time-To-Live values

PCH does not presently enforce any SOA parameters or TTL values on unsigned zones, but reserves the right to impose limitations on those input values in the future.

6.12 Verification of received unsigned zones

PCH does not presently conduct uniform or ubiquitous verification of the validity of unsigned zones received from Registries. PCH utilizes TSIG whenever the Registry supports it. PCH may in the future provide Registries with on-site appliances which will provide transport-layer encryption for unsigned zone data in transit between the Registry and PCH.

7 Compliance Audit

Audited documents (policy, procedures, and requirements) and any other relevant, verifiable information can be used in an audit.

7.1 Frequency of entity compliance audit

PCH determines the need for audits. Circumstances that may initiate an audit include but are not limited to recurring anomalies; significant organizational changes at the management level or in processes; issues of personnel competence; and new equipment.

7.2 Auditor's relationship to the audited party

An external auditing manager is appointed for the audit. No auditor or External Witness shall have any material interest in PCH or the outcome of the DNSSEC signing process, beyond the payment of their usual and customary fees, which may be conditional upon the completion *but shall not* be conditional upon the outcome of the audit. When necessary, the auditing manager shall be able to recruit specific expert knowledge. The auditing manager is responsible for implementation of the entire audit.

7.3 Topics covered by audit

The auditing manager's assignment includes ensuring the following:

- PCH possesses the appropriate competencies.
- Auditees are informed of the topic of the audit and prepared prior to the audit.
- Follow-up procedures of the audit results are in place.

7.4 Actions taken as result of deficiency

The auditing manager immediately informs PCH management of any anomalies.

7.5 Communication of results

The auditing manager submits a written report of the audit results to PCH management not later than thirty calendar days after completion of the audit.

8 Legal

8.1 Fees

PCH does not charge country-code top-level domain Registries fees for DNSSEC services. PCH charges fees to Registries of other domains on an individually-negotiated basis, as may be recorded in private documents between the Registry and PCH or PCH's commercial partner organizations DNScast or WoodyNet.

8.2 Privacy of personal information

All information is treated in accordance with the PCH Privacy Policy and the applicable written agreement between the Registry and PCH (the PCH-Registry Agreement). PCH does not receive personally identifiable information about individuals from Registries and thus undertakes no special responsibility with respect to the protection of personally identifiable information. Decisions regarding the disclosure of information to judicial or governmental authorities may be made upon direct request. The matter of disclosure is decided case-by-case by the PCH legal department.

8.3 Limitations of liability

ALL SERVICES PROVIDED BY OR ON BEHALF OF PCH UNDER OR IN CONNECTION WITH THIS DPS (COLLECTIVELY, "SERVICES") ARE PROVIDED "AS IS," "WHERE IS" AND "AS AVAILABLE" WITH ALL RISKS AND FAULTS THAT MAY BE ASSOCIATED IN CONNECTION THEREWITH. NOTWITHSTANDING ANYTHING TO THE CONTRARY, PCH MAKES NO REPRESENTATION, WARRANTY OR COVENANT OF ANY KIND WHATSOEVER WITH RESPECT TO ANY SERVICE, WHETHER EXPRESS OR IMPLIED, INCLUDING, WITHOUT LIMITATION, ANY IMPLIED WARRANTY OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, OR NON-INFRINGEMENT. ANY AND ALL REPRESENTATIONS, WARRANTIES AND COVENANTS ARE HEREBY DISCLAIMED BY PCH AND WAIVED BY EACH PERSON WHO USES, RELIES UPON, OR BENEFITS FROM ANY SERVICE.

NOTWITHSTANDING ANYTHING TO THE CONTRARY, PCH WILL NOT BE RESPONSIBLE OR OTHERWISE LIABLE, WHETHER AT LAW AND/OR IN EQUITY, FOR ANY CLAIMS AND/OR DAMAGES, INCLUDING, WITHOUT LIMITATION, CONSEQUENTIAL, INCIDENTAL, INDIRECT, PUNITIVE, EXEMPLARY, OR SPECIAL DAMAGES (INCLUDING, WITHOUT LIMITATION, LIABILITIES OR DAMAGES RELATING TO LOST PROFITS, LOST DATA, OR LOSS OF GOODWILL) ARISING OUT OF, RELATING TO, OR OTHERWISE IN CONNECTION WITH ANY SERVICE, WHETHER BASED ON CONTRACT, TORT, OR ANY CAUSE OF ACTION WHATSOEVER.

8.4 Term and termination

8.4.1 Validity period

This DPS applies until further notice.

8.4.2 Expiration of validity

This DPS is valid until it is replaced with an updated or new version as stated in Section 1.4.3.

8.4.3 Dispute resolution

Any dispute or conflict in connection with this DPS is to be filed in federal or state court, City and County of San Francisco, California.

8.4.4 Governing law

The laws of the State of California, excluding its conflict-of-laws principles, apply to this DPS.

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