Red Hat Certificate System Red Hat Certificate System 9 Planning, Installation, and Deployment Guide

preparing for a PKI infrastructure

Petr Bokoč
Tomáš Čapek
Aneta Petrová
Ella Deon Ballard

Red Hat Certificate System Red Hat Certificate System 9 Planning, Installation, and Deployment Guide

---

preparing for a PKI infrastructure

Petr Bokoč
Red Hat Customer Content Services
pbokoc@redhat.com

Tomáš Čapek
Red Hat Customer Content Services

Aneta Petrová
Red Hat Customer Content Services

Ella Deon Ballard
Red Hat Customer Content Services

Legal Notice

Abstract

This guide covers the major PKI (Public Key Infrastructure) concepts and decision areas for planning a PKI infrastructure.

Table of Contents

Part I. Planning How to Deploy Red Hat Certificate System

This section provides an overview of Certificate System, including general PKI principles and specific features of Certificate System and its subsystems. Planning a deployment is vital to designing a PKI infrastructure that adequately meets the needs of your organization.

Chapter 1. Introduction to Public-Key Cryptography

Public-key cryptography and related standards underlie the security features of many products such as signed and encrypted email, single sign-on, and Transport Layer Security/Secure Sockets Layer (SSL/TLS) communications. This chapter covers the basic concepts of public-key cryptography.

Internet traffic, which passes information through intermediate computers, can be intercepted by a third party:

Eavesdropping

Information remains intact, but its privacy is compromised. For example, someone could gather credit card numbers, record a sensitive conversation, or intercept classified information.

Tampering

Information in transit is changed or replaced and then sent to the recipient. For example, someone could alter an order for goods or change a person's resume.

Impersonation

Information passes to a person who poses as the intended recipient. Impersonation can take two forms:

- *Spoofing.* A person can pretend to be someone else. For example, a person can pretend to have the email address **`jdoe@example.net`** or a computer can falsely identify itself as a site called **`www.example.net`**.
- *Misrepresentation.* A person or organization can misrepresent itself. For example, a site called **`www.example.net`** can purport to be an on-line furniture store when it really receives credit-card payments but never sends any goods.

Public-key cryptography provides protection against Internet-based attacks through:

Encryption and decryption

Encryption and decryption allow two communicating parties to disguise information they send to each other. The sender encrypts, or scrambles, information before sending it. The receiver decrypts, or unscrambles, the information after receiving it. While in transit, the encrypted information is unintelligible to an intruder.

Tamper detection

Tamper detection allows the recipient of information to verify that it has not been modified in transit. Any attempts to modify or substitute data are detected.

Authentication

Authentication allows the recipient of information to determine its origin by confirming the sender's identity.

Nonrepudiation

Nonrepudiation prevents the sender of information from claiming at a later date that the information was never sent.

1.1. Encryption and Decryption

Encryption is the process of transforming information so it is unintelligible to anyone but the intended recipient. *Decryption* is the process of decoding encrypted information. A cryptographic algorithm, also called a *cipher*, is a mathematical function used for encryption or decryption. Usually, two related functions are used, one for encryption and the other for decryption.

With most modern cryptography, the ability to keep encrypted information secret is based not on the cryptographic algorithm, which is widely known, but on a number called a *key* that must be used with the algorithm to produce an encrypted result or to decrypt previously encrypted information. Decryption with the correct key is simple. Decryption without the correct key is very difficult, if not impossible.

1.1.1. Symmetric-Key Encryption

With symmetric-key encryption, the encryption key can be calculated from the decryption key and vice versa. With most symmetric algorithms, the same key is used for both encryption and decryption, as shown in Figure 1.1, “Symmetric-Key Encryption”.

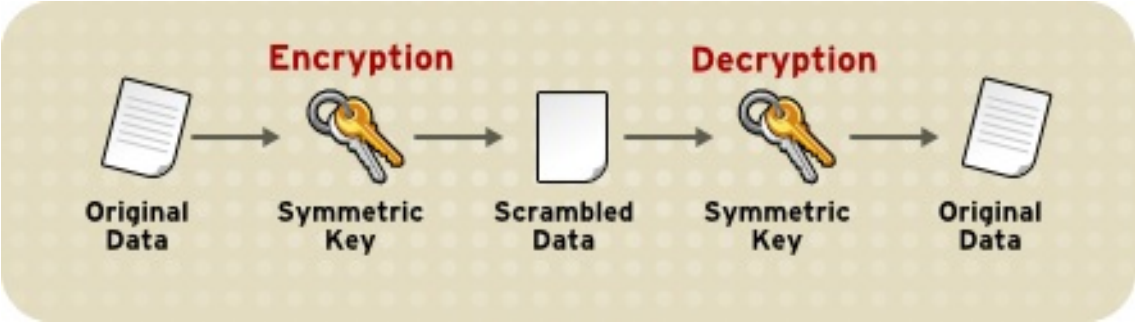


Figure 1.1. Symmetric-Key Encryption

Implementations of symmetric-key encryption can be highly efficient, so that users do not experience any significant time delay as a result of the encryption and decryption.

Symmetric-key encryption is effective only if the symmetric key is kept secret by the two parties involved. If anyone else discovers the key, it affects both confidentiality and authentication. A person with an unauthorized symmetric key not only can decrypt messages sent with that key, but can encrypt new messages and send them as if they came from one of the legitimate parties using the key.

Symmetric-key encryption plays an important role in SSL/TLS communication, which is widely used for authentication, tamper detection, and encryption over TCP/IP networks. SSL/TLS also uses techniques of public-key encryption, which is described in the next section.

1.1.2. Public-Key Encryption

Public-key encryption (also called asymmetric encryption) involves a pair of keys, a public key and a private key, associated with an entity. Each public key is published, and the corresponding private key is kept secret. (For more information about the way public keys are published, see Section 1.3, “Certificates and Authentication”.) Data encrypted with a public key can be decrypted only with the corresponding private key. Figure 1.2, “Public-Key Encryption” shows a simplified view of the way public-key encryption works.

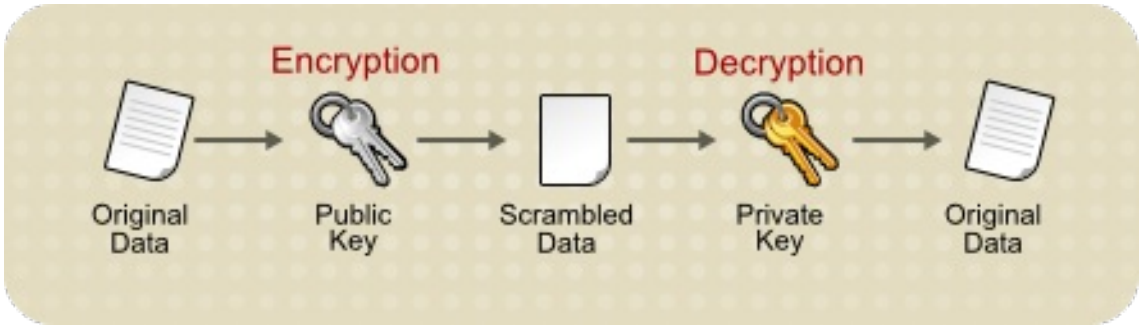


Figure 1.2. Public-Key Encryption

The scheme shown in Figure 1.2, “Public-Key Encryption” allows public keys to be freely distributed, while only authorized people are able to read data encrypted using this key. In general, to send encrypted data, the data is encrypted with that person's public key, and the person receiving the encrypted data decrypts it with the corresponding private key.

Compared with symmetric-key encryption, public-key encryption requires more processing and may not be feasible for encrypting and decrypting large amounts of data. However, it is possible to use public-key encryption to send a symmetric key, which can then be used to encrypt additional data. This is the approach used by the SSL/TLS protocols.

The reverse of the scheme shown in Figure 1.2, “Public-Key Encryption” also works: data encrypted with a private key can be decrypted only with the corresponding public key. This is not a recommended practice to encrypt sensitive data, however, because it means that anyone with the public key, which is by definition published, could decrypt the data. Nevertheless, private-key encryption is useful because it means the private key can be used to sign data with a digital signature, an important requirement for electronic commerce and other commercial applications of cryptography. Client software such as Mozilla Firefox can then use the public key to confirm that the message was signed with the appropriate private key and that it has not been tampered with since being signed. Section 1.2, “Digital Signatures” illustrates how this confirmation process works.

1.1.3. Key Length and Encryption Strength

Breaking an encryption algorithm is basically finding the key to the access the encrypted data in plain text. For symmetric algorithms, breaking the algorithm usually means trying to determine the key used to encrypt the text. For a public key algorithm, breaking the algorithm usually means acquiring the shared secret information between two recipients.

One method of breaking a symmetric algorithm is to simply try every key within the full algorithm until the right key is found. For public key algorithms, since half of the key pair is publicly known, the other half (private key) can be derived using published, though complex, mathematical calculations. Manually finding the key to break an algorithm is called a brute force attack.

Breaking an algorithm introduces the risk of intercepting, or even impersonating and fraudulently verifying, private information.

The *key strength* of an algorithm is determined by finding the fastest method to break the algorithm and comparing it to a brute force attack.

For symmetric keys, encryption strength is often described in terms of the size or *length* of the keys used to perform the encryption: longer keys generally provide stronger encryption. Key length is measured in bits.

An encryption key is considered full strength if the best known attack to break the key is no faster than a brute force attempt to test every key possibility.

Different types of algorithms — particularly public key algorithms — may require different key lengths to achieve the same level of encryption strength as a symmetric-key cipher. The RSA cipher can use only a subset of all possible values for a key of a given length, due to the nature of the mathematical problem on which it is based. Other ciphers, such as those used for symmetric-key encryption, can use all possible values for a key of a given length. More possible matching options means more security.

Because it is relatively trivial to break an RSA key, an RSA public-key encryption cipher must have a very long key — at least 2048 bits — to be considered cryptographically strong. On the other hand, symmetric-key ciphers are reckoned to be equivalently strong using a much shorter key length, as little as 80 bits for most algorithms. Similarly, public-key ciphers based on the elliptic curve cryptography (ECC), such as the Elliptic Curve Digital Signature Algorithm (ECDSA) ciphers, also require less bits than RSA ciphers.

1.2. Digital Signatures

Tamper detection relies on a mathematical function called a *one-way hash* (also called a *message digest*). A one-way hash is a number of fixed length with the following characteristics:

- The value of the hash is unique for the hashed data. Any change in the data, even deleting or altering a single character, results in a different value.
- The content of the hashed data cannot be deduced from the hash.

As mentioned in Section 1.1.2, “Public-Key Encryption”, it is possible to use a private key for encryption and the corresponding public key for decryption. Although not recommended when encrypting sensitive information, it is a crucial part of digitally signing any data. Instead of encrypting the data itself, the signing software creates a one-way hash of the data, then uses the private key to encrypt the hash. The encrypted hash, along with other information such as the hashing algorithm, is known as a digital signature.

Figure 1.3, “Using a Digital Signature to Validate Data Integrity” illustrates the way a digital signature can be used to validate the integrity of signed data.

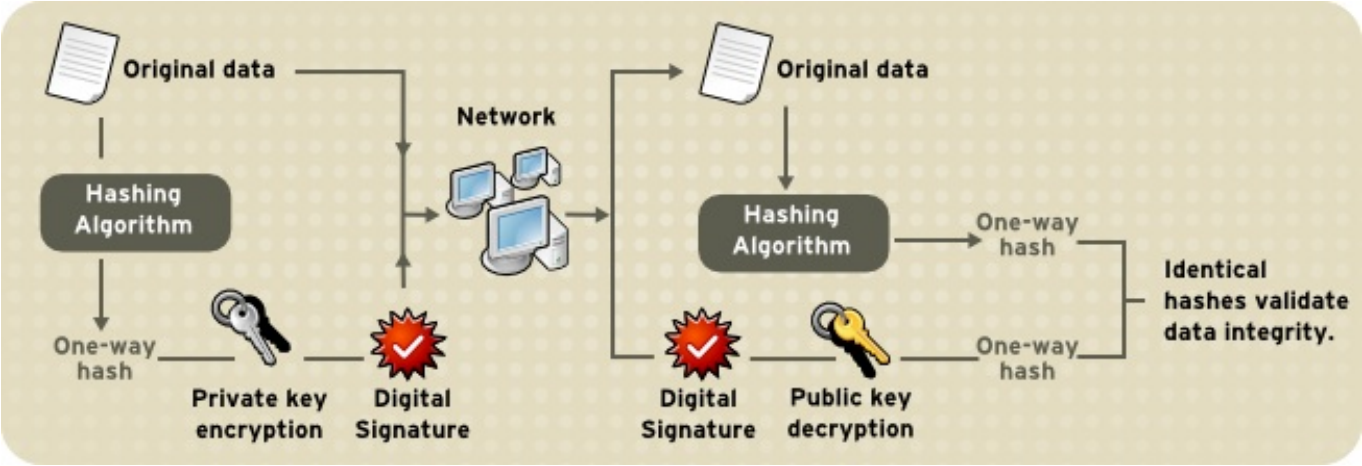


Figure 1.3. Using a Digital Signature to Validate Data Integrity

Figure 1.3, “Using a Digital Signature to Validate Data Integrity” shows two items transferred to the recipient of some signed data: the original data and the digital signature, which is a one-way hash of the original data encrypted with the signer's private key. To validate the integrity of the data, the receiving software first uses the public key to decrypt the hash. It then uses the same hashing algorithm that generated the original hash to generate a new one-way hash of the same data.

(Information about the hashing algorithm used is sent with the digital signature.) Finally, the receiving software compares the new hash against the original hash. If the two hashes match, the data has not changed since it was signed. If they do not match, the data may have been tampered with since it was signed, or the signature may have been created with a private key that does not correspond to the public key presented by the signer.

If the two hashes match, the recipient can be certain that the public key used to decrypt the digital signature corresponds to the private key used to create the digital signature. Confirming the identity of the signer also requires some way of confirming that the public key belongs to a particular entity. For more information on authenticating users, see Section 1.3, “Certificates and Authentication”.

A digital signature is similar to a handwritten signature. Once data have been signed, it is difficult to deny doing so later, assuming the private key has not been compromised. This quality of digital signatures provides a high degree of nonrepudiation; digital signatures make it difficult for the signer to deny having signed the data. In some situations, a digital signature is as legally binding as a handwritten signature.

1.3. Certificates and Authentication

1.3.1. A Certificate Identifies Someone or Something

A certificate is an electronic document used to identify an individual, a server, a company, or other entity and to associate that identity with a public key. Like a driver's license or passport, a certificate provides generally recognized proof of a person's identity. Public-key cryptography uses certificates to address the problem of impersonation.

To get personal ID such as a driver's license, a person has to present some other form of identification which confirms that the person is who he claims to be. Certificates work much the same way. Certificate authorities (CAs) validate identities and issue certificates. CAs can be either independent third parties or organizations running their own certificate-issuing server software, such as Certificate System. The methods used to validate an identity vary depending on the policies of a given CA for the type of certificate being requested. Before issuing a certificate, a CA must confirm the user's identity with its standard verification procedures.

The certificate issued by the CA binds a particular public key to the name of the entity the certificate identifies, such as the name of an employee or a server. Certificates help prevent the use of fake public keys for impersonation. Only the public key certified by the certificate will work with the corresponding private key possessed by the entity identified by the certificate.

In addition to a public key, a certificate always includes the name of the entity it identifies, an expiration date, the name of the CA that issued the certificate, and a serial number. Most importantly, a certificate always includes the digital signature of the issuing CA. The CA's digital signature allows the certificate to serve as a valid credential for users who know and trust the CA but do not know the entity identified by the certificate.

For more information about the role of CAs, see Section 1.3.6, “How CA Certificates Establish Trust”.

1.3.2. Authentication Confirms an Identity

Authentication is the process of confirming an identity. For network interactions, authentication involves the identification of one party by another party. There are many ways to use authentication over networks. Certificates are one of those way.

Network interactions typically take place between a client, such as a web browser, and a server. *Client authentication* refers to the identification of a client (the person assumed to be using the software) by a server. *Server authentication* refers to the identification of a server (the organization assumed to be running the server at the network address) by a client.

Client and server authentication are not the only forms of authentication that certificates support. For example, the digital signature on an email message, combined with the certificate that identifies the sender, can authenticate the sender of the message. Similarly, a digital signature on an HTML form, combined with a certificate that identifies the signer, can provide evidence that the person identified by that certificate agreed to the contents of the form. In addition to authentication, the digital signature in both cases ensures a degree of nonrepudiation; a digital signature makes it difficult for the signer to claim later not to have sent the email or the form.

Client authentication is an essential element of network security within most intranets or extranets. There are two main forms of client authentication:

Password-based authentication

Almost all server software permits client authentication by requiring a recognized name and password before granting access to the server.

Certificate-based authentication

Client authentication based on certificates is part of the SSL/TLS protocol. The client digitally signs a randomly generated piece of data and sends both the certificate and the signed data across the network. The server validates the signature and confirms the validity of the certificate.

1.3.2.1. Password-Based Authentication

Figure 1.4, “Using a Password to Authenticate a Client to a Server” shows the process of authenticating a user using a username and password. This example assumes the following:

- The user has already trusted the server, either without authentication or on the basis of server authentication over SSL/TLS.
- The user has requested a resource controlled by the server.
- The server requires client authentication before permitting access to the requested resource.

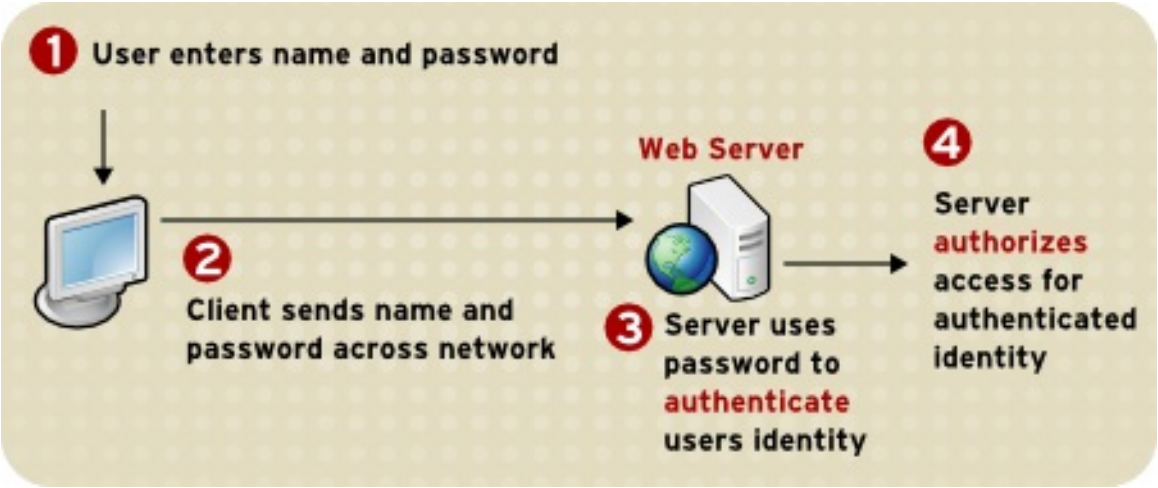


Figure 1.4. Using a Password to Authenticate a Client to a Server

These are the steps in this authentication process:

1. When the server requests authentication from the client, the client displays a dialog box requesting the username and password for that server.
2. The client sends the name and password across the network, either in plain text or over an encrypted SSL/TLS connection.
3. The server looks up the name and password in its local password database and, if they match, accepts them as evidence authenticating the user's identity.
4. The server determines whether the identified user is permitted to access the requested resource and, if so, allows the client to access it.

With this arrangement, the user must supply a new password for each server accessed, and the administrator must keep track of the name and password for each user.

1.3.2.2. Certificate-Based Authentication

One of the advantages of certificate-based authentication is that it can be used to replace the first three steps in authentication with a mechanism that allows the user to supply one password, which is not sent across the network, and allows the administrator to control user authentication centrally. This is called *single sign-on*.

Figure 1.5, “Using a Certificate to Authenticate a Client to a Server” shows how client authentication works using certificates and SSL/TLS. To authenticate a user to a server, a client digitally signs a randomly generated piece of data and sends both the certificate and the signed data across the network. The server authenticates the user's identity based on the data in the certificate and signed data.

Like Figure 1.4, “Using a Password to Authenticate a Client to a Server”, Figure 1.5, “Using a Certificate to Authenticate a Client to a Server” assumes that the user has already trusted the server and requested a resource and that the server has requested client authentication before granting access to the requested resource.

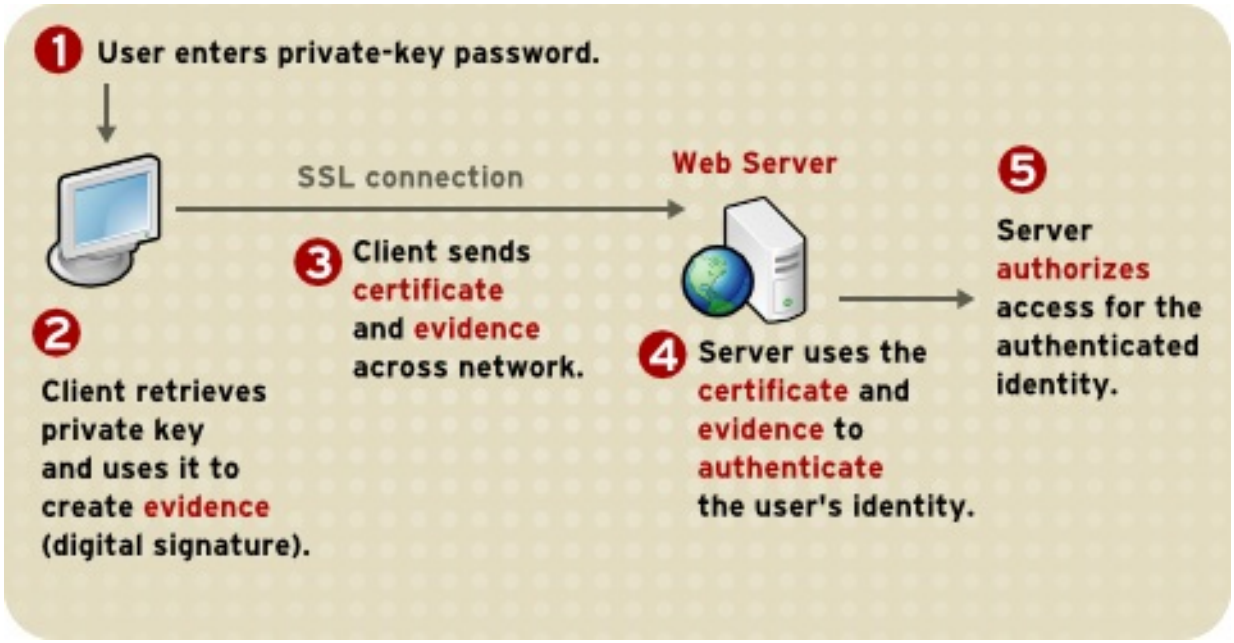
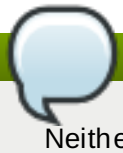


Figure 1.5. Using a Certificate to Authenticate a Client to a Server

Unlike the authentication process in Figure 1.4, “Using a Password to Authenticate a Client to a Server”, the authentication process in Figure 1.5, “Using a Certificate to Authenticate a Client to a Server” requires SSL/TLS. Figure 1.5, “Using a Certificate to Authenticate a Client to a Server” also assumes that the client has a valid certificate that can be used to identify the client to the server. Certificate-based authentication is preferred to password-based authentication because it is based on the user both possessing the private key and knowing the password. However, these two assumptions are true only if unauthorized personnel have not gained access to the user's machine or password, the password for the client software's private key database has been set, and the software is set up to request the password at reasonably frequent intervals.



Note

Neither password-based authentication nor certificate-based authentication address security issues related to physical access to individual machines or passwords. Public-key cryptography can only verify that a private key used to sign some data corresponds to the public key in a certificate. It is the user's responsibility to protect a machine's physical security and to keep the private-key password secret.

These are the authentication steps shown in Figure 1.5, “Using a Certificate to Authenticate a Client to a Server”:

1. The client software maintains a database of the private keys that correspond to the public keys published in any certificates issued for that client. The client asks for the password to this database the first time the client needs to access it during a given session, such as the first time the user attempts to access an SSL/TLS-enabled server that requires certificate-based client authentication.

   After entering this password once, the user does not need to enter it again for the rest of the session, even when accessing other SSL/TLS-enabled servers.

2. The client unlocks the private-key database, retrieves the private key for the user's certificate, and uses that private key to sign data randomly-generated from input from both the client and the server. This data and the digital signature are evidence of the private key's validity. The digital signature can be created only with that private key and can be validated with the corresponding public key against the signed data, which is unique to the SSL/TLS session.

3. The client sends both the user's certificate and the randomly-generated data across the network.

4. The server uses the certificate and the signed data to authenticate the user's identity.

5. The server may perform other authentication tasks, such as checking that the certificate presented by the client is stored in the user's entry in an LDAP directory. The server then evaluates whether the identified user is permitted to access the requested resource. This evaluation process can employ a variety of standard authorization mechanisms, potentially using additional information in an LDAP directory or company databases. If the result of the evaluation is positive, the server allows the client to access the requested resource.

Certificates replace the authentication portion of the interaction between the client and the server. Instead of requiring a user to send passwords across the network continually, single sign-on requires the user to enter the private-key database password once, without sending it across the network. For the rest of the session, the client presents the user's certificate to authenticate the user to each new server it encounters. Existing authorization mechanisms based on the authenticated user identity are not affected.

1.3.3. Uses for Certificates

The purpose of certificates is to establish trust. Their usage varies depending on the kind of trust they are used to ensure. Some kinds of certificates are used to verify the identity of the presenter; others are used to verify that an object or item has not been tampered with.

1.3.3.1. SSL/TLS

The Transport Layer Security/Secure Sockets Layer (SSL/TLS) protocol governs server authentication, client authentication, and encrypted communication between servers and clients. SSL/TLS is widely used on the Internet, especially for interactions that involve exchanging confidential information such as credit card numbers.

SSL/TLS requires an SSL/TLS server certificate. As part of the initial SSL/TLS handshake, the server presents its certificate to the client to authenticate the server's identity. The authentication uses public-key encryption and digital signatures to confirm that the server is the server it claims to be. Once the server has been authenticated, the client and server use symmetric-key encryption, which is very fast, to encrypt all the information exchanged for the remainder of the session and to detect any tampering.

Servers may be configured to require client authentication as well as server authentication. In this case, after server authentication is successfully completed, the client must also present its certificate to the server to authenticate the client's identity before the encrypted SSL/TLS session can be established.

For an overview of client authentication over SSL/TLS and how it differs from password-based authentication, see Section 1.3.2, “Authentication Confirms an Identity”.

1.3.3.2. Signed and Encrypted Email

Some email programs support digitally signed and encrypted email using a widely accepted protocol known as Secure Multipurpose Internet Mail Extension (S/MIME). Using S/MIME to sign or encrypt email messages requires the sender of the message to have an S/MIME certificate.

An email message that includes a digital signature provides some assurance that it was sent by the person whose name appears in the message header, thus authenticating the sender. If the digital signature cannot be validated by the email software, the user is alerted.

The digital signature is unique to the message it accompanies. If the message received differs in any way from the message that was sent, even by adding or deleting a single character, the digital signature cannot be validated. Therefore, signed email also provides assurance that the email has not been tampered with. This kind of assurance is known as nonrepudiation, which makes it difficult for the sender to deny having sent the message. This is important for business communication. For information about the way digital signatures work, see Section 1.2, “Digital Signatures”.

S/MIME also makes it possible to encrypt email messages, which is important for some business users. However, using encryption for email requires careful planning. If the recipient of encrypted email messages loses the private key and does not have access to a backup copy of the key, the encrypted messages can never be decrypted.

1.3.3.3. Single Sign-on

Network users are frequently required to remember multiple passwords for the various services they use. For example, a user might have to type a different password to log into the network, collect email, use directory services, use the corporate calendar program, and access various servers. Multiple passwords are an ongoing headache for both users and system administrators. Users have difficulty

keeping track of different passwords, tend to choose poor ones, and tend to write them down in obvious places. Administrators must keep track of a separate password database on each server and deal with potential security problems related to the fact that passwords are sent over the network routinely and frequently.

Solving this problem requires some way for a user to log in once, using a single password, and get authenticated access to all network resources that user is authorized to use-without sending any passwords over the network. This capability is known as single sign-on.

Both client SSL/TLS certificates and S/MIME certificates can play a significant role in a comprehensive single sign-on solution. For example, one form of single sign-on supported by Red Hat products relies on SSL/TLS client authentication. A user can log in once, using a single password to the local client's private-key database, and get authenticated access to all SSL/TLS-enabled servers that user is authorized to use-without sending any passwords over the network. This approach simplifies access for users, because they don't need to enter passwords for each new server. It also simplifies network management, since administrators can control access by controlling lists of certificate authorities (CAs) rather than much longer lists of users and passwords.

In addition to using certificates, a complete single-sign on solution must address the need to interoperate with enterprise systems, such as the underlying operating system, that rely on passwords or other forms of authentication.

1.3.3.4. Object Signing

Many software technologies support a set of tools called *object signing*. Object signing uses standard techniques of public-key cryptography to let users get reliable information about code they download in much the same way they can get reliable information about shrink-wrapped software.

Most important, object signing helps users and network administrators implement decisions about software distributed over intranets or the Internet-for example, whether to allow Java applets signed by a given entity to use specific computer capabilities on specific users' machines.

The objects signed with object signing technology can be applets or other Java code, JavaScript scripts, plug-ins, or any kind of file. The signature is a digital signature. Signed objects and their signatures are typically stored in a special file called a JAR file.

Software developers and others who wish to sign files using object-signing technology must first obtain an object-signing certificate.

1.3.4. Types of Certificates

The Certificate System is capable of generating different types of certificates for different uses and in different formats. Planning which certificates are required and planning how to manage them, including determining what formats are needed and how to plan for renewal, are important to manage both the PKI and the Certificate System instances.

This list is not exhaustive; there are certificate enrollment forms for dual-use certificates for LDAP directories, file-signing certificates, and other subsystem certificates. These forms are available through the Certificate Manager's end-entities page, at **`https://server.example.com:8443/ca/ee/ca`**.

When the different Certificate System subsystems are installed, the basic required certificates and keys are generated; for example, configuring the Certificate Manager generates the CA signing certificate for the self-signed root CA and the internal OCSP signing, audit signing, SSL/TLS server, and agent user certificates. During the KRA configuration, the Certificate Manager generates the storage, transport, audit signing, and agent certificates. Additional certificates can be created and installed separately.

Table 1.1. Common Certificates

Certificate Type	Use	Example
Client SSL/TLS certificates	Used for client authentication to servers over SSL/TLS. Typically, the identity of the client is assumed to be the same as the identity of a person, such as an employee. See Section 1.3.2.2, “Certificate-Based Authentication” for a description of the way SSL/TLS client certificates are used for client authentication. Client SSL/TLS certificates can also be used as part of single sign-on.	A bank gives a customer an SSL/TLS client certificate that allows the bank's servers to identify that customer and authorize access to the customer's accounts. A company gives a new employee an SSL/TLS client certificate that allows the company's servers to identify that employee and authorize access to the company's servers.
Server SSL/TLS certificates	Used for server authentication to clients over SSL/TLS. Server authentication may be used without client authentication. Server authentication is required for an encrypted SSL/TLS session. For more information, see Section 1.3.3.1, “SSL/TLS”.	Internet sites that engage in electronic commerce usually support certificate-based server authentication to establish an encrypted SSL/TLS session and to assure customers that they are dealing with the web site identified with the company. The encrypted SSL/TLS session ensures that personal information sent over the network, such as credit card numbers, cannot easily be intercepted.
S/MIME certificates	Used for signed and encrypted email. As with SSL/TLS client certificates, the identity of the client is assumed to be the same as the identity of a person, such as an employee. A single certificate may be used as both an S/MIME certificate and an SSL/TLS certificate; see Section 1.3.3.2, “Signed and Encrypted Email”. S/MIME certificates can also be used as part of single sign-on.	A company deploys combined S/MIME and SSL/TLS certificates solely to authenticate employee identities, thus permitting signed email and SSL/TLS client authentication but not encrypted email. Another company issues S/MIME certificates solely to sign and encrypt email that deals with sensitive financial or legal matters.
CA certificates	Used to identify CAs. Client and server software use CA certificates to determine what other certificates can be trusted. For more information, see Section 1.3.6, “How CA Certificates Establish Trust”.	The CA certificates stored in Mozilla Firefox determine what other certificates can be authenticated. An administrator can implement corporate security policies by controlling the CA certificates stored in each user's copy of Firefox.
Object-signing certificates	Used to identify signers of Java code, JavaScript scripts, or other signed files.	Software companies frequently sign software distributed over the Internet to provide users with some assurance that the software is a legitimate product of that company. Using certificates and digital signatures can also make it possible for users to identify and control the kind of access downloaded software has to their computers.

1.3.4.1. CA Signing Certificates

Every Certificate Manager has a CA signing certificate with a public/private key pair it uses to sign the certificates and certificate revocation lists (CRLs) it issues. This certificate is created and installed when the Certificate Manager is installed.

Note

For more information about CRLs, see Section 2.2.4, “Revoking Certificates and Checking Status”.

The Certificate Manager's status as a root or subordinate CA is determined by whether its CA signing certificate is self-signed or is signed by another CA. Self-signed root CAs set the policies they use to issue certificates, such as the subject names, types of certificates that can be issued, and to whom certificates can be issued. A subordinate CA has a CA signing certificate signed by another CA, usually the one that is a level above in the CA hierarchy (which may or may not be a root CA). If the Certificate Manager is a subordinate CA in a CA hierarchy, the root CA's signing certificate must be imported into individual clients and servers before the Certificate Manager can be used to issue certificates to them.

The CA certificate must be installed in a client if a server or user certificate issued by that CA is installed on that client. The CA certificate confirms that the server certificate can be trusted. Ideally, the certificate chain is installed.

1.3.4.2. Other Signing Certificates

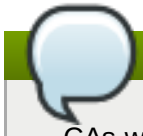
Other services, such as the Online Certificate Status Protocol (OCSP) responder service and CRL publishing, can use signing certificates other than the CA certificate. For example, a separate CRL signing certificate can be used to sign the revocation lists that are published by a CA instead of using the CA signing certificate.

Note

For more information about OCSP, see Section 2.2.4, “Revoking Certificates and Checking Status”.

1.3.4.3. SSL/TLS Server and Client Certificates

Server certificates are used for secure communications, such as SSL/TLS, and other secure functions. Server certificates are used to authenticate themselves during operations and to encrypt data; client certificates authenticate the client to the server.



Note

CAs which have a signing certificate issued by a third-party may not be able to issue server certificates. The third-party CA may have rules in place which prohibit its subordinates from issuing server certificates.

1.3.4.4. User Certificates

End user certificates are a subset of client certificates that are used to identify users to a server or system. Users can be assigned certificates to use for secure communications, such as SSL/TLS, and other functions such as encrypting email or for single sign-on. Special users, such as Certificate System agents, can be given client certificates to access special services.

1.3.4.5. Dual-Key Pairs

Dual-key pairs are a set of two private and public keys, where one set is used for signing and one for encryption. These dual keys are used to create dual certificates. The dual certificate enrollment form is one of the standard forms listed in the end-entities page of the Certificate Manager.

When generating dual-key pairs, set the certificate profiles to work correctly when generating separate certificates for signing and encryption.

1.3.4.6. Cross-Pair Certificates

The Certificate System can issue, import, and publish cross-pair CA certificates. With cross-pair certificates, one CA signs and issues a cross-pair certificate to a second CA, and the second CA signs and issues a cross-pair certificate to the first CA. Both CAs then store or publish both certificates as a **`crossCertificatePair`** entry.

Bridging certificates can be done to honor certificates issued by a CA that is not chained to the root CA. By establishing a trust between the Certificate System CA and another CA through a cross-pair CA certificate, the cross-pair certificate can be downloaded and used to trust the certificates issued by the other CA.

1.3.5. Contents of a Certificate

The contents of certificates are organized according to the X.509 v3 certificate specification, which has been recommended by the International Telecommunications Union (ITU), an international standards body.

Users do not usually need to be concerned about the exact contents of a certificate. However, system administrators working with certificates may need some familiarity with the information contained in them.

1.3.5.1. Certificate Data Formats

Certificate requests and certificates can be created, stored, and installed in several different formats. All of these formats conform to X.509 standards.

1.3.5.1.1. Binary

The following binary formats are recognized:

- *DER-encoded certificate*. This is a single binary DER-encoded certificate.
- *PKCS #7 certificate chain*. This is a PKCS #7 **`SignedData`** object. The only significant field in the **`SignedData`** object is the certificates; the signature and the contents, for example, are ignored. The PKCS #7 format allows multiple certificates to be downloaded at a single time.
- *Netscape Certificate Sequence*. This is a simpler format for downloading certificate chains in a PKCS #7 **`ContentInfo`** structure, wrapping a sequence of certificates. The value of the **`contentType`** field should be **`netscape-cert-sequence`**, while the content field has the following structure:

```
CertificateSequence ::= SEQUENCE OF Certificate
```

This format allows multiple certificates to be downloaded at the same time.

1.3.5.1.2. Text

Any of the binary formats can be imported in text form. The text form begins with the following line:

```
-----BEGIN CERTIFICATE-----
```

Following this line is the certificate data, which can be in any of the binary formats described. This data should be base-64 encoded, as described by RFC 1113. The certificate information is followed by this line:

```
-----END CERTIFICATE-----
```

1.3.5.2. Distinguished Names

An X.509 v3 certificate binds a distinguished name (DN) to a public key. A DN is a series of name-value pairs, such as **uid=doe**, that uniquely identify an entity. This is also called the certificate *subject name*.

This is an example DN of an employee for Example Corp.:

```
uid=doe, cn=John Doe,o=Example Corp.,c=US
```

In this DN, **uid** is the username, **cn** is the user's common name, **o** is the organization or company name, and **c** is the country.

DNs may include a variety of other name-value pairs. They are used to identify both certificate subjects and entries in directories that support the Lightweight Directory Access Protocol (LDAP).

The rules governing the construction of DNs can be complex; for comprehensive information about DNs, see *A String Representation of Distinguished Names* at http://www.ietf.org/rfc/rfc4514.txt.

1.3.5.3. A Typical Certificate

Every X.509 certificate consists of two sections:

The data section

This section includes the following information:

- The version number of the X.509 standard supported by the certificate.
- The certificate's serial number. Every certificate issued by a CA has a serial number that is unique among the certificates issued by that CA.
- Information about the user's public key, including the algorithm used and a representation of the key itself.
- The DN of the CA that issued the certificate.
- The period during which the certificate is valid; for example, between 1:00 p.m. on November 15, 2004, and 1:00 p.m. November 15, 2016.

- The DN of the certificate subject, which is also called the subject name; for example, in an SSL/TLS client certificate, this is the user's DN.
- Optional *certificate extensions*, which may provide additional data used by the client or server. For example:
  - the Netscape Certificate Type extension indicates the type of certificate, such as an SSL/TLS client certificate, an SSL/TLS server certificate, or a certificate for signing email
  - the Subject Alternative Name (SAN) extension links a certificate to one or more host names

  Certificate extensions can also be used for other purposes.

The signature section

This section includes the following information:

- The cryptographic algorithm, or cipher, used by the issuing CA to create its own digital signature.
- The CA's digital signature, obtained by hashing all of the data in the certificate together and encrypting it with the CA's private key.

Here are the data and signature sections of a certificate shown in the readable pretty-print format:

```
Certificate:
Data:
   Version: v3 (0x2)
   Serial Number: 3 (0x3)
   Signature Algorithm: PKCS #1 MD5 With RSA Encryption
   Issuer: OU=Example Certificate Authority, O=Example Corp, C=US
   Validity:
    Not Before: Fri Oct 17 18:36:25 1997
    Not  After: Sun Oct 17 18:36:25 1999
   Subject: CN=Jane Doe, OU=Finance, O=Example Corp, C=US
   Subject Public Key Info:
    Algorithm: PKCS #1 RSA Encryption
    Public Key:
       Modulus:
          00:ca:fa:79:98:8f:19:f8:d7:de:e4:49:80:48:e6:2a:2a:86:
          ed:27:40:4d:86:b3:05:c0:01:bb:50:15:c9:de:dc:85:19:22:
          43:7d:45:6d:71:4e:17:3d:f0:36:4b:5b:7f:a8:51:a3:a1:00:
          98:ce:7f:47:50:2c:93:36:7c:01:6e:cb:89:06:41:72:b5:e9:
          73:49:38:76:ef:b6:8f:ac:49:bb:63:0f:9b:ff:16:2a:e3:0e:
          9d:3b:af:ce:9a:3e:48:65:de:96:61:d5:0a:11:2a:a2:80:b0:
          7d:d8:99:cb:0c:99:34:c9:ab:25:06:a8:31:ad:8c:4b:aa:54:
          91:f4:15
       Public Exponent: 65537 (0x10001)
   Extensions:
    Identifier: Certificate Type
      Critical: no
      Certified Usage:
      TLS Client
    Identifier: Authority Key Identifier
      Critical: no
      Key Identifier:
```

```
        f2:f2:06:59:90:18:47:51:f5:89:33:5a:31:7a:e6:5c:fb:36:
        26:c9
    Signature:
     Algorithm: PKCS #1 MD5 With RSA Encryption
    Signature:
  6d:23:af:f3:d3:b6:7a:df:90:df:cd:7e:18:6c:01:69:8e:54:65:fc:06:
  30:43:34:d1:63:1f:06:7d:c3:40:a8:2a:82:c1:a4:83:2a:fb:2e:8f:fb:
  f0:6d:ff:75:a3:78:f7:52:47:46:62:97:1d:d9:c6:11:0a:02:a2:e0:cc:
  2a:75:6c:8b:b6:9b:87:00:7d:7c:84:76:79:ba:f8:b4:d2:62:58:c3:c5:
  b6:c1:43:ac:63:44:42:fd:af:c8:0f:2f:38:85:6d:d6:59:e8:41:42:a5:
  4a:e5:26:38:ff:32:78:a1:38:f1:ed:dc:0d:31:d1:b0:6d:67:e9:46:a8:
  d:c4
```

Here is the same certificate in the base-64 encoded format:

```
-----BEGIN CERTIFICATE-----
MIICKzCCAZSgAwIBAgIBAzANBgkqhkiG9w0BAQQFADA3MQswCQYDVQQGEwJVUzER
MA8GA1UEChMITmV0c2NhcGUxFTATBgNVBAsTDFN1cHJpeWEncyBDQTAeFw05NzEw
MTgwMTM2MjVaFw05OTEwMTgwMTM2MjVaMEgxCzAJBgNVBAYTAlVTMREwDwYDVQQK
EwhOZXRzY2FwZTENMAsGA1UECxMEUHViczEXMBUGA1UEAxMOU3Vwcml5YSBTaGV0
dHkwgZ8wDQYJKoZIhvcNAQEFBQADgY0AMIGJAoGBAMr6eZiPGfjX3uRJgEjmKiqG
7SdATYazBcABu1AVyd7chRkiQ31FbXFOGD3wNktbf6hRo6EAmM5/R1AskzZ8AW7L
iQZBcrXpc0k4du+2Q6xJu2MPm/8WKuMOnTuvzpo+SGXelmHVChEqooCwfdiZywyZ
NMmrJgaoMa2MS6pUkfQVAgMBAAGjNjA0MBEGCWCGSAGG+EIBAQQEAwIAgDAfBgNV
HSMEGDAWgBTy8gZZkBhHUfWJM1oxeuZc+zYmyTANBgkqhkiG9w0BAQQFAAOBgQBt
I6/z07Z635DfzX4XbAFpjlRl/AYwQzTSYx8GfcNAqCqCwaSDKvsuj/vwbf91o3j3
UkdGYpcd2cYRCgKi4MwqdWyLtpuHAH18hHZ5uvi00mJYw8W2wUOsY0RC/a/IDy84
hW3WWehBUqVK5SY4/zJ4oTjx7dwNMdGwbWfpRqjd1A==
-----END CERTIFICATE-----
```

1.3.6. How CA Certificates Establish Trust

CAs validate identities and issue certificates. They can be either independent third parties or organizations running their own certificate-issuing server software, such as the Certificate System.

Any client or server software that supports certificates maintains a collection of trusted CA certificates. These CA certificates determine which issuers of certificates the software can trust, or validate. In the simplest case, the software can validate only certificates issued by one of the CAs for which it has a certificate. It is also possible for a trusted CA certificate to be part of a chain of CA certificates, each issued by the CA above it in a certificate hierarchy.

The sections that follow explains how certificate hierarchies and certificate chains determine what certificates software can trust.

1.3.6.1. CA Hierarchies

In large organizations, responsibility for issuing certificates can be delegated to several different CAs. For example, the number of certificates required may be too large for a single CA to maintain; different organizational units may have different policy requirements; or a CA may need to be physically located in the same geographic area as the people to whom it is issuing certificates.

These certificate-issuing responsibilities can be divided among subordinate CAs. The X.509 standard includes a model for setting up a hierarchy of CAs, shown in Figure 1.6, “Example of a Hierarchy of Certificate Authorities”.

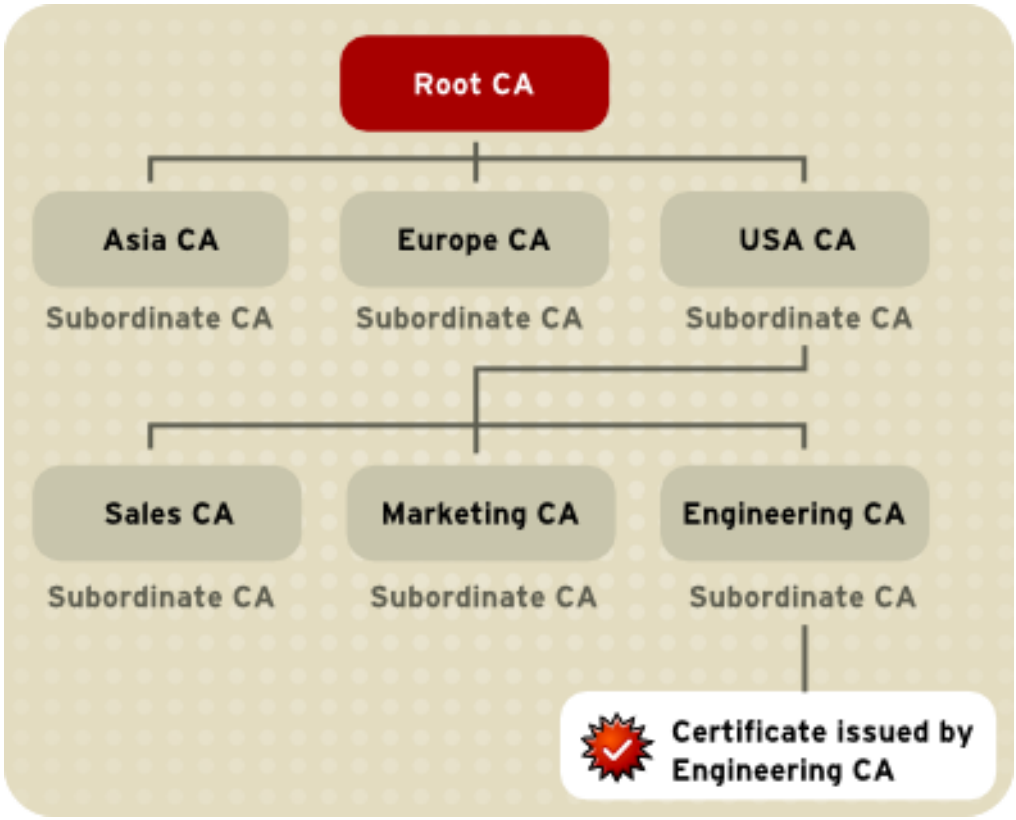


Figure 1.6. Example of a Hierarchy of Certificate Authorities

The root CA is at the top of the hierarchy. The root CA's certificate is a *self-signed certificate*; that is, the certificate is digitally signed by the same entity that the certificate identifies. The CAs that are directly subordinate to the root CA have CA certificates signed by the root CA. CAs under the subordinate CAs in the hierarchy have their CA certificates signed by the higher-level subordinate CAs.

Organizations have a great deal of flexibility in how CA hierarchies are set up; Figure 1.6, “Example of a Hierarchy of Certificate Authorities” shows just one example.

1.3.6.2. Certificate Chains

CA hierarchies are reflected in certificate chains. A *certificate chain* is series of certificates issued by successive CAs. Figure 1.7, “Example of a Certificate Chain” shows a certificate chain leading from a certificate that identifies an entity through two subordinate CA certificates to the CA certificate for the root CA, based on the CA hierarchy shown in Figure 1.6, “Example of a Hierarchy of Certificate Authorities”.

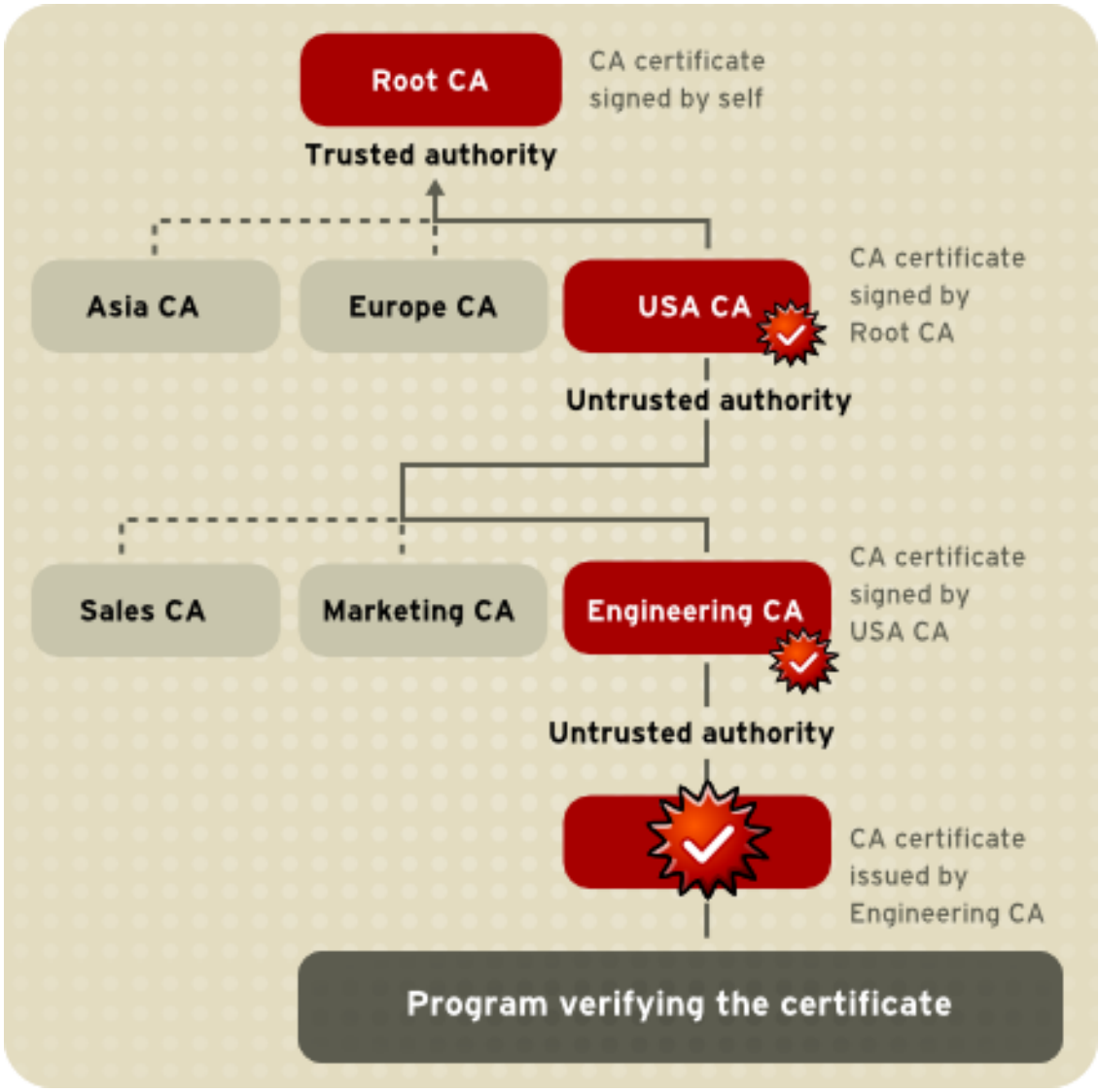


Figure 1.7. Example of a Certificate Chain

A certificate chain traces a path of certificates from a branch in the hierarchy to the root of the hierarchy. In a certificate chain, the following occur:

- Each certificate is followed by the certificate of its issuer.
- Each certificate contains the name (DN) of that certificate's issuer, which is the same as the subject name of the next certificate in the chain.

  In Figure 1.7, "Example of a Certificate Chain", the **`Engineering CA`** certificate contains the DN of the CA, **`USA CA`**, that issued that certificate. **`USA CA`**'s DN is also the subject name of the next certificate in the chain.
- Each certificate is signed with the private key of its issuer. The signature can be verified with the public key in the issuer's certificate, which is the next certificate in the chain.

  In Figure 1.7, "Example of a Certificate Chain", the public key in the certificate for the **`USA CA`** can be used to verify the **`USA CA`**'s digital signature on the certificate for the **`Engineering CA`**.

1.3.6.3. Verifying a Certificate Chain

Certificate chain verification makes sure a given certificate chain is well-formed, valid, properly signed, and trustworthy. The following description of the process covers the most important steps of forming and verifying a certificate chain, starting with the certificate being presented for authentication:

1. The certificate validity period is checked against the current time provided by the verifier's system clock.
2. The issuer's certificate is located. The source can be either the verifier's local certificate database on that client or server or the certificate chain provided by the subject, as with an SSL/TLS connection.
3. The certificate signature is verified using the public key in the issuer's certificate.
4. The host name of the service is compared against the Subject Alternative Name (SAN) extension. If the certificate has no such extension, the host name is compared against the subject's CN.
5. The system verifies the Basic Constraint requirements for the certificate, that is, whether the certificate is a CA and how many subsidiaries it is allowed to sign.
6. If the issuer's certificate is trusted by the verifier in the verifier's certificate database, verification stops successfully here. Otherwise, the issuer's certificate is checked to make sure it contains the appropriate subordinate CA indication in the certificate type extension, and chain verification starts over with this new certificate. Figure 1.8, “Verifying a Certificate Chain to the Root CA” presents an example of this process.

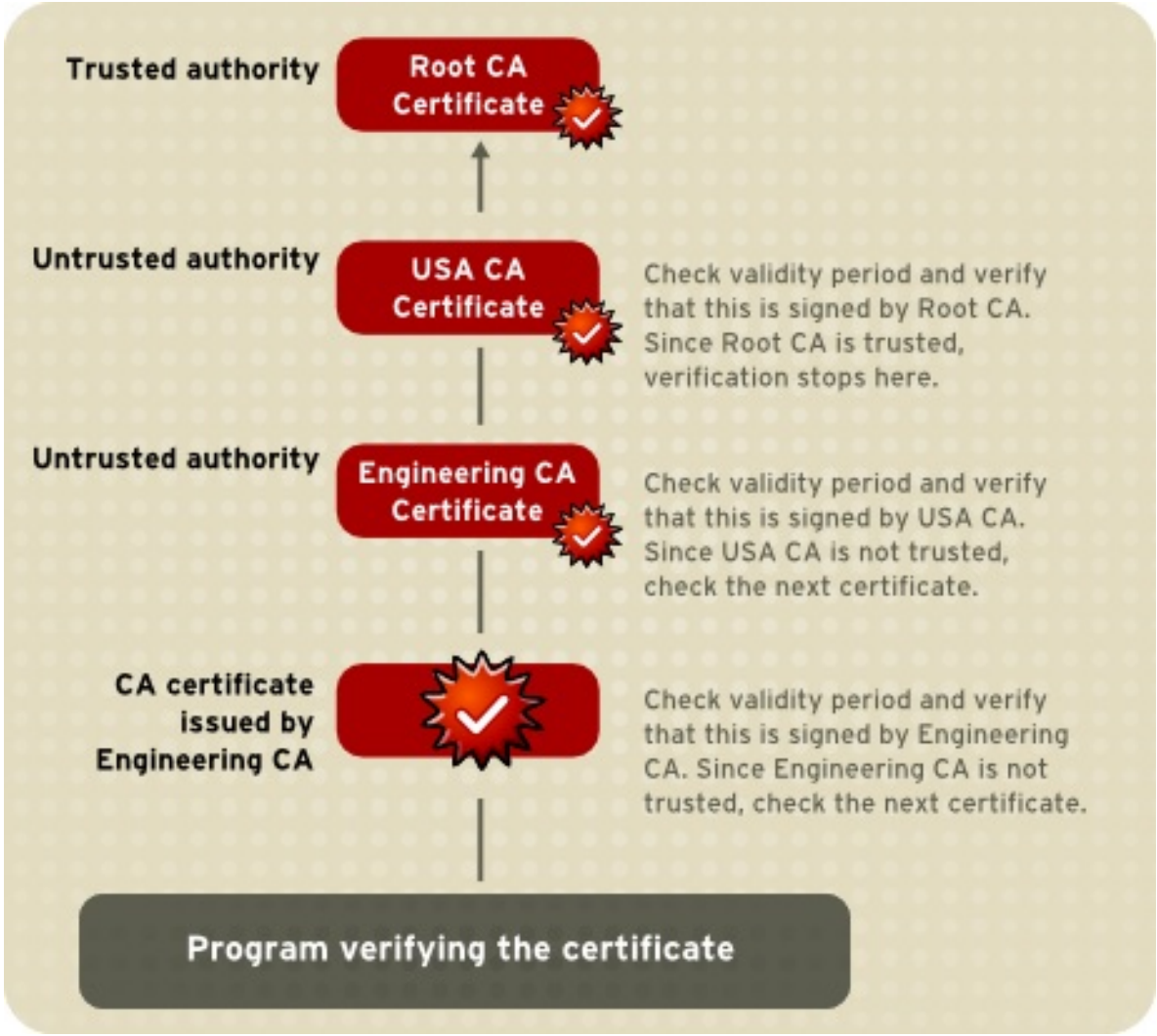


Figure 1.8. Verifying a Certificate Chain to the Root CA

Figure 1.8, “Verifying a Certificate Chain to the Root CA” illustrates what happens when only the root CA is included in the verifier's local database. If a certificate for one of the intermediate CAs, such as **`Engineering CA`**, is found in the verifier's local database, verification stops with that certificate, as shown in Figure 1.9, “Verifying a Certificate Chain to an Intermediate CA”.

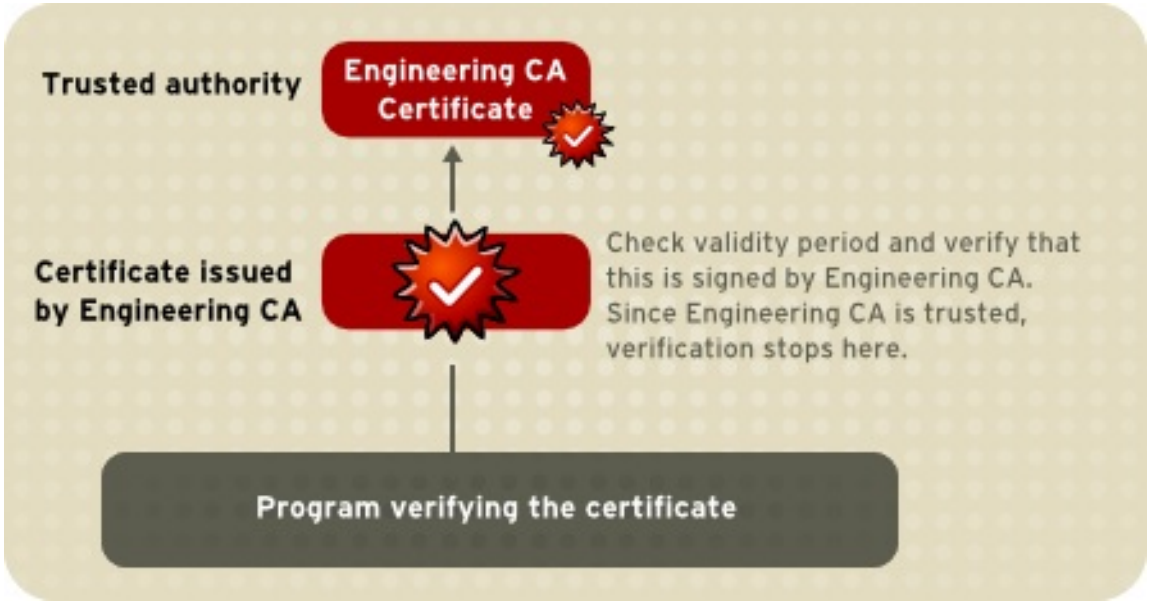


Figure 1.9. Verifying a Certificate Chain to an Intermediate CA

Expired validity dates, an invalid signature, or the absence of a certificate for the issuing CA at any point in the certificate chain causes authentication to fail. Figure 1.10, “A Certificate Chain That Cannot Be Verified” shows how verification fails if neither the root CA certificate nor any of the intermediate CA certificates are included in the verifier's local database.

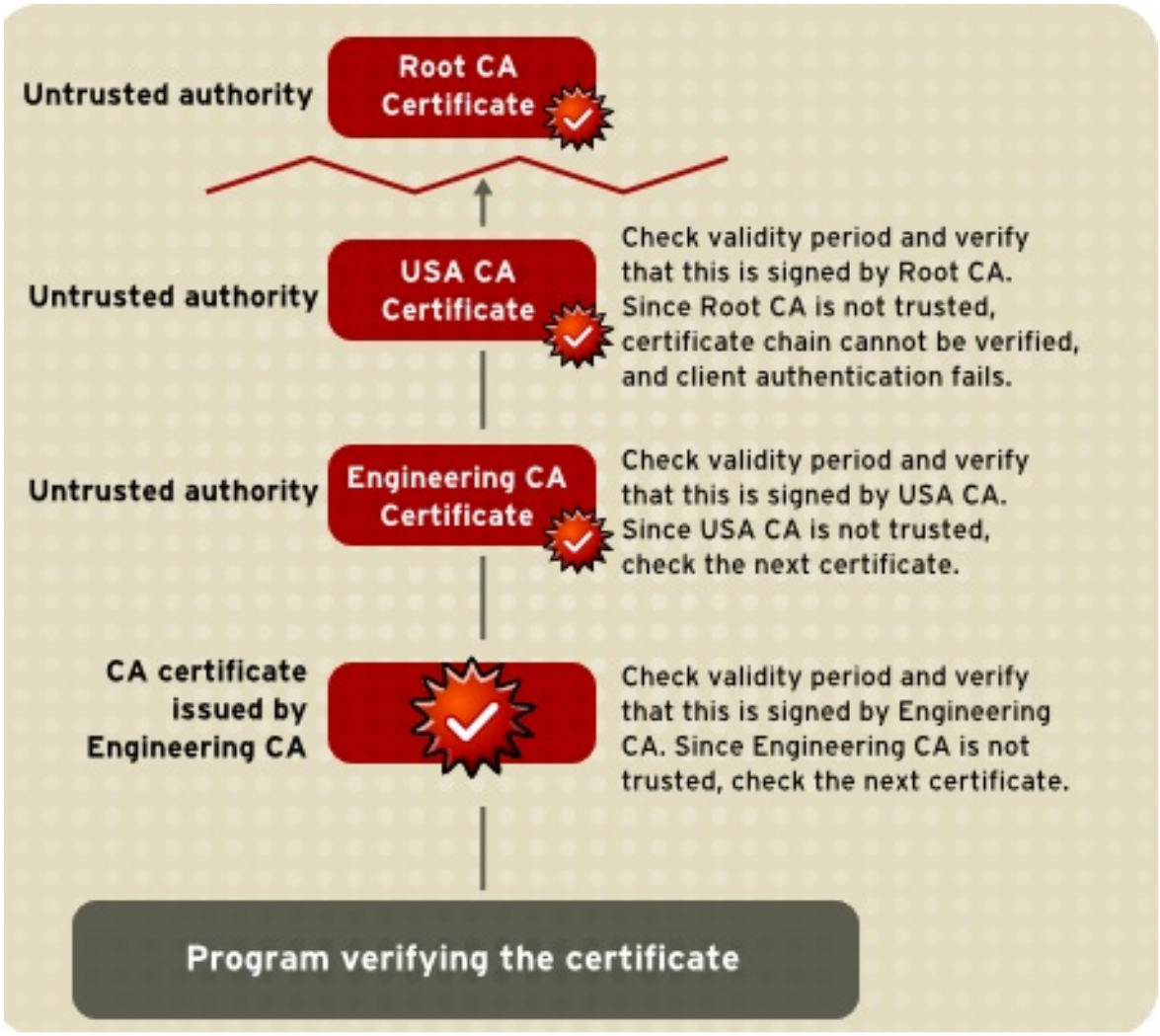


Figure 1.10. A Certificate Chain That Cannot Be Verified

1.4. Managing Certificates

Certificates are used in many applications, from encrypting email to accessing websites. There are two major stages in the lifecycle of the certificate: the point when it is issued (issuance and enrollment) and the period when the certificates are no longer valid (renewal or revocation). There are also ways to manage the certificate during its cycle. Making information about the certificate available to other applications is *publishing* the certificate and then backing up the key pairs so that the certificate can be recovered if it is lost.

1.4.1. Issuing Certificates

The process for issuing a certificate depends on the CA that issues it and the purpose for which it will be used. Issuing non-digital forms of identification varies in similar ways. The requirements to get a library card are different than the ones to get a driver's license. Similarly, different CAs have different procedures for issuing different kinds of certificates. Requirements for receiving a certificate can be as simple as an email address or username and password to notarized documents, a background check, and a personal interview.

Depending on an organization's policies, the process of issuing certificates can range from being completely transparent for the user to requiring significant user participation and complex procedures. In general, processes for issuing certificates should be flexible, so organizations can tailor them to their changing needs.

1.4.2. Key Management

Before a certificate can be issued, the public key it contains and the corresponding private key must be generated. Sometimes it may be useful to issue a single person one certificate and key pair for signing operations and another certificate and key pair for encryption operations. Separate signing and encryption certificates keep the private signing key only on the local machine, providing maximum nonrepudiation. This also aids in backing up the private encryption key in some central location where it can be retrieved in case the user loses the original key or leaves the company.

Keys can be generated by client software or generated centrally by the CA and distributed to users through an LDAP directory. There are costs associated with either method. Local key generation provides maximum nonrepudiation but may involve more participation by the user in the issuing process. Flexible key management capabilities are essential for most organizations.

Key recovery , or the ability to retrieve backups of encryption keys under carefully defined conditions, can be a crucial part of certificate management, depending on how an organization uses certificates. In some PKI setups, several authorized personnel must agree before an encryption key can be recovered to ensure that the key is only recovered to the legitimate owner in authorized circumstance. It can be necessary to recover a key when information is encrypted and can only be decrypted by the lost key.

1.4.3. Renewing and Revoking Certificates

Like a driver's license, a certificate specifies a period of time during which it is valid. Attempts to use a certificate for authentication before or after its validity period will fail. Managing certificate expirations and renewals are an essential part of the certificate management strategy. For example, an administrator may wish to be notified automatically when a certificate is about to expire so that an appropriate renewal process can be completed without disrupting the system operation. The renewal process may involve reusing the same public-private key pair or issuing a new one.

Additionally, it may be necessary to revoke a certificate before it has expired, such as when an employee leaves a company or moves to a new job in a different unit within the company.

Certificate revocation can be handled in several different ways:

Verify if the certificate is present in the directory

Servers can be configured so that the authentication process checks the directory for the presence of the certificate being presented. When an administrator revokes a certificate, the certificate can be automatically removed from the directory, and subsequent authentication attempts with that certificate will fail, even though the certificate remains valid in every other respect.

Certificate revocation list (CRL)

A list of revoked certificates, a CRL, can be published to the directory at regular intervals. The CRL can be checked as part of the authentication process.

Real-time status checking

The issuing CA can also be checked directly each time a certificate is presented for authentication. This procedure is sometimes called real-time status checking.

Online Certificate Status Protocol

The Online Certificate Status Protocol (OCSP) service can be configured to determine the status of certificates.

For more information about renewing certificates, see Section 2.2.2, “Renewing Certificates”. For more information about revoking certificates, including CRLs and OCSP, see Section 2.2.4, “Revoking Certificates and Checking Status”.

Chapter 2. Introduction to Red Hat Certificate System

Every common PKI operation, such as issuing, renewing, and revoking certificates; archiving and recovering keys; publishing CRLs and verifying certificate status, is carried out by interoperating subsystems within Red Hat Certificate System. The functions of each individual subsystem and the way that they work together to establish a robust and local PKI is described in this chapter.

2.1. A Review of Certificate System Subsystems

Red Hat Certificate System provides five different subsystems, each focusing on different aspects of a PKI deployment:

- A *certificate authority* called *Certificate Manager*. The CA is the core of the PKI; it issues and revokes all certificates. The Certificate Manager is also the core of the Certificate System. By establishing a *security domain* of trusted subsystems, it establishes and manages relationships between the other subsystems.
- A *key recovery authority* (KRA). Certificates are created based on a specific and unique key pair. If a private key is ever lost, then the data which that key was used to access (such as encrypted emails) is also lost because it is inaccessible. The KRA stores key pairs, so that a new, identical certificate can be generated based on recovered keys, and all of the encrypted data can be accessed even after a private key is lost or damaged.

Note

In previous versions of Certificate System, KRA was also referred to as the data recovery manager (DRM). Some code, configuration file entries, web panels, and other resources might still use the term DRM instead of KRA.

- An *online certificate status protocol* (OCSP) responder. The OCSP verifies whether a certificate is valid and not expired. This function can also be done by the CA, which has an internal OCSP service, but using an external OCSP responder lowers the load of the issuing CA.
- A *token key service* (TKS). The TKS derives keys based on the token CCID, private information, and a defined algorithm. These derived keys are used by the TPS to format tokens and enroll certificates on the token.
- A *token processing system* (TPS). The TPS interacts directly with external tokens, like smart cards, and manages the keys and certificates on those tokens through a local client, the Enterprise Security Client (ESC). The ESC contacts the TPS when there is a token operation, and the TPS interacts with the CA, KRA, or TKS, as required, then send the information back to the token by way of the Enterprise Security Client.

Even with all possible subsystems installed, the core of the Certificate System is still the CA (or CAs), since they ultimately process all certificate-related requests. The other subsystems connect to the CA or CAs likes spokes in a wheel. These subsystems work together, in tandem, to create a public key infrastructure (PKI). Depending on what subsystems are installed, a PKI can function in one (or both) of two ways:

- A *token management system* or *TMS* environment, which manages smart cards. This requires a CA, TKS, and TPS, with an optional KRA for server-side key generation.

- A traditional *non token management system* or *non-TMS* environment, which manages certificates used in an environment other than smart cards, usually in software databases. At a minimum, a non-TMS requires only a CA, but a non-TMS environment can use OCSP responders and KRA instances as well.

2.2. How Certificate System Creates PKI (Non-TMS Environment)

The Certificate System is comprised of subsystems which each contribute different functions of a public key infrastructure. A PKI environment can be customized to fit individual needs by implementing different features and functions for the subsystems.

Note

A conventional PKI environment provides the basic framework to manage certificates stored in software databases. This is a *non-TMS* environment, since it does not manage certificates on smart cards. A *TMS* environment manages the certificates on smart cards.

At a minimum, a non-TMS requires only a CA, but a non-TMS environment can use OCSP responders and KRA instances as well.

2.2.1. Issuing Certificates

As stated, the Certificate Manager is the heart of the Certificate System. It manages certificates at every stage, from requests through enrollment (issuing), renewal, and revocation.

The Certificate System supports enrolling and issuing certificates and processing certificate requests from a variety of end entities, such as web browsers, servers, and virtual private network (VPN) clients. Issued certificates conform to X.509 version 3 standards.

2.2.1.1. The Enrollment Process

An end entity enrolls in the PKI by submitting an enrollment request through the end-entity interface. There can be many kinds of enrollment that use different enrollment methods or require different authentication methods. For each enrollment, there is a separate enrollment page created that is specific to the type of enrollment, type of authentication, and the certificate profiles associated with the type of certificate. The forms associated with enrollment can be customized for both appearance and content. Alternatively, the enrollment process can be customized by creating certificate profiles for each enrollment type. Certificate profiles dynamically-generate forms which are customized by configuring the inputs associated with the certificate profile.

When an end entity enrolls in a PKI by requesting a certificate, the following events can occur, depending on the configuration of the PKI and the subsystems installed:

1. The end entity provides the information in one of the enrollment forms and submits a request.

   The information gathered from the end entity is customizable in the form depending on the information collected to store in the certificate or to authenticate against the authentication method associated with the form. The form creates a request that is then submitted to the Certificate Manager.

2. The enrollment form triggers the creation of the public and private keys or for dual-key pairs for the request.

3. The end entity provides authentication credentials before submitting the request, depending on the authentication type. This can be LDAP authentication, PIN-based authentication, or certificate-based authentication.

4. The request is submitted either to an agent-approved enrollment process or an automated process.

   - The agent-approved process, which involves no end-entity authentication, sends the request to the request queue in the agent services interface, where an agent must processes the request. An agent can then modify parts of the request, change the status of the request, reject the request, or approve the request.

     Automatic notification can be set up so an email is sent to an agent any time a request appears in the queue. Also, an automated job can be set to send a list of the contents of the queue to agents on a pre configured schedule.

   - The automated process, which involves end-entity authentication, processes the certificate request as soon as the end entity successfully authenticates.

5. The form collects information about the end entity from an LDAP directory when the form is submitted. For certificate profile-based enrollment, the defaults for the form can be used to collect the user LDAP ID and password.

6. The certificate profile associated with the form determine aspects of the certificate that is issued. Depending on the certificate profile, the request is evaluated to determine if the request meets the constraints set, if the required information is provided, and the contents of the new certificate.

7. The form can also request that the user export the private encryption key. If the KRA subsystem is set up with this CA, the end entity's key is requested, and an archival request is sent to the KRA. This process generally requires no interaction from the end entity.

8. The certificate request is either rejected because it did not meet the certificate profile or authentication requirements, or a certificate is issued.

9. The certificate is delivered to the end entity.

   - In automated enrollment, the certificate is delivered to the user immediately. Since the enrollment is normally through an HTML page, the certificate is returned as a response on another HTML page.

   - In agent-approved enrollment, the certificate can be retrieved by serial number or request Id in the end-entity interface.

   - If the notification feature is set up, the link where the certificate can be obtained is sent to the end user.

10. An automatic notice can be sent to the end entity when the certificate is issued or rejected.

11. The new certificate is stored in the Certificate Manager's internal database.

12. If publishing is set up for the Certificate Manager, the certificate is published to a file or an LDAP directory.

13. The internal OCSP service checks the status of certificates in the internal database when a certificate status request is received.

The end-entity interface has a search form for certificates that have been issued and for the CA certificate chain.

2.2.1.2. Certificate Profiles

The Certificate System uses certificate profiles to configure the content of the certificate, the constraints for issuing the certificate, the enrollment method used, and the input and output forms for that enrollment. A single certificate profile is associated with issuing a particular type of certificate.

A set of certificate profiles is included for the most common certificate types; the profile settings can be modified. Certificate profiles are configured by an administrator, and then sent to the agent services page for agent approval. Once a certificate profile is approved, it is enabled for use. A dynamically-generated HTML form for the certificate profile is used in the end-entities page for certificate enrollment, which calls on the certificate profile. The server verifies that the defaults and constraints set in the certificate profile are met before acting on the request and uses the certificate profile to determine the content of the issued certificate.

The Certificate Manager can issue certificates with any of the following characteristics, depending on the configuration in the profiles and the submitted certificate request:

- Certificates that are X.509 version 3-compliant
- Unicode support for the certificate subject name and issuer name
- Support for empty certificate subject names
- Support for customized subject name components
- Support for customized extensions

2.2.1.3. Authentication for Certificate Enrollment

Certificate System provides authentication options for certificate enrollment. These include agent-approved enrollment, in which an agent processes the request, and automated enrollment, in which an authentication method is used to authenticate the end entity and then the CA automatically issues a certificate. CMC enrollment is also supported, which automatically processes a request approved by an agent.

2.2.1.4. Dual Key Pairs

The Certificate System supports generating dual key pairs, separate key pairs for signing and encrypting email messages and other data. To support separate key pairs for signing and encrypting data, dual certificates are generated for end entities, and the encryption keys are archived. If a client makes a certificate request for dual key pairs, the server issues two separate certificates.

2.2.1.5. Cross-Pair Certificates

It is possible to create a trusted relationship between two separate CAs by issuing and storing cross-signed certificates between these two CAs. By using cross-signed certificate pairs, certificates issued outside the organization's PKI can be trusted within the system.

2.2.2. Renewing Certificates

When certificates reach their expiration date, they can either be allowed to lapse, or they can be renewed.

Renewal regenerates a certificate request using the existing key pairs for that certificate, and then resubmits the request to Certificate Manager. The renewed certificate is identical to the original (since it was created from the same profile using the same key material) with one exception — it has a different, later expiration date.

Renewal can make managing certificates and relationships between users and servers much smoother, because the renewed certificate functions precisely as the old one. For user certificates, renewal allows encrypted data to be accessed without any loss.

2.2.3. Publishing Certificates and CRLs

Certificates can be published to files and an LDAP directory, and CRLs to files, an LDAP directory, and an OCSP responder. The publishing framework provides a robust set of tools to publish to all three places and to set rules to define with more detail which types of certificates or CRLs are published where.

2.2.4. Revoking Certificates and Checking Status

End entities can request that their own certificates be revoked. When an end entity makes the request, the certificate has to be presented to the CA. If the certificate and the keys are available, the request is processed and sent to the Certificate Manager, and the certificate is revoked. The Certificate Manager marks the certificate as revoked in its database and adds it to any applicable CRLs.

An agent can revoke any certificate issued by the Certificate Manager by searching for the certificate in the agent services interface and then marking it revoked. Once a certificate is revoked, it is marked revoked in the database and in the publishing directory, if the Certificate is set up for publishing.

If the internal OCSP service has been configured, the service determines the status of certificates by looking them up in the internal database.

Automated notifications can be set to send email messages to end entities when their certificates are revoked by enabling and configuring the certificate revoked notification message.

2.2.4.1. CRLs

The Certificate System can create certificate revocation lists (CRLs) from a configurable framework which allows user-defined issuing points so a CRL can be created for each issuing point. Delta CRLs can also be created for any issuing point that is defined. CRLs can be issued for each type of certificate, for a specific subset of a type of certificate, or for certificates generated according to a profile or list of profiles. The extensions used and the frequency and intervals when CRLs are published can all be configured.

The Certificate Manager issues X.509-standard CRLs. A CRL can be automatically updated whenever a certificate is revoked or at specified intervals.

2.2.4.2. OCSP Services

The Certificate System CA supports the Online Certificate Status Protocol (OCSP) as defined in PKIX standard RFC 2560. The OCSP protocol enables OCSP-compliant applications to determine the state of a certificate, including the revocation status, without having to directly check a CRL published by a CA to the validation authority. The validation authority, which is also called an *OCSP responder*, checks for the application.

1. A CA is set up to issue certificates that include the Authority Information Access extension, which identifies an OCSP responder that can be queried for the status of the certificate.
2. The CA periodically publishes CRLs to an OCSP responder.
3. The OCSP responder maintains the CRL it receives from the CA.

4. An OCSP-compliant client sends requests containing all the information required to identify the certificate to the OCSP responder for verification. The applications determine the location of the OCSP responder from the value of the Authority Information Access extension in the certificate being validated.

5. The OCSP responder determines if the request contains all the information required to process it. If it does not or if it is not enabled for the requested service, a rejection notice is sent. If it does have enough information, it processes the request and sends back a report stating the status of the certificate.

2.2.4.2.1. OCSP Response Signing

Every response that the client receives, including a rejection notification, is digitally signed by the responder; the client is expected to verify the signature to ensure that the response came from the responder to which it submitted the request. The key the responder uses to sign the message depends on how the OCSP responder is deployed in a PKI setup. RFC 2560 recommends that the key used to sign the response belong to one of the following:

- The CA that issued the certificate that's status is being checked.
- A responder with a public key trusted by the client. Such a responder is called a *trusted responder*.
- A responder that holds a specially marked certificate issued to it directly by the CA that revokes the certificates and publishes the CRL. Possession of this certificate by a responder indicates that the CA has authorized the responder to issue OCSP responses for certificates revoked by the CA. Such a responder is called a *CA-designated responder* or a *CA-authorized responder*.

The end-entities page of a Certificate Manager includes a form for manually requesting a certificate for the OCSP responder. The default enrollment form includes all the attributes that identify the certificate as an OCSP responder certificate. The required certificate extensions, such as OCSPNoCheck and Extended Key Usage, can be added to the certificate when the certificate request is submitted.

2.2.4.2.2. OCSP Responses

The OCSP response that the client receives indicates the current status of the certificate as determined by the OCSP responder. The response could be any of the following:

- *Good or Verified* . Specifies a positive response to the status inquiry, meaning the certificate has not been revoked. It does not necessarily mean that the certificate was issued or that it is within the certificate's validity interval. Response extensions may be used to convey additional information on assertions made by the responder regarding the status of the certificate.
- *Revoked* . Specifies that the certificate has been revoked, either permanently or temporarily.

Based on the status, the client decides whether to validate the certificate.

Note

The OCSP responder will never return a response of *Unknown*. The response will always be either *Good* or *Revoked*.

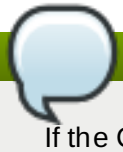
2.2.4.2.3. OCSP Services

There are two ways to set up OCSP services:

- The OCSP built into the Certificate Manager
- The Online Certificate Status Manager subsystem

In addition to the built-in OCSP service, the Certificate Manager can publish CRLs to an OCSP-compliant validation authority. CAs can be configured to publish CRLs to the Certificate System Online Certificate Status Manager. The Online Certificate Status Manager stores each Certificate Manager's CRL in its internal database and uses the appropriate CRL to verify the revocation status of a certificate when queried by an OCSP-compliant client.

The Certificate Manager can generate and publish CRLs whenever a certificate is revoked and at specified intervals. Because the purpose of an OCSP responder is to facilitate immediate verification of certificates, the Certificate Manager should publish the CRL to the Online Certificate Status Manager every time a certificate is revoked. Publishing only at intervals means that the OCSP service is checking an outdated CRL.



Note

If the CRL is large, the Certificate Manager can take a considerable amount of time to publish the CRL.

The Online Certificate Status Manager stores each Certificate Manager's CRL in its internal database and uses it as the CRL to verify certificates. The Online Certificate Status Manager can also use the CRL published to an LDAP directory, meaning the Certificate Manager does not have to update the CRLs directly to the Online Certificate Status Manager.

2.2.5. Archiving, Recovering, and Rotating Keys

To archive private encryption keys and recover them later, the PKI configuration must include the following elements:

- Clients that can generate dual keys and that support the key archival option (using the CRMF/CMMF protocol).
- An installed and configured KRA.
- HTML forms with which end entities can request dual certificates (based on dual keys) and key recovery agents can request key recovery.

Only keys that are used exclusively for encrypting data should be archived; signing keys in particular should never be archived. Having two copies of a signing key makes it impossible to identify with certainty who used the key; a second archived copy could be used to impersonate the digital identity of the original key owner.

Clients that generate single key pairs use the same private key for both signing and encrypting data, so a private key derived from a single key pair cannot be archived and recovered. Clients that can generate dual key pairs use one private key for encrypting data and the other for signing data. Since the private encryption key is separate, it can be archived.

In addition to generating dual key pairs, the clients must also support archiving the encryption key in certificate requests. This option archives keys at the time the private encryption keys are generated as a part of issuing the certificate.

2.2.5.1. Archiving Keys

The KRA automatically archives private encryption keys if archiving is configured.

If an end entity loses a private encryption key or is unavailable to use the private key, the key must be recovered before any data that was encrypted with the corresponding public key can be read. Recovery is possible if the private key was archived when the key was generated.

There are some common situations when it is necessary to recover encryption keys:

- An employee loses the private encryption key and cannot read encrypted mail messages.
- An employee is on an extended leave, and someone needs to access an encrypted document.
- An employee leaves the company, and company officials need to perform an audit that requires gaining access to the employee's encrypted mail.

The KRA stores private encryption keys in a secure key repository in its internal database; each key is encrypted and stored as a key record and is given a unique key identifier.

The archived copy of the key remains wrapped with the KRA's storage key. It can be decrypted, or unwrapped, only by using the corresponding private key pair of the storage certificate. A combination of one or more key recovery (or KRA) agents' certificates authorizes the KRA to complete the key recovery to retrieve its private storage key and use it to decrypt/recover an archived private key.

The KRA indexes stored keys by key number, owner name, and a hash of the public key, allowing for highly efficient searching. The key recovery agents have the privilege to insert, delete, and search for key records.

- When the key recovery agents search by the key ID, only the key that corresponds to that ID is returned.
- When the agents search by user name, all stored keys belonging to that owner are returned.
- When the agents search by the public key in a certificate, only the corresponding private key is returned.

When a Certificate Manager receives a certificate request that contains the key archival option, it automatically forwards the request to the KRA to archive the encryption key. The private key is encrypted by the transport key, and the KRA receives the encrypted copy and stores the key in its key repository. To archive the key, the KRA uses two special key pairs:

- A transport key pair and corresponding certificate.
- A storage key pair.

Figure 2.1, “How the Key Archival Process Works” illustrates how the key archival process occurs when an end entity requests a certificate.

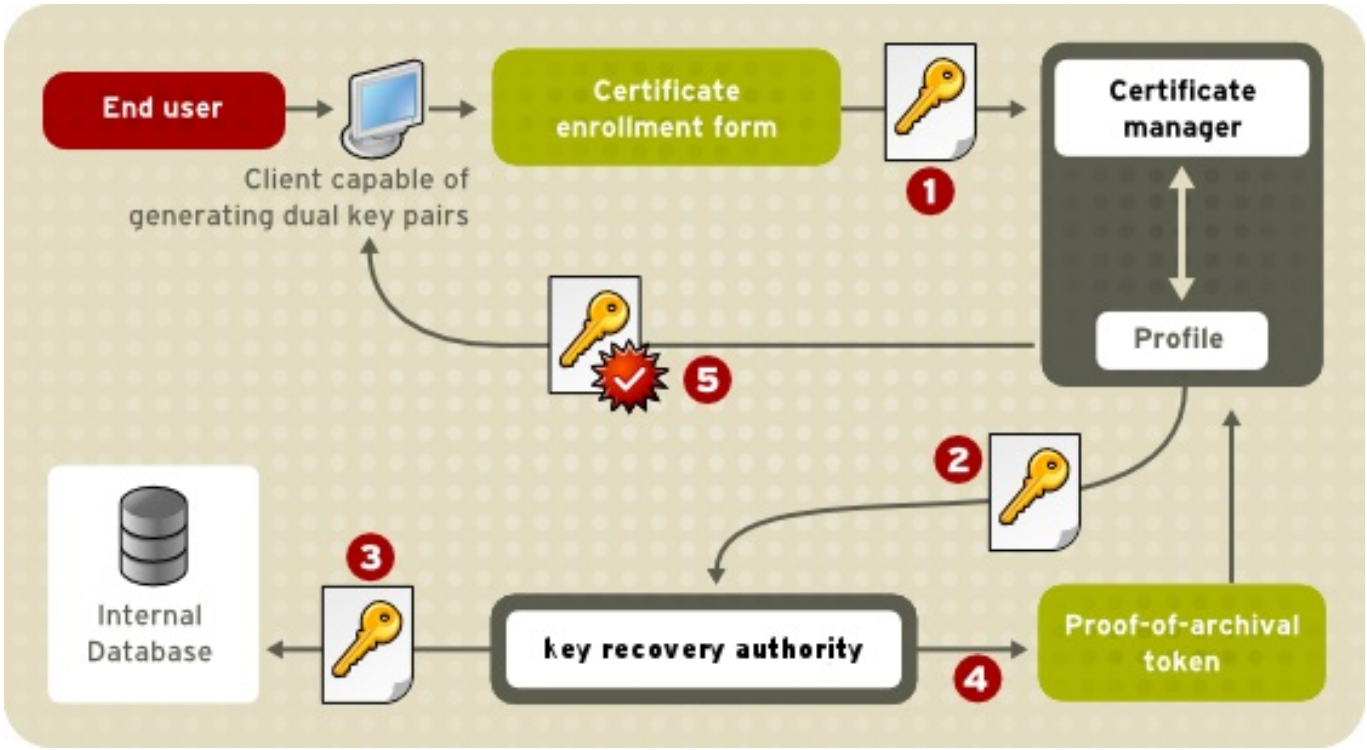


Figure 2.1. How the Key Archival Process Works

1. The client requests and generates a dual key pair.
    a. The end entity, using a client which can generate dual key pairs, submits a request through the Certificate Manager enrollment form.
    b. The client detects the JavaScript in the enrollment form and exports only the private encryption key, not the private signing key.
    c. The Certificate Manager detects the key archival option in the request and asks the client for the private encryption key.
    d. The client encrypts the private encryption key with the public key from the KRA's transport certificate embedded in the enrollment form.
2. After approving the certificate request and issuing the certificate, the Certificate Manager sends it to the KRA for storage, along with the public key. The Certificate Manager waits for verification from the KRA that the private key has been received and stored and that it corresponds to the public encryption key.
3. The KRA decrypts it with the private key. After confirming that the private encryption key corresponds to the public encryption key, the KRA encrypts it again with its public key pair of the storage key before storing it in its internal database.
4. Once the private encryption key has been successfully stored, the KRA uses the private key of its transport key pair to sign a token confirming that the key has been successfully stored; the KRA then sends the token to the Certificate Manager.
5. The Certificate Manager issues two certificates for the signing and encryption key pairs and returns them to the end entity.

Both subsystems subject the request to configured certificate profile constraints at appropriate stages. If the request fails to meet any of the profile constraints, the subsystem rejects the request.

2.2.5.2. Recovering Keys

The KRA supports *agent-initiated key recovery*. Agent-initiated recovery is when designated recovery agents use the key recovery form on the KRA agent services page to process and approve key recovery requests. With the approval of a specified number of agents, an organization can recover keys when the key's owner is unavailable or when keys have been lost.

Through the KRA agent services page, key recovery agents can collectively authorize and retrieve private encryption keys and associated certificates in a PKCS #12 package, which can then be imported into the client.

In key recovery authorization, one of the key recovery agents informs all required recovery agents about an impending key recovery. All recovery agents access the KRA key recovery page. One of the agents initiates the key recovery process. The KRA returns a notification to the agent includes a recovery authorization reference number identifying the particular key recovery request that the agent is required to authorize. Each agent uses the reference number and authorizes key recovery separately.

There are two different paths for key recovery.

- *Asynchronous recovery* means that each step of the recovery process — the initial request and each subsequent approval or rejection — is stored in the KRA's internal database, under the key entry. The data for the recovery process can be retrieved even if the original browser session is closed or the KRA is shut down. Agents search for the key to recover, without using a reference number.

- *Synchronous recovery* means that when the first agent initiates the key recovery process, the process persists and the original browser must remain open until the entire process is complete. When the agent starts the recovery process, the KRA returns a reference number. All subsequent agents use the **`Authorize Recovery`** area and that referral link to access the thread. Continuous updates on the approval status are sent to the initiating agent so they can check the status.

  With synchronous recovery, the page that the first agent used to initiate the key recovery request keeps refreshing until all agents required to authorize have performed the authorization. It is important that the first agent does not close this browser session until the authorization is complete. Otherwise, the key recovery request needs to be started again.

Important

The synchronous key recovery mechanism has been deprecated in Red Hat Certificate System 9. Red Hat recommends to use asynchronous key recovery instead.

These two recovery options are illustrated in Figure 2.2, “Async and Sync Recovery, Side by Side”.

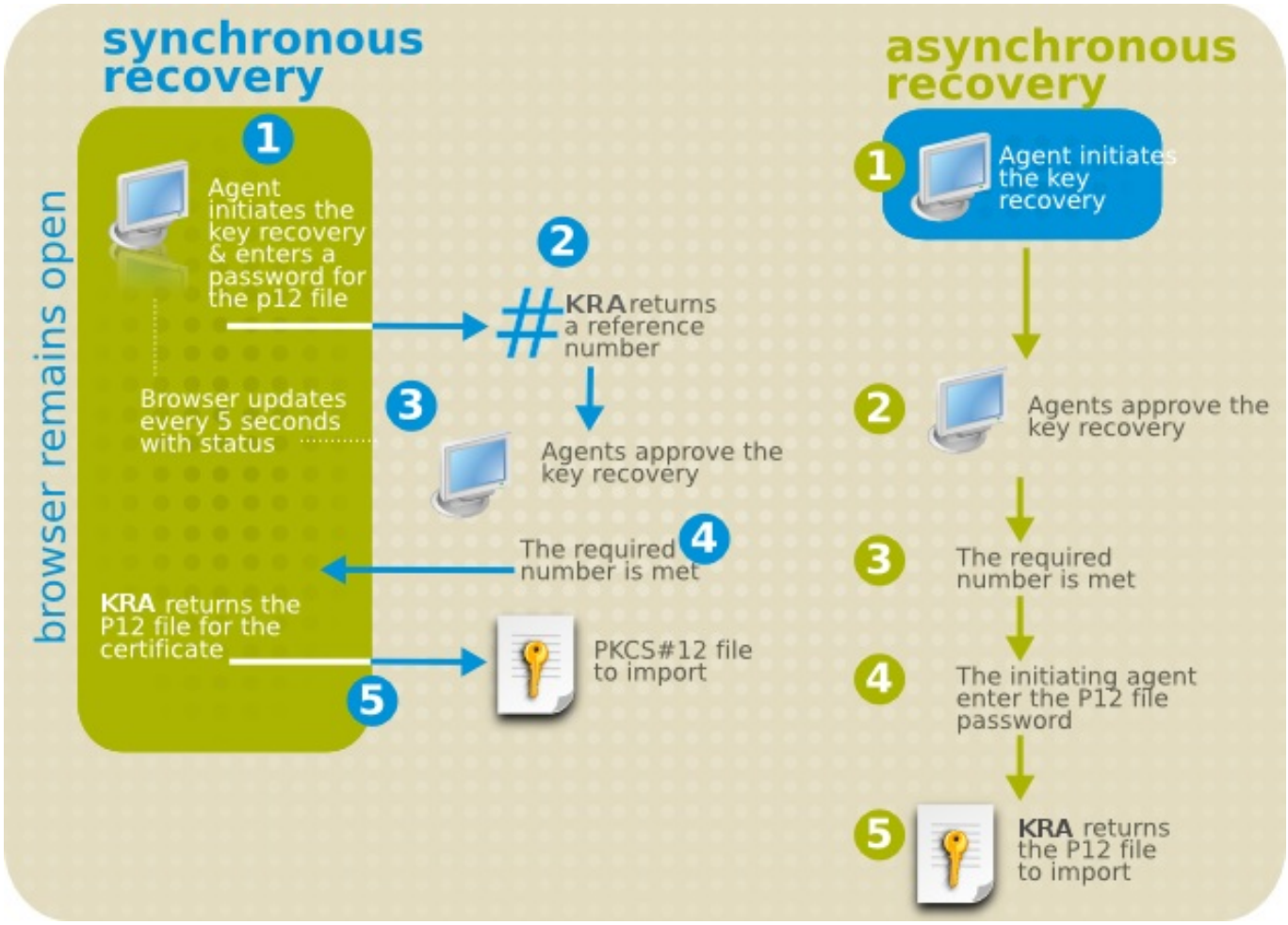


Figure 2.2. Async and Sync Recovery, Side by Side

The KRA informs the agent who initiated the key recovery process of the status of the authorizations.

When all of the authorizations are entered, the KRA checks the information. If the information presented is correct, it retrieves the requested key and returns it along with the corresponding certificate in the form of a PKCS #12 package to the agent who initiated the key recovery process.

Warning

The PKCS #12 package contains the private key. To minimize the risk of key compromise, the recovery agent must use a secure method to deliver the PKCS #12 package and password to the key recipient. The agent should use a good password to encrypt the PKCS #12 package and set up an appropriate delivery mechanism.

The *key recovery agent scheme* configures the KRA to recognize to which group the key recovery agents belong and specifies how many of these agents are required to authorize a key recovery request before the archived key is restored.

Starting with version 8.1, Certificate System began using an *m-of-n ACL-based recovery scheme*, rather than a secret-splitting-based recovery scheme. In versions of Certificate System older than 7.1, the password for the storage token was split and protected by individual recovery agent passwords. Now, Certificate System uses its existing access control scheme to ensure recovery agents are appropriately authenticated over SSL/TLS and requires that the agent belong to a specific recovery agent group, by default the Key Recovery Authority Agents Group. The recovery request is executed only when *m-of-n* (a required number of) recovery agents have granted authorization to the request.

Important

The above information refers to using a web browser, such as Firefox. However, functionality critical to KRA usage is no longer included in Firefox version 31.6 that was released on Red Hat Enterprise Linux 7 platforms. In such cases, it is necessary to use the **pki** utility to replicate this behavior. For more information, see the pki(1) and pki-key(1) man pages.

Apart from storing symmetric keys, KRA can also store secrets similar to symmetric keys, such as volume encryption secrets, or even passwords and passphrases. The **pki** utility supports options that enable storing and retrieving these other types of secrets.

2.2.6. KRA Transport Key Rotation

KRA transport rotation allows for seamless transition between CA and KRA subsystem instances using a current and a new transport key. This allows KRA transport keys to be periodically rotated for enhanced security by allowing both old and new transport keys to operate during the time of the transition; individual subsystem instances take turns being configured while other clones continue to serve with no downtime.

In the KRA transport key rotation process, a new transport key pair is generated, a certificate request is submitted, and a new transport certificate is retrieved. The new transport key pair and certificate have to be included in the KRA configuration to provide support for the second transport key. Once KRA supports two transport keys, administrators can start transitioning CAs to the new transport key. KRA support for the old transport key can be removed once all CAs are moved to the new transport key.

To configure KRA transport key rotation:

1. Generate a new KRA transport key and certificate
2. Transfer the new transport key and certificate to KRA clones
3. Update the CA configuration with the new KRA transport certificate
4. Update the KRA configuration to use only the new transport key and certificate

After this, the rotation of KRA transport certificates is complete, and all the affected CAs and KRAs use the new KRA certificate only. For more information on how to perform the above steps, see the procedures below.

Generating the new KRA transport key and certificate

1. Request the KRA transport certificate.
   a. Stop the KRA:

   ```
   systemctl stop pki-tomcatd@pki-kra.service
   ```

   b. Go to the KRA NSS database directory:

   ```
   cd /etc/pki/pki-kra/alias
   ```

   c. Create a subdirectory and save all the NSS database files into it. For example:

```
mkdir nss_db_backup
cp *.db nss_db_backup
```

d. Create a new request by using the **PKCS10Client** utility. For example:

```
PKCS10Client -p password -d '.' -o 'req.txt' -n
'CN=KRA Transport 2 Certificate,O=example.com Security
Domain'
```

Alternatively, use the **certutil** utility. For example:

```
certutil -d . -R -k rsa -g 2048 -s 'CN=KRA Transport 2
Certificate,O=example.com Security Domain' -f
password-file -a -o transport-certificate-request-
file
```

e. Submit the transport certificate request on the **Manual Data Recovery Manager Transport Certificate Enrollment** page of the CA End-Entity page.

f. Wait for the agent approval of the submitted request to retrieve the certificate by checking the request status on the End-Entity retrieval page.

2. Approve the KRA transport certificate through the CA Agent Services interface.

3. Retrieve the KRA transport certificate.

a. Go to the KRA NSS database directory:

```
cd /etc/pki/pki-kra/alias
```

b. Wait for the agent approval of the submitted request to retrieve the certificate by checking the request status on the End-Entity retrieval page.

c. Once the new KRA transport certificate is available, paste its Base64-encoded value into a text file, for example a file named ***cert-serial_number*.txt**. Do not include the header (**-----BEGIN CERTIFICATE-----**) or the footer (**-----END CERTIFICATE-----**).

4. Import the KRA transport certificate.

a. Go to the KRA NSS database directory:

```
cd /etc/pki/pki-kra/alias
```

b. Import the transport certificate into the KRA NSS database:

```
certutil -d . -A -n 'transportCert-serial_number
cert-pki-kra KRA' -t 'u,u,u' -a -i cert-
serial_number.txt
```

5. Update the KRA transport certificate configuration.

a. Go to the KRA NSS database directory:

```
cd /etc/pki/pki-kra/alias
```

b. Verify that the new KRA transport certificate is imported:

```
certutil -d . -L
certutil -d . -L -n 'transportCert-serial_number cert-
pki-kra KRA'
```

c. Open the **/var/lib/pki/pki-kra/kra/conf/CS.cfg** file and add the following line:

```
kra.transportUnit.newNickName=transportCert-
serial_number cert-pki-kra KRA
```

Propagating the new transport key and certificate to KRA clones

1. Start the KRA:

```
systemctl start pki-tomcatd@pki-kra.service
```

2. Extract the new transport key and certificate for propagation to clones.

a. Go to the KRA NSS database directory:

```
cd /etc/pki/pki-kra/alias
```

b. Stop the KRA:

```
systemctl stop pki-tomcatd@pki-kra.service
```

c. Verify that the new KRA transport certificate is present:

```
certutil -d . -L
certutil -d . -L -n 'transportCert-serial_number cert-
pki-kra KRA'
```

d. Export the KRA new transport key and certificate:

```
pk12util -o transport.p12 -d . -n 'transportCert-
serial_number cert-pki-kra KRA'
```

e. Verify the exported KRA transport key and certificate:

```
pk12util -l transport.p12
```

3. Perform these steps on each KRA clone:

a. Copy the **transport.p12** file, including the transport key and certificate, to the KRA clone location.

b. Go to the clone NSS database directory:

```
cd /etc/pki/pki-kra/alias
```

c. Stop the KRA clone:

```
systemctl stop pki-tomcatd@pki-kra.service
```

d. Check the content of the clone NSS database:

```
certutil -d . -L
```

e. Import the new transport key and certificate of the clone:

```
pk12util -i transport.p12 -d .
```

f. Add the following line to the **/var/lib/pki/pki-kra/kra/conf/CS.cfg** file on the clone:

```
kra.transportUnit.newNickName=transportCert-serial_number cert-pki-kra KRA
```

g. Start the KRA clone:

```
systemctl start pki-tomcatd@pki-kra.service
```

Updating the CA configuration with the new KRA transport certificate

1. Format the new KRA transport certificate for inclusion in the CA.

   a. Obtain the ***cert-serial_number*.txt** KRA transport certificate file created when retrieving the KRA transport certificate in the previous procedure.

   b. Convert the Base64-encoded certificate included in ***cert-serial_number*.txt** to a single-line file:

   ```
   tr -d '\n' < cert-serial_number.txt > cert-one-line-serial_number.txt
   ```

2. Do the following for the CA and all its clones corresponding to the KRA above:

   a. Stop the CA:

   ```
   systemctl stop pki-tomcatd@pki-ca.service
   ```

   b. In the **/var/lib/pki/pki-ca/ca/conf/CS.cfg** file, locate the certificate included in the following line:

   ```
   ca.connector.KRA.transportCert=certificate
   ```

   Replace that certificate with the one contained in ***cert-one-line-serial_number*.txt**.

   c. Start the CA:

   ```
   systemctl start pki-tomcatd@pki-ca.service
   ```

Note

While the CA and all its clones are being updated with the new KRA transport certificate, the CA instances that have completed the transition use the new KRA transport certificate, and the CA instances that have not yet been updated continue to use the old KRA transport certificate. Because the corresponding KRA and its clones have already been updated to use both transport certificates, no downtime occurs.

Updating the KRA configuration to use only the new transport key and certificate

For the KRA and each of its clones, do the following:

1. Go to the KRA NSS database directory:

```
cd /etc/pki/pki-kra/alias
```

2. Stop the KRA:

```
systemctl stop pki-tomcatd@pki-kra.service
```

3. Verify that the new KRA transport certificate is imported:

```
certutil -d . -L
certutil -d . -L -n 'transportCert-serial_number cert-pki-
kra KRA'
```

4. Open the **/var/lib/pki/pki-kra/kra/conf/CS.cfg** file, and look for the ***nickName*** value included in the following line:

```
kra.transportUnit.nickName=transportCert cert-pki-kra KRA
```

Replace the ***nickName*** value with the ***newNickName*** value included in the following line:

```
kra.transportUnit.newNickName=transportCert-serial_number
cert-pki-kra KRA
```

As a result, the **CS.cfg** file includes this line:

```
kra.transportUnit.nickName=transportCert-serial_number
cert-pki-kra KRA
```

5. Remove the following line from **/var/lib/pki/pki-kra/kra/conf/CS.cfg**:

```
kra.transportUnit.newNickName=transportCert-serial_number
cert-pki-kra KRA
```

6. Start the KRA:

```
systemctl start pki-tomcatd@pki-kra.service
```

2.3. Working with Smart Cards (TMS)

Most certificates are enrolled through the CA. When certificates will be enrolled through an application such as a web browser or web server and will only be used by that application, then a simple CA configuration is all that is required.

For security and for broader uses of the certificates, many organizations use smart cards (also called tokens). For managing smart cards, or tokens, Certificate System uses interlocking subsystems to create a *token management system* (TMS) which handles operations for certificates and keys stored on smart cards.

A TMS environment requires a CA, TKS, and TPS, with an optional KRA for server-side key generation:

- TPS interacts with smart cards to help them generate and store keys and certificates for a specific entity, such as a user or device. Smart card operations go through the TPS and are forwarded to the appropriate subsystem for action, such as the CA to generate certificates or the KRA to archive and recover keys.
- TKS generates, or derives, symmetric keys used for communication between the TPS and smart card. Each set of keys generated by the TKS is unique because they are based on the card's unique ID. The keys are formatted on the smart card and are used to encrypt communications, or provide authentication, between the smart card and TPS.
- CA creates and revokes user certificates stored on the smart card.
- Optionally, KRA archives and recovers keys for the smart card.

The **Enterprise Security Client** is the conduit through which TPS communicates with each token over a secure HTTP channel (HTTPS), and, through the TPS, with the Certificate System. As with a non-TMS environment, an OCSP responder can be used to check the revocation status of certificates.

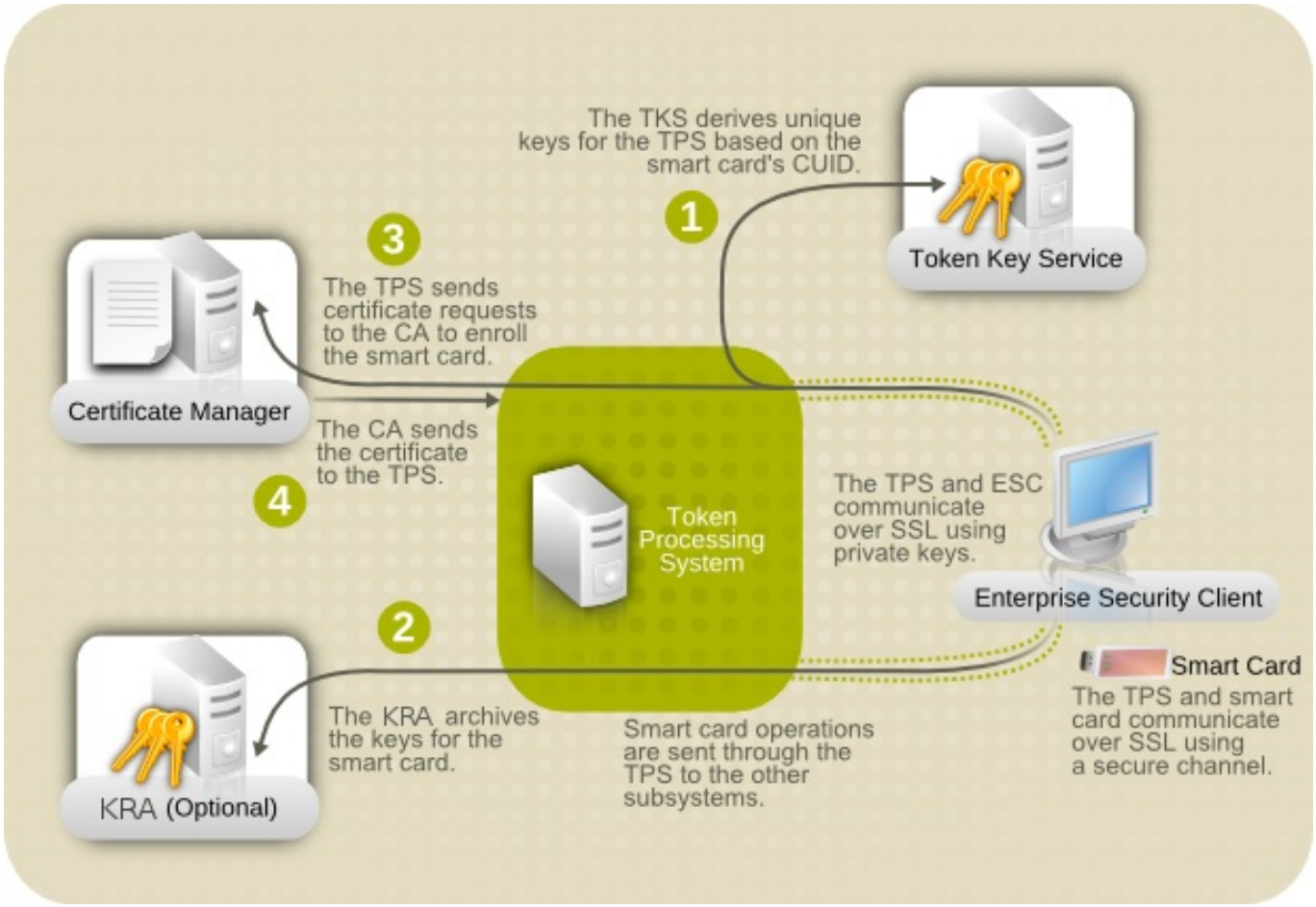


Figure 2.3. How the TMS Manages Smart Cards

To use the tokens, the Token Processing System must be able to recognize and communicate with them. The tokens must first be *enrolled* to format the tokens with required keys and certificates and add the tokens to the Certificate System. The **Enterprise Security Client** provides the user interface for end entities to enroll tokens.

2.3.1. The TKS and Secure Channels

The Token Key Service (TKS) generates the (token) keys the TPS uses to communicate with the Enterprise Security Client. The TPS communicates with the TKS over SSL/TLS, but the TPS communicates with the smart cards themselves over a secure channel. The secure channel is made from an agreed on algorithm which is used by the TPS and smart card to independently derive three keys. The TKS provides the security between tokens and the TPS since the security relies on the relationship between the master key and the token keys.

Every smart card has three keys stored on it:

- An *auth key* which is used for encryption and authentication; a session key derived from the auth key each time a secure channel is opened.
- A *MAC key* which is used for message authentication; like the auth keys, a session key is derived from the MAC key each time a secure channel is opened.
- A *key encryption key* (KEK) which is used to encrypt the session keys.

The TPS contacts the smart card to initialize a secure channel, sending key set information and a host challenge. The smart card creates a card challenge, generates the session keys, and generates a cryptogram, then sends its initialization response. The TKS — using the card UID number, an

agreed on algorithm, and the key information — independently derives the session keys and the host cryptogram. The TKS uses the host/server cryptogram to verify the card cryptogram, and then TPS establishes the secure channel with the smart card.

Having the TKS independently derive the session keys effectively shares secrets between the TPS and the smart card without having to store these symmetric keys on the server.

The TKS manages the master and transport keys required to generate and distribute keys for smart cards or tokens. A *master key* is a Triple DES symmetric key stored either in software or hardware token. The *transport key* wraps the other keys derived and used by the TKS and TPS.

The TKS actually carries out the key-related functions that the TPS needs for its communications:

- Helps establish a secure channel (signed and encrypted) between the token and TPS.
- Provides proof of presence for the security token during enrollment.
- Supports key changeover when the master key changes on the TKS. Tokens with older keys get new token keys.
- Helps generate a symmetric session key for the KRA to wrap (encrypt) the entity's private key for (optional) server-side key generation, where the entity's encryption keys are generated on the KRA.

Note

Because of the sensitivity of the data that the TKS manages, the TKS should be set behind the firewall with restricted access.

2.3.2. TPS Operations

The TPS is the conduit between the Enterprise Security Client and the other subsystems (CA, TKS, KRA). The token operations are posted to the TPS using SSL/TLS and the URL of the management interface:

```
https://localhost.localdomain:8443/tps/
```

There are a number of available *operations*, and each operation is limited so that only certain types of TPS users can initiate it (Section 2.4.6, “Users, Authorization, and Access Controls”). In general, TPS operations include:

- Formatting smart cards
- Resetting the PIN on smart card tokens
- Upgrading the applet for smart card tokens
- Enrolling smart cards through the Enterprise Security Client
- Performing LDAP authentication
- Managing the token database
- Logging token events

2.3.3. Token Profiles

Just like certificate profiles (Section 2.2.1.2, “Certificate Profiles”), there are different token profiles to format different kinds of tokens. A token profile defines two areas:

1. The steps to format and enroll the token (sort of like the forms used for certificate profiles)
2. The configuration of the final enrolled token

The profile configuration to format a smart card identify the authentication mechanisms to use, the LDAP database connection, the CA to use, and which entity generates the keys and the key settings. This also identifies the certificate profile on the CA to use to submit the token request.

Example 2.1. Token Profile for userKey

```
mappingResolver.enrollProfileMappingResolver.mapping.0.filter.tokenType
=userKey
mappingResolver.enrollProfileMappingResolver.mapping.0.target.tokenType
=userKey
mappingResolver.enrollProfileMappingResolver.mapping.2.target.tokenType
=userKey
mappingResolver.formatProfileMappingResolver.mapping.3.filter.tokenType
=userKey
mappingResolver.formatProfileMappingResolver.mapping.3.target.tokenType
=userKey
mappingResolver.pinResetProfileMappingResolver.mapping.0.target.tokenTy
pe=userKey
##########################################################################
####
# Profile for userKey
##########################################################################
####
op.format.userKey.auth.enable=true
op.format.userKey.auth.id=ldap1
op.format.userKey.ca.conn=ca1
op.format.userKey.cardmgr_instance=A0000000030000
op.format.userKey.cuidMustMatchKDD=false
op.format.userKey.enableBoundedGPKeyVersion=true
op.format.userKey.issuerinfo.enable=true
op.format.userKey.issuerinfo.value=http://localhost.localdomain:8080/tp
s/phoneHome
op.format.userKey.loginRequest.enable=true
op.format.userKey.maximumGPKeyVersion=FF
op.format.userKey.minimumGPKeyVersion=01
op.format.userKey.revokeCert=true
op.format.userKey.rollbackKeyVersionOnPutKeyFailure=false
op.format.userKey.tks.conn=tks1
op.format.userKey.update.applet.directory=/usr/share/pki/tps/applets
op.format.userKey.update.applet.emptyToken.enable=true
op.format.userKey.update.applet.encryption=true
op.format.userKey.update.applet.requiredVersion=1.4.54de790f
op.format.userKey.update.symmetricKeys.enable=false
op.format.userKey.update.symmetricKeys.requiredVersion=1
op.format.userKey.validateCardKeyInfoAgainstTokenDB=true
```

There are a handful of profiles defined for tokens already. New and custom tokens can be created.

Table 2.1. Default Token Types

Token Type	Description
cleanToken	For operations for any blank token, without any other applied token types.
tokenKey	For operations for generating keys for uses with servers or devices.
userKey	For operations for regular user tokens.
userKeyTemporary	For operations for temporary user tokens.

2.4. Management and Security for Subsystems

Certificate System has a number of different features for administrators to use which makes it easier to maintain the individual subsystems and the PKI as a whole.

2.4.1. Notifications

When a particular event occurs, such as when a certificate is issued or revoked, then a notification can be sent directly to a specified email address. The notification framework comes with default modules that can be enabled and configured.

2.4.2. Jobs

Automated jobs run at defined intervals.

2.4.3. Logging

The Certificate System and each subsystem produce extensive system and error logs that record system events so that the systems can be monitored and debugged. All log records are stored in the local file system for quick retrieval. Logs are configurable, so logs can be created for specific types of events and at the desired logging level.

Certificate System allows logs to be signed digitally before archiving them or distributing them for auditing. This feature enables log files to be checked for tampering after being signed.

2.4.4. Auditing

The Certificate System maintains audit logs for all events, such as requesting, issuing and revoking certificates and publishing CRLs. These logs are then signed. This allows authorized access or activity to be detected. An outside auditor can then audit the system if required. The assigned auditor user account is the only account which can view the signed audit logs. This user's certificate is used to sign and encrypt the logs. Audit logging is configured to specify the events that are logged.

2.4.5. Self-Tests

The Certificate System provides the framework for system self-tests that are automatically run at startup and can be run on demand. A set of configurable self-tests are already included with the Certificate System.

2.4.6. Users, Authorization, and Access Controls

Certificate System users can be assigned to groups, and they then have the privileges of whichever group they are members. A user only has privileges for the instance of the subsystem in which the user is created and the privileges of the group to which the user is a member.

Authentication is the means that Certificate System subsystems use to verify the identity of clients, whether they are authenticating to a certificate profile or to one of the services interfaces. There are a number of different ways that a client can authentication, including simple username/password, SSL/TLS client authentication, LDAP authentication, NIS authentication, or CMC. Authentication can be performed for any access to the subsystem; for certificate enrollments, for example, the profile defines how the requestor authenticates to the CA.

Once the client is identified and authenticated, then the subsystems perform an *authorization* check to determine what level of access to the subsystem that particular user is allowed.

Authorization is tied to group, or role, permissions, rather than directly to individual users. The Certificate System provides an authorization framework for creating groups and assigning access control to those groups. The default access control on preexisting groups can be modified, and access control can be assigned to individual users and IP addresses. Access points for authorization have been created for the major portions of the system, and access control rules can be set for each point.

The Certificate System is configured by default with three user types with different access levels to the system:

- *Administrators*, who can perform any administrative or configuration task for a subsystem.
- *Agents*, who perform PKI management tasks, like approving certificate requests, managing token enrollments, or recovering keys.
- *Auditors*, who can view and configure audit logs.

Additionally, when a security domain is created, the CA subsystem which hosts the domain is automatically granted the role of *Security Domain Administrator*, which gives the subsystem the ability to manage the security domain and the subsystem instances within it. Other security domain administrator roles can be created for the different subsystem instances.

2.4.7. Security-Enhanced Linux

SELinux is a collection of mandatory access control rules which are enforced across a system to restrict unauthorized access and tampering. SELinux is described in more detail in the SELinux section in the Red Hat Enterprise Linux Planning, Installation, and Deployment Guide.

Basically, SELinux identifies *objects* on a system, which can be files, directories, users, processes, sockets, or any other resource on a Linux host. These objects correspond to the Linux API objects. Each object is then mapped to a *security context*, which defines the type of object and how it is allowed to function on the Linux server.

Objects can be grouped into domains, and then each domain is assigned the proper rules. Each security context has rules which set restrictions on what operations it can perform, what resources it can access, and what permissions it has.

SELinux policies for the Certificate System are incorporated into the standard system SELinux policies. These SELinux policies apply to every subsystem and service used by Certificate System. By running Certificate System with SELinux in enforcing mode, the security of the information created and maintained by Certificate System is enhanced.

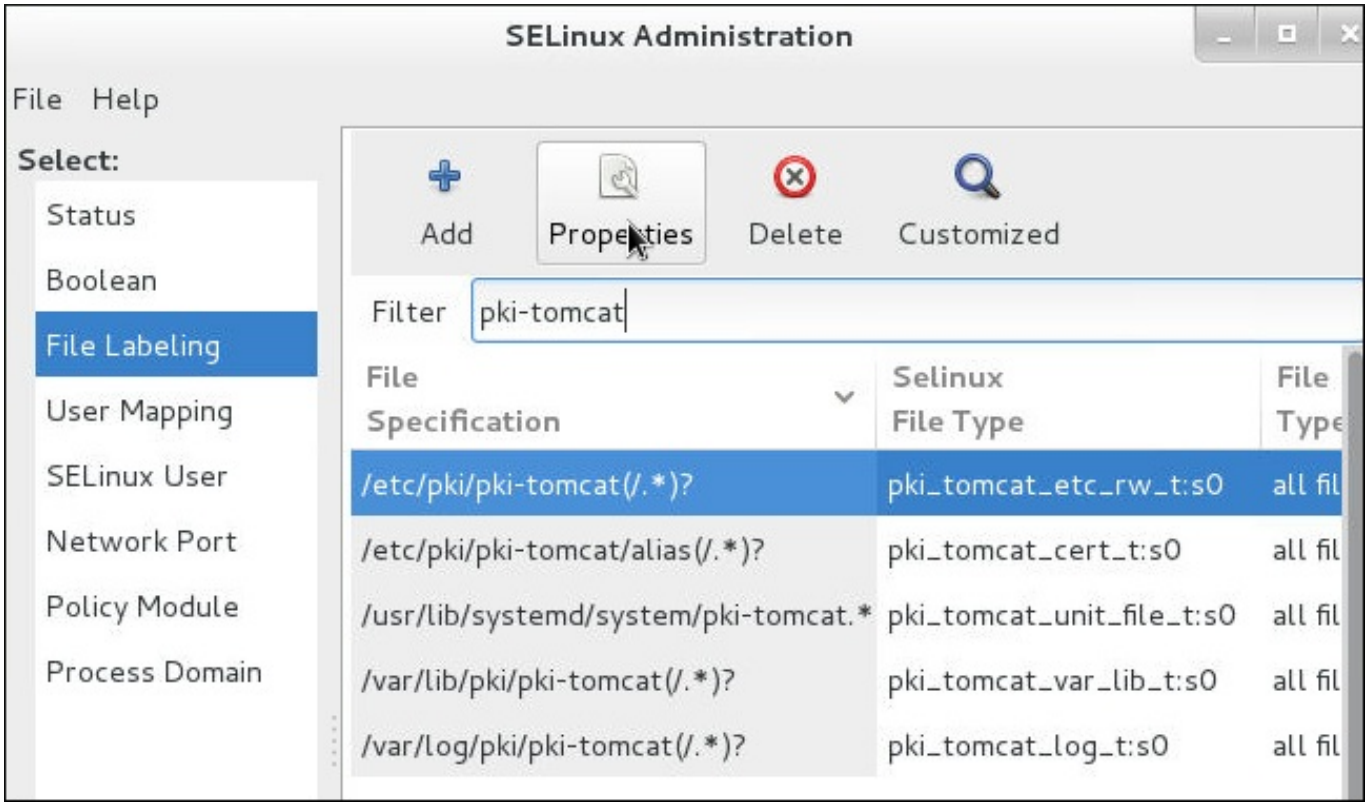


Figure 2.4. CA SELinux Port Policy

The Certificate System SELinux policies define the SELinux configuration for every subsystem instance:

- Files and directories for each subsystem instance are labeled with a specific SELinux context.
- The ports for each subsystem instance are labeled with a specific SELinux context.
- All Certificate System processes are constrained within a subsystem-specific domain.
- Each domain has specific rules that define what actions that are authorized for the domain.
- Any access not specified in the SELinux policy is denied to the Certificate System instance.

For Certificate System, each subsystem is treated as an SELinux object, and each subsystem has unique rules assigned to it. The defined SELinux policies allow Certificate System objects run with SELinux set in enforcing mode.

Every time **pkispawn** is run to configure a Certificate System subsystem, files and ports associated with that subsystem are labeled with the required SELinux contexts. These contexts are removed when the particular subsystems are removed using **pkidestroy**.

The central definition in an SELinux policy is the **pki_tomcat_t** domain. Certificate System instances are Tomcat servers, and the **pki_tomcat_t** domain extends the policies for a standard **tomcat_t** Tomcat domain. All Certificate System instances on a server share the same domain.

When each Certificate System process is started, it initially runs in an unconfined domain (**unconfined_t**) and then transitions into the **pki_tomcat_t** domain. This process then has certain access permissions, such as write access to log files labeled **pki_tomcat_log_t**, read and write access to configuration files labeled **pki_tomcat_etc_rw_t**, or the ability to open and write to **http_port_t** ports.

The SELinux mode can be changed from enforcing to permissive, or even off, though this is not recommended.

2.5. Red Hat Certificate System Services

There are three different interfaces for managing certificates and subsystems, depending on the user type: administrators, agents, and end users.

2.5.1. Administrative Consoles

The administrative interface is used to manage the subsystem itself. This includes adding users, configuring logs, managing profiles and plug-ins, and the internal database, among many other functions. This interface is also the only interface that does not directly deal with certificates, tokens, or keys, meaning it is not used for managing the *PKI*, only the *servers*.

There are two types of administrative consoles, Java-based and HTML-based. Although the interface is different, both are accessed using a server URL and the administrative port number.

2.5.1.1. The Java Administrative Console for CA, OCSP, KRA, and TKS Subsystems

The Java console is used by four subsystems: the CA, OCSP, KRA, and TKS. The console is accessed using a locally-installed **pkiconsole** utility. It can access any subsystem because the command requires the hostname, the subsystem's administrative SSL/TLS port, and the specific subsystem type.

```
pkiconsole https://server.example.com:admin_port/subsystem_type
```

This opens a console, as in Figure 2.5, “Certificate System Console”.

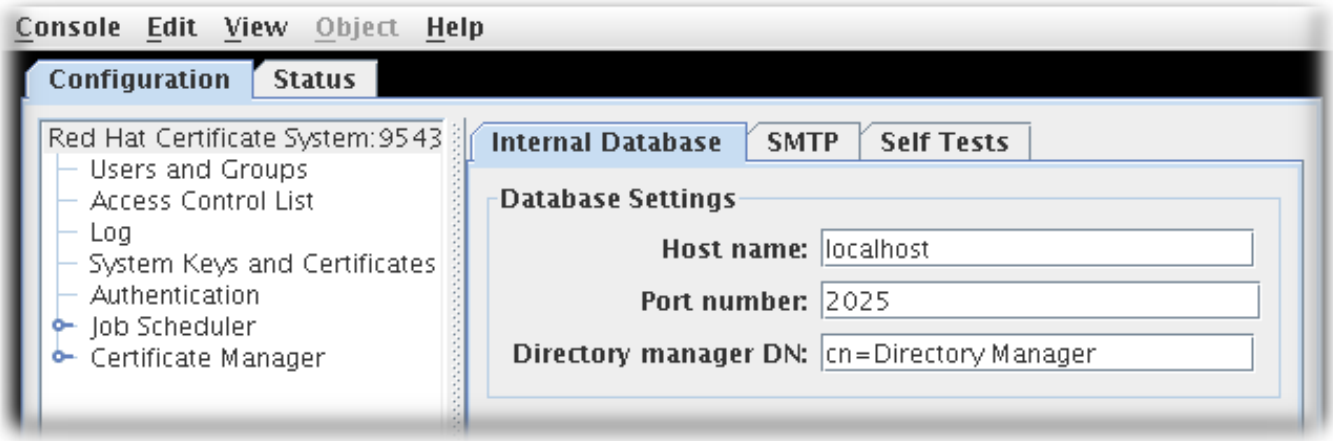


Figure 2.5. Certificate System Console

The **Configuration** tab controls all of the setup for the subsystem, as the name implies. The choices available in this tab are different depending on which subsystem type the instance is; the CA has the most options since it has additional configuration for jobs, notifications, and certificate enrollment authentication.

All subsystems have four basic options:

- Users and groups
- Access control lists

- Log configuration
- Subsystem certificates (meaning the certificates issued to the subsystem for use, for example, in the security domain or audit signing)

The **Status** tab shows the logs maintained by the subsystem.

2.5.1.2. The Administrative Interface for TPS

The TPS subsystems use HTML-based administrative interface. It is accessed by entering the hostname and secure port as the URL, authenticating with the administrator's certificate, and clicking the appropriate **Administrators** link.

Note

There is a single SSL/TLS port for TPS subsystems which is used for both administrator and agent services. Access to those services is restricted by certificate-based authentication.

The HTML admin interface is much more limited than the Java console; the primary administrative function is managing the subsystem users; all other administrative tasks are done by manually editing the **CS.cfg** file.

The TPS only allows operations to manage users for the TPS subsystem. However, the TPS admin page can also list tokens and display all activities (including normally-hidden administrative actions) performed on the TPS.

Figure 2.6. TPS Admin Page

2.5.2. Agent Interfaces

The agent services pages are where almost all of the certificate and token management tasks are performed. These services are HTML-based, and agents authenticate to the site using a special agent certificate.

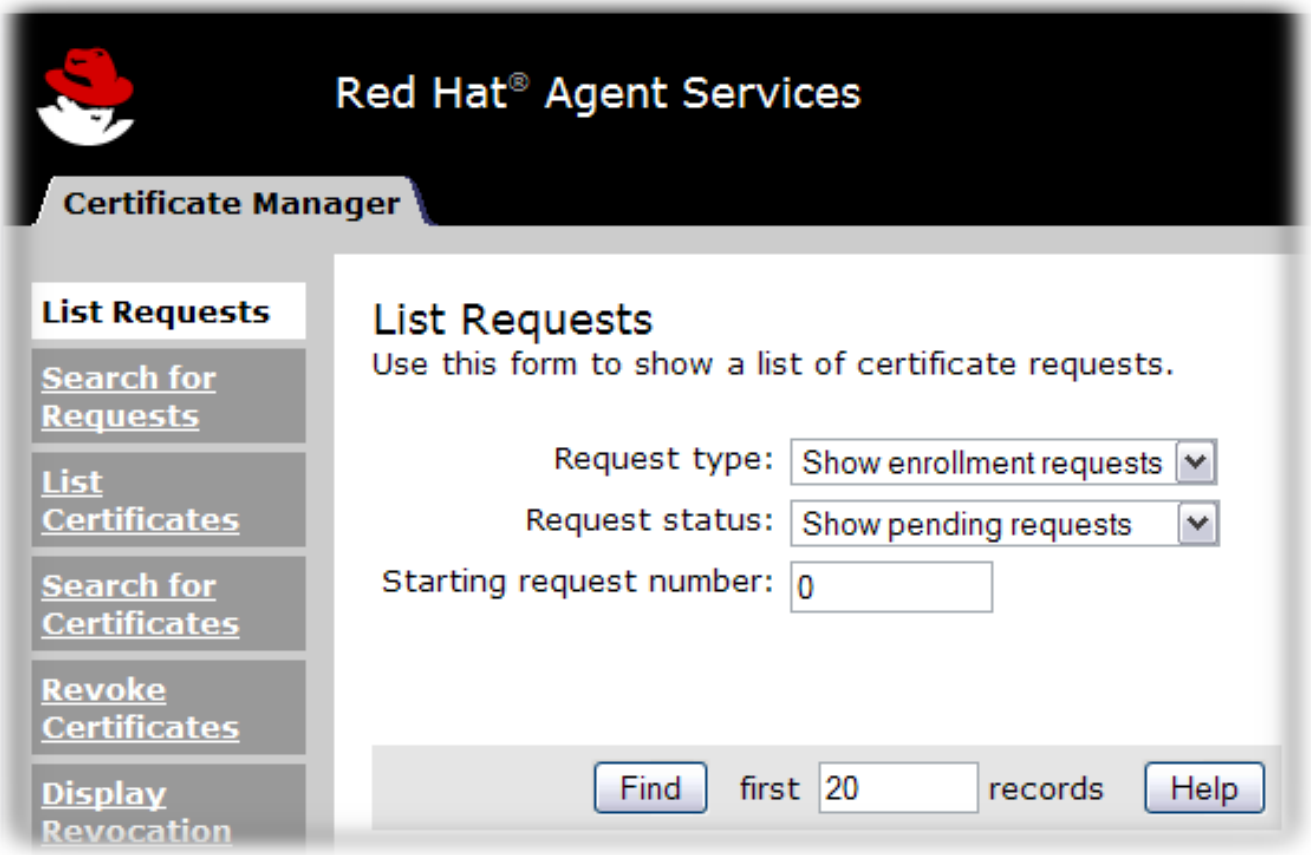


Figure 2.7. Certificate Manager's Agent Services Page

The operations vary depending on the subsystem:

- The Certificate Manager agent services include approving certificate requests (which issues the certificates), revoking certificates, and publishing certificates and CRLs. All certificates issued by the CA can be managed through its agent services page.
- The TPS agent services, like the CA agent services, manages all of the tokens which have been formatted and have had certificates issued to them through the TPS. Tokens can be enrolled, suspended, and deleted by agents. Two other roles (operator and admin) can view tokens in web services pages, but cannot perform any actions on the tokens.
- KRA agent services pages process key recovery requests, which set whether to allow a certificate to be issued reusing an existing key pair if the certificate is lost.
- The OCSP agent services page allows agents to configure CAs which publish CRLs to the OCSP, to load CRLs to the OCSP manually, and to view the state of client OCSP requests.

The TKS is the only subsystem without an agent services page.

2.5.3. End User Pages

The CA and TPS both process direct user requests in some way. That means that end users have to have a way to connect with those subsystems. The CA has end-user, or *end-entities*, HTML services. The TPS uses the Enterprise Security Client.

The end-user services are accessed over standard HTTP using the server's hostname and the standard port number; they can also be accessed over HTTPS using the server's hostname and the specific end-entities SSL/TLS port.

For CAs, each type of SSL/TLS certificate is processed through a specific online submission form, called a *profile*. There are about two dozen certificate profiles for the CA, covering all sorts of certificates — user SSL/TLS certificates, server SSL/TLS certificates, log and file signing certificates, email certificates, and every kind of subsystem certificate. There can also be custom profiles.

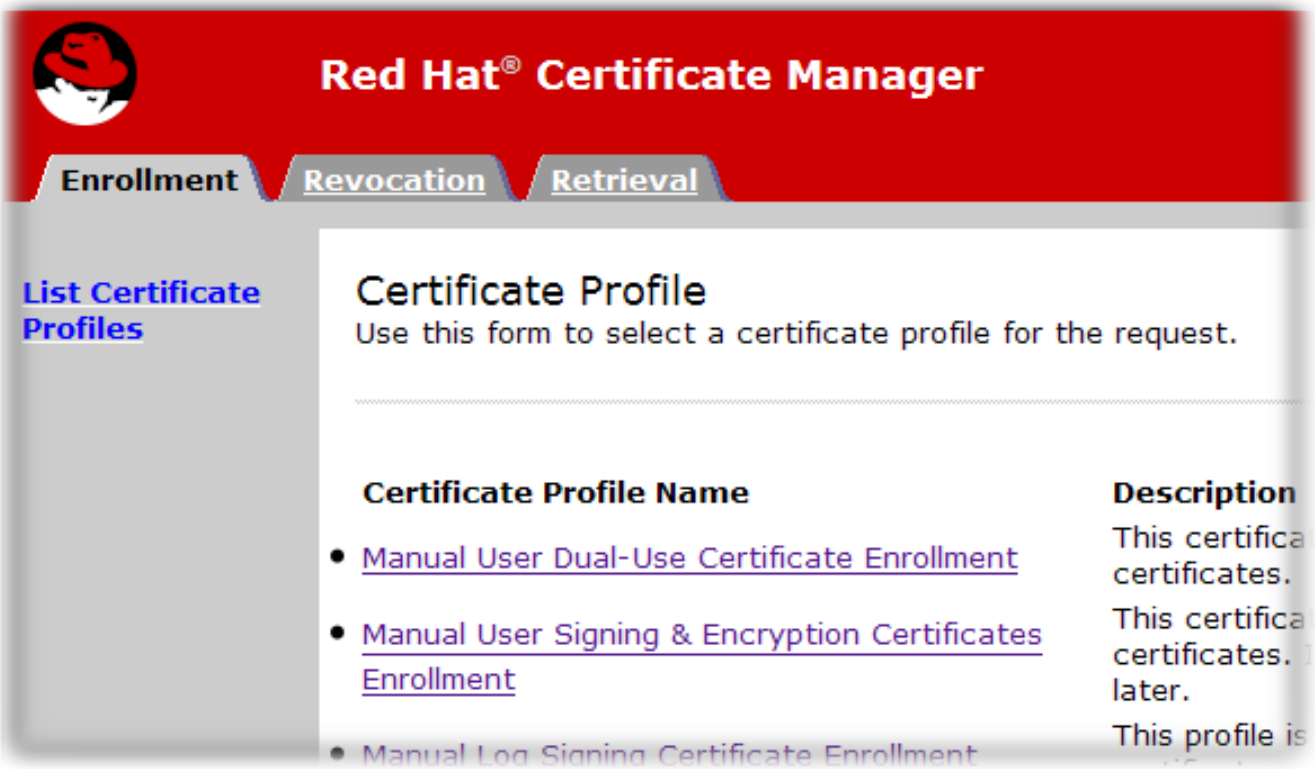


Figure 2.8. Certificate Manager's End-Entities Page

End users retrieve their certificates through the CA pages when the certificates are issued. They can also download CA chains and CRLs and can revoke or renew their certificates through those pages.

2.5.4. Enterprise Security Client

The **Enterprise Security Client** is a tool for Red Hat Certificate System which simplifies managing smart cards. End users can use security tokens (smart cards) to store user certificates used for applications such as single sign-on access and client authentication. End users are issued the tokens containing certificates and keys required for signing, encryption, and other cryptographic functions.

The **Enterprise Security Client** is the third part of Certificate System's complete token management system. Two subsystems — the Token Key Service (TKS) and Token Processing System (TPS) — are used to process token-related operations. The **Enterprise Security Client** is the interface which allows the smart card and user to access the token management system.

After a token is enrolled, applications such as Mozilla Firefox and Thunderbird can be configured to recognize the token and use it for security operations, like client authentication and S/MIME mail. Enterprise Security Client provides the following capabilities:

- Supports JavaCard 2.1 or higher cards and Global Platform 2.01-compliant smart cards like Safenet's 330J smart card.
- Supports Gemalto TOP IM FIPS CY2 tokens, both the smart card and GemPCKey USB form factor key.

- Supports SafeNet Smart Card 650 (SC650).
- Enrolls security tokens so they are recognized by TPS.
- Maintains the security token, such as re-enrolling a token with TPS.
- Provides information about the current status of the token or tokens being managed.
- Supports server-side key generation so that keys can be archived and recovered on a separate token if a token is lost.

The Enterprise Security Client is a client for end users to register and manage keys and certificates on smart cards or tokens. This is the final component in the Certificate System token management system, with the Token Processing System (TPS) and Token Key Service (TKS).

The Enterprise Security Client provides the user interface of the token management system. The end user can be issued security tokens containing certificates and keys required for signing, encryption, and other cryptographic functions. To use the tokens, the TPS must be able to recognize and communicate with them. Enterprise Security Client is the method for the tokens to be enrolled.

Enterprise Security Client communicates over an SSL/TLS HTTP channel to the backend of the TPS. It is based on an extensible Mozilla XULRunner framework for the user interface, while retaining a legacy web browser container for a simple HTML-based UI.

After a token is properly enrolled, web browsers can be configured to recognize the token and use it for security operations. Enterprise Security Client provides the following capabilities:

- Allows the user to enroll security tokens so they are recognized by the TPS.
- Allows the user to maintain the security token. For example, Enterprise Security Client makes it possible to re-enroll a token with the TPS.
- Provides support for several different kinds of tokens through default and custom token profiles. By default, the TPS can automatically enroll user keys, device keys, and security officer keys; additional profiles can be added so that tokens for different uses (recognized by attributes such as the token CUID) can automatically be enrolled according to the appropriate profile.
- Provides information about the current status of the tokens being managed.

Chapter 3. Supported Standards and Protocols

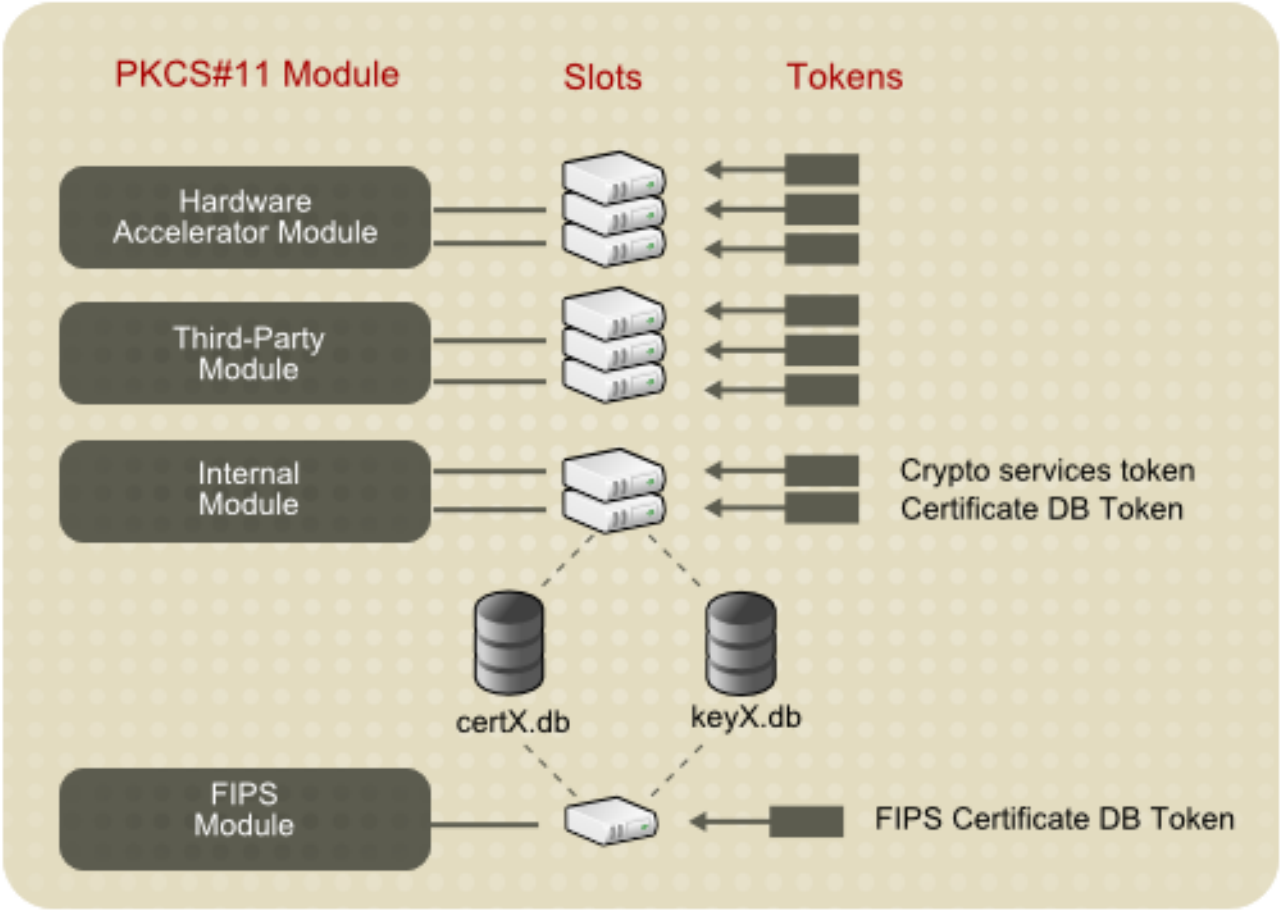
Red Hat Certificate System is based on many public and standard protocols and RFCs, to ensure the best possible performance and interoperability. The major standards and protocols used or supported by Certificate System 9.0 are outlined in this chapter, to help administrators plan their client services effectively.

3.1. PKCS #11

Public-Key Cryptography Standard (PKCS) #11 specifies an API used to communicate with devices that hold cryptographic information and perform cryptographic operations. Because it supports PKCS #11, Certificate System is compatible with a wide range of hardware and software devices.

At least one PKCS #11 module must be available to any Certificate System subsystem instance. A PKCS #11 module (also called a cryptographic module or cryptographic service provider) manages cryptographic services such as encryption and decryption. PKCS #11 modules are analogous to drivers for cryptographic devices that can be implemented in either hardware or software. Certificate System contains a built-in PKCS #11 module and can support third-party modules.

A PKCS #11 module always has one or more slots which can be implemented as physical hardware slots in a physical reader such as smart cards or as conceptual slots in software. Each slot for a PKCS #11 module can in turn contain a token, which is a hardware or software device that actually provides cryptographic services and optionally stores certificates and keys.



Two cryptographic modules are included in the Certificate System:

- The default internal PKCS #11 module, which comes with two tokens:

- The internal crypto services token, which performs all cryptographic operations such as encryption, decryption, and hashing.
- The internal key storage token ("Certificate DB token"), which handles all communication with the certificate and key database files that store certificates and keys.

- The FIPS 140 module. This module complies with the FIPS 140 government standard for cryptographic module implementations. The FIPS 140 module includes a single, built-in FIPS 140 certificate database token, which handles both cryptographic operations and communication with the certificate and key database files.

Any PKCS #11 module can be used with the Certificate System. To use an external hardware token with a subsystem, load its PKCS #11 module before the subsystem is configured, and the new token is available to the subsystem.

Available PKCS #11 modules are tracked in the **`secmod.db`** database for the subsystem. The **`modutil`** utility is used to modify this file when there are changes to the system, such as installing a hardware accelerator to use for signing operations. For more information on **`modutil`**, see http://www.mozilla.org/projects/security/pki/nss/tools/.

PKCS #11 hardware devices also provide key backup and recovery features for the information stored on hardware tokens. Refer to the PKCS #11 vendor documentation for information on retrieving keys from the tokens.

3.2. SSL/TLS, ECC, and RSA

Secure Sockets Layer (SSL) and Transport Layer Security (TLS) protocols are universally accepted standards for authenticated and encrypted communication between clients and servers. Both client and server authentication occur over SSL/TLS.

Note

Note that the TLS 1.0 protocol and its later versions are successors of SSL 3.0 and provide more modern security features. Conversely, due to the CVE-2014-3566 vulnerability, also known as POODLE, SSL 3.0 is now officially deprecated [1].

SSL/TLS uses a combination of public-key and symmetric-key encryption. Symmetric-key encryption is much faster than public-key encryption, but public-key encryption provides better authentication techniques. An SSL/TLS session always begins with an exchange of messages called *handshake*, initial communication between the server and client. The handshake allows the server to authenticate itself to the client using public-key techniques, optionally allows the client to authenticate to the server, then allows the client and the server to cooperate in the creation of symmetric keys used for rapid encryption, decryption, and integrity verification during the session that follows.

Both SSL and TLS support a variety of different cryptographic algorithms, or *ciphers*, for operations such as authenticating the server and client, transmitting certificates, and establishing session keys. Clients and servers may support different cipher suites, or sets of ciphers. Among other functions, the handshake determines how the server and client negotiate which cipher suite is used to authenticate each other, to transmit certificates, and to establish session keys.

Key-exchange algorithms like RSA and Elliptic Curve Diffie-Hellman (ECDH) govern the way the server and client determine the symmetric keys to use during an SSL/TLS session. The most common SSL cipher suites use RSA key exchange, while TLS supports ECC (Elliptic Curve Cryptography) cipher suites, as well as RSA. The Certificate System supports both RSA and ECC public-key

cryptographic systems natively.

In more recent practise, key-exchange algorithms are being superseded by *key-agreement protocols* where each of the two or more parties can influence the outcome when establishing a common key for secure communication. Key agreement is preferrable to key exchange because it allows for Perfect Forward Secrecy (PFS) to be implemented. When PFS is used, random public keys (also called temporary cipher parameters or *ephemeral keys*) are generated for each session by a non-deterministic algorithm for the purposes of key agreement. As a result, there is no single secret value which could lead to the compromise of multiple messages, protecting past and future communication alike.

Note

Longer RSA keys are required to provide security as computing capabilities increase. The recommended RSA key-length is 2048 bits. Though many servers continue to use 1024-bit keys, servers should migrate to at least 2048 bits. For 64-bit machines, consider using stronger keys. All CAs should use at least 2048-bit keys, and stronger keys (such as 3072 or 4096 bits) if possible.

3.2.1. Supported Cipher Suites

Cipher and hashing algorithms are in a constant flux with regard to various vulnerabilities and security strength. As a general rule, Red Hat Certificate System 9 follows the NIST guideline and supports TLS 1.1 and TLS 1.2 cipher suites pertaining to the server keys.

3.2.2. Using ECC

Elliptic Curve Cryptography (ECC) is a cryptographic system that uses elliptic curves to create keys for encrypting data. ECC creates cryptographically-stronger keys with shorter key lengths than RSA, which makes it faster and more efficient to implement.

ECC has several advantages over RSA, since it is faster and requires shorter key lengths for stronger keys. On the other hand, ECC is not yet as widely supported as RSA. For information on cipher key strength comparison, see "Table 2.1 Comparable strengths" in NIST Recommendation for Key Management – Part 1: General (Revision 3).

Certificate System supports ECC with the ECC with CA, KRA, and OCSP subsystems, so ECC certificate requests can be submitted to CAs through any of the enrollment profiles and ECC keys can be archived and restored in the KRA. Certificate System supports ECC natively; for more information, see Chapter 9, *Installing an Instance with ECC System Certificates*.

Note

A CA with an ECC CA signing certificate can issue both ECC and RSA certificates. A CA with an RSA CA signing certificate can only issue RSA certificates.

Only the CA signing certificate is required; if for support purposes it is better to use RSA client certificates with the CA, simply delete the ECC subsystem certificates (except for the signing certificate) and replace them with RSA certificates. [2].

3.3. IPv4 and IPv6 Addresses

Certificate System supports both IPv4 addresses and IPv6 addresses. In a very wide variety of circumstances, Certificate System subsystems or operations reference a host name or IP address; supporting both IPv4- and IPv6-style addresses ensures forward compatibility with network protocols. The operations that support IPv6 connections include the following:

- Communications between subsystems, including between the TPS, TKS, and CA and for joining security domains
- Token operations between the TPS and the Enterprise Security Client
- Subsystem logging
- Access control instructions
- Operations performed with Certificate System tools, including the **pki** utility, the Subject Alt Name Extension tool, HttpClient, and the Bulk Issuance Tool
- Client communications, including both the **pkiconsole** utility and IPv6-enabled browsers for web services
- Certificate request names and certificate subject names, including user, server, and router certificates
- Publishing
- Connecting to LDAP databases for internal databases and authentication directories

Any time a host name or URL is referenced, an IP address can be used:

- An IPv4 address must be in the format **n.n.n.n** or **n.n.n.n,m.m.m.m**. For example, **128.21.39.40** or **128.21.39.40,255.255.255.00**.
- An IPv6 address uses a 128-bit namespace, with the IPv6 address separated by colons and the netmask separated by periods. For example, *0:0:0:0:0:0:13.1.68.3*, *FF01::43*, or *0:0:0:0:0:0:13.1.68.3,FFFF:FFFF:FFFF:FFFF:FFFF:FFFF:255.255.255.0*.

If DNS is properly configured, then an IPv4 or IPv6 address can be used to connect to the web services pages and to the subsystem Java consoles. The most common method is to use fully-qualified domain names:

```
https://ipv6host.example.com:8443/ca/services
pkiconsole https://ipv6host.example.com:8443/ca
```

To use IPv6 numeric addresses, replace the fully-qualified domain name in the URL with the IPv6 address, enclosed in brackets (**[]**). For example:

```
https://[00:00:00:00:123:456:789:00:]:8443/ca/services
pkiconsole https://[00:00:00:00:123:456:789:00:]:8443/ca
```

3.4. Supported PKIX Formats and Protocols

The Certificate System supports many of the protocols and formats defined in Public-Key Infrastructure (X.509) by the IETF. In addition to the PKIX standards listed here, other PKIX-listed standards are available at the IETF Datatracker website.

Table 3.1. PKIX Standards Supported in Certificate System 9.0

Format or Protocol	RFC or Draft	Description
X.509 version 1 and version 3		Digital certificate formats recommended by the International Telecommunications Union (ITU).
Certificate Request Message Format (CRMF)	RFC 4211	A message format to send a certificate request to a CA.
Certificate Management Message Formats (CMMF)		Message formats to send certificate requests and revocation requests from end entities to a CA and to return information to end entities. CMMF has been subsumed by another standard, CMC.
Certificate Management Messages over CS (CMC)	RFC 5274	A general interface to public-key certification products based on CS and PKCS #10, including a certificate enrollment protocol for RSA-signed certificates with Diffie-Hellman public-keys. CMC incorporates CRMF and CMMF.
Cryptographic Message Syntax (CMS)	RFC 2630	A superset of PKCS #7 syntax used for digital signatures and encryption.
PKIX Certificate and CRL Profile	RFC 5280	A standard developed by the IETF for a public-key infrastructure for the Internet. It specifies profiles for certificates and CRLs.
Online Certificate Status Protocol (OCSP)	RFC 6960	A protocol useful in determining the current status of a digital certificate without requiring CRLs.

3.5. Supported Security and Directory Protocols

The Certificate System supports several common Internet and network protocols.

Table 3.2. Supported Security and Directory Protocols

Protocol	Description
FIPS PUBS 140	Federal Information Standards Publications (FIPS PUBS) 140 is a US government standard for implementing cryptographic modules such as hardware or software that encrypts and decrypts data, creates and verifies digital signatures, and provides other cryptographic functions. More information is available at http://csrc.nist.gov/publications/PubsFIPS.html.
Hypertext Transport Protocol (HTTP) and Hypertext Transport Protocol Secure (HTTPS)	Protocols used to communicate with web servers.

Protocol	Description
KEYGEN tag	An HTML tag that generates a key pair for use with a certificate.
Lightweight Directory Access Protocol (LDAP) v2, v3	A directory service protocol designed to run over TCP/IP and across multiple platforms. LDAP is a simplified version of Directory Access Protocol (DAP), used to access X.500 directories. LDAP is under IETF change control and has evolved to meet Internet requirements.
Public-Key Cryptography Standard (PKCS) #7	An encrypted data and message format developed by RSA Data Security to represent digital signatures, certificate chains, and encrypted data. This format is used to deliver certificates to end entities.
Public-Key Cryptography Standard (PKCS) #10	A message format developed by RSA Data Security for certificate requests. This format is supported by many server products.
Public-Key Cryptography Standard (PKCS) #11	Specifies an API used to communicate with devices such as hardware tokens that hold cryptographic information and perform cryptographic operations.
Transport Layer Security (TLS)	A set of rules governing server authentication, client authentication, and encrypted communication between servers and clients.
Security-Enhanced Linux	Security-enhanced Linux (SELinux) is a set of security protocols enforcing mandatory access control on Linux system kernels. SELinux was developed by the United States National Security Agency to keep applications from accessing confidential or protected files through lenient or flawed access controls.
Simple Certificate Enrollment Protocol (SCEP)	A protocol designed by Cisco to specify a way for a router to communicate with a CA for router certificate enrollment. Certificate System supports SCEP's CA mode of operation, where the request is encrypted with the CA signing certificate.
UTF-8	The certificate enrollment pages support all UTF-8 characters for specific fields (common name, organizational unit, requester name, and additional notes). The UTF-8 strings are searchable and correctly display in the CA, OCSP, and KRA end user and agents services pages. However, the UTF-8 support does not extend to internationalized domain names, such as those used in email addresses.
HTTPS	This protocol consists of communication over HTTP (Hypertext Transfer Protocol) within a connection encrypted by Transport Layer Security (TLS). The main purpose of HTTPS is authentication of the visited website and protection of privacy and integrity of the exchanged data.

Protocol	Description
IPv4 and IPv6	Certificate System supports both IPv4 and IPv6 address namespaces for communications and operations with all subsystems and tools, as well as for clients, subsystem creation, and token and certificate enrollment.

[1] For details, see https://tools.ietf.org/html/rfc7568.

[2] For more information on ECC, see RFC 4492 at http://ietf.org/rfc/rfc4492.txt

Chapter 4. Planning the Certificate System

Each Red Hat Certificate System subsystem can be installed on the same server machine, installed on separate servers, or have multiple instances installed across an organization. Before installing any subsystem, it is important to plan the deployment out: what kind of PKI services do you need? What are the network requirements? What people need to access the Certificate System, what are their roles, and what are their physical locations? What kinds of certificates do you want to issue and what constraints or rules need to be set for them?

This chapter covers some basic questions for planning a Certificate System deployment. Many of these decisions are interrelated; one choice impacts another, like deciding whether to use smart cards determines whether to install the TPS and TKS subsystems.

4.1. Deciding on the Required Subsystems

The Certificate System subsystems cover different aspects of managing certificates. Planning which subsystems to install is one way of defining what PKI operations the deployment needs to perform.

Certificates, like software or equipment, have a lifecycle with defined stages. At its most basic, there are three steps:

- It is requested and issued.
- It is valid.
- It expires.

However, this simplified scenario does not cover a lot of common issues with certificates:

- What if an employee leaves the company before the certificate expires?
- When a CA signing certificate expires, all of the certificates issued and signed using that certificate also expire. So will the CA signing certificate be renewed, allowing its issued certificates to remain valid, or will it be reissued?
- What if an employee loses a smart card or leaves it at home. Will a replacement certificate be issued using the original certificates keys? Will the other certificates be suspended or revoked? Are temporary certificates allowed?
- When a certificate expires, will a new certificate be issued or will the original certificate be renewed?

This introduces three other considerations for managing certificates: revocation, renewal, and replacements.

Other considerations are the loads on the certificate authority. Are there a lot of issuance or renewal requests? Is there a lot of traffic from clients trying to validate whether certificates are valid? How are people requesting certificates supposed to authenticate their identity, and does that process slow down the issuance process?

4.1.1. Using a Single Certificate Manager

The core of the Certificate System PKI is the Certificate Manager, a certificate authority. The CA receives certificate requests and issues all certificates.

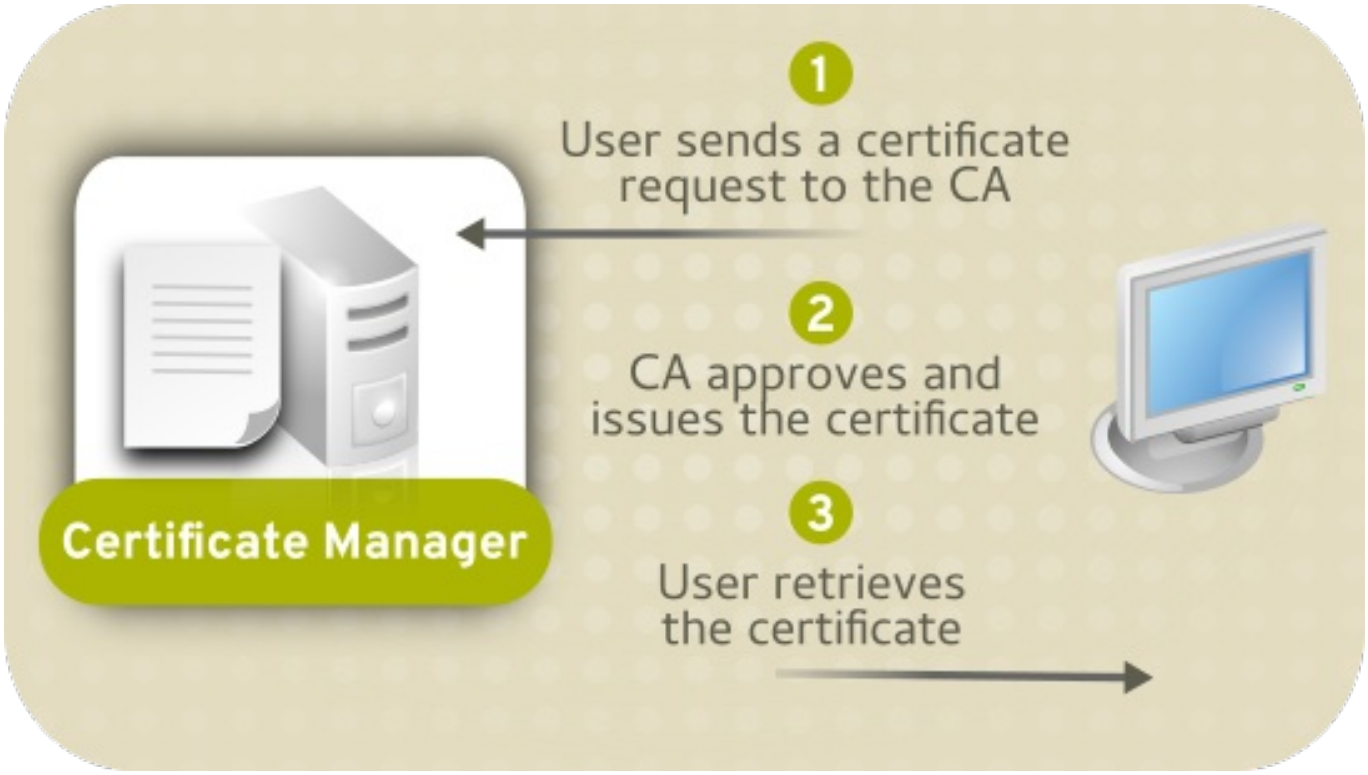
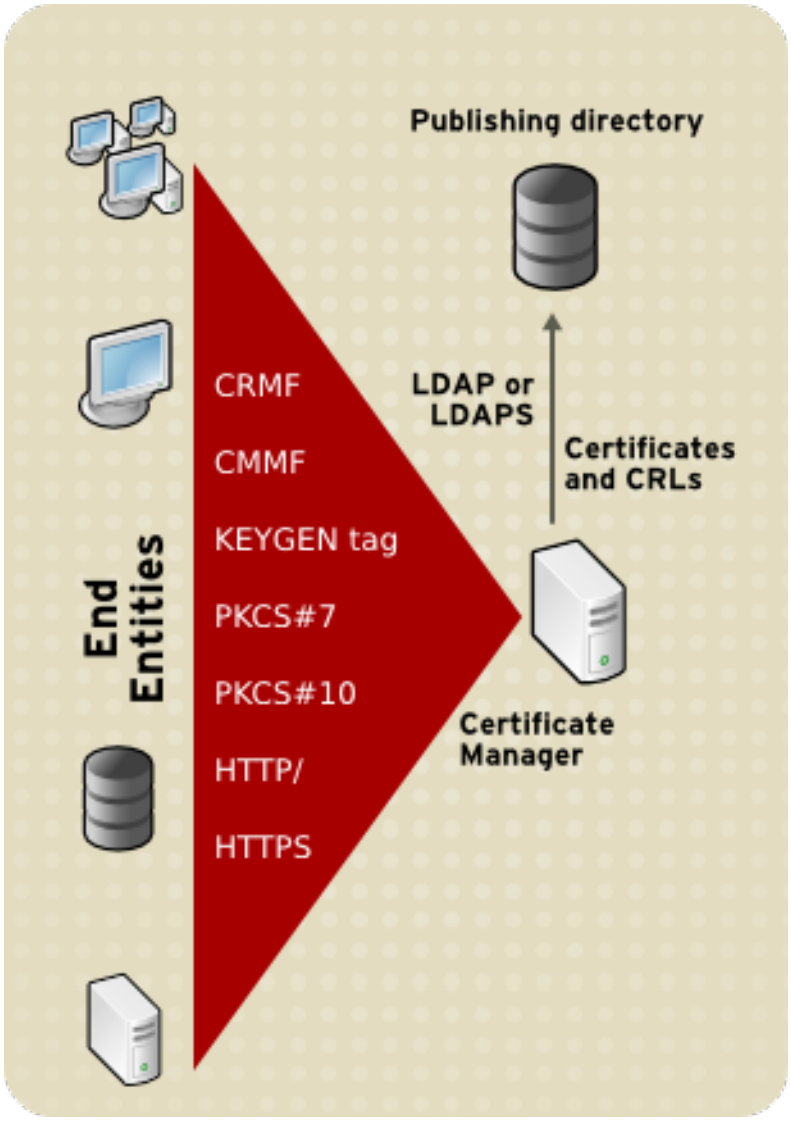


Figure 4.1. CA Only Certificate System

All of the basic processing for requests and issuing certificates can handled by the Certificate Manager, and it is the only required subsystem. There can be a single Certificate Manager or many Certificate Managers, arranged in many different relationships, depending on the demands of the organization.

Along with issuing certificates, a Certificate Manager can also revoke certificates. One question for administrators is how to handle certificates if they are lost, compromised, or if the person or equipment for which they are issued leaves the company. Revoking a certificate invalidates it before its expiration date, and a list of revoked certificates is compiled and published by the issuing CA so that clients can verify the certificate status.



4.1.2. Planning for Lost Keys: Key Archival and Recovery

One operation the CA cannot perform, though, is key archival and recovery. A very real scenario is that a user is going to lose his private key — for instance, the keys could be deleted from a browser database or a smart card could be left at home. Many common business operations use encrypted data, like encrypted email, and losing the keys which unlock that data means the data itself is lost. Depending on the policies in the company, there probably has to be a way to recover the keys in order to regenerate or reimport a replacement certificate, and both operations require the private key.

That requires a KRA, the subsystem which specially archives and retrieves keys.

Figure 4.2. CA and KRA

The Key Recovery Authority stores encryption keys (key archival) and can retrieve those keys so that the CA can reissue a certificate (key recovery). A KRA can store keys for any certificate generated by Certificate System, whether it is done for a regular certificate or when enrolling a smart card.

The key archival and recovery process is explained in more detail in Section 2.2.5, “Archiving, Recovering, and Rotating Keys”.

Note

The KRA is intended for archival and recovery of private encryption keys only. Therefore, end users must use a browser that supports dual-key generation to store their public-private key pairs.

4.1.3. Balancing Certificate Request Processing

Another aspect of how the subsystems work together is load balancing. If a site has high traffic, then it is possible to simply install a lot of CAs, as clones of each other or in a flat hierarchy (where each CA is independent) or in a tree hierarchy (where some CAs are subordinate to other CAs); this is covered more in Section 4.2, “Defining the Certificate Authority Hierarchy”.

4.1.4. Balancing Client OCSP Requests

If a certificate is within its validity period but needs be invalidated, it can be revoked. A Certificate Manager can publish lists of revoked certificates, so that when a client needs to verify that a certificate is still valid, it can check the list. These requests are *online certificate status protocol requests*, meaning that they have a specific request and response format. The Certificate Manager has a built-in OCSP responder so that it can verify OCSP requests by itself.

However, as with certificate request traffic, a site may have a significant number of client requests to verify certificate status. Example Corp. has a large web store, and each customer's browser tries to verify the validity of their SSL/TLS certificates. Again, the CA can handle issuing the number of certificates, but the high request traffic affects its performance. In this case, Example Corp. uses the external OCSP Manager subsystem to verify certificate statuses, and the Certificate Manager only has to publish updated CRLs every so often.

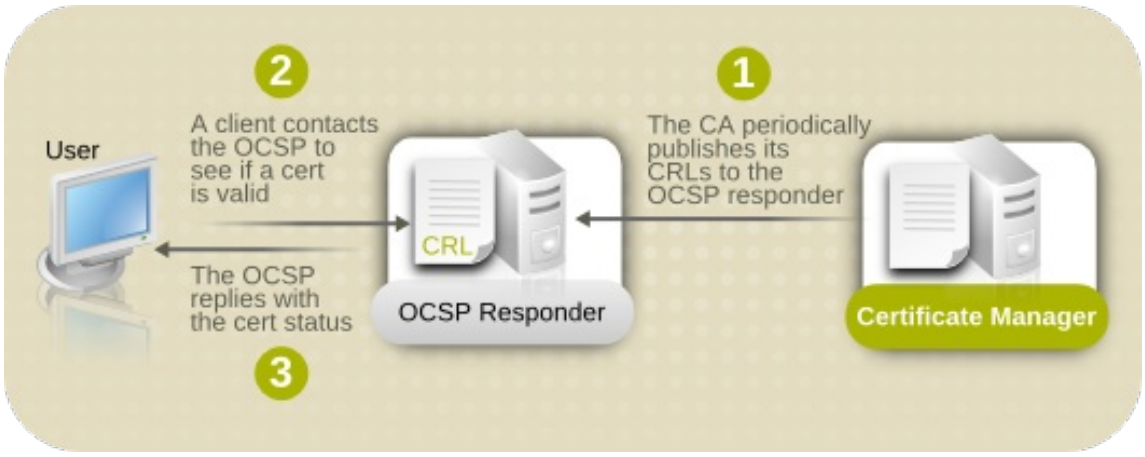
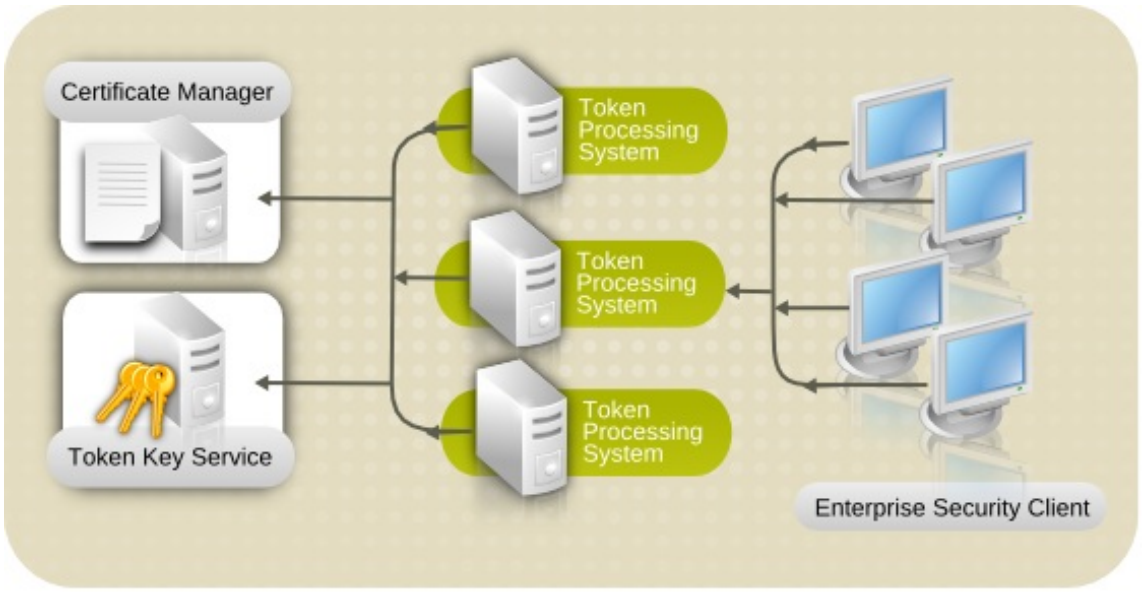


Figure 4.3. CA and OCSP

4.1.5. Using Smart Cards

Smart cards usually require in-person enrollment and approval processes, since they use a physical medium to store key and certificate data. That means that multiple agents need to have access to the TPS and, possibly, multiple TPS subsystems in different offices or geographic locations.

The token management system is very scalable. Multiple TPSs can be configured to work with a single CA, TKS, or KRA instance, while multiple Enterprise Security Clients can communicate with a single TPS. As additional clients are installed, they can point back to the TPS instance without having to reconfigure the TPS; likewise, as TPSs are added, they can point to the same CA, TKS, and KRA instances without having to reconfigure those subsystems.



After installation, the TPS configuration can be edited to use additional CA, KRA, and TKS instances for failover support, so if the primary subsystem is unavailable, the TPS can switch to the next available system without interrupting its token services.

4.2. Defining the Certificate Authority Hierarchy

The CA is the center of the PKI, so the relationship of CA systems, both to each other (CA hierarchy) and to other subsystems (security domain) is vital to planning a Certificate System PKI.

When there are multiple CAs in a PKI, the CAs are structured in a hierarchy or chain. The CA above another CA in a chain is called an *root CA*; a CA below another CA in the chain is called a *subordinate CA*. A CA can also be subordinate to a root outside of the Certificate System deployment; for example, a CA which functions as a root CA within the Certificate System deployment can be subordinate to a third-party CA.

A Certificate Manager (or CA) is subordinate to another CA because its CA signing certificate, the certificate that allows it to issue certificates, is issued by another CA. The CA that issued the subordinate CA signing certificate controls the CA through the contents of the CA signing certificate. The CA can constrain the subordinate CA through the kinds of certificates that it can issue, the extensions that it is allowed to include in certificates, the number of levels of subordinate CAs the subordinate CA can create, and the validity period of certificates it can issue, as well as the validity period of the subordinate CAs signing certificate.

Note

Although a subordinate CA can create certificates that violate these constraints, a client authenticating a certificate that violates those constraints will not accept that certificate.

A self-signed root CA signs its own CA signing certificate and sets its own constraints as well as setting constraints on the subordinate CA signing certificates it issues.

A Certificate Manager can be configured as either a root CA or a subordinate CA. It is easiest to make the first CA installed a self-signed root, so that it is not necessary to apply to a third party and wait for the certificate to be issued. Before deploying the full PKI, however, consider whether to have a root CA, how many to have, and where both root and subordinate CAs will be located.

4.2.1. Subordination to a Public CA

Chaining the Certificate System CA to a third-party public CA introduces the restrictions that public CAs place on the kinds of certificates the subordinate CA can issue and the nature of the certificate chain. For example, a CA that chains to a third-party CA might be restricted to issuing only Secure Multipurpose Internet Mail Extensions (S/MIME) and SSL/TLS client authentication certificates, but not SSL/TLS server certificates. There are other possible restrictions with using a public CA. This may not be acceptable for some PKI deployments.

One benefit of chaining to a public CA is that the third party is responsible for submitting the root CA certificate to a web browser or other client software. This can be a major advantage for an extranet with certificates that are accessed by different companies with browsers that cannot be controlled by the administrator. Creating a root CA in the CA hierarchy means that the local organization must get the root certificate into all the browsers which will use the certificates issued by the Certificate System. There are tools to do this within an intranet, but it can be difficult to accomplish with an extranet.

4.2.2. Subordination to a Certificate System CA

The Certificate System CA can function as a *root CA*, meaning that the server signs its own CA signing certificate as well as other CA signing certificates, creating an organization-specific CA hierarchy. The server can alternatively be configured as a *subordinate CA*, meaning the server's CA signing key is signed by another CA in an existing CA hierarchy.

Setting up a Certificate System CA as the root CA means that the Certificate System administrator has control over all subordinate CAs by setting policies that control the contents of the CA signing certificates issued. A subordinate CA issues certificates by evaluating its own authentication and certificate profile configuration, without regard for the root CA's configuration.

4.2.3. Linked CA

The Certificate System Certificate Manager can function as a *linked CA*, chaining up to many third-party or public CAs for validation; this provides cross-company trust, so applications can verify certificate chains outside the company certificate hierarchy. A Certificate Manager is chained to a third-party CA by requesting the Certificate Manager's *CA signing certificate* from the third-party CA.

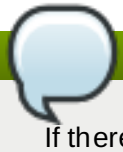
Related to this, the Certificate Manager also can issue *cross-pair* or *cross-signed certificates*. Cross-pair certificates create a trusted relationship between two separate CAs by issuing and storing cross-signed certificates between these two CAs. By using cross-signed certificate pairs, certificates issued outside the organization's PKI can be trusted within the system.

These are also called *bridge certificates*, related to the Federal Bridge Certification Authority (FBCA) definition.

4.2.4. CA Cloning

Instead of creating a hierarchy of root and subordinate CAs, it is possible to create multiple clones of a Certificate Manager and configure each clone to issue certificates within a range of serial numbers.

A *cloned* Certificate Manager uses the same CA signing key and certificate as another Certificate Manager, the *master* Certificate Manager.



Note

If there is a chance that a subsystem will be cloned, then it is easiest to export its key pairs during the configuration process and save them to a secure location. The key pairs for the original Certificate Manager have to be available when the clone instance is configured, so that the clone can generate its certificates from the original Certificate Manager's keys.

It is also possible to export the keys from the security databases at a later time, using the **`pk12util`** or the **`PKCS12Export`** commands.

Because clone CAs and original CAs use the same CA signing key and certificate to sign the certificates they issue, the *issuer name* in all the certificates is the same. Clone CAs and the original Certificate Managers issue certificates as if they are a single CA. These servers can be placed on different hosts for high availability failover support.

The advantage of cloning is that it distributes the Certificate Manager's load across several processes or even several physical machines. For a CA with a high enrollment demand, the distribution gained from cloning allows more certificates to be signed and issued in a given time interval.

A cloned Certificate Manager has the same features, such as agent and end-entity gateway functions, of a regular Certificate Manager.

The serial numbers for certificates issued by clones are distributed dynamically. The databases for each clone and master are replicated, so all of the certificate requests and issued certificates, both, are also replicated. This ensures that there are no serial number conflicts while serial number ranges do not have to be manually assigned to the cloned Certificate Managers.

4.3. Planning Security Domains

A *security domain* is a registry of PKI services. PKI services, such as CAs, register information about themselves in these domains so users of PKI services can find other services by inspecting the registry. The security domain service in Certificate System manages both the registration of PKI services for Certificate System subsystems and a set of shared trust policies.

The registry provides a complete view of all PKI services provided by the subsystems within that domain. Each Certificate System subsystem must be either a host or a member of a security domain.

A CA subsystem is the only subsystem which can host a security domain. The security domain shares the CA internal database for privileged user and group information to determine which users can update the security domain, register new PKI services, and issue certificates.

A security domain is created during CA configuration, which automatically creates an entry in the security domain CA's LDAP directory. Each entry contains all the important information about the domain. Every subsystem within the domain, including the CA registering the security domain, is recorded under the security domain container entry.

The URL to the CA uniquely identifies the security domain. The security domain is also given a friendly name, such as **`Example Corp Intranet PKI`**. All other subsystems — KRA, TPS, TKS, OCSP, and other CAs — must become members of the security domain by supplying the security domain URL when configuring the subsystem.

Each subsystem within the security domain shares the same trust policies and trusted roots which can be retrieved from different servers and browsers. The information available in the security domain is used during configuration of a new subsystem, which makes the configuration process streamlined and automated. For example, when a TPS needs to connect to a CA, it can consult the security domain to get a list of available CAs.

Each CA has its own LDAP entry. The security domain is an organizational group underneath that CA entry:

```
ou=Security Domain,dc=server.example.com-pki-ca
```

Then there is a list of each subsystem type beneath the security domain organizational group, with a special object class (**`pkiSecurityGroup`**) to identify the group type:

```
cn=KRAList,ou=Security Domain,o=pki-tomcat-CA
objectClass: top
objectClass: pkiSecurityGroup
cn: KRAList
```

Each subsystem instance is then stored as a member of that group, with a special **`pkiSubsystem`** object class to identify the entry type:

```
dn: cn=kra.example.com:8443,cn=KRAList,ou=Security Domain,o=pki-tomcat-CA
objectClass: top
objectClass: pkiSubsystem
cn: kra.example.com:8443
```

```
host: server.example.com
UnSecurePort: 8080
SecurePort: 8443
SecureAdminPort: 8443
SecureAgentPort: 8443
SecureEEClientAuthPort: 8443
DomainManager: false
Clone: false
SubsystemName: KRA kra.example.com 8443
```

If a subsystem needs to contact another subsystem to perform an operation, it contacts the CA which hosts the security domain (by invoking a servlet which connects over the administrative port of the CA). The security domain CA then retrieves the information about the subsystem from its LDAP database, and returns that information to the requesting subsystem.

The subsystem authenticates to the security domain using a subsystem certificate.

Consider the following when planning the security domain:

- The CA hosting the security domain can be signed by an external authority.
- Multiple security domains can be set up within an organization. However, each subsystem can belong to only one security domain.
- Subsystems within a domain can be cloned. Cloning subsystem instances distributes the system load and provides failover points.
- The security domain streamlines configuration between the CA and KRA; the KRA can push its KRA connector information and transport certificates automatically to the CA instead of administrators having to manually copy the certificates over to the CA.
- The Certificate System security domain allows an offline CA to be set up. In this scenario, the offline root has its own security domain. All online subordinate CAs belong to a different security domain.
- The security domain streamlines configuration between the CA and OCSP. The OCSP can push its information to the CA for the CA to set up OCSP publishing and also retrieve the CA certificate chain from the CA and store it in the internal database.

4.4. Determining the Requirements for Subsystem Certificates

The CA configuration determines many of the characteristics of the certificates which it issues, regardless of the actual type of certificate being issued. Constraints on the CA's own validity period, distinguished name, and allowed encryption algorithms impact the same characteristics in their issued certificates. Additionally, the Certificate Managers have predefined profiles that set rules for different kinds of certificates that they issue, and additional profiles can be added or modified. These profile configurations also impact issued certificates.

4.4.1. Determining Which Certificates to Install

When a Certificate System subsystem is first installed and configured, the certificates necessary to access and administer it are automatically created. These include an agent's certificate, server certificate, and subsystem-specific certificates. These initial certificates are shown in Table 4.1, “Initial Subsystem Certificates”.

Table 4.1. Initial Subsystem Certificates

Subsystem	Certificates
Certificate Manager	CA signing certificate OCSP signing certificate SSL/TLS server certificate Subsystem certificate User's (agent/administrator) certificate Audit log signing certificate
OCSP	OCSP signing certificate SSL/TLS server certificate Subsystem certificate User's (agent/administrator) certificate Audit log signing certificate
KRA	Transport certificate Storage certificate SSL/TLS server certificate Subsystem certificate User's (agent/administrator) certificate Audit log signing certificate
TKS	SSL/TLS server certificate User's (agent/administrator) certificate Audit log signing certificate
TPS	SSL/TLS server certificate User's (agent/administrator) certificate Audit log signing certificate

There are some cautionary considerations about replacing existing subsystem certificates.

- Generating new key pairs when creating a new self-signed CA certificate for a root CA will invalidate all certificates issued under the previous CA certificate.

  This means none of the certificates issued or signed by the CA using its old key will work; subordinate Certificate Managers, KRAs, OCSPs, TKSs, and TPSs will no longer function, and agents can no longer to access agent interfaces.

  This same situation occurs if a subordinate CA's CA certificate is replaced by one with a new key pair; all certificates issued by that CA are invalidated and will no longer work.

  Instead of creating new certificates from new key pairs, consider renewing the existing CA signing certificate.

- If the CA is configured to publish to the OCSP and it has a new CA signing certificate or a new CRL signing certificate, the CA must be identified again to the OCSP.

- If a new transport certificate is created for the KRA, the KRA information must be updated in the CA's configuration file, **`CS.cfg`**. The existing transport certificate must be replaced with the new one in the **`ca.connector.KRA.transportCert`** parameter.

- If a CA is cloned, then when creating a new SSL/TLS server certificate for the master Certificate Manager, the clone CAs' certificate databases all need updated with the new SSL/TLS server certificate.

- If the Certificate Manager is configured to publish certificates and CRLs to an LDAP directory and uses the SSL/TLS server certificate for SSL/TLS client authentication, then the new SSL/TLS server certificate must be requested with the appropriate extensions. After installing the certificate, the publishing directory must be configured to use the new server certificate.
- Any number of SSL/TLS server certificates can be issued for a subsystem instance, but it really only needs one SSL/TLS certificate. This certificate can be renewed or replaced as many times as necessary.

4.4.2. Planning the CA Distinguished Name

The core elements of a CA are a signing unit and the Certificate Manager identity. The signing unit digitally signs certificates requested by end entities. A Certificate Manager must have its own distinguished name (DN), which is listed in every certificate it issues.

Like any other certificate, a CA certificate binds a DN to a public key. A DN is a series of name-value pairs that in combination uniquely identify an entity. For example, the following DN identifies a Certificate Manager for the Engineering department of a corporation named Example Corporation:

```
cn=demoCA, o=Example Corporation, ou=Engineering, c=US
```

Many combinations of name-value pairs are possible for the Certificate Manager's DN. The DN must be unique and readily identifiable, since any end entity can examine it.

4.4.3. Setting the CA Signing Certificate Validity Period

Every certificate, including a Certificate Manager signing certificate, must have a validity period. The Certificate System does not restrict the validity period that can be specified. Set as long a validity period as possible, depending on the requirements for certificate renewal, the place of the CA in the certificate hierarchy, and the requirements of any public CAs that are included in the PKI.

A Certificate Manager cannot issue a certificate that has a validity period longer than the validity period of its CA signing certificate. If a request is made for a period longer than the CA certificate's validity period, the requested validity date is ignored and the CA signing certificate validity period is used.

4.4.4. Choosing the Signing Key Type and Length

A signing key is used by a subsystem to verify and "seal" something. CAs use a CA signing certificate to sign certificates or CRLs that it issues; OCSPs use signing certificates to verify their responses to certificate status requests; all subsystems use log file signing certificates to sign their audit logs.

The signing key must be cryptographically strong to provide protection and security for its signing operations. The following signing algorithms are considered secure:

- SHA256withRSA
- SHA512withRSA
- SHA256withEC
- SHA512withEC

Note

Certificate System includes native ECC support. It is also possible to load and use a third-party PKCS #11 module with ECC-enabled. This is covered in Chapter 9, *Installing an Instance with ECC System Certificates*.

Along with a key *type*, each key has a specific *bit length*. Longer keys are considered cryptographically stronger than shorter keys. However, longer keys require more time for signing operations.

The default RSA key length in the configuration wizard is 2048 bits; for certificates that provide access to highly sensitive data or services, consider increasing the length to 4096 bits. ECC keys are much stronger than RSA keys, so the recommended length for ECC keys is 256 bits, which is equivalent in strength to a 2048-bit RSA key.

4.4.5. Using Certificate Extensions

An X.509 v3 certificate contains an extension field that permits any number of additional fields to be added to the certificate. Certificate extensions provide a way of adding information such as alternative subject names and usage restrictions to certificates. Older Netscape servers, such as Red Hat Directory Server and Red Hat Certificate System, require Netscape-specific extensions because they were developed before PKIX part 1 standards were defined.

The X.509 v1 certificate specification was originally designed to bind public keys to names in an X.500 directory. As certificates began to be used on the Internet and extranets and directory lookups could not always be performed, problem areas emerged that were not covered by the original specification.

- *Trust*. The X.500 specification establishes trust by means of a strict directory hierarchy. By contrast, Internet and extranet deployments frequently involve distributed trust models that do not conform to the hierarchical X.500 approach.
- *Certificate use*. Some organizations restrict how certificates are used. For example, some certificates may be restricted to client authentication only.
- *Multiple certificates*. It is not uncommon for certificate users to possess multiple certificates with identical subject names but different key material. In this case, it is necessary to identify which key and certificate should be used for what purpose.
- *Alternate names*. For some purposes, it is useful to have alternative subject names that are also bound to the public key in the certificate.
- *Additional attributes*. Some organizations store additional information in certificates, such as when it is not possible to look up information in a directory.
- *Relationship with CA*. When certificate chaining involves intermediate CAs, it is useful to have information about the relationships among CAs embedded in their certificates.
- *CRL checking*. Since it is not always possible to check a certificate's revocation status against a directory or with the original certificate authority, it is useful for certificates to include information about where to check CRLs.

The X.509 v3 specification addressed these issues by altering the certificate format to include additional information within a certificate by defining a general format for certificate extensions and specifying extensions that can be included in the certificate. The extensions defined for X.509 v3 certificates enable additional attributes to be associated with users or public keys and manage the

certification hierarchy. The *Internet X.509 Public Key Infrastructure Certificate and CRL Profile* recommends a set of extensions to use for Internet certificates and standard locations for certificate or CA information. These extensions are called *standard extensions*.

Note

For more information on standard extensions, see RFC 2459, RFC 3280, and RFC 3279.

The X.509 v3 standard for certificates allows organizations to define custom extensions and include them in certificates. These extensions are called *private*, *proprietary*, or *custom* extensions, and they carry information unique to an organization or business. Applications may not able to validate certificates that contain private critical extensions, so it not recommended that these be used in wide-spread situations.

The X.500 and X.509 specifications are controlled by the International Telecommunication Union (ITU), an international organization that primarily serves large telecommunication companies, government organizations, and other entities concerned with the international telecommunications network. The Internet Engineering Task Force (IETF), which controls many of the standards that underlie the Internet, is currently developing public-key infrastructure X.509 (PKIX) standards. These proposed standards further refine the X.509 v3 approach to extensions for use on the Internet. The recommendations for certificates and CRLs have reached proposed standard status and are in a document referred to as *PKIX Part 1*.

Two other standards, Abstract Syntax Notation One (ASN.1) and Distinguished Encoding Rules (DER), are used with Certificate System and certificates in general. These are specified in the CCITT Recommendations X.208 and X.209. For a quick summary of ASN.1 and DER, see *A Layman's Guide to a Subset of ASN.1, BER, and DER*, which is available at RSA Laboratories' web site, http://www.rsa.com.

4.4.5.1. Structure of Certificate Extensions

In RFC 3280, an X.509 certificate extension is defined as follows:

```
Extension  ::=  SEQUENCE  {

extnID OBJECT IDENTIFIER,
critical BOOLEAN DEFAULT FALSE,
extnValue OCTET STRING  }
```

The means a certificate extension consists of the following:

- The object identifier (OID) for the extension. This identifier uniquely identifies the extension. It also determines the ASN.1 type of value in the value field and how the value is interpreted. When an extension appears in a certificate, the OID appears as the extension ID field (**`extnID`**) and the corresponding ASN.1 encoded structure appears as the value of the octet string (**`extnValue`**).
- A flag or Boolean field called **`critical`**.

  The value, which can be either **`true`** or **`false`**, assigned to this field indicates whether the extension is critical or noncritical to the certificate.

  - If the extension is critical and the certificate is sent to an application that does not understand the extension based on the extension's ID, the application must reject the certificate.

- If the extension is not critical and the certificate is sent to an application that does not understand the extension based on the extension's ID, the application can ignore the extension and accept the certificate.

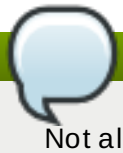
- An octet string containing the DER encoding of the value of the extension.

Typically, the application receiving the certificate checks the extension ID to determine if it can recognize the ID. If it can, it uses the extension ID to determine the type of value used.

Some of the standard extensions defined in the X.509 v3 standard include the following:

- Authority Key Identifier extension, which identifies the CA's public key, the key used to sign the certificate.

- Subject Key Identifier extension, which identifies the subject's public key, the key being certified.



Note

Not all applications support certificates with version 3 extensions. Applications that do support these extensions may not be able to interpret some or all of these specific extensions.

4.4.6. Using and Customizing Certificate Profiles

Certificates have different types and different applications. They can be used to establish a single sign-on environment for a corporate network, to set up VPNs, to encrypt email, or to authenticate to a website. The requirements for all of these certificates can be different, just as there may also be different requirements for the same type of certificate for different kinds of users. These certificate characteristics are set in *certificate profiles*. The Certificate Manager defines a set of certificate profiles that it uses as enrollment forms when users or machines request certificates.

Certificate Profiles

A certificate profile defines everything associated with issuing a particular type of certificate, including the authentication method, the certificate content (defaults), constraints for the values of the content, and the contents of the input and output for the certificate profile. Enrollment requests are submitted to a certificate profile and are then subject to the defaults and constraints set in that certificate profile. These constraints are in place whether the request is submitted through the input form associated with the certificate profile or through other means. The certificate that is issued from a certificate profile request contains the content required by the defaults with the information required by the default parameters. The constraints provide rules for what content is allowed in the certificate.

For example, a certificate profile for user certificates defines all aspects of that certificate, including the validity period of the certificate. The default validity period can be set to two years, and a constraint can be set on the profile that the validity period for certificates requested through this certificate profile cannot exceed two years. When a user requests a certificate using the input form associated with this certificate profile, the issued certificate contains the information specified in the defaults and will be valid for two years. If the user submits a pre-formatted request for a certificate with a validity period of four years, the request is rejected since the constraints allow a maximum of two years validity period for this type of certificate.

A set of certificate profiles have been predefined for the most common certificates issued. These certificate profiles define defaults and constraints, associate the authentication method, and define the needed inputs and outputs for the certificate profile.

Modifying the Certificate Profile Parameters

The parameters of the default certificate profiles can be modified; this includes the authentication method, the defaults, the constraints used in each profile, the values assigned to any of the parameters in a profile, the input, and the output. It is also possible to create new certificate profiles for other types of certificates or for creating more than one certificate profile for a certificate type. There can be multiple certificate profiles for a particular type of certificate to issue the same type of certificate with a different authentication method or different definitions for the defaults and constraints. For example, there can be two certificate profiles for enrollment of SSL/TLS server certificates where one certificate profile issues certificates with a validity period of six months and another certificate profile issues certificates with a validity period of two years.

An input sets a text field in the enrollment form and what kind of information needs gathered from the end entity; this includes setting the text area for a certificate request to be pasted, which allows a request to be created outside the input form with any of the request information desired. The input values are set as values in the certificate. The default inputs are not configurable in the Certificate System.

An output specifies how the response page to a successful enrollment is presented. It usually displays the certificate in a user-readable format. The default output shows a printable version of the resultant certificate; other outputs set the type of information generated at the end of the enrollment, such as PKCS #7.

Policy sets are sets of constraints and default extensions attached to every certificate processed through the profile. The extensions define certificate content such as validity periods and subject name requirements. A profile handles one certificate request, but a single request can contain information for multiple certificates. A PKCS#10 request contains a single public key. One CRMF request can contain multiple public keys, meaning multiple certificate requests. A profile may contain multiple sets of policies, with each set specifying how to handle one certificate request within a CRMF request.

Certificate Profile Administration

An administrator sets up a certificate profile by associating an existing authentication plug-in, or method, with the certificate profile; enabling and configuring defaults and constraints; and defining inputs and outputs. The administrator can use the existing certificate profiles, modify the existing certificate profiles, create new certificate profiles, and delete any certificate profile that will not be used in this PKI.

Once a certificate profile is set up, it appears on the **`Manage Certificate Profiles`** page of the agent services page where an agent can approve, and thus enable, a certificate profile. Once the certificate profile is enabled, it appears on the **`Certificate Profile`** tab of the end-entities page where end entities can enroll for a certificate using the certificate profile.

The certificate profile enrollment page in the end-entities interface contains links to each certificate profile that has been enabled by the agents. When an end entity selects one of those links, an enrollment page appears containing an enrollment form specific to that certificate profile. The enrollment page is dynamically generated from the inputs defined for the profile. If an authentication plug-in is configured, additional fields may be added to authenticate the user.

When an end entity submits a certificate profile request that is associated with an agent-approved (manual) enrollment, an enrollment where no authentication plug-in is configured, the certificate request is queued in the agent services interface. The agent can change some aspects of the enrollment, request, validate it, cancel it, reject it, update it, or approve it. The agent is able to update the request without submitting it or validate that the request adheres to the profile's defaults and

constraints. This validation procedure is only for verification and does not result in the request being submitted. The agent is bound by the constraints set; they cannot change the request in such a way that a constraint is violated. The signed approval is immediately processed, and a certificate is issued.

When a certificate profile is associated with an authentication method, the request is approved immediately and generates a certificate automatically if the user successfully authenticates, all the information required is provided, and the request does not violate any of the constraints set up for the certificate profile. There are profile policies which allow user-supplied settings like subject names or validity periods. The certificate profile framework can also preserve user-defined content set in the original certificate request in the issued certificate.

The issued certificate contains the content defined in the defaults for this certificate profile, such as the extensions and validity period for the certificate. The content of the certificate is constrained by the constraints set for each default. Multiple policies (defaults and constraints) can be set for one profile, distinguishing each set by using the same value in the policy set ID. This is particularly useful for dealing with dual keys enrollment where encryption keys and signing keys are submitted to the same profile. The server evaluates each set with each request it receives. When a single certificate is issued, one set is evaluated, and any other sets are ignored. When dual-key pairs are issued, the first set is evaluated with the first certificate request, and the second set is evaluated with the second certificate request. There is no need for more than one set for issuing a single certificate or more than two sets for issuing dual-key pairs.

Guidelines for Customizing Certificate Profiles

Tailor the profiles for the organization to the real needs and anticipated certificate types used by the organization:

- Decide which certificate profiles are needed in the PKI. There should be at least one profile for each type of certificate issued. There can be more than one certificate profile for each type of certificate to set different authentication methods or different defaults and constraints for a particular type of certificate type. Any certificate profile available in the administrative interface can be approved by an agent and then used by an end entity to enroll.
- Delete any certificate profiles that will not be used.
- Modify the existing certificate profiles for specific characteristics for the company's certificates.
  - Change the defaults set up in the certificate profile, the values of the parameters set in the defaults, or the constraints that control the certificate content.
  - Change the constraints set up by changing the value of the parameters.
  - Change the authentication method.
  - Change the inputs by adding or deleting inputs in the certificate profile, which control the fields on the input page.
  - Add or delete the output.

4.4.6.1. Adding SAN Extensions to the SSL Server Certificate

Certificate System enables adding Subject Alternative Name (SAN) extensions to the SSL server certificate during the installation of non-root CA or other Certificate System instances. To do so, follow the instructions in the **`/usr/share/pki/ca/profiles/ca/caInternalAuthServerCert.cfg`** file and add the following parameters to the configuration file supplied to the **`pkispawn`** utility:

pki_san_inject

Set the value of this parameter to **True**.

pki_san_for_server_cert

Provide a list of the required SAN extensions separated by commas (,).

For example:

```
pki_san_inject=True
pki_san_for_server_cert=intca01.example.com,intca02.example.com,intca.exa
mple.com
```

4.4.7. Planning Authentication Methods

As implied in Section 4.4.6, “Using and Customizing Certificate Profiles”, *authentication* for the certificate process means the way that a user or entity requesting a certificate proves that they are who they say they are. There are three ways that the Certificate System can authenticate an entity:

- In *agent-approved* enrollment, end-entity requests are sent to an agent for approval. The agent approves the certificate request.
- In *automatic* enrollment, end-entity requests are authenticated using a plug-in, and then the certificate request is processed; an agent is not involved in the enrollment process.
- In *CMC enrollment*, a third party application can create a request that is signed by an agent and then automatically processed.

A Certificate Manager is initially configured for agent-approved enrollment and for CMC authentication. Automated enrollment is enabled by configuring one of the authentication plug-in modules. More than one authentication method can be configured in a single instance of a subsystem. The HTML registration pages contain hidden values specifying the method used. With certificate profiles, the end-entity enrollment pages are dynamically-generated for each enabled profile. The authentication method associated with this certificate profile is specified in the dynamically-generated enrollment page.

The authentication process is simple.

1. An end entity submits a request for enrollment. The form used to submit the request identifies the method of authentication and enrollment. All HTML forms are dynamically-generated by the profiles, which automatically associate the appropriate authentication method with the form.
2. If the authentication method is an agent-approved enrollment, the request is sent to the request queue of the CA agent. If the automated notification for a request in queue is set, an email is sent to the appropriate agent that a new request has been received. The agent can modify the request as allowed for that form and the profile constraints. Once approved, the request must pass the certificate profiles set for the Certificate Manager, and then the certificate is issued. When the certificate is issued, it is stored in the internal database and can be retrieved by the end entity from the end-entities page by serial number or by request ID.
3. If the authentication method is automated, the end entity submits the request along with required information to authenticate the user, such as an LDAP username and password. When the user is successfully authenticated, the request is processed without being sent to an agent's queue. If the request passes the certificate profile configuration of the Certificate

Manager, the certificate is issued and stored in the internal database. It is delivered to the end entity immediately through the HTML forms.

The requirements for how a certificate request is authenticated can have a direct impact on the necessary subsystems and profile settings. For example, if an agent-approved enrollment requires that an agent meet the requester in person and verify their identity through supported documentation, the authentication process can be time-intensive, as well as constrained by the physical availability of both the agent and the requester.

4.4.8. Publishing Certificates and CRLs

A CA can publish both certificates and CRLs. Certificates can be published to a plain file or to an LDAP directory; CRLs can be published to file or an LDAP directory, as well, and can also be published to an OCSP responder to handle certificate verification.

Configuring publishing is fairly straightforward and is easily adjusted. For continuity and accessibility, though, it is good to plan out where certificates and CRLs need to be published and what clients need to be able to access them.

Publishing to an LDAP directory requires special configuration in the directory for publishing to work:

- If certificates are published to the directory, than every user or server to which a certificate is issued must have a corresponding entry in the LDAP directory.
- If CRLs are published to the directory, than they must be published to an entry for the CA which issued them.
- For SSL/TLS, the directory service has to be configured in SSL/TLS and, optionally, be configured to allow the Certificate Manager to use certificate-based authentication.
- The directory administrator should configure appropriate access control rules to control DN (entry name) and password based authentication to the LDAP directory.

4.4.9. Renewing or Reissuing CA Signing Certificates

When a CA signing certificate expires, all certificates signed with the CA's corresponding signing key become invalid. End entities use information in the CA certificate to verify the certificate's authenticity. If the CA certificate itself has expired, applications cannot chain the certificate to a trusted CA.

There are two ways of resolving CA certificate expiration:

- *Renewing* a CA certificate involves issuing a new CA certificate with the same subject name and public and private key material as the old CA certificate, but with an extended validity period. As long as the new CA certificate is distributed to all users before the old CA certificate expires, renewing the certificate allows certificates issued under the old CA certificate to continue working for the full duration of their validity periods.
- *Reissuing* a CA certificate involves issuing a new CA certificate with a new name, public and private key material, and validity period. This avoids some problems associated with renewing a CA certificate, but it requires more work for both administrators and users to implement. All certificates issued by the old CA, including those that have not yet expired, must be renewed by the new CA.

There are problems and advantages with either renewing or reissuing a CA certificate. Begin planning the CA certificate renewal or re-issuance before installing any Certificate Managers, and consider the ramifications the planned procedures may have for extensions, policies, and other aspects of the PKI deployment.

Note

Correct use of extensions, for example the **`authorityKeyIdentifier`** extension, can affect the transition from an old CA certificate to a new one.

4.5. Planning for Network and Physical Security

When deploying any Certificate System subsystem, the physical and network security of the subsystem instance has to be considered because of the sensitivity of the data generated and stored by the subsystems.

4.5.1. Considering Firewalls

There are two considerations about using firewalls with Certificate System subsystems:

- Protecting sensitive subsystems from unauthorized access
- Allowing appropriate access to other subsystems and clients outside of the firewall

The CA, KRA, and TKS are always placed inside a firewall because they contain critical information that can cause devastating security consequences if they are compromised.

The TPS and OCSP can be placed outside the firewall. Likewise, other services and clients used by the Certificate System can be on a different machine outside the firewall. In that case, the local networks have to be configured to allow access between the subsystems behind the firewall and the services outside it.

The LDAP database can be on a different server, even on a different network, than the subsystem which uses it. In this case, all LDAP ports (**389** for LDAP and **636** for LDAPS, by default) need to be open in the firewall to allow traffic to the directory service. Without access to the LDAP database, all subsystem operations can fail.

As part of configuring the firewalls, if iptables is enabled, then it must have configured policies to allow communication over the appropriate Certificate System ports. Configuring iptables is described in the Red Hat Enterprise Linux *Deployment Guide*, such as "Using iptables."

4.5.2. Considering Physical Security and Location

Because of the sensitive data they hold, consider keeping the CA, KRA, and TKS in a secure facility with adequate physical access restrictions. Just as network access to the systems needs to be restricted, the physical access also needs to be restricted.

Along with finding a secure location, consider the proximity to the subsystem agents and administrators. Key recovery, for example, can require multiple agents to give approval; if these agents are spread out over a large geographical area, then the time differences may negatively impact the ability to retrieve keys. Plan the physical locations of the subsystems, then according to the locations of the agents and administrators who will manage the subsystem.

4.5.3. Planning Ports

Each Certificate System server uses up to four ports:

- A non-secure HTTP port for end entity services that do not require authentication

- A secure HTTP port for end entity services, agent services, administrative console, and admin services that require authentication
- A Tomcat Server Management port
- A Tomcat AJP Connector Port

All of the service pages and interfaces described in Section 2.5, “Red Hat Certificate System Services” are connected to using the instance's URL and the corresponding port number. For example:

```
https://server.example.com:8443/ca/ee/ca
```

To access the admin console, the URL specifies the admin port:

```
pkiconsole https://server.example.com:8443/ca
```

All agent and admin functions require SSL/TLS client authentication. For requests from end entities, the Certificate System listens on both the SSL/TLS (encrypted) port and non-SSL/TLS ports.

The ports are defined in the **server.xml** file. If a port is not used, it can be disabled in that file. For example:

```
<Service name="Catalina">
    <!--Connector port="8080" ... /-->  unused standard port
    <Connector port="8443" ... />
```

Whenever a new instance in installed, make sure that the new ports are unique on the host system.

To verify that a port is available for use, check the appropriate file for the operating system. Port numbers for network-accessible services are usually maintained in a file named **services**. On Red Hat Enterprise Linux, it is also helpful to confirm that a port is not assigned by SELinux, by running the command **semanage port -l** to list all ports which currently have an SELinux context.

When a new subsystem instance is created, any number between 1 and 65535 can be specified as the secure port number.

4.6. Tokens for Storing Certificate System Subsystem Keys and Certificates

A *token* is a hardware or software device that performs cryptographic functions and stores public-key certificates, cryptographic keys, and other data. The Certificate System defines two types of tokens, *internal* and *external*, for storing key pairs and certificates that belong to the Certificate System subsystems.

An internal (software) token is a pair of files, usually called the *certificate database* (**cert8.db**) and *key database* (**key3.db**), that the Certificate System uses to generate and store its key pairs and certificates. The Certificate System automatically generates these files in the filesystem of its host machine when first using the internal token. These files are created during the Certificate System subsystem configuration if the internal token was selected for key-pair generation.

These security databases are located in the **/var/lib/pki/*instance_name*/alias** directory.

An external token refers to an external hardware device, such as a smart card or hardware security module (HSM), that the Certificate System uses to generate and store its key pairs and certificates. The Certificate System supports any hardware tokens that are compliant with PKCS #11.

PKCS #11 is a standard set of APIs and shared libraries which isolate an application from the details of the cryptographic device. This enables the application to provide a unified interface for PKCS #11-compliant cryptographic devices.

The PKCS #11 module implemented in the Certificate System supports cryptographic devices supplied by many different manufacturers. This module allows the Certificate System to plug in shared libraries supplied by manufacturers of external encryption devices and use them for generating and storing keys and certificates for the Certificate System managers.

Consider using external tokens for generating and storing the key pairs and certificates used by Certificate System. These devices are another security measure to safeguard private keys because hardware tokens are sometimes considered more secure than software tokens.

Before using external tokens, plan how the external token is going to be used with the subsystem:

- All system keys for a subsystem must be generated on the same token.
- The subsystem must be installed in an empty HSM slot. If the HSM slot has previously been used to store other keys, then use the HSM vendor's utilities to delete the contents of the slot. The Certificate System has to be able to create certificates and keys on the slot with default nicknames. If not properly cleaned up, the names of these objects may collide with previous instances.

The Certificate System can also use *hardware cryptographic accelerators* with external tokens. Many of the accelerators provide the following security features:

- Fast SSL/TLS connections. Speed is important to accommodate a high number of simultaneous enrollment or service requests.
- Hardware protection of private keys. These devices behave like smart cards by not allowing private keys to be copied or removed from the hardware token. This is important as a precaution against key theft from an active attack of an online Certificate Manager.

The Certificate System supports the nCipher nShield hardware security module (HSM), by default. Certificate System-supported HSMs are automatically added to the **`secmod.db`** database with **`modutil`** during the pre-configuration stage of the installation, if the PKCS #11 library modules are in the default installation paths.

During configuration, the **`Security Modules`** panel displays the supported modules, along with the NSS internal software PKCS #11 module. All supported modules that are detected show a status of **`Found`** and is individually marked as either **`Logged in`** or **`Not logged in`**. If a token is found but not logged in, it is possible to log in using the **`Login`** under **`Operations`**. If the administrator can log into a token successfully, the password is stored in a configuration file. At the next start or restart of the Certificate System instance, the passwords in the password store are used to attempt a login for each corresponding token.

Administrators are allowed to select any of the tokens that are logged in as the default token, which is used to generate system keys.

4.7. Implementing a Common Criteria Environment

The *Common Criteria for Information Technology Security Evaluation* is an international standard that helps to define the security aspects and secure implementations of software and hardware. To receive certification, software is evaluated for security in a defined and controlled environment with clearly delineated configuration and environment parameters. This environment is called the *evaluated configuration*.

Red Hat Certificate System 9.0 is Common Criteria certified at Evaluation Assurance Level 4 (EAL4).

More information on Common Criteria, evaluation guidelines, and technology security is available at the National Information Assurance Partnership: Common Criteria Evaluation and Validation Scheme website.

Some configuration is required.

As part of the Common Criteria environment, several otherwise optional features in Certificate System are required to be configured:

- FIPS mode for any hardware security modules used to store key and certification information
- Both secure client connections and secure server connections with the internal LDAP database (meaning all connections to the Red Hat Directory Server are over SSL/TLS)
- SSL/TLS session timeouts for all secure connections
- Signed audit logging
- Established backup and restore procedures
- CRL checking (OCSP validation) for clients
- **sudo** permissions to run Certificate System scripts and processes
- Defined operating systems users and groups for Certificate System subsystems
- SELinux in enforcing mode
- Removing unused CA interfaces from the **web.xml** file
- Self-test diagnostics, which are enabled by default

These features are listed as part of the installation process and in Chapter 14, *After Configuration: Checklist of Configuration Areas for Deploying Certificate System*.

All of the Red Hat Certificate System subsystems (CA, KRA, OCSP, TKS, and TPS) were targets of evaluation for the Common Criteria certification process.

4.8. A Checklist for Planning the PKI

Q:

How many security domains will be created, and what subsystem instances will be placed in each domain?

A: A subsystem can only communicate with another subsystem if they have a trusted relationship. Because the subsystems within a security domain have automatic trusted relationships with each other, it is important what domain a subsystem joins. Security domains can have different certificate issuing policies, different kinds of subsystems within them, or a different Directory Server database. Map out where (both on the physical machine and in relation to each other) each subsystem belongs, and assign it to the security domain accordingly.

Q:

What ports should be assigned for each subsystem? Is it necessary to have a single SSL/TLS port, or is it better to have port separation for extra security?

A: The most secure solution is to use separate ports for each SSL/TLS interface. However, the feasibility of implementing multiple ports may depends on your network setup, firewall rules, and other network conditions.

Q:

What subsystems should be placed behind firewalls? What clients or other subsystems need to access those firewall-protected subsystems and how will access be granted? Is firewall access allowed for the LDAP database?

A: The location to install a subsystem depends on the network design. The OCSP subsystem is specifically designed to operate outside a firewall for user convenience, while the CA, KRA, and TPS should all be secured behind a firewall for increased security.

When deciding the location of the subsystems, it is critical to plan what *other* subsystems or services that server needs to access (including the internal database, a CA, or external users) and look at firewall, subnet, and VPN configuration.

Q:

What subsystems need to be physically secured? How will access be granted, and who will be granted access?

A: The CA, TKS, and KRA all store extremely sensitive key and certificate information. For some deployments, it may be necessary to limit physical access to the machines these subsystems run on. In that case, both the subsystems and their host machines must be included in the larger infrastructure inventory and security design.

Q:

What is the physical location of all agents and administrators? What is the physical location of the subsystems? How will administrators or agents access the subsystem services in a timely-manner? Is it necessary to have subsystems in each geographical location or time zone?

A: The physical location of Certificate System users may impact things like request approval and token enrollment, as well as system performance because of network lag time. The importance of response time for processing certificate operations should be taken into account when deciding where and how many subsystems to install.

Q:

How many subsystems do you need to install?

A: The primary consideration is the expected load for each subsystem and then, secondarily, geographical or departmental divisions. Subsystems with fairly low loads (like the KRA or TKS) may only require a single instance for the entire PKI. Systems with high load (the CA) or which may benefit from local instances for local agents (like the RA and TPS) may require multiple instances.

Subsystems can be cloned, meaning they essentially are clustered, operating as a single unit, which is good for load balancing and high availability. Cloning is especially good for CAs and KRAs, where the same key and certificate data may need to be accessed by larger numbers of users or to have reliable failover.

When planning for multiple subsystem instances, keep in mind how the subsystems fit within the

established security domains. Security domains create trusted relationships between subsystems, allowing them to work together to find available subsystems to respond to immediate needs. Multiple security domains can be used in a single PKI, with multiple instances of any kind of subsystem, or a single security domain can be used for all subsystems.

Q:

Will any subsystems need to be cloned and, if so, what are the methods for securely storing their key materials?

A: Cloned subsystems work together, essentially as a single instance. This can be good for high demand systems, failover, or load balancing, but it can become difficult to maintain. For example, cloned CAs have serial number ranges for the certificates they issue, and a clone could hit the end of its range.

Q:

Will the subsystem certificates and keys be stored on the internal software token in Certificate System or on an external hardware token?

A: Certificate System supports two hardware security modules (HSM): nCipher nShield and Safenet LunaSA. Using a hardware token can require additional setup and configuration before installing the subsystems, but it also adds another layer of security.

Q:

What are the requirements for the CA signing certificate? Does the Certificate System need control over attributes like the validity period? How will the CA certificates be distributed?

A: The real question here is, will the CA bee a root CA which sets its own rules on issuing certificates or will it be a subordinate CA where another CA (another CA in your PKI or even an external CA) sets restrictions on what kind of certificates it can issue.

A Certificate Manager can be configured as either a root CA or a subordinate CA. The difference between a root CA and a subordinate CA is who signs the CA signing certificate. A root CA signs its own certificate. A subordinate CA has another CA (either internal or external) sign its certificate.

A self-signing root CA issues and signs its own CA signing certificate. This allows the CA to set its own configuration rules, like validity periods and the number of allowed subordinate CAs.

A subordinate CA has its certificates issued by a public CA or another Certificate System root CA. This CA is *subordinate* to the other CA's rules about its certificate settings and how the certificate can be used, such as the kinds of certificates that it can issue, the extensions that it is allowed to include in certificates, and the levels of subordinate CAs the subordinate CA can create.

One option is to have the Certificate manager subordinate to a public CA. This can be very restrictive, since it introduces the restrictions that public CAs place on the kinds of certificates the subordinate CA can issue and the nature of the certificate chain. On the other hand, one benefit of chaining to a public CA is that the third party is responsible for submitting the root CA certificate to a web browser or other client software, which is a major advantage for certificates that are accessed by different companies with browsers that cannot be controlled by the administrator.

The other option is make the CA subordinate to a Certificate System CA. Setting up a Certificate System CA as the root CA means that the Certificate System administrator has control over all subordinate CAs by setting policies that control the contents of the CA signing certificates issued.

It is easiest to make the first CA installed a self-signed root, so that it is not necessary to apply to a third party and wait for the certificate to be issued. Make sure that you determine how many root CAs to have and where both root and subordinate CAs will be located.

Q:

What kinds of certificates will be issued? What characteristics do they need to have, and what profile settings are available for those characteristics? What restrictions need to be placed on the certificates?

A: As touched on in Section 4.4.6, "Using and Customizing Certificate Profiles", the profiles (the forms which configure each type of certificate issued by a CA) can be customized. This means that the subject DN, the validity period, the type of SSL/TLS client, and other elements can be defined by an administrator for a specific purpose. For security, profiles should provide only the functionality that is required by the PKI. Any unnecessary profiles should be disabled.

Q:

What are the requirements for approving a certificate request? How does the requester authenticate himself, and what kind of process is required to approve the request?

A: The request approval process directly impacts the security of the certificate. Automated processes are much faster but are less secure since the identity of the requester is only superficially verified. Likewise, agent-approved enrollments are more secure (since, in the most secure scenario they can require an in-person verification and supporting identification) but they can also be the most time-consuming.

First determine how secure the identity verification process needs to be, then determine what authentication (approval) mechanism is required to validate that identity.

Q:

Will many external clients need to validate certificate status? Can the internal OCSP in the Certificate Manager handle the load?

A: Publishing CRLs and validating certificates is critical. Determine what kinds of clients will be checking the certificate status (will it mainly be internal clients? external clients? will they be validating user certificates or server certificates?) and also try to determine how many OCSP checks will be run. The CA has an internal OCSP which can be used for internal checks or infrequent checks, but a large number of OCSP checks could slow down the CA performance. For a larger number of OCSP checks and especially for large CRLs, consider using a separate OCSP Manager to take the load off the CA.

Q:

Will the PKI allow replacement keys? Will it require key archival and recovery?

A: If lost certificates or tokens are simply revoked and replaced, then there doesn't need to be a mechanism to recover them. However, when certificates are used to sign or encrypt data such as emails, files, or harddrives, then the key must always be available so that the data can be recovered. In that case, use a KRA to archive the keys so the data can always be accessed.

Q:

Will the organization use smart cards? If so, will temporary smart cards be allowed if smart cards are mislaid, requiring key archival and recovery?

A: If no smart cards are used, then it is never necessary to configure the TPS or TKS, since those subsystems are only used for token management. However, if smart cards are used, then the TPS and TKS are required. If tokens can be lost and replaced, then it is also necessary to have a KRA to archive the keys so that the token's certificates can be regenerated.

Q:

Where will certificates and CRLs be published? What configuration needs to be done on the receiving end for publishing to work? What kinds of certificates or CRLs need to be published and how frequently?

A: The important thing to determine is what clients need to be able to access the certificate or CRL information and how that access is allowed. From there, you cna define the publishing policy.

Part II. Installing Red Hat Certificate System

This section describes the requirements and procedures for installing Red Hat Certificate System, both for normal operating environments and Common Critera-certified environments.

Chapter 5. Prerequisites and Preparation for Installation

The installation process for Red Hat Certificate System subsystems requires the environment to be suitably configured. This chapter covers the requirements and dependencies for specific platforms, required packages, and other prerequisites for installing Certificate System subsystems.

5.1. Supported Platforms, Hardware, and Programs

5.1.1. Supported Platforms

The Certificate System subsystems (CA, KRA, OCSP, TKS, and TPS) are supported on the Red Hat Enterprise Linux 7.1 and later (x86_64, 64-bit) platforms.

The Enterprise Security Client, which manages smart cards for end users, is also supported on the Red Hat Enterprise Linux 7.1 and later (x86_64, 64-bit) platforms.

5.1.2. Supported Web Browsers

The services pages for the subsystems require a web browser that supports SSL/TLS. It is strongly recommended that users such as agents or administrators use Mozilla Firefox to access the agent services pages. Regular users should use Mozilla Firefox .

Table 5.1. Supported Web Browsers by Platform

Platform	Agent Services	End User Pages
Red Hat Enterprise Linux	Firefox 38 and later	Firefox 38 and later
Windows 7	Firefox 40 and later	Firefox 40 and later Internet Explorer 10
Windows Server 2012	Firefox 40 and later	Firefox 40 and later

Important

Firefox versions 33, 35, and later, regardless of platform, no longer support the crypto web object used to generate and archive keys from the browser. As a result, expect limited functionality in this area.

Internet Explorer version 11 is currently not supported by Red Hat Certificate System 9 because the Certificate System Internet Explorer enrollment code depends upon the VBScript language which has been deprecated in Internet Explorer 11.

5.1.3. Supported Smart Cards

The Enterprise Security Client supports Global Platform 2.01-compliant smart cards and JavaCard 2.1 or higher.

The Certificate System subsystems have been tested using the following tokens:

- Gemalto TOP IM FIPS CY2 64K token, both as a smart card and GemPCKey USB form factor key

- SafeNet Smart Card 650 (SC650), with support for both SCP01 and SCP02

Note that all versions of SC650 require the Omnikey 3121 reader. Legacy smart cards can be used with the SCM SCR331 CCID reader.

The only card manager applet supported with Certificate System is the CoolKey applet, which is part of the *pki-tps* package in Red Hat Certificate System.

5.1.4. Supported HSM

The following table lists hardware security modules (HSM) supported by Red Hat Certificate System.

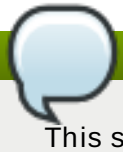
HSM	Firmware	Appliance Software	Client Software
nCipher nShield connect 6000	0.4.11cam2	CipherTools-linux64-dev-11.70.00	CipherTools-linux64-dev-11.70.00
Gemalto SafeNet Luna SA 1700	6.22.0	6.0.0-41	libcryptoki-5.4.1-2.x86_64

5.1.5. Supported Character Sets

Red Hat Certificate System fully supports UTF-8 characters in the CA end users forms for specific fields. This means that end users can submit certificate requests with UTF-8 characters in those fields and can search for and retrieve certificates and CRLs in the CA and retrieve keys in the KRA when using those field values as the search parameters.

Four fields fully-support UTF-8 characters:

- Common name (used in the subject name of the certificate)
- Organizational unit (used in the subject name of the certificate)
- Requester name
- Additional notes (comments appended by the agent to the certificate)



Note

This support does not include supporting internationalized domain names, like in email addresses.

5.2. Installing the Required Packages

When preparing to install a Certificate System subsystem, users are only required to install the top-level package for the subsystem named *pki-subsystem*, where *subsystem* is replaced with the particular subsystem. Other required packages as well as all the Certificate System command-line utilities are automatically installed as dependencies of the top-level package. For example, to install all packages required for the CA subsystem, install the *pki-ca* package:

```
yum install pki-ca
```

To access the PKI subsystems using a browser, install the following additional package:

- *redhat-pki-server-theme*

If you require additional administrative functionality, install the following two packages:

- *pki-console*
- *redhat-pki-console-theme*

Note

Theme packages which contain images, colors, titles, and other theme components are required to use a browser and *pki-console*. For Red Hat Enterprise Linux, the default theme package for browsers is *redhat-pki-server-theme*. Similarly, the *pki-console* package always requires the *redhat-pki-console-theme* GUI theme package to work properly.

Alternatively, using the **`yum install redhat-pki`** command, users can install all the following Certificate System components at once:

- all packages required for all Certificate System subsystems
- the Certificate System command-line utilities
- the PKI console
- both Red Hat Enterprise Linux-based theme packages
- all the **`javadocs`** documentation associated with the Certificate System

5.3. Before Installation: Setting up the Operating Environment

To install any Red Hat Certificate System subsystems on Red Hat Enterprise Linux, three programs are required: OpenJDK, Tomcat, and Red Hat Directory Server. All other required packages should be present as part of the base Red Hat Enterprise Linux operating system packages.

The system itself must be configured in certain ways to ensure that the packages can be properly installed and the instances created. There are several factors that must be in place, depending on the planned deployment:

- SELinux should be enabled.
- A system user must be created. The Certificate System instance will run as this user.
- The system should have a Java Security Manager running to manage the Java-based subsystems.
- Any external hardware tokens that will be used to store subsystem certificates and keys must be installed, configured, and running before the subsystems are created.
- Check for any Fedora EPEL repos in **`/etc/yum.repos.d/`** directory; these are usually named **`epel.repo`** or **`epel-testing.repo`**. Either remove these repo files or disable the repos (setting the enabled line to zero, **`enabled=0`**). Disabling the EPEL repos prevents any EPEL packages from overriding the official Red Hat Enterprise Linux packages.

5.3.1. Installing the Required Java Development Kit (JDK)

Certificate System supports and automatically installs OpenJDK 1.7.0.

If you require another version, the OpenJDK can be installed by using **yum** or by downloading the packages directly from http://openjdk.java.net/install/. For example:

```
# yum install java-1.7.0-openjdk
```

After installing the JDK, run **/usr/sbin/alternatives** as root to ensure that the proper JDK is available and selected in order to use Red Hat Certificate System 9:

```
# /usr/sbin/alternatives --config java

There are 3 programs which provide 'java'.

  Selection    Command
-----------------------------------------------
   1           /usr/lib/jvm/jre-1.4.2-gcj/bin/java
 + 2           /usr/lib/jvm/jre-1.7.0-openjdk/bin/java
 *  3           /usr/lib/jvm/jre-1.6.0-sun.x86_64/bin/java
```

Use the **/usr/sbin/alternatives** command to configure the appropriate selection if it has not already been selected.

5.3.2. Installing Red Hat Directory Server

All subsystems require access to Red Hat Directory Server. This Directory Server instance is used by the subsystems to store their system certificates and user data.

- Directory Server 10 must be installed on the local system or on a remote system that is reachable by the machine that the Certificate System subsystem installation will reside on.
- The Directory Server can be installed on any supported platform for its version, regardless of what platform the Certificate System is installed on.

Install and configure Red Hat Directory Server, if a directory service is not already available. For example, on the machine where the Directory Server instance resides:

1. Install the Directory Server packages:

   ```
   [root@server ~]# yum install redhat-ds
   ```

2. Ensure that a real domain name is specified in the **/etc/resolv.conf** file and that a host name is set within the **/etc/hosts** file.

3. Run the Directory Server installation script, selecting the defaults or customizing as required:

   ```
   [root@server ~]# setup-ds-admin.pl
   ```

Installing Red Hat Directory Server is described in more detail in the Red Hat Directory Server *Installation Guide*.

Important

The Certificate System SELinux policies assume that the Red Hat Directory Server is listening over the standard LDAP/LDAPS ports, 389 and 636, respectively. If the Directory Server is using non-standard ports, then edit the SELinux policy using **semanage** to relabel the LDAP/LDAPS ports and allow the subsystem to access the Directory Server.

5.3.3. Verifying Firewall Configuration and iptables

Any firewalls must be configured to allow access to the Certificate System ports and to any other applications, like Red Hat Directory Server, which are required for the operation of the subsystems. Use caution when configuring the firewall, so that the system remains secure.

As part of configuring the firewalls, if iptables is enabled, then it must have configured policies to allow communication over the appropriate Certificate System ports. Configuring iptables is described in the Red Hat Enterprise Linux *Deployment Guide*, such as "Using iptables." Installing the subsystems will fail unless iptables is turned on and properly configured.

5.3.4. Enabling SELinux

SELinux is a collection of mandatory access control rules which are enforced across a system to restrict unauthorized access and tampering. SELinux is described in more detail in the SELinux User's and Administrator's Guide.

SELinux policies for Red Hat Certificate System are defined in the system SELinux policies. These policies define objects, domains, and labels for each Red Hat Certificate System instance, as well as the rules the instance must follow. As long as SELinux is enabled (in either enforcing or permissive mode), SELinux labels are automatically updated whenever a Certificate System instance is created using the **pkispawn** utility, or deleted using the **pkidestroy** utility.

SELinux policies have been defined for the Certificate System subsystems run with SELinux set in enforcing mode, meaning that Certificate System operations can be successfully performed even when all SELinux rules are required to be followed.

Red Hat recommends running Certificate System with SELinux in **enforcing** mode, to make the most of the security policies.

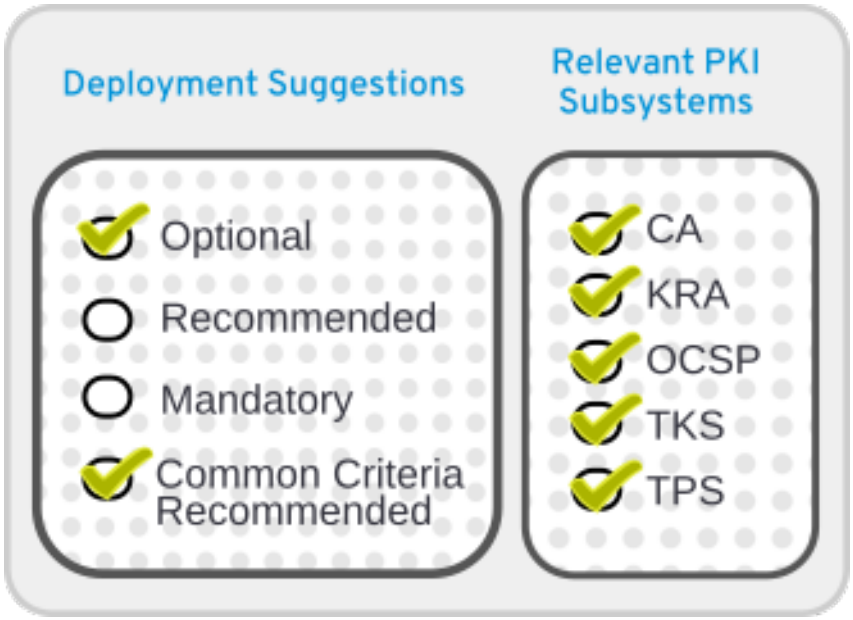
The Certificate System SELinux policies assume that the Red Hat Directory Server is listening over the standard LDAP/LDAPS ports, 389 and 636, respectively. If the Directory Server is using non-standard ports, then edit the SELinux policy using **semanage** to relabel the LDAP/LDAPS ports and allow the subsystem to access the Directory Server.

If SELinux is set to **enforcing**, then any external modules or hardware which interact with the subsystems must be configured with the proper SELinux settings to proceed with subsystem installation:

- Third-party modules, such as for ECC or HSM, must have an SELinux policy configured for them, or SELinux needs to be changed from **enforcing** mode to **permissive** mode to allow the module to function. Otherwise, any subsystem operations which require the ECC module will fail.

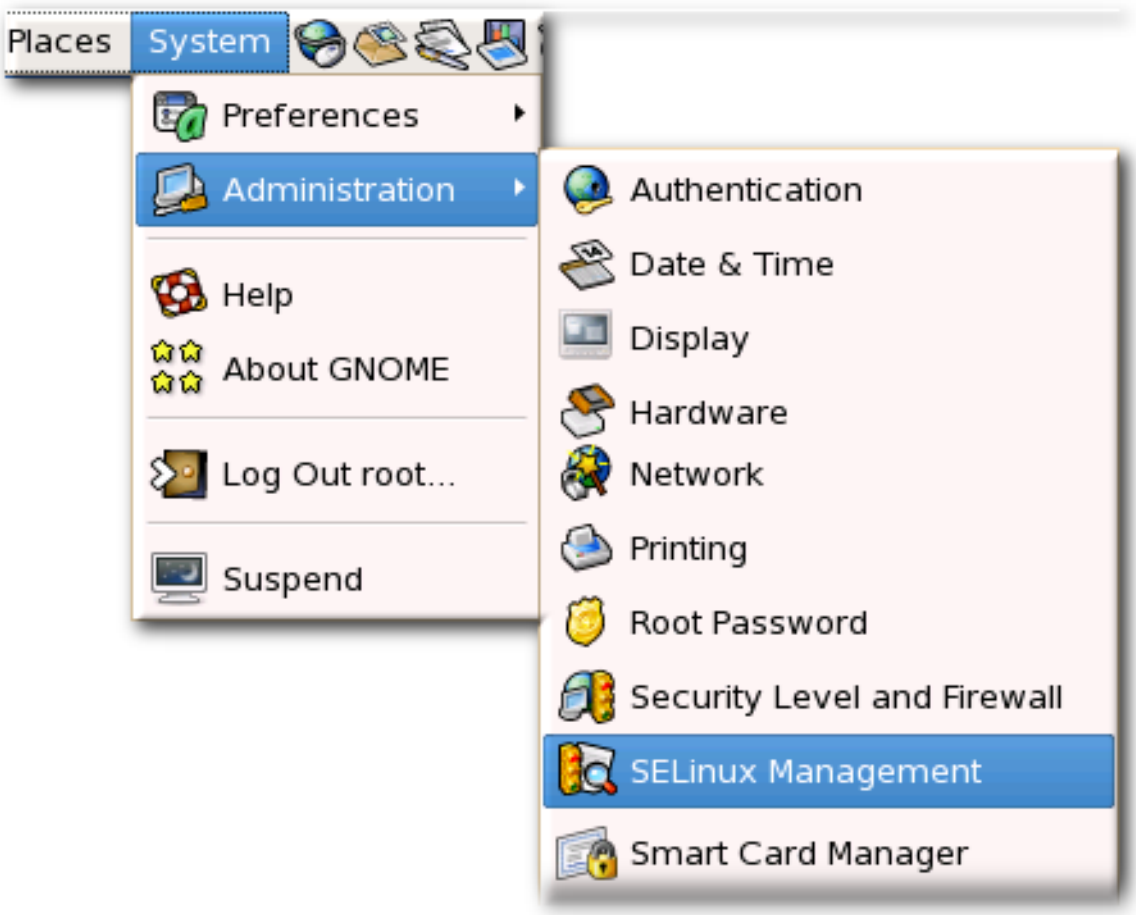
  Changing SELinux policies is covered in the SELinux User's and Administrator's Guide.

- SELinux policies must be set for any nCipher nShield modules, as described in Section 8.2.2, “Setting up SELinux for an HSM”.

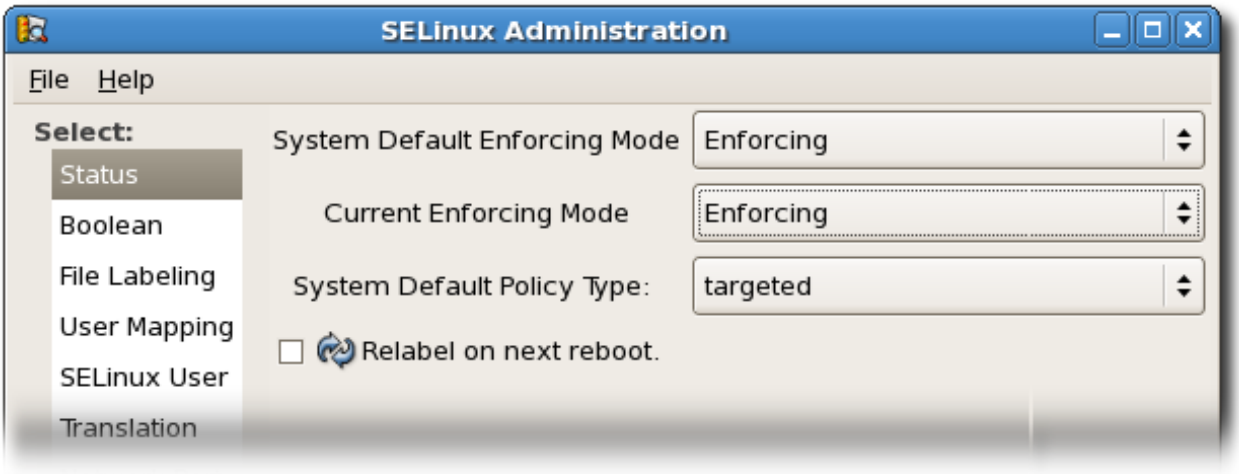


To make sure SELinux is in the proper mode:

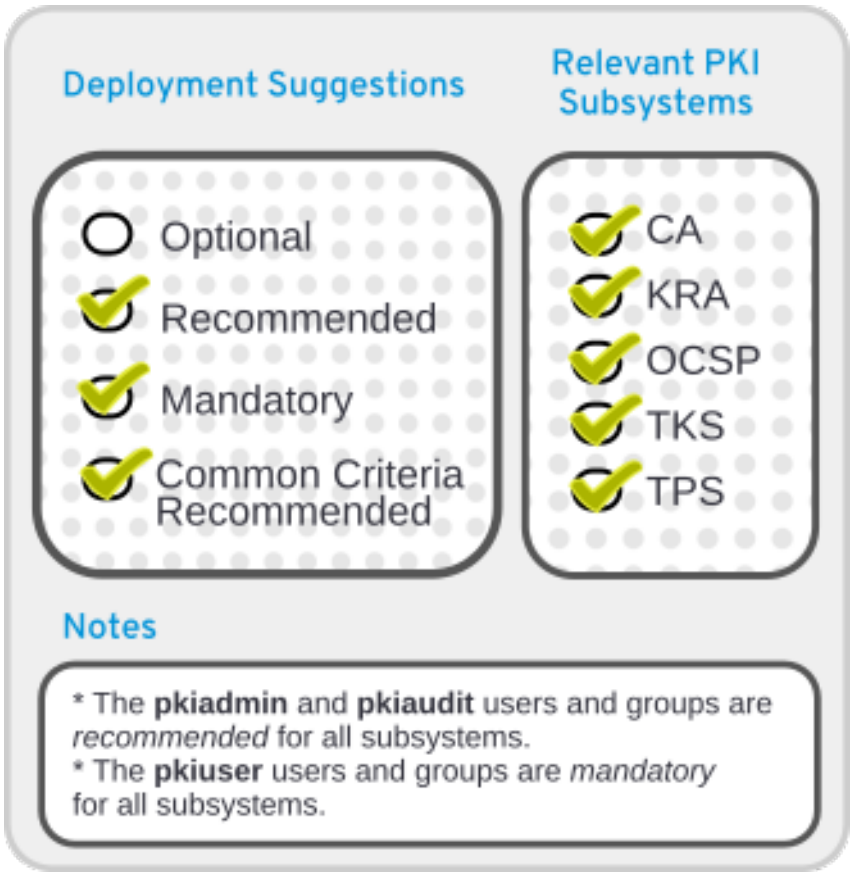
1. Open the **Systems** menu.
2. Open the **Administration** menu, and select the **SELinux Management** item.



3. In the **Status** area, set the system default and current enforcing modes to the desired setting. **Enforcing** mode is recommended.



5.3.5. Setting up Operating System Users and Groups



Certificate System uses operating system user and groups to run the subsystem processes. The groups used by Certificate System must be created on the operating systems *before* the packages are installed and any operating system users must be created or associated with those groups.

Note

The administrator who creates these groups and users must have the required access to the operating system and any associated programs (like NIS).

5.3.5.1. Creating Operating System Groups

Certificate System uses three and possibly four operating system groups:

- pkiuser
- pkiadmin
- pkiaudit
- A hardware token group, such as nfast (optional)

The first group, **pkiuser**, is used by the Certificate System subsystems; this is the user which the subsystem daemons run as. The other two groups, **pkiadmin** and **pkiaudit**, are used by Certificate System users who manage the subsystem instances. If the subsystem uses a hardware token, then the PKI administrator users must also belong to that group, such as **nfast** for an nCipher token.

All of the PKI groups are system accounts. They must meet certain criteria as system accounts:

- They must have a GID and UID lower than 500. It is strongly recommended that the **pkiuser** group has a GID and UID of 17. On Red Hat Enterprise Linux systems, the **pkiuser** group might already be configured and has a GID of 17.
- The groups must not have a login shell, meaning that the login shell has a value of **/sbin/nologin**.
- All PKI groups must be created before attempting to install any subsystem. This account must be present in **/etc/group**.
- The PKI user should be create before installing any subsystems. This account must be present in **/etc/passwd**.

Note

The **pkiuser** group and user are automatically created if they did not already exist and if the RPM package pre-installation scripts for the Certificate System packages were not suppressed.

Both the **pkiadmin** and **pkiaudit** groups must be created for Certificate System. This is done using the **groupadd** tool, which is described in the the SELinux section in the Red Hat Enterprise Linux Planning, Installation, and Deployment Guide.

1. For Red Hat Enterprise Linux systems, the **pkiuser** group might already be created. This can be verified by checking the **/etc/group** file:

   ```
   grep pkiuser /etc/group
   pkiuser:x:17:
   ```

   If the **pkiuser** group does not exist, then make sure that the appropriate tool packages are installed:

   ```
   # rpm -q setup
   setup-2.8.71-5.el7.noarch

   # rpm -q shadow-utils
   shadow-utils-4.1.5.1-18.el7.x86_64
   ```

Then, if the **pkiuser** group does not exist or if it has a GID other than 17, create the **pkiuser** group. This group *must* have a GID value of 17; this can be specified using the **-g** option.

```
# userdel pkiuser
# groupdel pkiuser
# groupadd -g 17 -r pkiuser
```

2. Create the **pkiadmin** group. This group can have any randomly assigned GID for a system account. Use the **-r** option to create a system group.

```
# groupadd -r pkiadmin
```

3. Create the **pkiaudit** group. This group can have any randomly assigned GID for a system account. Use the **-r** option to create a system group.

```
# groupadd -r pkiaudit
```

4. Assign user accounts to the group so that users can perform the administrative and audit tasks for the subsystems. (If necessary, also create users for the groups.) This is described in Section 5.3.5.2, "Creating Operating System Users".

```
# usermod -a -G pkiadmin bjensen
```

Along with assigning regular users to the **pkiadmin** and **pkiaudit** groups, be sure to add the **pkiuser** system user account.

Note

Using **groupadd** or the Red Hat Enterprise Linux UI tools updates all of the group files on the system, including **/etc/group**, **/etc/gshadow**, and **/etc/login.defs**.

5.3.5.2. Creating Operating System Users

As with system groups, Certificate System uses a system user account for its subsystem process. This is the **pkiuser** account, which is associated with the **pkiuser** system group.

The other Certificate System groups — **pkiadmin** and **pkiaudit** — allow real users (not system users) to be members so that those users can carry out normal administrative and auditing functions. These user accounts simply need to be added to the PKI groups, as described in Section 5.3.5.2.3, "Associating Existing User Accounts with PKI Groups".

5.3.5.2.1. Checking the pkiuser System Account

On Red Hat Enterprise Linux machines, the **pkiuser** account might already exist; this can be verified by checking the **/etc/passwd** file:

```
# grep pkiuser /etc/passwd
pkiuser:x:17:
```

As with the **pkiuser** group, the **pkiuser** account **must** have a UID number of 17. If the **pkiuser** account does not exist or if it does not have a UID of 17, then check that the appropriate setup packages are installed:

```
# rpm -q setup
setup-2.8.71-5.el7.noarch

# rpm -q shadow-utils
shadow-utils-4.1.5.1-18.el7.x86_64
```

Then create the **pkiuser** user. Use the **-g** option to give the group to add the user to, and use the **-r** option to create a system account. To set the UID explicitly, use the **-u** option.

```
# userdel pkiuser

# useradd -g pkiuser -d /usr/share/pki -s /sbin/nologin -c "Red Hat
Certificate System" -u 17 -r pkiuser
```

5.3.5.2.2. Creating New User Accounts

Other PKI Users, associated with the administrator and auditor groups, can be regular users rather than system accounts. When creating new users, always use the system tools, like **useradd** or the UI tools, because those automatically update *all* system files related to users, including **/etc/passwd**, **/etc/shadow**, **/etc/group**, **/etc/gshadow**, **/etc/default/useradd**, **/etc/skel**, and **/etc/login.defs**.

The process and options for adding users is described in the *Red Hat Enterprise Linux System Administrator's Guide*. When users are created, they can simultaneously be associated with a group using the **-g** option. For example, this creates a **jsmith** user who belongs to the **pkiadmin** group, and then creates the user password:

```
# useradd -g pkiadmin -d /home/jsmith -s /bin/bash -c "Red Hat
Certificate System Administrator" -m jsmith

# passwd jsmith
New password:
Re-enter new password:
```

5.3.5.2.3. Associating Existing User Accounts with PKI Groups

Existing users can be added to a PKI group using the **usermod** command. As with **useradd**, **usermod** updates all of the related user account files, including **/etc/passwd**, **/etc/shadow**, and **/etc/group**.

```
# usermod -a -G pkiadmin bjensen
```

Note

The users added to the admin and audit groups are regular user accounts, not a system account like **pkiuser**.

Add the user accounts to the appropriate PKI management group, *and only to that one group*. Users are either an administrator or an auditor; the same user cannot be in both groups.

- PKI auditors only need to be added to the **pkiaudit** group.

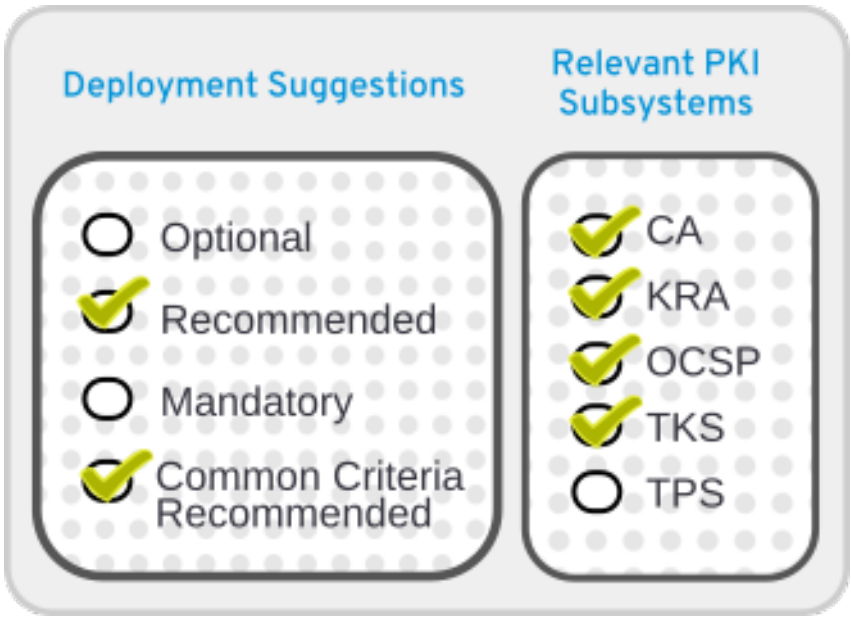
- PKI administrators need to be added to the **pkiadmin** group and any group uses by a hardware token used by the subsystem, such as **nfast** for an nCipher hardware token.

The **pkiuser** user should be added to both the **pkiadmin** and **pkiaudit** groups:

```
# usermod -a -G pkiadmin pkiuser

# usermod -a -G pkiaudit pkiuser
```

5.3.6. Using a Java Security Manager



Java services have the option of having a Security Manager which defines unsafe and safe operations for applications to perform. When the subsystems are installed, they have the Security Manager enabled automatically, meaning each Tomcat instance starts with the Security Manager running.

The Security Manager is disabled if the instance is created by running **pkispawn** and using an override configuration file which specifies the ***pki_security_manager=false*** option under its own **Tomcat** section.

5.3.7. Disabling Certificate Profiles

As explained in Section 4.4.6, “Using and Customizing Certificate Profiles”, certificate profiles can be customized. Subject DN, validity period, the type of the SSL/TLS client determining certain certificate requirements, such as whether the SSL server certificate requires a Subject Alternative Name (SAN) extension, and other elements can be defined by an administrator for a specific purpose.

For security, Red Hat recommends that profiles provide only the functionality that is required by the PKI. To achieve this, disable any unnecessary profiles.

Chapter 6. Installing and Configuring Certificate System

The Certificate System is comprised of subsystems which can be independently installed on different servers, multiple instances installed on a single server, and other flexible configurations for availability, scalability, and failover support. The procedures for downloading, installing, and configuring instances of Certificate System subsystems are described in this chapter.

There are different paths for the installation process, depending on the planning decisions that you made and the needs of your environment.

The Certificate System servers include five subsystems:

- Certificate Authority (CA)
- Key Recovery Authority (KRA)
- Online Certificate Status Protocol (OCSP) Responder
- Token Key Service (TKS)
- Token Processing System (TPS)

Each subsystem is installed and configured individually as a standalone Tomcat web server instance.

Note

Introduced in Red Hat Certificate System 9, it is also possible to create a single shared Tomcat web server instance that can contain up to one of each of the five subsystems.

The order in which subsystems are configured is important because of the basic relationships which are established between subsystems at the time they are installed:

- At least one CA running as a security domain is required before any of the other PKI subsystems may be installed.
- The OSCP, KRA, and TKS subsystems can be installed in any order, after the CA has been configured.
- TPS is configured last because it requires information about a specific CA, TKS, and optionally KRA for its configuration.

The installation process includes not only setting up the individual subsystems but also setting up the environment. The environment configuration is flexible and largely optional; the configuration that you select should depend on the existing network environment and security requirements.

The complete subsystem setup process includes the preparation for the environment, the instance creation, setup, and configuration of major features for each subsystem. This chapter covers the basic installation procedures for general PKI subsystems and the token management system.

6.1. About `pkispawn`

In previous versions of Certificate System, the setup procedure consisted of two separate tasks:

- a PKI instance installation using the **`pkicreate`** utility,

- a batch PKI instance configuration using the **pkisilent** utility. This step could also be done in a web browser GUI configuration wizard.

In Red Hat Certificate System 9, these utilities have been replaced by a single command-line utility, **pkispawn**.

When run, **pkispawn** first reads its default values from the **default.cfg** file, see the pki_default.cfg man page for details.

In the next step, **pkispawn** obtains its passwords and other deployment-specific information in one of the following modes:

- interactive, in which the user is asked a series of questions; this mode is useful for simple deployments,
- batch, in which the user supplies a configuration file with passwords and any other information required to override the default values in **default.cfg**.

The **pkispawn** utility then performs installation of the requested PKI instance before wrapping up its data and passing it to a Java configuration servlet which performs the configuration based upon the passed-in data.

For more information about **pkispawn**, along with numerous usage examples, see the pkispawn man page.

6.2. Basic Installation

There are three major steps to be taken when setting up Certificate System:

- setting up the machine and the environment that will host the subsystem instance, ensuring that the platform meets requirements, installing necessary applications and packages, and setting up the operating system. See Chapter 5, *Prerequisites and Preparation for Installation* for more details.
- creating and configuring the subsystem instance itself.
- customizing the instance by setting up recommended features. See Chapter 14, *After Configuration: Checklist of Configuration Areas for Deploying Certificate System* for more details.

The walk-through below simply shows, at a very high level, the major steps for setting up a functional PKI. The exact configuration, like what subsystem types are installed and the desired post-installation configuration, are dependent on the specific PKI design that you developed as part of planning your Certificate System deployment.

1. Install a Red Hat Directory Server, as described in Section 5.3.2, “Installing Red Hat Directory Server”. This can be on a different machine from the Certificate System, which is the recommended scenario for most deployments.
2. Create new, specific operating system groups for the Certificate System subsystems to run as. This is described in Section 5.3.5.1, “Creating Operating System Groups”.
3. Assign users to the operating system groups to perform the subsystem administrative tasks. This is described in Section 5.3.5.2.3, “Associating Existing User Accounts with PKI Groups”.
4. Download the Certificate System packages from the Red Hat Network channel.
5. Install the packages.
6. Run **pkispawn** to create the subsystem instances.

7. Configure the Certificate System CA subsystem. At least one CA subsystem must be installed and fully configured before any other type of subsystem can be configured.
8. Configure the OCSP and KRA subsystems. Once the CA is installed, the other subsystems can be installed and configured in any order.

6.2.1. Installing and Configuring a CA

1. Set up the required **yum** repositories.
    a. Log into the Customer Portal.
    b. Open the **Downloads** tab.
    c. Under the **Product** group, click **Red Hat Certificate System** to access the available resources for download.
    d. From the **Version** and **Architecture** dropdowns, select appropriate values.
    e. On the **Product Downloads** tab, click the **Binary Disc** link and save the ISO image to media.
    f. On the machine which hosts the repository, if necessary, install the VSFTP daemon. For example:

```
[root@server ~]# yum install vsftpd
```

    g. On the machine which hosts the repository, mount the media with the ISO. For example:

```
[root@server ~]# mount /dev/cdrom /mnt
```

    h. On the machine which hosts the repository, create a directory for the Certificate System packages.

```
[root@server ~]# mkdir /var/pub/rhcsrepo
```

    i. Copy the Certificate System ISO into the new repository directory.
    j. Create the **yum** repository, pointing to the RPM directory in the ISO.

```
[root@server ~]# createrepo -g /var/pub/rhcsrepo/RedHat/RPMS
```

    k. Start the **vsftpd** service.

```
[root@server ~]# systemctl start vsftpd.service
[root@server ~]# systemctl start vsftpd.service
```

    l. On each client machine, create a **.repo** file with the repository information. For example:

```
[root@client ~]# touch /etc/yum.repos.d/rhcs.repo
[root@client ~]# vim /etc/yum.repos.d/rhcs.repo

[rhcs]
```

```
name=rhcs
baseurl=ftp://repo_ip_address/pub/rhcsrepo
enabled=1
gpgcheck=0
```

2. To use an IPv6 host name for configuration, set the host name in the **PKI_HOSTNAME** environment variable before installing the packages. This is described in Section 11.2, “Enabling IPv6 for a Subsystem”.

3. Run **yum** to install the CA packages. Optionally, include the console packages.

```
[root@server ~]# yum install pki-ca pki-console
```

4. To install a root CA in a new instance execute the following command:

```
pkispawn -s CA -f myconfig.txt
```

where **myconfig.txt** contains the following text:

```
[DEFAULT]
pki_admin_password=Secret123
pki_client_pkcs12_password=Secret123
pki_ds_password=Secret123
```

For more details, see the pkispawn man page and look for "Installing a root CA" in the EXAMPLES section.

6.2.2. Installing and Configuring a KRA

1. A CA must be configured and running somewhere on the network. A KRA depends on the CA to issue their certificates and to create a security domain. If the security domain CA is not available, then the configuration process fails.

2. Set up the required **yum** repositories.

Create a **.repo** file with the repository information (this was likely configured in Section 6.2.1, “Installing and Configuring a CA”). For example:

```
[root@client ~]# touch /etc/yum.repos.d/rhcs.repo
[root@client ~]# vim /etc/yum.repos.d/rhcs.repo

[rhcs]
 name=rhcs
 baseurl=ftp://repo_ip_address/pub/rhcsrepo
 enabled=1
 gpgcheck=0
```

3. Run **yum** to install the KRA packages. Optionally, include the console packages.

```
[root@server ~]# yum install pki-kra pki-console
```

4. To install a KRA in the same shared Tomcat web server instance used by the CA, run the following command:

```
pkispawn -s KRA -f myconfig.txt
```

where **myconfig.txt** contains the following text:

```
[DEFAULT]
pki_admin_password=replace_with_strong_passwd_1
pki_client_database_password=replace_with_strong_passwd_2
pki_client_pkcs12_password=replace_with_strong_passwd_3
pki_ds_password=replace_with_strong_passwd_4
pki_security_domain_password=replace_with_strong_passwd_5
```

For more details, see the pkispawn man page and look for "Installing a KRA, OCSP, TKS, or TPS, in a shared instance" in the EXAMPLES section.

Alternatively, to install a KRA as a standalone separate Tomcat web server instance, see the pkispawn man page and look for "Installing a KRA, OCSP, TKS, or TPS in a separate instance" in the EXAMPLES section.

6.2.3. Installing and Configuring an OCSP Responder

1. A CA must be configured and running somewhere on the network. An OCSP responder depends on the CA to issue their certificates and to create a security domain. If the security domain CA is not available, then the configuration process fails.

2. Set up the required **yum** repositories.

   Create a **.repo** file with the repository information (this was likely configured in Section 6.2.1, “Installing and Configuring a CA”). For example:

   ```
   [root@client ~]# touch /etc/yum.repos.d/rhcs.repo
   [root@client ~]# vim /etc/yum.repos.d/rhcs.repo

   [rhcs]
    name=rhcs
    baseurl=ftp://repo_ip_address/pub/rhcsrepo
    enabled=1
    gpgcheck=0
   ```

3. Run **yum** to install the OCSP packages. Optionally, include the console packages.

   ```
   [root@server ~]# yum install pki-ocsp pki-console
   ```

4. To install an OCSP responder in the same shared Tomcat web server instance used by the CA execute the following command:

   ```
   pkispawn -s OCSP -f myconfig.txt
   ```

   where **myconfig.txt** contains the following text:

   ```
   [DEFAULT]
   pki_admin_password=replace_with_strong_passwd_1
   pki_client_database_password=replace_with_strong_passwd_2
   pki_client_pkcs12_password=replace_with_strong_passwd_3
   ```

```
pki_ds_password=replace_with_strong_passwd_4
pki_security_domain_password=replace_with_strong_passwd_5
```

For more details, see the pkispawn man page and look for "Installing a KRA, OCSP, TKS, or TPS, in a shared instance" in the EXAMPLES section.

Alternatively, to install a OCSP as a standalone separate Tomcat web server instance, see the pkispawn man page and look for "Installing a KRA, OCSP, TKS, or TPS in a separate instance" in the EXAMPLES section.

6.3. Configuring a Token Management System

As covered in Section 2.3, “Working with Smart Cards (TMS)”, there are two subsystems that are dedicated to managing smart cards and tokens: the Token Key Service (TKS) and the Token Processing System (TPS). The TPS performs actual operations on smart cards; the TKS derives the keys used to communication between TPS and a smart card.

The order of installation is important when creating a *token management system*. Three subsystems are required and must be installed in this order: CA, TKS, and TPS. The TKS requires a CA for configuration, and the TPS requires a CA and TKS.

This walk-through shows, at a very high level, the major steps for setting up a functional token management system.

1. Install a Red Hat Directory Server, as described in Section 5.3.2, “Installing Red Hat Directory Server”. This can be on a different machine from the Certificate System, which is the recommended scenario for most deployments.
2. Create new, specific operating system groups for the Certificate System subsystems to run as. This is described in Section 5.3.5.1, “Creating Operating System Groups”.
3. Assign users to the operating system groups to perform the subsystem administrative tasks. This is described in Section 5.3.5.2.3, “Associating Existing User Accounts with PKI Groups”.
4. Subscribe the system via Red Hat Subscription Manager and attach the subscription providing Red Hat Certificate System.
5. Install the packages.
6. Run **pkispawn** to create the subsystem instances.
7. Configure the Certificate System CA subsystem.
8. Optionally, configure the KRA subsystem.
9. Configure the TKS subsystem.
10. Configure the TPS subsystem. The TPS requires having an existing TKS and, optionally, KRA available when it is configured, so this is the last subsystem to set up.

6.3.1. Installing and Configuring a TKS

1. A CA must be configured and running somewhere on the network. A TKS depends on the CA to issue their certificates and to create a security domain. If the security domain CA is not available, then the configuration process fails.
2. Set up the required **yum** repositories.

Create a **.repo** file with the repository information (this was likely configured in Section 6.2.1, "Installing and Configuring a CA"). For example:

```
[root@client ~]# touch /etc/yum.repos.d/rhcs.repo
[root@client ~]# vim /etc/yum.repos.d/rhcs.repo

[rhcs]
 name=rhcs
 baseurl=ftp://repo_ip_address/pub/rhcsrepo
 enabled=1
 gpgcheck=0
```

3. Run **yum** to install the TKS packages. Optionally, include the console packages.

```
[root@server ~]# yum install pki-tks pki-console
```

4. To install a TKS in the same shared Tomcat web server instance used by the CA execute the following command:

```
pkispawn -s TKS -f myconfig.txt
```

where **myconfig.txt** contains the following text:

```
[DEFAULT]
pki_admin_password=replace_with_strong_passwd_1
pki_client_database_password=replace_with_strong_passwd_2
pki_client_pkcs12_password=replace_with_strong_passwd_3
pki_ds_password=replace_with_strong_passwd_4
pki_security_domain_password=replace_with_strong_passwd_5
```

For more details, see the pkispawn man page and look for "Installing a KRA, OCSP, TKS, or TPS, in a shared instance" in the EXAMPLES section.

Alternatively, to install a TKS as a standalone separate Tomcat web server instance, see the pkispawn man page and look for "Installing a KRA, OCSP, TKS, or TPS in a separate instance" in the EXAMPLES section.

6.3.2. Installing and Configuring a TPS

1. A CA must be configured and running somewhere on the network.
2. A TKS must be configured and running somewhere on the network.
3. If a KRA will be used to store keys, then it must be configured and running somewhere on the network.
4. On the TPS host machine, set up the required **yum** repositories.

Create a **.repo** file with the repository information (this was likely configured in Section 6.2.1, "Installing and Configuring a CA"). For example:

```
[root@client ~]# touch /etc/yum.repos.d/rhcs.repo
[root@client ~]# vim /etc/yum.repos.d/rhcs.repo

[rhcs]
```

```
name=rhcs
baseurl=ftp://repo_ip_address/pub/rhcsrepo
enabled=1
gpgcheck=0
```

5. Run **yum** to install the TPS packages.

```
[root@server ~]# yum install pki-tps
```

6. To install a TPS in the same shared Tomcat web server instance used by the CA execute the following command:

```
pkispawn -s TPS -f myconfig.txt
```

where **myconfig.txt** contains the following text:

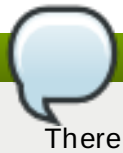
```
[DEFAULT]
pki_admin_password=replace_with_strong_passwd_1
pki_client_database_password=replace_with_strong_passwd_2
pki_client_pkcs12_password=replace_with_strong_passwd_3
pki_ds_password=replace_with_strong_passwd_4
pki_security_domain_password=replace_with_strong_passwd_5
[TPS]
pki_authdb_basedn=dc=example,dc=com
```

For more details, see the pkispawn man page and look for "Installing a KRA, OCSP, TKS, or TPS, in a shared instance" in the EXAMPLES section.

Alternatively, to install a TPS as a standalone separate Tomcat web server instance, see the pkispawn man page and look for "Installing a KRA, OCSP, TKS, or TPS in a separate instance" in the EXAMPLES section.

Chapter 7. Installing Red Hat Certificate System with SSL/TLS Connections to Red Hat Directory Server

The CA, KRA, OCSP, TKS, and TPS all use a back-end Red Hat Directory Server instance to store their certificate and configuration information. SSL/TLS connections can be configured between the Directory Server instance and the Certificate System subsystem instance by configuring SSL/TLS in the Directory Server and then enabling the Certificate System instance to use that connection.



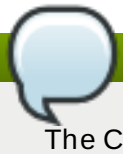
Note

There are three parts to using SSL/TLS server connections with the Directory Server:

1. The Directory Server must be configured to use SSL/TLS.
2. The next part exports the Directory Server's CA certificate.
3. The last part configures the Certificate System instance to use the certificate to connect to the Directory Server over SSL/TLS.

7.1. Using an External CA to Issue Directory Server Certificates

When first setting up Certificate System, a local CA may not be available. An external CA or a CA in a different PKI environment can be used to issue the certificates that are used to enable SSL/TLS on the Directory Server instance. In that case, the only configuration necessary on the Certificate System side is to trust the CA which issued the Directory Server certificates.



Note

The CA certificate for the external CA which issued the Directory Server's certificates must be imported into the security database for *every* subsystem instance which connects to that Directory Server.

1. Configure the Red Hat Directory Server instance to run over SSL/TLS. This is described in detail in the SSL/TLS configuration chapter in the Directory Server Administration Guide.

    a. Obtain and install CA and server certificates for the Directory Server from the external authority. Each CA will have its own path for requesting and receiving certificates.

    When importing the CA certificate into the Directory Server security databases in the Directory Server Console, make sure to allow the CA certificate to be trusted for both client and server authentication.

    b. In the Directory Server Console, open the **Configuration** tab and the **Encryption** subtab. Check the **Enable SSL for this server** checkbox and select all the ciphers and certificates to use.

    c. At the bottom of the window, select the **Allow client authentication** radio button. **Do not** select **Require client authentication** because it prevents the Certificate System server from connecting to the Directory Server instance.

    d. Restart the Directory Server instance.

```
systemctl restart dirsrv.target
```

2. If necessary, export the Directory Server's CA certificate so it can be imported into the Certificate System security database. The CA certificate had to be imported into the Directory Server, so a copy should be available. If not, the CA certificate can be exported from the Directory Server Console or by using the **certutil** utility.

```
certutil -L -d /ldap/alias/directory -n "DS CA certificate" -A >
cacert.crt
```

3. Import that Directory Server's CA certificate into the Certificate System security database. Importing the CA certificate allows the Certificate System instance to connect to the Directory Server over the secure port during its setup process.

```
# systemctl stop pki-tomcatd@instance_name.service

# certutil -A -i cacert.crt -t "CT,C,C" -n "CA_cert_nickname" -a -
d /var/lib/pki/instance_name/alias

# systemctl start pki-tomcatd@instance_name.service
```

4. *For the TPS only.* After the CA is configured, and after the TPS is created but before it is configured, import the Directory Server's CA certificate into the TPS's security databases.

```
# certutil -A -i cacert.crt -t "CT,C,C" -n "CA_cert_nickname" -a -
d /var/lib/pki/instance_name/alias
```

5. Begin the instance setup. When the wizard comes to the section to configure the LDAP instance to use, supply the SSL/TLS port for the Directory Server instance and select the **TLS/SSL** checkbox.

6. *Optional.* Configure SSL/TLS client authentication between the Certificate System and LDAP server. This is done after the instance is set up.

7.2. Using Temporary Self-Signed Directory Server Certificates

When first setting up Certificate System, a local CA may not be available. The Directory Server can be initially configured to use SSL/TLS based on *temporary self-signed certificates* which are generated using **certutil**. Once a new Certificate System CA is fully setup and configured, the Directory Server can then request permanent SSL/TLS certificates from the CA. The Directory Server instance and the CA must then be reconfigured to use the new, permanent certificates.

Note

The CA certificate for the external CA which issued the Directory Server's certificates only needs to be imported into the security database for the first CA configured. Once the temporary certificates are replaced by the ones issued by the Certificate System CA, every subsystem instance in the security domain will automatically trust the Directory Server because they will already trust the issuing Certificate System CA.

1. Configure the Red Hat Directory Server instance to run over SSL/TLS. This is described in detail in the SSL/TLS configuration chapter in the Directory Server Administration Guide.

    a. Open the Directory Server instance's security directory.

    ```
    cd /etc/dirsrv/slapd-instance
    ```

    The Directory Server instance should have its security databases already set up in the **/etc/dirsrv/slapd-*instance*** directory. If these databases are missing for some reason, they can be created using the **certutil** command.

    ```
    certutil -N -d .
    ```

    b. Generate temporary self-signed certificates for the Directory Server using **certutil**. For example:

    ```
    certutil -S -n "Temporary CA certificate" -s "cn=Temporary CA
    cert,dc=example,dc=com" -2 -x -t "CT,," -m 1000 -v 120 -d . -
    k rsa

    certutil -S -n "Server-Cert" -s "cn=ldap.example.com" -c
    "Temporary CA certificate" -t "u,u,u" -m 1001 -v 120 -d . -k
    rsa
    ```

    c. Import the temporary server and CA certificates into the Directory Server using the Directory Server Console. When importing the CA certificate into the Directory Server security databases in the Directory Server Console, make sure to allow the CA certificate to be trusted for both client and server authentication.

    d. In the Directory Server Console, open the **Configuration** tab and the **Encryption** subtab. Check the **Enable SSL for this server** checkbox and select all the ciphers and certificates to use. The only server certificate listed should be the temporary server certificate, **Server-Cert**.

    e. At the bottom of the window, select the **Allow client authentication** radio button. **Do not** select **Require client authentication** because it prevents the Certificate System server from connecting to the Directory Server instance.

    f. Restart the Directory Server instance.

    ```
    service dirsrv restart
    ```

2. Export that Directory Server's *temporary* CA certificate from its security database.

    ```
    certutil -L -d /etc/dirsrv/slapd-instance -n "Temporary CA
    certificate" -A > tempcacert.crt
    ```

3. Import that Directory Server's *temporary* CA certificate into the Certificate System security database. Importing the CA certificate allows the Certificate System instance to connect to the Directory Server over the secure port during its setup process.

    ```
    # systemctl stop pki-tomcatd@instance_name.service

    # certutil -A -i tempcacert.crt -t "CT,C,C" -n "Temporary CA
    certificate" -a -d /var/lib/pki/instance_name/alias
    ```

```
# systemctl start pki-tomcatd@instance_name.service
```

4. Begin the **CA** instance setup. When the wizard comes to the section to configure the LDAP instance to use, supply the SSL/TLS port for the Directory Server instance and select the **TLS/SSL** checkbox.

5. Once the CA is configured, it can be used to issue new certificates to the Directory Server instance.

    a. Generate a new certificate request for the Directory Server. This **must** have the same certificate nickname as the original, temporary certificate.

    A certificate request can be generated in the Directory Server Console or using **certutil**. For example:

    ```
    certutil -R -n "Server-Cert" -s "cn=ldap.example.com" -d
    /ldap/alias/directory -a
    ```

    b. Submit the generated certificate request through the CA's end-entities forms:

    ```
    https://server.example.com:8443/ca/ee/ca
    ```

    c. Log into the CA's agent forms as an agent, and approve the request.

    d. When the request is approved, the agent form returns the base 64-encoded version of the new certificate. Copy and save this certificate, including the header and footer lines, to a file.

    e. Export the CA certificate so that it can be imported into the Directory Server.

    ```
    certutil -L -d /var/lib/pki/instance_name/alias -n "CA
    certificate" -A > cacert.crt
    ```

    f. Stop the Directory Server.

    ```
    systemctl stop dirsrv.target
    ```

    g. Stop the CA.

    ```
    systemctl stop pki-tomcatd@instance_name.service
    ```

    h. Delete the temporary Server-Cert SSL/TLS certificate from the Directory Server's security database:

    ```
    certutil -D -d /ldap/alias/directory -n "Server-Cert"
    ```

    i. Delete the temporary CA certificate from the Directory Server's security database:

    ```
    certutil -D -d /ldap/alias/directory -n "Temporary CA
    certificate"
    ```

    j. Import the new, permanent Server-Cert SSL/TLS certificate into the Directory Server's security database:

```
certutil -A -i ldap-server.crt -t "u,u,u" -d
/ldap/alias/directory -n "Server-Cert"
```

k. Import the new, permanent CA signing certificate into the Directory Server's security database:

```
certutil -A -i casigning-b64.crt -t "CT,C,C" -d
/ldap/alias/directory -n "caSigningCert cert-pki-ca"
```

l. Start the Directory Server.

```
systemctl start dirsrv.target
```

m. Start the CA.

```
systemctl start pki-tomcatd@instance_name.service
```

6. *For the TPS only.* After the CA is configured, and after the TPS is created but before it is configured, import the Directory Server's CA certificate into the TPS's security databases. The TPS instance must be stopped before the certificates can be imported.

```
# systemctl stop pki-tomcatd@instance_name.service

# certutil -A -i cacert.crt -t "CT,C,C" -n "CA_cert_nickname" -a -
d /var/lib/pki/instance_name/alias

# systemctl start pki-tomcatd@instance_name.service
```

7. *Optional.* Configure SSL/TLS client authentication between each Certificate System subsystem instance and the LDAP server. This is done after the instance is set up.

Chapter 8. Using Hardware Security Modules for Subsystem Security Databases

A subsystem instance generates and stores its key information in a key store, called a *security module* or a *token*. A subsystem instance can be configured for the keys to be generated and stored using the internal NSS token or on a separate cryptographic device, a hardware token.

8.1. Types of Hardware Tokens

A *token* is a hardware or software device that performs cryptographic functions and stores public-key certificates, cryptographic keys, and other data. The Certificate System defines two types of tokens, *internal* and *external*, for storing key pairs and certificates that belong to the Certificate System subsystems.

8.1.1. Internal Tokens

An internal (software) token is a pair of files, usually called the *certificate database* and *key database*, that the Certificate System uses to generate and store its key pairs and certificates. The Certificate System automatically generates these files in the file system of its host machine when the **pkispawn** command is run to create the subsystem instance.

In the Certificate System, the certificate database is named **cert8.db**; the key database is named **key3.db**. These files are located in the *instanceID*/**alias/** directory.

8.1.2. External Tokens

An external token refers to an external hardware device, such as a smart card or hardware security module (HSM), that the Certificate System uses to generate and store its key pairs and certificates. The Certificate System should work with most hardware tokens that are compliant with PKCS #11 but officially, Certificate System 9 only supports certain models of the Gemalto Safenet LunaSA and nCipher nShield HSMs.

Note

See your specific HSM vendor documentation for installation and configuration instructions for using the HSM.

PKCS #11 is a standard set of APIs and shared libraries which isolate an application from the details of the cryptographic device. This enables the application to provide a unified interface for PKCS #11-compliant cryptographic devices.

The PKCS #11 module provided by NSS in the Certificate System supports cryptographic devices supplied by many different manufacturers. This module allows the Certificate System to plug in shared libraries supplied by manufacturers of external encryption devices and use them for generating and storing keys and certificates for the Certificate System managers.

Consider using HSMs for generating and storing the key pairs and certificates used by Certificate System. These devices are another security measure to safeguard private keys because hardware tokens are in general considered more secure than software tokens.

Before using external tokens, plan how the external token is going to be used with the subsystem:

- All system keys for a subsystem must be generated on the same token.
- Preferably, the subsystem keys should be generated in an empty HSM slot. If the HSM slot has previously been used to store other keys, then use the HSM vendor's utilities to delete the contents of the slot. The Certificate System has to be able to create certificates and keys on the slot with default nicknames. If not properly cleaned up, the names of these objects may collide with previous instances.
- A single HSM can be used to store certificates and keys for multiple subsystem instances, which may be installed on multiple hosts. When an HSM is used, any certificate nickname for a subsystem must be unique for every subsystem instance managed on the HSM.

Note

For KRA to perform wrapping and unwrapping on an HSM for key archival and recovery, the HSM must have the capability to wrap and unwrap private keys. If the HSM does not have this capability, the KRA has to be downgraded to be able to encrypt and decrypt user private keys for its key archival and recovery functionalities.

8.1.3. Hardware Cryptographic Accelerators

The Certificate System can use hardware cryptographic accelerators with external tokens. Many of the accelerators provide the following security features:

- Fast SSL connections. Speed is important to accommodate a high number of simultaneous enrollment or service requests.
- Hardware protection of private keys. These devices behave like smart cards by not allowing private keys to be copied or extracted from the hardware token. This is important as a precaution against key theft from an active attack of an online Certificate Manager.

8.2. Using Hardware Security Modules with Subsystems

The Certificate System supports the nCipher nShield hardware security module (HSM) and Gemalto Safenet LunaSA HSM by default. Certificate System-supported HSMs are automatically added to the **`secmod.db`** database with the **`modutil`** command during the pre-configuration stage of the installation, if the PKCS #11 library modules are in the specified installation paths.

Important

Certain deployments require to setup their HSM to use FIPS mode. For example, to enable FIPS mode on an nCipher HSM, open the security UI:

```
# /opt/nfast/bin/ksafe
```

Then in the **`Security World`** tab, ensure that **`Strict FIPS 140-2 Level III`** is set to *yes*.

For information on configuring FIPS mode, see the hardware vendor documentation.

8.2.1. Adding or Managing the HSM Entry for a Subsystem

When an HSM is selected as the default token, some parameters are added to the instance's **CS.cfg** file to configure the HSM. For example:

```
#RHCS supported modules
preop.configModules.module0.userFriendlyName=NSS Internal PKCS #11 Module
preop.configModules.module0.commonName=NSS Internal PKCS #11 Module
preop.configModules.module0.imagePath=/pki/images/clearpixel.gif
preop.configModules.module1.userFriendlyName=nCipher's nFast Token
Hardware Module
preop.configModules.module1.commonName=nfast
preop.configModules.module1.imagePath=/pki/images/clearpixel.gif
preop.configModules.module2.userFriendlyName=SafeNet's LunaSA Token
Hardware Module
preop.configModules.module2.commonName=lunasa
preop.configModules.module2.imagePath=/pki/images/clearpixel.gif
preop.configModules.count=3
#selected token
preop.module.token=Internal Key Storage Token
```

In addition, a parameter is added to the **password.conf** file for the HSM password. For example:

```
hardware-NHSM6000=caPassword
```

8.2.2. Setting up SELinux for an HSM

SELinux policies are created and configured automatically for all Certificate System instances, so Certificate System can run with SELinux in enforcing or permissive modes.

If SELinux is in enforcing mode, then any hardware tokens to be used with the Certificate System instances must also be configured to run with SELinux in enforcing mode, otherwise the HSM will not be available during subsystem installation. For some HSMs, such as nCipher nShield, this may require additional configuration, whereas for Gemalto Safenet LunaSA, no additional configuration is necessary.

Important

For an nCipher nShield HSM, SELinux must be configured for the HSM before installing any Certificate System instances.

1. Reset the context of files in /opt/nfast to match the newly-installed policy:

   ```
   # /sbin/restorecon -R /opt/nfast
   ```

2. Restart the **nfast** software.

8.2.3. Installing a Subsystem Using nCipher nShield HSM

To install a subsystem instance that use nCipher nShield HSM, follow this procedure:

1. Prepare an override file, which corresponds to your particular deployment. The following **`default_hms.txt`** file is an example of such an override file:

Note

This file serves only as an example of an nCipher HSM override configuration file -- numerous other values can be overridden including default hashing algorithms. Also, only one of the [CA], [KRA], [OCSP], [TKS], or [TPS] sections will be utilized depending upon the subsystem invocation specified on the **`pkispawn`** command-line.

Example 8.1. An Override File Sample to Use with nCipher HSM

```
##################################################################
###############
##################################################################
###############
##################################################################
###############
##
##
## EXAMPLE: Configuration File used to override
'/etc/pki/default.cfg'       ##
##          when using an nCipher Hardware Security Module
(HSM):            ##
##
##
##
##
##     # modutil -dbdir . -list
##
##
##
##     Listing of PKCS #11 Modules
##
##     -----------------------------------------------------------
--           ##
##       1. NSS Internal PKCS #11 Module
##
##              slots: 2 slots attached
##
##             status: loaded
##
##
##
##              slot: NSS Internal Cryptographic Services
##
##             token: NSS Generic Crypto Services
##
##
##
##              slot: NSS User Private Key and Certificate
Services          ##
```

```
##             token: NSS Certificate DB
##
##
##
##      2. nfast
##
##            library name:
/opt/nfast/toolkits/pkcs11/libcknfast.so         ##
##             slots: 2 slots attached
##
##            status: loaded
##
##
##
##             slot: 061C-37A2-3CB3 Rt1
##
##            token: accelerator
##
##
##
##             slot: 061C-37A2-3CB3 Rt1 slot 0
##
##            token: NHSM6000
##
##     ------------------------------------------------------------
--           ##
##
##
##
##
##     Based on the example above, substitute all password
values,           ##
##     as well as the following values:
##
##
##
##
<hsm_libfile>=/opt/nfast/toolkits/pkcs11/libcknfast.so
##
##         <hsm_modulename>=nfast
##
##         <hsm_token_name>=NHSM6000
##
##
##
################################################################
###############
################################################################
###############
################################################################
###############

[DEFAULT]
############################
# Provide HSM parameters #
############################
```

```
pki_hsm_enable=True
pki_hsm_libfile=<hsm_libfile>
pki_hsm_modulename=<hsm_modulename>
pki_token_name=<hsm_token_name>
pki_token_password=<pki_token_password>

########################################
# Provide PKI-specific HSM token names #
########################################
pki_audit_signing_token=<hsm_token_name>
pki_ssl_server_token=<hsm_token_name>
pki_subsystem_token=<hsm_token_name>

###################################
# Provide PKI-specific passwords #
###################################
pki_admin_password=<pki_admin_password>
pki_client_pkcs12_password=<pki_client_pkcs12_password>
pki_ds_password=<pki_ds_password>

#####################################
# Provide non-CA-specific passwords #
#####################################
pki_client_database_password=<pki_client_database_password>

#####################################################################
# ONLY required if specifying a non-default PKI instance name #
#####################################################################
#pki_instance_name=<pki_instance_name>

#################################################################
# ONLY required if specifying non-default PKI instance ports #
#################################################################
#pki_http_port=<pki_http_port>
#pki_https_port=<pki_https_port>

#####################################################################
######
# ONLY required if specifying non-default 389 Directory Server
ports #
#####################################################################
######
#pki_ds_ldap_port=<pki_ds_ldap_port>
#pki_ds_ldaps_port=<pki_ds_ldaps_port>

#####################################################################
######
# ONLY required if PKI is using a Security Domain on a remote
system #
#####################################################################
######
#pki_ca_hostname=<pki_ca_hostname>
#pki_issuing_ca_hostname=<pki_issuing_ca_hostname>
#pki_issuing_ca_https_port=<pki_issuing_ca_https_port>
#pki_security_domain_hostname=<pki_security_domain_hostname>
#pki_security_domain_https_port=<pki_security_domain_https_port>
```

```
#############################################################
# ONLY required for PKI using an existing Security Domain #
#############################################################
# NOTE:  pki_security_domain_password == pki_admin_password
#        of CA Security Domain Instance
#pki_security_domain_password=<pki_admin_password>


[Tomcat]
#################################################################
# ONLY required if specifying non-default PKI instance ports #
#################################################################
#pki_ajp_port=<pki_ajp_port>
#pki_tomcat_server_port=<pki_tomcat_server_port>


[CA]
########################################
# Provide CA-specific HSM token names #
########################################
pki_ca_signing_token=<hsm_token_name>
pki_ocsp_signing_token=<hsm_token_name>

#####################################################################
###########
# ONLY required if 389 Directory Server for CA resides on a
remote system #
#####################################################################
###########
#pki_ds_hostname=<389 hostname>


[KRA]
########################################
# Provide KRA-specific HSM token names #
########################################
pki_storage_token=<hsm_token_name>
pki_transport_token=<hsm_token_name>

#####################################################################
###########
# ONLY required if 389 Directory Server for KRA resides on a
remote system #
#####################################################################
###########
#pki_ds_hostname=<389 hostname>


[OCSP]
########################################
# Provide OCSP-specific HSM token names #
########################################
pki_ocsp_signing_token=<hsm_token_name>

#################################################################
```

```
#############
# ONLY required if 389 Directory Server for OCSP resides on a
remote system #
#####################################################################
#############
#pki_ds_hostname=<389 hostname>


[TKS]
########################################
# Provide TKS-specific HSM token names #
########################################

#####################################################################
#############
# ONLY required if 389 Directory Server for TKS resides on a
remote system #
#####################################################################
#############
#pki_ds_hostname=<389 hostname>


[TPS]
###################################
# Provide TPS-specific parameters #
###################################
pki_authdb_basedn=<dnsdomainname where hostname.b.c.d is
dc=b,dc=c,dc=d>

########################################
# Provide TPS-specific HSM token names #
########################################

#####################################################################
#############
# ONLY required if 389 Directory Server for TPS resides on a
remote system #
#####################################################################
#############
#pki_ds_hostname=<389 hostname>

#############################################################
# ONLY required if TPS requires a CA on a remote machine #
#############################################################
#pki_ca_uri=https://<pki_ca_hostname>:<pki_ca_https_port>

#######################################
# ONLY required if TPS requires a KRA #
#######################################
#pki_enable_server_side_keygen=True

#############################################################
# ONLY required if TPS requires a KRA on a remote machine #
#############################################################
#pki_kra_uri=https://<pki_kra_hostname>:<pki_kra_https_port>
```

```
############################################################
# ONLY required if TPS requires a TKS on a remote machine #
############################################################
#pki_tks_uri=https://<pki_tks_hostname>:<pki_tks_https_port>
```

2. Run one of the following commands in dependency on the subsystem being installed:

```
# pkispawn -s CA -f ./default_hsm.txt -vvv
```

```
# pkispawn -s KRA -f ./default_hsm.txt -vvv
```

```
# pkispawn -s OCSP -f ./default_hsm.txt -vvv
```

```
# pkispawn -s TKS -f ./default_hsm.txt -vvv
```

```
# pkispawn -s TPS -f ./default_hsm.txt -vvv
```

8.2.4. Installing a Subsystem Using Gemalto Safenet LunaSA HSM

To install a subsystem instance that use Gemalto Safenet LunaSA HSM, follow the procedure detailed in Section 8.2.3, “Installing a Subsystem Using nCipher nShield HSM”. The override file should be similar to the sample provided in Example 8.1, “An Override File Sample to Use with nCipher HSM”, differing in values related to the particular deployment. The following example provides a sample LunaSA header that is to be substituted for the header of the nCipher override file and to be used with the [DEFAULT], [Tomcat], [CA], [KRA], [OCSP], [TKS], and [TPS] sections provided in the aforementioned nCipher example.

Example 8.2. A Sample of the LunaSA Override File Header

```
##############################################################################
#########
##############################################################################
#########
##############################################################################
#########
##
##
## EXAMPLE: Configuration File used to override '/etc/pki/default.cfg'
##
##          when using a LunaSA Hardware Security Module (HSM):
##
##
##
##
##
##     # modutil -dbdir . -list
##
##
##
```

```
##     Listing of PKCS #11 Modules
##
##     -----------------------------------------------------------
##
##       1. NSS Internal PKCS #11 Module
##
##              slots: 2 slots attached
##
##             status: loaded
##
##
##
##              slot: NSS Internal Cryptographic Services
##
##             token: NSS Generic Crypto Services
##
##
##
##              slot: NSS User Private Key and Certificate Services
##
##             token: NSS Certificate DB
##
##
##
##      2. lunasa
##
##             library name:
/usr/safenet/lunaclient/lib/libCryptoki2_64.so   ##
##              slots: 4 slots attached
##
##             status: loaded
##
##
##
##              slot: LunaNet Slot
##
##             token: dev-intca
##
##
##
##              slot: Luna UHD Slot
##
##             token:
##
##
##
##              slot: Luna UHD Slot
##
##             token:
##
##
##
##              slot: Luna UHD Slot
##
##             token:
##
```

```
##     ------------------------------------------------------------
##
##
##
##
##
##     Based on the example above, substitute all password values,
##
##     as well as the following values:
##
##
##
##
<hsm_libfile>=/usr/safenet/lunaclient/lib/libCryptoki2_64.so      ##
##          <hsm_modulename>=lunasa
##
##          <hsm_token_name>=dev-intca
##
##
##
#########################################################################
#########
#########################################################################
#########
#########################################################################
#########
```

8.3. Installing External Tokens and Unsupported HSM

Similarly with the supported HSMs, the following fields in the pkispawn override file can be modified to allow using of other PKCS#11 modules:

```
[DEFAULT]
############################
# Provide HSM parameters #
############################
pki_hsm_enable=True
pki_hsm_libfile=<hsm_libfile>
pki_hsm_modulename=<hsm_modulename>
pki_token_name=<hsm_token_name>
pki_token_password=<pki_token_password>

########################################
# Provide PKI-specific HSM token names #
########################################
pki_audit_signing_token=<hsm_token_name>
pki_ssl_server_token=<hsm_token_name>
pki_subsystem_token=<hsm_token_name>
```

8.4. Retrieving Keys from an HSM

It is not possible to export keys and certificates stored on an HSM to a **.p12** file. If such an instance is to be backed-up, contact the manufacturer of your HSM for support.

8.5. Installing a Clone Subsystem Using an HSM

Normally, clone subsystems are created using a PKCS #12 file that is generated during installation of the master subsystem. Such a file is generated by specifying **pki_backup_keys=True** along with the defined value for the **pki_backup_password** option.

However, it is not possible to generate a PKCS #12 file when using an HSM because the keys cannot be copied out of the HSM. Therefore, when attempting to create a clone from a master which has its keys stored on an HSM, the clone must actually share its master's keys that are stored on the HSM.

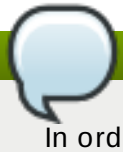
This means that you need to specify less options for creating an HSM clone than is required for creating a non-HSM clone. The following example lists options from the **[Tomcat]** section of the respective PKI configuration file that are required for generating a CA clone.

For generating a non-HSM CA clone:

- **pki_clone**=True
- **pki_clone_pkcs12_password**=Secret123
- **pki_clone_pkcs12_path**=<path_to_pkcs12_file>
- **pki_clone_replicate_schema**=True (default value)
- **pki_clone_uri**=https://<master_ca_hostname>:<master_ca_https_port>

For generating a CA clone using an HSM:

- **pki_clone**=True
- **pki_clone_replicate_schema**=True (default value)
- **pki_clone_uri**=https://<master_ca_hostname>:<master_ca_https_port>



Note

In order for the master subsystem to share the same certificates and keys with its clones, the HSM must be on a network that is in shared mode and accessible by all subsystems.

8.6. Viewing Tokens

To view a list of the tokens currently installed for a Certificate System instance, use the **modutil** utility.

1. Change to the instance **alias** directory. For example:

```
# cd /var/lib/pki/pki-tomcat/alias
```

2. Show the information about the installed PKCS #11 modules installed as well as information on the corresponding tokens using the **modutil** tool.

```
# modutil -dbdir . -nocertdb -list
```

8.7. Detecting Tokens

To see if a token can be detected by Certificate System, use the **TokenInfo** utility, pointing to the **alias** directory for the subsystem instance. This is a Certificate System tool which is available after the Certificate System packages are installed.

For example:

```
# TokenInfo /var/lib/pki/pki-tomcat/alias
```

This utility returns all tokens which can be detected by the Certificate System, not only tokens which are installed in the Certificate System.

Chapter 9. Installing an Instance with ECC System Certificates

Elliptic curve cryptography (ECC) is much more secure than the more common RSA-style encryption, which allows it to use much shorter key lengths and makes it faster to generate certificates. CAs which are ECC-enabled can issue both RSA and ECC certificates, using their ECC signing certificate.

Certificate System includes native support for ECC features; the support is enabled by default starting from NSS 3.16. It is also possible to load and use a third-party PKCS #11 module, such as a hardware security module (HSM). To use the ECC module, it must be loaded before the subsystem instance is configured.

Important

Third-party ECC modules must have an SELinux policy configured for them, or SELinux needs to be changed from **`enforcing`** mode to **`permissive`** mode to allow the module to function. Otherwise, any subsystem operations which require the ECC module will fail.

9.1. Loading a Third-Party ECC Module

Loading a third-party ECC module follows the same principles as loading HSMs supported by Certificate System, which is described in Chapter 8, *Using Hardware Security Modules for Subsystem Security Databases*. See this chapter for more information and for instructions.

9.2. Using ECC with an HSM

The HSMs supported by Certificate System support their own native ECC modules. To create an instance with ECC system certificates:

1. Set up the HSM per manufacturer's instructions. If multiple hosts are sharing the HSM, make sure they can all access the same partition if needed and if the site policies allow it.
2. Define the required parameters in the **`pkispawn`** utility configuration file and run **`pkispawn`**. For example, to configure Certificate System to create an ECC CA, assuming the configuration file is **`ecc.inf`**:
    a. Edit **`ecc.inf`** to specify the appropriate settings. For an example of the configuration file, see the pkispawn(8) man page.
    b. Run **`pkispawn`** against **`ecc.inf`**:

```
$ script -c 'pkispawn -s CA -f /root/pki/ecc.inf -vvv'
```

Note

For information on installing HSMs that are not supported by Red Hat Certificate System, see Section 8.3, “Installing External Tokens and Unsupported HSM”.

Chapter 10. Cloning Subsystems

When a new subsystem instance is first configured, the Red Hat Certificate System allows subsystems to be cloned, or duplicated, for high availability of the Certificate System. The cloned instances run on different machines to avoid a single point of failure and their databases are synchronized through replication.

The master CA and its clones are functionally identical, they only differ in serial number assignments and CRL generation. Therefore, this chapter refers to master or any of its clones as *replicated CAs*.

10.1. About Cloning

Planning for *high availability* reduces unplanned outages and other problems by making one or more subsystem clones available. When a host machine goes down, the cloned subsystems can handle requests and perform services, taking over from the master (original) subsystem seamlessly and keeping uninterrupted service.

Using cloned subsystems also allows systems to be taken offline for repair, troubleshooting, or other administrative tasks without interrupting the services of the overall PKI system.

Note

All of the subsystems except the TPS can be cloned.

Cloning is one method of providing scalability to the PKI by assigning the same task, such as handling certificate requests, to separate instances on different machines. The internal databases for the master and its clones are replicated between each other, so the information about certificate requests or archived keys on one subsystem is available on all the others.

Typically, master and cloned instances are installed on different machines, and those machines are placed behind a *load balancer*. The load balancer accepts HTTP and HTTPS requests made to the Certificate System subsystems and directs those requests appropriately between the master and cloned instances. In the event that one machine fails, the load balancer transparently redirects all requests to the machine that is still running until the other machine is brought back online.

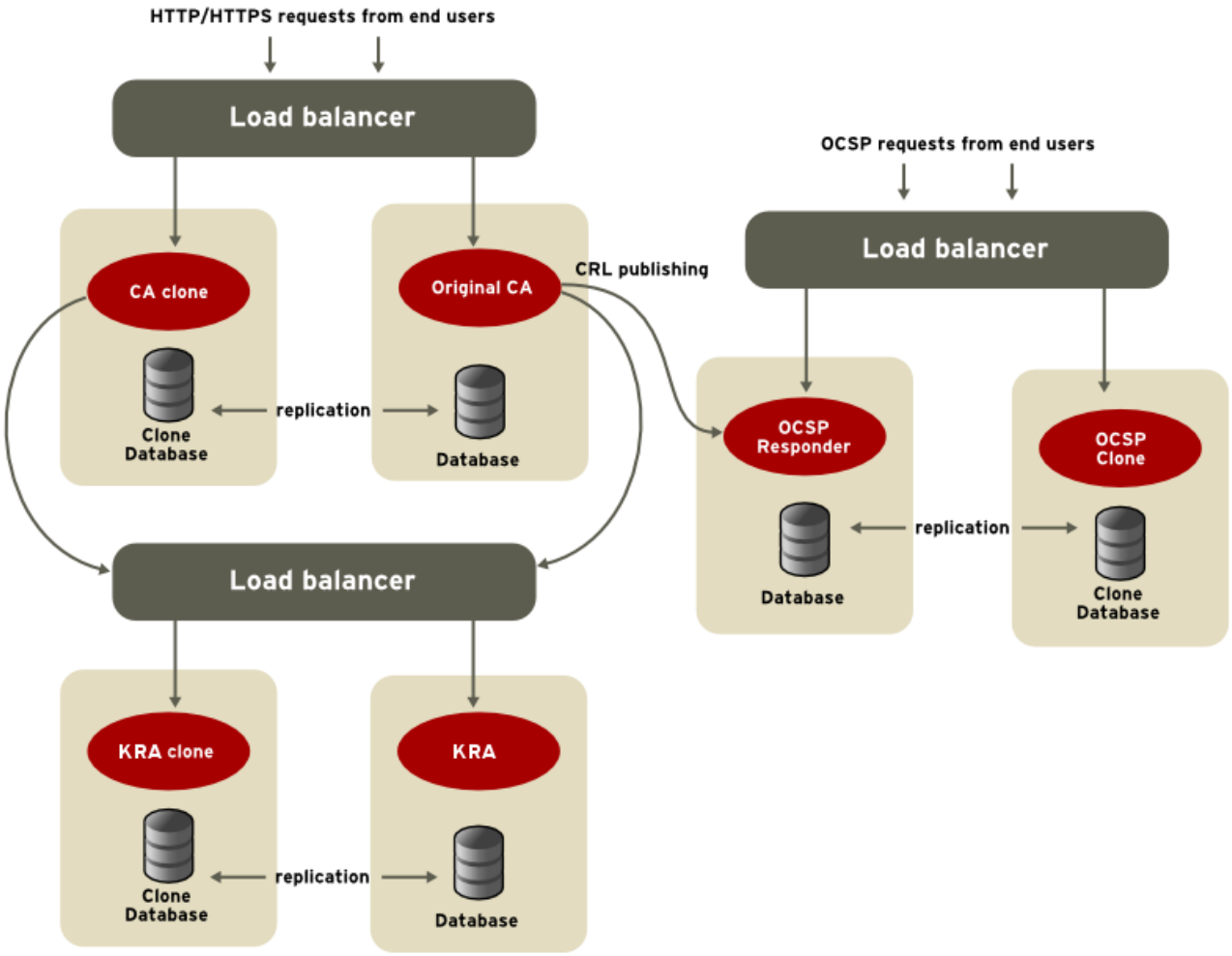


Figure 10.1. Cloning Example

The load balancer in front of a Certificate System subsystem is what provides the actual failover support in a high availability system. A load balancer can also provide the following advantages as part of a Certificate System subsystem:

- DNS round-robin, a feature for managing network congestion that distributes load across several different servers.
- Sticky SSL/TLS, which makes it possible for a user returning to the system to be routed the same host used previously.

10.1.1. Cloning for CAs

Cloned instances have the exact same private keys as the master, so their certificates are identical. For CAs, that means that the CA signing certificates are identical for the original master CA and its cloned CAs. From the perspectives of clients, these look like a single CA.

Every CA, both cloned and master, can issue certificates and process revocation requests.

The main issue with managing replicated CAs is how to assign serial numbers to the certificates they issue. Different replicated CAs can have different levels of traffic, using serial numbers at different rates, and it is imperative that no two replicated CAs issue certificates with the same serial number. These serial number ranges are assigned and managed dynamically by using a shared, replicated

entry that defines the ranges for each CA and the next available range to reassign when one CA range runs low.

The serial number ranges with cloned CAs are fluid. All replicated CAs share a common configuration entry which defines the next available range. When one CA starts running low on available numbers, it checks this configuration entry and claims the next range. The entry is automatically updated, so that the next CA gets a new range.

The ranges are defined in ***begin*Number*** and ***end*Number*** attributes, with separate ranges defined for requests and certificate serial numbers. For example:

```
dbs.beginRequestNumber=1
dbs.beginSerialNumber=1
dbs.enableSerialManagement=true
dbs.endRequestNumber=9980000
dbs.endSerialNumber=ffe0000
dbs.replicaCloneTransferNumber=5
```

Only one replicated CA can generate, cache, and publish CRLs; this is the CRL CA. CRL requests submitted to other replicated CAs are immediately redirected to the CRL CA. While other replicated CAs can revoke, display, import, and download CRLs previously generated by the CRL CA, synchronization problems might occur if they generate new CRLs. For instructions on how to move CRL generation to a different replicated CA, see Section 10.8.1, “Converting CA Clones and Masters”.

Master CAs also manage the relationships and information sharing between the cloned CAs by monitoring replication changes to the internal databases.

Note

If a CA which is a security domain master is cloned, then that cloned CA is also a security domain master. In that case, both the original CA and its clone share the same security domain configuration.

Important

As covered in Section 10.1.7, “Custom Configuration and Clones”, the data within the LDAP database is replicated among a master and clones, but the *configuration files* for the different instances are not replicated. This means that any changes which affect the **CS.cfg** file — such as adding a KRA connection or creating a custom profile — are not copied into a clone's configuration if the change occurs *after* the clone is created.

Any changes to the CA configuration should either be made to the master *before* any clones are created (so the custom changes are included in the cloning process) or any configuration changes must be copied over manually to the clone instances after they are created.

10.1.2. Cloning for KRAs

With KRAs, all keys archived in one KRA are replicated to the internal databases of the other KRAs. This allows a key recovery to be initiated on any clone KRA, regardless of which KRA the key was originally archived on.

After a key recovery is processed, the record of the recovery is stored in the internal database of all of the cloned KRAs.

With synchronous key recovery, although the recovery process can be initiated on any clone, it must be completed on the same single KRA on which it was initiated. This is because a recovery operation is recorded in the replicated database only after the appropriate number of approvals have been obtained from the KRA agents. Until then, the KRA on which the recovery is initiated is the only one which knows about the recovery operation.

Important

The synchronous key recovery mechanism has been deprecated in Red Hat Certificate System 9. Red Hat recommends to use asynchronous key recovery instead.

10.1.3. Cloning for Other Subsystems

There is no real operational difference between replicated TKSs; the information created or maintained on one is replicated along the other servers.

For OCSPs, only one replicated OCSP receives CRL updates, and then the published CRLs are replicated to the clones.

10.1.4. Cloning and Key Stores

Cloning a subsystem creates two server processes performing the same functions: another new instance of the subsystem is created and configured to use the same keys and certificates to perform its operations. Depending on where the keys are stored for the master clone, the method for the clone to access the keys is very different.

If the keys and certificates are stored in the internal software token, then they must be exported from the master subsystem when it is first configured. When configuring the master instance, it is possible to backup the system keys and certificates to a PKCS #12 file by specifying the ***pki_backup_keys*** and ***pki_backup_password*** parameters in the **pkispawn** configuration file. See the **BACKUP PARAMETERS** section in the pki_default.cfg(5) man page for more details.

If the keys were not backed up during the initial configuration, you can extract them to a PKCS #12 file using the **PKCS12Export** utility, as described in Section 10.2, “Backing up Subsystem Keys from a Software Database”.

Then copy the PKCS #12 file over to the clone subsystem, and define its location and password in the **pkispawn** configuration file using the ***pki_clone_pkcs12_password*** and ***pki_clone_pkcs12_path*** parameters For more information, see the **Installing a Clone** section in the pkispawn(8) man page. In particular, make sure that the PKCS#12 file is accessible by the **pkiuser** user and that it has the correct SELinux label.

If the keys and certificates are stored on a hardware token, then the keys and certificates must be copied using hardware token specific utilities or referenced directly in the token:

- Duplicate all the required keys and certificates, except the SSL/TLS server key and certificate to the clone instance. Keep the nicknames for those certificates the same. Additionally, copy all the necessary trusted root certificates from the master instance to the clone instance, such as chains or cross-pair certificates.
- If the token is network-based, then the keys and certificates simply need to be available to the token; the keys and certificates do not need to be copied.

- When using a network-based hardware token, make sure the high-availability feature is enabled on the hardware token to avoid single point of failure.

10.1.5. LDAP and Port Considerations

As mentioned in Section 10.1, “About Cloning”, part of the behavior of cloning is to replicate information between replicated subsystems, so that they work from an identical set of data and records. This means that the LDAP servers for the replicated subsystems need to be able to communicate.

If the Directory Server instances are on different hosts, then make sure that there is appropriate firewall access to allow the Directory Server instances to connect with each other.

Note

Cloned subsystems and their masters must use separate LDAP servers while they replicate data between common suffixes.

A subsystem can connect to its internal database using either SSL/TLS over an LDAPS port or over a standard connection over an LDAP port. When a subsystem is cloned, the clone instance uses the same connection method (SSL/TLS or standard) as its master to connect to the database. With cloning, there is an additional database connection though: the master Directory Server database to the clone Directory Server database. For that connection, there are *three* connection options:

- If the master uses SSL/TLS to connect to its database, then the clone uses SSL/TLS, and the master/clone Directory Server databases use SSL/TLS connections for replication.
- If the master uses a standard connection to its database, then the clone must use a standard connection, and the Directory Server databases *can* use unencrypted connections for replication.
- If the master uses a standard connection to its database, then the clone must use a standard connection, *but* there is an option to use Start TLS for the master/clone Directory Server databases for replication. Start TLS opens a secure connection over a standard port.

Note

To use Start TLS, the Directory Server must still be configured to accept SSL/TLS connections. This means that prior to configuring the clone, a server certificate and a CA certificate must be installed on the Directory Server, and SSL/TLS must be enabled.

Whatever connection method (secure or standard) used by the master must be used by the clone and must be properly configured for the Directory Server databases prior to configuring the clone.

Important

Even if the clone connects to the master over a secure connection, the standard LDAP port (389 by default) must still be open and enabled on the LDAP server while cloning is configured.

For secure environments, the standard LDAP port can be disabled on the master's Directory Server instance once the clone is configured.

10.1.6. Replica ID Numbers

Cloning is based on setting up a replication agreement between the Directory Server for the master instance and the Directory Server for the cloned instance.

Servers involved together with replication are in the same replication *topology*. Every time a subsystem instance is cloned, it is added to the overall topology. Directory Server discerns between different servers in the topology based on their *replica ID number*. This replica ID must be unique among all of the servers in the topology.

As with the serial number ranges used for requests and certificates (covered in Section 10.1.1, “Cloning for CAs”), every subsystem is assigned a range of allowed replica IDs. When the subsystem is cloned, it assigns one of the replica IDs from its range to the new clone instance.

```
dbs.beginReplicaNumber=1
dbs.endReplicaNumber=95
```

The replica ID range can be refreshed with new numbers if an instance begins to exhaust its current range.

10.1.7. Custom Configuration and Clones

After a clone is created, *configuration* changes are not replicated between clones or between a master and a clone. The instance configuration is in the **`CS.cfg`** file — outside the replicated database.

For example, there are two CAs, a master and a clone. A new KRA is installed which is associated, at its configuration, with the master CA. The CA-KRA connector information is stored in the master CA's **`CS.cfg`** file, but this connector information is not added to the clone CA configuration. If a certificate request that includes a key archival is submitted to the master CA, then the key archival is forwarded to the KRA using the CA-KRA connector information. If the request is submitted to the clone CA, no KRA is recognized, and the key archival request is disallowed.

Changes made to the configuration of a master server or to a clone server are not replicated to other cloned instances. Any critical settings must be added manually to clones.

Note

You can set all required, custom configuration for a master server before configuring any clones. For example, install all KRAs so that all the connector information is in the master CA configuration file, create any custom profiles, or configure all publishing points for a master OCSP responder. Note that if the LDAP profiles are stored in the Directory Server, they are replicated and kept in sync across servers.

Any custom settings in the master instance will be included in the cloned instances *at the time they are cloned* (but not after).

10.2. Backing up Subsystem Keys from a Software Database

Ideally, the keys for the master instance are backed up when the instance is first created. If the keys were not backed up then or if the backup file is lost, then it is possible to extract the keys from the internal software database for the subsystem instance using the **PKCS12Export** utility. For example:

```
PKCS12Export -debug -d /var/lib/pki/instance_name/alias -w p12pwd.txt -p
internal.txt -o master.p12
```

Then copy the PKCS #12 file to the clone machine to be used in the clone instance configuration. For more details, see Section 10.1.4, “Cloning and Key Stores”.

Note

Keys cannot be exported from an HSM. However, in a typical deployment, HSMs support networked access, as long as the clone instance is installed using the same HSM as the master. If both instances use the same key store, then the keys are naturally available to the clone.

If backing up keys from the HSM is required, contact the HSM manufacturer for assistance.

10.3. Cloning a CA

1. Configure the master CA, and back up the keys.
2. In the **CS.cfg** file for the master CA, enable the master CA to monitor replication database changes by adding the **ca.listenToCloneModifications** parameter:

   ```
   ca.listenToCloneModifications=true
   ```

3. Create the clone subsystem instance.

   For information on using the **pkispawn** utility, see the Red Hat Certificate System Command-Line Tools Guide. For examples of the configuration file required by **pkispawn** when cloning CA subsystems, see the **Installing a CA clone** and **Installing a CA clone on the same host** sections of the pkispawn(8) man page.

4. Restart the Directory Server instance used by the clone.

```
systemctl restart pki-tomcatd@kra-clone-ds-instance.service
```

Note

Restarting the Directory Server reloads the updated schema, which is required for proper performance.

5. Restart the clone instance.

```
systemctl restart pki-tomcatd@instance_name.service
```

After configuring the clone, test to make sure that the master-clone relationship is functioning:

1. Request a certificate from the cloned CA.
2. Approve the request.
3. Download the certificate to the browser.
4. Revoke the certificate.
5. Check master CA's CRL for the revoked certificate. In the master Certificate Manager's agent services page, click **`Update Certificate Revocation List`**. Find the CRL in the list.

   The CRL should show the certificate revoked by the cloned Certificate Manager. If that certificate is not listed, check logs to resolve the problem.

10.4. Updating CA-KRA Connector Information After Cloning

As covered in Section 10.1.7, “Custom Configuration and Clones”, configuration information is not updated in clone instances if it is made *after* the clone is created. Likewise, changes made to a clone are not copied back to the master instance.

If a new KRA is installed or cloned after a clone CA is created, then the clone CA does not have the new KRA connector information in its configuration. This means that the clone CA is not able to send any archival requests to the KRA.

Whenever a new KRA is created or cloned, copy its connector information into all of the *cloned* CAs in the deployment. To do this, use the **`pki ca-kraconnector-add`** command. For information about the **`pki`** utility, see the Red Hat Certificate System Command-Line Tools Guide.

If it is required to do this manually, follow these steps:

1. On the master clone machine, open the master CA's **`CS.cfg`** file, and copy all of the ***`ca.connector.KRA.*`*** lines for the new KRA connector.

```
[root@master ~]# vim /var/lib/pki/pki-tomcat/ca/conf/CS.cfg
```

2. Stop the clone CA instance. For example:

```
[root@clone-ca ~] systemctl stop pki-tomcatd@instance_name.service
```

3. Open the clone CA's **CS.cfg** file.

```
[root@clone-ca ~]# vim /var/lib/pki/pki-tomcat/ca/conf/CS.cfg
```

4. Copy in the connector information for the new KRA instance or clone.

```
ca.connector.KRA.enable=true ca.connector.KRA.host=server-
kra.example.com
ca.connector.KRA.local=false
ca.connector.KRA.nickName=subsystemCert cert-pki-ca
ca.connector.KRA.port=10444 ca.connector.KRA.timeout=30
ca.connector.KRA.transportCert=MIIDbD...ZR0Y2zA==
ca.connector.KRA.uri=/kra/agent/kra/connector
```

5. Start the clone CA.

```
[root@clone-ca ~] systemctl start pki-tomcatd@instance_name.service
```

10.5. Cloning OCSP Subsystems

1. Configure the master OCSP, and back up the keys.
2. In the **CS.cfg** file for the master OCSP, set the **OCSP.Responder.store.defStore.refreshInSec** parameter to any non-zero number other than 21600; 21600 is the setting for a clone.

```
vim /etc/instance_name/CS.cfg

OCSP.Responder.store.defStore.refreshInSec=15000
```

3. Create the clone subsystem instance using the **pkispawn** utility.

   For information on using the **pkispawn** utility, see the Red Hat Certificate System Command-Line Tools Guide. For examples of the configuration file required by **pkispawn** when cloning OCSP subsystems, see the pkispawn(8) man page.

4. Restart the Directory Server instance used by the clone.

```
systemctl dirsrv@instance_name.service
```

Note

Restarting the Directory Server reloads the updated schema, which is required for proper performance.

5. Restart the clone instance.

```
systemctl restart pki-tomcatd@instance_name.service
```

After configuring the clone, test to make sure that the master-clone relationship is functioning:

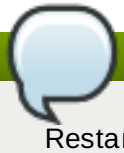
1. Set up OCSP publishing in the master CA so that the CRL is published to the master OCSP.
2. Once the CRL is successfully published, check both the master and cloned OCSP's **List Certificate Authorities** link in the agent pages. The list should be identical.
3. Use the **OCSPClient** tool to submit OCSP requests to the master and the cloned Online Certificate Status Manager. The tool should receive identical OCSP responses from both managers.

10.6. Cloning KRA Subsystems

1. Configure the master subsystem, and back up the keys.
2. Create the clone subsystem instance using the **pkispawn** utility.

   For information on using the **pkispawn** utility, see the Red Hat Certificate System Command-Line Tools Guide. For examples of the configuration file required by **pkispawn** when cloning KRA subsystems, see the **Installing a KRA or TPS clone** section of the pkispawn(8) man page.
3. Restart the Directory Server instance used by the clone.

   ```
   systemctl dirsrv@instance_name.service
   ```

   Note

   Restarting the Directory Server reloads the updated schema, which is required for proper performance.
4. Restart the clone instance.

   ```
   systemctl restart pki-tomcatd@instance_name.service
   ```

For the KRA clone, test to make sure that the master-clone relationship is functioning:

1. Go to the KRA agent's page.
2. Click **List Requests**.
3. Select **Show all requests** for the request type and status.
4. Click **Submit**.
5. Compare the results from the cloned KRA and the master KRA. The results ought to be identical.

10.7. Cloning TKS Subsystems

1. Configure the master subsystem, and back up the keys.
2. Create the clone subsystem instance using the **pkispawn** utility.

For information on using the **pkispawn** utility, see the Red Hat Certificate System Command-Line Tools Guide. For examples of the configuration file required by **pkispawn** when cloning TKS subsystems, see the **Installing a KRA or TKS clone** section of the pkispawn(8) man page.

3. Restart the clone instance.

```
systemctl restart pki-tomcatd@instance_name.service
```

For the TKS, enroll a smart card and then run an **ldapsearch** to make sure that the same key information is contained in both databases.

10.8. Converting Masters and Clones

Only one single active CA generating CRLs can exist within the same topology. Similarly, only one OCSP receiving CRLs can exist within the same topology. As such, there can be any number of clones, but there can only be a single configured master for CA and OCSP.

For KRAs and TKSs, there is no configuration difference between masters and clones, but CAs and OCSPs do have some configuration differences. This means that when a master is taken offline — because of a failure or for maintenance or to change the function of the subsystem in the PKI — then the existing master must be reconfigured to be a clone, and one of the clones promoted to be the master.

10.8.1. Converting CA Clones and Masters

1. Stop the master CA if it is still running.
2. Open the existing master CA configuration directory:

```
cd /var/lib/pki/pki-tomcat/ca/conf
```

3. Edit the **CS.cfg** file for the master, and change the CRL and maintenance thread settings so that it is set as a clone:
   - Disable control of the database maintenance thread:

```
ca.certStatusUpdateInterval=0
```

   - Disable monitoring database replication changes:

```
ca.listenToCloneModifications=false
```

   - Disable maintenance of the CRL cache:

```
ca.crl.IssuingPointId.enableCRLCache=false
```

   - Disable CRL generation:

```
ca.crl.IssuingPointId.enableCRLUpdates=false
```

   - Set the CA to redirect CRL requests to the new master:

```
master.ca.agent.host=new_master_hostname
master.ca.agent.port=new_master_port
```

4. Stop the cloned CA server.

```
systemctl stop pki-tomcatd@instance_name.service
```

5. Open the cloned CA's configuration directory.

```
cd /etc/instance_name
```

6. Edit the **CS.cfg** file to configure the clone as the new master.

    a. Delete each line which begins with the **ca.crl.** prefix.

    b. Copy each line beginning with the **ca.crl.** prefix from the former master CA **CS.cfg** file into the cloned CA's **CS.cfg** file.

    c. Enable control of the database maintenance thread; the default value for a master CA is **600**.

    ```
    ca.certStatusUpdateInterval=600
    ```

    d. Enable monitoring database replication:

    ```
    ca.listenToCloneModifications=true
    ```

    e. Enable maintenance of the CRL cache:

    ```
    ca.crl.IssuingPointId.enableCRLCache=true
    ```

    f. Enable CRL generation:

    ```
    ca.crl.IssuingPointId.enableCRLUpdates=true
    ```

    g. Disable the redirect settings for CRL generation requests:

    ```
    master.ca.agent.host=hostname
    master.ca.agent.port=port number
    ```

7. Start the new master CA server.

```
systemctl start pki-tomcatd@instance_name.service
```

10.8.2. Converting OCSP Clones

1. Stop the OCSP master, if it is still running.

2. Open the existing master OCSP configuration directory.

```
cd /etc/instance_name
```

3. Edit the **CS.cfg**, and reset the **OCSP.Responder.store.defStore.refreshInSec** parameter to **21600**:

```
OCSP.Responder.store.defStore.refreshInSec=21600
```

4. Stop the online cloned OCSP server.

```
systemctl stop pki-tomcatd@instance_name.service
```

5. Open the cloned OCSP responder's configuration directory.

```
cd /etc/instance_name
```

6. Open the **CS.cfg** file, and delete the **OCSP.Responder.store.defStore.refreshInSec** parameter or change its value to any non-zero number:

```
OCSP.Responder.store.defStore.refreshInSec=15000
```

7. Start the new master OCSP responder server.

```
systemctl start pki-tomcatd@instance_name.service
```

10.9. Cloning a CA That Has Been Re-Keyed

When a certificate expires, it has to be replaced. This can either be done by renewing the certificate, which re-uses the original keypair to generate a new certificate, or it can be done by generating a new keypair and certificate. The second method is called *re-keying*.

When a CA is re-keyed, new keypairs are stored in its certificate database, and these are the keys references for normal operations. However, for cloning a subsystem, the cloning process checks for the CA private key IDs as stored in its **CS.cfg** configuration file — and those key IDs are not updated when the certificate database keys change.

If a CA has been re-keyed and then an administrator attempts to clone it, the cloned CA fails to generate any certificates for the certificates which were re-keyed, and it shows up in the error logs with this error:

```
CertUtil::createSelfSignedCert() - CA private key is null!
```

To clone a CA that has been re-keyed:

1. Find all of the private key IDs in the **CS.cfg** file.

```
# grep privkey.id /var/lib/pki/pki-tomcat/ca/conf/CS.cfg
cloning.signing.privkey.id     =-
4d798441aa7230910d4e1c39fa132ea228d5d1bc
cloning.ocsp_signing.privkey.id =-
3e23e743e0ddd88f2a7c6f69fa9f9bcebef1a60
cloning.subsystem.privkey.id     =-
c3c1b3b4e8f5dd6d2bdefd07581c0b15529536
```

```
cloning.sslserver.privkey.id
=3023d30245804a4fab42be209ebb0dc683423a8f
cloning.audit_signing.privkey.id=2fe35d9d46b373efabe9ef01b8436667a70
df096
```

2. Print all of the current private key IDs stored in the NSS database and compare them to the private key IDs stored in the **CS.cfg** file:

```
# certutil -K -d alias
certutil: Checking token "NSS Certificate DB" in slot "NSS User
Private Key and Certificate Services"
Enter Password or Pin for "NSS Certificate DB":
< 0> rsa      a7b0944b7b8397729a4c8c9af3a9c2b96f49c6f3
caSigningCert cert-ca4-test-master
< 1> rsa      6006094af3e5d02aaa91426594ca66cb53e73ac0
ocspSigningCert cert-ca4-test-master
< 2> rsa      d684da39bf4f2789a3fc9d42204596f4578ad2d9
subsystemCert cert-ca4-test-master
< 3> rsa      a8edd7c2b5c94f13144cacd99624578ae30b7e43
sslserverCert cert-ca4-test1
< 4> rsa      2fe35d9d46b373efabe9ef01b8436667a70df096
auditSigningCert cert-ca4-test1
```

In this example, only the audit signing key is the same; the others have been changed.

3. Take the keys returned in step 2 and convert them from unsigned values (which is what **certutil** returns) to signed Java BigIntegers (which is how the keys are stored in the Certificate System database).

   This can be done with a calculator or by using the script in Example 10.1, “Certutil to BigInteger Conversion Program”.

4. Copy the new key values into the **CS.cfg** file.

```
# vim /var/lib/pki/pki-tomcat/ca/conf/CS.cfg

cloning.signing.privkey.id     =-
584f6bb4847c688d65b373650c563d4690b6390d
cloning.ocsp_signing.privkey.id
=6006094af3e5d02aaa91426594ca66cb53e73ac0
cloning.subsystem.privkey.id   =-
297b25c640b0d8765c0362bddfba690ba8752d27
cloning.sslserver.privkey.id   =-
5712283d4a36b0ecebb3532669dba8751cf481bd
cloning.audit_signing.privkey.id=2fe35d9d46b373efabe9ef01b8436667a70
df096
```

5. Clone the CA as described in Section 10.3, “Cloning a CA”.

Example 10.1. Certutil to BigInteger Conversion Program

This Java program can convert the key output from **certutil** to the required BigInteger format.

Save this as a **.java** file, such as **Test.java**.

```
import java.math.BigInteger;

public class Test
{

  public static byte[] hexStringToByteArray(String s) {
      int len = s.length();
      byte[] data = new byte[len / 2];
      for (int i = 0; i < len; i += 2) {
          data[i / 2] = (byte) ((Character.digit(s.charAt(i), 16) << 4)
                               + Character.digit(s.charAt(i+1), 16));
      }
      return data;
  }

  public static void main(String[] args)
  {
      byte[] bytes = hexStringToByteArray(args[0]);
      BigInteger big = new BigInteger (bytes);
      System.out.println("Result is  ==> " + big.toString(16));
  }
}
```

Then, compile the file:

```
# javac Test.java
```

Chapter 11. Additional Installation Options

All Red Hat Certificate System instances created with **pkispawn** make certain assumptions about the instances being installed, such as the default signing algorithm to use for CA signing certificates and whether to allow IPv6 addresses for hosts.

This chapter describes additional configuration options that impact the installation and configuration for new instances, so many of these procedures occur before the instance is created.

11.1. Requesting Subsystem Certificates from an External CA

Most of the time, it is easier and simpler to have a CA within your PKI be the root CA, since this affords a lot of flexibility for defining the rules and settings of the PKI deployment. However, for public-facing networks, this can be a difficult thing to implement, because web administrators have to find some way to propagate and update CA certificate chains to their clients so that any site is trusted. For this reason, people often use public CAs, hosted by companies like VeriSign or Thawte, to issue CA signing certificates and make all of their CAs subordinate to the public CA. This is one of the planning considerations covered in the *Certificate System Planning, Installation, and Deployment Guide*.

All subsystem certificates can be submitted to an external CA when the subsystem is configured. When the certificates are generated from a CA outside the Certificate System deployment (or from a Certificate System CA in a different security domain), then the configuration process does not occur in one sitting. The configuration process is on hold until the certificates can be retrieved. Aside from that delay, the process is more or less the same as in Chapter 6, *Installing and Configuring Certificate System*.

To see an example of installation and configuration of a Certificate System instance using an External CA, run the **man pkispawn** command and read the *Installing an externally signed CA* part under the *EXAMPLES* section.

11.2. Enabling IPv6 for a Subsystem

Certificate System automatically configures and manages connections between subsystems. Every subsystem must interact with a CA as members of a security domain and to perform their PKI operations.

For these connections, Certificate System subsystems can be recognized by their host's fully-qualified domain name or an IP address. By default, Certificate System resolves IPv4 addresses and hostnames automatically, but Certificate System can also use IPv6 for their connections. IPv6 is supported for all server connections: to other subsystems, to the administrative console (**pkiconsole**), or through command-line scripts such as **tpsclient**:

```
op=var_set name=ca_host value=IPv6 address
```

1. Install the Red Hat Certificate System packages.
2. Set the IPv4 and IPv6 addresses in the **/etc/hosts** file. For example:

```
 vim /etc/hosts

 192.0.0.0    server.example.com IPv4 address
 3ffe:1234:2222:2000:202:55ff:fe67:f527         server6.example.com
IPv6 address
```

3. Then, export the environment variable to use the IPv6 address for the server. For example:

```
export PKI_HOSTNAME=server6.example.com
```

4. Run **pkispawn** to create the new instance. The values for the server hostname in the **CS.cfg** file will be set to the IPv6 address.

Chapter 12. Updating and Removing Subsystem Packages

Certificate System is installed using individual packages for each of its subsystems and its supporting systems, like Red Hat Directory Server and NSS. This makes the Certificate System modular, and each individual subsystem and its packages can be installed, updated, and removed independently.

12.1. Updating Certificate System Packages

There are many packages, listed in Section 5.2, “Installing the Required Packages”, installed with Certificate System for related applications and dependencies, not just the subsystem packages. For all supported platforms, individual Certificate System packages may be updated through the native package utility, **yum**.

Note

All Certificate System instances must be stopped before beginning any updates.

The recommended way to update packages is to use **yum** to manage the updates.

1. Log in as root.
2. Stop all Certificate System instances.

```
systemctl stop pki-tomcatd@instance_name.service
```

3. Run **yum** for the package. For example:

```
yum update pki-ca
```

4. Start the Certificate System instances.

```
systemctl start pki-tomcatd@instance_name.service
```

Alternatively, any updated RPMs can be downloaded and installed manually.

1. Log in as root.
2. Stop all Certificate System instances.

```
systemctl stop pki-tomcatd@instance_name.service
```

3. Install the updated package. For example:

```
rpm -Uvh pki-ca-10.2.6-1.noarch.rpm
```

4. Start the Certificate System instances.

```
systemctl start pki-tomcatd@instance_name.service
```

12.2. Uninstalling Certificate System Subsystems

It is possible to remove individual subsystems or to uninstall all packages associated with an entire subsystem. Subsystems are installed and uninstalled individually. For example, it is possible to uninstall a KRA subsystem while leaving an installed and configured CA subsystem. It is also possible to remove a single CA subsystem while leaving other CA subsystems on the machine.

12.2.1. Removing a Subsystem

Removing a subsystem requires specifying the subsystem type and the name of the server in which the subsystem is running. This command removes all files associated with the subsystem (without removing the subsystem packages).

```
pkidestroy -s subsystem_type -i instance_name
```

The **-s** option specifies the subsystem to be removed (such as CA, KRA, OCSP, TKS, or TPS). The **-i** option specifies the instance name, such as **pki-tomcat**.

Example 12.1. Removing a CA Subsystem

```
$ pkidestroy -s CA -i pki-tomcat
Loading deployment configuration from /var/lib/pki/pki-
tomcat/ca/registry/ca/deployment.cfg.
Uninstalling CA from /var/lib/pki/pki-tomcat.
Removed symlink /etc/systemd/system/multi-user.target.wants/pki-
tomcatd.target.

Uninstallation complete.
```

The **pkidestroy** utility removes the subsystem and any related files, such as the certificate databases, certificates, keys, and associated users. It does not uninstall the subsystem packages. If the subsystem is the last subsystem on the server instance, the server instance is removed as well.

12.2.2. Removing Certificate System Subsystem Packages

A number of subsystem-related packages and dependencies are installed with Red Hat Certificate System; these are listed in Section 5.2, “Installing the Required Packages”. Removing a subsystem removes only the files and directories associated with that specific subsystem. It does not remove the actual installed packages that are used by that instance. Completely uninstalling Red Hat Certificate System or one of its subsystems requires using package management tools, like **yum**, to remove each package individually.

To uninstall an individual Certificate System subsystem packages:

1. Remove all the associated subsystems. For example:

   ```
   pkidestroy -s CA -i pki-tomcat
   ```

2. Run the uninstall utility. For example:

   ```
   yum remove pki-subsystem_type
   ```

The subsystem type can be **ca**, **kra**, **ocsp**, **tks**, or **tps**.

3. To remove other packages and dependencies, remove the packages specifically, using **yum**. The complete list of installed packages is at Section 5.2, “Installing the Required Packages”.

Chapter 13. Troubleshooting Installation and Cloning

This chapter covers some of the more common installation and migration issues that are encountered when installing Certificate System.

13.1. Installation

Q:

I can't see any Certificate System packages or updates.

A: Certificate System packages are delivered through Red Hat Network, so you need to have your **yum** repositories configured to point to Red Hat Network or a local Satellite and then to use an account with the appropriate subscriptions to access the Red Hat Certificate System channels.

Q:

The init script returned an OK status, but my CA instance does not respond. Why?

A: This should not happen. Usually (but not always), this indicates a listener problem with the CA, but it can have many different causes. To see what errors have occurred, examine the **journal** log by running the following command:

```
journalctl -u pki-tomcatd@instance_name.service
```

Alternatively, examine the debug log files at **/var/log/pki/*instance_name*/*subsystem_type*/debug**.

One situation is when there is a PID for the CA, indicating the process is running, but that no listeners have been opened for the server. This would return Java invocation class errors in the **catalina.out** file:

```
Oct 29, 2010 4:15:44 PM org.apache.coyote.http11.Http11Protocol init
INFO: Initializing Coyote HTTP/1.1 on http-9080
java.lang.reflect.InvocationTargetException
        at sun.reflect.NativeMethodAccessorImpl.invoke0(Native
Method)
        at
sun.reflect.NativeMethodAccessorImpl.invoke(NativeMethodAccessorImpl.
java:64)
        at
sun.reflect.DelegatingMethodAccessorImpl.invoke(DelegatingMethodAcces
sorImpl.java:43)
        at java.lang.reflect.Method.invoke(Method.java:615)
        at
org.apache.catalina.startup.Bootstrap.load(Bootstrap.java:243)
        at
org.apache.catalina.startup.Bootstrap.main(Bootstrap.java:408)
Caused by: java.lang.UnsatisfiedLinkError: jss4
```

This could mean that you have the wrong version of JSS or NSS. The process requires **libnss3.so** in the path. Check this with this command:

```
ldd /usr/lib64/libjss4.so
```

If **libnss3.so** is not found, set the correct classpath in the **/etc/sysconfig/*instance_name*** configuration file. Then restart the CA using the **systemctl restart pki-tomcatd@*instance_name*.service** command.

Q:

I want to customize the subject name for the CA signing certificate, but do not see a way to do this using the pkispawn interactive install mode.

A: To do this, a configuration file representing delta links to the **/etc/pki/default.cfg** file is required. See the pkispawn(8) and pki_default.cfg(5) man pages.

Q:

I want to set different certificate validity periods and extensions for my root certificate authority — but I do not see a way to set it using pkispawn.

A: You cannot currently do this using **pkispawn**. However, there *is* a way to edit the certificate profiles used by **pkispawn** to generate the root CA certificates.

Important

You must do this *before* running **pkispawn** to create a new CA instance.

1. Back up the original CA certificate profile used by **pkispawn**.

```
cp -p /usr/share/pki/ca/conf/caCert.profile
/usr/share/pki/ca/conf/caCert.profile.orig
```

2. Open the CA certificate profile used by the configuration wizard.

```
vim /usr/share/pki/ca/conf/caCert.profile
```

3. Reset the validity period in the Validity Default to whatever you want. For example, to change the period to two years:

```
2.default.class=com.netscape.cms.profile.def.ValidityDefault
2.default.name=Validity Default
2.default.params.range=7200
```

4. Add any extensions by creating a new default entry in the profile and adding it to the list. For example, to add the Basic Constraint Extension, add the default (which, in this example, is default #9):

```
9.default.class=com.netscape.cms.profile.def.BasicConstraintsExt
Default
9.default.name=Basic Constraint Extension Constraint
9.default.params.basicConstraintsCritical=true
9.default.params.basicConstraintsIsCA=true
9.default.params.basicConstraintsPathLen=2
```

Then, add the default number to the list of defaults to use the new default:

```
list=2,4,5,6,7,8,9
```

5. Once the new profile is set up, then run **pkispawn** to create the new CA instance and go through the configuration wizard.

Q:

I'm seeing an HTTP 500 error code when I try to connect to the web services pages after configuring my subsystem instance.

A: This is an unexpected generic error which can have many different causes. Check in the **journal**, **system**, and **debug** log files for the instance to see what errors have occurred. This lists a couple of common errors, but there are many other possibilities.

Error #1: The LDAP database is not running.

If the Red Hat Directory Server instance use for the internal database is not running, then you cannot connect to the instance. This will be apparent in exceptions in the **journal** file that the instance is not ready:

```
java.io.IOException: CS server is not ready to serve.

com.netscape.cms.servlet.base.CMSServlet.service(CMSServlet.java:409)
        javax.servlet.http.HttpServlet.service(HttpServlet.java:688)
```

The Tomcat logs will specifically identify the problem with the LDAP connection:

```
5558.main - [29/Oct/2010:11:13:40 PDT] [8] [3] In Ldap (bound)
connection pool
to host ca1 port 389, Cannot connect to LDAP server. Error:
netscape.ldap.LDAPException: failed to connect to server
ldap://ca1.example.com:389 (91)
```

As will the instance's **debug** log:

```
[29/Oct/2010:11:39:10][main]: CMS:Caught EBaseException
Internal Database Error encountered: Could not connect to LDAP
server host
ca1 port 389 Error netscape.ldap.LDAPException: failed to connect to
server ldap://ca1:389 (91)
        at
com.netscape.cmscore.dbs.DBSubsystem.init(DBSubsystem.java:262)
```

Error #2: A VPN is blocking access.

Another possibility is that you are connecting to the subsystem over a VPN. The VPN **must** have a configuration option like **Use this connection only for resources on its network** enabled. If that option is not enabled, then the **journal** log file for the instance's Tomcat service shows a series of connection errors that result in the HTTP 500 error:

```
May 26, 2010 7:09:48 PM
org.apache.catalina.core.StandardWrapperValve invoke
SEVERE: Servlet.service() for servlet services threw exception
java.io.IOException: CS server is not ready to serve.
        at
com.netscape.cms.servlet.base.CMSServlet.service(CMSServlet.java:441)
        at
javax.servlet.http.HttpServlet.service(HttpServlet.java:803)
        at
org.apache.catalina.core.ApplicationFilterChain.internalDoFilter(App
licationFilterChain.java:269)
        at
org.apache.catalina.core.ApplicationFilterChain.doFilter(Application
FilterChain.java:188)
        at
org.apache.catalina.core.StandardWrapperValve.invoke(StandardWrapper
Valve.java:210)
        at
org.apache.catalina.core.StandardContextValve.invoke(StandardContext
Valve.java:172)
        at
org.apache.catalina.core.StandardHostValve.invoke(StandardHostValve.
java:127)
        at
org.apache.catalina.valves.ErrorReportValve.invoke(ErrorReportValve.
java:117)
        at
org.apache.catalina.valves.AccessLogValve.invoke(AccessLogValve.java:
542)
        at
org.apache.catalina.core.StandardEngineValve.invoke(StandardEngineVa
lve.java:108)
        at
org.apache.catalina.connector.CoyoteAdapter.service(CoyoteAdapter.ja
va:151)
        at
org.apache.coyote.http11.Http11Processor.process(Http11Processor.java:
870)
        at
org.apache.coyote.http11.Http11BaseProtocol$Http11ConnectionHandler.p
rocessConnection(Http11BaseProtocol.java:665)
        at
org.apache.tomcat.util.net.PoolTcpEndpoint.processSocket(PoolTcpEndp
oint.java:528)
        at
org.apache.tomcat.util.net.LeaderFollowerWorkerThread.runIt(LeaderFo
llowerWorkerThread.java:81)
        at
org.apache.tomcat.util.threads.ThreadPool$ControlRunnable.run(Thread
Pool.java:685)
 at java.lang.Thread.run(Thread.java:636)
```

13.2. Java Console

Q:

I can't open the `pkiconsole` and I'm seeing Java exceptions in stdout.

A: This probably means that you have the wrong JRE installed or the wrong JRE set as the default. Run **`alternatives --config java`** to see what JRE is selected. Red Hat Certificate System requires OpenJDK 1.7.

Q:

I tried to run `pkiconsole`, and I got Socket exceptions in stdout. Why?

A: This means that there is a port problem. Either there are incorrect SSL/TLS settings for the administrative port (meaning there is bad configuration in the **`server.xml`**) or the wrong port was given to access the admin interface.

Port errors will look like the following:

```
NSS Cipher Supported '0xff04'
java.io.IOException: SocketException cannot read on socket
        at org.mozilla.jss.ssl.SSLSocket.read(SSLSocket.java:1006)
        at
org.mozilla.jss.ssl.SSLInputStream.read(SSLInputStream.java:70)
        at
com.netscape.admin.certsrv.misc.HttpInputStream.fill(HttpInputStream.
java:303)
        at
com.netscape.admin.certsrv.misc.HttpInputStream.readLine(HttpInputStr
eam.java:224)
        at
com.netscape.admin.certsrv.connection.JSSConnection.readHeader(JSSCon
nection.java:439)
        at
com.netscape.admin.certsrv.connection.JSSConnection.initReadResponse(
JSSConnection.java:430)
        at
com.netscape.admin.certsrv.connection.JSSConnection.sendRequest(JSSCo
nnection.java:344)
        at
com.netscape.admin.certsrv.connection.AdminConnection.processRequest(
AdminConnection.java:714)
        at
com.netscape.admin.certsrv.connection.AdminConnection.sendRequest(Adm
inConnection.java:623)
        at
com.netscape.admin.certsrv.connection.AdminConnection.sendRequest(Adm
inConnection.java:590)
        at
com.netscape.admin.certsrv.connection.AdminConnection.authType(Admin
Connection.java:323)
        at
com.netscape.admin.certsrv.CMSServerInfo.getAuthType(CMSServerInfo.ja
va:113)
        at
```

```
com.netscape.admin.certsrv.CMSAdmin.run(CMSAdmin.java:499)
        at
com.netscape.admin.certsrv.CMSAdmin.run(CMSAdmin.java:548)
        at com.netscape.admin.certsrv.Console.main(Console.java:1655)
```

Q:

I attempt to start the console, and the system prompts me for my user name and password. After I enter these credentials, the console fails to appear.

A: Make sure the user name and password you entered are valid. If so, enable the debug output and examine it.

To enable the debug output, open the **/usr/bin/pkiconsole** file, and add the following lines:

```
============================================
${JAVA} ${JAVA_OPTIONS} -cp ${CP} -
Djava.util.prefs.systemRoot=/tmp/.java -
Djava.util.prefs.userRoot=/tmp/java
com.netscape.admin.certsrv.Console -s instanceID -D 9:all -a $1
----------
note: "-D 9:all" is for verbose output on the console.
============================================
```

Part III. After Installing Red Hat Certificate System

This part has basic information for finding subsystem services pages, configuration files, and related scripts.

Chapter 14. After Configuration: Checklist of Configuration Areas for Deploying Certificate System

The **pkispawn** process sets up the subsystem instances so that they are running and fully functional. However, the details of deploying a PKI — like defining what kind of certificates to issue — must still be done.

The features and performance of Certificate System subsystems can be matched to the requirements of your specific deployment. The most common (and recommended) features to configure are listed in Table 14.1, “Certificate System Features to Configure after Setup”.

Table 14.1. Certificate System Features to Configure after Setup

Feature	Why It's Useful	Admin Guide Link	Recommended or Required
Create agents and administrative users	The setup process only creates a single administrative user account. To manage a PKI environment in real life requires a number more administrators and agents, which are created after the instance is set up.	CA, OCSP, KRA, and TKS users TPS users	Mandatory (agents only) Recommended (administrators only) Common Criteria required
Import the certificate chain into the browser.	Any browser which will be used to access agent or admin services pages must have the client certificate and the CA certificate chain imported into its trust store.	Importing certs	Optional Common Criteria required
Set sudo permissions on PKI services for PKI administrators	Granting sudo permissions for Certificate System and Directory Server services to PKI administrators makes it easier to manage the instances.	Setting sudo permissions	Optional Common Criteria required
Set up backup and restore procedures	A reliable backup and restore strategy is vital for disaster and data recovery.	Backup and restore	Recommended Common Criteria required
Enable signed audit logs	This can be done when an instance is first created by using the **-audit_group** option, but it can also be done post-installation.	Audit logs for CA, KRA, OCSP, and TKS Audit logs for TPS	Recommended Common Criteria required

Feature	Why It's Useful	Admin Guide Link	Recommended or Required
Configure LDAP publishing	LDAP publishing publishes the certificates to specific entries within an LDAP database, so other clients can access the entries.	LDAP publishing	Recommended
Configure client authentication with the backend Directory Server	Client authentication allows the Certificate System instance to bind automatically to its backend Directory Server over SSL/TLS by presenting a recognized SSL/TLS client certificate (similar to the way agents connect to a subsystem instance).	Client authentication	Recommended
Customize certificate profiles	A certificate profile defines everything associated with issuing a particular type of certificate, including the authentication method, the authorization method, the certificate content (defaults), constraints for the values of the content, and the contents of the input and output for the certificate profile. Existing certificate profiles can be edited and new profiles added to allow deployment-specific certificates and tokens to be issued.	Certificate profiles	Recommended
Enable revocation checking and OCSP responses	There are two methods for checking whether a certificate is active (and not revoked): CRL checking and OCSP services. Checking the revocation status helps ensure that a revoked certificate isn't wrongly accepted just because it is within its validity period.	Revocation checking OCSP responders	Recommended Common Criteria required

Feature	Why It's Useful	Admin Guide Link	Recommended or Required
Configure a timeout period for SSL/TLS sessions	Using session timeouts prevents unauthorized users from accessing an open, but otherwise inactive, session with a subsystem.	Session timeouts	Recommended Common Criteria required
Use port forwarding	The default URLs used by Certificate System subsystems can be very long, which makes it possible for users to mistype the URL. Port forwarding allows users to access a much simpler, more intuitive URL for a better experience.	Port forwarding	Optional
Set up cross-pair certificates (also called FBCA or bridge certificates).	Cross-pair certificates set up a trusted environment between two separate PKI environments, so that certificates issued in one PKI are automatically recognized and trusted by the other PKI environment.	Cross-pair certificate profiles	Optional
Run self-tests	Self-tests are subsystem type-specific diagnostics. These are usually run when the server starts, but they can also be run on demand. Additionally, self-tests can be customized by creating new self-test plug-ins or to accommodate changes to the subsystem configuration like new certificates or changed certificate nicknames.	Self-tests	Recommended Common Criteria required
Remove the **password.conf** file.	The **password.conf** file stores system passwords in plaintext.	Running without the password.conf file	Recommended Common Criteria required

Feature	Why It's Useful	Admin Guide Link	Recommended or Required
Remove unused CA connection interfaces.	Several legacy interfaces are included in the CA's **`web.xml`**. While these can be used for custom or legacy applications to connect to the CA, for secure environments, these deprecated interfaces should be removed from the CA configuration to prevent unauthorized access.	Remove unused CA connection interfaces	- Recommended - Common Criteria required
Assign POSIX system ACLs for PKI subsystem users.	This provides finer control over the ACLs used for the subsystems' system users.	Configuring POSIX system ACLs	- Recommended - Common Criteria required

Chapter 15. Basic Information for Using Certificate System

Using any Certificate System has basic tasks such as editing the configuration file, starting and stopping the server instance and Console, opening web services, and locating logs.

15.1. Starting the Certificate System Console

The CA, KRA, OCSP, and TKS subsystems have a Java interface which can be accessed to perform administrative functions. For the KRA, OCSP, and TKS, this includes very basic tasks like configuring logging and managing users and groups. For the CA, this includes other configuration settings such as creating certificate profiles and configuring publishing.

The Console is opened by connecting to the subsystem instance over its SSL/TLS port using the **pkiconsole** utility. This utility uses the format:

```
pkiconsole https://server.example.com:admin_port/subsystem_type
```

The *subsystem_type* can be **ca**, **kra**, **ocsp**, or **tks**. For example, this opens the KRA console:

```
pkiconsole https://server.example.com:8443/kra
```

If DNS is not configured, then an IPv4 or IPv6 address can be used to connect to the console. For example:

```
https://192.0.2.1:8443/ca
https://[2001:DB8::1111]:8443/ca
```

15.2. Starting, Stopping, and Restarting an Instance

The Certificate System subsystem instances can be stopped and started using system tools on Red Hat Enterprise Linux. For example, the following command manages the CA:

```
systemctl {start|stop|restart} pki-tomcatd@instance_name.service
```

15.3. Starting the Instance Automatically

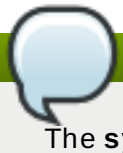
The **systemctl** utility in Red Hat Enterprise Linux 7 manages the automatic startup and shutdown settings for each process on the server. This means that when a system reboots, some services can be automatically restarted. System unit files control service startup to ensure that services are started in the correct order. The **systemd** service and **systemctl** utility are described in the *Red Hat Enterprise Linux System Administrator's Guide*

Certificate System instances can be managed by **systemctl**, so this utility can set whether to restart instances automatically. After a Certificate System instance is created, it is enabled on boot. This can be changed by using **systemctl** to disable the instance. For example, the following command disables automatic startup of the **pki-tomcat** Certificate System instance:

```
systemctl disable pki-tomcatd@pki-tomcat.service
```

To re-enable the instance:

```
systemctl enable pki-tomcatd@pki-tomcat.service
```



Note

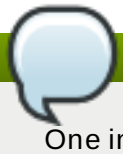
The **systemctl enable** and **systemctl disable** commands do not immediately start or stop Certificate System.

15.4. Enabling and Disabling an Installed Subsystem

To enable or disable an installed subsystem, use the **pki-server** utility.

```
pki-server subsystem-disable -i instance_id subsystem_id
pki-server subsystem-enable -i instance_id subsystem_id
```

Replace *subsystem_id* with a valid subsystem identifier: **ca**, **kra**, **tks**, **ocsp**, or **tps**.



Note

One instance can have only one of each type of subsystem.

For example, to disable the OCSP subsystem on an instance named **pki-tomcat**:

```
pki-server subsystem-disable -i pki-tomcat ocsp
```

To list the installed subsystems for an instance:

```
pki-server subsystem-find -i instance_id
```

To show the status of a particular subsystem:

```
pki-server subsystem-find -i instance_id subsystem_id
```

15.5. Finding the Subsystem Web Services Pages

The CA, KRA, OCSP, TKS, and TPS subsystems have web services pages for agents, as well as regular users and administrators, when appropriate. These web services can be accessed by opening the URL to the subsystem host over the subsystem's secure end user's port. For example, for the CA:

```
https://server.example.com:8443/ca/services
```

Note

To get a complete list of all of the interfaces, URLs, and ports for an instance, check the status of the service. For example:

```
pkidaemon status tomcat instance_name
```

The main web services page for each subsystem has a list of available services pages; these are summarized in Table 15.1, “Default Web Services Pages”. To access any service specifically, access the appropriate port and append the appropriate directory to the URL. For example, to access the CA's end entities (regular users) web services:

```
https://server.example.com:8443/ca/ee/ca
```

If DNS is not configured, then an IPv4 or IPv6 address can be used to connect to the services pages. For example:

```
https://192.0.2.1:8443/ca/services
https://[2001:DB8::1111]:8443/ca/services
```

Note

Anyone can access the end user pages for a subsystem. However, accessing agent or admin web services pages requires that an agent or administrator certificate be issued and installed in the web browser. Otherwise, authentication to the web services fails.

Table 15.1. Default Web Services Pages

Port	Used for SSL/TLS	Used for Client Authentication [a]	Web Services	Web Service Location
Certificate Manager				
8080	No		End Entities	ca/ee/ca
8443	Yes	No	End Entities	ca/ee/ca
8443	Yes	Yes	Agents	ca/agent/ca
8443	Yes	No	Services	ca/services
8443	Yes	No	Console	pkiconsole https://*host:port*/ca
Key Recovery Authority				
8080	No		End Entities [b]	kra/ee/kra
8443	Yes	No	End Entities [b]	kra/ee/kra
8443	Yes	Yes	Agents	kra/agent/kra
8443	Yes	No	Services	kra/services

Port	Used for SSL/TLS	Used for Client Authentication	Web Services	Web Service Location
8443	Yes	No	Console	pkiconsole https://*host:port*/kra
Online Certificate Status Manager				
8080	No		End Entities [c]	ocsp/ee/ocsp
8443	Yes	No	End Entities[c]	ocsp/ee/ocsp
8443	Yes	Yes	Agents	ocsp/agent/ocsp
8443	Yes	No	Services	ocsp/services
8443	Yes	No	Console	pkiconsole https://*host:port*/ocsp
Token Key Service				
8080	No		End Entities[b]	tks/ee/tks
8443	Yes	No	End Entities[b]	tks/ee/tks
8443	Yes	Yes	Agents	tks/agent/tks
8443	Yes	No	Services	tks/services
8443	Yes	No	Console	pkiconsole https://*host:port*/tks
Token Processing System				
8080	No		Unsecure Services	tps/tps
8443	Yes		Secure Services	tps/tps
8080	No		Enterprise Security Client Phone Home	tps/phoneHome
8443	Yes		Enterprise Security Client Phone Home	tps/phoneHome
8443	Yes	Yes	Admin, Agent, and Operator Services [d]	tps/ui

[a] Services with a client authentication value of **No** can be reconfigured to require client authentication. Services which do not have either a **Yes** or **No** value cannot be configured to use client authentication.

[b] Although this subsystem type does have end entities ports and interfaces, these end-entity services are not accessible through a web browser, as other end-entity services are.

[c] Although the OCSP does have end entities ports and interfaces, these end-entity services are not accessible through a web browser, as other end-entity services are. End user OCSP services are accessed by a client sending an OCSP request.

[d] The agent, admin, and operator services are all accessed through the same web services page. Each role can only access specific sections which are only visible to the members of that role.

15.6. File and Directory Locations for Certificate System

Certificate System servers are Tomcat instances which consist of one or more Certificate System subsystems. Certificate System subsystems are web applications that provide specific type of PKI functions. General, shared subsystem information is contained in non-relocatable, RPM-defined shared libraries, Java archive files, binaries, and templates. These are stored in a fixed location.

15.6.1. Tomcat Instance Information

The directories are instance specific, tied to the instance name. In these examples, the instance name is **`pki-tomcat`**; the true value is whatever is specified at the time the subsystem is created with **`pkispawn`**.

The directories contain customized configuration files and templates, profiles, certificate databases, and other files for the subsystem.

Table 15.2. Tomcat Instance Information

Setting	Value
Ports	Non-secure port Secure port Tomcat Server Management port Tomcat AJP port
Main Directory	/var/lib/pki/pki-tomcat
Configuration Directory	/etc/pki/pki-tomcat
Configuration File	/etc/pki/pki-tomcat/server.xml /etc/pki/pki-tomcat/password.conf
Security Databases	/var/lib/pki/pki-tomcat/alias
Subsystem Certificates	SSL server certificate Subsystem certificate [a]
Log Files	/var/log/pki/pki-tomcat
Web Services Files	/usr/share/pki/server/webapps/ROOT - Main page /usr/share/pki/server/webapps/pki/admin - Admin templates /usr/share/pki/server/webapps/pki/js - JavaScript libraries

[a] The subsystem certificate is always issued by the security domain so that domain-level operations that require client authentication are based on this subsystem certificate.

15.6.2. CA Subsystem Information

The directories are instance specific, tied to the instance name. In these examples, the instance name is **`pki-tomcat`**; the true value is whatever is specified at the time the subsystem is created with **`pkispawn`**.

Table 15.3. CA Subsystem Information

Setting	Value
Main Directory	/var/lib/pki/pki-tomcat/ca
Configuration Directory	/etc/pki/pki-tomcat/ca
Configuration File	/etc/pki/pki-tomcat/ca/CS.cfg
Subsystem Certificates	CA signing certificate OCSP signing certificate (for the CA's internal OCSP service) Audit log signing certificate
Log Files	/var/log/pki/pki-tomcat/ca
Install Logs	/var/log/pki/pki-ca-spawn.YYYYMMDDhhmmss.log
Profile Files	/var/lib/pki/pki-tomcat/ca/profiles/ca
Email Notification Templates	/var/lib/pki/pki-tomcat/ca/emails
Web Services Files	/usr/share/pki/ca/webapps/ca/agent - Agent services /usr/share/pki/ca/webapps/ca/admin - Admin services /usr/share/pki/ca/webapps/ca/ee - End user services

15.6.3. KRA Subsystem Information

The directories are instance specific, tied to the instance name. In these examples, the instance name is **`pki-tomcat`**; the true value is whatever is specified at the time the subsystem is created with **`pkispawn`**.

Table 15.4. KRA Subsystem Information

Setting	Value
Main Directory	/var/lib/pki/pki-tomcat/kra
Configuration Directory	/etc/pki/pki-tomcat/kra
Configuration File	/etc/pki/pki-tomcat/kra/CS.cfg
Subsystem Certificates	Transport certificate Storage certificate Audit log signing certificate
Log Files	/var/log/pki/pki-tomcat/kra
Install Logs	/var/log/pki/pki-kra-spawn.YYYYMMDDhhmmss.log
Web Services Files	/usr/share/pki/kra/webapps/kra/agent - Agent services /usr/share/pki/kra/webapps/kra/admin - Admin services

15.6.4. OCSP Subsystem Information

The directories are instance specific, tied to the instance name. In these examples, the instance name is **`pki-tomcat`**; the true value is whatever is specified at the time the subsystem is created with **`pkispawn`**.

Table 15.5. OCSP Subsystem Information

Setting	Value
Main Directory	/var/lib/pki/pki-tomcat/ocsp
Configuration Directory	/etc/pki/pki-tomcat/ocsp
Configuration File	/etc/pki/pki-tomcat/ocsp/CS.cfg
Subsystem Certificates	OCSP signing certificate Audit log signing certificate
Log Files	/var/log/pki/pki-tomcat/ocsp
Install Logs	/var/log/pki/pki-ocsp-spawn.YYYYMMDDhhmmss.log
Web Services Files	/usr/share/pki/ocsp/webapps/ocsp/agent - Agent services /usr/share/pki/ocsp/webapps/ocsp/admin - Admin services

15.6.5. TKS Subsystem Information

The directories are instance specific, tied to the instance name. In these examples, the instance name is **`pki-tomcat`**; the true value is whatever is specified at the time the subsystem is created with **`pkispawn`**.

Table 15.6. TKS Subsystem Information

Setting	Value
Main Directory	/var/lib/pki/pki-tomcat/tks
Configuration Directory	/etc/pki/pki-tomcat/tks
Configuration File	/etc/pki/pki-tomcat/tks/CS.cfg
Subsystem Certificates	Audit log signing certificate
Log Files	/var/log/pki/pki-tomcat/tks
Install Logs	/var/log/pki/pki-tomcat/pki-tks-spawn.YYYYMMDDhhmmss.log

15.6.6. TPS Subsystem Information

The directories are instance specific, tied to the instance name. In these examples, the instance name is **`pki-tomcat`**; the true value is whatever is specified at the time the subsystem is created with **`pkispawn`**.

Table 15.7. TPS Subsystem Information

Setting	Value
Main Directory	/var/lib/pki/pki-tomcat/tps
Configuration Directory	/etc/pki/pki-tomcat/tps
Configuration File	/etc/pki/pki-tomcat/tps/CS.cfg
Subsystem Certificates	Audit log signing certificate
Log Files	/var/log/pki/pki-tomcat/tps
Install Logs	/var/log/pki/pki-tps-spawn.YYYYMMDDhhhmmss.log
Web Services Files	/usr/share/pki/tps/webapps/tps - TPS services

15.6.7. Shared Certificate System Subsystem File Locations

There are some directories used by or common to all Certificate System subsystem instances for general server operations, listed in Table 15.8, “Subsystem File Locations”.

Table 15.8. Subsystem File Locations

Directory Location	Contents
/usr/share/pki	Contains common files and templates used to create Certificate System instances. Along with shared files for all subsystems, there are subsystem-specific files in subfolders: • pki/ca (CA) • pki/kra (KRA) • pki/ocsp (OCSP) • pki/tks (TKS) • pki/tps (TPS)
/usr/bin	Contains the **pkispawn** and **pkidestroy** instance configuration scripts and tools (Java, native, and security) shared by the Certificate System subsystems.
/usr/share/java/pki	Contains Java archive files shared by local Tomcat web applications and shared by the Certificate System subsystems.

Glossary

A

access control

The process of controlling what particular users are allowed to do. For example, access control to servers is typically based on an identity, established by a password or a certificate, and on rules regarding what that entity can do. See also access control list (ACL).

access control instructions (ACI)

An access rule that specifies how subjects requesting access are to be identified or what rights are allowed or denied for a particular subject. See access control list (ACL).

access control list (ACL)

A collection of access control entries that define a hierarchy of access rules to be evaluated when a server receives a request for access to a particular resource. See access control instructions (ACI).

administrator

The person who installs and configures one or more Certificate System managers and sets up privileged users, or agents, for them. See also agent.

Advanced Encryption Standard (AES)

The Advanced Encryption Standard (AES), like its predecessor Data Encryption Standard (DES), is a FIPS-approved symmetric-key encryption standard. AES was adopted by the US government in 2002. It defines three block ciphers, AES-128, AES-192 and AES-256. The National Institute of Standards and Technology (NIST) defined the AES standard in U.S.

FIPS PUB 197. For more information, see http://csrc.nist.gov/publications/fips/fips197/fips-197.pdf.

agent

A user who belongs to a group authorized to manage agent services for a Certificate System manager. See also Certificate Manager agent, Key Recovery Authority agent.

agent services

1. Services that can be administered by a Certificate System agent through HTML pages served by the Certificate System subsystem for which the agent has been assigned the necessary privileges.

2. The HTML pages for administering such services.

agent-approved enrollment

An enrollment that requires an agent to approve the request before the certificate is issued.

APDU

Application protocol data unit. A communication unit (analogous to a byte) that is used in communications between a smart card and a smart card reader.

attribute value assertion (AVA)

An assertion of the form *attribute* = *value*, where *attribute* is a tag, such as **o** (organization) or **uid** (user ID), and *value* is a value such as "Red Hat, Inc." or a login name. AVAs are used to form the distinguished name (DN) that identifies the subject of a certificate, called the subject name of the certificate.

audit log

A log that records various system events. This log can be signed, providing proof that it was not tampered with, and can only be read by an auditor user.

auditor

A privileged user who can view the signed audit logs.

authentication

Confident identification; assurance that a party to some computerized transaction is not an impostor. Authentication typically involves the use of a password, certificate, PIN, or other information to validate identity over a computer network. See also password-based authentication, certificate-based authentication, client authentication, server authentication.

authentication module

A set of rules (implemented as a Java™ class) for authenticating an end entity, agent, administrator, or any other entity that needs to interact with a Certificate System subsystem. In the case of typical end-user enrollment, after the user has supplied the information requested by the enrollment form, the enrollment servlet uses an authentication module associated with that form to validate the information and authenticate the user's identity. See servlet.

authorization

Permission to access a resource controlled by a server. Authorization typically takes place after the ACLs associated with a resource have been evaluated by a server. See access control list (ACL).

automated enrollment

A way of configuring a Certificate System subsystem that allows automatic authentication for end-entity enrollment, without human intervention. With this form of authentication, a certificate request that completes authentication module processing successfully is automatically approved for profile processing and certificate issuance.

B

bind DN

A user ID, in the form of a distinguished name (DN), used with a password to authenticate to Red Hat Directory Server.

C

CA certificate

A certificate that identifies a certificate authority. See also certificate authority (CA), subordinate CA, root CA.

CA hierarchy

A hierarchy of CAs in which a root CA delegates the authority to issue certificates to subordinate CAs. Subordinate CAs can also expand the hierarchy by delegating issuing status to other CAs. See also certificate authority (CA), subordinate CA, root CA.

CA server key

The SSL server key of the server providing a CA service.

CA signing key

The private key that corresponds to the public key in the CA certificate. A CA uses its signing key to sign certificates and CRLs.

certificate

Digital data, formatted according to the X.509 standard, that specifies the name of an individual, company, or other entity (the subject name of the certificate) and certifies that a public key, which is also included in the certificate, belongs to that entity. A certificate is issued and digitally signed by a certificate authority (CA). A certificate's validity can be verified by checking the CA's digital signature through public-key cryptography techniques. To be trusted within a public-key infrastructure (PKI), a certificate must be issued and signed by a CA that is trusted by other entities enrolled in the PKI.

certificate authority (CA)

A trusted entity that issues a certificate after verifying the identity of the person or entity the certificate is intended to identify. A CA also renews and revokes certificates and generates CRLs. The entity named in the issuer field of a certificate is always a CA. Certificate authorities can be independent third parties or a person or organization using certificate-

issuing server software, such as Red Hat Certificate System.

certificate chain

A hierarchical series of certificates signed by successive certificate authorities. A CA certificate identifies a certificate authority (CA) and is used to sign certificates issued by that authority. A CA certificate can in turn be signed by the CA certificate of a parent CA, and so on up to a root CA. Certificate System allows any end entity to retrieve all the certificates in a certificate chain.

certificate extensions

An X.509 v3 certificate contains an extensions field that permits any number of additional fields to be added to the certificate. Certificate extensions provide a way of adding information such as alternative subject names and usage restrictions to certificates. A number of standard extensions have been defined by the PKIX working group.

certificate fingerprint

A one-way hash associated with a certificate. The number is not part of the certificate itself, but is produced by applying a hash function to the contents of the certificate. If the contents of the certificate changes, even by a single character, the same function produces a different number. Certificate fingerprints can therefore be used to verify that certificates have not been tampered with.

Certificate Management Message Formats (CMMF)

Message formats used to convey certificate requests and revocation requests from end entities to a Certificate Manager and to send a variety of information to end entities. A proposed standard from the Internet Engineering Task Force (IETF) PKIX working group. CMMF is subsumed by another proposed standard, Certificate Management Messages over Cryptographic Message Syntax (CMC). For detailed information, see http://www.ietf.org/internet-drafts/draft-ietf-pkix-cmmf-02.txt.

Certificate Management Messages over Cryptographic Message Syntax (CMC)

Message format used to convey a request for a certificate to a Certificate Manager. A proposed standard from the Internet Engineering Task Force (IETF) PKIX working group. For detailed information, see http://www.ietf.org/internet-drafts/draft-ietf-pkix-cmc-02.txt.

Certificate Manager

An independent Certificate System subsystem that acts as a certificate authority. A Certificate Manager instance issues, renews, and revokes certificates, which it can publish along with CRLs to an LDAP directory. It accepts requests from end entities. See certificate authority (CA).

Certificate Manager agent

A user who belongs to a group authorized to manage agent services for a Certificate Manager. These services include the ability to access and modify (approve and reject) certificate requests and issue certificates.

certificate profile

A set of configuration settings that defines a certain type of enrollment. The certificate profile sets policies for a particular type of enrollment along with an authentication method in a certificate profile.

Certificate Request Message Format (CRMF)

Format used for messages related to management of X.509 certificates. This format is a subset of CMMF. See also Certificate Management Message Formats (CMMF). For detailed information, see ftp://ftp.isi.edu/in-notes/rfc2511.txt.

certificate revocation list (CRL)

As defined by the X.509 standard, a list of revoked certificates by serial number, generated and signed by a certificate authority (CA).

Certificate System

See Red Hat Certificate System, Cryptographic Message Syntax (CS).

Certificate System console

A console that can be opened for any single Certificate System instance. A Certificate System console allows the Certificate System administrator to control configuration settings for the corresponding Certificate System instance.

Certificate System subsystem

One of the five Certificate System managers: Certificate Manager, Online Certificate Status Manager, Key Recovery Authority, Token Key Service, or Token Processing System.

certificate-based authentication

Authentication based on certificates and public-key cryptography. See also password-based authentication.

chain of trust

See certificate chain.

chained CA

See linked CA.

cipher

See cryptographic algorithm.

client authentication

The process of identifying a client to a server, such as with a name and password or with a certificate and some digitally signed data. See certificate-based authentication, password-based authentication, server authentication.

client SSL certificate

A certificate used to identify a client to a server using the SSL protocol. See Secure Sockets Layer (SSL).

CMC

See Certificate Management Messages over Cryptographic Message Syntax (CMC).

CMC Enrollment

Features that allow either signed enrollment or signed revocation requests to be sent to a Certificate Manager using an agent's signing certificate. These requests are then automatically processed by the Certificate Manager.

CMMF

See Certificate Management Message Formats (CMMF).

Common Criteria

A certification standard that evaluates computer security, both for software and hardware components. The software or hardware vendor defines the operating environment and specified configuration, identifies any threats, and outlines both the development and deployment processes for the target of evaluation (the thing being evaluated). The Common Criteria certification laboratory then tests the implementation design to look for any vulnerabilities.

CRL

See certificate revocation list (CRL).

CRMF

See Certificate Request Message Format (CRMF).

cross-certification

The exchange of certificates by two CAs in different certification hierarchies, or chains. Cross-certification extends the chain of trust so that it encompasses both hierarchies. See also certificate authority (CA).

cross-pair certificate

A certificate issued by one CA to another CA which is then stored by both CAs to form a circle of trust. The two CAs issue certificates to each other, and then store both cross-pair certificates as a certificate pair.

cryptographic algorithm

A set of rules or directions used to perform cryptographic operations such as encryption and decryption.

Cryptographic Message Syntax (CS)

The syntax used to digitally sign, digest, authenticate, or encrypt arbitrary messages, such as CMMF.

cryptographic module

See PKCS #11 module.

cryptographic service provider (CSP)

A cryptographic module that performs cryptographic services, such as key generation, key storage, and encryption, on behalf of software that uses a standard interface such as that defined by PKCS #11 to request such services.

CSP

See cryptographic service provider (CSP).

D

decryption

Unscrambling data that has been encrypted. See encryption.

delta CRL

A CRL containing a list of those certificates that have been revoked since the last full CRL was issued.

digital ID

See certificate.

digital signature

To create a digital signature, the signing software first creates a one-way hash from the data to be signed, such as a newly issued certificate. The one-way hash is then encrypted with the private key of the signer. The resulting digital signature is unique for each piece of data signed. Even a single comma added to a message changes the digital signature for that message. Successful decryption of the digital signature with the signer's public key and comparison with another hash of the same data provides tamper detection. Verification of the certificate chain for the certificate containing the public key provides authentication of the signer. See also nonrepudiation, encryption.

distinguished name (DN)

A series of AVAs that identify the subject of a certificate. See attribute value assertion (AVA).

distribution points

Used for CRLs to define a set of certificates. Each distribution point is defined by a set of certificates that are issued. A CRL can be created for a particular distribution point.

dual key pair

Two public-private key pairs, four keys altogether, corresponding to two separate certificates. The private key of one pair is used for signing operations, and the public and private keys of the other pair are used for encryption and decryption operations. Each pair corresponds to a separate certificate. See also encryption key, public-key cryptography, signing key.

Key Recovery Authority

An optional, independent Certificate System subsystem that manages the long-term archival and recovery of RSA encryption keys for end entities. A Certificate Manager can be configured to archive end entities' encryption keys with a Key Recovery Authority before

issuing new certificates. The Key Recovery Authority is useful only if end entities are encrypting data, such as sensitive email, that the organization may need to recover someday. It can be used only with end entities that support dual key pairs: two separate key pairs, one for encryption and one for digital signatures.

Key Recovery Authority agent

A user who belongs to a group authorized to manage agent services for a Key Recovery Authority, including managing the request queue and authorizing recovery operation using HTML-based administration pages.

Key Recovery Authority recovery agent

One of the *m of n* people who own portions of the storage key for the Key Recovery Authority.

Key Recovery Authority storage key

Special key used by the Key Recovery Authority to encrypt the end entity's encryption key after it has been decrypted with the Key Recovery Authority's private transport key. The storage key never leaves the Key Recovery Authority.

Key Recovery Authority transport certificate

Certifies the public key used by an end entity to encrypt the entity's encryption key for transport to the Key Recovery Authority. The Key Recovery Authority uses the private key corresponding to the certified public key to decrypt the end entity's key before encrypting it with the storage key.

E

eavesdropping

Surreptitious interception of information sent over a network by an entity for which the information is not intended.

Elliptic Curve Cryptography (ECC)

A cryptographic algorithm which uses elliptic curves to create additive logarithms for the mathematical problems which are the basis of the cryptographic keys. ECC ciphers are more efficient to use than RSA ciphers and, because of their intrinsic complexity, are stronger at smaller bits than RSA ciphers. For more information, see http://ietfreport.isoc.org/idref/draft-ietf-tls-ecc/.

encryption

Scrambling information in a way that disguises its meaning. See decryption.

encryption key

A private key used for encryption only. An encryption key and its equivalent public key, plus a signing key and its equivalent public key, constitute a dual key pair.

end entity

In a public-key infrastructure (PKI), a person, router, server, or other entity that uses a certificate to identify itself.

enrollment

The process of requesting and receiving an X.509 certificate for use in a public-key infrastructure (PKI). Also known as *registration*.

extensions field

See certificate extensions.

F

Federal Bridge Certificate Authority (FBCA)

A configuration where two CAs form a circle of trust by issuing cross-pair certificates to each other and storing the two cross-pair certificates as a single certificate pair.

fingerprint

See certificate fingerprint.

FIPS PUBS 140

Federal Information Standards Publications (FIPS PUBS) 140 is a US government standard for implementations of cryptographic modules, hardware or software that encrypts and decrypts data or performs other cryptographic operations, such as creating or verifying digital signatures. Many products sold to the US government must comply with one or more of the FIPS standards. See http://www.nist.gov/itl/fipscurrent.cfm.

firewall

A system or combination of systems that enforces a boundary between two or more networks.

I

impersonation

The act of posing as the intended recipient of information sent over a network. Impersonation can take two forms: spoofing and misrepresentation.

input

In the context of the certificate profile feature, it defines the enrollment form for a particular certificate profile. Each input is set, which then dynamically creates the enrollment form from all inputs configured for this enrollment.

intermediate CA

A CA whose certificate is located between the root CA and the issued certificate in a certificate chain.

IP spoofing

The forgery of client IP addresses.

J

JAR file

A digital envelope for a compressed collection of files organized according to the Java™ archive (JAR) format.

Java™ archive (JAR) format

A set of conventions for associating digital signatures, installer scripts, and other information with files in a directory.

Java™ Cryptography Architecture (JCA)

The API specification and reference developed by Sun Microsystems for cryptographic services. See http://java.sun.com/products/jdk/1.2/docs/guide/security/CryptoSpec.Introduction.

Java™ Development Kit (JDK)

Software development kit provided by Sun Microsystems for developing applications and applets using the Java™ programming language.

Java™ Native Interface (JNI)

A standard programming interface that provides binary compatibility across different implementations of the Java™ Virtual Machine (JVM) on a given platform, allowing existing code written in a language such as C or C++ for a single platform to bind to Java™. See http://java.sun.com/products/jdk/1.2/docs/guide/jni/index.html.

Java™ Security Services (JSS)

A Java™ interface for controlling security operations performed by Netscape Security Services (NSS).

K

KEA

See Key Exchange Algorithm (KEA).

key

A large number used by a cryptographic algorithm to encrypt or decrypt data. A person's public key, for example, allows other people to encrypt messages intended for that person. The messages must then be decrypted by using the corresponding private key.

key exchange

A procedure followed by a client and server to determine the symmetric keys they will both use during an SSL session.

Key Exchange Algorithm (KEA)

An algorithm used for key exchange by the US Government.

L

Lightweight Directory Access Protocol (LDAP)

A directory service protocol designed to run over TCP/IP and across multiple platforms. LDAP is a simplified version of Directory Access Protocol (DAP), used to access X.500 directories. LDAP is under IETF change control and has evolved to meet Internet requirements.

linked CA

An internally deployed certificate authority (CA) whose certificate is signed by a public, third-party CA. The internal CA acts as the root CA for certificates it issues, and the third-party CA acts as the root CA for certificates issued by other CAs that are linked to the same third-party root CA. Also known as "chained CA" and by other terms used by different public CAs.

M

manual authentication

A way of configuring a Certificate System subsystem that requires human approval of each certificate request. With this form of authentication, a servlet forwards a certificate request to a request queue after successful authentication module processing. An agent with appropriate privileges must then approve each request individually before profile processing and certificate issuance can proceed.

MD5

A message digest algorithm that was developed by Ronald Rivest. See also one-way hash.

message digest

See one-way hash.

misrepresentation

The presentation of an entity as a person or organization that it is not. For example, a website might pretend to be a furniture store when it is really a site that takes credit-card payments but never sends any goods. Misrepresentation is one form of impersonation. See also spoofing.

N

Netscape Security Services (NSS)

A set of libraries designed to support cross-platform development of security-enabled communications applications. Applications built using the NSS libraries support the Secure Sockets Layer (SSL) protocol for authentication, tamper detection, and encryption, and the PKCS #11 protocol for cryptographic token interfaces. NSS is also available separately as a software development kit.

non-TMS

Non-token management system. Refers to a configuration of subsystems (the CA and, optionally, KRA and OCSP) which do *not* handle smart cards directly.

See Also token management system (TMS).

nonrepudiation

The inability by the sender of a message to deny having sent the message. A digital signature provides one form of nonrepudiation.

O

object signing

A method of file signing that allows software developers to sign Java code, JavaScript scripts, or any kind of file and allows users to identify the signers and control access by signed code to local system resources.

object-signing certificate

A certificate that's associated private key is used to sign objects; related to object signing.

OCSP

Online Certificate Status Protocol.

one-way hash

1. A number of fixed-length generated from data of arbitrary length with the aid of a hashing algorithm. The number, also called a message digest, is unique to the hashed data. Any change in the data, even deleting or altering a single character, results in a different value.

2. The content of the hashed data cannot be deduced from the hash.

operation

The specific operation, such as read or write, that is being allowed or denied in an access control instruction.

output

In the context of the certificate profile feature, it defines the resulting form from a successful certificate enrollment for a particular certificate profile. Each output is set, which then dynamically creates the form from all outputs configured for this enrollment.

P

password-based authentication

Confident identification by means of a name and password. See also authentication, certificate-based authentication.

PKCS #10

The public-key cryptography standard that governs certificate requests.

PKCS #11

The public-key cryptography standard that governs cryptographic tokens such as smart cards.

PKCS #11 module

A driver for a cryptographic device that provides cryptographic services, such as encryption and decryption, through the PKCS #11 interface. A PKCS #11 module, also called a *cryptographic module* or *cryptographic service provider*, can be implemented in either hardware or software. A PKCS #11 module always has one or more slots, which may be implemented as physical hardware slots in some form of physical reader, such as for smart

cards, or as conceptual slots in software. Each slot for a PKCS #11 module can in turn contain a token, which is the hardware or software device that actually provides cryptographic services and optionally stores certificates and keys. Red Hat provides a built-in PKCS #11 module with Certificate System.

PKCS #12

The public-key cryptography standard that governs key portability.

PKCS #7

The public-key cryptography standard that governs signing and encryption.

private key

One of a pair of keys used in public-key cryptography. The private key is kept secret and is used to decrypt data encrypted with the corresponding public key.

proof-of-archival (POA)

Data signed with the private Key Recovery Authority transport key that contains information about an archived end-entity key, including key serial number, name of the Key Recovery Authority, subject name of the corresponding certificate, and date of archival. The signed proof-of-archival data are the response returned by the Key Recovery Authority to the Certificate Manager after a successful key archival operation. See also Key Recovery Authority transport certificate.

public key

One of a pair of keys used in public-key cryptography. The public key is distributed freely and published as part of a certificate. It is typically used to encrypt data sent to the public key's owner, who then decrypts the data with the corresponding private key.

public-key cryptography

A set of well-established techniques and standards that allow an entity to verify its identity electronically or to sign and encrypt electronic data. Two keys are involved, a public key and a private key. A public key is published as part of a certificate, which associates that key with a particular identity. The corresponding private key is kept secret. Data encrypted with the public key can be decrypted only with the private key.

public-key infrastructure (PKI)

The standards and services that facilitate the use of public-key cryptography and X.509 v3 certificates in a networked environment.

R

RC2, RC4

Cryptographic algorithms developed for RSA Data Security by Rivest. See also cryptographic algorithm.

Red Hat Certificate System

A highly configurable set of software components and tools for creating, deploying, and managing certificates. Certificate System is comprised of five major subsystems that can be installed in different Certificate System instances in different physical locations: Certificate

Manager, Online Certificate Status Manager, Key Recovery Authority, Token Key Service, and Token Processing System.

registration

See enrollment.

root CA

The certificate authority (CA) with a self-signed certificate at the top of a certificate chain. See also CA certificate, subordinate CA.

RSA algorithm

Short for Rivest-Shamir-Adleman, a public-key algorithm for both encryption and authentication. It was developed by Ronald Rivest, Adi Shamir, and Leonard Adleman and introduced in 1978.

RSA key exchange

A key-exchange algorithm for SSL based on the RSA algorithm.

S

sandbox

A Java™ term for the carefully defined limits within which Java™ code must operate.

secure channel

A security association between the TPS and the smart card which allows encrypted communciation based on a shared master key generated by the TKS and the smart card APDUs.

Secure Sockets Layer (SSL)

A protocol that allows mutual authentication between a client and server and the establishment of an authenticated and encrypted connection. SSL runs above TCP/IP and below HTTP, LDAP, IMAP, NNTP, and other high-level network protocols.

security domain

A centralized repository or inventory of PKI subsystems. Its primary purpose is to facilitate the installation and configuration of new PKI services by automatically establishing trusted relationships between subsystems.

self tests

A feature that tests a Certificate System instance both when the instance starts up and on-demand.

server authentication

The process of identifying a server to a client. See also client authentication.

server SSL certificate

A certificate used to identify a server to a client using the Secure Sockets Layer (SSL) protocol.

servlet

Java™ code that handles a particular kind of interaction with end entities on behalf of a Certificate System subsystem. For example, certificate enrollment, revocation, and key recovery requests are each handled by separate servlets.

SHA-1

Secure Hash Algorithm, a hash function used by the US government.

signature algorithm

A cryptographic algorithm used to create digital signatures. Certificate System supports the MD5 and SHA-1 signing algorithms. See also cryptographic algorithm, digital signature.

signed audit log

See audit log.

signing certificate

A certificate that's public key corresponds to a private key used to create digital signatures. For example, a Certificate Manager must have a signing certificate that's public key corresponds to the private key it uses to sign the certificates it issues.

signing key

A private key used for signing only. A signing key and its equivalent public key, plus an encryption key and its equivalent public key, constitute a dual key pair.

single sign-on

1. In Certificate System, a password that simplifies the way to sign on to Red Hat Certificate System by storing the passwords for the internal database and tokens. Each time a user logs on, he is required to enter this single password.

2. The ability for a user to log in once to a single computer and be authenticated automatically by a variety of servers within a network. Partial single sign-on solutions can take many forms, including mechanisms for automatically tracking passwords used with different servers. Certificates support single sign-on within a public-key infrastructure (PKI). A user can log in once to a local client's private-key database and, as long as the client software is running, rely on certificate-based authentication to access each server within an organization that the user is allowed to access.

slot

The portion of a PKCS #11 module, implemented in either hardware or software, that contains a token.

smart card

A small device that contains a microprocessor and stores cryptographic information, such as keys and certificates, and performs cryptographic operations. Smart cards implement some or all of the PKCS #11 interface.

spoofing

Pretending to be someone else. For example, a person can pretend to have the email address **jdoe@example.com**, or a computer can identify itself as a site called **www.redhat.com** when it is not. Spoofing is one form of impersonation. See also misrepresentation.

SSL

See Secure Sockets Layer (SSL).

subject

The entity identified by a certificate. In particular, the subject field of a certificate contains a subject name that uniquely describes the certified entity.

subject name

A distinguished name (DN) that uniquely describes the subject of a certificate.

subordinate CA

A certificate authority that's certificate is signed by another subordinate CA or by the root CA. See CA certificate, root CA.

symmetric encryption

An encryption method that uses the same cryptographic key to encrypt and decrypt a given message.

T

tamper detection

A mechanism ensuring that data received in electronic form entirely corresponds with the original version of the same data.

token

A hardware or software device that is associated with a slot in a PKCS #11 module. It provides cryptographic services and optionally stores certificates and keys.

token key service (TKS)

A subsystem in the token management system which derives specific, separate keys for every smart card based on the smart card APDUs and other shared information, like the token CUID.

token management system (TMS)

The interrelated subsystems — CA, TKS, TPS, and, optionally, the KRA — which are used to manage certificates on smart cards (tokens).

token processing system (TPS)

A subsystem which interacts directly the Enterprise Security Client and smart cards to manage the keys and certificates on those smart cards.

tree hierarchy

The hierarchical structure of an LDAP directory.

trust

Confident reliance on a person or other entity. In a public-key infrastructure (PKI), trust refers to the relationship between the user of a certificate and the certificate authority (CA) that issued the certificate. If a CA is trusted, then valid certificates issued by that CA can be trusted.

V

virtual private network (VPN)

A way of connecting geographically distant divisions of an enterprise. The VPN allows the divisions to communicate over an encrypted channel, allowing authenticated, confidential transactions that would normally be restricted to a private network.

Index

Appendix A. Revision History

Note that revision numbers relate to the edition of this manual, not to version numbers of Red Hat Certificate System.

Revision 9.0-3 **Tue Aug 02 2016** **Petr Bokoč**

Asynchronous update

Revision 9.0-2 **Thu Oct 22 2015** **Aneta Petrová**

Updated the transport key rotation section

Revision 9.0-1 **Fri Sep 04 2015** **Tomáš Čapek**

Section on transport key rotation added

Revision 9.0-0 **Fri Aug 28 2015** **Tomáš Čapek**

Version for Red Hat Certificate System 9 release