PKIX Working Group
INTERNET DRAFT

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Expires in six months from September 8,1998

Internet X.509 Public Key Infrastructure
PKIX Roadmap
<draft-ietf-pkix-roadmap-00.txt>

Status of this Memo

Abstract

This document provides an overview or 'roadmap' of the work done by the IETF PKIX working group. It describes some of the terminology used in the working group's documents, and the theory behind an X.509-based PKI. It identifies each document developed by the PKIX working group, and describes the relationships among the various document. It also provides advice to would-be PKIX implementors about some of the issues discussed at length during PKIX development, in hopes of making it easier to build implementations that will actually interoperate.

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1 INTRODUCTION

This document is an informational Internet draft that provides a "roadmap" to the documents produced by the PKIX working group. It is intended to provide information; there are no requirements or specifications in this document.

Section 2 of this document defines key terms used in this document. Section 3 covers "PKIX theory"; it explains what the PKIX working group's basic assumptions were. Section 4 provides an overview of the various PKIX documents. It identifies which documents address which areas, and describes the relationships among the various documents. Section 5 contains "Advice to implementors". Its primary purpose is to capture some of the major issues discussed by the PKIX working group, as a way of explaining WHY some of the requirements and specifications say what they say. This should cut down on the number of misinterpretations of the documents, and help developers build interoperable implementations. Section 6 contains a list of references. Section 7 discusses security considerations, and Section 8 provides contact information for the editors.

2 Terminology

There are a number of terms used and misused throughout PKI-related literature. To limit confusion caused by some of those terms, throughout this document, we will use the following terms in the following ways:

- Certification Authority (CA) - an authority trusted by one or more users to create and assign certificates. Optionally the certification authority may create the users' key'. (It is important to note that the CA is responsible for the certificates during their whole lifetime, not just for issuing them.)
- Certificate policy - a named set of rules that indicates the applicability of a certificate to a particular community and/or class of application with common security requirements. For example, a particular certificate policy might indicate applicability of a type of certificate to the authentication of electronic data interchange transaction s for the trading of goods within a given price range.
- Root CA - a CA whose certificate is self-signed; that is, the issuer and subject are the same entity.
- Registration Agent (RA) - an optional entity given responsibility for performing some of the administrative tasks necessary in the registration of subjects, such as: confirming the subject's identity; validating that the subject is entitled to have the attributes requested in a certificate; and verifying that the subject has possession of the private key associated with the public key requested for a certificate.

- End-entity - a subject of a certificate who is not a CA.
- Relying party - a user or agent (e.g., a client or server) who relies on the data in a certificate in making decisions.
- Subject - a subject is the entity (CA or end-entity) named in a certificate. Subjects can be human users, computers (as represented by DNS names or IP addresses), or even software agents.

3 PKIX Theory

3.1 Certificate-using Systems and PKIs

At the heart of recent efforts to improve Internet security are a group of security protocols such as S/MIME, TLS, and IPSec. All of these protocols rely on public-key cryptography to provide services such as confidentiality, data integrity, data origin authentication, and non-repudiation. The purpose of a PKI is to provide trusted and efficient key- and certificate management, thus enabling the use of authentication, non-repudiation, and confidentiality.

Users of public key-based systems must be confident that, any time they rely on a public key, the associated private key is owned by the subject with which they are communicating. (This applies whether an encryption or digital signature mechanism is used.) This confidence is obtained through the use of public key certificates, which are data structures that bind public key values to subjects. The binding is achieved by having a trusted CA verify the subject's identity and digitally sign each certificate.

A certificate has a limited valid lifetime which is indicated in its signed contents. Because a certificate's signature and timeliness can be independently checked by a certificate-using client, certificates can be distributed via untrusted communications and server systems, and can be cached in unsecured storage in certificate-using systems.

Certificates are used in the process of validating signed data. Specifics vary according to which algorithm is used, but the general process works as follows: (note: there is no specific order in which the checks listed below must be made; implementors are free to implement them in the most efficient way for their systems)

- the recipient of signed data verifies that the claimed identity of the user is in accordance wit the identity contained in the certificate;
- the recipient validates that no certificate in the path has been

revoked (e.g., by retrieving a suitably-current Certificate Revocation List (CRL) or querying an on-line certificate status responder), and that all certificates were within their validity periods at the time the data were signed;
- the recipient verifies that the data are not claimed to have any attributes for which the certificate indicates that the signer is not authorized;
- the recipient verifies that the data have not been altered since signing, by using the public key in the certificate.

If all of these checks pass, the recipient can accept that the data were signed by the purported signer. The process for keys used for encryption is similar.

(Note: it is of course possible that data were signed by someone very different from the signer, if for example the purported signer's private key was compromised. Security depends on all parts of the certificate-using SYSTEM, including but not limited to: physical security of the place the computer resides; personnel security (i.e., the trustworthiness of the people who actually develop, install, run, and maintain the system); the security provided by the operating system on which the private key is used; and the security provided the CA. A failure in any one of these areas can cause the entire system security to fail. PKIX is limited in scope, however, and only directly addresses issues related to the operation of the PKI subsystem. For guidance in many of the other areas, see [PKIX-4].)

A collection of certificates, with their issuing CA's, subjects, relying parties, RA's, and repositories, is referred to as a Public Key Infrastructure, or PKI.

3.2 Overview of the PKIX Approach

PKIX is an effort to develop specifications for a Public Key Infrastructure for the Internet using X.509 certificates. The PKIX working group was initially chartered in 1995. A Public Key Infrastructure, or PKI, is defined as:

The set of hardware, software, people, policies and procedures needed to create, manage, store, distribute, and revoke certificates based on public-key cryptography.

A PKI consists five types of components[MISPC]:

* Certification Authorities (CAs) that issue and revoke certificates;
* Organizational Registration Authorities (ORAs) that vouch for the binding between public keys and certificate holder identities and other attributes;
* Certificate holders that are issued certificates and can sign digital documents;
* Clients that validate digital signatures and their certification paths from a known public key of a trusted CA;
* Repositories that store and make available certificates and Certificate Revocation Lists (CRLs).

Figure 1 is a simplified view of the architectural model assumed by the PKIX Working Group.

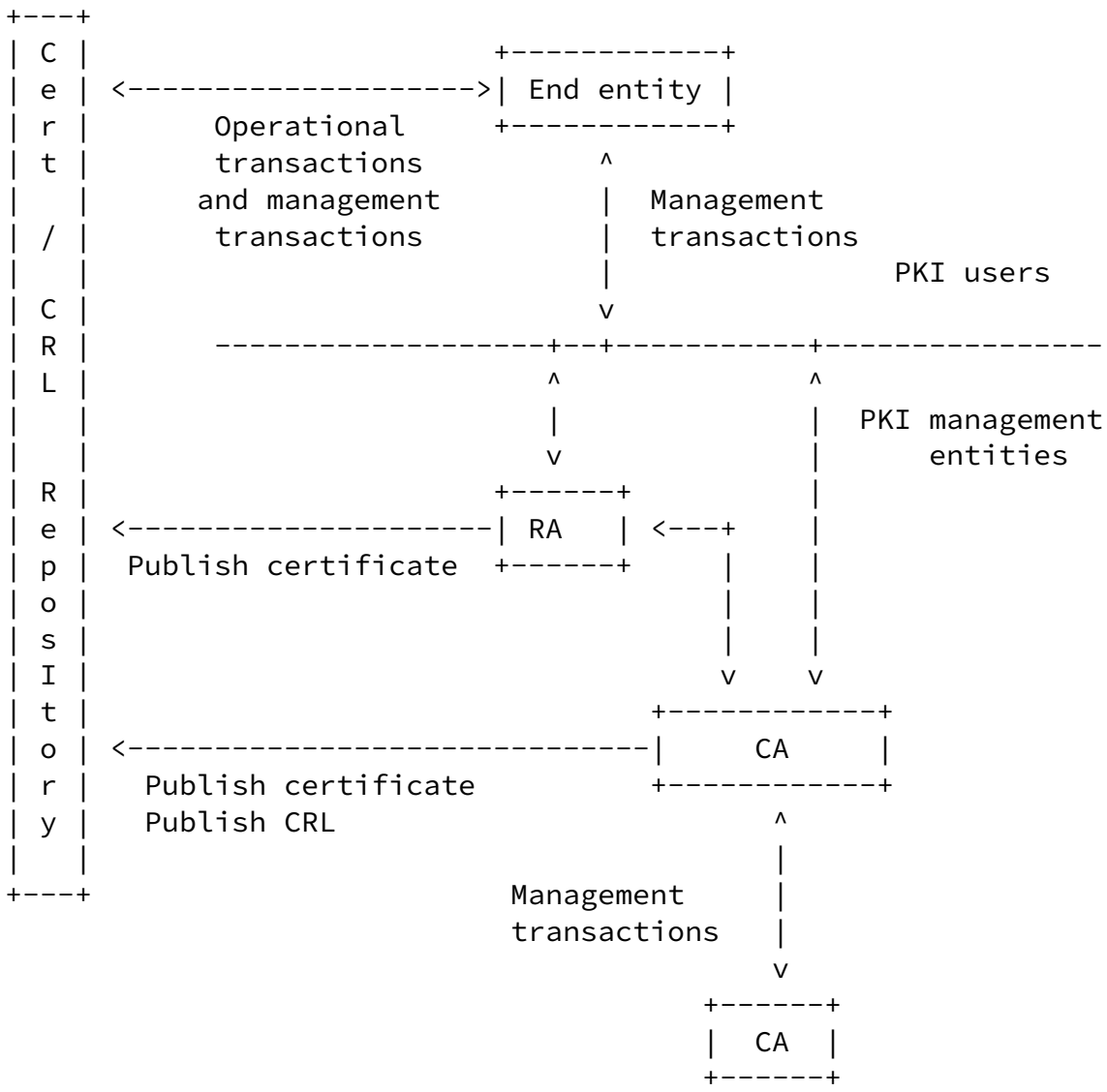

Figure 1 - PKI Entities

3.3 X.509 certificates

ITU-T X.509 (formerly CCITT X.509) or ISO/IEC/ITU 9594-8, which was first published in 1988 as part of the X.500 Directory recommendations, defines a standard certificate format [X.509]. The certificate format in the 1988 standard is called the version 1 (v1) format.

When X.500 was revised in 1993, two more fields were added, resulting in the version 2 (v2) format. These two fields may be used to support directory access control.

The Internet Privacy Enhanced Mail (PEM) RFCs, published in 1993, include specifications for a public key infrastructure based on X.509v1 certificates [RFC 1422]. The experience gained in attempts to deploy RFC 1422 made it clear that the v1 and v2 certificate formats are deficient in several respects. Most importantly, more fields were needed to carry information which PEM design and implementation experience has proven necessary. In response to these new requirements, ISO/IEC/ITU and ANSI X9 developed the X.509 version 3 (v3) certificate format. The v3 format extends the v2 format by adding provision for additional extension fields. Particular extension field types may be specified in standards or may be defined and registered by any organization or community. In June 1996, standardization of the basic v3 format was completed [X.509].

ISO/IEC/ITU and ANSI X9 have also developed standard extensions for use in the v3 extensions field [X.509][X9.55]. These extensions can convey such data as additional subject identification information, key attribute information, policy information, and certification path constraints. However, the ISO/IEC/ITU and ANSI X9 standard extensions are very broad in their applicability. In order to develop interoperable implementations of X.509 v3 systems for Internet use, it is necessary to specify a profile for use of the X.509 v3 extensions tailored for the Internet. It is one goal of PKIX to specify a profile for Internet WWW, electronic mail, and IPsec applications. Environments with additional requirements may build on this profile or may replace it.

3.4 Functions of a PKI

This section describes the major functions of a PKI. In some cases, PKIs may provide extra functions.

3.4.1 Registration

This is the process whereby a subject first makes itself known to a CA (directly, or through an RA), prior to that CA issuing a certificate or certificates for that subject. Registration involves the subject providing its name (e.g., common name, fully-qualified domain name, IP address), and other attributes to be put in the certificate, followed by the CA (possibly with help from the RA) verifying in accordance with its CPS that the name and other attributes are correct.

3.4.2 Initialization

Initialization is when the subject - e.g., the user or client system - gets the values needed to begin communicating with the PKI. For example, initialization can involve providing the client system with the public key and/or certificate of a CA, or generating the client system's own public/private key pair.

3.4.3 Certification

This is the process in which a CA issues a certificate for a subject's public key, and returns that certificate to the subject and/or posts that certificate in a repository.

3.4.4 Key Pair Recovery

In some implementations, key exchange or encryption keys will be required by local policy to be "backed up", or recoverable in case the key is lost and access to previously-encrypted information is needed. Such implementations can include those where the private key exchange key is stored on a hardware token which can be lost or broken, or when a private key file is protected by a password which can be forgotten. Often, a company is concerned about being able to read mail encrypted by or for a particular employee when that employee is no longer available because she is ill or no longer works for the company.

In these cases, the user's private key can be backed up by a CA or by a separate key backup system. If a user or her employer needs to recover these backed up key materials, the PKI must provide a system that permits the recovery WITHOUT providing an unacceptable risk of compromise of the private key.

3.4.5 Key Generation

Depending on the CA's policy, the private/public key pair can either be generated by the user in his local environment, or generated by the CA. In the latter case, the key material may be distributed to the user in an encrypted file or on a physical token - e.g., a smart card or PCMCIA card.

3.4.6 Key Update

All key pairs need to be updated regularly, i.e., replaced with a new key pair, and new certificates issued. This will happen in two cases: normally, when a key has passed its maximum usable lifetime; and exceptionally, when a key has been compromised and must be replaced.

In the normal case, a PKI needs to provide a facility to gracefully transition from a certificate with an existing key to a new certificate with a new key. This is particularly true when the key to be updated is that of a CA. Users will know in advance that the key will expire on a certain date; the PKI, working together with certificate-using applications, should allow for appropriate keys to work before and after the transition. There are a number of ways to do this; see [insert appropriate reference here] for an example of one.

In the case of a key compromise, the transition will not be "graceful" in that there will be an unplanned switch of certificates and keys; users will not have known in advance what was about to happen. Still, the PKI must support the ability to declare that the previous certificate is now invalid and shall not be used, and to announce the validity and availability of the new certificate.

Note, however, that the compromise of a private key associated with a self-signed rootCA certificate is always catastrophic. That is, once the rootCA's private signature key has been compromised, there is no way to reliably convince users and subordinate CA's to accept a new key for the rootCA. If the key is compromised, any "update" message telling subordinates to switch to a new key could have come from an attacker in possession of the old key, and could point to a new public key for which the attacker already has the private key.

When a rootCA's private signature key is compromised, the only option is dismantling the entire infrastructure subordinate to that rootCA and starting over again from scratch. It is possible to have anticipated this event, and "pre-placed" replacement rootCA keys with all relying parties, but some secure, out-of-band mechanism will have to be used to tell users to make the switch, and this will only help if the

replacement key has not been compromised.

3.4.7 Cross-certification

A cross-certificate is a certificate issued by one CA to another CA which contains a public CA key associated with the private CA signature key used for issuing certificates. Typically, a cross-certificate is used to allow client systems/end entities in one administrative domain to communicate security with client systems/end users in another administrative domain. Use of a cross-certificate issued from CA_1 to CA_2 allows user Alice, who trusts CA_1, to accept a certificate used by Bob, which was issued by CA_2. (Note: cross-certificates can also be issued from one CA to another CA in the same administrative domain, if required.)

Cross-certificates can be issued in only one direction, or in both directions, between two CA's. That is, just because CA_1 issues a cross-certificate for CA_2 does not require CA_2 to issue a cross-certificate for CA_1.

3.4.8 Revocation

When a certificate is issued, it is expected to be in use for its entire validity period. However, various circumstances may cause a certificate to become invalid prior to the expiration of the validity period. Such circumstances include change of name, change of association between subject and CA (e.g., an employee terminates employment with an organization), and compromise or suspected compromise of the corresponding private key. Under such circumstances, the CA needs to revoke the certificate.

X.509 defines one method of certificate revocation. This method involves each CA periodically issuing a signed data structure called a

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certificate revocation list (CRL). A CRL is a time stamped list identifying revoked certificates which is signed by a CA and made freely available in a public repository. Each revoked certificate is identified in a CRL by its certificate serial number. When a certificate-using system uses a certificate (e.g., for verifying a remote user's digital signature), that system not only checks the certificate signature and validity but also acquires a suitably-recent CRL and checks that the certificate serial number is not on that CRL. The meaning of "suitably-recent" may vary with local policy, but it usually means the most recently-issued CRL. A CA issues a new CRL on a regular periodic basis (e.g., hourly, daily, or weekly). CA's may also

issue CRLs aperiodically; e.g., if an important key is deemed compromised, the CA may issue a new CRL to expedite notification of that fact, even if the next CRL does not have to be issued for some time. (A problem of aperiodic CRL issuance is that end-entities may not know that a new CRL has been issued, and thus may not retrieve it from a repository.)

An entry is added to the CRL as part of the next update following notification of revocation. An entry may be removed from the CRL after appearing on one regularly scheduled CRL issued beyond the revoked certificate's validity period.

An advantage of the CRL revocation method is that CRLs may be distributed by exactly the same means as certificates themselves, namely, via untrusted communications and server systems.

One limitation of the CRL revocation method, using untrusted communications and servers, is that the time granularity of revocation is limited to the CRL issue period. For example, if a revocation is reported now, that revocation will not be reliably notified to certificate-using systems until the next CRL is issued -- this may be up to one hour, one day, or one week depending on the frequency that the CA issues CRLs.

As with the X.509 v3 certificate format, in order to facilitate interoperable implementations from multiple vendors, the X.509 v2 CRL format needs to be profiled for Internet use. It is one goal of PKIX to specify that profile. However, PKIX does not require CAs to issue CRLs. Message formats and protocols supporting on-line revocation notification may be defined in other PKIX specifications. On-line methods of revocation notification may be applicable in some environments as an alternative to the X.509 CRL.

On-line revocation checking may significantly reduce the latency between a revocation report and the distribution of the information to relying parties. Once the CA accepts the report as authentic and valid, any query to the on-line service will correctly reflect the certificate validation impacts of the revocation. However, these methods impose new security requirements; the certificate validator must trust the on-line validation service while the repository does not need to be trusted.

3.4.9 Certificate and Revocation Notice Distribution/Publication

As alluded to in sections 3.4.3 and 3.4.8 above, the PKI is responsible for the distribution of certificates and certificate revocation notices (whether in CRL form or in some other form) in the system. "Distribution" of certificates includes transmission of the certificate to its owner, and may also include publication of the certificate in a repository. "Distribution" of revocation notices may involve posting CRLs in a repository, transmitting them to end-entities, and/or forwarding them to on-line responders.

3.5 Parts of PKIX

This section identifies the four different areas in which the PKIX working group has developed documents. The first area involves profiles of the X.509 v3 certificate standards and the X.509v2 CRL standards for the Internet. The second area involves operational protocols, in which relying parties can obtain information such as certificates or certificate status. The third area covers management protocols, in which different entities in the system exchange information needed for proper management of the PKI. The last area provides information about certificate policies and certificate practice statements, covering the areas of PKI security not directly addressed in the rest of PKIX.

3.5.1 Profile

An X.509v3 certificate is a very complex data structure. It consists of basic information fields, plus a number of optional certificate extensions. Many of the fields and numerous extensions can take on a wide range of options. This provides an enormous degree of flexibility, which allows the X.509v3 certificate format to be used with a wide range of applications in a wide range of environments. Unfortunately, this same flexibility makes it extremely difficult to produce independent implementations that will actually interoperate with one another. In order to build an Internet PKI based on X.509v3 certificates, the PKIX working group had to develop a profile of the X.509v3 specification.

A profile of the X.509v3 specification is a description of the contents of the certificate and which certificate extensions must be supported, which extensions may be supported, and which extensions may not be supported. [PKIX-1] provides such a profile of X.509v3 for the Internet PKI. In addition, [PKIX-1] suggests ranges of values for many of the extensions.

[PKIX-1] also provides a profile for Version 2 CRLs for use in the Internet PKI. CRLs, like certificates, have a number of optional extensions. In order to promote interoperability, it is necessary to constrain the choices an implementor supports.

In addition to profiling the certificate and CRL formats, it is necessary to specify particular Object Identifiers (OIDs) for certain

encryption algorithms, because there are a variety of OIDs registered for some algorithm suites. Thus, PKIX has produced at least two documents ([ECDSA] and [KEA]) which provide guidance on the proper implementation of specific algorithms.

3.5.2 Operational Protocols

Operational protocols are required to deliver certificates and CRLs (or other certificate status information) to certificate using systems. Provision is needed for a variety of different means of certificate and CRL delivery, including distribution procedures based on LDAP, HTTP, FTP, and X.500. Operational protocols supporting these functions are defined in other [FTP], [OCSP],[LDAP], and [WEB].

3.5.3 Management Protocols

Management protocols are required to support on-line interactions between PKI user and management entities. For example, a management protocol might be used between a CA and a client system with which a key pair is associated, or between two CAs which cross-certify each other. A management protocol can be used to carry user or client system registration information, or a request for revocation of a certificate.

There are two parts to a "management protocol". The first is the format of the messages that will be sent, and the second is the actual protocol that governs the transmission of those messages. The PKIX working group has developed two documents ([CRMF] and [CMMF]) that together describe the necessary set of message, and two other documents ([CMP] and [CMC]) that describe protocols for exchanging those messages.

3.5.4 Policy Outline

As mentioned before, profiling certificates and specifying operational and management protocols only addresses a part of the problem of actually developing and implementing a secure PKI. What is also needed is the development of a certificate policy and certification practice statement, and then following those documents. The CP and CPS should address physical and personnel security, subject identification requirements, revocation policy, and a number of other topics. [PKIX-4] provides a framework for certification practice statements.

4 PKIX Documents

This section describes each of the documents written by the PKIX working

group. As PKIX progresses, this section will need to be continually updated to reflect the status of each document (e.g., Proposed Standard, Draft Standard, Standard, Informational Draft, Informational RFC, something-that-was-just-thrown-out-for-consideration, etc.)

4.1 Profile

DOCUMENT TITLE: Internet X.509 Public Key Infrastructure Certificate and CRL Profile <draft-ietf-pkix-ipki-part1-08.txt>

DESCRIPTION: This document describes the profiles to be used for X.509v3 certificates and version2 CRLs by Internet PKI participants. The profiles include the identification of ISO/IEC/ITU and ANSI extensions which may be useful in the Internet PKI. The profiles are presented in the 1988 Abstract Syntax Notation One (ASN.1) rather than the 1994

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syntax used in the ISO/IEC/ITU standards. Would-be PKIX implementors and developers of certificate-using applications should start with [PKIX-1] to ensure that their systems will be able to interoperate with other users of the PKI.

[PKIX-1]also includes path validation procedures. The procedures presented are based upon the ISO/IEC/ITU definition, but the presentation assumes one or more self-signed trusted CA certificates. The procedures are provided as examples only. Implementations are not required to use the procedures provided; they may implement whichever procedures are efficient for their situation. However, implementations are required to derive the same results as the example procedures.

STATUS:

DOCUMENT TITLE: Internet X.509 Public Key Infrastructure: Representation of Elliptic Curve Digital Signature Algorithm (ECDSA) Keys and Signatures in Internet X.509 Public Key Infrastructure Certificates <draft-ietf-pkix-ipki-ecdsa-01.txt>

DESCRIPTION: This document provides Object Identifiers (OIDs) and other guidance for IPKI users who use the Elliptic Curve Digital Signature Algorithm (ECDSA). It profiles the format and semantics of the subjectPublicKeyInfo field and the keyUsage extension in X.509 V3 certificates containing ECDSA keys. This document should be used by anyone wishing to support ECDSA; others who do not support ECDSA are not required to comply with it.

STATUS:

DOCUMENT TITLE: Internet X.509 Public Key Infrastructure Representation of Key Exchange Algorithm (KEA) Keys in Internet X.509 Public Key Infrastructure Certificates

DESCRIPTION: This document provides Object Identifiers (OIDs) and other guidance for IPKI users who use the Key Exchange Algorithm (KEA). It profiles the format and semantics of the subjectPublicKeyInfo field and the keyUsage extension in X.509 V3 certificates containing KEA keys. This document should be used by anyone wishing to support KEA; others who do not support ECDSA are not required to comply with it.

STATUS:

DOCUMENT TITLE: Internet X.509 Public Key Infrastructure OPEN CRL DISTRIBUTION PROCESS (OpenCDP) <draft-ietf-pkix-ocdp-00.txt>

DESCRIPTION: This document proposes an alternative to the CRL Distribution Point (CDP) approach documented in [PKIX-1]. OCDP separates the CRL location function from the process of certificate and CRL validation, and thus claims some benefits over the CDP approach.

STATUS:

4.2 Operational Protocols

DOCUMENT TITLE: Internet X.509 Public Key Infrastructure Operational Protocols - LDAPv2 <draft-ietf-pkix-ipki2opp-07.txt>

DESCRIPTION: This document describes the use of LDAPv2 as a protocol for PKI elements to publish and retrieve certificates and CRLs from a certificate repository. LDAPv2 [RFC abcd] is a protocol that allows publishing and retrieving of information.

STATUS:

DOCUMENT TITLE: Internet X.509 Public Key Infrastructure LDAPv2 Schema <draft-ietf-pkix-ldapv2-schema-00.txt>

DESCRIPTION: This document defines a minimal schema necessary to support the use of LDAPv2 for certificate and CRL retrieval and related functions for PKIX. This document supplements [LDAP] by identifying the

PKIX-related attributes that must be present.

STATUS:

DOCUMENT TITLE: X.509 Internet Public Key Infrastructure Online Certificate Status Protocol - OCSP <draft-ietf-pkix-ocsp-04.txt>

DESCRIPTION: This document specifies a protocol useful in determining the current status of a certificate without the use of CRLs. A major complaint about certificate-based systems is the need for a relying party to retrieve a current CRL as part of the certificate validation process. Depending on the size of the CRL, this can cause severe problems for bandwidth-challenged devices. Depending on the frequency of CRL issuance, this can also cause timeliness problems. (E.g., if CRLs are only published weekly, with no interim releases, a certificate could actually have been revoked for just short of one week without it being on the current CRL, and thus improper use of that certificate could still be occurring.)

OCSP attempts to address those problems. It provides a mechanism whereby a relying party identifies one or more certificates to an approved OCSP "responder", and the responder sends back the current status of the certificate(s) - e.g., "revoked", "notRevoked", "unknown". This can dramatically reduce the bandwidth required to transmit revocation status - a relying party does not have to retrieve a CRL of many entries to check the status of one certificate. It can (although it is not guaranteed to) improve the timeliness of revocation notification, and thus reduce the window of opportunity for someone trying to use a revoked certificate.

STATUS:

DOCUMENT TITLE: Internet Public Key Infrastructure: Caching the Online Certificate Status Protocol <draft-ietf-pkix-ocsp-caching-00.txt>

DESCRIPTION: To improve the degree to which it can scale, OCSP allows caching of responses - e.g., at intermediary servers, or even at the

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relying party's end system. This document describes how to support OCSP caching at intermediary servers.

STATUS:

DOCUMENT TITLE: Internet X.509 Public Key Infrastructure Operational Protocols: FTP and HTTP <draft-ietf-pkix-opp-ftp-http-04.txt>

DESCRIPTION: This document describes the use of the File Transfer Protocol (FTP) and the Hyper-text Transfer Protocol (HTTP) to obtain certificates and CRLs from PKI repositories.

STATUS:

DOCUMENT TITLE: WEB based Certificate Access Protocol-- WebCAP/1.0

DESCRIPTION: This document specifies a set of methods, headers, and content-types ancillary to HTTP/1.1 to publish, retrieve X.509 certificates and Certificate Revocation Lists. This protocol also facilitates determining current status of a digital certificate without the use of CRLs. This protocol defines new methods, request and response bodies, error codes to HTTP/1.1 protocol for securely publishing, retrieving, and validating certificates across a firewall.

STATUS:

4.3 Management Protocols

DOCUMENT TITLE: Certificate Management Messages over CMS <draft-ietf-pkix-cmc-00.txt>

DESCRIPTION: This document defines the means by which PKI clients and servers may exchange PKI messages when using S/MIME's Cryptographic Message Syntax [CMS]as a transaction envelope. CMC supports message bodies specified in the Certificate Management Message Formats [CMMF] and Certificate Request Message Format [CRMF] documents. The purpose of this specification is to allow the use of an existing protocol (S/MIME) as a PKI management protocol, rather than requiring the development of a new, custom protocol for the task.

STATUS:

DOCUMENT TITLE: Internet X.509 Public Key Infrastructure Certificate Management Message Formats <draft-ietf-pkix-cmmf-02.txt>

DESCRIPTION: This document contains the formats for a series of messages important in certificate/PKI management. These messages let CA's, RA's, and relying parties communicate with each other. Note that this document only specifies message formats; it does not specify a protocol for transferring messages. That protocol can be either CMP or CMC, or perhaps another custom protocol.

STATUS:

DOCUMENT TITLE: Internet X.509 Certificate Request Message Format <draft-ietf-pkix-crmf-01.txt>

DESCRIPTION: CRMF specifies a format recommended for use whenever a relying party is requesting a certificate from a CA or requesting that an RA help it get a certificate. This document is distinct from CMMF for historical reasons - the request message format was needed before many of the other message formats had to be finalized, and so it was put into a separate document. Like CMMF, this document only specifies the format of a message. Specification of a protocol to transport that message is beyond the scope of CRMF.

STATUS:

DOCUMENT TITLE: Internet X.509 Public Key Infrastructure Certificate Management Protocols <draft-ietf-pkix-ipki3cmp-08.txt>

DESCRIPTION: This document specifies a new protocol specifically developed for the purpose of transporting messages like those specified in CMMF and CRMF among PKI elements. In general, CMP will be used in conjunction with CMMF and CRMF, and will then be run over a transfer service (e.g., S/MIME, HTTP) to provide a complete PKI management service.

STATUS:

4.4 Policy Outline

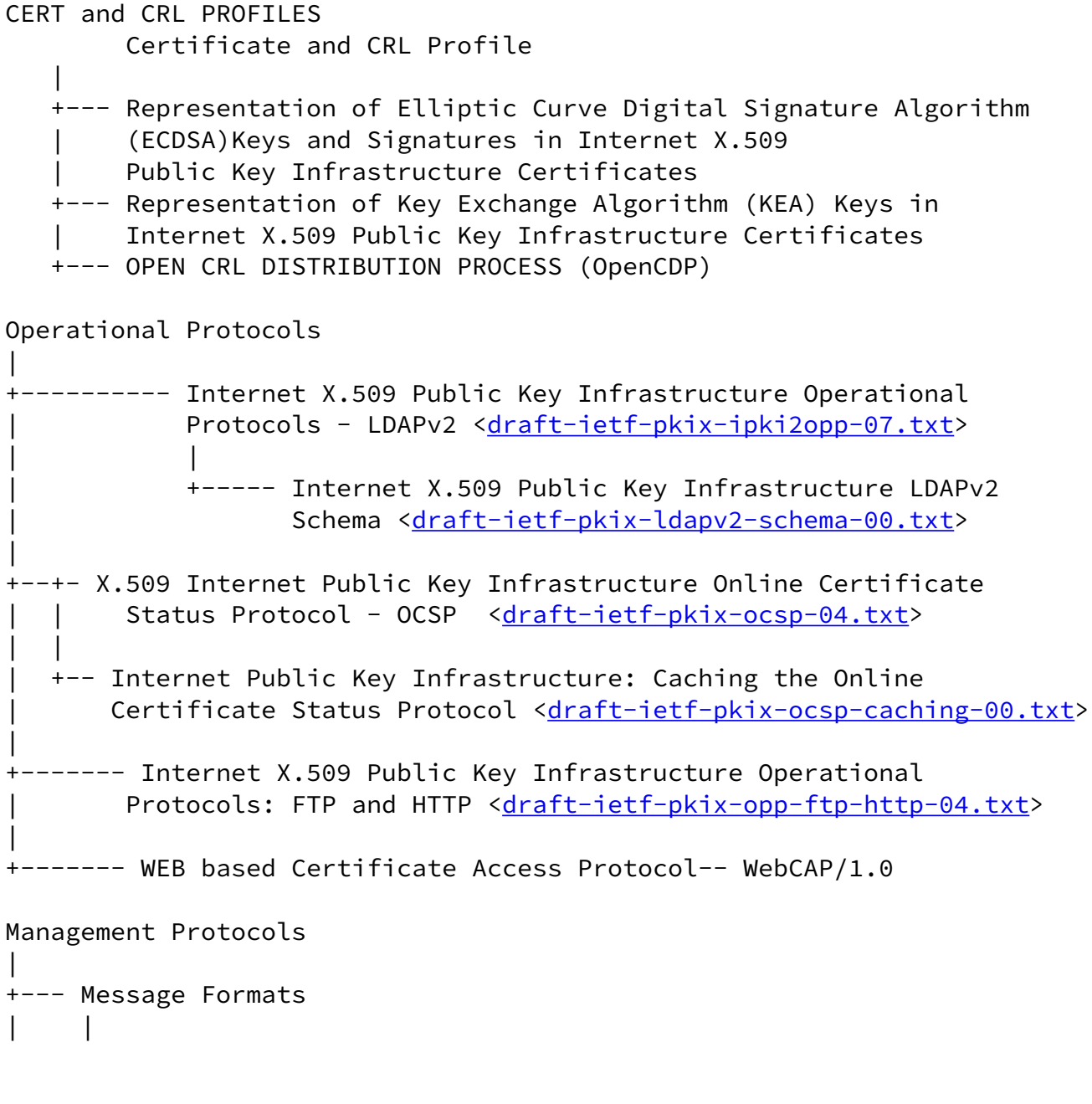
DOCUMENT TITLE: Internet X.509 Public Key Infrastructure Certificate Policy and Certification Practices Framework <draft-ietf-pkix-ipki-part4-03.txt>

DESCRIPTION: As noted before, the specification and implementation of certificate profiles, operational protocols, and management protocols is only part of building a PKI. Equally as important - if not more important - is the development and enforcement of a certificate security policy, and a Certification Practice Statement (CPS). The purpose of this document (PKIX-4) is to establish a clear relationship between certificate policies and(CPSs), and to present a framework to assist the writers of certificate policies or CPSs with their tasks. In particular, the framework identifies the elements that may need to be considered in formulating a certificate policy or a CPS. The purpose is not to define particular certificate policies or CPSs, per se.

STATUS:

4.5 DOCUMENT RELATIONSHIPS

Figure 2 shows graphically the relationships among the PKIX documents.



```
|    +--- Internet X.509 Public Key Infrastructure Certificate
|    |    Management Message Formats
|    +--- Internet X.509 Certificate Request Message Format
|         <draft-ietf-pkix-crmf-01.txt>
|
+--- Protocols
     |
     +--- Internet X.509 Public Key Infrastructure Certificate
     |    Management Protocols
     +--- Certificate Management Messages over CMS
          <draft-ietf-pkix-cmc-00.txt>

Policy Outline
|
+-- Internet X.509 Public Key Infrastructure Certificate Policy and
    Certification Practices Framework
```

Figure 2: Document Relationships

5 Advice to Implementors

This section provides guidance to those who would implement various parts of the PKIX suite of documents. The topics discussed in this section engendered significant discussion in the working group, and there was at times either widespread disagreement or widespread misunderstanding of them. Thus, this discussion is provided to help readers of the PKIX document set understand these issues, in the hope of fostering greater interoperability among eventual PKIX implementations.

5.1 Names

PKIX has been referred to as a "name-centric" PKI because the certificates associate public keys with names of entities. Each certificate contains at least one name for the owner of a particular public key. The name can be an X.500 distinguished name, contained in the subjectDN field of the certificate. There can also be names such as RFC822 e-mail addresses, DNS domain names, and URIs associated with the key; these attributes are kept in the subjectAltName extension of the certificate. A certificate must contain at least one of these name forms, it may contain multiple forms if deemed appropriate by the CA based on the intended usage of the certificate.

5.1.1 Name Forms

There are two possible places to put a name in an X.509v3 certificate.

One is the subject field in the base certificate (often called the "Distinguished Name" or "DN" field), and the other is in the subjectAltName extension.

5.1.1.1 Distinguished Names

According to [PKIX-1], a PKIX certificate must have a non-null value in the Distinguished Name field, except for an end-entity certificate, which is permitted to have an empty DN field.

5.1.1.2 SubjectAltName Forms

In addition to the DN, a PKIX certificate may have one or more values in the subjectAltName extension.

The subjectAltName extension allows additional identities to be bound to the subject of the certificate - e.g., it allows "umbc.edu" and "130.85.1.3" to be associated with a particular subject, as well as "C=US, O=University of Maryland, L=Baltimore, CN=UMBC". X.509-defined options for this extension include: Internet electronic mail addresses; DNS names; IP addresses; and uniform resource indentifiers (URIs). Other options can exist, including locally-defined name forms.

A single subjectAltName extension can include multiple name forms, and multiple instances of each name form.

Note: whenever such Alternate Name forms are to be bound into a certificate, the subject alternative name (or issuer alternative name) extension must be used. It is technically possible to embed an

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Alternate Name Form in the subject field. For example, one could make a DN contain an IP address via a kludge such as "C=US, L=Baltimore, CN=130.85.1.3". However, this usage is deprecated; the alternative name extension is the preferred location for finding such information.)

In line with this, if the only subject identity included in a certificate is an alternative name form, then the subject distinguished name must be empty (technically, an empty sequence), and the subjectAltName extension must be present. If the subject field contains an empty sequence, the subjectAltName extension must be marked critical.

If the subjectAltName extension is present, the sequence must contain at least one entry. Unlike the subject field, conforming CAs shall not issue certificates with subjectAltNames containing empty GeneralName fields. For example, an rfc822Name is represented as an IA5String. While

an empty string is a valid IA5String, such an rfc822Name is not permitted by PKIX. The behavior of clients that encounter such a certificate when processing a certification path is not defined by this working group.

Because the subject alternative name is considered to be definitively bound to the public key, all parts of the subject alternative name must be verified by the CA.

5.1.1.2.1 Internet e-mail addresses

When the subjectAltName extension contains an Internet mail address, the adress is included as an rfc822Name. The format of an rfc822Name is an "addr-spec" as defined in RFC 822 [RFC 822]. An addr-spec has the form local-part@domain; it does not have a phrase (such as a common name) before it, or a comment (text surrounded in parentheses) after it, and it is not surrounded by "<" and ">".

5.1.1.2.2 DNS Names

When the subjectAltName extension contains a domain name service label, the domain name is stored in the dNSName attribute(an IA5String). The string shall be in the "preferred name syntax," as specified by RFC 1034 [RFC 1034]. Note that while upper and lower case letters are allowed in domain names, no significance is attached to the case. In addition, while the string " " is a legal domain name, subjectAltName extensions with a dNSName " " are not permitted. Finally, the use of the DNS representation for Internet mail addresses (wpolk.nist.gov instead of wpolk@nist.gov) is not permitted; such identities are to be encoded as rfc822Name.

5.1.1.2.3 IP addresses

When the subjectAltName extension contains an iPAddress, the address shall be stored in the octet string in "network byte order," as specified in RFC 791 [RFC 791]. The least significant bit (LSB) of each octet is the LSB of the corresponding byte in the network address. For IP Version 4, as specified in RFC 791, the octet string must contain exactly four octets. For IP Version 6, as specified in RFC 1883, the octet string must contain exactly sixteen octets [RFC1883].

5.1.1.2.4 URIs

(is there any guidance about URIs as name forms?)

5.1.2 Scope of Names

The original X.500 work presumed that every subject in the world would have a globally-unique distinguished name. Thus, every subject could be easily located, and there would never be a conflict. All that would be needed is a sufficiently-large name space, and rules for constructing names based on subordination and location.

Obviously, that is not practical in the real world, for a variety of reasons. There is no single entity in the world trusted by everybody to reside at the top of the name space, and there is no way to enforce uniqueness on names for all entities. (These were among the reasons for the failure of PEM to be widely implemented.)

This does not mean, however, that a name-based PKI cannot work. It is important to recognize that the scope of names in PKIX is local; they need to be defined and unique only within their own domain.

Suppose for example that a rootCA is established with DN "O=IETF, OU=PKIX, CN=PKIX_CA". That CA will then issue certificates for names subordinate to it. The only requirement - and this can be enforced procedurally - is that no two distinct entities beneath this rootCA have the same name. We can't prevent somebody else in the world from creating her own CA, called "O=IETF, OU=PKIX, CN=PKIX_CA", and it is not necessary to do so. Within the domain of the original rootCA, there will be no conflict, and the fact that there is another CA of the same name in some other domain is irrelevant.

This is analogous to the current DNS or IP address situations. On the Internet, there is only one node called www.ietf.org. The fact that there might be 10 different intranets, each with a host given the DNS name www.ieft.org, is irrelevant and causes no interoperability problems - those are different domains. However, if there were to be another node on the Internet with domain name www.ietf.org, then there would be a problem due to name duplication.

The same applies for IP addresses. As long as only one node on the Internet responds to the IP address 130.85.1.3, there is no problem, despite the fact that there are 100 different corporate Intranets, each using that same IP address. However, if two different nodes on the Internet each responded to the IP address 130.85.1.3, there would be a problem.

5.1.3 Certificate Path Construction

Path construction - make point that there is no single best way to construct a path. Implementors can pick the way that is most efficient for them. Discuss some of the issues being hashed out in the "ldap" discussion on the mail list. If there is ever a resolution, include it in this section.

5.1.4 Name Constraints

(Note: this section still needs a lot of work.)

A question that has arisen a number of times is "how does one enforce Name constraints when there is more than one name form in a certificate?" That is, [PKIX-1] states that:

Subject alternative names may be constrained in the same manner as subject distinguished names using the name constraints extension as described in section 4.2.1.11.

What does this mean? Suppose that there is a CA with DN "O=IETF, OU=PKIX, CN=PKIX_CA", with the subjectAltName extension having dNSName "PKIX_CA.IETF.ORG". Suppose that that CA has issued a certificate with an empty DN, with subjectAltName extension having dNSName set to "PKIX_CA.IETF.ORG", and rfc822Name set to Steve@PKIX_CA.IETF.ORG. The question is, are name constraints enforced on these two certificates - is the name of the end-entity certificate considered to be properly subordinate to the name of the CA?

The answer is "yes". In deciding whether a name form meets name constraints, the following rules apply:

- for DNs:
- for rfc822Names:
- for dNSNames:
- for URIs:
- for iPaddresses

The general rules are:

If a certificate complies with name constraints in any one of its name forms, then the certificate is deemed to comply with name constraints.

If a certificate contains a name form that its issuer does not, the certificate is deemed to comply with name constraints for that name form.

5.1.5 Wildcards in Name Forms

A "wildcard" in a name form is a placeholder for a set of names; e.g. "*.mit.edu" meaning "any domain name ending in .mit.edu", and *@aol.com meaning "email address that uses aol.com". There are many people who believe that allowing wildcards in name forms in PKIX

certificates would be a useful thing to do, because it would allow a single certificate to be used by all members of a group. These members would presumably have attributes in common; e.g., access rights to some set of resources, and so issuance of a certificate with a wildcard for the group would simplify management.

After much discussion, the PKIX working group decided to permit the use of wildcards in certificates. That is, it is permissible for a PKIX-conformant CA to issue a certificate with a wildcard. However, the semantics of subject alternative names that include wildcard

characters are not addressed by PKIX. Applications with specific requirements may use such names but must define the semantics.

5.1.6 Name Encoding

(insert a section on encoding non-ASCII names. Key points to make:)
- UTF8 is the long-term goal for IETF, and is mandatory in 2003 and later
- BMPString is presently supported by most vendors
- Teletexstring containing ISO 8859-1 is also used by many CA's

5.2 POP

- The importance of PoP
- PoP for signature keys vs. PoP for key-management keys
- What the CA/RA has to do
- Different ways of accomplishing this

5.3 Key Usage Bits

The key usage extension defines the purpose (e.g., encipherment, signature, certificate signing) of the key contained in the certificate. This extension is used when a key that could be used for more than one operation is to be restricted. For example, when an RSA key should be used only for signing, the digitalSignature and/or nonRepudiation bits would be asserted. Likewise, when an RSA key should be used only for key management, the keyEncipherment bit would be asserted. When used, this extension should be marked critical.

The eight bits defined for this extension identify seven mechanisms and one service, namely:
- digitalSignature
- nonRepudiation

- keyEncipherment
- dataEncipherment
- keyAgreement
- keyCertSign
- cRLSign
- encipherOnly
- decipherOnly

According to [PKIX-1], bits in the KeyUsage type are used as follows:

The digitalSignature bit is asserted when the subject public key is used to verify digital signatures that have purposes other than non-repudiation, certificate signature, and CRL signature. For example, the digitalSignature bit is asserted when the subject public key is used to provide authentication via the signing of ephemeral data.

The nonRepudiation bit is asserted when the subject public key is used to verify digital signatures used to provide a non-repudiation service which protects against the signing entity falsely denying some action, excluding certificate or CRL signing.

The keyEncipherment bit is asserted when the subject public key is used for key transport. For example, when an RSA key is to be used for key management, this bit must asserted.

The dataEncipherment bit is asserted when the subject public key is used for enciphering user data, other than cryptographic keys.

The keyAgreement bit is asserted when the subject public key is used for key agreement. For example, when a Diffie-Hellman key is to be used for key management, this bit must asserted.

The keyCertSign bit is asserted when the subject public key is used for verifying a signature on certificates. This bit may only be asserted in CA certificates.

The cRLSign bit is asserted when the subject public key is used for verifying a signature on revocation information (e.g., a CRL).

The meaning of the encipherOnly bit is undefined in the absence of the keyAgreement bit. When the encipherOnly bit is asserted and the keyAgreement bit is also set, the subject public key may be used only for enciphering data while performing key agreement.

The meaning of the decipherOnly bit is undefined in the absence of the keyAgreement bit. When the decipherOnly bit is asserted and the keyAgreement bit is also set, the subject public key may be used only for deciphering data while performing key agreement.

PKIX does not restrict the combinations of bits that may be set in an instantiation of the keyUsage extension.

The discussion on the PKIX mailing list has centered on the digitalSignature bit and the nonRepudiation bit. The question has come down to something like: When support for the service of non-repudiation is desired, should both the digitalSignature and nonRepudiation bits be set, or just the nonRepudiation bit?

(It is noted that provision of the service of non-repudiation requires more than a single bit set in a certificate. It requires an entire infrastructure of components to preserve for some period of time the keys, certificates, revocation status, signed material, etc., as well as a trusted source of time. However, the nonRepudiation key usage bit is provided as an indicator that such keys should not be used as a component of a system providing a non-repudiation service.)

According to [SIMONETTI], the intent is that the digitalSignature bit should be set when what is desired is the ability to sign ephemeral transactions; e.g., for a single session authentication. These transactions are "ephemeral" in the sense that they are important only while they are in existence; after the session is terminated, there is no long-term record of the digital signature and its properties kept. When something is intended to be kept for some period of time, the nonRepudiation bit should be set. This generally implies that an application will digitally sign something; thus, some implementors turn on the digitalSignature bit as well. Other implementors, however, keep

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the two bits mutually exclusive, to prevent a single key from being used for both ephemeral and long-term signing.

While [PKIX-1] is silent on this specific issue, the working group's general conclusion is that a certificate may have either or both bits set. If only the nonRepudiation bit is set, the key should not be used for ephemeral transactions. If only the digitalSignature bit is set, the key should not be used for long-term signing. If both bits are set, the key may be used for either purpose.

To actually enforce this requires that an application understands

whether it is signing ephemeral transactions or for the long-term. The application developers will have to understand the difference, and set up their checks on the key usage bits field accordingly. For example, TLS implementors should check only the digitalSignature bit, and ignore the nonRepudiation bit. S/MIME implementors, though, will have a difficult choice to make, since their application could be used for either purpose, and they will generally accept signing using keys associated with certificates having either or both bits being turned on. Certification Authorities should know what applications they are providing certificates for, and provide certificates according to the requirements of those applications. If CA's are tied into non-repudiation systems, they may treat certificates differently when the nonRepudiation bit is turned on (e.g., store information associated with the certificate - like the user's identification provided during certificate registration, or certificate generation date/time stamps - for longer periods of time, in more secure environments).

The bottom line is that this is an area where PKI implementors are somewhat limited in what they can do. The onus is on developers of certificate-using systems to understand their requirements, and request certificates with the appropriate bits set.

5.4 Trust Models

(This section will describe the various trust models that PKIX can support. It is important to note that PKIX is bound to neither a pure hierarchical model a la PEM, nor a web of trust model a la PGP. PKIX can support either of those models, or any flavor in between. The implications of different trust models should be described:

- efficiency of revocation
- certification path building
- etc.)

6 Acknowledgements

A lot of the information in this document was taken from the PKIX source documents; the authors of those deserve the credit for their own words. Other good material was taken from mail posted to the PKIX working group mail list (ietf-pkix@imc.org). Among those with good things to say were (in alphabetical order, with apologies to anybody I've missed): Sharon Boeyen, Santosh Chokhani, Warwick Ford, Russ Housley, Steve Kent, Ambarish Malpani, Michael Myers, Tim Polk, Stefan Santesson, Dave Simonetti,

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8 Security Considerations

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