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Public Key Cryptography for Initial Authentication in Kerberos

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[1.](#) Abstract

This document defines extensions (PKINIT) to the Kerberos protocol

specification ([RFC 1510](#) [1]) to provide a method for using public key cryptography during initial authentication. The methods defined specify the ways in which preauthentication data fields and error data fields in Kerberos messages are to be used to transport public key data.

2. Introduction

The popularity of public key cryptography has produced a desire for its support in Kerberos [2]. The advantages provided by public key cryptography include simplified key management (from the Kerberos perspective) and the ability to leverage existing and developing public key certification infrastructures.

Public key cryptography can be integrated into Kerberos in a number of ways. One is to associate a key pair with each realm, which can then be used to facilitate cross-realm authentication; this is the topic of another draft proposal. Another way is to allow users with public key certificates to use them in initial authentication. This is the concern of the current document.

PKINIT utilizes Diffie-Hellman keys in combination with digital signature keys as the primary, required mechanism. It also allows for the use of RSA keys. Note that PKINIT supports the use of separate signature and encryption keys.

PKINIT enables access to Kerberos-secured services based on initial authentication utilizing public key cryptography. PKINIT utilizes standard public key signature and encryption data formats within the standard Kerberos messages. The basic mechanism is as follows: The user sends a request to the KDC as before, except that if that user is to use public key cryptography in the initial authentication step, his certificate and a signature accompany the initial request in the preauthentication fields. Upon receipt of this request, the KDC verifies the certificate and issues a ticket granting ticket (TGT) as before, except that the encPart from the AS-REP message carrying the TGT is now encrypted utilizing either a Diffie-Hellman derived key or the user's public key. This message is authenticated utilizing the public key signature of the KDC.

The PKINIT specification may also be used as a building block for other specifications. PKCROSS [3] utilizes PKINIT for establishing the inter-realm key and associated inter-realm policy to be applied in issuing cross realm service tickets. As specified in [4], anonymous Kerberos tickets can be issued by applying a NULL signature in combination with Diffie-Hellman in the PKINIT exchange. Additionally, the PKINIT specification may be used for direct peer to peer authentication without contacting a central KDC. This application of PKINIT is described in PKTAPP [5] and is based on concepts introduced in [6, 7]. For direct client-to-server authentication, the client uses PKINIT to authenticate to the end

server (instead of a central KDC), which then issues a ticket for itself. This approach has an advantage over TLS [8] in that the server does not need to save state (cache session keys). Furthermore, an additional benefit is that Kerberos tickets can facilitate delegation (see [9]).

3. Proposed Extensions

This section describes extensions to [RFC 1510](#) for supporting the use of public key cryptography in the initial request for a ticket granting ticket (TGT).

In summary, the following change to [RFC 1510](#) is proposed:

- * Users may authenticate using either a public key pair or a conventional (symmetric) key. If public key cryptography is used, public key data is transported in preauthentication data fields to help establish identity. The user presents a public key certificate and obtains an ordinary TGT that may be used for subsequent authentication, with such authentication using only conventional cryptography.

[Section 3.1](#) provides definitions to help specify message formats. [Section 3.2](#) describes the extensions for the initial authentication method.

3.1. Definitions

The extensions involve new preauthentication fields; we introduce the following preauthentication types:

PA-PK-AS-REQ	14
PA-PK-AS-REP	15

The extensions also involve new error types; we introduce the following types:

KDC_ERR_CLIENT_NOT_TRUSTED	62
KDC_ERR_KDC_NOT_TRUSTED	63
KDC_ERR_INVALID_SIG	64
KDC_ERR_KEY_TOO_WEAK	65
KDC_ERR_CERTIFICATE_MISMATCH	66
KDC_ERR_CANT_VERIFY_CERTIFICATE	70
KDC_ERR_INVALID_CERTIFICATE	71
KDC_ERR_REVOKED_CERTIFICATE	72
KDC_ERR_REVOCATION_STATUS_UNKNOWN	73
KDC_ERR_REVOCATION_STATUS_UNAVAILABLE	74
KDC_ERR_CLIENT_NAME_MISMATCH	75
KDC_ERR_KDC_NAME_MISMATCH	76

We utilize the following typed data for errors:

TD-PKINIT-CMS-CERTIFICATES	101
TD-KRB-PRINCIPAL	102
TD-KRB-REALM	103
TD-TRUSTED-CERTIFIERS	104
TD-CERTIFICATE-INDEX	105

We utilize the following encryption types (which map directly to OIDs):

dsaWithSHA1-CmsOID	9
md5WithRSAEncryption-CmsOID	10
sha1WithRSAEncryption-CmsOID	11
rc2CBC-EnvOID	12
rsaEncryption-EnvOID (PKCS#1 v1.5)	13
rsaES-OAEP-ENV-OID (PKCS#1 v2.0)	14
des-ede3-cbc-Env-OID	15

These mappings are provided so that a client may send the appropriate encyptes in the AS-REQ message in order to indicate support for the corresponding OIDs (for performing PKINIT).

In many cases, PKINIT requires the encoding of an X.500 name as a Realm. In these cases, the realm will be represented using a different style, specified in [RFC 1510](#) with the following example:

```
NAMETYPE:rest/of.name=without-restrictions
```

For a realm derived from an X.500 name, NAMETYPE will have the value X500-RFC2253. The full realm name will appear as follows:

```
X500-RFC2253:RFC2253Encode(DistinguishedName)
```

where DistinguishedName is an X.500 name, and RFC2253Encode is a readable UTF encoding of an X.500 name, as defined by [RFC 2253](#) [14] (part of LDAPv3).

To ensure that this encoding is unique, we add the following rule to those specified by [RFC 2253](#):

The order in which the attributes appear in the [RFC 2253](#) encoding must be the reverse of the order in the ASN.1 encoding of the X.500 name that appears in the public key certificate. The order of the relative distinguished names (RDNs), as well as the order of the AttributeTypeAndValues within each RDN, will be reversed. (This is despite the fact that an RDN is defined as a SET of AttributeTypeAndValues, where an order is normally not important.)

Similarly, PKINIT may require the encoding of an X.500 name as a PrincipalName. In these cases, the name-type of the principal name

shall be set to KRB_NT-X500-PRINCIPAL. This new name type is defined as:

```
KRB_NT_X500_PRINCIPAL    6
```

The name-string shall be set as follows:

```
RFC2253Encode(DistinguishedName)
```

as described above.

[RFC 1510](#) specifies the ASN.1 structure for PrincipalName as follows:

```
PrincipalName ::= SEQUENCE {  
                    name-type[0]    INTEGER,  
                    name-string[1]  SEQUENCE OF GeneralString  
                }
```

For the purposes of encoding an X.500 name within this structure, the name-string shall be encoded as a single GeneralString.

Note that name mapping may be required or optional based on policy.

[3.1.1.](#) Encryption and Key Formats

In the exposition below, we use the terms public key and private key generically. It should be understood that the term "public key" may be used to refer to either a public encryption key or a signature verification key, and that the term "private key" may be used to refer to either a private decryption key or a signature generation key. The fact that these are logically distinct does not preclude the assignment of bitwise identical keys.

In the case of Diffie-Hellman, the key shall be produced from the agreed bit string as follows:

- * Truncate the bit string to the appropriate length.
- * Rectify parity in each byte (if necessary) to obtain the key.

For instance, in the case of a DES key, we take the first eight bytes of the bit stream, and then adjust the least significant bit of each byte to ensure that each byte has odd parity.

[3.1.2.](#) Algorithm Identifiers

PKINIT does not define, but does permit, the algorithm identifiers listed below.

[3.1.2.1.](#) Signature Algorithm Identifiers

The following signature algorithm identifiers specified in [11] and in [15] shall be used with PKINIT:

```
id-dsa-with-sha1      (DSA with SHA1)
md5WithRSAEncryption (RSA with MD5)
sha-1WithRSAEncryption (RSA with SHA1)
```

[3.1.2.2](#) Diffie-Hellman Key Agreement Algorithm Identifier

The following algorithm identifier shall be used within the SubjectPublicKeyInfo data structure: dhpublicnumber

This identifier and the associated algorithm parameters are specified in [RFC 2459](#) [15].

[3.1.2.3](#). Algorithm Identifiers for RSA Encryption

These algorithm identifiers are used inside the EnvelopedData data structure, for encrypting the temporary key with a public key:

```
rsaEncryption (RSA encryption, PKCS#1 v1.5)
id-RSAES-OAEP (RSA encryption, PKCS#1 v2.0)
```

Both of the above RSA encryption schemes are specified in [16]. Currently, only PKCS#1 v1.5 is specified by CMS [11], although the CMS specification says that it will likely include PKCS#1 v2.0 in the future. (PKCS#1 v2.0 addresses adaptive chosen ciphertext vulnerability discovered in PKCS#1 v1.5.)

[3.1.2.4](#). Algorithm Identifiers for Encryption with Secret Keys

These algorithm identifiers are used inside the EnvelopedData data structure in the PKINIT Reply, for encrypting the reply key with the temporary key:

```
des-ede3-cbc (3-key 3-DES, CBC mode)
rc2-cbc      (RC2, CBC mode)
```

The full definition of the above algorithm identifiers and their corresponding parameters (an IV for block chaining) is provided in the CMS specification [11].

[3.2](#). Public Key Authentication

Implementation of the changes in this section is REQUIRED for compliance with PKINIT.

It is assumed that all public keys are signed by some certification authority (CA). The initial authentication request is sent as per [RFC 1510](#), except that a preauthentication field containing data signed by the user's private key accompanies the request:

```

PA-PK-AS-REQ ::= SEQUENCE {
    signedAuthPack      -- PA TYPE 14
                        [0] SignedData
                            -- defined in CMS [11]
                            -- AuthPack (below) defines the data
                            -- that is signed
    trustedCertifiers    [1] SEQUENCE OF TrustedCas OPTIONAL,
                            -- CAs that the client trusts
    kdcCert              [2] IssuerAndSerialNumber OPTIONAL
                            -- as defined in CMS [11]
                            -- specifies a particular KDC
                            -- certificate if the client
                            -- already has it;
                            -- must be accompanied by
                            -- a single trustedCertifier
    encryptionCert      [3] IssuerAndSerialNumber OPTIONAL
                            -- For example, this may be the
                            -- client's Diffie-Hellman
                            -- certificate, or it may be the
                            -- client's RSA encryption
                            -- certificate.
}

```

```

TrustedCas ::= CHOICE {
    principalName        [0] KerberosName,
                            -- as defined below
    caName               [1] Name
                            -- fully qualified X.500 name
                            -- as defined by X.509
    issuerAndSerial      [2] IssuerAndSerialNumber OPTIONAL
                            -- Since a CA may have a number of
                            -- certificates, only one of which
                            -- a client trusts
}

```

Usage of SignedData:

The SignedData data type is specified in the Cryptographic Message Syntax, a product of the S/MIME working group of the IETF.

- The encapContentInfo field must contain the PKAuthenticator and, optionally, the client's Diffie Hellman public value.
- The eContentType field shall contain the OID value for id-data: iso(1) member-body(2) us(840) rsadsi(113549) pkcs(1) pkcs7(7) data(1)
- The eContent field is data of the type AuthPack (below).
- The signerInfos field contains the signature of AuthPack.
- The Certificates field, when non-empty, contains the client's certificate chain. If present, the KDC uses the public key from the client's certificate to verify the signature in the request. Note that the client may pass different certificates that are used for signing or for encrypting. Thus, the KDC may utilize a different client certificate for signature verification than the

one it uses to encrypt the reply to the client. For example, the client may place a Diffie-Hellman certificate in this field in order to convey its static Diffie Hellman certificate to the KDC enable static-ephemeral Diffie-Hellman mode for the reply. As another example, the client may place an RSA encryption certificate in this field.

```
AuthPack ::= SEQUENCE {  
    pkAuthenticator          [0] PKAuthenticator,  
    clientPublicValue        [1] SubjectPublicKeyInfo OPTIONAL  
                                -- if client is using Diffie-Hellman  
}
```

```
PKAuthenticator ::= SEQUENCE {  
    kdcName                  [0] PrincipalName,  
    kdcRealm                  [1] Realm,  
    cusec                     [2] INTEGER,  
                                -- for replay prevention  
    ctime                     [3] KerberosTime,  
                                -- for replay prevention  
    nonce                     [4] INTEGER  
}
```

```
SubjectPublicKeyInfo ::= SEQUENCE {  
    algorithm                  AlgorithmIdentifier,  
                                -- dhKeyAgreement  
    subjectPublicKey            BIT STRING  
                                -- for DH, equals  
                                -- public exponent (INTEGER encoded  
                                -- as payload of BIT STRING)  
} -- as specified by the X.509 recommendation [10]
```

```
AlgorithmIdentifier ::= SEQUENCE {  
    algorithm                  ALGORITHM.&id,  
    parameters                  ALGORITHM.&type  
} -- as specified by the X.509 recommendation [10]
```

If the client passes an issuer and serial number in the request, the KDC is requested to use the referred-to certificate. If none exists, then the KDC returns an error of type KDC_ERR_CERTIFICATE_MISMATCH. It also returns this error if, on the other hand, the client does not pass any trustedCertifiers, believing that it has the KDC's certificate, but the KDC has more than one certificate. The KDC should include information in the KRB-ERROR message that indicates the KDC certificate(s) that a client may utilize. This data is specified in the e-data, which is defined in [RFC 1510](#) revisions as a SEQUENCE of TypedData:

```
TypedData ::= SEQUENCE {  
    data-type                  [0] INTEGER,  
    data-value                  [1] OCTET STRING,
```



```
} -- per Kerberos RFC 1510 revisions
```

where:

```
data-type = TD-PKINIT-CMS-CERTIFICATES = 101
```

```
data-value = CertificateSet // as specified by CMS [11]
```

The PKAuthenticator carries information to foil replay attacks, to bind the request and response. The PKAuthenticator is signed with the private key corresponding to the public key in the certificate found in userCert (or cached by the KDC).

The trustedCertifiers field contains a list of certification authorities trusted by the client, in the case that the client does not possess the KDC's public key certificate. If the KDC has no certificate signed by any of the trustedCertifiers, then it returns an error of type KDC_ERR_KDC_NOT_TRUSTED.

KDCs should try to (in order of preference):

1. Use the KDC certificate identified by the serialNumber included in the client's request.
2. Use a certificate issued to the KDC by the client's CA (if in the middle of a CA key roll-over, use the KDC cert issued under same CA key as user cert used to verify request).
3. Use a certificate issued to the KDC by one of the client's trustedCertifier(s);

If the KDC is unable to comply with any of these options, then the KDC returns an error message of type KDC_ERR_KDC_NOT_TRUSTED to the client.

Upon receipt of the AS_REQ with PA-PK-AS-REQ pre-authentication type, the KDC attempts to verify the user's certificate chain (userCert), if one is provided in the request. This is done by verifying the certification path against the KDC's policy of legitimate certifiers. This may be based on a certification hierarchy, or it may be simply a list of recognized certifiers in a system like PGP.

If the client's certificate chain contains no certificate signed by a CA trusted by the KDC, then the KDC sends back an error message of type KDC_ERR_CANT_VERIFY_CERTIFICATE. The accompanying e-data is a SEQUENCE of one TypedData (with type TD-TRUSTED-CERTIFIERS=104) whose data-value is an OCTET STRING which is the DER encoding of

```
TrustedCertifiers ::= SEQUENCE OF PrincipalName
-- X.500 name encoded as a principal name
-- see Section 3.1
```

If the signature on one of the certificates in the client's chain fails verification, then the KDC returns an error of type KDC_ERR_INVALID_CERTIFICATE. The accompanying e-data is a SEQUENCE of one TypedData (with type TD-CERTIFICATE-INDEX=105) whose

data-value is an OCTET STRING which is the DER encoding of

```
CertificateIndex ::= INTEGER
                    -- 0 = 1st certificate,
                    --      (in order of encoding)
                    -- 1 = 2nd certificate, etc
```

The KDC may also check whether any of the certificates in the client's chain has been revoked. If one of the certificates has been revoked, then the KDC returns an error of type KDC_ERR_REVOKED_CERTIFICATE; if such a query reveals that the certificate's revocation status is unknown, the KDC returns an error of type KDC_ERR_REVOCATION_STATUS_UNKNOWN; if the revocation status is unavailable, the KDC returns an error of type KDC_ERR_REVOCATION_STATUS_UNAVAILABLE. In any of these three cases, the affected certificate is identified by the accompanying e-data, which contains a CertificateIndex as described for KDC_ERR_INVALID_CERTIFICATE.

If the certificate chain can be verified, but the name of the client in the certificate does not match the client's name in the request, then the KDC returns an error of type KDC_ERR_CLIENT_NAME_MISMATCH. There is no accompanying e-data field in this case.

Finally, if the certificate chain is verified, but the KDC's name or realm as given in the PKAuthenticator does not match the KDC's actual principal name, then the KDC returns an error of type KDC_ERR_KDC_NAME_MISMATCH. The accompanying e-data field is again a SEQUENCE of one TypedData (with type TD-KRB-PRINCIPAL=102 or TD-KRB-REALM=103 as appropriate) whose data-value is an OCTET STRING whose data-value is the DER encoding of a PrincipalName or Realm as defined in [RFC 1510](#) revisions.

Even if all succeeds, the KDC may--for policy reasons--decide not to trust the client. In this case, the KDC returns an error message of type KDC_ERR_CLIENT_NOT_TRUSTED.

If a trust relationship exists, the KDC then verifies the client's signature on AuthPack. If that fails, the KDC returns an error message of type KDC_ERR_INVALID_SIG. Otherwise, the KDC uses the timestamp (ctime and cusec) in the PKAuthenticator to assure that the request is not a replay. The KDC also verifies that its name is specified in the PKAuthenticator.

If the clientPublicValue field is filled in, indicating that the client wishes to use Diffie-Hellman key agreement, then the KDC checks to see that the parameters satisfy its policy. If they do not (e.g., the prime size is insufficient for the expected encryption type), then the KDC sends back an error message of type KDC_ERR_KEY_TOO_WEAK. Otherwise, it generates its own public and

private values for the response.

The KDC also checks that the timestamp in the PKAuthenticator is within the allowable window and that the principal name and realm are correct. If the local (server) time and the client time in the authenticator differ by more than the allowable clock skew, then the KDC returns an error message of type KRB_AP_ERR_SKEW.

Assuming no errors, the KDC replies as per [RFC 1510](#), except as follows. The user's name in the ticket is determined by the following decision algorithm:

1. If the KDC has a mapping from the name in the certificate to a Kerberos name, then use that name.
Else
2. If the certificate contains a Kerberos name in an extension field, and local KDC policy allows, then use that name.
Else
3. Use the name as represented in the certificate, mapping as necessary (e.g., as per [RFC 2253](#) for X.500 names). In this case the realm in the ticket shall be the name of the certification authority that issued the user's certificate.

The KDC encrypts the reply not with the user's long-term key, but with a random key generated only for this particular response. This random key is sealed in the preauthentication field:

```
PA-PK-AS-REP ::= CHOICE {  
    -- PA TYPE 15  
    dhSignedData      [0] SignedData,  
    -- Defined in CMS and used only with  
    -- Diffie-Hellman key exchange  
    -- This choice MUST be supported  
    -- by compliant implementations.  
    encKeyPack        [1] EnvelopedData,  
    -- Defined in CMS  
    -- The temporary key is encrypted  
    -- using the client public key  
    -- key  
    -- SignedReplyKeyPack, encrypted  
    -- with the temporary key, is also  
    -- included.  
}
```

Usage of SignedData:

If the Diffie-Hellman option is used, dhSignedData in PA-PK-AS-REP provides authenticated Diffie-Hellman parameters of the KDC. The reply key used to encrypt part of the KDC reply message is derived from the Diffie-Hellman exchange:

- Both the KDC and the client calculate a secret value ($g^{ab} \bmod p$), where a is the client's private exponent and b is the KDC's

- private exponent.
- Both the KDC and the client take the first N bits of this secret value and convert it into a reply key. N depends on the reply key type.
 - If the reply key is DES, N=64 bits, where some of the bits are replaced with parity bits, according to FIPS PUB 74.
 - If the reply key is (3-key) 3-DES, N=192 bits, where some of the bits are replaced with parity bits, according to FIPS PUB 74.
 - The encapContentInfo field must contain the KdcDHKeyInfo as defined below.
 - The eContentType field shall contain the OID value for
id-data: iso(1) member-body(2) us(840) rsadsi(113549)
pkcs(1) pkcs7(7) data(1)
 - The certificates field must contain the certificates necessary for the client to establish trust in the KDC's certificate based on the list of trusted certifiers sent by the client in the PA-PK-AS-REQ. This field may be empty if the client did not send to the KDC a list of trusted certifiers (the trustedCertifiers field was empty, meaning that the client already possesses the KDC's certificate).
 - The signerInfos field is a SET that must contain at least one member, since it contains the actual signature.

Usage of EnvelopedData:

The EnvelopedData data type is specified in the Cryptographic Message Syntax, a product of the S/MIME working group of the IETF. It contains an temporary key encrypted with the PKINIT client's public key. It also contains a signed and encrypted reply key.

- The originatorInfo field is not required, since that information may be presented in the signedData structure that is encrypted within the encryptedContentInfo field.
- The optional unprotectedAttrs field is not required for PKINIT.
- The recipientInfos field is a SET which must contain exactly one member of the KeyTransRecipientInfo type for encryption with an RSA public key.
 - The encryptedKey field (in KeyTransRecipientInfo) contains the temporary key which is encrypted with the PKINIT client's public key.
- The encryptedContentInfo field contains the signed and encrypted reply key.
 - The contentType field shall contain the OID value for
id-signedData: iso(1) member-body(2) us(840) rsadsi(113549)
pkcs(1) pkcs7(7) signedData(2)
 - The encryptedContent field is encrypted data of the CMS type signedData as specified below.
 - The encapContentInfo field must contains the ReplyKeyPack.
 - The eContentType field shall contain the OID value for
id-data: iso(1) member-body(2) us(840) rsadsi(113549)
pkcs(1) pkcs7(7) data(1)
 - The eContent field is data of the type ReplyKeyPack (below).

- The certificates field must contain the certificates necessary for the client to establish trust in the KDC's certificate based on the list of trusted certifiers sent by the client in the PA-PK-AS-REQ. This field may be empty if the client did not send to the KDC a list of trusted certifiers (the trustedCertifiers field was empty, meaning that the client already possesses the KDC's certificate).
- The signerInfos field is a SET that must contain at least one member, since it contains the actual signature.

```

KdcDHKeyInfo ::= SEQUENCE {
    -- used only when utilizing Diffie-Hellman
    nonce          [0] INTEGER,
    -- binds response to the request
    subjectPublicKey [2] BIT STRING
    -- Equals public exponent ( $g^a \bmod p$ )
    -- INTEGER encoded as payload of
    -- BIT STRING
}

ReplyKeyPack ::= SEQUENCE {
    -- not used for Diffie-Hellman
    replyKey       [0] EncryptionKey,
    -- used to encrypt main reply
    -- ENCTYPE is at least as strong as
    -- ENCTYPE of session key
    nonce          [1] INTEGER,
    -- binds response to the request
    -- must be same as the nonce
    -- passed in the PKAuthenticator
}

```

Since each certifier in the certification path of a user's certificate is essentially a separate realm, the name of each certifier must be added to the transited field of the ticket. The format of these realm names is defined in [Section 3.1](#) of this document. If applicable, the transit-policy-checked flag should be set in the issued ticket.

The KDC's certificate must bind the public key to a name derivable from the name of the realm for that KDC. X.509 certificates shall contain the principal name of the KDC as the SubjectAltName version 3 extension. Below is the definition of this version 3 extension, as specified by the X.509 standard:

```

subjectAltName EXTENSION ::= {
    SYNTAX GeneralNames
    IDENTIFIED BY id-ce-subjectAltName
}

```

```
GeneralNames ::= SEQUENCE SIZE(1..MAX) OF GeneralName
```

```
GeneralName ::= CHOICE {  
    otherName      [0] INSTANCE OF OTHER-NAME,  
    ...  
}
```

```
OTHER-NAME ::= TYPE-IDENTIFIER
```

In this definition, otherName is a name of any form defined as an instance of the OTHER-NAME information object class. For the purpose of specifying a Kerberos principal name, INSTANCE OF OTHER-NAME will be chosen and replaced by the type KerberosName:

```
KerberosName ::= SEQUENCE {  
    realm          [0] Realm,  
                  -- as define in RFC 1510  
    principalName  [1] PrincipalName,  
                  -- as define in RFC 1510  
}
```

This specific syntax is identified within subjectAltName by setting the OID id-ce-subjectAltName to krb5PrincipalName, where (from the Kerberos specification) we have

```
krb5 OBJECT IDENTIFIER ::= { iso (1)  
                               org (3)  
                               dod (6)  
                               internet (1)  
                               security (5)  
                               kerberosv5 (2) }
```

```
krb5PrincipalName OBJECT IDENTIFIER ::= { krb5 2 }
```

This specification may also be used to specify a Kerberos name within the user's certificate.

If a non-KDC X.509 certificate contains the principal name within the subjectAltName version 3 extension, that name may utilize KerberosName as defined below, or, in the case of an S/MIME certificate [\[17\]](#), may utilize the email address. If the KDC is presented with as S/MIME certificate, then the email address within subjectAltName will be interpreted as a principal and realm separated by the "@" sign, or as a name that needs to be canonicalized. If the resulting name does not correspond to a registered principal name, then the principal name is formed as defined in [section 3.1](#).

The client then extracts the random key used to encrypt the main reply. This random key (in encPaReply) is encrypted with either the client's public key or with a key derived from the DH values

exchanged between the client and the KDC.

3.2.2. Required Algorithms

Not all of the algorithms in the PKINIT protocol specification have to be implemented in order to comply with the proposed standard. Below is a list of the required algorithms:

- Diffie-Hellman public/private key pairs
 - utilizing Diffie-Hellman ephemeral-ephemeral mode
- SHA1 digest and DSA for signatures
- 3-key triple DES keys derived from the Diffie-Hellman Exchange
- 3-key triple DES Temporary and Reply keys

4. Logistics and Policy

This section describes a way to define the policy on the use of PKINIT for each principal and request.

The KDC is not required to contain a database record for users who use public key authentication. However, if these users are registered with the KDC, it is recommended that the database record for these users be modified to an additional flag in the attributes field to indicate that the user should authenticate using PKINIT. If this flag is set and a request message does not contain the PKINIT preauthentication field, then the KDC sends back an error of type KDC_ERR_PREAUTH_REQUIRED indicating that a preauthentication field of type PA-PK-AS-REQ must be included in the request.

5. Security Considerations

PKINIT raises a few security considerations, which we will address in this section.

First of all, PKINIT introduces a new trust model, where KDCs do not (necessarily) certify the identity of those for whom they issue tickets. PKINIT does allow KDCs to act as their own CAs, in order to simplify key management, but one of the additional benefits is to align Kerberos authentication with a global public key infrastructure. Anyone using PKINIT in this way must be aware of how the certification infrastructure they are linking to works.

Secondly, PKINIT also introduces the possibility of interactions between different cryptosystems, which may be of widely varying strengths. Many systems, for instance, allow the use of 512-bit public keys. Using such keys to wrap data encrypted under strong conventional cryptosystems, such as triple-DES, is inappropriate; it adds a weak link to a strong one at extra cost. Implementors and administrators should take care to avoid such wasteful and deceptive interactions.

Lastly, PKINIT calls for randomly generated keys for conventional cryptosystems. Many such systems contain systematically "weak" keys. PKINIT implementations MUST avoid use of these keys, either by discarding those keys when they are generated, or by fixing them in some way (e.g., by XORing them with a given mask). These precautions vary from system to system; it is not our intention to give an explicit recipe for them here.

6. Transport Issues

Certificate chains can potentially grow quite large and span several UDP packets; this in turn increases the probability that a Kerberos message involving PKINIT extensions will be broken in transit. In light of the possibility that the Kerberos specification will require KDCs to accept requests using TCP as a transport mechanism, we make the same recommendation with respect to the PKINIT extensions as well.

7. Bibliography

[1] J. Kohl, C. Neuman. The Kerberos Network Authentication Service (V5). Request for Comments 1510.

[2] B.C. Neuman, Theodore Ts'o. Kerberos: An Authentication Service for Computer Networks, IEEE Communications, 32(9):33-38. September 1994.

[3] B. Tung, T. Ryutov, C. Neuman, G. Tsudik, B. Sommerfeld, A. Medvinsky, M. Hur. Public Key Cryptography for Cross-Realm Authentication in Kerberos.

[draft-ietf-cat-kerberos-pk-cross-04.txt](#)

[4] A. Medvinsky, J. Cargille, M. Hur. Anonymous Credentials in Kerberos.

[draft-ietf-cat-kerberos-anoncred-00.txt](#)

[5] A. Medvinsky, M. Hur, B. Clifford Neuman. Public Key Utilizing Tickets for Application Servers (PKTAPP).

[draft-ietf-cat-pktapp-00.txt](#)

[6] M. Sirbu, J. Chuang. Distributed Authentication in Kerberos Using Public Key Cryptography. Symposium On Network and Distributed System Security, 1997.

[7] B. Cox, J.D. Tygar, M. Sirbu. NetBill Security and Transaction Protocol. In Proceedings of the USENIX Workshop on Electronic Commerce, July 1995.

[8] T. Dierks, C. Allen. The TLS Protocol, Version 1.0 Request for Comments 2246, January 1999.

[9] B.C. Neuman, Proxy-Based Authorization and Accounting for Distributed Systems. In Proceedings of the 13th International Conference on Distributed Computing Systems, May 1993.

[10] ITU-T (formerly CCITT) Information technology - Open Systems Interconnection - The Directory: Authentication Framework Recommendation X.509 ISO/IEC 9594-8

[11] R. Housley. Cryptographic Message Syntax.
[draft-ietf-smime-cms-13.txt](#), April 1999.

[12] PKCS #7: Cryptographic Message Syntax Standard,
An RSA Laboratories Technical Note Version 1.5
Revised November 1, 1993

[13] R. Rivest, MIT Laboratory for Computer Science and RSA Data Security, Inc. A Description of the RC2(r) Encryption Algorithm March 1998.
Request for Comments 2268.

[14] M. Wahl, S. Kille, T. Howes. Lightweight Directory Access Protocol (v3): UTF-8 String Representation of Distinguished Names.
Request for Comments 2253.

[15] R. Housley, W. Ford, W. Polk, D. Solo. Internet X.509 Public Key Infrastructure, Certificate and CRL Profile, January 1999.
Request for Comments 2459.

[16] B. Kaliski, J. Staddon. PKCS #1: RSA Cryptography Specifications, October 1998.
Request for Comments 2437.

[17] S. Dusse, P. Hoffman, B. Ramsdell, J. Weinstein.
S/MIME Version 2 Certificate Handling, March 1998.
Request for Comments 2312

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9. Expiration Date

This draft expires December 1, 1999.

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