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AEAD Modes for Kerberos GSS-API
draft-howard-gssapi-aead-00

Abstract

This document updates RFC4121 with support for encryption mechanisms that can authenticate associated data such as Counter with CBC-MAC (CCM) and Galois/Counter Mode (GCM). These mechanisms are often more performant and need not expand the message as much as conventional modes.

Status of This Memo

This Internet-Draft is submitted in full conformance with the provisions of BCP 78 and BCP 79.

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This Internet-Draft will expire on June 15, 2016.

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1. Introduction

This document updates [RFC4121] with support for encryption mechanisms that support Authenticated Encryption with Associated Data (AEAD). These mechanisms often have performance advantage over conventional encryption modes as they can be efficiently parallelized and do not expand the plaintext when encrypting.

In addition, this document defines new GSS-API functions for protecting associated data in addition to a plaintext.

2. Requirements notation

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [RFC2119].

3. Authenticated Encryption with Associated Data (AEAD) Overview

The Kerberos 5 GSS-API mechanism specified in [RFC4121] provides for the authenticated encryption of plaintext, that is, it provides both for confidentiality and a way to check the for integrity and authenticity.

It can be useful in many applications to provide for the integrity and authenticity of some additional unencrypted data; this is termed Authenticated Encryption with Associated Data (AEAD). This can be done by the generic composition of existing encryption and checksum mechanisms, or using algorithms which specifically provide for AEAD (see [RFC5116]). The latter class of algorithms, referred to as native AEAD, may have additional constraints (further described in [KRB-AEAD]).

4. Updates to RFC 2743

[RFC2743] is updated with variations of GSS_Wrap() and GSS_Unwrap() that permit the inclusion of associated data to be authenticated along with a plaintext.

[[CREF1: TBD: do we allow interleaved plaintext and associated data (which SSPI does and indeed requires for DCE), or do we limit it to a single octet string each? If the former, we need to define GSS_Wrap_IOV instead of GSS_Wrap_AEAD (and the Unwrap equivalents).]]

4.1. GSS_Wrap_AEAD

Inputs:

- context_handle CONTEXT HANDLE,
- conf_req_flag BOOLEAN,
- qop_req INTEGER, -- 0 specifies default QOP
- input_assoc_data OCTET STRING, -- associated data
- input_message OCTET STRING -- plaintext

Outputs:

- major_status INTEGER,
- minor_status INTEGER,
- conf_state BOOLEAN,
- output_message OCTET STRING -- caller must release with GSS_Release_buffer()

Performs the data origin authentication, data integrity and (optionally) data confidentiality functions of GSS_Wrap(), additionally integrity protecting the data in input_assoc_data.

Return values are as for GSS_Wrap(). Note that output_message does not include the data in input_assoc_data.

4.2. GSS_Unwrap_AEAD

Inputs:

- context_handle CONTEXT HANDLE,
- input_message OCTET STRING, -- plaintext
- input_assoc_data OCTET STRING -- associated data

Outputs:

- conf_state BOOLEAN,
- qop_state INTEGER,
- major_status INTEGER,
- minor_status INTEGER,
- output_message OCTET STRING -- caller must release with GSS_Release_buffer()

Processes a data element generated (and optionally encrypted) by GSS_Wrap(), provided as input_message, additionally validating the data origin and integrity of input_assoc_data. Return values are as for GSS_Unwrap(). Note that output_message does not include the data in input_assoc_data.

5. Updates to RFC 4121

5.1. Support for Associated Data

The generation of per-message tokens using the GSS_Wrap_AEAD() and GSS_Unwrap_AEAD() functions is identical to GSS_Wrap() and GSS_Unwrap(), except that:

- the encrypt-with-ad and decrypt-with-ad functions are used instead of the encrypt and decrypt functions (respectively)
- the input_assoc_data parameter is passed as the associated data
- the is-longterm parameter is always false

5.2. Existing Encryption Types

For existing encryption mechanisms that use a generic composition of encryption and checksum functions (such as the Simplified Profile in [RFC3961]), the only operative difference to [RFC4121] is that the associated data is prepended to the plaintext before invoking the checksum function. As such, for these encryption types GSS_Wrap_AEAD() with no associated data has an identical output to GSS_Wrap().

5.3. Native AEAD Encryption Types

When used with native AEAD encryption types as defined in [KRB-AEAD], the generation of [RFC4121] per-message tokens is modified as described below.

5.3.1. Restriction on Native AEAD Usage

Implementations SHALL NOT use native AEAD encryption types where the deterministic cipherstate length is less than 12 octets (96 bytes).

[[CREF2: TBD: if we want to support CCM with a 32-bit counter, we could remove the Filler byte and reduce the required cipherstate length to 11 octets. However, this may make it more difficult to use TLS-oriented GCM implementations that expose the Fixed-Common and Fixed-Distinct nonce components independently.]]

Native AEAD encryption types that do not support long-term keys SHOULD only be negotiated for use in GSS-API using the cryptosystem negotiation extension defined in [RFC4537].

5.3.2. Application-provided Cipherstate

The cipherstate for each invocation of encrypt-with-ad or decrypt-with-ad is given as follows. (For consistency with [RFC4121] the following definition uses 0-based indexing.)

Octet no	Name	Description
0..1	TOK_ID	Identification field, per RFC4121 Section 4.2.6
2	Flags	Attributes field, per RFC4121 Section 4.2.6
3	Filler	One octet of the hex value FF
4..11	SND_SEQ	Sequence number field, per RFC4121 Section 4.2.6
12..		Remaining octets (if any) are set to zero

The output cipherstate from the encrypt-with-ad and decrypt-with-ad functions is discarded as it is always specified explicitly as described above.

The use of application-managed cipherstate allows the per-message token size be reduced by omitting the confounder and encrypted copy of the token header. There is no limit on the number or size of messages that can be protected beyond those imposed by the sequence number size and the underlying cryptosystem.

5.3.3. Encryption and Checksum Operations

This text amends [RFC4121] Section 4.2.4.

In Wrap tokens that provide for confidentiality, the first 16 octets of the token (the "header", as defined in [RFC4121] Section 4.2.6) SHALL NOT be appended to the plaintext data before encryption. Instead, the TOK_ID, Flags and SND_SEQ fields of the token header are protected by the initialization vector (cipherstate). The EC field is unprotected, a change from [RFC4121]. The receiver MUST explicitly validate the EC field. For the native AEAD encryption types profiled in [KRB-AEAD] Section 5, EC SHALL be zero (except when GSS_C_DCE_STYLE is in use, see below). This specification does not support native AEAD encryption types that require the plaintext to be padded.

In Wrap tokens that do not provide for confidentiality, the first 16 octets of the token SHALL NOT be appended to the to-be-signed plaintext data. As with Wrap tokens that do provide for confidentiality, all fields except EC and RRC are protected by the initialization vector. The receiver MUST validate that EC is the correct constant value. For the AEAD encryption types defined in

[KRB-AEAD] Section 5, EC SHALL be sixteen, reflecting the tag length of 16 octets (128 bits).

Because native AEAD encryption types lack an explicit checksum operation, MIC tokens are generated similarly to Wrap tokens, using the encrypt-with-ad function passing the to-be-signed data as the associated data and using a plaintext length of zero. The key usage and initialization vector serve to disambiguate MIC from Wrap tokens. The octet string output by the encrypt-with-ad function contains the authentication tag, which is placed in the SGN_CKSUM field of the token.

5.3.4. DCE RPC Interoperability

Existing implementations that support the GSS_C_DCE_STYLE context flag will, when this flag is in set, set EC for Wrap tokens with confidentiality to the underlying cipher's block size and use an effective Right Rotation Count (RRC) of EC + RRC bytes. This document does not specify otherwise.

When GSS_C_DCE_STYLE is set, receivers MUST verify that the otherwise unprotected EC field is the underlying cipher's block size for Wrap tokens with confidentiality. (For Wrap tokens without confidentiality, the EC field remains the length of the authentication tag.)

DCE interleaves plaintext and associated data; because native AEAD algorithms may require associated data to be processed before any plaintext, any plaintext and associated data must each be coalesced before encrypting or decrypting. This document does not specify an API for processing interleaved plaintext and associated data.

6. Security Considerations

The combination of a context-specific session key and the presence of the the TOK_ID and SND_SEQ fields in the cipherstate guarantees that the key/IV combination is safe from reuse. The allows native AEAD modes such as [GCM] and [CCM] to be used securely.

Because the initialization vector has a deterministic (but non-repeating) construction, it is safe for use with GCM without any limitation on the number of invocations of the authenticated encryption function other than that imposed by the requirement that the cipherstate not repeat. (Section 8.3 of [GCM] imposes an invocation limit of 2^32 where the cipherstate is randomly generated or is a length other than 96 bits.)

The reordering of plaintext and associated data for GSS_C_DCE_STYLE interoperability may be problematic where the plaintext and associated data lengths are variable.

7. Acknowledgements

The author would like to thank the following individuals for their comments and suggestions: Nicolas Williams and Greg Hudson.

8. References

8.1. Normative References

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AES Encryption with HMAC-SHA2 for Kerberos 5
draft-ietf-kitten-aes-cts-hmac-sha2-11

Abstract

This document specifies two encryption types and two corresponding checksum types for Kerberos 5. The new types use AES in CTS mode (CBC mode with ciphertext stealing) for confidentiality and HMAC with a SHA-2 hash for integrity.

Status of this Memo

This Internet-Draft is submitted in full conformance with the provisions of BCP 78 and BCP 79.

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1. Introduction

This document defines two encryption types and two corresponding checksum types for Kerberos 5 using AES with 128-bit or 256-bit keys.

To avoid ciphertext expansion, we use a variation of the CBC-CS3 mode defined in [SP800-38A+], also referred to as ciphertext stealing or CTS mode. The new types conform to the framework specified in [RFC3961], but do not use the simplified profile, as the simplified profile is not compliant with modern cryptographic best practices such as calculating MACs over ciphertext rather than plaintext.

The encryption and checksum types defined in this document are intended to support environments that desire to use SHA-256 or SHA-384 (defined in [FIPS180]) as the hash algorithm. Differences between the encryption and checksum types defined in this document and the pre-existing Kerberos AES encryption and checksum types specified in [RFC3962] are:

* The pseudorandom function used by PBKDF2 is HMAC-SHA-256 or HMAC-SHA-384 (HMAC is defined in [RFC2104]).

* A key derivation function from [SP800-108] using the SHA-256 or SHA-384 hash algorithm is used to produce keys for encryption, integrity protection, and checksum operations.

* The HMAC is calculated over the cipherstate concatenated with the AES output, instead of being calculated over the confounder and plaintext. This allows the message receiver to verify the integrity of the message before decrypting the message.

* The HMAC algorithm uses the SHA-256 or SHA-384 hash algorithm for integrity protection and checksum operations.

2. Protocol Key Representation

The AES key space is dense, so we can use random or pseudorandom octet strings directly as keys. The byte representation for the key is described in [FIPS197], where the first bit of the bit string is the high bit of the first byte of the byte string (octet string).

3. Key Derivation Function

We use a key derivation function from Section 5.1 of [SP800-108] which uses the HMAC algorithm as the PRF.

```
function KDF-HMAC-SHA2(key, label, [context,] k):
   k-truncate(K1)
```

where the value of K1 is computed as below.

key: The source of entropy from which subsequent keys are derived (this is known as Ki in [SP800-108]).

label: An octet string describing the intended usage of the derived key.

context: This parameter is optional. An octet string containing the information related to the derived keying material. This specification does not dictate a specific format for the context field. The context field is only used by the pseudo-random function defined in section 5, where it is set to the pseudo-random function's octet-string input parameter. The content of the octet-string input parameter is defined by the application that uses it.

k: Length in bits of the key to be outputted, expressed in big-endian binary representation in 4 bytes (this is called L in [SP800-108]). Specifically, k=128 is represented as 0x00000080, 192 as 0x000000C0, 256 as 0x00000100, and 384 as 0x00000180.

When the encryption type is aes128-cts-hmac-sha256-128, k must be no greater than 256 bits. When the encryption type is aes256-cts-hmac-sha384-192, k must be no greater than 384 bits.

The k-truncate function is defined in [RFC3961], Section 5.1. It returns the 'k' leftmost bits of the bitstring input.

In all computations in this document, | indicates concatenation.

When the encryption type is aes128-cts-hmac-sha256-128, then K1 is computed as follows:

If the context parameter is not present:
K1 = HMAC-SHA-256(key, 0x00000001 | label | 0x00 | k)

If the context parameter is present:
K1 = HMAC-SHA-256(key, 0x00000001 | label | 0x00 | context | k)

When the encryption type is aes256-cts-hmac-sha384-192, then K1 is computed as follows:

If the context parameter is not present:
K1 = HMAC-SHA-384(key, 0x00000001 | label | 0x00 | k)

If the context parameter is present:
K1 = HMAC-SHA-384(key, 0x00000001 | label | 0x00 | context | k)

In the definitions of K1 above, '0x00000001' is the i parameter (the iteration counter) from Section 5.1 of [SP800-108].

4. Key Generation from Pass Phrases

As defined below, the string-to-key function uses PBKDF2 [RFC2898] and KDF-HMAC-SHA2 to derive the base-key from a passphrase and salt. The string-to-key parameter string is four octets indicating an unsigned number in big-endian order, consistent with [RFC3962], except that the default is decimal 32768 if the parameter is not specified.

To ensure that different long-term base-keys are used with different enctypes, we prepend the enctype name to the salt, separated by a null byte. The enctype-name is "aes128-cts-hmac-sha256-128" or "aes256-cts-hmac-sha384-192" (without the quotes).

The user's long-term base-key is derived as follows:

```
iter_count = string-to-key parameter, default is decimal 32768
saltp = enctype-name | 0x00 | salt
tkey = random-to-key(PBKDF2(passphrase, saltp,
                            iter_count, keylength))
base-key = random-to-key(KDF-HMAC-SHA2(tkey, "kerberos",
                                       keylength))

where "kerberos" is the octet-string 0x6B65726265726F73.
```

where PBKDF2 is the function of that name from RFC 2898, the pseudorandom function used by PBKDF2 is HMAC-SHA-256 when the enctype is "aes128-cts-hmac-sha256-128" and HMAC-SHA-384 when the enctype is "aes256-cts-hmac-sha384-192", the value for keylength is the AES key length (128 or 256 bits), and the algorithm KDF-HMAC-SHA2 is defined in Section 3.

5. Kerberos Algorithm Protocol Parameters

The RFC 3961 cipher state that maintains cryptographic state across different encryption operations using the same key is used as the formal initialization vector (IV) input into CBC-CS3. The plaintext is prepended with a 16-octet random value generated by the message originator, known as a confounder.

The ciphertext is a concatenation of the output of AES in CBC-CS3 mode and the HMAC of the cipher state concatenated with the AES output. The HMAC is computed using either SHA-256 or SHA-384 depending on the encryption type. The output of HMAC-SHA-256 is truncated to 128 bits and the output of HMAC-SHA-384 is truncated to

192 bits. Sample test vectors are given in Appendix A.

Decryption is performed by removing the HMAC, verifying the HMAC against the cipher state concatenated with the ciphertext, and then decrypting the ciphertext if the HMAC is correct. Finally, the first 16 octets of the decryption output (the confounder) is discarded, and the remainder is returned as the plaintext decryption output.

The following parameters apply to the encryption types aes128-cts-hmac-sha256-128 and aes256-cts-hmac-sha384-192.

protocol key format: as defined in Section 2.

specific key structure: three derived keys: { Kc, Ke, Ki }.

Kc: the checksum key, inputted into HMAC to provide the checksum mechanism defined in Section 6.

Ke: the encryption key, inputted into AES encryption and decryption as defined in "encryption function" and "decryption function" below.

Ki: the integrity key, inputted into HMAC to provide authenticated encryption as defined in "encryption function" and "decryption function" below.

required checksum mechanism: as defined in Section 6.

key-generation seed length: key size (128 or 256 bits).

string-to-key function: as defined in Section 4.

default string-to-key parameters: iteration count of decimal 32768.

random-to-key function: identity function.

key-derivation function: KDF-HMAC-SHA2 as defined in Section 3. The key usage number is expressed as four octets in big-endian order.

If the enctype is aes128-cts-hmac-sha256-128:
Kc = KDF-HMAC-SHA2(base-key, usage | 0x99, 128)
Ke = KDF-HMAC-SHA2(base-key, usage | 0xAA, 128)
Ki = KDF-HMAC-SHA2(base-key, usage | 0x55, 128)

If the enctype is aes256-cts-hmac-sha384-192:
Kc = KDF-HMAC-SHA2(base-key, usage | 0x99, 192)
Ke = KDF-HMAC-SHA2(base-key, usage | 0xAA, 256)
Ki = KDF-HMAC-SHA2(base-key, usage | 0x55, 192)

cipher state: a 128-bit CBC initialization vector derived from a previous (if any) ciphertext using the same encryption key, as specified below.

initial cipher state: all bits zero.

encryption function: as follows, where E() is AES encryption in CBC-CS3 mode, and h is the size of truncated HMAC (128 bits or 192 bits as described above).

```
N = random value of length 128 bits (the AES block size)
IV = cipher state
C = E(Ke, N | plaintext, IV)
H = HMAC(Ki, IV | C)
ciphertext = C | H[1..h]

Steps to compute the 128-bit cipher state:
 L = length of C in bits
 portion C into 128-bit blocks, placing any remainder
 of less than 128 bits into a final block
 if L == 128: cipher state = C
 else if L mod 128 > 0: cipher state = last full (128-bit)
                                       block of C (the
                                       next-to-last block)
 else if L mod 128 == 0: cipher state = next-to-last block
                                        of C
 (note that L will never be less than 128 because of the
 presence of N in the encryption input)
```

decryption function: as follows, where D() is AES decryption in CBC-CS3 mode, and h is the size of truncated HMAC.

```
(C, H) = ciphertext (Note: H is the last h bits of the ciphertext)
IV = cipher state
if H != HMAC(Ki, IV | C)[1..h]
    stop, report error
(N, P) = D(Ke, C, IV)
Note: N is set to the first block of the decryption output,
P is set to the rest of the output.
cipher state = same as described above in encryption function
```

pseudo-random function:

```
If the enctype is aes128-cts-hmac-sha256-128:
PRF = KDF-HMAC-SHA2(input-key, "prf", octet-string, 256)

If the enctype is aes256-cts-hmac-sha384-192:
PRF = KDF-HMAC-SHA2(input-key, "prf", octet-string, 384)
```

where "prf" is the octet-string 0x707266

6. Checksum Parameters

The following parameters apply to the checksum types hmac-sha256-128-aes128 and hmac-sha384-192-aes256, which are the associated checksums for aes128-cts-hmac-sha256-128 and aes256-cts-hmac-sha384-192, respectively.

associated cryptosystem: aes128-cts-hmac-sha256-128 or aes256-cts-hmac-sha384-192 as appropriate.

get_mic: HMAC(Kc, message)[1..h].
where h is 128 bits for checksum type hmac-sha256-128-aes128 and 192 bits for checksum type hmac-sha384-192-aes256

verify_mic: get_mic and compare.

7. IANA Considerations

IANA is requested to assign:

Encryption type numbers for aes128-cts-hmac-sha256-128 and aes256-cts-hmac-sha384-192 in the Kerberos Encryption Type Numbers registry.

Etype	Encryption type	Reference
TBD1	aes128-cts-hmac-sha256-128	[this document]
TBD2	aes256-cts-hmac-sha384-192	[this document]

Checksum type numbers for hmac-sha256-128-aes128 and hmac-sha384-192-aes256 in the Kerberos Checksum Type Numbers registry.

Sumtype	Checksum type	Size	Reference
TBD3	hmac-sha256-128-aes128	16	[this document]
TBD4	hmac-sha384-192-aes256	24	[this document]

8. Security Considerations

This specification requires implementations to generate random values. The use of inadequate pseudo-random number generators (PRNGs) can result in little or no security. The generation of quality random numbers is difficult. [RFC4086] offers random number

generation guidance.

This document specifies a mechanism for generating keys from passphrases or passwords. The use of PBKDF2, a salt, and a large iteration count adds some resistance to off-line dictionary attacks by passive eavesdroppers. Salting prevents rainbow table attacks, while large iteration counts slow password guess attempts. Nonetheless, computing power continues to rapidly improve, including the potential for use of graphics processing units (GPUs) in password guess attempts. It is important to choose strong passphrases. Use of Kerberos extensions that protect against off-line dictionary attacks should also be considered, as should the use of public key cryptography for initial Kerberos authentication [RFC4556] to eliminate the use of passwords or passphrases within the Kerberos protocol.

The NIST guidance in section 5.3 of [SP800-38A], requiring that CBC initialization vectors be unpredictable, is satisfied by the use of a random confounder as the first block of plaintext. The confounder fills the cryptographic role typically played by an initialization vector. This approach was chosen to align with other Kerberos cryptosystem approaches.

8.1. Random Values in Salt Strings

NIST guidance in Section 5.1 of [SP800-132] requires at least 128 bits of the salt to be randomly generated. The string-to-key function as defined in [RFC3961] requires the salt to be valid UTF-8 strings [RFC3629]. Not every 128-bit random string will be valid UTF-8, so a UTF-8 compatible encoding would be needed to encapsulate the random bits. However, using a salt containing a random portion may have the following issues with some implementations:

* Cross-realm krbtgt keys are typically managed by entering the same password at two KDCs to get the same keys. If each KDC uses a random salt, they won’t have the same keys.

* Random salts may interfere with password history checking.

8.2. Algorithm Rationale

This document has been written to be consistent with common implementations of AES and SHA-2. The encryption and hash algorithm sizes have been chosen to create a consistent level of protection, with consideration to implementation efficiencies. So, for instance, SHA-384, which would normally be matched to AES-192, is instead matched to AES-256 to leverage the fact that there are efficient hardware implementations of AES-256. Note that, as indicated by the

enc-type name "aes256-cts-hmac-sha384-192", the truncation of the HMAC-SHA-384 output to 192-bits results in an overall 192-bit level of security.

9. Acknowledgements

Kelley Burgin was employed at the National Security Agency during much of the work on this document.

10. References

10.1. Normative References

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Appendix A. Test Vectors

Sample results for string-to-key conversion:

Iteration count = 32768
Pass phrase = "password"
Saltp for creating 128-bit base-key:
61 65 73 31 32 38 2D 63 74 73 2D 68 6D 61 63 2D
73 68 61 32 35 36 2D 31 32 38 00 10 DF 9D D7 83
E5 BC 8A CE A1 73 0E 74 35 5F 61 41 54 48 45 4E
41 2E 4D 49 54 2E 45 44 55 72 61 65 62 75 72 6E

(The saltp is "aes128-cts-hmac-sha256-128" | 0x00 |
random 16 byte valid UTF-8 sequence | "ATHENA.MIT.EDUraeburn")
128-bit base-key:
08 9B CA 48 B1 05 EA 6E A7 7C A5 D2 F3 9D C5 E7

Saltp for creating 256-bit base-key:
61 65 73 32 35 36 2D 63 74 73 2D 68 6D 61 63 2D
73 68 61 33 38 34 2D 31 39 32 00 10 DF 9D D7 83
E5 BC 8A CE A1 73 0E 74 35 5F 61 41 54 48 45 4E
41 2E 4D 49 54 2E 45 44 55 72 61 65 62 75 72 6E
(The saltp is "aes256-cts-hmac-sha384-192" | 0x00 |
random 16 byte valid UTF-8 sequence | "ATHENA.MIT.EDUraeburn")
256-bit base-key:
45 BD 80 6D BF 6A 83 3A 9C FF C1 C9 45 89 A2 22
36 7A 79 BC 21 C4 13 71 89 06 E9 F5 78 A7 84 67

Sample results for key derivation:
---

enctype aes128-cts-hmac-sha256-128:
128-bit base-key:
37 05 D9 60 80 C1 77 28 A0 E8 00 EA B6 E0 D2 3C

```
   Kc value for key usage 2 (label = 0x0000000299):
      B3 1A 01 8A 48 F5 47 76 F4 03 E9 A3 96 32 5D C3
   Ke value for key usage 2 (label = 0x00000002AA):
      9B 19 7D D1 E8 C5 60 9D 6E 67 C3 E3 7C 62 C7 2E
   Ki value for key usage 2 (label = 0x0000000255):
      9F DA 0E 56 AB 2D 85 E1 56 9A 68 86 96 C2 6A 6C

   enctype aes256-cts-hmac-sha384-192:
   256-bit base-key:
      6D 40 4D 37 FA F7 9F 9D F0 D3 35 68 D3 20 66 98
      00 EB 48 36 47 2E A8 A0 26 D1 6B 71 82 46 0C 52
   Kc value for key usage 2 (label = 0x0000000299):
      EF 57 18 BE 86 CC 84 96 3D 8B BB 50 31 E9 F5 C4
      BA 41 F2 8F AF 69 E7 3D
   Ke value for key usage 2 (label = 0x00000002AA):
      56 AB 22 BE E6 3D 82 D7 BC 52 27 F6 77 3F 8E A7
      A5 EB 1C 82 51 60 C3 83 12 98 0C 44 2E 5C 7E 49
   Ki value for key usage 2 (label = 0x0000000255):
      69 B1 65 14 E3 CD 8E 56 B8 20 10 D5 C7 30 12 B6
      22 C4 D0 0F FC 23 ED 1F

   Sample encryptions (all using the default cipher state):
   ---------------------------------------------------------
   These sample encryptions use the above sample key
   derivation results, including use of the same
   base-key and key usage values.

   The following test vectors are for
   enctype aes128-cts-hmac-sha256-128:

   Plaintext: (empty)
   Confounder:
      7E 58 95 EA F2 67 24 35 BA D8 17 F5 45 A3 71 48
   128-bit AES key (Ke):
      9B 19 7D D1 E8 C5 60 9D 6E 67 C3 E3 7C 62 C7 2E
   128-bit HMAC key (Ki):
      9F DA 0E 56 AB 2D 85 E1 56 9A 68 86 96 C2 6A 6C
   AES Output:
      EF 85 FB 89 0B B8 47 2F 4D AB 20 39 4D CA 78 1D
   Truncated HMAC Output:
      AD 87 7E DA 39 D5 0C 87 0C 0D 5A 0A 8E 48 C7 18
   Ciphertext (AES Output | HMAC Output):
      EF 85 FB 89 0B B8 47 2F 4D AB 20 39 4D CA 78 1D
      AD 87 7E DA 39 D5 0C 87 0C 0D 5A 0A 8E 48 C7 18

   Plaintext: (length less than block size)
      00 01 02 03 04 05
   Confounder:
```

```
      7B CA 28 5E 2F D4 13 0F B5 5B 1A 5C 83 BC 5B 24
   128-bit AES key (Ke):
      9B 19 7D D1 E8 C5 60 9D 6E 67 C3 E3 7C 62 C7 2E
   128-bit HMAC key (Ki):
      9F DA 0E 56 AB 2D 85 E1 56 9A 68 86 96 C2 6A 6C
   AES Output:
      84 D7 F3 07 54 ED 98 7B AB 0B F3 50 6B EB 09 CF
      B5 54 02 CE F7 E6
   Truncated HMAC Output:
      87 7C E9 9E 24 7E 52 D1 6E D4 42 1D FD F8 97 6C
   Ciphertext:
      84 D7 F3 07 54 ED 98 7B AB 0B F3 50 6B EB 09 CF
      B5 54 02 CE F7 E6 87 7C E9 9E 24 7E 52 D1 6E D4
      42 1D FD F8 97 6C

   Plaintext: (length equals block size)
      00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F
   Confounder:
      56 AB 21 71 3F F6 2C 0A 14 57 20 0F 6F A9 94 8F
   128-bit AES key (Ke):
      9B 19 7D D1 E8 C5 60 9D 6E 67 C3 E3 7C 62 C7 2E
   128-bit HMAC key (Ki):
      9F DA 0E 56 AB 2D 85 E1 56 9A 68 86 96 C2 6A 6C
   AES Output:
      35 17 D6 40 F5 0D DC 8A D3 62 87 22 B3 56 9D 2A
      E0 74 93 FA 82 63 25 40 80 EA 65 C1 00 8E 8F C2
   Truncated HMAC Output:
      95 FB 48 52 E7 D8 3E 1E 7C 48 C3 7E EB E6 B0 D3
   Ciphertext:
      35 17 D6 40 F5 0D DC 8A D3 62 87 22 B3 56 9D 2A
      E0 74 93 FA 82 63 25 40 80 EA 65 C1 00 8E 8F C2
      95 FB 48 52 E7 D8 3E 1E 7C 48 C3 7E EB E6 B0 D3

   Plaintext: (length greater than block size)
      00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F
      10 11 12 13 14
   Confounder:
      A7 A4 E2 9A 47 28 CE 10 66 4F B6 4E 49 AD 3F AC
   128-bit AES key (Ke):
      9B 19 7D D1 E8 C5 60 9D 6E 67 C3 E3 7C 62 C7 2E
   128-bit HMAC key (Ki):
      9F DA 0E 56 AB 2D 85 E1 56 9A 68 86 96 C2 6A 6C
   AES Output:
      72 0F 73 B1 8D 98 59 CD 6C CB 43 46 11 5C D3 36
      C7 0F 58 ED C0 C4 43 7C 55 73 54 4C 31 C8 13 BC
      E1 E6 D0 72 C1
   Truncated HMAC Output:
      86 B3 9A 41 3C 2F 92 CA 9B 83 34 A2 87 FF CB FC
```

```
   Ciphertext:
      72 0F 73 B1 8D 98 59 CD 6C CB 43 46 11 5C D3 36
      C7 0F 58 ED C0 C4 43 7C 55 73 54 4C 31 C8 13 BC
      E1 E6 D0 72 C1 86 B3 9A 41 3C 2F 92 CA 9B 83 34
      A2 87 FF CB FC

   The following test vectors are for enctype
   aes256-cts-hmac-sha384-192:

   Plaintext: (empty)
   Confounder:
      F7 64 E9 FA 15 C2 76 47 8B 2C 7D 0C 4E 5F 58 E4
   256-bit AES key (Ke):
      56 AB 22 BE E6 3D 82 D7 BC 52 27 F6 77 3F 8E A7
      A5 EB 1C 82 51 60 C3 83 12 98 0C 44 2E 5C 7E 49
   192-bit HMAC key (Ki):
      69 B1 65 14 E3 CD 8E 56 B8 20 10 D5 C7 30 12 B6
      22 C4 D0 0F FC 23 ED 1F
   AES Output:
      41 F5 3F A5 BF E7 02 6D 91 FA F9 BE 95 91 95 A0
   Truncated HMAC Output:
      58 70 72 73 A9 6A 40 F0 A0 19 60 62 1A C6 12 74
      8B 9B BF BE 7E B4 CE 3C
   Ciphertext:
      41 F5 3F A5 BF E7 02 6D 91 FA F9 BE 95 91 95 A0
      58 70 72 73 A9 6A 40 F0 A0 19 60 62 1A C6 12 74
      8B 9B BF BE 7E B4 CE 3C

   Plaintext: (length less than block size)
      00 01 02 03 04 05
   Confounder:
      B8 0D 32 51 C1 F6 47 14 94 25 6F FE 71 2D 0B 9A
   256-bit AES key (Ke):
      56 AB 22 BE E6 3D 82 D7 BC 52 27 F6 77 3F 8E A7
      A5 EB 1C 82 51 60 C3 83 12 98 0C 44 2E 5C 7E 49
   192-bit HMAC key (Ki):
      69 B1 65 14 E3 CD 8E 56 B8 20 10 D5 C7 30 12 B6
      22 C4 D0 0F FC 23 ED 1F
   AES Output:
      4E D7 B3 7C 2B CA C8 F7 4F 23 C1 CF 07 E6 2B C7
      B7 5F B3 F6 37 B9
   Truncated HMAC Output:
      F5 59 C7 F6 64 F6 9E AB 7B 60 92 23 75 26 EA 0D
      1F 61 CB 20 D6 9D 10 F2
   Ciphertext:
      4E D7 B3 7C 2B CA C8 F7 4F 23 C1 CF 07 E6 2B C7
      B7 5F B3 F6 37 B9 F5 59 C7 F6 64 F6 9E AB 7B 60
      92 23 75 26 EA 0D 1F 61 CB 20 D6 9D 10 F2
```

```
   Plaintext: (length equals block size)
      00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F
   Confounder:
      53 BF 8A 0D 10 52 65 D4 E2 76 42 86 24 CE 5E 63
   256-bit AES key (Ke):
      56 AB 22 BE E6 3D 82 D7 BC 52 27 F6 77 3F 8E A7
      A5 EB 1C 82 51 60 C3 83 12 98 0C 44 2E 5C 7E 49
   192-bit HMAC key (Ki):
      69 B1 65 14 E3 CD 8E 56 B8 20 10 D5 C7 30 12 B6
      22 C4 D0 0F FC 23 ED 1F
   AES Output:
      BC 47 FF EC 79 98 EB 91 E8 11 5C F8 D1 9D AC 4B
      BB E2 E1 63 E8 7D D3 7F 49 BE CA 92 02 77 64 F6
   Truncated HMAC Output:
      8C F5 1F 14 D7 98 C2 27 3F 35 DF 57 4D 1F 93 2E
      40 C4 FF 25 5B 36 A2 66
   Ciphertext:
      BC 47 FF EC 79 98 EB 91 E8 11 5C F8 D1 9D AC 4B
      BB E2 E1 63 E8 7D D3 7F 49 BE CA 92 02 77 64 F6
      8C F5 1F 14 D7 98 C2 27 3F 35 DF 57 4D 1F 93 2E
      40 C4 FF 25 5B 36 A2 66

   Plaintext: (length greater than block size)
      00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F
      10 11 12 13 14
   Confounder:
      76 3E 65 36 7E 86 4F 02 F5 51 53 C7 E3 B5 8A F1
   256-bit AES key (Ke):
      56 AB 22 BE E6 3D 82 D7 BC 52 27 F6 77 3F 8E A7
      A5 EB 1C 82 51 60 C3 83 12 98 0C 44 2E 5C 7E 49
   192-bit HMAC key (Ki):
      69 B1 65 14 E3 CD 8E 56 B8 20 10 D5 C7 30 12 B6
      22 C4 D0 0F FC 23 ED 1F
   AES Output:
      40 01 3E 2D F5 8E 87 51 95 7D 28 78 BC D2 D6 FE
      10 1C CF D5 56 CB 1E AE 79 DB 3C 3E E8 64 29 F2
      B2 A6 02 AC 86
   Truncated HMAC Output:
      FE F6 EC B6 47 D6 29 5F AE 07 7A 1F EB 51 75 08
      D2 C1 6B 41 92 E0 1F 62
   Ciphertext:
      40 01 3E 2D F5 8E 87 51 95 7D 28 78 BC D2 D6 FE
      10 1C CF D5 56 CB 1E AE 79 DB 3C 3E E8 64 29 F2
      B2 A6 02 AC 86 FE F6 EC B6 47 D6 29 5F AE 07 7A
      1F EB 51 75 08 D2 C1 6B 41 92 E0 1F 62

   Sample checksums:
   -----------------
```

These sample checksums use the above sample key derivation results, including use of the same base-key and key usage values.

```
Checksum type: hmac-sha256-128-aes128
128-bit HMAC key (Kc):
   B3 1A 01 8A 48 F5 47 76 F4 03 E9 A3 96 32 5D C3
Plaintext:
   00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F
   10 11 12 13 14
Checksum:
   D7 83 67 18 66 43 D6 7B 41 1C BA 91 39 FC 1D EE

Checksum type: hmac-sha384-192-aes256
192-bit HMAC key (Kc):
   EF 57 18 BE 86 CC 84 96 3D 8B BB 50 31 E9 F5 C4
   BA 41 F2 8F AF 69 E7 3D
Plaintext:
   00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F
   10 11 12 13 14
Checksum:
   45 EE 79 15 67 EE FC A3 7F 4A C1 E0 22 2D E8 0D
   43 C3 BF A0 66 99 67 2A
```

```
   Sample pseudorandom function (PRF) invocations:
   ----------------------------------------

   PRF input octet-string: "test" (0x74657374)

   enctype aes128-cts-hmac-sha256-128:
   input-key value / HMAC-SHA-256 key:
      37 05 D9 60 80 C1 77 28 A0 E8 00 EA B6 E0 D2 3C
   HMAC-SHA-256 input message:
      00 00 00 01 70 72 66 00 74 65 73 74 00 00 01 00
   PRF output:
      9D 18 86 16 F6 38 52 FE 86 91 5B B8 40 B4 A8 86
      FF 3E 6B B0 F8 19 B4 9B 89 33 93 D3 93 85 42 95

   enctype aes256-cts-hmac-sha384-192:
   input-key value / HMAC-SHA-384 key:
      6D 40 4D 37 FA F7 9F 9D F0 D3 35 68 D3 20 66 98
      00 EB 48 36 47 2E A8 A0 26 D1 6B 71 82 46 0C 52
   HMAC-SHA-384 input message:
      00 00 00 01 70 72 66 00 74 65 73 74 00 00 01 80
   PRF output:
      98 01 F6 9A 36 8C 2B F6 75 E5 95 21 E1 77 D9 A0
      7F 67 EF E1 CF DE 8D 3C 8D 6F 6A 02 56 E3 B1 7D
      B3 C1 B6 2A D1 B8 55 33 60 D1 73 67 EB 15 14 D2
```

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Namespace Considerations and Registries for GSS-API Extensions
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Abstract

This document describes the ways in which the GSS-API may be extended and directs the creation of an IANA registry for various GSS-API namespaces.

Status of This Memo

This Internet-Draft is submitted in full conformance with the provisions of BCP 78 and BCP 79.

Internet-Drafts are working documents of the Internet Engineering Task Force (IETF). Note that other groups may also distribute working documents as Internet-Drafts. The list of current Internet-Drafts is at http://datatracker.ietf.org/drafts/current/.

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This Internet-Draft will expire on October 1, 2017.

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1. Conventions used in this document

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [RFC2119].

2. Introduction

There is a need for private-use and mechanism-specific extensions to the Generic Security Services Application Programming Interface (GSS-API). As such extensions are designed and standardized (or not), both at the IETF and elsewhere, there is a non-trivial risk of namespace pollution and conflicts. To avoid this we set out guidelines for extending the GSS-API and direct the creation of an IANA registry for GSS-API namespaces.

Registrations of individual items and sub-namespaces are allowed. Each sub-namespace may provide different rules for registration, e.g., for mechanism-specific and private-use extensions.

3. Extensions to the GSS-API

Extensions to the GSS-API can be categorized as follows:

- Abstract API extensions

- Implementation-specific
- Mechanism-specific
- Language binding-specific

Extensions to the GSS-API may be purely semantic, without effect on the GSS-API's namespaces. Or they may introduce new functions, constants, types, etc...; these clearly affect the GSS-API namespaces.

Extensions that affect the GSS-API namespaces should be registered with the IANA as described herein.

4. Generic GSS-API Namespaces

The abstract API namespaces for the GSS-API are:

- Type names
- Function names
- Constant names for various types
- Constant values for various types
- Name types (OID, type name and syntaxes)

Additionally we have namespaces associates with the OBJECT IDENTIFIER (OID) type. The IANA already maintains a registry of such OIDs:

- Mechanism OIDs
- Name Type OIDs

5. Language Binding-Specific GSS-API Namespaces

Language binding specific namespaces include, among others:

- Header/interface module names
- Object classes and/or types
- Methods and/or functions
- Constant names
- Constant values

6. Extension-Specific GSS-API Namespaces

Extensions to the GSS-API may create additional namespaces. See Section 8.2.

7. Registration Form

Registrations for GSS-API namespaces SHALL take the following form:

Registration Field	Possible Values	Description
Bindings	'Generic', 'C-bindings', 'Java', 'C#', <programming language name>	Indicates the name of the programming language that this registration involves, or, if 'Generic', that this is an entry for the generic abstract GSS-API (i.e., not specific to any programming language).
Registration type	'Instance', 'Sub-Namespace'	Indicates whether this entry reserves a given symbol name (and possibly, constant value), or whether it reserves an entire sub-namespace (the name is a pattern) or constant value range.
Object Type	<Symbol> defined by the binding language (for example 'Data-Type', 'Function', 'Method', 'Integer', 'String', 'OID', 'Context-Flag', 'Name-Type', 'Macro', 'Header-File-Name', 'Module-Name', 'Class')	Indicates the type of the object whose symbolic name or constant value this entry registers. The possible values of this field depend on the programming language in question, therefore they are not all specified here.
Symbol Name/Prefix	<Symbol name or name pattern>	The name of a symbol or symbol sub-namespace being

		registered. See Section 8.2.1
Binding of	<Name of abstract API element of which this object is a binding>	If the registration is for a specific language binding of the GSS-API, then this names the abstract API element of which it is a binding (OPTIONAL).
Constant Value/Range	<Constant value> or <constant value range>	The value of the constant named by the <Symbol Name/Prefix>. This field is present only for Instance and Sub-namespace registrations of Constant object types.
Description	<Text>	Description of the registration. Multiple instances of this field may result (see Section 8.2.3).
Registration Rules	<Reference> to an IANA registration Policy defined in [RFC5226] (or an RFC that updates it), for instance 'IESG Approval', 'Expert Review', 'First Come First Served', 'Private Use'.	Describes the rules for allocation of items that fall in this sub-namespace, for entries with Registration Type of Sub-namespace (OPTIONAL). For private use sub-namespaces the submitter MUST provide the e-mail address of a responsible contact. If this field is not specified for a sub-namespace, the default registration rules specified in Section 8.2 apply.
Reference	<Reference>	Reference to a document that describes the registration, if any (OPTIONAL). Multiple instances of this field are allowed, with one reference each.
Expert Reviewer	<Name of expert reviewers, possibly	OPTIONAL, see Section 8.2.2. Multiple instances of this

	WG names>	field are allowed, with one expert reviewer per-instance. Leave this field blank when requesting a registration. It will be filled in by the Expert who reviews the registration.
Expert Review Notes	<Notes from the expert review>	Expert reviewers may request that some comments be included with the registration, e.g., regarding security considerations of the registered extension.
Status	'Registered' or 'Obsoleted'	Status of the registration.
Obsoleting Reference	<Reference>	Reference to a document, if any, that obsoletes this registration. Multiple instances of this field are allowed, with one reference each. (OPTIONAL)

The IANA should create a single GSS-API namespace registry, or multiple registries, one for symbolic names and one for constant values, and/or it may create a registry per-programming language, at its convenience.

Entries in these registries should consist of all the fields from their corresponding registration entries.

Entries should be sorted by: programming language, registration type, object type, and symbol name/pattern.

8. IANA Considerations

This document deals with IANA considerations throughout. Specifically it creates a single registry of various kinds of things, though the IANA may instead create multiple registries, each for one of those kinds of things. Of particular interest may be that IANA will now be the registration authority for the GSS-API name type OID space.

8.1. Initial Namespace Registrations

Initial registry content corresponding to the items defined in [RFC2743], [RFC2744], [RFC2853], [RFC1964] and [RFC4121] and others will be supplied during the IANA review portion of the RFC publishing process. [[Note to RFC Editor: Delete the following sentence before publication:]] The KITTEN WG chairs MUST indicate that such content has been reviewed by the WG and that there is WG consensus that the entries are in agreement with those RFCs.

8.1.1. Example registrations

In order to sanity check recommended IANA registration templates, this section registers several entries.

Registration Field	Possible Values
Bindings	C-bindings
Registration type	Instance
Object Type	Function
Symbol Name	gss_init_sec_context
Binding of	GSS_Init_sec_context
Constant Value/Range	N/A
Description	Create a security context by initiator
Registration Rules	N/A
Reference	RFC 2744
Expert Reviewer	Kitten WG
Expert Review Notes	
Status	Registered
Obsoleting Reference	N/A

Registration Field	Possible Values
Bindings	C-bindings
Registration type	Instance
Object Type	Function
Symbol Name	gss_accept_sec_context
Binding of	GSS_Accept_sec_context
Constant Value/Range	N/A
Description	Accept a security context from initiator
Registration Rules	N/A
Reference	RFC 2744
Expert Reviewer	Kitten WG
Expert Review Notes	
Status	Registered
Obsoleting Reference	N/A

Registration Field	Possible Values
Bindings	C-bindings
Registration type	Instance
Object Type	Context-Flag
Symbol Name	GSS_C_DELEG_FLAG
Binding of	deleg_state or deleg_req_flag
Constant Value/Range	1
Description	On output (if set): Delegated credentials are available via the delegated_cred_handle parameter of GSS_Accept_sec_context. On input (if set): With the call to GSS_Init_sec_context, delegate credentials to the acceptor.
Registration Rules	N/A
Reference	RFC 2744
Expert Reviewer	Kitten WG
Expert Review Notes	
Status	Registered
Obsoleting Reference	N/A

8.2. Registration Maintenance Guidelines

Standards-Track RFCs can create new items with any non-conflicting Symbol Name/Prefix value for this registry by virtue of IESG approval to publish as a Standards-Track RFC -- that is, without additional expert review.

Standards-Track RFCs can mark existing entries as obsolete, and can even create conflicting entries if explicitly stated (the IESG, of course, should review conflicts carefully, and may reject them).

IANA shall also consider submissions from individuals, and via Informational and Experimental RFCs, subject to Expert Review. IANA SHALL allow such registrations if a) they are not conflicting, b) provided that the registration is for object types other than Context-Flags, and c) subject to expert review. Guidelines for expert reviews are given below.

8.2.1. Sub-Namespace Symbol Pattern Matching

Sub-namespace registrations must provide a pattern for matching symbols for which the sub-namespace's registration rules apply. The pattern consists of a string with the following special tokens:

- '*', meaning "match any string."
- "%m", meaning "match any mechanism family short-hand name."
- "%i", meaning "match any implementor vanity short-hand name."

For example, "GSS_%m_*" matches "GSS_krb5_foo" since "krb5" is a common short-hand for the Kerberos V GSS-API mechanism [RFC1964]. But "GSS_%m_*" does not match "GSS_foo_bar" unless "foo" is asserted to be a short-hand for some mechanism.

8.2.2. Expert Reviews of Individual Submissions

[[The following paragraph should be deleted from the document before publication, as it will not age well. It should be moved to the shepherding write-up.]]

Expert review selection SHALL be done as follows. If, at the time that the IANA receives an individual submission for registration in this registry, there are any IETF Working Groups chartered to produce GSS-API-related documents, then the IANA SHALL ask the chairs of such WGs to be expert reviewers or to name one. If there are no such WGs at that time, then the IANA SHALL ask past chairs of the KITTEN WG and the author/editor of this RFC to act as expert reviewers or name an alternate.

Expert reviewers of individual registration submissions with Registration Type == Sub-namespace should check that the registration request has a suitable description (which doesn't need to be sufficiently detailed for others to implement) and that the Symbol Name/Prefix is sufficiently descriptive of the purpose of the sub-namespace or reflective of the name of the submitter or associated company.

Expert reviewers of individual registration submissions with

Registration Type == Instance should check that the Symbol Name falls under a sub-namespace controlled by the submitter. Registration of such entries which do not fall under such a sub-namespace may be allowed provided that they correspond to long existing non-standard extensions to the GSS-API and this can be easily checked or demonstrated, otherwise IESG Protocol Action is REQUIRED (see previous section). Also, reviewers should check that any registration of constant values have a detailed description that is suitable for other implementors to reproduce, and that they don't conflict with other usages or are otherwise dangerous in the reviewers estimation.

Expert reviewers should review impact on mechanisms, security and interoperability, and may reject or annotate registrations which can have mechanism impact that requires IESG protocol action. Consider, for example, new versions of GSS_Init_sec_context() and/or GSS_Accept_sec_context which have new input and/or output parameters which imply changes on the wire or in behaviour that may result in interoperability issues. A reviewer could choose to add notes to the registration describing such issues, or the reviewer might conclude that the danger to Internet interoperability is sufficient to warrant rejecting the registration.

8.2.3. Change Control

Registered entries may be marked obsoleted using the same expert review process as for registering new entries. Obsoleted entries are not, however, to be deleted, but merely marked having Obsoleted Status. Note that entries may be created as obsoleted to record the fact that the given symbol(s) have been used before, even though continued use of them is discouraged.

Registered entries may also be updated in two other ways: additional references, obsoleting references, and descriptions may be added.

All changes are subject to expert review, except for changes to registrations in a sub-namespace which are subject to the rules of the relevant sub-namespace. The submitter of a change request need not be the same as the original submitter.

Registrations may be modified by addition, but under no circumstance may any fields be modified except for the Status field or Contact Address, or to correct for transcription errors in filing or processing registration requests.

The IANA SHALL add a field describing the date that a an addition or modification was made, and a description of the change.

9. Security Considerations

General security considerations relating to IANA registration services apply; see [RFC5226].

Also, expert reviewers should look for and may document security related issues with submitters' GSS-API extensions, to the best of the reviewers' ability given the information furnished by the submitter. Reviewers may add comments regarding their limited ability to review a submission for security problems if the submitter is unwilling to provide sufficient documentation.

10. References

10.1. Normative References

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Initial and Pass Through Authentication Using Kerberos V5 and the GSS-API (IAKERB)
draft-ietf-kitten-iakerb-03

Abstract

This document defines extensions to the Kerberos protocol and the GSS-API Kerberos mechanism that enable a GSS-API Kerberos client to exchange messages with the KDC by using the GSS-API acceptor as a proxy, encapsulating the Kerberos messages inside GSS-API tokens. With these extensions a client can obtain Kerberos tickets for services where the KDC is not accessible to the client, but is accessible to the application server.

Status of This Memo

This Internet-Draft is submitted in full conformance with the provisions of BCP 78 and BCP 79.

Internet-Drafts are working documents of the Internet Engineering Task Force (IETF). Note that other groups may also distribute working documents as Internet-Drafts. The list of current Internet-Drafts is at http://datatracker.ietf.org/drafts/current/.

Internet-Drafts are draft documents valid for a maximum of six months and may be updated, replaced, or obsoleted by other documents at any time. It is inappropriate to use Internet-Drafts as reference material or to cite them other than as "work in progress."

This Internet-Draft will expire on October 1, 2017.

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Table of Contents

1. Introduction

When authenticating using Kerberos V5, clients obtain tickets from a KDC and present them to services. This model of operation cannot work if the client does not have access to the KDC. For example, in remote access scenarios, the client must initially authenticate to an access point in order to gain full access to the network. Here the client may be unable to directly contact the KDC either because it does not have an IP address, or the access point packet filter does not allow the client to send packets to the Internet before it authenticates to the access point. The Initial and Pass Through Authentication Using Kerberos (IAKERB) mechanism allows for the use of Kerberos in such scenarios where the client is unable to directly contact the KDC, by using the service to pass messages between the client and the KDC. This allows the client to obtain tickets from the KDC and present them to the service, as in normal Kerberos operation.

Recent advancements in extending Kerberos permit Kerberos authentication to complete with the assistance of a proxy. The

Kerberos [RFC4120] pre-authentication framework [RFC6113] prevents the exposure of weak client keys over the open network. The Kerberos support of anonymity [RFC6112] provides for privacy and further complicates traffic analysis. The kdc-referrals option defined in [RFC6113] may reduce the number of messages exchanged while obtaining a ticket to exactly two even in cross-realm authentications.

Building upon these Kerberos extensions, this document extends [RFC4120] and [RFC4121] such that the client can communicate with the KDC using a Generic Security Service Application Program Interface (GSS-API) [RFC2743] acceptor as a message-passing proxy. (This is completely unrelated to the type of proxy specified in [RFC4120].) The client acts as a GSS-API initiator, and the GSS-API acceptor relays the KDC request and reply messages between the client and the KDC, transitioning to normal [RFC4121] GSS-krb5 messages once the client has obtained the necessary credentials. Consequently, IAKERB as defined in this document requires the use of the GSS-API.

The GSS-API acceptor, when relaying these Kerberos messages, is called an IAKERB proxy.

2. Conventions Used in This Document

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [RFC2119].

3. GSS-API Encapsulation

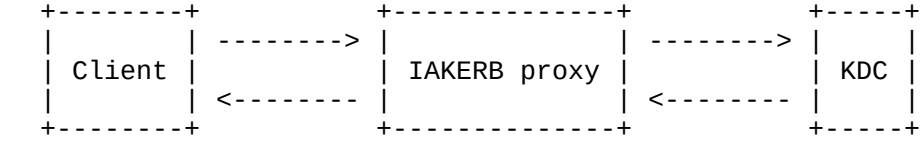
The GSS-API mechanism Objection Identifier (OID) for IAKERB is id-kerberos-iakerb:

```
id-kerberos-iakerb ::=
{ iso(1) org(3) dod(6) internet(1) security(5) kerberosV5(2)
iakerb(5) }
```

All context establishment tokens of IAKERB MUST have the token framing described in section 4.1 of [RFC4121] with the mechanism OID being id-kerberos-iakerb. MIT implemented an earlier draft of this specification; details on how to interoperate with that implementation can be found in Appendix A.

The client starts by constructing a ticket request, as if it is being made directly to the KDC. Instead of contacting the KDC directly, the client encapsulates the request message into the output token of the GSS_Init_security_context() call and returns GSS_S_CONTINUE_NEEDED [RFC2743], indicating that at least one more token is required in order to establish the context. The output

token is then passed over the application protocol for use as the input token to the GSS_Accept_sec_context() call in accordance with GSS-API. The GSS-API acceptor extracts the Kerberos request from the input token, locates the target KDC, and sends the request on behalf of the client. After receiving the KDC reply, the GSS-API acceptor then encapsulates the reply message into the output token of GSS_Accept_sec_context(). The GSS-API acceptor returns GSS_S_CONTINUE_NEEDED [RFC2743] indicating that at least one more token is required in order to establish the context. The output token is passed to the initiator over the application protocol in accordance with GSS-API.



For all context tokens generated by the IAKERB mechanism, the innerToken described in section 4.1 of [RFC4121] has the following format: it starts with a two-octet token-identifier (TOK_ID), which is followed by an IAKERB message or a Kerberos message.

Only one IAKERB specific message, namely the IAKERB_PROXY message, is defined in this document. The TOK_ID values for Kerberos messages are the same as defined in [RFC4121].

Token	TOK_ID Value in Hex
IAKERB_PROXY	05 01

The content of the IAKERB_PROXY message is defined as an IAKERB-HEADER structure immediately followed by a Kerberos message, which is optional. The Kerberos message can be an AS-REQ, an AS-REP, a TGS-REQ, a TGS-REP, or a KRB-ERROR as defined in [RFC4120].

```
IAKERB-HEADER ::= SEQUENCE {
    -- Note that the tag numbers start at 1, not 0, which would
    -- be more conventional for Kerberos.
    target-realm      [1] UTF8String,
       -- The name of the target realm.
    cookie            [2] OCTET STRING OPTIONAL,
       -- Opaque data, if sent by the server,
       -- MUST be copied by the client verbatim into
       -- the next IAKRB_PROXY message.
    ...
}
```

The IAKERB-HEADER structure and all the Kerberos messages MUST be encoded using Abstract Syntax Notation One (ASN.1) Distinguished Encoding Rules (DER) [CCITT.X680.2002] [CCITT.X690.2002].

The client fills out the IAKERB-HEADER structure as follows: the target-realm contains the realm name the ticket request is addressed to. In the initial message from the client, the cookie field is absent. The client MAY send a completely empty IAKERB_PROXY message (consisting solely of the octets 05 01 and an IAKERB_HEADER with zero-length target-realm) in order to query the Kerberos realm of the acceptor, see Section 3.1. In all other cases, the client MUST specify a target-realm. This can be the realm of the client's host, if no other realm information is available. client's host.

Upon receipt of the IAKERB_PROXY message, the GSS-API acceptor inspects the target-realm field in the IAKERB_HEADER, locates a KDC for that realm, and sends the ticket request to that KDC. The IAKERB proxy MAY engage in fallback behavior, retransmitting packets to a given KDC and/or sending the request to other KDCs in that realm if the initial transmission does not receive a reply, as would be done if the proxy was making requests on its own behalf.

The GSS-API acceptor encapsulates the KDC reply message in the returned IAKERB message. It fills out the target realm using the realm sent by the client and the KDC reply message is included immediately following the IAKERB-HEADER header.

When the GSS-API acceptor is unable to obtain an IP address for a KDC in the client's realm, it sends a KRB_ERROR message with the code KRB_AP_ERR_IAKERB_KDC_NOT_FOUND to the client in place of an actual reply from the KDC, and the context fails to establish. There is no accompanying error data defined in this document for this error code.

```
KRB_AP_ERR_IAKERB_KDC_NOT_FOUND      85
    -- The IAKERB proxy could not find a KDC.
```

When the GSS-API acceptor has an IP address for at least one KDC in the target realm, but does not receive a response from any KDC in the realm (including in response to retries), it sends a KRB_ERROR message with the code KRB_AP_ERR_IAKERB_KDC_NO_RESPONSE to the client and the context fails to establish. There is no accompanying error data defined in this document for this error code.

```
KRB_AP_ERR_IAKERB_KDC_NO_RESPONSE    86
    -- The KDC did not respond to the IAKERB proxy.
```

The IAKERB proxy can send opaque data in the cookie field of the IAKERB-HEADER structure in the server reply to the client, in order

to, for example, minimize the amount of state information kept by the GSS-API acceptor. The content and the encoding of the cookie field is a local matter of the IAKERB proxy. Whenever the cookie is present in a token received by the initiator, the initiator MUST copy the cookie verbatim into its subsequent response tokens which contain IAKERB_PROXY messages.

The client and the server can repeat the sequence of sending and receiving the IAKERB messages as described above for an arbitrary number of message exchanges, in order to allow the client to interact with the KDC through the IAKERB proxy, and to obtain Kerberos tickets as needed to authenticate to the acceptor.

Once the client has obtained the service ticket needed to authenticate to the acceptor, subsequent GSS-API context tokens are of type KRB_AP_REQ, not IAKERB_PROXY, and the client performs the client-server application exchange as defined in [RFC4120] and [RFC4121].

For implementations conforming to this specification, both the authenticator subkey and the GSS_EXTS_FINISHED extension as defined in Section 4 MUST be present in the AP-REQ authenticator. This checksum provides integrity protection for the IAKERB messages previously exchanged, including the unauthenticated clear texts in the IAKERB-HEADER structure.

If the pre-authentication data is encrypted in the long-term password-based key of the principal, the risk of security exposures is significant. Implementations SHOULD utilize the AS_REQ armoring as defined in [RFC6113] unless an alternative protection is deployed. In addition, the anonymous Kerberos FAST option is RECOMMENDED for the client to complicate traffic analysis.

3.1. Enterprise principal names

The introduction of principal name canonicalization by [RFC6806] created the possibility for a client to have a principal name (of type NT-ENTERPRISE) for which it is trying to obtain credentials, but no information about what realm’s KDC to contact to obtain those credentials. A Kerberos client not using IAKERB would typically resolve the NT-ENTERPRISE name to a principal name by starting from the realm of the client’s host and finding out the true realm of the enterprise principal based on referrals [RFC6806].

A client using IAKERB may not have any realm information, even for the realm of the client’s host, or may know that the client host’s realm is not appropriate for a given enterprise principal name. In such cases, the client can retrieve the realm of the GSS-API acceptor

as follows: the client returns GSS_S_CONTINUE_NEEDED with the output token containing an IAKERB message with an empty target-realm in the IAKERB-HEADER and no Kerberos message following the IAKERB-HEADER structure. Upon receipt of the realm request, the GSS-API acceptor fills out an IAKERB_PROXY response message, filling the target-realm field with the realm of the acceptor, and returns GSS_S_CONTINUE_NEEDED with the output token containing the IAKERB message with the server's realm and no Kerberos message following the IAKERB-HEADER header. The GSS-API initiator can then use the returned realm in subsequent IAKERB messages to resolve the NT-ENTERPRISE name type. Since the GSS-API acceptor can act as a Kerberos acceptor, it always has an associated Kerberos realm.

4. Finish Message

For implementations conforming to this specification, the authenticator subkey in the AP-REQ MUST alway be present, and the Exts field in the GSS-API authenticator [RFC6542] MUST contain an extension of type GSS_EXTS_FINISHED with extension data containing the ASN.1 DER encoding of the structure KRB-FINISHED.

```
GSS_EXTS_FINISHED             2
     --- Data type for the IAKERB checksum.

KRB-FINISHED ::= {
     -- Note that the tag numbers start at 1, not 0, which would be
     -- more conventional for Kerberos.
     gss-mic [1] Checksum,
         -- Contains the checksum [RFC3961] of the GSS-API tokens
         -- exchanged between the initiator and the acceptor,
         -- and prior to the containing AP_REQ GSS-API token.
         -- The checksum is performed over the GSS-API tokens
         -- exactly as they were transmitted and received,
         -- in the order that the tokens were sent.
      ...
}
```

The gss-mic field in the KRB-FINISHED structure contains a Kerberos checksum [RFC3961] of all the preceding context tokens of this GSS-API context (including the generic token framing of the GSSAPI-Token type from [RFC4121]), concatenated in chronological order (note that GSS-API context token exchanges are synchronous). The checksum type is the required checksum type of the enctype of the subkey in the authenticator, the protocol key for the checksum operation is the authenticator subkey, and the key usage number is KEY_USAGE_FINISHED.

```
KEY_USAGE_FINISHED            41
```

The GSS-API acceptor MUST then verify the checksum contained in the GSS_EXTS_FINISHED extension. This checksum provides integrity protection for the messages exchanged including the unauthenticated clear texts in the IAKERB-HEADER structure.

5. Addresses in Tickets

In IAKERB, the machine sending requests to the KDC is the GSS-API acceptor and not the client. As a result, the client should not include its addresses in any KDC requests for two reasons. First, the KDC may reject the forwarded request as being from the wrong client. Second, in the case of initial authentication for a dial-up client, the client machine may not yet possess a network address. Hence, as allowed by [RFC4120], the addresses field of the AS-REQ and TGS-REQ requests SHOULD be blank.

6. Security Considerations

The IAKERB proxy is a man-in-the-middle for the client's Kerberos exchanges. The Kerberos protocol is designed to be used over an untrusted network, so this is not a critical flaw, but it does expose to the IAKERB proxy all information sent in cleartext over those exchanges, such as the principal names in requests. Since the typical usage involves the client obtaining a service ticket for the service operating the proxy, which will receive the client principal as part of normal authentication, this is also not a serious concern. However, an IAKERB client not using an armored FAST channel [RFC6113] sends an AS_REQ with pre-authentication data encrypted in the long-term keys of the user, even before the acceptor is authenticated. This subjects the user's long-term key to an offline attack by the proxy. To mitigate this threat, the client SHOULD use FAST [RFC6113] and its KDC authentication facility to protect the user's credentials.

Similarly, the client principal name is in cleartext in the AS and TGS exchanges, whereas in the AP exchanges embedded in GSS context tokens for the regular krb5 mechanism, the client principal name is present only in encrypted form. Thus, more information is exposed over the network path between initiator and acceptor when IAKERB is used than when the krb5 mechanism is used, unless FAST armor is employed. (This information would be exposed in other traffic from the initiator when the krb5 mech is used.) As such, to complicate traffic analysis and provide privacy for the client, the client SHOULD request the anonymous Kerberos FAST option [RFC6113].

Similar to other network access protocols, IAKERB allows an unauthenticated client (possibly outside the security perimeter of an organization) to send messages that are proxied to servers inside the

perimeter. To reduce the attack surface, firewall filters can be applied to restrict from which hosts client requests can be proxied, and the proxy can further restrict the set of realms to which requests can be proxied.

In the intended use scenario, the client uses the proxy to obtain a TGT and then a service ticket for the service it is authenticating to (possibly preceeded by exchanges to produce FAST armor). However, the protocol allows arbitrary KDC-REQs to be passed through, and there is no limit to the number of exchanges that may be proxied. The client can send KDC-REQs unrelated to the current authentication, and obtain service tickets for other service principals in the database of the KDC being contacted.

In a scenario where DNS SRV RR's are being used to locate the KDC, IAKERB is being used, and an external attacker can modify DNS responses to the IAKERB proxy, there are several countermeasures to prevent arbitrary messages from being sent to internal servers:

1. KDC port numbers can be statically configured on the IAKERB proxy. In this case, the messages will always be sent to KDC's. For an organization that runs KDC's on a static port (usually port 88) and does not run any other servers on the same port, this countermeasure would be easy to administer and should be effective.

2. The proxy can do application level sanity checking and filtering. This countermeasure should eliminate many of the above attacks.

3. DNS security can be deployed. This countermeasure is probably overkill for this particular problem, but if an organization has already deployed DNS security for other reasons, then it might make sense to leverage it here. Note that Kerberos could be used to protect the DNS exchanges. The initial DNS SRV KDC lookup by the proxy will be unprotected, but an attack here is at most a denial of service (the initial lookup will be for the proxy's KDC to facilitate Kerberos protection of subsequent DNS exchanges between itself and the DNS server).

7. Acknowledgements

Jonathan Trostle, Michael Swift, Bernard Aboba and Glen Zorn wrote earlier revision of this document.

The hallway conversations between Larry Zhu and Nicolas Williams formed the basis of this document.

8. Assigned Numbers

The value for the error code KRB_AP_ERR_IAKERB_KDC_NOT_FOUND is 85.

The value for the error code KRB_AP_ERR_IAKERB_KDC_NO_RESPONSE is 86.

The key usage number KEY_USAGE_FINISHED is 41.

The key usage number KEY_USAGE_IAKERB_FINISHED is 42.

9. IANA Considerations

IANA is requested to make a modification in the "Kerberos GSS-API Token Type Identifiers" registry.

The following data to the table:

ID	Description	Reference
05 01	IAKERB_PROXY	[THIS RFC]

10. References

10.1. Normative References

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International Telephone and Telegraph Consultative Committee, "Abstract Syntax Notation One (ASN.1): Specification of basic notation", CCITT Recommendation X.680, July 2002.

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[RFC6113] Hartman, S. and L. Zhu, "A Generalized Framework for Kerberos Pre-Authentication", RFC 6113, DOI 10.17487/RFC6113, April 2011, <http://www.rfc-editor.org/info/rfc6113>.

[RFC6806] Hartman, S., Ed., Raeburn, K., and L. Zhu, "Kerberos Principal Name Canonicalization and Cross-Realm Referrals", RFC 6806, DOI 10.17487/RFC6806, November 2012, <http://www.rfc-editor.org/info/rfc6806>.

Appendix A. Interoperate with Previous MIT version

MIT implemented an early draft version of this document. This section gives a method for detecting and interoperating with that version.

Initiators behave as follows:

- If the first acceptor token begins with generic token framing as described in section 3.1 of [RFC2743], then use the protocol as defined in this document.

- If the first acceptor token is missing the generic token framing (i.e., the token begins with the two-byte token ID 05 01), then

  * When creating the finish message, the value of one (1) should be used in place of GSS_EXTS_FINISHED.

  * When computing the checksum, the value of KEY_USAGE_IAKERB_FINISHED should be used in place of KEY_USAGE_FINISHED.

    KEY_USAGE_IAKERB_FINISHED 42

Acceptors behave as follows:

- After the first initiator token, allow initiator tokens to omit generic token framing. This allowance is required only for IAKERB_PROXY messages (those using token ID 05 01), not for tokens defined in [RFC4121].

- If the AP-REQ authenticator contains an extension of type 1 containing a KRB-FINISHED message, then process the extension as if it were of type GSS_EXTS_FINISHED, except with a key usage of KEY_USAGE_IAKERB_FINISHED (42) instead of KEY_USAGE_FINISHED (41).

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March 30, 2017

Move Kerberos protocol parameter registries to IANA
draft-ietf-kitten-kerberos-iana-registries-04

Abstract

The Keberos 5 network authentication protocol has several numeric protocol parameters. Most of these parameters are not currently under IANA maintenance. This document requests that IANA take over the maintenance of the remainder of these Kerberos parameters.

Status of This Memo

This Internet-Draft is submitted in full conformance with the provisions of BCP 78 and BCP 79.

Internet-Drafts are working documents of the Internet Engineering Task Force (IETF). Note that other groups may also distribute working documents as Internet-Drafts. The list of current Internet-Drafts is at http://datatracker.ietf.org/drafts/current/.

Internet-Drafts are draft documents valid for a maximum of six months and may be updated, replaced, or obsoleted by other documents at any time. It is inappropriate to use Internet-Drafts as reference material or to cite them other than as "work in progress."

This Internet-Draft will expire on October 1, 2017.

1. Requirements Notation

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [RFC2119].

2. Introduction

The Keberos 5 network authentication protocol[RFC4120][RFC1510] has several numeric protocol parameters. This document requests that IANA take over the maintenance of the Kerberos protocol parameters that are not currently under IANA maintenance. Several instances of number conflicts in Kerberos implementations could have been prevented by having IANA registries for those numbers. This document updates [RFC4120].

3. General registry format

Unless otherwise specified, each Kerberos protocol number registry will have the following fields: "number", "name", "reference", and "comments".

The name must begin with a lowercase letter, and must consist of ASCII letters, digits, and hyphens. Two or more hyphens must not appear directly adjacent to each other. A hyphen must not appear at the end of a name. It is preferred that words in a name be separated by hyphens, and that all of the letters be lowercase.

(These rules are consistent with the lexical rules for an ASN.1 valuereference or identifier. Where the constraints are stricter than the ASN.1 lexical rules, they make it easier to systematically transform the names for use in implementation languages.)

Names for numeric parameter values have no inherent meaning in the Kerberos protocol, but they can guide choices for internal implementation symbol names and for user-visible non-numeric representations. When written in English prose in specifications, or when used as symbolic constants in implementation languages (e.g., C preprocessor macros), it is common to transform the name into all uppercase letters, and possibly to replace hyphens with underscores.

4. General registration procedure

This document requests that the IESG establish a pool of Kerberos experts who will manage the Kerberos registries using these guidelines. The IESG may wish to consider including the set of designated IANA experts for existing Kerberos IANA registries as candidates for this pool.

IANA will select an expert from this pool for each registration request. The expert will review the registration request and may approve the registration, decline the registration with comments, or recommend that the registration request should follow a specific alternative process. The alternative processes that the expert may recommend are the IETF review process and the standards action process.

Initially, the expert reviewers will use a permissive process, generally approving registrations that are architecturally consistent with Kerberos and the protocol parameter in question. Over time, with input from the community, the experts may refine the requirements that registrations are expected to meet. The experts will maintain a current version of these guidelines in a manner that is generally accessible to the entire community. As the guidelines evolve, experts may consider the technical quality of specifications, security impacts of the registrations, architectural consistency, and interoperability impact. Experts may require a publicly available specification in order to make certain registrations.

[For the individual registries, include "Registrations in this registry are managed by the expert review process [RFC5226] or in exceptional cases by IESG approval. See section x for guidelines for the experts to be used with this registry."]

5. Integer assignments

Names for integer assignments must be unique across all Kerberos integer parameter registries. This is normally accomplished by including a name prefix that identifies the registry.

Assignments for integers parameters will follow the general registration procedure outlined above, except as otherwise noted in the section that contains the description of the parameter. Kerberos integer parameters take on signed 32-bit values (-2147483648 to 2147483647). Negative values are for private or local use.

5.1. Address types

Registry name: Address types

Assignment policy: General registration procedure

Valid values: Signed 32-bit integers

Address types historically align with numeric constants used in the Berkeley sockets API. Future address type assignments should conform

to this historical practice when possible. The name prefix for address types is "addrtype-".

5.2. Authorization data types

Registry name: Authorization data types

Assignment policy: General registration procedure

Valid values: Signed 32-bit integers

The name prefix for authorization data types is "ad-".

5.3. Error codes

Registry name: Error codes

Assignment policy: Standards action

Valid values: Signed 32-bit integers

Assignments for error codes require standards action due to their scarcity: assigning error codes greater than 127 could require significant changes to certain implementations. The name prefixes for error codes are "kdc-err-", "krb-err-", and "krb-ap-err-".

5.4. Key usages

Registry name: Key usages

Assignment policy: General registration procedure

Valid values: Unsigned 32-bit integers

Key usages are unsigned 32-bit integers (0 to 4294967295). Zero is reserved and may not be assigned.

The name prefix for key usages is "ku-".

5.5. Name types

Registry name: Name types

Assignment policy: General registration procedure

Valid values: Signed 32-bit integers

The name prefix for name types is "nt-".

number	name	reference	comment
0	nt-unknown	RFC4120	Name type not known
1	nt-principal	RFC4120	Just the name of the principal as in DCE, or for users
2	nt-srv-inst	RFC4120	Service and other unique instance (krbtgt)
3	nt-srv-hst	RFC4120	Service with host name as instance (telnet, rcommands)
4	nt-srv-xhst	RFC4120	Service with host as remaining components
5	nt-uid	RFC4120	Unique ID
6	nt-x500-principal	RFC4120	Encoded X.509 Distinguished name [RFC2253]
7	nt-smtp-name	RFC4120	Name in form of SMTP email name (e.g., user@example.com)
10	nt-enterprise	RFC4120	Enterprise name - may be mapped to principal name
11	nt-wellknown	RFC6111	Well-known principal name
12	nt-srv-hst-domain	RFC5179	Domain-based names

5.6. Pre-authentication and typed data

Registry name: Pre-authentication and typed data

Assignment policy: General registration procedure

Valid values: Signed 32-bit integers

This document requests that IANA modify the existing Kerberos Pre-authentication and typed data registry to be consistent with the procedures in this document.

The name prefix for pre-authentication type numbers is "pa-". The name prefix for typed data numbers is "td-". Pre-authentication and typed data numbers are in the same registry, but a pre-authentication number may be also be assigned to a related typed data number.

6. Named bit assignments

Assignments for named bits require standards action, due to their scarcity: assigning bit numbers greater than 31 could require significant changes to implementations. Names for named bit assignments must be unique within a given named bit registry, and typically do not have name prefixes that identify which registry they belong to.

6.1. AP-REQ options

Registry name: AP-REQ options

Assignment policy: Standards action

Valid values: ASN.1 bit numbers 0 through 31

6.2. KDC-REQ options

Registry name: KDC-REQ options

Assignment policy: Standards action

Valid values: ASN.1 bit numbers 0 through 31

6.3. Ticket flags

Registry name: Ticket flags

Assignment policy: Standards action

Valid values: ASN.1 bit numbers 0 through 31

7. Numbers that will not be registered

ASN.1 application tag numbers (which are always equal to the "msg-type" field in Kerberos messages where they appear) will not be registered. Any Kerberos protocol change that requires a new application tag number will be a sufficiently major change that the specification of the change MUST define a new ASN.1 module and MUST be Standards Track.

Transited encoding values will not be registered. There is only one transited encoding type for the Kerberos protocol. The interoperability concerns inherent to the cross-realm operation of Kerberos mean that specifications of new transited encoding types are very unlikely. Any specification of new transited encoding types MUST be Standards Action.

Protocol version number (pvno) values will not be registered. The location of the "pvno" value in Kerberos messages is not in a place that implementations can meaningfully use to distinguish among different variants of the Kerberos protocol.

8. Contributors

Sam Hartman proposed the text of the expert review guidelines. Love Hornquist Astrand wrote a previous document (draft-lha-krb-wg-some-numbers-to-iana-00) with the same goals as this document.

9. Acknowledgments

Thanks to Tom Petch for providing useful feedback on previous versions of this document.

10. Security Considerations

Assignments of new Keberos protocol parameter values can have security implications. In cases where the assignment policy calls for expert review, the reviewer is responsible for evaluating whether adequate documentation exists concerning the security considerations for the requested assignment. For assignments that require IETF review or standards action, the normal IETF processes ensure adequate treatment of security considerations.

11. IANA Considerations

This document requests that IANA create several registries for Kebreros protocol parameters:

- Address types
- Authorization data types
- Error codes
- Key usages
- Name types
- AP-REQ options
- KDC-REQ options
- Ticket flags

This document requests that IANA modify the existing "Pre-authentication data and typed data" registry to contain an additional reference to this document, and to transform existing names in that registry to the lowercase-and-hyphens style.

12. Open issues

Do we make a registry for application tag numbers (equal to message type numbers)? We've said that we would replace the entire ASN.1 module in that case, but Nico's recent proposal doesn't do that, and if we want to accommodate that sort of proposal, it would probably be best to establish a registry. (It should require standards action for registrations.)

Do transited encodings need a registry? They would probably require standards action, even if there were a registry.

13. References

13.1. Normative References

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, DOI 10.17487/RFC2119, March 1997, <http://www.rfc-editor.org/info/rfc2119>.

[RFC3961] Raeburn, K., "Encryption and Checksum Specifications for Kerberos 5", RFC 3961, DOI 10.17487/RFC3961, February 2005, <http://www.rfc-editor.org/info/rfc3961>.

[RFC4120] Neuman, C., Yu, T., Hartman, S., and K. Raeburn, "The Kerberos Network Authentication Service (V5)", RFC 4120, DOI 10.17487/RFC4120, July 2005, <http://www.rfc-editor.org/info/rfc4120>.

[RFC5226] Narten, T. and H. Alvestrand, "Guidelines for Writing an IANA Considerations Section in RFCs", BCP 26, RFC 5226, DOI 10.17487/RFC5226, May 2008, <http://www.rfc-editor.org/info/rfc5226>.

13.2. Informative References

[RFC1510] Kohl, J. and C. Neuman, "The Kerberos Network Authentication Service (V5)", RFC 1510, DOI 10.17487/RFC1510, September 1993, <http://www.rfc-editor.org/info/rfc1510>.

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Authentication Indicator in Kerberos Tickets
draft-ietf-kitten-krb-auth-indicator-07

Abstract

This document updates RFC 4120 in order to specify an extension in the Kerberos protocol. It defines a new authorization data type AD-AUTHENTICATION-INDICATOR. The purpose of introducing this data type is to include an indicator of the strength of a client's authentication in service tickets so that application services can use it as an input into policy decisions.

Status of This Memo

This Internet-Draft is submitted in full conformance with the provisions of BCP 78 and BCP 79.

Internet-Drafts are working documents of the Internet Engineering Task Force (IETF). Note that other groups may also distribute working documents as Internet-Drafts. The list of current Internet-Drafts is at http://datatracker.ietf.org/drafts/current/.

Internet-Drafts are draft documents valid for a maximum of six months and may be updated, replaced, or obsoleted by other documents at any time. It is inappropriate to use Internet-Drafts as reference material or to cite them other than as "work in progress."

This Internet-Draft will expire on August 13, 2017.

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Table of Contents

1. Introduction

Kerberos [RFC4120] allows secure interaction among users and services over a network. It supports a variety of authentication mechanisms using its pre-authentication framework [RFC6113]. The Kerberos authentication service has been architected to support password-based authentication as well as multi-factor authentication using one-time password devices, public-key cryptography and other pre-authentication schemes. Implementations that offer pre-authentication mechanisms supporting significantly different strengths of client authentication may choose to keep track of the strength of the authentication that was used, for use as an input into policy decisions.

This document specifies a new authorization data type to convey authentication strength information to application services. Elements of this type appear within an AD-CAMMAC (authorization data type Container Authenticated by Multiple Message Authentication Codes) [RFC7751] container.

2. Document Conventions

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in RFC 2119 [RFC2119].

3. AD Type Specification

The Key Distribution Center (KDC) MAY include authorization data of ad-type 97, wrapped in AD-CAMMAC, in initial credentials. The KDC MAY copy it from a ticket-granting ticket into service tickets.

The corresponding ad-data field contains the DER encoding [X.690] of the following ASN.1 [X.680] type:

```
AD-AUTHENTICATION-INDICATOR ::= SEQUENCE OF UTF8String
```

Each UTF8String value is a short string that indicates that a particular set of requirements was met during the initial authentication. These strings are intended to be compared against known values. They are not intended to store structured data. Each string MUST be either:

* A URI which references a Level of Assurance Profile [RFC6711]

* A site-defined string, which MUST NOT contain a colon, whose meaning is determined by the realm administrator.

Authorization data elements of type AD-AUTHENTICATION-INDICATOR MUST be included in an AD-CAMMAC container so that their contents can be verified as originating from the KDC. Elements of type AD-AUTHENTICATION-INDICATOR MAY safely be ignored by applications and KDCs that do not implement this element.

4. Assigned Numbers

RFC 4120 [RFC4120] is updated in the following way:

- The ad-type number 97 is assigned for AD-AUTHENTICATION-INDICATOR, updating the table in Section 7.5.4 of RFC 4120 [RFC4120].

- The table in Section 5.2.6 of RFC 4120 [RFC4120] is updated to map the ad-type 97 to "DER encoding of AD-AUTHENTICATION-INDICATOR".

5. Security Considerations

Elements of type AD-AUTHENTICATION-INDICATOR are wrapped in AD-CAMMAC containers. AD-CAMMAC supersedes AD-KDC-ISSUED, and allows both application services and the KDC to verify the authenticity of the contained authorization data.

KDC implementations MUST use AD-CAMMAC verifiers as described in the the security considerations of RFC 7751 [RFC7751] to ensure that AD-AUTHENTICATION-INDICATOR elements are not modified by an attacker.

Application servers MUST validate the AD-CAMMAC container before making authorization decisions based on AD-AUTHENTICATION-INDICATOR elements. Application servers MUST NOT make authorization decisions based on AD-AUTHENTICATION-INDICATOR elements which appear outside of AD-CAMMAC containers.

Using multiple strings in AD-AUTHENTICATION-INDICATOR may lead to ambiguity when a service tries to make a decision based on the AD-AUTHENTICATION-INDICATOR values. This ambiguity can be avoided if indicator values are always used as a positive indication of certain requirements being met during the initial authentication. For example, if a "without-password" indicator is inserted whenever authentication occurs without a password, a service might assume this is an indication that a higher-strength client authentication occurred. However, this indicator might also be inserted when no authentication occurred at all (such as anonymous PKINIT).

Service evaluation of site-defined indicators MUST consider the realm of original authentication in order to avoid cross-realm indicator collisions. Failure to enforce this property can result in invalid authorization.

6. IANA Considerations

This document has no actions for IANA.

7. References

7.1. Normative References

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, DOI 10.17487/RFC2119, March 1997, <http://www.rfc-editor.org/info/rfc2119>.

[RFC4120] Neuman, C., Yu, T., Hartman, S., and K. Raeburn, "The Kerberos Network Authentication Service (V5)", RFC 4120, DOI 10.17487/RFC4120, July 2005, <http://www.rfc-editor.org/info/rfc4120>.

[RFC6113] Hartman, S. and L. Zhu, "A Generalized Framework for Kerberos Pre-Authentication", RFC 6113, DOI 10.17487/RFC6113, April 2011, <http://www.rfc-editor.org/info/rfc6113>.

[RFC7751] Sorce, S. and T. Yu, "Kerberos Authorization Data Container Authenticated by Multiple Message Authentication Codes (MACs)", RFC 7751, DOI 10.17487/RFC7751, March 2016, <http://www.rfc-editor.org/info/rfc7751>.

[X.680] ITU-T, "Information technology -- Abstract Syntax Notation One (ASN.1): Specification of basic notation -- ITU-T Recommendation X.680 (ISO/IEC International Standard 8824-1:2008)", 2008.

[X.690] ITU-T, "Information technology -- ASN.1 encoding rules: Specification of Basic Encoding Rules (BER), Canonical Encoding Rules (CER) and Distinguished Encoding Rules (DER) -- ITU-T Recommendation X.690 (ISO/IEC International Standard 8825-1:2008)", 2008.

7.2. Informative References

[RFC6711] Johansson, L., "An IANA Registry for Level of Assurance (LoA) Profiles", RFC 6711, DOI 10.17487/RFC6711, August 2012, <http://www.rfc-editor.org/info/rfc6711>.

Appendix A. ASN.1 Module

```
KerberosV5AuthenticationIndicators {
        iso(1) identified-organization(3) dod(6) internet(1)
        security(5) kerberosV5(2) modules(4)
        authentication-indicators(9)
} DEFINITIONS EXPLICIT TAGS ::= BEGIN

AD-AUTHENTICATION-INDICATOR ::= SEQUENCE OF UTF8String

END
```

Appendix B. Acknowledgements

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PKINIT Algorithm Agility
draft-ietf-kitten-pkinit-alg-agility-08

Abstract

This document updates the Public Key Cryptography for Initial Authentication in Kerberos standard (PKINIT) [RFC4556], to remove protocol structures tied to specific cryptographic algorithms. The PKINIT key derivation function is made negotiable, and the digest algorithms for signing the pre-authentication data and the client's X.509 certificates are made discoverable.

These changes provide preemptive protection against vulnerabilities discovered in the future against any specific cryptographic algorithm, and allow incremental deployment of newer algorithms.

Table of Contents

1. Introduction

The Public Key Cryptography for Initial Authentication in Kerberos (PKINIT) standard [RFC4556] defines several protocol structures that are either tied to SHA-1 [RFC6234], or do not support negotiation or discovery, but are instead based on local policy:

- The checksum algorithm in the authentication request is hardwired to use SHA-1.
- The acceptable digest algorithms for signing the authentication data are not discoverable.
- The key derivation function in Section 3.2.3.1 of [RFC4556] is hardwired to use SHA-1.
- The acceptable digest algorithms for signing the client X.509 certificates are not discoverable.

In August 2004, Xiaoyun Wang's research group reported MD4 [RFC6150] collisions generated using hand calculation [WANG04], alongside attacks on later hash function designs in the MD4, MD5 [RFC1321] and SHA [RFC6234] family. These attacks and their consequences are discussed in [RFC6194]. These discoveries challenged the security of protocols relying on the collision resistance properties of these hashes.

The Internet Engineering Task Force (IETF) called for actions to update existing protocols to provide crypto algorithm agility so that protocols support multiple cryptographic algorithms (including hash functions) and provide clean, tested transition strategies between algorithms, as recommended by BCP 201 [RFC7696].

To address these concerns, new key derivation functions (KDFs), identified by object identifiers, are defined. The PKINIT client provides a list of KDFs in the request and the Key Distribution Center (KDC) picks one in the response, thus a mutually-supported KDF is negotiated.

Furthermore, structures are defined to allow the client to discover the Cryptographic Message Syntax (CMS) [RFC5652] digest algorithms supported by the KDC for signing the pre-authentication data and signing the client X.509 certificate.

2. Requirements Notation

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in BCP 14 [RFC2119] [RFC8174] when, and only when, they appear in all capitals, as shown here.

3. paChecksum Agility

The paChecksum defined in Section 3.2.1 of [RFC4556] provides a cryptographic binding between the client's pre-authentication data and the corresponding Kerberos request body. This also prevents the KDC-REQ body from being tampered with. SHA-1 is the only allowed checksum algorithm defined in [RFC4556]. This facility relies on the collision resistance properties of the SHA-1 checksum [RFC6234].

When the reply key delivery mechanism is based on public key encryption as described in Section 3.2.3.2 of [RFC4556], the asChecksum in the KDC reply provides the binding between the pre-authentication and the ticket request and response messages, and integrity protection for the unauthenticated clear text in these messages. However, if the reply key delivery mechanism is based on the Diffie-Hellman key agreement as described in Section 3.2.3.1 of [RFC4556], the security provided by using SHA-1 in the paChecksum is weak, and nothing else cryptographically binds the AS request to the ticket response. In this case, the new KDF selected by the KDC as described in Section 6 provides the cryptographic binding and integrity protection.

4. CMS Digest Algorithm Agility

Section 3.2.2 of [RFC4556] is updated to add optional typed data to the KDC_ERR_DIGEST_IN_SIGNED_DATA_NOT_ACCEPTED error. When a KDC implementation conforming to this specification returns this error code, it MAY include in a list of supported CMS types signifying the digest algorithms supported by the KDC, in the decreasing preference order. This is accomplished by including a TD_CMS_DATA_DIGEST_ALGORITHMS typed data element in the error data.

```
td-cms-digest-algorithms INTEGER ::= 111
```

The corresponding data for the TD_CMS_DATA_DIGEST_ALGORITHMS contains the ASN.1 Distinguished Encoding Rules (DER) [X680] [X690] encoded TD-CMS-DIGEST-ALGORITHMS-DATA structure defined as follows:

```
TD-CMS-DIGEST-ALGORITHMS-DATA ::= SEQUENCE OF
    AlgorithmIdentifier
        -- Contains the list of CMS algorithm [RFC5652]
        -- identifiers indicating the digest algorithms
        -- acceptable to the KDC for signing CMS data in
        -- the order of decreasing preference.
```

The algorithm identifiers in the TD-CMS-DIGEST-ALGORITHMS identifiy digest algorithms supported by the KDC.

This information sent by the KDC via TD_CMS_DATA_DIGEST_ALGORITHMS can facilitate trouble-shooting when none of the digest algorithms supported by the client is supported by the KDC.

5. X.509 Certificate Signer Algorithm Agility

Section 3.2.2 of [RFC4556] is updated to add optional typed data to the KDC_ERR_DIGEST_IN_CERT_NOT_ACCEPTED error. When a KDC conforming to this specification returns this error, it MAY send a list of digest algorithms acceptable to the KDC for use by the Certificate Authority (CA) in signing the client's X.509 certificate, in the decreasing preference order. This is accomplished by including a TD_CERT_DIGEST_ALGORITHMS typed data element in the error data. The corresponding data contains the ASN.1 DER encoding of the structure TD-CERT-DIGEST-ALGORITHMS-DATA defined as follows:

```
td-cert-digest-algorithms INTEGER ::= 112

TD-CERT-DIGEST-ALGORITHMS-DATA ::= SEQUENCE {
        allowedAlgorithms [0] SEQUENCE OF AlgorithmIdentifier,
                    -- Contains the list of CMS algorithm [RFC5652]
                    -- identifiers indicating the digest algorithms
                    -- that are used by the CA to sign the client's
                    -- X.509 certificate and are acceptable to the KDC
                    -- in the process of validating the client's X.509
                    -- certificate, in the order of decreasing
                    -- preference.
        rejectedAlgorithm [1] AlgorithmIdentifier OPTIONAL,
                    -- This identifies the digest algorithm that was
                    -- used to sign the client's X.509 certificate and
                    -- has been rejected by the KDC in the process of
                    -- validating the client's X.509 certificate
                    -- [RFC5280].
        ...
}
```

The KDC fills in the allowedAlgorithm field with the list of algorithm [RFC5652] identifiers indicating digest algorithms that are used by the CA to sign the client's X.509 certificate and are acceptable to the KDC in the process of validating the client's X.509 certificate, in the order of decreasing preference. The rejectedAlgorithm field identifies the signing algorithm for use in signing the client's X.509 certificate that has been rejected by the KDC in the process of validating the client's certificate [RFC5280].

6. KDF agility

Section 3.2.3.1 of [RFC4556] is updated to define additional Key Derivation Functions (KDFs) to derive a Kerberos protocol key based on the secret value generated by the Diffie-Hellman key exchange. Section 3.2.1 of [RFC4556] is updated to add a new field to the AuthPack structure to indicate which new KDFs are supported by the client. Section 3.2.3 of [RFC4556] is updated to add a new field to the DHRepInfo structure to indicate which KDF is selected by the KDC.

The KDF algorithm described in this document (based on [SP80056A]) can be implemented using any cryptographic hash function.

A new KDF for PKINIT usage is identified by an object identifier. The following KDF object identifiers are defined:

```
id-pkinit OBJECT IDENTIFIER ::=
         { iso(1) identified-organization(3) dod(6) internet(1)
           security(5) kerberosv5(2) pkinit (3) }
    -- Defined in RFC 4556 and quoted here for the reader.

id-pkinit-kdf OBJECT IDENTIFIER      ::= { id-pkinit kdf(6) }
    -- PKINIT KDFs

id-pkinit-kdf-ah-sha1 OBJECT IDENTIFIER
    ::= { id-pkinit-kdf sha1(1) }
    -- SP800-56A ASN.1 structured hash-based KDF using SHA-1

id-pkinit-kdf-ah-sha256 OBJECT IDENTIFIER
    ::= { id-pkinit-kdf sha256(2) }
    -- SP800-56A ASN.1 structured hash-based KDF using SHA-256

id-pkinit-kdf-ah-sha512 OBJECT IDENTIFIER
    ::= { id-pkinit-kdf sha512(3) }
    -- SP800-56A ASN.1 structured hash-based KDF using SHA-512

id-pkinit-kdf-ah-sha384 OBJECT IDENTIFIER
    ::= { id-pkinit-kdf sha384(4) }
    -- SP800-56A ASN.1 structured hash-based KDF using SHA-384
```

Where id-pkinit is defined in [RFC4556]. All key derivation functions specified above use the one-step key derivation method described in Section 5.8.2.1 of [SP80056A], using the ASN.1 format for FixedInfo, and Section 4.1 of [SP80056C], using option 1 for the auxiliary function H. id-pkinit-kdf-ah-sha1 uses SHA-1 [RFC6234] as the hash function. id-pkinit-kdf-ah-sha256, id-pkinit-kdf-ah-sha356, and id-pkinit-kdf-ah-sha512 use SHA-256 [RFC6234], SHA-384 ([RFC6234] and SHA-512 [RFC6234] respectively.

To name the input parameters, an abbreviated version of the key derivation method is described below.

1. reps = ceiling(L/H_outputBits)

2. Initialize a 32-bit, big-endian bit string counter as 1.

3. For i = 1 to reps by 1, do the following:

    1. Compute Hashi = H(counter || Z || OtherInfo).

    2. Increment counter (not to exceed 2^32-1)

4. Set key_material = Hash1 || Hash2 || ... so that the length of key_material is L bits, truncating the last block as necessary.

5. The above KDF produces a bit string of length L in bits as the keying material. The AS reply key is the output of random-to-key() [RFC3961] using that keying material as the input.

The input parameters for these KDFs are provided as follows:

- H_outputBits is 160 bits for id-pkinit-kdf-ah-sha1, 256 bits for id-pkinit-kdf-ah-sha256, 384 bits for id-pkinit-kdf-ah-sha384, and 512 bits for id-pkinit-kdf-ah-sha512.

- max_H_inputBits is 2^64.

- The secret value (Z) is the shared secret value generated by the Diffie-Hellman exchange. The Diffie-Hellman shared value is first padded with leading zeros such that the size of the secret value in octets is the same as that of the modulus, then represented as a string of octets in big-endian order.

- The key data length (L) is the key-generation seed length in bits [RFC3961] for the Authentication Service (AS) reply key. The enctype of the AS reply key is selected according to [RFC4120].

- The algorithm identifier (algorithmID) input parameter is the identifier of the respective KDF. For example, this is id-pkinit-kdf-ah-sha1 if the KDF uses SHA-1 as the hash.

- The initiator identifier (partyUInfo) contains the ASN.1 DER encoding of the KRB5PrincipalName [RFC4556] that identifies the client as specified in the AS-REQ [RFC4120] in the request.

- The recipient identifier (partyVInfo) contains the ASN.1 DER encoding of the KRB5PrincipalName [RFC4556] that identifies the TGS as specified in the AS-REQ [RFC4120] in the request.

- The supplemental public information (suppPubInfo) is the ASN.1 DER encoding of the structure PkinitSuppPubInfo as defined later in this section.

- The supplemental private information (suppPrivInfo) is absent.

OtherInfo is the ASN.1 DER encoding of the following sequence:

```
OtherInfo ::= SEQUENCE {
        algorithmID   AlgorithmIdentifier,
        partyUInfo     [0] OCTET STRING,
        partyVInfo     [1] OCTET STRING,
        suppPubInfo    [2] OCTET STRING OPTIONAL,
        suppPrivInfo   [3] OCTET STRING OPTIONAL
}
```

The structure PkinitSuppPubInfo is defined as follows:

```
PkinitSuppPubInfo ::= SEQUENCE {
       enctype           [0] Int32,
           -- The enctype of the AS reply key.
       as-REQ            [1] OCTET STRING,
           -- The DER encoding of the AS-REQ [RFC4120] from the
           -- client.
       pk-as-rep         [2] OCTET STRING,
           -- The DER encoding of the PA-PK-AS-REP [RFC4556] in the
           -- KDC reply.
       ...
}
```

The PkinitSuppPubInfo structure contains mutually-known public information specific to the authentication exchange. The enctype field is the enctype of the AS reply key as selected according to [RFC4120]. The as-REQ field contains the DER encoding of the type AS-REQ [RFC4120] in the request sent from the client to the KDC. Note that the as-REQ field does not include the wrapping 4 octet length field when TCP is used. The pk-as-rep field contains the DER encoding of the type PA-PK-AS-REP [RFC4556] in the KDC reply. The PkinitSuppPubInfo provides a cryptographic bindings between the pre-authentication data and the corresponding ticket request and response, thus addressing the concerns described in Section 3.

The KDF is negotiated between the client and the KDC. The client sends an unordered set of supported KDFs in the request, and the KDC picks one from the set in the reply.

To accomplish this, the AuthPack structure in [RFC4556] is extended as follows:

```
AuthPack ::= SEQUENCE {
       pkAuthenticator   [0] PKAuthenticator,
       clientPublicValue [1] SubjectPublicKeyInfo OPTIONAL,
       supportedCMSTypes [2] SEQUENCE OF AlgorithmIdentifier
                OPTIONAL,
       clientDHNonce     [3] DHNonce OPTIONAL,
       ...,
       supportedKDFs     [4] SEQUENCE OF KDFAlgorithmId OPTIONAL,
           -- Contains an unordered set of KDFs supported by the
           -- client.
       ...
}

KDFAlgorithmId ::= SEQUENCE {
       kdf-id            [0] OBJECT IDENTIFIER,
           -- The object identifier of the KDF
       ...
}
```

The new field supportedKDFs contains an unordered set of KDFs supported by the client.

The KDFAlgorithmId structure contains an object identifier that identifies a KDF. The algorithm of the KDF and its parameters are defined by the corresponding specification of that KDF.

The DHRepInfo structure in [RFC4556] is extended as follows:

```
DHRepInfo ::= SEQUENCE {
        dhSignedData         [0] IMPLICIT OCTET STRING,
        serverDHNonce        [1] DHNonce OPTIONAL,
        ...,
        kdf                  [2] KDFAlgorithmId OPTIONAL,
            -- The KDF picked by the KDC.
        ...
}
```

The new field kdf in the extended DHRepInfo structure identifies the KDF picked by the KDC. If the supportedKDFs field is present in the request, a KDC conforming to this specification MUST choose one of the KDFs supported by the client and indicate its selection in the kdf field in the reply. If the supportedKDFs field is absent in the request, the KDC MUST omit the kdf field in the reply and use the key derivation function from Section 3.2.3.1 of [RFC4556]. If none of the KDFs supported by the client is acceptable to the KDC, the KDC MUST reply with the new error code KDC_ERR_NO_ACCEPTABLE_KDF:

- KDC_ERR_NO_ACCEPTABLE_KDF 100

If the client fills the supportedKDFs field in the request, but the kdf field in the reply is not present, the client can deduce that the KDC is not updated to conform with this specification, or that the exchange was subjected to a downgrade attack. It is a matter of local policy on the client whether to reject the reply when the kdf field is absent in the reply; if compatibility with non-updated KDCs is not a concern, the reply should be rejected.

Implementations conforming to this specification MUST support id-pkinit-kdf-ah-sha256.

7. Interoperability

An old client interoperating with a new KDC will not recognize a TD-CMS-DIGEST-ALGORITHMS-DATA element in a KDC_ERR_DIGEST_IN_SIGNED_DATA_NOT_ACCEPTED error, or a TD-CERT-DIGEST-ALGORITHMS-DATA element in a KDC_ERR_DIGEST_IN_CERT_NOT_ACCEPTED error. Because the error data is encoded as typed data, the client will ignore the unrecognized elements.

An old KDC interoperating with a new client will not include a TD-CMS-DIGEST-ALGORITHMS-DATA element in a KDC_ERR_DIGEST_IN_SIGNED_DATA_NOT_ACCEPTED error, or a TD-CERT-DIGEST-ALGORITHMS-DATA element in a KDC_ERR_DIGEST_IN_CERT_NOT_ACCEPTED error. To the client this appears just as if a new KDC elected not to include a list of digest algorithms.

An old client interoperating with a new KDC will not include the supportedKDFs field in the request. The KDC MUST omit the kdf field in the reply and use the [RFC4556] KDF as expected by the client, or reject the request if local policy forbids use of the old KDF.

A new client interoperating with an old KDC will include the supportedKDFs field in the request; this field will be ignored as an unknown extension by the KDC. The KDC will omit the kdf field in the reply and will use the [RFC4556] KDF. The client can deduce from the omitted kdf field that the KDC is not updated to conform to this specification, or that the exchange was subjected to a downgrade attack. The client MUST use the [RFC4556] KDF, or reject the reply if local policy forbids the use of the old KDF.

8. Test vectors

This section contains test vectors for the KDF defined above.

8.1. Common Inputs

Z: Length = 256 bytes, Hex Representation = (All Zeros)
00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000
00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000
00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000
00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000
00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000
00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000
00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000
00000000 00000000 00000000 00000000 00000000 00000000 00000000 00000000

client: Length = 9 bytes, ASCII Representation = lha@SU.SE

server: Length = 18 bytes, ASCII Representation = krbtgt/SU.SE@SU.SE

as-req: Length = 10 bytes, Hex Representation =
AAAAAAAA AAAAAAAA AAAA

pk-as-rep: Length = 9 bytes, Hex Representation =
BBBBBBBB BBBBBBBB BB

ticket: Length = 55 bytes, Hex Representation =
61353033 A0030201 05A1071B 0553552E 5345A210 300EA003 020101A1 0730051B
036C6861 A311300F A0030201 12A20804 0668656A 68656A

8.2. Test Vector for SHA-1, enctype 18

8.2.1. Specific Inputs

algorithm-id: (id-pkinit-kdf-ah-sha1) Length = 8 bytes, Hex Representation = 2B060105 02030601

enctype: (aes256-cts-hmac-sha1-96) Length = 1 byte, Decimal Representation = 18

8.2.2. Outputs

key-material: Length = 32 bytes, Hex Representation =
E6AB38C9 413E035B B079201E D0B6B73D 8D49A814 A737C04E E6649614 206F73AD

key: Length = 32 bytes, Hex Representation =
E6AB38C9 413E035B B079201E D0B6B73D 8D49A814 A737C04E E6649614 206F73AD

8.3. Test Vector for SHA-256, enctype

8.3.1. Specific Inputs

algorithm-id: (id-pkinit-kdf-ah-sha256) Length = 8 bytes, Hex Representation = 2B060105 02030602

enctype: (aes256-cts-hmac-sha1-96) Length = 1 byte, Decimal Representation = 18

8.3.2. Outputs

key-material: Length = 32 bytes, Hex Representation =
77EF4E48 C420AE3F EC75109D 7981697E ED5D295C 90C62564 F7BFD101 FA9bC1D5

key: Length = 32 bytes, Hex Representation =
77EF4E48 C420AE3F EC75109D 7981697E ED5D295C 90C62564 F7BFD101 FA9bC1D5

8.4. Test Vector for SHA-512, enctype

8.4.1. Specific Inputs

algorithm-id: (id-pkinit-kdf-ah-sha512) Length = 8 bytes, Hex Representation = 2B060105 02030603

enctype: (des3-cbc-sha1-kd) Length = 1 byte, Decimal Representation = 16

8.4.2. Outputs

key-material: Length = 24 bytes, Hex Representation =
D3C78A79 D65213EF E9A826F7 5DFB01F7 2362FB16 FB01DAD6

key: Length = 32 bytes, Hex Representation =
D3C78A79 D65213EF E9A826F7 5DFB01F7 2362FB16 FB01DAD6

9. Security Considerations

This document describes negotiation of checksum types, key derivation functions and other cryptographic functions. If a given negotiation is unauthenticated, care must be taken to accept only secure values; to do otherwise allows an active attacker to perform a downgrade attack.

The discovery method described in Section 4 uses a Kerberos error message, which is unauthenticated in a typical exchange. An attacker may attempt to downgrade a client to a weaker CMS type by forging a KDC_ERR_DIGEST_IN_SIGNED_DATA_NOT_ACCEPTED error. It is a matter of local policy whether a client accepts a downgrade to a weaker CMS type, and whether the KDC accepts the weaker CMS type. A client may reasonably assume that the real KDC implements all hash functions used in the client's X.509 certificate, and refuse attempts to downgrade to weaker hash functions.

The discovery method described in Section 5 also uses a Kerberos error message. An attacker may attempt to downgrade a client to a certificate using a weaker signing algorithm by forging a KDC_ERR_DIGEST_IN_CERT_NOT_ACCEPTED error. It is a matter of local policy whether a client accepts a downgrade to a weaker certificate, and whether the KDC accepts the weaker certificate. This attack is only possible if the client device possesses multiple client certificates of varying strength.

In the KDF negotiation method described in Section 6, the client supportedKDFs value is protected by the signature on the signedAuthPack field in the request. If this signature algorithm is weak to collision attacks, an attacker may attempt to downgrade the negotiation by substituting an AuthPack with a different or absent supportedKDFs value, using a PKINIT freshness token [RFC8070] to partially control the legitimate AuthPack value. A client performing anonymous PKINIT [RFC8062] does not sign the AuthPack, so an attacker can easily remove the supportedKDFs value in this case. Finally, the kdf field in the DHRepInfo of the KDC response is unauthenticated, so could be altered or removed by an attacker, although this alteration will likely result in a decryption failure by the client rather than a successful downgrade. It is a matter of local policy whether a client accepts a downgrade to the old KDF, and whether the KDC allows the use of the old KDF.

The paChecksum field, which binds the client pre-authentication data to the Kerberos request body, remains fixed at SHA-1. If an attacker substitutes a different request body using an attack against SHA-1 (a second preimage attack is likely required as the attacker does not control any part of the legitimate request body), the KDC will not

detect the substitution. Instead, if a new KDF is negotiated, the client will detect the substitution by failing to decrypt the reply.

An attacker may attempt to impersonate the KDC to the client via an attack on the hash function used in the dhSignedData signature, substituting the attacker's subjectPublicKey for the legitimate one without changing the hash value. It is a matter of local policy which hash function the KDC uses in its signature and which hash functions the client will accept in the KDC signature. A KDC may reasonably assume that the client implements all hash functions used in the KDF algorithms listed the supportedKDFs field of the request.

10. Acknowledgements

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11. IANA Considerations

IANA is requested to update the following registrations in the Kerberos Pre-authentication and Typed Data Registry created by section 7.1 of RFC 6113 to refer to this specification. These values were reserved for this specification in the initial registrations.

TD-CMS-DIGEST-ALGORITHMS	111	[ALG-AGILITY]
TD-CERT-DIGEST-ALGORITHMS	112	[ALG-AGILITY]

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12.1. Normative References

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Appendix A. PKINIT ASN.1 Module

```
KerberosV5-PK-INIT-Agility-SPEC {
       iso(1) identified-organization(3) dod(6) internet(1)
       security(5) kerberosV5(2) modules(4) pkinit(5) agility (1)
} DEFINITIONS EXPLICIT TAGS ::= BEGIN

IMPORTS
   AlgorithmIdentifier, SubjectPublicKeyInfo
       FROM PKIX1Explicit88 { iso (1)
         identified-organization (3) dod (6) internet (1)
         security (5) mechanisms (5) pkix (7) id-mod (0)
```

```
            id-pkix1-explicit (18) }
            -- As defined in RFC 5280.

       Ticket, Int32, Realm, EncryptionKey, Checksum
           FROM KerberosV5Spec2 { iso(1) identified-organization(3)
             dod(6) internet(1) security(5) kerberosV5(2)
             modules(4) krb5spec2(2) }
             -- as defined in RFC 4120.

       PKAuthenticator, DHNonce, id-pkinit
           FROM KerberosV5-PK-INIT-SPEC {
             iso(1) identified-organization(3) dod(6) internet(1)
             security(5) kerberosV5(2) modules(4) pkinit(5) };
             -- as defined in RFC 4556.

   id-pkinit-kdf OBJECT IDENTIFIER      ::= { id-pkinit kdf(6) }
       -- PKINIT KDFs

   id-pkinit-kdf-ah-sha1 OBJECT IDENTIFIER
       ::= { id-pkinit-kdf sha1(1) }
       -- SP800-56A ASN.1 structured hash-based KDF using SHA-1

   id-pkinit-kdf-ah-sha256 OBJECT IDENTIFIER
       ::= { id-pkinit-kdf sha256(2) }
       -- SP800-56A ASN.1 structured hash-based KDF using SHA-256

   id-pkinit-kdf-ah-sha512 OBJECT IDENTIFIER
       ::= { id-pkinit-kdf sha512(3) }
       -- SP800-56A ASN.1 structured hash-based KDF using SHA-512

   id-pkinit-kdf-ah-sha384 OBJECT IDENTIFIER
       ::= { id-pkinit-kdf sha384(4) }
       -- SP800-56A ASN.1 structured hash-based KDF using SHA-384

   TD-CMS-DIGEST-ALGORITHMS-DATA ::= SEQUENCE OF
       AlgorithmIdentifier
           -- Contains the list of CMS algorithm [RFC5652]
           -- identifiers indicating the digest algorithms
           -- acceptable to the KDC for signing CMS data in
           -- the order of decreasing preference.

   TD-CERT-DIGEST-ALGORITHMS-DATA ::= SEQUENCE {
          allowedAlgorithms [0] SEQUENCE OF AlgorithmIdentifier,
              -- Contains the list of CMS algorithm [RFC5652]
              -- identifiers indicating the digest algorithms
              -- that are used by the CA to sign the client's
              -- X.509 certificate and are acceptable to the KDC
              -- in the process of validating the client's X.509
```

```
            -- certificate, in the order of decreasing
            -- preference.
        rejectedAlgorithm [1] AlgorithmIdentifier OPTIONAL,
            -- This identifies the digest algorithm that was
            -- used to sign the client's X.509 certificate and
            -- has been rejected by the KDC in the process of
            -- validating the client's X.509 certificate
            -- [RFC5280].
        ...
}

OtherInfo ::= SEQUENCE {
        algorithmID   AlgorithmIdentifier,
        partyUInfo     [0] OCTET STRING,
        partyVInfo     [1] OCTET STRING,
        suppPubInfo    [2] OCTET STRING OPTIONAL,
        suppPrivInfo   [3] OCTET STRING OPTIONAL
}

PkinitSuppPubInfo ::= SEQUENCE {
        enctype           [0] Int32,
            -- The enctype of the AS reply key.
        as-REQ            [1] OCTET STRING,
            -- The DER encoding of the AS-REQ [RFC4120] from the
            -- client.
        pk-as-rep         [2] OCTET STRING,
            -- The DER encoding of the PA-PK-AS-REP [RFC4556] in the
            -- KDC reply.
        ...
}

AuthPack ::= SEQUENCE {
        pkAuthenticator   [0] PKAuthenticator,
        clientPublicValue [1] SubjectPublicKeyInfo OPTIONAL,
        supportedCMSTypes [2] SEQUENCE OF AlgorithmIdentifier
                  OPTIONAL,
        clientDHNonce     [3] DHNonce OPTIONAL,
        ...,
        supportedKDFs     [4] SEQUENCE OF KDFAlgorithmId OPTIONAL,
            -- Contains an unordered set of KDFs supported by the
            -- client.
        ...
}

KDFAlgorithmId ::= SEQUENCE {
        kdf-id            [0] OBJECT IDENTIFIER,
            -- The object identifier of the KDF
        ...
```

```
   }

   DHRepInfo ::= SEQUENCE {
          dhSignedData      [0] IMPLICIT OCTET STRING,
          serverDHNonce     [1] DHNonce OPTIONAL,
          ...,
          kdf               [2] KDFAlgorithmId OPTIONAL,
              -- The KDF picked by the KDC.
          ...
   }
   END
```

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Public Key Cryptography for Initial Authentication in Kerberos (PKINIT) Freshness Extension
draft-ietf-kitten-pkinit-freshness-07

Abstract

This document describes how to further extend the Public Key Cryptography for Initial Authentication in Kerberos (PKINIT) extension [RFC4556] to exchange an opaque data blob that a KDC can validate to ensure that the client is currently in possession of the private key during a PKINIT AS exchange.

Status of This Memo

This Internet-Draft is submitted in full conformance with the provisions of BCP 78 and BCP 79.

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This Internet-Draft will expire on November 24, 2016.

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Table of Contents

1. Introduction

The Kerberos PKINIT extension [RFC4556] defines two schemes for using asymmetric cryptography in a Kerberos preauthenticator. One uses Diffie-Hellman key exchange and the other depends on public key encryption. The public key encryption scheme is less commonly used for two reasons:

- Elliptic Curve Cryptography (ECC) Support for PKINIT [RFC5349] only specified Elliptic Curve Diffie-Hellman (ECDH) key agreement, so it cannot be used for public key encryption.

- Public key encryption requires certificates with an encryption key, that is not deployed on many existing smart cards.

In the Diffie-Hellman exchange, the client uses its private key only to sign the AuthPack structure (specified in Section 3.2.1 of [RFC4556]), that is performed before any traffic is sent to the KDC. Thus a client can generate requests with future times in the PKAuthenticator, and then send those requests at those future times. Unless the time is outside the validity period of the client's certificate, the KDC will validate the PKAuthenticator and return a TGT the client can use without possessing the private key.

As a result, a client performing PKINIT with the Diffie-Hellman key exchange does not prove current possession of the private key being used for authentication. It proves only prior use of that key. Ensuring that the client has current possession of the private key requires that the signed PKAuthenticator data include information that the client could not have predicted.

1.1. Kerberos message flow using KRB_AS_REQ without pre-authentication

Today, password-based AS exchanges [RFC4120] often begin with the client sending a KRB_AS_REQ without pre-authentication. When the principal requires pre-authentication, the KDC responds with a KRB_ERROR containing information needed to complete an AS exchange, such as the supported encryption types and salt values. This message flow is illustrated below:

```
KDC                     Client

               <----    AS-REQ without pre-authentication
KRB-ERROR      ---->

               <----    AS-REQ
AS-REP         ---->

               <----    TGS-REQ
TGS-REP        ---->
```

Figure 1

We can use a similar message flow with PKINIT, allowing the KDC to provide a token for the client to include in its KRB_AS_REQ to ensure that the PA_PK_AS_REQ [RFC4556] was not pregenerated.

1.2. Requirements Language

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in RFC 2119 [RFC2119].

2. Message Exchanges

The following summarizes the message flow with extensions to [RFC4120] and [RFC4556] required to support a KDC-provided freshness token during the initial request for a ticket:

1. The client generates a KRB_AS_REQ as specified in Section 2.9.3 of [RFC4120] that contains no PA_PK_AS_REQ and includes a freshness token request.

2. The KDC generates a KRB_ERROR as specified in Section 3.1.3 of [RFC4120] providing a freshness token.

3. The client receives the error as specified in Section 3.1.4 of [RFC4120], extracts the freshness token, and includes it as part of the KRB_AS_REQ as specified in [RFC4120] and [RFC4556].

4. The KDC receives and validates the KRB_AS_REQ as specified in Section 3.2.2 of [RFC4556], then additionally validates the freshness token.

5. The KDC and client continue as specified in [RFC4120] and [RFC4556].

2.1. Generation of KRB_AS_REQ Message

The client indicates support of freshness tokens by adding a padata element with padata-type PA_AS_FRESHNESS and padata-value of an empty octet string.

2.2. Generation of KRB_ERROR Message

The KDC will respond with a KRB_ERROR [RFC4120] message with the error-code KDC_ERR_PREAUTH_REQUIRED [RFC4120] adding a padata element with padata-type PA_AS_FRESHNESS and padata-value of the freshness token to the METHOD-DATA object.

2.3. Generation of KRB_AS_REQ Message

After the client receives the KRB-ERROR message containing a freshness token, it extracts the PA_AS_FRESHNESS padata-value field of the PA-DATA structure as an opaque data blob. The PA_AS_FRESHNESS padata-value field of the PA-DATA structure SHALL then be added as an opaque blob in the freshnessToken field when the client generates the PKAuthenticator specified in Section 4 for the PA_PK_AS_REQ message. This ensures that the freshness token value will be included in the signed data portion of the KRB_AS_REQ value.

2.4. Receipt of KRB_AS_REQ Message

If the realm requires freshness and the PA_PK_AS_REQ message does not contain the freshness token, the KDC MUST return a KRB_ERROR [RFC4120] message with the error-code KDC_ERR_PREAUTH_FAILED [RFC4120] with a padata element with padata-type PA_AS_FRESHNESS and padata-value of the freshness token to the METHOD-DATA object.

When the PA_PK_AS_REQ message contains a freshness token, after validating the PA_PK_AS_REQ message normally, the KDC will validate

the freshnessToken value in the PKAuthenticator in an implementation-specific way. If the freshness token is not valid, the KDC MUST return a KRB_ERROR [RFC4120] message with the error-code KDC_ERR_PREAUTH_EXPIRED [RFC6113]. The e-data field of the error contains a METHOD-DATA object [RFC4120] which specifies a valid PA_AS_FRESHNESS padata-value. Since the freshness tokens are validated by KDCs in the same realm, standardizing the contents of the freshness token is not a concern for interoperability.

2.5. Receipt of second KRB_ERROR Message

If a client receives a KDC_ERR_PREAUTH_EXPIRED KRB_ERROR message that includes a freshness token, it SHOULD retry using the new freshness token.

3. PreAuthentication Data Types

The following are the new PreAuthentication data types:

Padata and Data Type	Padata-type Value
PA_AS_FRESHNESS	150

4. Extended PKAuthenticator

The PKAuthenticator structure specified in Section 3.2.1 of [RFC4556] is extended to include a new freshnessToken as follows:

```
PKAuthenticator ::= SEQUENCE {
   cusec        [0] INTEGER (0..999999),
   ctime        [1] KerberosTime,
             -- cusec and ctime are used as in [RFC4120], for
             -- replay prevention.
   nonce        [2] INTEGER (0..4294967295),
             -- Chosen randomly;  this nonce does not need to
             -- match with the nonce in the KDC-REQ-BODY.
   paChecksum   [3] OCTET STRING OPTIONAL,
             -- MUST be present.
             -- Contains the SHA1 checksum, performed over
             -- KDC-REQ-BODY.
   ...,
   freshnessToken     [4] OCTET STRING OPTIONAL,
             -- PA_AS_FRESHNESS padata value as recieved from the
             -- KDC. MUST be present if sent by KDC
   ...
}
```

5. Acknowledgements

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6. IANA Considerations

IANA is requested to assign numbers for PA_AS_FRESHNESS listed in the Kerberos Parameters registry Pre-authentication and Typed Data as follows:

Type	Value	Reference
150	PA_AS_FRESHNESS	[This RFC]

7. Security Considerations

The freshness token SHOULD include signing, encrypting or sealing data from the KDC to determine authenticity and prevent tampering.

Freshness tokens serve to guarantee that the client had the key when constructing the AS-REQ. They are not required to be single use tokens or bound to specific AS exchanges. Part of the reason the token is opaque is to allow KDC implementers the freedom to add additional functionality as long as the "freshness" guarantee remains.

8. Interoperability Considerations

Since the client treats the KDC-provided data blob as opaque, changing the contents will not impact existing clients. Thus extensions to the freshness token do not impact client interoperability.

Clients SHOULD NOT reuse freshness tokens across multiple exchanges. There is no guarantee that a KDC will allow a once-valid token to be used again. Thus clients that do not retry with a new freshness token may not be compatible with KDCs, depending on how they choose to implement freshness validation.

Since upgrading clients takes time, implementers may consider allowing both freshness-token based exchanges and "legacy" exchanges without use of freshness tokens. However, until freshness tokens are required by the realm, the existing risks of pre-generated PKAuthenticators will remain.

9. Normative References

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Generic Security Service API Version 2: Java Bindings Update
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Abstract

The Generic Security Services Application Program Interface (GSS-API) offers application programmers uniform access to security services atop a variety of underlying cryptographic mechanisms. This document updates the Java bindings for the GSS-API that are specified in "Generic Security Service API Version 2 : Java Bindings Update" (RFC 5653). This document obsoletes RFC 5653 by adding a new output token field to the GSSException class so that when the initSecContext or acceptSecContext methods of the GSSContext class fails it has a chance to emit an error token which can be sent to the peer for debugging or informational purpose. The stream-based GSSContext methods are also removed in this version.

The GSS-API is described at a language-independent conceptual level in "Generic Security Service Application Program Interface Version 2, Update 1" (RFC 2743). The GSS-API allows a caller application to authenticate a principal identity, to delegate rights to a peer, and to apply security services such as confidentiality and integrity on a per-message basis. Examples of security mechanisms defined for GSS-API are "The Simple Public-Key GSS-API Mechanism" (RFC 2025) and "The Kerberos Version 5 Generic Security Service Application Program Interface (GSS-API) Mechanism: Version 2" (RFC 4121).

Status of This Memo

This Internet-Draft is submitted in full conformance with the provisions of BCP 78 and BCP 79.

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time. It is inappropriate to use Internet-Drafts as reference material or to cite them other than as "work in progress."

This Internet-Draft will expire on August 13, 2018.

Table of Contents

1. Introduction

This document specifies Java language bindings for the Generic Security Services Application Programming Interface version 2 (GSS-API). GSS-API version 2 is described in a language-independent format in RFC 2743 [RFC2743]. The GSS-API allows a caller application to authenticate a principal identity, to delegate rights to a peer, and to apply security services such as confidentiality and integrity on a per-message basis.

This document and its predecessor, RFC 2853 [RFC2853] and RFC 5653 [RFC5653], leverage the work done by the working group (WG) in the area of RFC 2743 [RFC2743] and the C-bindings of RFC 2744 [RFC2744]. Whenever appropriate, text has been used from the C-bindings document (RFC 2744) to explain generic concepts and provide direction to the implementors.

The design goals of this API have been to satisfy all the functionality defined in RFC 2743 [RFC2743] and to provide these services in an object-oriented method. The specification also aims to satisfy the needs of both types of Java application developers, those who would like access to a "system-wide" GSS-API implementation, as well as those who would want to provide their own "custom" implementation.

A system-wide implementation is one that is available to all applications in the form of a library package. It may be the standard package in the Java runtime environment (JRE) being used or it may be additionally installed and accessible to any application via the CLASSPATH.

A custom implementation of the GSS-API, on the other hand, is one that would, in most cases, be bundled with the application during distribution. It is expected that such an implementation would be

meant to provide for some particular need of the application, such as support for some specific mechanism.

The design of this API also aims to provide a flexible framework to add and manage GSS-API mechanisms. GSS-API leverages the Java Cryptography Architecture (JCA) provider model to support the plugability of mechanisms. Mechanisms can be added on a system-wide basis, where all users of the framework will have them available. The specification also allows for the addition of mechanisms per-instance of the GSS-API.

Lastly, this specification presents an API that will naturally fit within the operation environment of the Java platform. Readers are assumed to be familiar with both the GSS-API and the Java platform.

2. Notational Conventions

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in BCP 14 [RFC2119] [RFC8174] when, and only when, they appear in all capitals, as shown here.

3. GSS-API Operational Paradigm

"Generic Security Service Application Programming Interface, Version 2" [RFC2743] defines a generic security API to calling applications. It allows a communicating application to authenticate the user associated with another application, to delegate rights to another application, and to apply security services such as confidentiality and integrity on a per-message basis.

There are four stages to using GSS-API:

1) The application acquires a set of credentials with which it may prove its identity to other processes. The application’s credentials vouch for its global identity, which may or may not be related to any local username under which it may be running.

2) A pair of communicating applications establish a joint security context using their credentials. The security context encapsulates shared state information, which is required in order that per-message security services may be provided. Examples of state information that might be shared between applications as part of a security context are cryptographic keys and message sequence numbers. As part of the establishment of a security context, the context initiator is authenticated to the responder, and may require that the responder is authenticated back to the

initiator. The initiator may optionally give the responder the right to initiate further security contexts, acting as an agent or delegate of the initiator. This transfer of rights is termed "delegation", and is achieved by creating a set of credentials, similar to those used by the initiating application, but which may be used by the responder.

A GSSContext object is used to establish and maintain the shared information that makes up the security context. Certain GSSContext methods will generate a token, which applications treat as cryptographically protected, opaque data. The caller of such a GSSContext method is responsible for transferring the token to the peer application, encapsulated if necessary in an application-to-application protocol. On receipt of such a token, the peer application should pass it to a corresponding GSSContext method which will decode the token and extract the information, updating the security context state information accordingly.

3) Per-message services are invoked on a GSSContext object to apply either:

integrity and data origin authentication, or

confidentiality, integrity and data origin authentication

to application data, which are treated by GSS-API as arbitrary octet-strings. An application transmitting a message that it wishes to protect will call the appropriate GSSContext method (getMIC or wrap) to apply protection, and send the resulting token to the receiving application. The receiver will pass the received token (and, in the case of data protected by getMIC, the accompanying message-data) to the corresponding decoding method of the GSSContext interface (verifyMIC or unwrap) to remove the protection and validate the data.

4) At the completion of a communications session (which may extend across several transport connections), each application uses a GSSContext method to invalidate the security context and release any system or cryptographic resources held. Multiple contexts may also be used (either successively or simultaneously) within a single communications association, at the discretion of the applications.

4. Additional Controls

This section discusses the OPTIONAL services that a context initiator may request of the GSS-API before the context establishment. Each of these services is requested by calling the appropriate mutator method

in the GSSContext object before the first call to init is performed. Only the context initiator can request context flags.

The OPTIONAL services defined are:

Delegation: The (usually temporary) transfer of rights from initiator to acceptor, enabling the acceptor to authenticate itself as an agent of the initiator.

Mutual Authentication: In addition to the initiator authenticating its identity to the context acceptor, the context acceptor SHOULD also authenticate itself to the initiator.

Replay Detection: In addition to providing message integrity services, GSSContext per-message operations of getMIC and wrap SHOULD include message numbering information to enable verifyMIC and unwrap to detect if a message has been duplicated.

Out-of-Sequence Detection: In addition to providing message integrity services, GSSContext per-message operations (getMIC and wrap) SHOULD include message sequencing information to enable verifyMIC and unwrap to detect if a message has been received out of sequence.

Anonymous Authentication: The establishment of the security context SHOULD NOT reveal the initiator’s identity to the context acceptor.

Some mechanisms may not support all OPTIONAL services, and some mechanisms may only support some services in conjunction with others. The GSSContext interface offers query methods to allow the verification by the calling application of which services will be available from the context when the establishment phase is complete. In general, if the security mechanism is capable of providing a requested service, it SHOULD do so even if additional services must be enabled in order to provide the requested service. If the mechanism is incapable of providing a requested service, it SHOULD proceed without the service leaving the application to abort the context establishment process if it considers the requested service to be mandatory.

Some mechanisms MAY specify that support for some services is optional, and that implementors of the mechanism need not provide it. This is most commonly true of the confidentiality service, often because of legal restrictions on the use of data-encryption, but may apply to any of the services. Such mechanisms are required to send at least one token from acceptor to initiator during context establishment when the initiator indicates a desire to use such a

service, so that the initiating GSS-API can correctly indicate whether the service is supported by the acceptor's GSS-API.

4.1. Delegation

The GSS-API allows delegation to be controlled by the initiating application via the requestCredDeleg method before the first call to init has been issued. Some mechanisms do not support delegation, and for such mechanisms, attempts by an application to enable delegation are ignored.

The acceptor of a security context, for which the initiator enabled delegation, can check if delegation was enabled by using the getCredDelegState method of the GSSContext interface. In cases when it is enabled, the delegated credential object can be obtained by calling the getDelegCred method. The obtained GSSCredential object may then be used to initiate subsequent GSS-API security contexts as an agent or delegate of the initiator. If the original initiator's identity is "A" and the delegate's identity is "B", then, depending on the underlying mechanism, the identity embodied by the delegated credential may be either "A" or "B acting for A".

For many mechanisms that support delegation, a simple boolean does not provide enough control. Examples of additional aspects of delegation control that a mechanism might provide to an application are duration of delegation, network addresses from which delegation is valid, and constraints on the tasks that may be performed by a delegate. Such controls are presently outside the scope of the GSS-API. GSS-API implementations supporting mechanisms offering additional controls SHOULD provide extension routines that allow these controls to be exercised (perhaps by modifying the initiator's GSS-API credential object prior to its use in establishing a context). However, the simple delegation control provided by GSS-API SHOULD always be able to override other mechanism-specific delegation controls. If the application instructs the GSSContext object that delegation is not desired, then the implementation MUST NOT permit delegation to occur. This is an exception to the general rule that a mechanism may enable services even if they are not requested -- delegation may only be provided at the explicit request of the application.

4.2. Mutual Authentication

Usually, a context acceptor will require that a context initiator authenticate itself so that the acceptor may make an access-control decision prior to performing a service for the initiator. In some cases, the initiator may also request that the acceptor authenticate itself. GSS-API allows the initiating application to request this

mutual authentication service by calling the requestMutualAuth method of the GSSContext interface with a "true" parameter before making the first call to init. The initiating application is informed as to whether or not the context acceptor has authenticated itself. Note that some mechanisms may not support mutual authentication, and other mechanisms may always perform mutual authentication, whether or not the initiating application requests it. In particular, mutual authentication may be required by some mechanisms in order to support replay or out-of-sequence message detection, and for such mechanisms, a request for either of these services will automatically enable mutual authentication.

4.3. Replay and Out-of-Sequence Detection

The GSS-API MAY provide detection of mis-ordered messages once a security context has been established. Protection MAY be applied to messages by either application, by calling either getMIC or wrap methods of the GSSContext interface, and verified by the peer application by calling verifyMIC or unwrap for the peer's GSSContext object.

The getMIC method calculates a cryptographic checksum (authentication tag) of an application message, and returns that checksum in a token. The application SHOULD pass both the token and the message to the peer application, which presents them to the verifyMIC method of the peer's GSSContext object.

The wrap method calculates a cryptographic checksum of an application message, and places both the checksum and the message inside a single token. The application SHOULD pass the token to the peer application, which presents it to the unwrap method of the peer's GSSContext object to extract the message and verify the checksum.

Either pair of routines may be capable of detecting out-of-sequence message delivery or the duplication of messages. Details of such mis-ordered messages are indicated through supplementary query methods of the MessageProp object that is filled in by each of these routines.

A mechanism need not maintain a list of all tokens that have been processed in order to support these status codes. A typical mechanism might retain information about only the most recent "N" tokens processed, allowing it to distinguish duplicates and missing tokens within the most recent "N" messages; the receipt of a token older than the most recent "N" would result in the isOldToken method of the instance of MessageProp to return "true".

4.4. Anonymous Authentication

In certain situations, an application may wish to initiate the authentication process to authenticate a peer, without revealing its own identity. As an example, consider an application providing access to a database containing medical information and offering unrestricted access to the service. A client of such a service might wish to authenticate the service (in order to establish trust in any information retrieved from it), but might not wish the service to be able to obtain the client's identity (perhaps due to privacy concerns about the specific inquiries, or perhaps simply to avoid being placed on mailing-lists).

In normal use of the GSS-API, the initiator's identity is made available to the acceptor as a result of the context establishment process. However, context initiators may request that their identity not be revealed to the context acceptor. Many mechanisms do not support anonymous authentication, and for such mechanisms, the request will not be honored. An authentication token will still be generated, but the application is always informed if a requested service is unavailable, and has the option to abort context establishment if anonymity is valued above the other security services that would require a context to be established.

In addition to informing the application that a context is established anonymously (via the isAnonymous method of the GSSContext class), the getSrcName method of the acceptor's GSSContext object will, for such contexts, return a reserved internal-form name, defined by the implementation.

The toString method for a GSSName object representing an anonymous entity will return a printable name. The returned value will be syntactically distinguishable from any valid principal name supported by the implementation. The associated name-type object identifier will be an oid representing the value of NT_ANONYMOUS. This name-type oid will be defined as a public, static Oid object of the GSSName class. The printable form of an anonymous name SHOULD be chosen such that it implies anonymity, since this name may appear in, for example, audit logs. For example, the string "<anonymous>" might be a good choice, if no valid printable names supported by the implementation can begin with "<" and end with ">".

When using the equal method of the GSSName interface, and one of the operands is a GSSName instance representing an anonymous entity, the method MUST return "false".

4.5. Integrity and Confidentiality

If a GSSContext supports the integrity service, getMic method may be used to create message integrity check tokens on application messages.

If a GSSContext supports the confidentiality service, wrap method may be used to encrypt application messages. Messages are selectively encrypted, under the control of the setPrivacy method of the MessageProp object used in the wrap method. Confidentiality will be applied if the privacy state is set to true.

4.6. Inter-process Context Transfer

GSS-APIv2 provides functionality that allows a security context to be transferred between processes on a single machine. These are implemented using the export method of GSSContext and a byte array constructor of the same class. The most common use for such a feature is a client-server design where the server is implemented as a single process that accepts incoming security contexts, which then launches child processes to deal with the data on these contexts. In such a design, the child processes must have access to the security context object created within the parent so that they can use per-message protection services and delete the security context when the communication session ends.

Since the security context data structure is expected to contain sequencing information, it is impractical in general to share a context between processes. Thus, the GSSContext interface provides an export method that the process, which currently owns the context, can call to declare that it has no intention to use the context subsequently, and to create an inter-process token containing information needed by the adopting process to successfully recreate the context. After successful completion of export, the original security context is made inaccessible to the calling process by GSS-API, and any further usage of this object will result in failures. The originating process transfers the inter-process token to the adopting process, which creates a new GSSContext object using the byte array constructor. The properties of the context are equivalent to that of the original context.

The inter-process token MAY contain sensitive data from the original security context (including cryptographic keys). Applications using inter-process tokens to transfer security contexts MUST take appropriate steps to protect these tokens in transit.

Implementations are not required to support the inter-process transfer of security contexts. Calling the isTransferable method of

the GSSContext interface will indicate if the context object is transferable.

4.7. The Use of Incomplete Contexts

Some mechanisms may allow the per-message services to be used before the context establishment process is complete. For example, a mechanism may include sufficient information in its initial context-level tokens for the context acceptor to immediately decode messages protected with wrap or getMIC. For such a mechanism, the initiating application need not wait until subsequent context-level tokens have been sent and received before invoking the per-message protection services.

An application can invoke the isProtReady method of the GSSContext class to determine if the per-message services are available in advance of complete context establishment. Applications wishing to use per-message protection services on partially established contexts SHOULD query this method before attempting to invoke wrap or getMIC.

5. Calling Conventions

Java provides the implementors with not just a syntax for the language, but also an operational environment. For example, memory is automatically managed and does not require application intervention. These language features have allowed for a simpler API and have led to the elimination of certain GSS-API functions.

Moreover, the JCA defines a provider model that allows for implementation-independent access to security services. Using this model, applications can seamlessly switch between different implementations and dynamically add new services. The GSS-API specification leverages these concepts by the usage of providers for the mechanism implementations.

5.1. Package Name

The classes and interfaces defined in this document reside in the package called "org.ietf.jgss". Applications that wish to make use of this API should import this package name as shown in section 8.

5.2. Provider Framework

The Java security API’s use a provider architecture that allows applications to be implementation independent and security API implementations to be modular and extensible. The java.security.Provider class is an abstract class that a vendor extends. This class maps various properties that represent different

security services that are available to the names of the actual vendor classes that implement those services. When requesting a service, an application simply specifies the desired provider and the API delegates the request to service classes available from that provider.

Using the Java security provider model insulates applications from implementation details of the services they wish to use. Applications can switch between providers easily and new providers can be added as needed, even at runtime.

The GSS-API may use providers to find components for specific underlying security mechanisms. For instance, a particular provider might contain components that will allow the GSS-API to support the Kerberos v5 mechanism [RFC4121] and another might contain components to support the Simple Public-Key GSS-API Mechanism (SPKM) [RFC2025]. By delegating mechanism-specific functionality to the components obtained from providers, the GSS-API can be extended to support an arbitrary list of mechanism.

How the GSS-API locates and queries these providers is beyond the scope of this document and is being deferred to a Service Provider Interface (SPI) specification. The availability of such an SPI specification is not mandatory for the adoption of this API specification nor is it mandatory to use providers in the implementation of a GSS-API framework. However, by using the provider framework together with an SPI specification, one can create an extensible and implementation-independent GSS-API framework.

5.3. Integer Types

All numeric values are declared as "int" primitive Java type. The Java specification guarantees that this will be a 32-bit two’s complement signed number.

Throughout this API, the "boolean" primitive Java type is used wherever a boolean value is required or returned.

5.4. Opaque Data Types

Java byte arrays are used to represent opaque data types that are consumed and produced by the GSS-API in the form of tokens. Java arrays contain a length field that enables the users to easily determine their size. The language has automatic garbage collection that alleviates the need by developers to release memory and simplifies buffer ownership issues.

5.5. Strings

The String object will be used to represent all textual data. The Java String object transparently treats all characters as two-byte Unicode characters, which allows support for many locals. All routines returning or accepting textual data will use the String object.

5.6. Object Identifiers

An Oid object will be used to represent Universal Object Identifiers (Oids). Oids are ISO-defined, hierarchically globally interpretable identifiers used within the GSS-API framework to identify security mechanisms and name formats. The Oid object can be created from a string representation of its dot notation (e.g., "1.3.6.1.5.6.2") as well as from its ASN.1 DER encoding. Methods are also provided to test equality and provide the DER representation for the object.

An important feature of the Oid class is that its instances are immutable -- i.e., there are no methods defined that allow one to change the contents of an Oid. This property allows one to treat these objects as "statics" without the need to perform copies.

Certain routines allow the usage of a default oid. A "null" value can be used in those cases.

5.7. Object Identifier Sets

The Java bindings represent object identifier sets as arrays of Oid objects. All Java arrays contain a length field, which allows for easy manipulation and reference.

In order to support the full functionality of RFC 2743 [RFC2743], the Oid class includes a method that checks for existence of an Oid object within a specified array. This is equivalent in functionality to gss_test_oid_set_member. The use of Java arrays and Java’s automatic garbage collection has eliminated the need for the following routines: gss_create_empty_oid_set, gss_release_oid_set, and gss_add_oid_set_member. Java GSS-API implementations will not contain them. Java’s automatic garbage collection and the immutable property of the Oid object eliminates the memory management issues of the C counterpart.

Whenever a default value for an Object Identifier Set is required, a "null" value can be used. Please consult the detailed method description for details.

5.8. Credentials

GSS-API credentials are represented by the GSSCredential interface. The interface contains several constructs to allow for the creation of most common credential objects for the initiator and the acceptor. Comparisons are performed using the interface's "equals" method. The following general description of GSS-API credentials is included from the C-bindings specification:

> GSS-API credentials can contain mechanism-specific principal authentication data for multiple mechanisms. A GSS-API credential is composed of a set of credential-elements, each of which is applicable to a single mechanism. A credential may contain at most one credential-element for each supported mechanism. A credential-element identifies the data needed by a single mechanism to authenticate a single principal, and conceptually contains two credential-references that describe the actual mechanism-specific authentication data, one to be used by GSS-API for initiating contexts, and one to be used for accepting contexts. For mechanisms that do not distinguish between acceptor and initiator credentials, both references would point to the same underlying mechanism-specific authentication data.

Credentials describe a set of mechanism-specific principals, and give their holder the ability to act as any of those principals. All principal identities asserted by a single GSS-API credential SHOULD belong to the same entity, although enforcement of this property is an implementation-specific matter. A single GSSCredential object represents all the credential elements that have been acquired.

The creation of an GSSContext object allows the value of "null" to be specified as the GSSCredential input parameter. This will indicate a desire by the application to act as a default principal. While individual GSS-API implementations are free to determine such default behavior as appropriate to the mechanism, the following default behavior by these routines is RECOMMENDED for portability:

For the initiator side of the context:

1) If there is only a single principal capable of initiating security contexts for the chosen mechanism that the application is authorized to act on behalf of, then that principal shall be used; otherwise,

2) If the platform maintains a concept of a default network-identity for the chosen mechanism, and if the application is authorized to act on behalf of that identity for the purpose of initiating

security contexts, then the principal corresponding to that identity shall be used; otherwise,

3) If the platform maintains a concept of a default local identity, and provides a means to map local identities into network-identities for the chosen mechanism, and if the application is authorized to act on behalf of the network-identity image of the default local identity for the purpose of initiating security contexts using the chosen mechanism, then the principal corresponding to that identity shall be used; otherwise,

4) A user-configurable default identity should be used.

For the acceptor side of the context:

1) If there is only a single authorized principal identity capable of accepting security contexts for the chosen mechanism, then that principal shall be used; otherwise,

2) If the mechanism can determine the identity of the target principal by examining the context-establishment token processed during the accept method, and if the accepting application is authorized to act as that principal for the purpose of accepting security contexts using the chosen mechanism, then that principal identity shall be used; otherwise,

3) If the mechanism supports context acceptance by any principal, and if mutual authentication was not requested, any principal that the application is authorized to accept security contexts under using the chosen mechanism may be used; otherwise,

4) A user-configurable default identity shall be used.

The purpose of the above rules is to allow security contexts to be established by both initiator and acceptor using the default behavior whenever possible. Applications requesting default behavior are likely to be more portable across mechanisms and implementations than ones that instantiate an GSSCredential object representing a specific identity.

5.9. Contexts

The GSSContext interface is used to represent one end of a GSS-API security context, storing state information appropriate to that end of the peer communication, including cryptographic state information. The instantiation of the context object is done differently by the initiator and the acceptor. After the context has been instantiated, the initiator MAY choose to set various context options that will

determine the characteristics of the desired security context. When all the application-desired characteristics have been set, the initiator will call the initSecContext method, which will produce a token for consumption by the peer's acceptSecContext method. It is the responsibility of the application to deliver the authentication token(s) between the peer applications for processing. Upon completion of the context-establishment phase, context attributes can be retrieved, by both the initiator and acceptor, using the accessor methods. These will reflect the actual attributes of the established context and might not match the initiator-requested values. If any retrieved attribute does not match the desired value but it is necessary for the application protocol, the application SHOULD destroy the security context and not use it for application traffic. Otherwise, at this point, the context can be used by the application to apply cryptographic services to its data.

5.10. Authentication Tokens

A token is a caller-opaque type that GSS-API uses to maintain synchronization between each end of the GSS-API security context. The token is a cryptographically protected octet-string, generated by the underlying mechanism at one end of a GSS-API security context for use by the peer mechanism at the other end. Encapsulation (if required) within the application protocol and transfer of the token are the responsibility of the peer applications.

Java GSS-API uses byte arrays to represent authentication tokens.

5.11. Inter-Process Tokens

Certain GSS-API routines are intended to transfer data between processes in multi-process programs. These routines use a caller-opaque octet-string, generated by the GSS-API in one process for use by the GSS-API in another process. The calling application is responsible for transferring such tokens between processes. Note that, while GSS-API implementors are encouraged to avoid placing sensitive information within inter-process tokens, or to cryptographically protect them, many implementations will be unable to avoid placing key material or other sensitive data within them. It is the application's responsibility to ensure that inter-process tokens are protected in transit, and transferred only to processes that are trustworthy. An inter-process token is represented using a byte array emitted from the export method of the GSSContext interface. The receiver of the inter-process token would initialize an GSSContext object with this token to create a new context. Once a context has been exported, the GSSContext object is invalidated and is no longer available.

5.12. Error Reporting

RFC 2743 [RFC2743] defined the usage of major and minor status values for the signaling of GSS-API errors. The major code, also called GSS status code, is used to signal errors at the GSS-API level, independent of the underlying mechanism(s). The minor status value or Mechanism status code, is a mechanism-defined error value indicating a mechanism-specific error code.

Java GSS-API uses exceptions implemented by the GSSException class to signal both minor and major error values. Both mechanism-specific errors and GSS-API level errors are signaled through instances of this class. The usage of exceptions replaces the need for major and minor codes to be used within the API calls. The GSSException class also contains methods to obtain textual representations for both the major and minor values, which is equivalent to the functionality of gss_display_status. A GSSException object MAY also include an output token that SHOULD be sent to the peer.

If an exception is thrown during context establishment, the context negotiation has failed and the GSSContext object MUST be abandoned. If it is thrown in a per-message call, the context MAY remain useful.

5.12.1. GSS Status Codes

GSS status codes indicate errors that are independent of the underlying mechanism(s) used to provide the security service. The errors that can be indicated via a GSS status code are generic API routine errors (errors that are defined in the GSS-API specification). These bindings take advantage of the Java exceptions mechanism, thus, eliminating the need for calling errors.

A GSS status code indicates a single fatal generic API error from the routine that has thrown the GSSException. Using exceptions announces that a fatal error has occurred during the execution of the method. The GSS-API operational model also allows for the signaling of supplementary status information from the per-message calls. These need to be handled as return values since using exceptions is not appropriate for informatory or warning-like information. The methods that are capable of producing supplementary information are the two per-message methods GSSContext.verifyMIC() and GSSContext.unwrap(). These methods fill the supplementary status codes in the MessageProp object that was passed in.

A GSSException object, along with providing the functionality for setting of the various error codes and translating them into textual representation, also contains the definitions of all the numeric

error values. The following table lists the definitions of error codes:

Table: GSS Status Codes

Name	Value	Meaning
BAD_BINDINGS	1	Incorrect channel bindings were supplied.
BAD_MECH	2	An unsupported mechanism was requested.
BAD_NAME	3	An invalid name was supplied.
BAD_NAMETYPE	4	A supplied name was of an unsupported type.
BAD_STATUS	5	An invalid status code was supplied.
BAD_MIC	6	A token had an invalid MIC.
CONTEXT_EXPIRED	7	The context has expired.
CREDENTIALS_EXPIRED	8	The referenced credentials have expired.
DEFECTIVE_CREDENTIAL	9	A supplied credential was invalid.
DEFECTIVE_TOKEN	10	A supplied token was invalid.
FAILURE	11	Miscellaneous failure, unspecified at the GSS-API level.
NO_CONTEXT	12	Invalid context has been supplied.
NO_CRED	13	No credentials were supplied, or the credentials were unavailable or inaccessible.
BAD_QOP	14	The quality-of-protection (QOP) requested could not be provided.
UNAUTHORIZED	15	The operation is forbidden by the local security policy.

UNAVAILABLE	16	The operation or option is unavailable.
DUPLICATE_ELEMENT	17	The requested credential element already exists.
NAME_NOT_MN	18	The provided name was not a mechanism name.

The following four status codes (DUPLICATE_TOKEN, OLD_TOKEN, UNSEQ_TOKEN, and GAP_TOKEN) are contained in a GSSException only if detected during context establishment, in which case it is a fatal error. (During per-message calls, these values are indicated as supplementary information contained in the MessageProp object.) They are:

Name	Value	Meaning
DUPLICATE_TOKEN	19	The token was a duplicate of an earlier version.
OLD_TOKEN	20	The token’s validity period has expired.
UNSEQ_TOKEN	21	A later token has already been processed.
GAP_TOKEN	22	The expected token was not received.

The GSS major status code of FAILURE is used to indicate that the underlying mechanism detected an error for which no specific GSS status code is defined. The mechanism-specific status code can provide more details about the error.

The different major status codes that can be contained in the GSSException object thrown by the methods in this specification are the same as the major status codes returned by the corresponding calls in RFC 2743 [RFC2743].

5.12.2. Mechanism-Specific Status Codes

Mechanism-specific status codes are communicated in two ways, they are part of any GSSException thrown from the mechanism-specific layer to signal a fatal error, or they are part of the MessageProp object that the per-message calls use to signal non-fatal errors.

A default value of 0 in either the GSSException object or the MessageProp object will be used to represent the absence of any mechanism-specific status code.

5.12.3. Supplementary Status Codes

Supplementary status codes are confined to the per-message methods of the GSSContext interface. Because of the informative nature of these errors it is not appropriate to use exceptions to signal them. Instead, the per-message operations of the GSSContext interface return these values in a MessageProp object.

The MessageProp class defines query methods that return boolean values indicating the following supplementary states:

Table: Supplementary Status Methods

Method Name	Meaning when "true" is returned
isDuplicateToken	The token was a duplicate of an earlier token.
isOldToken	The token’s validity period has expired.
isUnseqToken	A later token has already been processed.
isGapToken	An expected per-message token was not received.

A "true" return value for any of the above methods indicates that the token exhibited the specified property. The application MUST determine the appropriate course of action for these supplementary values. They are not treated as errors by the GSS-API.

5.13. Names

A name is used to identify a person or entity. GSS-API authenticates the relationship between a name and the entity claiming the name.

Since different authentication mechanisms may employ different namespaces for identifying their principals, GSS-API’s naming support is necessarily complex in multi-mechanism environments (or even in some single-mechanism environments where the underlying mechanism supports multiple namespaces).

Two distinct conceptual representations are defined for names:

1) A GSS-API form represented by implementations of the GSSName interface: A single GSSName object MAY contain multiple names from different namespaces, but all names SHOULD refer to the same entity. An example of such an internal name would be the name returned from a call to the getName method of the GSSCredential interface, when applied to a credential containing credential elements for multiple authentication mechanisms employing different namespaces. This GSSName object will contain a distinct name for the entity for each authentication mechanism.

   For GSS-API implementations supporting multiple namespaces, GSSName implementations MUST contain sufficient information to determine the namespace to which each primitive name belongs.

2) Mechanism-specific contiguous byte array and string forms: Different GSSName initialization methods are provided to handle both byte array and string formats and to accommodate various calling applications and name types. These formats are capable of containing only a single name (from a single namespace). Contiguous string names are always accompanied by an object identifier specifying the namespace to which the name belongs, and their format is dependent on the authentication mechanism that employs that name. The string name forms are assumed to be printable, and may therefore be used by GSS-API applications for communication with their users. The byte array name formats are assumed to be in non-printable formats (e.g., the byte array returned from the export method of the GSSName interface).

A GSSName object can be converted to a contiguous representation by using the toString method. This will guarantee that the name will be converted to a printable format. Different initialization methods in the GSSName interface are defined allowing support for multiple syntaxes for each supported namespace, and allowing users the freedom to choose a preferred name representation. The toString method SHOULD use an implementation-chosen printable syntax for each supported name type. To obtain the printable name type, getStringNameType method can be used.

There is no guarantee that calling the toString method on the GSSName interface will produce the same string form as the original imported string name. Furthermore, it is possible that the name was not even constructed from a string representation. The same applies to namespace identifiers, which may not necessarily survive unchanged after a journey through the internal name form. An example of this might be a mechanism that authenticates X.500 names, but provides an algorithmic mapping of Internet DNS names into X.500. That mechanism’s implementation of GSSName might, when presented with a DNS name, generate an internal name that contained both the original

DNS name and the equivalent X.500 name. Alternatively, it might only store the X.500 name. In the latter case, the toString method of GSSName would most likely generate a printable X.500 name, rather than the original DNS name.

The context acceptor can obtain a GSSName object representing the entity performing the context initiation (through the usage of getSrcName method). Since this name has been authenticated by a single mechanism, it contains only a single name (even if the internal name presented by the context initiator to the GSSContext object had multiple components). Such names are termed internal-mechanism names (or MNs), and the names emitted by GSSContext interface in the getSrcName and getTargName are always of this type. Since some applications may require MNs without wanting to incur the overhead of an authentication operation, creation methods are provided that take not only the name buffer and name type, but also the mechanism oid for which this name should be created. When dealing with an existing GSSName object, the canonicalize method may be invoked to convert a general internal name into an MN.

GSSName objects can be compared using their equal method, which returns "true" if the two names being compared refer to the same entity. This is the preferred way to perform name comparisons instead of using the printable names that a given GSS-API implementation may support. Since GSS-API assumes that all primitive names contained within a given internal name refer to the same entity, equal can return "true" if the two names have at least one primitive name in common. If the implementation embodies knowledge of equivalence relationships between names taken from different namespaces, this knowledge may also allow successful comparisons of internal names containing no overlapping primitive elements. However, applications SHOULD note that to avoid surpising behavior, it is best to ensure that the names being compared are either both mechanism names for the same mechanism, or both internal names that are not mechanism names. This holds whether the equals method is used directly, or the export method is used to generate byte strings that are then compared byte-by-byte.

When used in large access control lists, the overhead of creating a GSSName object on each name and invoking the equal method on each name from the Access Control List (ACL) may be prohibitive. As an alternative way of supporting this case, GSS-API defines a special form of the contiguous byte array name, which MAY be compared directly (byte by byte). Contiguous names suitable for comparison are generated by the export method. Exported names MAY be re-imported by using the byte array constructor and specifying the NT_EXPORT_NAME as the name type object identifier. The resulting GSSName name will also be a MN.

The GSSName interface defines public static Oid objects representing the standard name types. Structurally, an exported name object consists of a header containing an OID identifying the mechanism that authenticated the name, and a trailer containing the name itself, where the syntax of the trailer is defined by the individual mechanism specification. Detailed description of the format is specified in the language-independent GSS-API specification [RFC2743].

Note that the results obtained by using the equals method will in general be different from those obtained by invoking canonicalize and export, and then comparing the byte array output. The first series of operation determines whether two (unauthenticated) names identify the same principal; the second whether a particular mechanism would authenticate them as the same principal. These two operations will in general give the same results only for MNs.

It is important to note that the above are guidelines as to how GSSName implementations SHOULD behave, and are not intended to be specific requirements of how name objects must be implemented. The mechanism designers are free to decide on the details of their implementations of the GSSName interface as long as the behavior satisfies the above guidelines.

5.14. Channel Bindings

GSS-API supports the use of user-specified tags to identify a given context to the peer application. These tags are intended to be used to identify the particular communications channel that carries the context. Channel bindings are communicated to the GSS-API using the ChannelBinding object. The application MAY use byte arrays to specify the application data to be used in the channel binding as well as using instances of the InetAddress. The InetAddress for the initiator and/or acceptor can be used within an instance of a ChannelBinding. ChannelBinding can be set for the GSSContext object using the setChannelBinding method before the first call to init or accept has been performed. Unless the setChannelBinding method has been used to set the ChannelBinding for a GSSContext object, "null" ChannelBinding will be assumed. InetAddress is currently the only address type defined within the Java platform and as such, it is the only one supported within the ChannelBinding class. Applications that use other types of addresses can include them as part of the application-specific data.

Conceptually, the GSS-API concatenates the initiator and acceptor address information, and the application-supplied byte array to form an octet-string. The mechanism calculates a Message Integrity Code (MIC) over this octet-string and binds the MIC to the context

establishment token emitted by the init method of the GSSContext interface. The same bindings are set by the context acceptor for its GSSContext object and during processing of the accept method, a MIC is calculated in the same way. The calculated MIC is compared with that found in the token, and if the MICs differ, accept will throw a GSSException with the major code set to BAD_BINDINGS, and the context will not be established. Some mechanisms may include the actual channel binding data in the token (rather than just a MIC); applications SHOULD therefore not use confidential data as channel-binding components.

Individual mechanisms may impose additional constraints on addresses that may appear in channel bindings. For example, a mechanism may verify that the initiator address field of the channel binding contains the correct network address of the host system. Portable applications SHOULD therefore ensure that they either provide correct information for the address fields, or omit the setting of the addressing information.

5.15. Optional Parameters

Whenever the application wishes to omit an optional parameter the "null" value SHALL be used. The detailed method descriptions indicate which parameters are optional. Method overloading has also been used as a technique to indicate default parameters.

6. Introduction to GSS-API Classes and Interfaces

This section presents a brief description of the classes and interfaces that constitute the GSS-API. The implementations of these are obtained from the CLASSPATH defined by the application. If Java GSS becomes part of the standard Java APIs, then these classes will be available by default on all systems as part of the JRE’s system classes.

This section also shows the corresponding RFC 2743 [RFC2743] functionality implemented by each of the classes. Detailed description of these classes and their methods is presented in section 7

6.1. GSSManager Class

This abstract class serves as a factory to instantiate implementations of the GSS-API interfaces and also provides methods to make queries about underlying security mechanisms.

A default implementation can be obtained using the static method getInstance(). Applications that desire to provide their own

implementation of the GSSManager class can simply extend the abstract class themselves.

This class contains equivalents of the following RFC 2743 [RFC2743] routines:

RFC 2743 Routine	Function	Section(s)
gss_import_name	Create an internal name from the supplied information.	7.1.5 - 7.1.8
gss_acquire_cred	Acquire credential for use.	7.1.9 - 7.1.11
gss_import_sec_context	Create a previously exported context.	7.1.14
gss_indicate_mechs	List the mechanisms supported by this GSS-API implementation.	7.1.2
gss_inquire_mechs_for_name	List the mechanisms supporting the specified name type.	7.1.4
gss_inquire_names_for_mech	List the name types supported by the specified mechanism.	7.1.3

6.2. GSSName Interface

GSS-API names are represented in the Java bindings through the GSSName interface. Different name formats and their definitions are identified with Universal Object Identifiers (oids). The format of the names can be derived based on the unique oid of each name type. The following GSS-API routines are provided by the GSSName interface:

RFC 2743 Routine	Function	Section(s)
gss_display_name	Convert internal name representation to text format.	7.2.6
gss_compare_name	Compare two internal names.	7.2.2, 7.2.3
gss_release_name	Release resources associated with the internal name.	N/A
gss_canonicalize_name	Convert an internal name to a mechanism name.	7.2.4
gss_export_name	Convert a mechanism name to export format.	7.2.5
gss_duplicate_name	Create a copy of the internal name.	N/A

The gss_release_name call is not provided as Java does its own garbage collection. The gss_duplicate_name call is also redundant; the GSSName interface has no mutator methods that can change the state of the object so it is safe for sharing across threads.

6.3. GSSCredential Interface

The GSSCredential interface is responsible for the encapsulation of GSS-API credentials. Credentials identify a single entity and provide the necessary cryptographic information to enable the creation of a context on behalf of that entity. A single credential may contain multiple mechanism-specific credentials, each referred to as a credential element. The GSSCredential interface provides the functionality of the following GSS-API routines:

RFC 2743 Routine	Function	Section(s)
gss_add_cred	Constructs credentials incrementally.	7.3.11
gss_inquire_cred	Obtain information about credential.	7.3.3 - 7.3.10
gss_inquire_cred_by_mech	Obtain per-mechanism information about a credential.	7.3.4 - 7.3.9
gss_release_cred	Dispose of credentials after use.	7.3.2

6.4. GSSContext Interface

This interface encapsulates the functionality of context-level calls required for security context establishment and management between peers as well as the per-message services offered to applications. A context is established between a pair of peers and allows the usage of security services on a per-message basis on application data. It is created over a single security mechanism. The GSSContext interface provides the functionality of the following GSS-API routines:

RFC 2743 Routine	Function	Section(s)
gss_init_sec_context	Initiate the creation of a security context with a peer.	7.4.2
gss_accept_sec_context	Accept a security context initiated by a peer.	7.4.3
gss_delete_sec_context	Destroy a security context.	7.4.5
gss_context_time	Obtain remaining context time.	7.4.30
gss_inquire_context	Obtain context characteristics.	7.4.21 - 7.4.35
gss_wrap_size_limit	Determine token-size limit for gss_wrap.	7.4.6
gss_export_sec_context	Transfer security context to another process.	7.4.11
gss_get_mic	Calculate a cryptographic Message Integrity Code (MIC) for a message.	7.4.9
gss_verify_mic	Verify integrity on a received message.	7.4.10
gss_wrap	Attach a MIC to a message and optionally encrypt the message content.	7.4.7
gss_unwrap	Obtain a previously wrapped application message verifying its integrity and optionally decrypting it.	7.4.8

The functionality offered by the gss_process_context_token routine has not been included in the Java bindings specification. The corresponding functionality of gss_delete_sec_context has also been modified to not return any peer tokens. This has been proposed in accordance to the recommendations stated in RFC 2743 [RFC2743]. GSSContext does offer the functionality of destroying the locally stored context information.

6.5. MessageProp Class

This helper class is used in the per-message operations on the context. An instance of this class is created by the application and then passed into the per-message calls. In some cases, the application conveys information to the GSS-API implementation through this object and in other cases the GSS-API returns information to the application by setting it in this object. See the description of the per-message operations wrap, unwrap, getMIC, and verifyMIC in the GSSContext interfaces for details.

6.6. GSSException Class

Exceptions are used in the Java bindings to signal fatal errors to the calling applications. This replaces the major and minor codes used in the C-bindings specification as a method of signaling failures. The GSSException class handles both minor and major codes, as well as their translation into textual representation. All GSS-API methods are declared as throwing this exception.

RFC 2743 Routine	Function	Section
gss_display_status	Retrieve textual representation of error codes.	7.8.5, 7.8.6, 7.8.9, 7.8.10

6.7. Oid Class

This utility class is used to represent Universal Object Identifiers and their associated operations. GSS-API uses object identifiers to distinguish between security mechanisms and name types. This class, aside from being used whenever an object identifier is needed, implements the following GSS-API functionality:

RFC 2743 Routine	Function	Section
gss_test_oid_set_member	Determine if the specified oid is part of a set of oids.	7.7.5

6.8. ChannelBinding Class

An instance of this class is used to specify channel binding information to the GSSContext object before the start of a security context establishment. The application may use a byte array to

specify application data to be used in the channel binding as well as to use instances of the InetAddress. InetAddress is currently the only address type defined within the Java platform and as such, it is the only one supported within the ChannelBinding class. Applications that use other types of addresses can include them as part of the application data.

7. Detailed GSS-API Class Description

This section lists a detailed description of all the public methods that each of the GSS-API classes and interfaces MUST provide.

7.1. public abstract class GSSManager

The GSSManager class is an abstract class that serves as a factory for three GSS interfaces: GSSName, GSSCredential, and GSSContext. It also provides methods for applications to determine what mechanisms are available from the GSS implementation and what name types these mechanisms support. An instance of the default GSSManager subclass MAY be obtained through the static method getInstance(), but applications are free to instantiate other subclasses of GSSManager.

All but one method in this class are declared abstract. This means that subclasses have to provide the complete implementation for those methods. The only exception to this is the static method getInstance(), which will have platform-specific code to return an instance of the default subclass.

Platform providers of GSS are REQUIRED not to add any constructors to this class, private, public, or protected. This will ensure that all subclasses invoke only the default constructor provided to the base class by the compiler.

A subclass extending the GSSManager abstract class MAY be implemented as a modular provider-based layer that utilizes some well-known service provider specification. The GSSManager API provides the application with methods to set provider preferences on such an implementation. These methods also allow the implementation to throw a well-defined exception in case provider-based configuration is not supported. Applications that expect to be portable SHOULD be aware of this and recover cleanly by catching the exception.

It is envisioned that there will be three most common ways in which providers will be used:

1) The application does not care about what provider is used (the default case).

2) The application wants a particular provider to be used preferentially, either for a particular mechanism or all the time, irrespective of the mechanism.

3) The application wants to use the locally configured providers as far as possible, but if support is missing for one or more mechanisms, then it wants to fall back on its own provider.

The GSSManager class has two methods that enable these modes of usage: addProviderAtFront() and addProviderAtEnd(). These methods have the effect of creating an ordered list of <provider, oid> pairs where each pair indicates a preference of provider for a given oid.

The use of these methods does not require any knowledge of whatever service provider specification the GSSManager subclass follows. It is hoped that these methods will serve the needs of most applications. Additional methods MAY be added to an extended GSSManager that could be part of a service provider specification that is standardized later.

When neither of the methods is called, the implementation SHOULD choose a default provider for each mechanism it supports.

7.1.1. getInstance

```
public static GSSManager getInstance()
```

Returns the default GSSManager implementation.

7.1.2. getMechs

```
public abstract Oid[] getMechs()
```

Returns an array of Oid objects indicating the mechanisms available to GSS-API callers. A "null" value is returned when no mechanism are available (an example of this would be when mechanism are dynamically configured, and currently no mechanisms are installed).

7.1.3. getNamesForMech

```
public abstract Oid[] getNamesForMech(Oid mech)
                      throws GSSException
```

Returns name type Oid’s supported by the specified mechanism.

Parameters:

mech The Oid object for the mechanism to query.

7.1.4. getMechsForName

```
public abstract Oid[] getMechsForName(Oid nameType)
```

Returns an array of Oid objects corresponding to the mechanisms that support the specific name type. "null" is returned when no mechanisms are found to support the specified name type.

Parameters:

nameType	The Oid object for the name type.

7.1.5. createName

```
public abstract GSSName createName(String nameStr, Oid nameType)
                throws GSSException
```

Factory method to convert a contiguous string name from the specified namespace to a GSSName object. In general, the GSSName object created will not be an MN; two examples that are exceptions to this are when the namespace type parameter indicates NT_EXPORT_NAME or when the GSS-API implementation is not multi-mechanism.

Parameters:

nameStr	The string representing a printable form of the name to create.
nameType	The Oid specifying the namespace of the printable name is supplied. Note that nameType serves to describe and qualify the interpretation of the input nameStr, it does not necessarily imply a type for the output GSSName implementation. The "null" value can be used to specify that a mechanism-specific default printable syntax SHOULD be assumed by each mechanism that examines nameStr.

7.1.6. createName

```
public abstract GSSName createName(byte[] name, Oid nameType)
                throws GSSException
```

Factory method to convert a contiguous byte array containing a name from the specified namespace to a GSSName object. In general, the GSSName object created will not be an MN; two examples that are exceptions to this are when the namespace type parameter indicates

NT_EXPORT_NAME or when the GSS-API implementation is not multi-mechanism.

Parameters:

name	The byte array containing the name to create.
nameType	The Oid specifying the namespace of the name supplied in the byte array. Note that nameType serves to describe and qualify the interpretation of the input name byte array; it does not necessarily imply a type for the output GSSName implementation. The "null" value can be used to specify that a mechanism-specific default syntax SHOULD be assumed by each mechanism that examines the byte array.

7.1.7. createName

```
public abstract GSSName createName(String nameStr, Oid nameType,
                Oid mech) throws GSSException
```

Factory method to convert a contiguous string name from the specified namespace to a GSSName object that is a mechanism name (MN). In other words, this method is a utility that does the equivalent of two steps: the createName described in section 7.1.5, and then also the GSSName.canonicalize() described in section 7.2.4.

Parameters:

nameStr	The string representing a printable form of the name to create.
nameType	The Oid specifying the namespace of the printable name supplied. Note that nameType serves to describe and qualify the interpretation of the input nameStr; it does not necessarily imply a type for the output GSSName implementation. The "null" value can be used to specify that a mechanism-specific default printable syntax SHOULD be assumed when the mechanism examines nameStr.
mech	Oid specifying the mechanism for which this name should be created.

7.1.8. createName

```
public abstract GSSName createName(byte[] name, Oid nameType,
                Oid mech) throws GSSException
```

Factory method to convert a contiguous byte array containing a name from the specified namespace to a GSSName object that is an MN. In other words, this method is a utility that does the equivalent of two steps: the createName described in section 7.1.6, and then also the GSSName.canonicalize() described in section 7.2.4.

Parameters:

name	The byte array representing the name to create.
nameType	The Oid specifying the namespace of the name supplied in the byte array. Note that nameType serves to describe and qualify the interpretation of the input name byte array, it does not necessarily imply a type for the output GSSName implementation. The "null" value can be used to specify that a mechanism-specific default syntax SHOULD be assumed by each mechanism that examines the byte array.
mech	Oid specifying the mechanism for which this name should be created.

7.1.9. createCredential

```
public abstract GSSCredential createCredential(int usage)
                throws GSSException
```

Factory method for acquiring default credentials. This will cause the GSS-API to use system-specific defaults for the set of mechanisms, name, and a DEFAULT lifetime.

Parameters:

usage	The intended usage for this credential object. The value of this parameter MUST be one of: GSSCredential.INITIATE_AND_ACCEPT(0), GSSCredential.INITIATE_ONLY(1), or GSSCredential.ACCEPT_ONLY(2)

7.1.10. createCredential

```
public abstract GSSCredential createCredential(GSSName aName,
                int lifetime, Oid mech, int usage)
                throws GSSException
```

Factory method for acquiring a single mechanism credential.

Parameters:

aName	Name of the principal for whom this credential is to be acquired. Use "null" to specify the default principal.
lifetime	The number of seconds that credentials should remain valid. Use GSSCredential.INDEFINITE_LIFETIME to request that the credentials have the maximum permitted lifetime. Use GSSCredential.DEFAULT_LIFETIME to request default credential lifetime.
mech	The oid of the desired mechanism. Use "(Oid) null" to request the default mechanism(s).
usage	The intended usage for this credential object. The value of this parameter MUST be one of: GSSCredential.INITIATE_AND_ACCEPT(0), GSSCredential.INITIATE_ONLY(1), or GSSCredential.ACCEPT_ONLY(2)

7.1.11. createCredential

```
public abstract GSSCredential createCredential(GSSName aName,
                int lifetime, Oid[] mechs, int usage)
                throws GSSException
```

Factory method for acquiring credentials over a set of mechanisms. Acquires credentials for each of the mechanisms specified in the array called mechs. To determine the list of mechanisms' for which the acquisition of credentials succeeded, the caller should use the GSSCredential.getMechs() method.

Parameters:

aName	Name of the principal for whom this credential is to be acquired. Use "null" to specify the default principal.

lifetime	The number of seconds that credentials should remain valid. Use GSSCredential.INDEFINITE_LIFETIME to request that the credentials have the maximum permitted lifetime. Use GSSCredential.DEFAULT_LIFETIME to request default credential lifetime.
mechs	The array of mechanisms over which the credential is to be acquired. Use "(Oid[]) null" for requesting a system-specific default set of mechanisms.
usage	The intended usage for this credential object. The value of this parameter MUST be one of: GSSCredential.INITIATE_AND_ACCEPT(0), GSSCredential.INITIATE_ONLY(1), or GSSCredential.ACCEPT_ONLY(2)

7.1.12. createContext

```
public abstract GSSContext createContext(GSSName peer, Oid mech,
                GSSCredential myCred, int lifetime)
                throws GSSException
```

Factory method for creating a context on the initiator's side. Context flags may be modified through the mutator methods prior to calling GSSContext.initSecContext().

Parameters:

peer	Name of the target peer.
mech	Oid of the desired mechanism. Use "(Oid) null" to request the default mechanism.
myCred	Credentials of the initiator. Use "null" to act as a default initiator principal.
lifetime	The request lifetime, in seconds, for the context. Use GSSContext.INDEFINITE_LIFETIME and GSSContext.DEFAULT_LIFETIME to request indefinite or default context lifetime.

7.1.13. createContext

```
public abstract GSSContext createContext(GSSCredential myCred)
                throws GSSException
```

Factory method for creating a context on the acceptor' side. The context's properties will be determined from the input token supplied to the accept method.

Parameters:

myCred	Credentials for the acceptor. Use "null" to act as a default acceptor principal.

7.1.14. createContext

```
public abstract GSSContext createContext(byte[] interProcessToken)
                throws GSSException
```

Factory method for importing a previously exported context. The context properties will be determined from the input token and can't be modified through the set methods.

Parameters:

interProcessToken	The token previously emitted from the export method.

7.1.15. addProviderAtFront

```
public abstract void addProviderAtFront(Provider p, Oid mech)
                throws GSSException
```

This method is used to indicate to the GSSManager that the application would like a particular provider to be used ahead of all others when support is desired for the given mechanism. When a value of "null" is used instead of an Oid for the mechanism, the GSSManager MUST use the indicated provider ahead of all others no matter what the mechanism is. Only when the indicated provider does not support the needed mechanism should the GSSManager move on to a different provider.

Calling this method repeatedly preserves the older settings but lowers them in preference thus forming an ordered list of provider and Oid pairs that grows at the top.

Calling addProviderAtFront with a null Oid will remove all previous preferences that were set for this provider in the GSSManager

instance. Calling addProviderAtFront with a non-null Oid will remove any previous preference that was set using this mechanism and this provider together.

If the GSSManager implementation does not support an SPI with a pluggable provider architecture, it SHOULD throw a GSSException with the status code GSSException.UNAVAILABLE to indicate that the operation is unavailable.

Parameters:

p	The provider instance that should be used whenever support is needed for mech.
mech	The mechanism for which the provider is being set.

7.1.15.1. addProviderAtFront Example Code

Suppose an application desired that the provider A always be checked first when any mechanism is needed, it would call:

```
<CODE BEGINS>
GSSManager mgr = GSSManager.getInstance();
// mgr may at this point have its own pre-configured list
// of provider preferences.  The following will prepend to
// any such list:

mgr.addProviderAtFront(A, null);
<CODE ENDS>
```

Now if it also desired that the mechanism of Oid m1 always be obtained from the provider B before the previously set A was checked, it would call:

```
<CODE BEGINS>
mgr.addProviderAtFront(B, m1);
<CODE ENDS>
```

The GSSManager would then first check with B if m1 was needed. In case B did not provide support for m1, the GSSManager would continue on to check with A. If any mechanism m2 is needed where m2 is different from m1, then the GSSManager would skip B and check with A directly.

Suppose, at a later time, the following call is made to the same GSSManager instance:

```
<CODE BEGINS>
mgr.addProviderAtFront(B, null)
<CODE ENDS>
```

then the previous setting with the pair (B, m1) is subsumed by this and SHOULD be removed. Effectively, the list of preferences now becomes {(B, null), (A, null), ... //followed by the pre-configured list}.

Please note, however, that the following call:

```
<CODE BEGINS>
mgr.addProviderAtFront(A, m3)
<CODE ENDS>
```

does not subsume the previous setting of (A, null), and the list will effectively become {(A, m3), (B, null), (A, null), ...}

7.1.16. addProviderAtEnd

```
public abstract void addProviderAtEnd(Provider p, Oid mech)
                throws GSSException
```

This method is used to indicate to the GSSManager that the application would like a particular provider to be used if no other provider can be found that supports the given mechanism. When a value of "null" is used instead of an Oid for the mechanism, the GSSManager MUST use the indicated provider for any mechanism.

Calling this method repeatedly preserves the older settings, but raises them above newer ones in preference thus forming an ordered list of providers and Oid pairs that grows at the bottom. Thus, the older provider settings will be utilized first before this one is.

If there are any previously existing preferences that conflict with the preference being set here, then the GSSManager SHOULD ignore this request.

If the GSSManager implementation does not support an SPI with a pluggable provider architecture, it SHOULD throw a GSSException with the status code GSSException.UNAVAILABLE to indicate that the operation is unavailable.

Parameters:

p	The provider instance that should be used whenever support is needed for mech.

mech	The mechanism for which the provider is being set.

7.1.16.1. addProviderAtEnd Example Code

Suppose an application desired that when a mechanism of Oid m1 is needed, the system default providers always be checked first, and only when they do not support m1 should a provider A be checked. It would then make the call:

```
<CODE BEGINS>
GSSManager mgr = GSSManager.getInstance();

mgr.addProviderAtEnd(A, m1);
<CODE ENDS>
```

Now, if it also desired that for all mechanisms the provider B be checked after all configured providers have been checked, it would then call:

```
<CODE BEGINS>
mgr.addProviderAtEnd(B, null);
<CODE ENDS>
```

Effectively, the list of preferences now becomes {..., (A, m1), (B, null)}.

Suppose, at a later time, the following call is made to the same GSSManager instance:

```
<CODE BEGINS>
mgr.addProviderAtEnd(B, m2)
<CODE ENDS>
```

then the previous setting with the pair (B, null) subsumes this; therefore, this request SHOULD be ignored. The same would happen if a request is made for the already existing pairs of (A, m1) or (B, null).

Please note, however, that the following call:

```
<CODE BEGINS>
mgr.addProviderAtEnd(A, null)
<CODE ENDS>
```

is not subsumed by the previous setting of (A, m1) and the list will effectively become {..., (A, m1), (B, null), (A, null)}.

7.1.17. Example Code

```
<CODE BEGINS>
GSSManager mgr = GSSManager.getInstance();

// What mechs are available to us?

Oid[] supportedMechs = mgr.getMechs();

// Set a preference for the provider to be used when support
// is needed for the mechanisms:
//  "1.2.840.113554.1.2.2" and "1.3.6.1.5.5.1.1".

Oid krb = new Oid("1.2.840.113554.1.2.2");
Oid spkm1 = new Oid("1.3.6.1.5.5.1.1");

Provider p = (Provider) (new com.foo.security.Provider());

mgr.addProviderAtFront(p, krb);
mgr.addProviderAtFront(p, spkm1);

// What name types does this spkm implementation support?
Oid[] nameTypes = mgr.getNamesForMech(spkm1);
<CODE ENDS>
```

7.2. public interface GSSName

This interface encapsulates a single GSS-API principal entity. Different name formats and their definitions are identified with Universal Object Identifiers (Oids). The format of the names can be derived based on the unique oid of its namespace type.

7.2.1. Static Constants

public static final Oid NT_HOSTBASED_SERVICE

Oid indicating a host-based service name form. It is used to represent services associated with host computers. This name form is constructed using two elements, "service" and "hostname", as follows:

service@hostname

Values for the "service" element are registered with the IANA. It represents the following value: { iso(1) member-body(2) Unites States(840) mit(113554) infosys(1) gssapi(2) generic(1) service_name(4) }

public static final Oid NT_USER_NAME

Name type to indicate a named user on a local system. It represents the following value: { iso(1) member-body(2) United States(840) mit(113554) infosys(1) gssapi(2) generic(1) user_name(1) }

public static final Oid NT_MACHINE_UID_NAME

Name type to indicate a numeric user identifier corresponding to a user on a local system (e.g., Uid). It represents the following value: { iso(1) member-body(2) United States(840) mit(113554) infosys(1) gssapi(2) generic(1) machine_uid_name(2) }

public static final Oid NT_STRING_UID_NAME

Name type to indicate a string of digits representing the numeric user identifier of a user on a local system. It represents the following value: { iso(1) member-body(2) United States(840) mit(113554) infosys(1) gssapi(2) generic(1) string_uid_name(3) }

public static final Oid NT_ANONYMOUS

Name type for representing an anonymous entity. It represents the following value: { iso(1), org(3), dod(6), internet(1), security(5), nametypes(6), gss-anonymous-name(3) }

public static final Oid NT_EXPORT_NAME

Name type used to indicate an exported name produced by the export method. It represents the following value: { iso(1), org(3), dod(6), internet(1), security(5), nametypes(6), gss-api-exported-name(4) }

7.2.2. equals

public boolean equals(GSSName another) throws GSSException

Compares two GSSName objects to determine whether they refer to the same entity. This method MAY throw a GSSException when the names cannot be compared. If either of the names represents an anonymous entity, the method will return "false".

Parameters:

another GSSName object with which to compare.

7.2.3. equals

public boolean equals(Object another)

A variation of the equals method, described in section 7.2.2, that is provided to override the Object.equals() method that the implementing class will inherit. The behavior is exactly the same as that in section 7.2.2 except that no GSSException is thrown; instead, "false" will be returned in the situation where an error occurs. (Note that the Java language specification requires that two objects that are equal according to the equals(Object) method MUST return the same integer result when the hashCode() method is called on them.)

Parameters:

another GSSName object with which to compare.

7.2.4. canonicalize

public GSSName canonicalize(Oid mech) throws GSSException

Creates a mechanism name (MN) from an arbitrary internal name. This is equivalent to using the factory methods described in sections 7.1.7 or 7.1.8 that take the mechanism name as one of their parameters.

Parameters:

mech The oid for the mechanism for which the canonical form of the name is requested.

7.2.5. export

public byte[] export() throws GSSException

Returns a canonical contiguous byte representation of a mechanism name (MN), suitable for direct, byte-by-byte comparison by authorization functions. If the name is not an MN, implementations MAY throw a GSSException with the NAME_NOT_MN status code. If an implementation chooses not to throw an exception, it SHOULD use some system-specific default mechanism to canonicalize the name and then export it. The format of the header of the output buffer is specified in RFC 2743 [RFC2743].

7.2.6. toString

public String toString()

Returns a textual representation of the GSSName object. To retrieve the printed name format, which determines the syntax of the returned string, the getStringNameType method can be used.

7.2.7. getStringNameType

```
public Oid getStringNameType() throws GSSException
```

Returns the oid representing the type of name returned through the toString method. Using this oid, the syntax of the printable name can be determined.

7.2.8. isAnonymous

```
public boolean isAnonymous()
```

Tests if this name object represents an anonymous entity. Returns "true" if this is an anonymous name.

7.2.9. isMN

```
public boolean isMN()
```

Tests if this name object contains only one mechanism element and is thus a mechanism name as defined by RFC 2743 [RFC2743].

7.2.10. Example Code

Included below are code examples utilizing the GSSName interface. The code below creates a GSSName, converts it to a mechanism name (MN), performs a comparison, obtains a printable representation of the name, exports it and then re-imports to obtain a new GSSName.

```
<CODE BEGINS>
GSSManager mgr = GSSManager.getInstance();

// create a host-based service name
GSSName name = mgr.createName("service@host",
                GSSName.NT_HOSTBASED_SERVICE);

Oid krb5 = new Oid("1.2.840.113554.1.2.2");

GSSName mechName = name.canonicalize(krb5);

// the above two steps are equivalent to the following
GSSName mechName = mgr.createName("service@host",
                GSSName.NT_HOSTBASED_SERVICE, krb5);

// perform name comparison
if (name.equals(mechName))
        print("Names are equals.");

// obtain textual representation of name and its printable
// name type
print(mechName.toString() +
      mechName.getStringNameType().toString());

// export the name
byte[] exportName = mechName.export();

// create a new name object from the exported buffer
GSSName newName = mgr.createName(exportName,
                  GSSName.NT_EXPORT_NAME);
<CODE ENDS>
```

7.3. public interface GSSCredential implements Cloneable

This interface encapsulates the GSS-API credentials for an entity. A credential contains all the necessary cryptographic information to enable the creation of a context on behalf of the entity that it represents. It MAY contain multiple, distinct, mechanism-specific credential elements, each containing information for a specific security mechanism, but all referring to the same entity.

A credential MAY be used to perform context initiation, acceptance, or both.

GSS-API implementations MUST impose a local access-control policy on callers to prevent unauthorized callers from acquiring credentials to which they are not entitled. GSS-API credential creation is not intended to provide a "login to the network" function, as such a

function would involve the creation of new credentials rather than merely acquiring a handle to existing credentials. Such functions, if required, SHOULD be defined in implementation-specific extensions to the API.

If credential acquisition is time-consuming for a mechanism, the mechanism MAY choose to delay the actual acquisition until the credential is required (e.g., by GSSContext). Such mechanism-specific implementation decisions SHOULD be invisible to the calling application; thus, the query methods immediately following the creation of a credential object MUST return valid credential data, and may therefore incur the overhead of a deferred credential acquisition.

Applications will create a credential object passing the desired parameters. The application can then use the query methods to obtain specific information about the instantiated credential object (equivalent to the gss_inquire routines). When the credential is no longer needed, the application SHOULD call the dispose (equivalent to gss_release_cred) method to release any resources held by the credential object and to destroy any cryptographically sensitive information.

Classes implementing this interface also implement the Cloneable interface. This indicates that the class will support the clone() method that will allow the creation of duplicate credentials. This is useful when called just before the add() call to retain a copy of the original credential.

7.3.1. Static Constants

public static final int INITIATE_AND_ACCEPT

Credential usage flag requesting that it be able to be used for both context initiation and acceptance. The value of this constant is 0.

public static final int INITIATE_ONLY

Credential usage flag requesting that it be able to be used for context initiation only. The value of this constant is 1.

public static final int ACCEPT_ONLY

Credential usage flag requesting that it be able to be used for context acceptance only. The value of this constant is 2.

public static final int DEFAULT_LIFETIME

A lifetime constant representing the default credential lifetime. The value of this constant is 0.

public static final int INDEFINITE_LIFETIME

A lifetime constant representing indefinite credential lifetime. The value of this constant is the maximum integer value in Java - Integer.MAX_VALUE.

7.3.2. dispose

public void dispose() throws GSSException

Releases any sensitive information that the GSSCredential object may be containing. Applications SHOULD call this method as soon as the credential is no longer needed to minimize the time any sensitive information is maintained.

7.3.3. getName

public GSSName getName() throws GSSException

Retrieves the name of the entity that the credential asserts.

7.3.4. getName

public GSSName getName(Oid mechOID) throws GSSException

Retrieves a mechanism name of the entity that the credential asserts. Equivalent to calling canonicalize() on the name returned by section 7.3.3.

Parameters:

mechOID	The mechanism for which information should be returned.

7.3.5. getRemainingLifetime

public int getRemainingLifetime() throws GSSException

Returns the remaining lifetime in seconds for a credential. The remaining lifetime is the minimum lifetime for any of the underlying credential mechanisms. A return value of GSSCredential.INDEFINITE_LIFETIME indicates that the credential does not expire. A return value of 0 indicates that the credential is already expired.

7.3.6. getRemainingInitLifetime

public int getRemainingInitLifetime(Oid mech) throws GSSException

Returns the remaining lifetime in seconds for the credential to remain capable of initiating security contexts under the specified mechanism. A return value of GSSCredential.INDEFINITE_LIFETIME indicates that the credential does not expire for context initiation. A return value of 0 indicates that the credential is already expired.

Parameters:

mechOID	The mechanism for which information should be returned.

7.3.7. getRemainingAcceptLifetime

public int getRemainingAcceptLifetime(Oid mech) throws GSSException

Returns the remaining lifetime in seconds for the credential to remain capable of accepting security contexts under the specified mechanism. A return value of GSSCredential.INDEFINITE_LIFETIME indicates that the credential does not expire for context acceptance. A return value of 0 indicates that the credential is already expired.

Parameters:

mechOID	The mechanism for which information should be returned.

7.3.8. getUsage

public int getUsage() throws GSSException

Returns the credential usage flag as a union over all mechanisms. The return value will be one of GSSCredential.INITIATE_AND_ACCEPT(0), GSSCredential.INITIATE_ONLY(1), or GSSCredential.ACCEPT_ONLY(2).

Specifically, GSSCredential.INITIATE_AND_ACCEPT(0) SHOULD be returned as long as there exists one credential element allowing context initiation and one credential element allowing context acceptance. These two credential elements are not necessarily the same one, nor do they need to use the same mechanism(s).

7.3.9. getUsage

```
public int getUsage(Oid mechOID) throws GSSException
```

Returns the credential usage flag for the specified mechanism only. The return value will be one of GSSCredential.INITIATE_AND_ACCEPT(0), GSSCredential.INITIATE_ONLY(1), or GSSCredential.ACCEPT_ONLY(2).

Parameters:

mechOID	The mechanism for which information should be returned.

7.3.10. getMechs

```
public Oid[] getMechs() throws GSSException
```

Returns an array of mechanisms supported by this credential.

7.3.11. add

```
public void add(GSSName aName, int initLifetime, int acceptLifetime,
                Oid mech, int usage) throws GSSException
```

Adds a mechanism-specific credential-element to an existing credential. This method allows the construction of credentials one mechanism at a time.

This routine is envisioned to be used mainly by context acceptors during the creation of acceptance credentials, which are to be used with a variety of clients using different security mechanisms.

This routine adds the new credential element "in-place". To add the element in a new credential, first call clone() to obtain a copy of this credential, then call its add() method.

Parameters:

aName	Name of the principal for whom this credential is to be acquired. Use "null" to specify the default principal.
initLifetime	The number of seconds that credentials should remain valid for initiating of security contexts. Use GSSCredential.INDEFINITE_LIFETIME to request that the credentials have the maximum permitted lifetime. Use GSSCredential.DEFAULT_LIFETIME to request default credential lifetime.

acceptLifetime	The number of seconds that credentials should remain valid for accepting of security contexts. Use GSSCredential.INDEFINITE_LIFETIME to request that the credentials have the maximum permitted lifetime. Use GSSCredential.DEFAULT_LIFETIME to request default credential lifetime.
mech	The mechanisms over which the credential is to be acquired.
usage	The intended usage for this credential object. The value of this parameter MUST be one of: GSSCredential.INITIATE_AND_ACCEPT(0), GSSCredential.INITIATE_ONLY(1), or GSSCredential.ACCEPT_ONLY(2)

7.3.12. equals

public boolean equals(Object another)

Tests if this GSSCredential refers to the same entity as the supplied object. The two credentials MUST be acquired over the same mechanisms and MUST refer to the same principal. Returns "true" if the two GSSCredentials refer to the same entity; "false" otherwise. (Note that the Java language specification [JLS] requires that two objects that are equal according to the equals(Object) method MUST return the same integer result when the hashCode() method is called on them.)

Parameters:

another	Another GSSCredential object for comparison.

7.3.13. Example Code

This example code demonstrates the creation of a GSSCredential implementation for a specific entity, querying of its fields, and its release when it is no longer needed.

```
<CODE BEGINS>
GSSManager mgr = GSSManager.getInstance();

// start by creating a name object for the entity
GSSName name = mgr.createName("userName", GSSName.NT_USER_NAME);

// now acquire credentials for the entity
GSSCredential cred = mgr.createCredential(name,
                     GSSCredential.ACCEPT_ONLY);

// display credential information - name, remaining lifetime,
// and the mechanisms it has been acquired over
print(cred.getName().toString());
print(cred.getRemainingLifetime());

Oid[] mechs = cred.getMechs();
if (mechs != null) {
   for (int i = 0; i < mechs.length; i++)
       print(mechs[i].toString());
}
// release system resources held by the credential
cred.dispose();
<CODE ENDS>
```

7.4. public interface GSSContext

This interface encapsulates the GSS-API security context and provides the security services (wrap, unwrap, getMIC, verifyMIC) that are available over the context. Security contexts are established between peers using locally acquired credentials. Multiple contexts may exist simultaneously between a pair of peers, using the same or different set of credentials. GSS-API functions in a manner independent of the underlying transport protocol and depends on its calling application to transport its tokens between peers.

Before the context establishment phase is initiated, the context initiator may request specific characteristics desired of the established context. These can be set using the set methods. After the context is established, the caller can check the actual characteristic and services offered by the context using the query methods.

The context establishment phase begins with the first call to the init method by the context initiator. During this phase, the initSecContext and acceptSecContext methods will produce GSS-API authentication tokens, which the calling application needs to send to its peer. If an error occurs at any point, an exception will get thrown and the code will start executing in a catch block where the

exception may contain an output token that should be sent to the peer for debugging or informational purpose. If not, the normal flow of code continues and the application can make a call to the isEstablished() method. If this method returns "false" it indicates that a token is needed from its peer in order to continue the context establishment phase. A return value of "true" signals that the local end of the context is established. This may still require that a token be sent to the peer, if one is produced by GSS-API. During the context establishment phase, the isProtReady() method may be called to determine if the context can be used for the per-message operations. This allows applications to use per-message operations on contexts that aren't fully established.

After the context has been established or the isProtReady() method returns "true", the query routines can be invoked to determine the actual characteristics and services of the established context. The application can also start using the per-message methods of wrap and getMIC to obtain cryptographic operations on application supplied data.

When the context is no longer needed, the application SHOULD call dispose to release any system resources the context may be using.

7.4.1. Static Constants

public static final int DEFAULT_LIFETIME

A lifetime constant representing the default context lifetime. The value of this constant is 0.

public static final int INDEFINITE_LIFETIME

A lifetime constant representing indefinite context lifetime. The value of this constant is the maximum integer value in Java - Integer.MAX_VALUE.

7.4.2. initSecContext

public byte[] initSecContext(byte[] inputBuf, int offset, int len)
throws GSSException

Called by the context initiator to start the context creation process. This method MAY return an output token that the application will need to send to the peer for processing by the accept call. The application can call isEstablished() to determine if the context establishment phase is complete for this peer. A return value of "false" from isEstablished() indicates that more tokens are expected to be supplied to the initSecContext() method. Note that it is

possible that the initSecContext() method will return a token for the peer and isEstablished() will return "true" also. This indicates that the token needs to be sent to the peer, but the local end of the context is now fully established.

Upon completion of the context establishment, the available context options may be queried through the get methods.

A GSSException will be thrown if the call fails. Users SHOULD call its getOutputToken() method to find out if there is a token that can be sent to the acceptor to communicate the reason for the error.

Parameters:

inputBuf	Token generated by the peer. This parameter is ignored on the first call.
offset	The offset within the inputBuf where the token begins.
len	The length of the token within the inputBuf (starting at the offset).

7.4.3. acceptSecContext

```
public byte[] acceptSecContext(byte[] inTok, int offset, int len)
          throws GSSException
```

Called by the context acceptor upon receiving a token from the peer.

This method MAY return an output token that the application will need to send to the peer for further processing by the init call.

The "null" return value indicates that no token needs to be sent to the peer. The application can call isEstablished() to determine if the context establishment phase is complete for this peer. A return value of "false" from isEstablished() indicates that more tokens are expected to be supplied to this method.

Note that it is possible that acceptSecContext() will return a token for the peer and isEstablished() will return "true" also. This indicates that the token needs to be sent to the peer, but the local end of the context is now fully established.

Upon completion of the context establishment, the available context options may be queried through the get methods.

A GSSException will be thrown if the call fails. Users SHOULD call its getOutputToken() method to find out if there is a token that can be sent to the initiator to communicate the reason for the error.

Parameters:

inTok	Token generated by the peer.
offset	The offset within the inTok where the token begins.
len	The length of the token within the inTok (starting at the offset).

7.4.4. isEstablished

```
public boolean isEstablished()
```

Used during context establishment to determine the state of the context. Returns "true" if this is a fully established context on the caller's side and no more tokens are needed from the peer. Should be called after a call to initSecContext() or acceptSecContext() when no GSSException is thrown.

7.4.5. dispose

```
public void dispose() throws GSSException
```

Releases any system resources and cryptographic information stored in the context object. This will invalidate the context.

7.4.6. getWrapSizeLimit

```
public int getWrapSizeLimit(int qop, boolean confReq,
          int maxTokenSize) throws GSSException
```

Returns the maximum message size that, if presented to the wrap method with the same confReq and qop parameters, will result in an output token containing no more than the maxTokenSize bytes.

This call is intended for use by applications that communicate over protocols that impose a maximum message size. It enables the application to fragment messages prior to applying protection.

GSS-API implementations are RECOMMENDED but not required to detect invalid QOP values when getWrapSizeLimit is called. This routine guarantees only a maximum message size, not the availability of specific QOP values for message protection.

Successful completion of this call does not guarantee that wrap will be able to protect a message of the computed length, since this ability may depend on the availability of system resources at the time that wrap is called. However, if the implementation itself imposes an upper limit on the length of messages that may be processed by wrap, the implementation SHOULD NOT return a value that is greater than this length.

Parameters:

qop	Indicates the level of protection wrap will be asked to provide.
confReq	Indicates if wrap will be asked to provide privacy service.
maxTokenSize	The desired maximum size of the token emitted by wrap.

7.4.7. wrap

```
public byte[] wrap(byte[] inBuf, int offset, int len,
                   MessageProp msgProp) throws GSSException
```

Applies per-message security services over the established security context. The method will return a token with a cryptographic MIC and MAY optionally encrypt the specified inBuf. The returned byte array will contain both the MIC and the message.

The MessageProp object is instantiated by the application and used to specify a QOP value that selects cryptographic algorithms, and a privacy service to optionally encrypt the message. The underlying mechanism that is used in the call may not be able to provide the privacy service. It sets the actual privacy service that it does provide in this MessageProp object, which the caller SHOULD then query upon return. If the mechanism is not able to provide the requested QOP, it throws a GSSException with the BAD_QOP code.

Since some application-level protocols may wish to use tokens emitted by wrap to provide "secure framing", implementations SHOULD support the wrapping of zero-length messages.

The application will be responsible for sending the token to the peer.

Parameters:

inBuf	Application data to be protected.

offset	The offset within the inBuf where the data begins.
len	The length of the data within the inBuf (starting at the offset).
msgProp	Instance of MessageProp that is used by the application to set the desired QOP and privacy state. Set the desired QOP to 0 to request the default QOP. Upon return from this method, this object will contain the actual privacy state that was applied to the message by the underlying mechanism.

7.4.8. unwrap

```
public byte[] unwrap(byte[] inBuf, int offset, int len,
                     MessageProp msgProp) throws GSSException
```

Used by the peer application to process tokens generated with the wrap call. The method will return the message supplied in the peer application to the wrap call, verifying the embedded MIC.

The MessageProp object is instantiated by the application and is used by the underlying mechanism to return information to the caller such as the QOP, whether confidentiality was applied to the message, and other supplementary message state information.

Since some application-level protocols may wish to use tokens emitted by wrap to provide "secure framing", implementations SHOULD support the wrapping and unwrapping of zero-length messages.

Parameters:

inBuf	GSS-API wrap token received from peer.
offset	The offset within the inBuf where the token begins.
len	The length of the token within the inBuf (starting at the offset).
msgProp	Upon return from the method, this object will contain the applied QOP, the privacy state of the message, and supplementary information, described in section 5.12.3, stating whether the token was a duplicate, old, out of sequence, or arriving after a gap.

7.4.9. getMIC

```
public byte[] getMIC(byte[] inMsg, int offset, int len,
                     MessageProp msgProp) throws GSSException
```

Returns a token containing a cryptographic MIC for the supplied message for transfer to the peer application. Unlike wrap, which encapsulates the user message in the returned token, only the message MIC is returned in the output token.

Note that privacy can only be applied through the wrap call.

Since some application-level protocols may wish to use tokens emitted by getMIC to provide "secure framing", implementations SHOULD support derivation of MICs from zero-length messages.

Parameters:

inMsg	Message over which to generate MIC.
offset	The offset within the inMsg where the token begins.
len	The length of the token within the inMsg (starting at the offset).
msgProp	Instance of MessageProp that is used by the application to set the desired QOP. Set the desired QOP to 0 in msgProp to request the default QOP. Alternatively, pass in "null" for msgProp to request default QOP.

7.4.10. verifyMIC

```
public void verifyMIC(byte[] inTok, int tokOffset, int tokLen,
                      byte[] inMsg, int msgOffset, int msgLen,
                      MessageProp msgProp) throws GSSException
```

Verifies the cryptographic MIC, contained in the token parameter, over the supplied message.

The MessageProp object is instantiated by the application and is used by the underlying mechanism to return information to the caller such as the QOP indicating the strength of protection that was applied to the message and other supplementary message state information.

Since some application-level protocols may wish to use tokens emitted by getMIC to provide "secure framing", implementations SHOULD support the calculation and verification of MICs over zero-length messages.

Parameters:

inTok	Token generated by peer's getMIC method.
tokOffset	The offset within the inTok where the token begins.
tokLen	The length of the token within the inTok (starting at the offset).
inMsg	Application message over which to verify the cryptographic MIC.
msgOffset	The offset within the inMsg where the message begins.
msgLen	The length of the message within the inMsg (starting at the offset).
msgProp	Upon return from the method, this object will contain the applied QOP and supplementary information, described in section 5.12.3, stating whether the token was a duplicate, old, out of sequence, or arriving after a gap. The confidentiality state will be set to "false".

7.4.11. export

```
public byte[] export() throws GSSException
```

Provided to support the sharing of work between multiple processes. This routine will typically be used by the context acceptor, in an application where a single process receives incoming connection requests and accepts security contexts over them, then passes the established context to one or more other processes for message exchange.

This method deactivates the security context and creates an inter-process token which, when passed to the byte array constructor of the GSSContext interface in another process, will re-activate the context in the second process. Only a single instantiation of a given context may be active at any one time; a subsequent attempt by a context exporter to access the exported security context will fail.

The implementation MAY constrain the set of processes by which the inter-process token may be imported, either as a function of local security policy, or as a result of implementation decisions. For example, some implementations may constrain contexts to be passed only between processes that run under the same account, or which are part of the same process group.

The inter-process token MAY contain security-sensitive information (for example, cryptographic keys). While mechanisms are encouraged to either avoid placing such sensitive information within inter-process tokens or to encrypt the token before returning it to the application, in a typical GSS-API implementation, this may not be possible. Thus, the application MUST take care to protect the inter-process token, and ensure that any process to which the token is transferred is trustworthy.

7.4.12. requestMutualAuth

```
public void requestMutualAuth(boolean state) throws GSSException
```

Sets the request state of the mutual authentication flag for the context. This method is only valid before the context creation process begins and only for the initiator.

Parameters:

state	Boolean representing if mutual authentication should be requested during context establishment.

7.4.13. requestReplayDet

```
public void requestReplayDet(boolean state) throws GSSException
```

Sets the request state of the replay detection service for the context. This method is only valid before the context creation process begins and only for the initiator.

Parameters:

state	Boolean representing if replay detection is desired over the established context.

7.4.14. requestSequenceDet

```
public void requestSequenceDet(boolean state) throws GSSException
```

Sets the request state for the sequence checking service of the context. This method is only valid before the context creation process begins and only for the initiator.

Parameters:

state	Boolean representing if sequence detection is desired over the established context.

7.4.15. requestCredDeleg

```
public void requestCredDeleg(boolean state) throws GSSException
```

Sets the request state for the credential delegation flag for the context. This method is only valid before the context creation process begins and only for the initiator.

Parameters:

state	Boolean representing if credential delegation is desired.

7.4.16. requestAnonymity

```
public void requestAnonymity(boolean state) throws GSSException
```

Requests anonymous support over the context. This method is only valid before the context creation process begins and only for the initiator.

Parameters:

state	Boolean representing if anonymity support is requested.

7.4.17. requestConf

```
public void requestConf(boolean state) throws GSSException
```

Requests that confidentiality service be available over the context. This method is only valid before the context creation process begins and only for the initiator.

Parameters:

state	Boolean indicating if confidentiality services are to be requested for the context.

7.4.18. requestInteg

public void requestInteg(boolean state) throws GSSException

Requests that integrity services be available over the context. This method is only valid before the context creation process begins and only for the initiator.

Parameters:

state	Boolean indicating if integrity services are to be requested for the context.

7.4.19. requestLifetime

public void requestLifetime(int lifetime) throws GSSException

Sets the desired lifetime for the context in seconds. This method is only valid before the context creation process begins and only for the initiator. Use GSSContext.INDEFINITE_LIFETIME and GSSContext.DEFAULT_LIFETIME to request indefinite or default context lifetime.

Parameters:

lifetime	The desired context lifetime in seconds.

7.4.20. setChannelBinding

public void setChannelBinding(ChannelBinding cb) throws GSSException

Sets the channel bindings to be used during context establishment. This method is only valid before the context creation process begins.

Parameters:

cb	Channel bindings to be used.

7.4.21. getCredDelegState

public boolean getCredDelegState()

Returns the state of the delegated credentials for the context. When issued before context establishment is completed or when the isProtReady method returns "false", it returns the desired state; otherwise, it will indicate the actual state over the established context.

7.4.22. getMutualAuthState

```
public boolean getMutualAuthState()
```

Returns the state of the mutual authentication option for the context. When issued before context establishment completes or when the isProtReady method returns "false", it returns the desired state; otherwise, it will indicate the actual state over the established context.

7.4.23. getReplayDetState

```
public boolean getReplayDetState()
```

Returns the state of the replay detection option for the context. When issued before context establishment completes or when the isProtReady method returns "false", it returns the desired state; otherwise, it will indicate the actual state over the established context.

7.4.24. getSequenceDetState

```
public boolean getSequenceDetState()
```

Returns the state of the sequence detection option for the context. When issued before context establishment completes or when the isProtReady method returns "false", it returns the desired state; otherwise, it will indicate the actual state over the established context.

7.4.25. getAnonymityState

```
public boolean getAnonymityState()
```

Returns "true" if this is an anonymous context. When issued before context establishment completes or when the isProtReady method returns "false", it returns the desired state; otherwise, it will indicate the actual state over the established context.

7.4.26. isTransferable

```
public boolean isTransferable() throws GSSException
```

Returns "true" if the context is transferable to other processes through the use of the export method. This call is only valid on fully established contexts.

7.4.27. isProtReady

```
public boolean isProtReady()
```

Returns "true" if the per-message operations can be applied over the context. Some mechanisms may allow the usage of per-message operations before the context is fully established. This will also indicate that the get methods will return actual context state characteristics instead of the desired ones.

7.4.28. getConfState

```
public boolean getConfState()
```

Returns the confidentiality service state over the context. When issued before context establishment completes or when the isProtReady method returns "false", it returns the desired state; otherwise, it will indicate the actual state over the established context.

7.4.29. getIntegState

```
public boolean getIntegState()
```

Returns the integrity service state over the context. When issued before context establishment completes or when the isProtReady method returns "false", it returns the desired state; otherwise, it will indicate the actual state over the established context.

7.4.30. getLifetime

```
public int getLifetime()
```

Returns the context lifetime in seconds. When issued before context establishment completes or when the isProtReady method returns "false", it returns the desired lifetime; otherwise, it will indicate the remaining lifetime for the context.

7.4.31. getSrcName

```
public GSSName getSrcName() throws GSSException
```

Returns the name of the context initiator. This call is valid only after the context is fully established or the isProtReady method returns "true". It is guaranteed to return an MN.

7.4.32. getTargName

public GSSName getTargName() throws GSSException

Returns the name of the context target (acceptor). This call is valid only after the context is fully established or the isProtReady method returns "true". It is guaranteed to return an MN.

7.4.33. getMech

public Oid getMech() throws GSSException

Returns the mechanism oid for this context. This method MAY be called before the context is fully established, but the mechanism returned MAY change on successive calls in negotiated mechanism case.

7.4.34. getDelegCred

public GSSCredential getDelegCred() throws GSSException

Returns the delegated credential object on the acceptor’s side. To check for availability of delegated credentials call getDelegCredState. This call is only valid on fully established contexts.

7.4.35. isInitiator

public boolean isInitiator() throws GSSException

Returns "true" if this is the initiator of the context. This call is only valid after the context creation process has started.

7.4.36. Example Code

The example code presented below demonstrates the usage of the GSSContext interface for the initiating peer. Different operations on the GSSContext object are presented, including: object instantiation, setting of desired flags, context establishment, query of actual context flags, per-message operations on application data, and finally context deletion.

```
<CODE BEGINS>
GSSManager mgr = GSSManager.getInstance();

// start by creating the name for a service entity
GSSName targetName = mgr.createName("service@host",
                     GSSName.NT_HOSTBASED_SERVICE);
// create a context using default credentials for the above entity
```

```
   // and the implementation-specific default mechanism
   GSSContext context = mgr.createContext(targetName,
                   null,   /* default mechanism */
                   null,   /* default credentials */
                   GSSContext.INDEFINITE_LIFETIME);

   // set desired context options - all others are "false" by default
   context.requestConf(true);
   context.requestMutualAuth(true);
   context.requestReplayDet(true);
   context.requestSequenceDet(true);

   // establish a context between peers - using byte arrays
   byte[]inTok = new byte[0];

   try {
       do {
           byte[] outTok = context.initSecContext(inTok, 0,
                                                  inTok.length);

           // send the token if present
           if (outTok != null)
               sendToken(outTok);

           // check if we should expect more tokens
           if (context.isEstablished())
               break;

           // another token expected from peer
           inTok = readToken();

       } while (true);

   } catch (GSSException e) {
       print("GSSAPI error: " + e.getMessage());

       // If the exception contains an output token,
       // it should be sent to the acceptor.
       byte[] outTok = e.getOutputToken();
       if (outTok != null) {
           sendToken(outTok);
       }

       return;
   }

   // display context information
   print("Remaining lifetime in seconds = " + context.getLifetime());
```

```
print("Context mechanism = " + context.getMech().toString());
print("Initiator = " + context.getSrcName().toString());
print("Acceptor = " + context.getTargName().toString());

if (context.getConfState())
    print("Confidentiality security service available");

if (context.getIntegState())
    print("Integrity security service available");

// perform wrap on an application-supplied message, appMsg,
// using QOP = 0, and requesting privacy service
byte[] appMsg ...

MessageProp mProp = new MessageProp(0, true);

byte[] tok = context.wrap(appMsg, 0, appMsg.length, mProp);

if (mProp.getPrivacy())
    print("Message protected with privacy.");

sendToken(tok);

// release the local end of the context
context.dispose();
<CODE ENDS>
```

7.5. public class MessageProp

This is a utility class used within the per-message GSSContext methods to convey per-message properties.

When used with the GSSContext interface's wrap and getMIC methods, an instance of this class is used to indicate the desired QOP and to request if confidentiality services are to be applied to caller supplied data (wrap only). To request default QOP, the value of 0 should be used for QOP. A QOP is an integer value defined by an mechanism.

When used with the unwrap and verifyMIC methods of the GSSContext interface, an instance of this class will be used to indicate the applied QOP and confidentiality services over the supplied message. In the case of verifyMIC, the confidentiality state will always be "false". Upon return from these methods, this object will also contain any supplementary status values applicable to the processed token. The supplementary status values can indicate old tokens, out of sequence tokens, gap tokens, or duplicate tokens.

7.5.1. Constructors

public MessageProp(boolean privState)

Constructor that sets QOP to 0 indicating that the default QOP is requested.

Parameters:

privState	The desired privacy state. "true" for privacy and "false" for integrity only.

public MessageProp(int qop, boolean privState)

Constructor that sets the values for the qop and privacy state.

Parameters:

qop	The desired QOP. Use 0 to request a default QOP.
privState	The desired privacy state. "true" for privacy and "false" for integrity only.

7.5.2. getQOP

public int getQOP()

Retrieves the QOP value.

7.5.3. getPrivacy

public boolean getPrivacy()

Retrieves the privacy state.

7.5.4. getMinorStatus

public int getMinorStatus()

Retrieves the minor status that the underlying mechanism might have set.

7.5.5. getMinorString

public String getMinorString()

Returns a string explaining the mechanism-specific error code. "null" will be returned when no mechanism error code has been set.

7.5.6. setQOP

public void setQOP(int qopVal)

Sets the QOP value.

Parameters:

qopVal	The QOP value to be set. Use 0 to request a default QOP value.

7.5.7. setPrivacy

public void setPrivacy(boolean privState)

Sets the privacy state.

Parameters:

privState	The privacy state to set.

7.5.8. isDuplicateToken

public boolean isDuplicateToken()

Returns "true" if this is a duplicate of an earlier token.

7.5.9. isOldToken

public boolean isOldToken()

Returns "true" if the token’s validity period has expired.

7.5.10. isUnseqToken

public boolean isUnseqToken()

Returns "true" if a later token has already been processed.

7.5.11. isGapToken

public boolean isGapToken()

Returns "true" if an expected per-message token was not received.

7.5.12. setSupplementaryStates

```
public void setSupplementaryStates(boolean duplicate,
               boolean old, boolean unseq, boolean gap,
               int minorStatus, String minorString)
```

This method sets the state for the supplementary information flags and the minor status in MessageProp. It is not used by the application but by the GSS implementation to return this information to the caller of a per-message context method.

Parameters:

duplicate	"true" if the token was a duplicate of an earlier token; otherwise, "false".
old	"true" if the token's validity period has expired; otherwise, "false".
unseq	"true" if a later token has already been processed; otherwise, "false".
gap	"true" if one or more predecessor tokens have not yet been successfully processed; otherwise, "false".
minorStatus	The integer minor status code that the underlying mechanism wants to set.
minorString	The textual representation of the minorStatus value.

7.6. public class ChannelBinding

The GSS-API accommodates the concept of caller-provided channel binding information. Channel bindings are used to strengthen the quality with which peer entity authentication is provided during context establishment. They enable the GSS-API callers to bind the establishment of the security context to relevant characteristics like addresses or to application-specific data.

The caller initiating the security context MUST determine the appropriate channel binding values to set in the GSSContext object. The acceptor MUST provide an identical binding in order to validate that received tokens possess correct channel-related characteristics.

Use of channel bindings is OPTIONAL in GSS-API. Since channel-binding information may be transmitted in context establishment

tokens, applications SHOULD therefore not use confidential data as channel-binding components.

7.6.1. Constructors

```
public ChannelBinding(InetAddress initAddr, InetAddress acceptAddr,
                      byte[] appData)
```

Create a ChannelBinding object with user-supplied address information and data. "null" values can be used for any fields that the application does not want to specify.

Parameters:

initAddr	The address of the context initiator. "null" value can be supplied to indicate that the application does not want to set this value.
acceptAddr	The address of the context acceptor. "null" value can be supplied to indicate that the application does not want to set this value.
appData	Application-supplied data to be used as part of the channel bindings. "null" value can be supplied to indicate that the application does not want to set this value.

```
public ChannelBinding(byte[] appData)
```

Creates a ChannelBinding object without any addressing information.

Parameters:

appData	Application supplied data to be used as part of the channel bindings.

7.6.2. getInitiatorAddress

```
public InetAddress getInitiatorAddress()
```

Returns the initiator’s address for this channel binding. "null" is returned if the address has not been set.

7.6.3. getAcceptorAddress

```
public InetAddress getAcceptorAddress()
```

Returns the acceptor's address for this channel binding. "null" is returned if the address has not been set.

7.6.4. getApplicationData

public byte[] getApplicationData()

Returns application data being used as part of the ChannelBinding. "null" is returned if no application data has been specified for the channel binding.

7.6.5. equals

public boolean equals(Object obj)

Returns "true" if two channel bindings match. (Note that the Java language specification requires that two objects that are equal according to the equals(Object) method MUST return the same integer result when the hashCode() method is called on them.)

Parameters:

obj Another channel binding with which to compare.

7.7. public class Oid

This class represents Universal Object Identifiers (Oids) and their associated operations.

Oids are hierarchically globally interpretable identifiers used within the GSS-API framework to identify mechanisms and name formats.

The structure and encoding of Oids is defined in ISOIEC-8824 and ISOIEC-8825. For example, the Oid representation of the Kerberos v5 mechanism is "1.2.840.113554.1.2.2".

The GSSName name class contains public static Oid objects representing the standard name types defined in GSS-API.

7.7.1. Constructors

public Oid(String strOid) throws GSSException

Creates an Oid object from a string representation of its integer components (e.g., "1.2.840.113554.1.2.2").

Parameters:

strOid The string representation for the oid.

public Oid(InputStream derOid) throws GSSException

Creates an Oid object from its DER encoding. This refers to the full encoding including tag and length. The structure and encoding of Oids is defined in ISOIEC-8824 and ISOIEC-8825. This method is identical in functionality to its byte array counterpart.

Parameters:

derOid Stream containing the DER-encoded oid.

public Oid(byte[] DEROid) throws GSSException

Creates an Oid object from its DER encoding. This refers to the full encoding including tag and length. The structure and encoding of Oids is defined in ISOIEC-8824 and ISOIEC-8825. This method is identical in functionality to its byte array counterpart.

Parameters:

derOid Byte array storing a DER-encoded oid.

7.7.2. toString

public String toString()

Returns a string representation of the oid’s integer components in dot separated notation (e.g., "1.2.840.113554.1.2.2").

7.7.3. equals

public boolean equals(Object Obj)

Returns "true" if the two Oid objects represent the same oid value. (Note that the Java language specification [JLS] requires that two objects that are equal according to the equals(Object) method MUST return the same integer result when the hashCode() method is called on them.)

Parameters:

obj Another Oid object with which to compare.

7.7.4. getDER

public byte[] getDER()

Returns the full ASN.1 DER encoding for this oid object, which includes the tag and length.

7.7.5. containedIn

public boolean containedIn(Oid[] oids)

A utility method to test if an Oid object is contained within the supplied Oid object array.

Parameters:

oids An array of oids to search.

7.8. public class GSSException extends Exception

This exception is thrown whenever a fatal GSS-API error occurs including mechanism-specific errors. It MAY contain both, the major and minor, GSS-API status codes. The mechanism implementors are responsible for setting appropriate minor status codes when throwing this exception. Aside from delivering the numeric error code(s) to the caller, this class performs the mapping from their numeric values to textual representations. This exception MAY also include an output token that SHOULD be sent to the peer. For example, when an initSecContext call fails due to a fatal error, the mechanism MAY define an error token that SHOULD be sent to the peer for debugging or informational purpose. All Java GSS-API methods are declared throwing this exception.

All implementations are encouraged to use the Java internationalization techniques to provide local translations of the message strings.

7.8.1. Static Constants

All valid major GSS-API error code values are declared as constants in this class.

public static final int BAD_BINDINGS

Channel bindings mismatch error. The value of this constant is 1.

public static final int BAD_MECH

Unsupported mechanism requested error. The value of this constant is 2.

public static final int BAD_NAME

Invalid name provided error. The value of this constant is 3.

public static final int BAD_NAMETYPE

Name of unsupported type provided error. The value of this constant is 4.

public static final int BAD_STATUS

Invalid status code error - this is the default status value. The value of this constant is 5.

public static final int BAD_MIC

Token had invalid integrity check error. The value of this constant is 6.

public static final int CONTEXT_EXPIRED

Specified security context expired error. The value of this constant is 7.

public static final int CREDENTIALS_EXPIRED

Expired credentials detected error. The value of this constant is 8.

public static final int DEFECTIVE_CREDENTIAL

Defective credential error. The value of this constant is 9.

public static final int DEFECTIVE_TOKEN

Defective token error. The value of this constant is 10.

public static final int FAILURE

General failure, unspecified at GSS-API level. The value of this constant is 11.

public static final int NO_CONTEXT

Invalid security context error. The value of this constant is 12.

public static final int NO_CRED

Invalid credentials error. The value of this constant is 13.

public static final int BAD_QOP

Unsupported QOP value error. The value of this constant is 14.

public static final int UNAUTHORIZED

Operation unauthorized error. The value of this constant is 15.

public static final int UNAVAILABLE

Operation unavailable error. The value of this constant is 16.

public static final int DUPLICATE_ELEMENT

Duplicate credential element requested error. The value of this constant is 17.

public static final int NAME_NOT_MN

Name contains multi-mechanism elements error. The value of this constant is 18.

public static final int DUPLICATE_TOKEN

The token was a duplicate of an earlier token. This is contained in an exception only when detected during context establishment, in which case it is considered a fatal error. (Non-fatal supplementary codes are indicated via the MessageProp object.) The value of this constant is 19.

public static final int OLD_TOKEN

The token’s validity period has expired. This is contained in an exception only when detected during context establishment, in which case it is considered a fatal error. (Non-fatal supplementary codes are indicated via the MessageProp object.) The value of this constant is 20.

public static final int UNSEQ_TOKEN

A later token has already been processed. This is contained in an exception only when detected during context establishment, in which case it is considered a fatal error. (Non-fatal supplementary codes

are indicated via the MessageProp object.) The value of this constant is 21.

public static final int GAP_TOKEN

An expected per-message token was not received. This is contained in an exception only when detected during context establishment, in which case it is considered a fatal error. (Non-fatal supplementary codes are indicated via the MessageProp object.) The value of this constant is 22.

7.8.2. Constructors

public GSSException(int majorCode)

Creates a GSSException object with a specified major code.

Calling this constructor is equivalent to calling GSSException(majorCode, null, 0, null, null).

public GSSException(int majorCode, int minorCode, String minorString)

Creates a GSSException object with the specified major code, minor code, and minor code textual explanation. This constructor is to be used when the exception is originating from the security mechanism. It allows to specify the GSS code and the mechanism code.

Calling this constructor is equivalent to calling GSSException(majorCode, null, minorCode, minorString, null).

```
public GSSException(int majorCode, String majorString,
                    int minorCode, String minorString,
                    byte[] outputToken)
```

Creates a GSSException object with the specified major code, major code textual explanation, minor code, minor code textual explanation, and an output token. This is a general-purpose constructor that can be used to create any type of GSSException.

Parameters:

majorCode	The GSS error code causing this exception to be thrown.
majorString	The textual explanation of the GSS error code. If null is provided, a default explanation that matches the majorCode will be set.

minorCode	The mechanism error code causing this exception to be thrown. Can be 0 if no mechanism error code is available.
minorString	The textual explanation of the mechanism error code. Can be null if no textual explanation is available.
outputToken	The output token that SHOULD be sent to the peer. Can be null if no such token is available. It MUST NOT be an empty array. When provided, the array will be cloned to protect against subsequent modifications.

7.8.3. getMajor

```
public int getMajor()
```

Returns the major code representing the GSS error code that caused this exception to be thrown.

7.8.4. getMinor

```
public int getMinor()
```

Returns the mechanism error code that caused this exception. The minor code is set by the underlying mechanism. Value of 0 indicates that mechanism error code is not set.

7.8.5. getMajorString

```
public String getMajorString()
```

Returns a string explaining the GSS major error code causing this exception to be thrown.

7.8.6. getMinorString

```
public String getMinorString()
```

Returns a string explaining the mechanism-specific error code. "null" will be returned when no string explaining the mechanism error code has been set.

7.8.7. getOutputToken

public byte[] getOutputToken

Returns the output token in a new byte array.

If the method (For example, GSSContext#initSecContext) that throws this GSSException needs to generate an output token that SHOULD be sent to the peer, that token will be stored in this GSSException and can be retrieved with this method.

The return value MUST be null if no such token is generated. It MUST NOT be an empty byte array.

7.8.8. setMinor

public void setMinor(int minorCode, String message)

Used internally by the GSS-API implementation and the underlying mechanisms to set the minor code and its textual representation.

Parameters:

minorCode	The mechanism-specific error code.
message	A textual explanation of the mechanism error code.

7.8.9. toString

public String toString()

Returns a textual representation of both the major and minor status codes.

7.8.10. getMessage

public String getMessage()

Returns a detailed message of this exception. Overrides Throwable.getMessage. It is customary in Java to use this method to obtain exception information.

8. Sample Applications

8.1. Simple GSS Context Initiator

```
<CODE BEGINS>
import org.ietf.jgss.*;

/**
 * This is a partial sketch for a simple client program that acts
 * as a GSS context initiator.  It illustrates how to use the Java
 * bindings for the GSS-API specified in
 * Generic Security Service API Version 2 : Java bindings
 *
 *
 * This code sketch assumes the existence of a GSS-API
 * implementation that supports the mechanism that it will need
 * and is present as a library package (org.ietf.jgss) either as
 * part of the standard JRE or in the CLASSPATH the application
 * specifies.
 */

 public class SimpleClient {

     private String serviceName; // name of peer (i.e., server)
     private GSSCredential clientCred = null;
     private GSSContext context = null;
     private Oid mech; // underlying mechanism to use

     private GSSManager mgr = GSSManager.getInstance();

     ...
     ...

     private void clientActions() {
        initializeGSS();
        establishContext();
        doCommunication();
     }

    /**
     * Acquire credentials for the client.
     */
    private void initializeGSS() {

        try {

            clientCred = mgr.createCredential(null /*default princ*/,
                GSSCredential.INDEFINITE_LIFETIME /* max lifetime */,
                mech /* mechanism to use */,
                GSSCredential.INITIATE_ONLY /* init context */);
```

```
            print("GSSCredential created for " +
                    cred.getName().toString());
            print("Credential lifetime (sec)=" +
                    cred.getRemainingLifetime());
        } catch (GSSException e) {
            print("GSS-API error in credential acquisition: "
                  + e.getMessage());
            ...
            ...
        }
        ...
        ...
    }

    /**
     * Does the security context establishment with the
     * server.
     */
    private void establishContext() {

        byte[] inToken = new byte[0];
        byte[] outToken = null;

        try {

            GSSName peer = mgr.createName(serviceName,
                                GSSName.NT_HOSTBASED_SERVICE);
            context = mgr.createContext(peer, mech, gssCred,
                   GSSContext.INDEFINITE_LIFETIME/*lifetime*/);

            // Will need to support confidentiality
            context.requestConf(true);

            while (!context.isEstablished()) {

                outToken = context.initSecContext(inToken, 0,
                                                  inToken.length);

                if (outToken != null)
                    writeGSSToken(outToken);

                if (!context.isEstablished())
                    inToken = readGSSToken();
            }

            GSSName peer = context.getSrcName();
            print("Security context established with " + peer +
                  " using underlying mechanism " + mech.toString());
```

```
            } catch (GSSException e) {
                 print("GSS-API error during context establishment: "
                       + e.getMessage());

                 // If the exception contains an output token,
                 // it should be sent to the acceptor.
                 byte[] outTok = e.getOutputToken();
                 if (outTok != null) {
                     writeGSSToken(outTok);
                 }
                 ...
                 ...
            }
            ...
            ...
        }

        /**
         * Sends some data to the server and reads back the
         * response.
         */
        private void doCommunication()  {
            byte[] inToken = null;
            byte[] outToken = null;
            byte[] buffer;

            // Container for multiple input-output arguments to and
            // from the per-message routines (e.g., wrap/unwrap).
            MessageProp messgInfo = new MessageProp();

            try {

                /*
                 * Now send some bytes to the server to be
                 * processed.  They will be integrity protected
                 * but not encrypted for privacy.
                 */

                buffer = readFromFile();

                // Set privacy to "false" and use the default QOP
                messgInfo.setPrivacy(false);

                outToken = context.wrap(buffer, 0, buffer.length,
                                        messgInfo);

                writeGSSToken(outToken);
```

```
                /*
                 * Now read the response from the server.
                 */

                inToken = readGSSToken();
                buffer = context.unwrap(inToken, 0,
                                inToken.length, messgInfo);
                // All ok if no exception was thrown!

                GSSName peer = context.getSrcName();

                print("Message from "  + peer.toString()
                      + " arrived.");
                print("Was it encrypted? "  +
                      messgInfo.getPrivacy());
                print("Duplicate Token? "   +
                      messgInfo.isDuplicateToken());
                print("Old Token? "         +
                      messgInfo.isOldToken());
                print("Unsequenced Token? " +
                      messgInfo.isUnseqToken());
                print("Gap Token? "         +
                      messgInfo.isGapToken());
                ...
                ...
            } catch (GSSException e) {
                print("GSS-API error in per-message calls: "
                      + e.getMessage());
                ...
                ...
            }
            ...
            ...
        } // end of doCommunication method

        ...
        ...

   } // end of class SimpleClient
   <CODE ENDS>
```

8.2. Simple GSS Context Acceptor

```
   <CODE BEGINS>
   import org.ietf.jgss.*;

   /**
    * This is a partial sketch for a simple server program that acts
```

```
    * as a GSS context acceptor.  It illustrates how to use the Java
    * bindings for the GSS-API specified in
    * Generic Security Service API Version 2 : Java bindings.
    *
    * This code sketch assumes the existence of a GSS-API
    * implementation that supports the mechanisms that it will need
    * and is present as a library package (org.ietf.jgss) either as
    * part of the standard JRE or in the CLASSPATH the application
    * specifies.
    */

   import org.ietf.jgss.*;

   public class SimpleServer {

       private String serviceName;
       private GSSName name;
       private GSSCredential cred;

       private GSSManager mgr;

       ...
       ...

       /**
        * Wait for client connections, establish security contexts
        * and provide service.
        */
       private void loop() {
           ...
           ...
           mgr = GSSManager.getInstance();

           name = mgr.createName(serviceName,
                     GSSName.NT_HOSTBASED_SERVICE);

           cred = mgr.createCredential(name,
                     GSSCredential.INDEFINITE_LIFETIME,
                     null,
                     GSSCredential.ACCEPT_ONLY);

           // Loop infinitely
           while (true) {
               Socket s = serverSock.accept();

               // Start a new thread to serve this connection
               Thread serverThread = new ServerThread(s);
               serverThread.start();
```

```
        }
    }

    /**
     * Inner class ServerThread whose run() method provides the
     * secure service to a connection.
     */

    private class ServerThread extends Thread {

        ...
        ...

        /**
         * Deals with the connection from one client.  It also
         * handles all GSSException's thrown while talking to
         * this client.
         */
        public void run() {

            byte[] inToken = null;
            byte[] outToken = null;
            byte[] buffer;

            GSSName peer;

            // Container for multiple input-output arguments to
            // and from the per-message routines
            // (i.e., wrap/unwrap).
            MessageProp supplInfo = new MessageProp();
            GSSContext secContext = null;

            try {
                // Now do the context establishment loop
                GSSContext context = mgr.createContext(cred);

                while (!context.isEstablished()) {

                    inToken = readGSSToken();
                    outToken = context.acceptSecContext(inToken,
                                                0, inToken.length);
                    if (outToken != null)
                        writeGSSToken(outToken);
                }

                // SimpleServer wants confidentiality to be
                // available.  Check for it.
                if (!context.getConfState()){
```

```
    ...
    ...
}

GSSName peer = context.getSrcName();
Oid mech = context.getMech();
print("Security context established with " +
       peer.toString() +
      " using underlying mechanism " +
      mech.toString() +
      " from Provider " +
      context.getProvider().getName());

// Now read the bytes sent by the client to be
// processed.
inToken = readGSSToken();

// Unwrap the message
buffer = context.unwrap(inToken, 0,
           inToken.length, supplInfo);
// All ok if no exception was thrown!

// Print other supplementary per-message status
// information.

print("Message from " +
        peer.toString() + " arrived.");
print("Was it encrypted? " +
        supplInfo.getPrivacy());
print("Duplicate Token? " +
        supplInfo.isDuplicateToken());
print("Old Token? "  + supplInfo.isOldToken());
print("Unsequenced Token? " +
        supplInfo.isUnseqToken());
print("Gap Token? "  + supplInfo.isGapToken());

/*
 * Now process the bytes and send back an
 * encrypted response.
 */

buffer = serverProcess(buffer);

// Encipher it and send it across

supplInfo.setPrivacy(true); // privacy requested
supplInfo.setQOP(0); // default QOP
outToken = context.wrap(buffer, 0, buffer.length,
```

```
                                            supplInfo);
                    writeGSSToken(outToken);

                } catch (GSSException e) {
                    print("GSS-API Error: " + e.getMessage());
                    // Alternatively, could call e.getMajorMessage()
                    // and e.getMinorMessage()

                    // If the exception contains an output token,
                    // it should be sent to the initiator.
                    byte[] outTok = e.getOutputToken();
                    if (outTok != null) {
                        writeGSSToken(outTok);
                    }
                    print("Abandoning security context.");
                    ...
                    ...
                }
                ...
                ...
            } // end of run method in ServerThread

        } // end of inner class ServerThread

        ...
        ...

    } // end of class SimpleServer
    <CODE ENDS>
```

9. Security Considerations

The Java language security model allows platform providers to have policy-based fine-grained access control over any resource that an application wants. When using a Java security manager (such as, but not limited to, the case of applets running in browsers) the application code is in a sandbox by default.

Administrators of the platform JRE determine what permissions, if any, are to be given to source from different codebases. Thus, the administrator has to be aware of any special requirements that the GSS provider might have for system resources. For instance, a Kerberos provider might wish to make a network connection to the Key Distribution Center (KDC) to obtain initial credentials. This would not be allowed under the sandbox unless the administrator had granted permissions for this. Also, note that this granting and checking of permissions happens transparently to the application and is outside the scope of this document.

The Java language allows administrators to pre-configure a list of security service providers in the <JRE>/lib/security/java.security file. At runtime, the system approaches these providers in order of preference when looking for security related services. Applications have a means to modify this list through methods in the "Security" class in the "java.security" package. However, since these modifications would be visible in the entire Java Virtual Machine (JVM) and thus affect all code executing in it, this operation is not available in the sandbox and requires special permissions to perform. Thus, when a GSS application has special needs that are met by a particular security provider, it has two choices:

1) To install the provider on a JVM-wide basis using the java.security.Security class and then depend on the system to find the right provider automatically when the need arises. (This would require the application to be granted a "insertProvider SecurityPermission".)

2) To pass an instance of the provider to the local instance of GSSManager so that only factory calls going through that GSSManager use the desired provider. (This would not require any permissions.)

10. IANA Considerations

This document has no actions for IANA.

11. Acknowledgments

This proposed API leverages earlier work performed by the IETF's CAT WG as outlined in both RFC 2743 [RFC2743] and RFC 2744 [RFC2744]. Many conceptual definitions, implementation directions, and explanations have been included from these documents.

We would like to thank Mike Eisler, Lin Ling, Ram Marti, Michael Saltz, and other members of Sun's development team for their helpful input, comments, and suggestions.

We would also like to thank Joe Salowey, and Michael Smith for many insightful ideas and suggestions that have contributed to this document.

12. Changes since RFC 5653

This document has following changes:

1) New error token embedded in GSSException

There is a design flaw in the initSecContext and acceptSecContext methods of the GSSContext class defined in Generic Security Service API Version 2: Java Bindings Update [RFC5653].

The methods could either return a token (possibly null if no more tokens are needed) when the call succeeds or throw a GSSException if there is a failure, but NOT both. On the other hand, the C bindings of GSS-API [RFC2744] can return both, that is to say, a call to the GSS_Init_sec_context() function can return a major status code, and at the same time, fill in the output_token argument if there is one.

Without the ability to emit an error token when there is a failure, a Java application has no mechanism to tell the other side what the error is. For example, a "reject" NegTokenResp token can never be transmitted for the SPNEGO mechanism [RFC4178].

While a Java method can never return a value and throw an exception at the same time, we can embed the error token inside the exception so that the caller has a chance to retrieve it. This update adds a new GSSException constructor to include this token inside a GSSException object, and a getOutputToken() method to retrieve the token. The specification for the initSecContext and acceptSecContext methods are updated to describe the new behavior. Various examples are also updated.

New JGSS programs SHOULD make use of this new feature but it is not mandatory. A program that intends to run with both old and new GSS Java bindings can use reflection to check the availability of this new method and call it accordingly.

2) Removing stream-based GSSContext methods

The overloaded methods of GSSContext that use input and output streams as the means to convey authentication and per-message GSS-API tokens as described in Section 5.15 of RFC 5653 [RFC5653] are removed in this update as the wire protocol should be defined by an application and not a library. It’s also impossible to implement these methods correctly when the token has no self-framing (where the end cannot be determined) or the library has no knowledge of the token format (for example, as a bridge talking to another GSS library). These methods include initSecContext (Section 7.4.5 of RFC 5653 [RFC5653]), acceptSecContext (Section 7.4.9 of RFC 5653 [RFC5653]), wrap (Section 7.4.15 of RFC 5653 [RFC5653]), unwrap (Section 7.4.17 of RFC 5653 [RFC5653]), getMIC (Section 7.4.19 of RFC 5653 [RFC5653]), and verifyMIC (Section 7.4.21 of RFC 5653 [RFC5653]).

13. Changes since RFC 2853

This document has following changes:

1) Major GSS Status Code Constant Values

   RFC 2853 listed all the GSS status code values in two different sections: section 4.12.1 defined numeric values for them, and section 6.8.1 defined them as static constants in the GSSException class without assigning any values. Due to an inconsistent ordering between these two sections, all of the GSS major status codes resulted in misalignment, and a subsequent disagreement between deployed implementations.

   This document defines the numeric values of the GSS status codes in both sections, while maintaining the original ordering from section 6.8.1 of RFC 2853 [RFC2853], and obsoletes the GSS status code values defined in section 4.12.1. The relevant sections in this document are sections 5.12.1 and 7.8.1.

2) GSS Credential Usage Constant Values

   RFC 2853 section 6.3.2 defines static constants for the GSSCredential usage flags. However, the values of these constants were not defined anywhere in RFC 2853 [RFC2853].

   This document defines the credential usage values in section 7.3.1. The original ordering of these values from section 6.3.2 of RFC 2853 [RFC2853] is maintained.

3) GSS Host-Based Service Name

   RFC 2853 [RFC2853], section 6.2.2, defines the static constant for the GSS host-based service OID NT_HOSTBASED_SERVICE, using a deprecated OID value.

   This document updates the NT_HOSTBASED_SERVICE OID value in section 7.2.1 to be consistent with the C-bindings in RFC 2744 [RFC2744].

14. References

14.1. Normative References

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14.2. Informative References

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Anonymity Support for Kerberos
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Abstract

This document defines extensions to the Kerberos protocol to allow a Kerberos client to securely communicate with a Kerberos application service without revealing its identity, or without revealing more than its Kerberos realm. It also defines extensions that allow a Kerberos client to obtain anonymous credentials without revealing its identity to the Kerberos Key Distribution Center (KDC). This document updates RFCs 4120, 4121, and 4556. This document obsoletes RFC 6112 and reclassifies that document as historic. RFC 6112 contained errors and the protocol described in that specification is not interoperable with any known implementation. This specification describes a protocol that interoperates with multiple implementations.

Status of This Memo

This Internet-Draft is submitted in full conformance with the provisions of BCP 78 and BCP 79.

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This Internet-Draft will expire on May 20, 2017.

Table of Contents

1. Introduction

In certain situations, the Kerberos [RFC4120] client may wish to authenticate a server and/or protect communications without revealing the client's own identity. For example, consider an application that provides read access to a research database and that permits queries by arbitrary requesters. A client of such a service might wish to authenticate the service, to establish trust in the information received from it, but might not wish to disclose the client's identity to the service for privacy reasons.

Extensions to Kerberos are specified in this document by which a client can authenticate the Key Distribution Center (KDC) and request an anonymous ticket. The client can use the anonymous ticket to authenticate the server and protect subsequent client-server communications.

By using the extensions defined in this specification, the client can request an anonymous ticket where the client may reveal the client's identity to the client's own KDC, or the client can hide the client's identity completely by using anonymous Public Key Cryptography for Initial Authentication in Kerberos (PKINIT) as defined in Section 4.1. Using the returned anonymous ticket, the client remains anonymous in subsequent Kerberos exchanges thereafter to KDCs on the cross-realm authentication path and to the server with which it communicates.

In this specification, the client realm in the anonymous ticket is the anonymous realm name when anonymous PKINIT is used to obtain the ticket. The client realm is the client's real realm name if the client is authenticated using the client's long-term keys. Note that a membership in a realm can imply a member of the community represented by the realm.

The interaction with Generic Security Service Application Program Interface (GSS-API) is described after the protocol description.

This specification replaces [RFC6112] to correct technical errors in that specification. RFC 6112 is classified as historic; implementation of RFC 6112 is NOT RECOMMENDED: existing implementations comply with this specification and not RFC 6112.

1.1. Changes Since RFC 6112

In Section 7, the pepper2 string, "KeyExchange", is corrected to comply with the string actually used by implementations.

The requirement for the anonymous option to be used when an anonymous ticket is used in a TGS request is reduced from a MUST to a SHOULD. At least one implementation does not require this and is not necessary that both be used as an indicator of request type.

Corrected the authorization data type name, AD-INITIAL-VERIFIED-CAS, referenced in this document.

2. Conventions Used in This Document

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [RFC2119].

3. Definitions

The anonymous Kerberos realm name is defined as a well-known realm name based on [RFC6111], and the value of this well-known realm name is the literal "WELLKNOWN:ANONYMOUS".

The anonymous Kerberos principal name is defined as a well-known Kerberos principal name based on [RFC6111]. The value of the name-type field is KRB_NT_WELLKNOWN [RFC6111], and the value of the name-string field is a sequence of two KerberosString components: "WELLKNOWN", "ANONYMOUS".

The anonymous ticket flag is defined as bit 16 (with the first bit being bit 0) in the TicketFlags:

```
        TicketFlags     ::= KerberosFlags
          -- anonymous(16)
          -- TicketFlags and KerberosFlags are defined in [RFC4120]
```

This is a new ticket flag that is used to indicate that a ticket is an anonymous one.

An anonymous ticket is a ticket that has all of the following properties:

- The cname field contains the anonymous Kerberos principal name.

- The crealm field contains the client's realm name or the anonymous realm name.

- The anonymous ticket contains no information that can reveal the client's identity. However, the ticket may contain the client realm, intermediate realms on the client's authentication path, and authorization data that may provide information related to the client's identity. For example, an anonymous principal that is identifiable only as being in a particular group of users can be implemented using authorization data. Such authorization data, if included in the anonymous ticket, would disclose that the client is a member of the group observed.

- The anonymous ticket flag is set.

The anonymous KDC option is defined as bit 16 (with the first bit being bit 0) in the KDCOptions:

```
KDCOptions      ::= KerberosFlags
  -- anonymous(16)
  -- KDCOptions and KerberosFlags are defined in [RFC4120]
```

As described in Section 4, the anonymous KDC option is set to request an anonymous ticket in an Authentication Service (AS) request or a Ticket Granting Service (TGS) request.

4. Protocol Description

In order to request an anonymous ticket, the client sets the anonymous KDC option in an AS request or a TGS request.

The rest of this section is organized as follows: it first describes protocol actions specific to AS exchanges, then it describes those of TGS exchanges. These are then followed by the description of protocol actions common to both AS and TGS and those in subsequent exchanges.

4.1. Anonymity Support in AS Exchange

The client requests an anonymous ticket by setting the anonymous KDC option in an AS exchange.

The Kerberos client can use the client's long-term keys, the client's X.509 certificates [RFC4556], or any other pre-authentication data,

to authenticate to the KDC and request an anonymous ticket in an AS exchange where the client's identity is known to the KDC.

If the client in the AS request is anonymous, the anonymous KDC option MUST be set in the request. Otherwise, the KDC MUST return a KRB-ERROR message with the code KDC_ERR_BADOPTION.

If the client is anonymous and the KDC does not have a key to encrypt the reply (this can happen when, for example, the KDC does not support PKINIT [RFC4556]), the KDC MUST return an error message with the code KDC_ERR_NULL_KEY [RFC4120].

When policy allows, the KDC issues an anonymous ticket. If the client name in the request is the anonymous principal, the client realm (crealm) in the reply is the anonymous realm, otherwise, the client realm is the realm of the AS. As specified by [RFC4120], the client name and the client realm in the EncTicketPart of the reply MUST match with the corresponding client name and the client realm of the KDC reply; the client MUST use the client name and the client realm returned in the KDC-REP in subsequent message exchanges when using the obtained anonymous ticket.

The KDC MUST NOT reveal the client's identity in the authorization data of the returned ticket when populating the authorization data in a returned anonymous ticket.

The AD_INITIAL_VERIFIED_CAS authorization data, as defined in [RFC4556], contains the issuer name of the client certificate. This authorization is not applicable and MUST NOT be present in the returned anonymous ticket when anonymous PKINIT is used. When the client is authenticated (i.e., anonymous PKINIT is not used), if it is undesirable to disclose such information about the client's identity, the AD_INITIAL_VERIFIED_CAS authorization data SHOULD be removed from the returned anonymous ticket.

The client can use the client's key to mutually authenticate with the KDC and request an anonymous Ticket Granting Ticket (TGT) in the AS request. In that case, the reply key is selected as normal, according to Section 3.1.3 of [RFC4120].

4.1.1. Anonymous PKINIT

This sub-section defines anonymous PKINIT.

As described earlier in this section, the client can request an anonymous ticket by authenticating to the KDC using the client's identity; alternatively, without revealing the client's identity to the KDC, the Kerberos client can request an anonymous ticket as

follows: the client sets the client name as the anonymous principal in the AS exchange and provides PA_PK_AS_REQ pre-authentication data [RFC4556] where the signerInfos field of the SignedData [RFC5652] of the PA_PK_AS_REQ is empty, and the certificates field is absent. Because the anonymous client does not have an associated asymmetric key pair, the client MUST choose the Diffie-Hellman key agreement method by filling in the Diffie-Hellman domain parameters in the clientPublicValue [RFC4556]. This use of the anonymous client name in conjunction with PKINIT is referred to as anonymous PKINIT. If anonymous PKINIT is used, the realm name in the returned anonymous ticket MUST be the anonymous realm.

Upon receiving the anonymous PKINIT request from the client, the KDC processes the request, according to Section 3.1.2 of [RFC4120]. The KDC skips the checks for the client's signature and the client's public key (such as the verification of the binding between the client's public key and the client name), but performs otherwise applicable checks, and proceeds as normal, according to [RFC4556]. For example, the AS MUST check if the client's Diffie-Hellman domain parameters are acceptable. The Diffie-Hellman key agreement method MUST be used and the reply key is derived according to Section 3.2.3.1 of [RFC4556]. If the clientPublicValue is not present in the request, the KDC MUST return a KRB-ERROR with the code KDC_ERR_PUBLIC_KEY_ENCRYPTION_NOT_SUPPORTED [RFC4556]. If all goes well, an anonymous ticket is generated, according to Section 3.1.3 of [RFC4120], and PA_PK_AS_REP [RFC4556] pre-authentication data is included in the KDC reply, according to [RFC4556]. If the KDC does not have an asymmetric key pair, it MAY reply anonymously or reject the authentication attempt. If the KDC replies anonymously, the signerInfos field of the SignedData [RFC5652] of PA_PK_AS_REP in the reply is empty, and the certificates field is absent. The server name in the anonymous KDC reply contains the name of the TGS.

Upon receipt of the KDC reply that contains an anonymous ticket and PA_PK_AS_REP [RFC4556] pre-authentication data, the client can then authenticate the KDC based on the KDC's signature in the PA_PK_AS_REP. If the KDC's signature is missing in the KDC reply (the reply is anonymous), the client MUST reject the returned ticket if it cannot authenticate the KDC otherwise.

A KDC that supports anonymous PKINIT MUST indicate the support of PKINIT, according to Section 3.4 of [RFC4556]. In addition, such a KDC MUST indicate support for anonymous PKINIT by including a padata element of padata-type PA_PKINIT_KX and empty padata-value when including PA-PK-AS-REQ in an error reply.

When included in a KDC error, PA_PKINIT_KX indicates support for anonymous PKINIT. As discussed in Section 7, when included in an AS-

REP, PA_PKINIT_KX proves that the KDC and client both contributed to the session key for any use of Diffie-Hellman key agreement with PKINIT.

Note that in order to obtain an anonymous ticket with the anonymous realm name, the client MUST set the client name as the anonymous principal in the request when requesting an anonymous ticket in an AS exchange. Anonymous PKINIT is the only way via which an anonymous ticket with the anonymous realm as the client realm can be generated in this specification.

4.2. Anonymity Support in TGS Exchange

The client requests an anonymous ticket by setting the anonymous KDC option in a TGS exchange, and in that request the client can use a normal Ticket Granting Ticket (TGT) with the client's identity, or an anonymous TGT, or an anonymous cross-realm TGT. If the client uses a normal TGT, the client's identity is known to the TGS.

Note that the client can completely hide the client's identity in an AS exchange using anonymous PKINIT, as described in the previous section.

If the ticket in the PA-TGS-REQ of the TGS request is an anonymous one, the anonymous KDC option SHOULD be set in the request.

When policy allows, the KDC issues an anonymous ticket. If the ticket in the TGS request is an anonymous one, the client name and the client realm are copied from that ticket; otherwise, the ticket in the TGS request is a normal ticket, the returned anonymous ticket contains the client name as the anonymous principal and the client realm as the true realm of the client. In all cases, according to [RFC4120] the client name and the client realm in the EncTicketPart of the reply MUST match with the corresponding client name and the client realm of the anonymous ticket in the reply; the client MUST use the client name and the client realm returned in the KDC-REP in subsequent message exchanges when using the obtained anonymous ticket.

The TGS MUST NOT reveal the client's identity in the authorization data of the returned ticket. When propagating authorization data in the ticket or in the enc-authorization-data field of the request, the TGS MUST ensure that the client confidentiality is not violated in the returned anonymous ticket. The TGS MUST process the authorization data recursively, according to Section 5.2.6 of [RFC4120], beyond the container levels such that all embedded authorization elements are interpreted. The TGS SHOULD NOT populate identity-based authorization data into an anonymous ticket in that

such authorization data typically reveals the client's identity. The specification of a new authorization data type MUST specify the processing rules of the authorization data when an anonymous ticket is returned. If there is no processing rule defined for an authorization data element or the authorization data element is unknown, the TGS MUST process it when an anonymous ticket is returned as follows:

- If the authorization data element may reveal the client's identity, it MUST be removed unless otherwise specified.

- If the authorization data element, that could reveal the client's identity, is intended to restrict the use of the ticket or limit the rights otherwise conveyed in the ticket, it cannot be removed in order to hide the client's identity. In this case, the authentication attempt MUST be rejected, and the TGS MUST return an error message with the code KDC_ERR_POLICY. Note this is applicable to both critical and optional authorization data.

- If the authorization data element is unknown, the TGS MAY remove it, or transfer it into the returned anonymous ticket, or reject the authentication attempt, based on local policy for that authorization data type unless otherwise specified. If there is no policy defined for a given unknown authorization data type, the authentication MUST be rejected. The error code is KDC_ERR_POLICY when the authentication is rejected.

The AD_INITIAL_VERIFIED_CAS authorization data, as defined in [RFC4556], contains the issuer name of the client certificate. If it is undesirable to disclose such information about the client's identity, the AD_INITIAL_VERIFIED_CAS authorization data SHOULD be removed from an anonymous ticket.

The TGS encodes the name of the previous realm into the transited field, according to Section 3.3.3.2 of [RFC4120]. Based on local policy, the TGS MAY omit the previous realm, if the cross realm TGT is an anonymous one, in order to hide the authentication path of the client. The unordered set of realms in the transited field, if present, can reveal which realm may potentially be the realm of the client or the realm that issued the anonymous TGT. The anonymous Kerberos realm name MUST NOT be present in the transited field of a ticket. The true name of the realm that issued the anonymous ticket MAY be present in the transited field of a ticket.

4.3. Subsequent Exchanges and Protocol Actions Common to AS and TGS for Anonymity Support

In both AS and TGS exchanges, the realm field in the KDC request is always the realm of the target KDC, not the anonymous realm when the client requests an anonymous ticket.

Absent other information, the KDC MUST NOT include any identifier in the returned anonymous ticket that could reveal the client's identity to the server.

Unless anonymous PKINIT is used, if a client requires anonymous communication, then the client MUST check to make sure that the ticket in the reply is actually anonymous by checking the presence of the anonymous ticket flag in the flags field of the EncKDCRepPart. This is because KDCs ignore unknown KDC options. A KDC that does not understand the anonymous KDC option will not return an error, but will instead return a normal ticket.

The subsequent client and server communications then proceed as described in [RFC4120].

Note that the anonymous principal name and realm are only applicable to the client in Kerberos messages, the server cannot be anonymous in any Kerberos message per this specification.

A server accepting an anonymous service ticket may assume that subsequent requests using the same ticket originate from the same client. Requests with different tickets are likely to originate from different clients.

Upon receipt of an anonymous ticket, the transited policy check is performed in the same way as that of a normal ticket if the client's realm is not the anonymous realm; if the client realm is the anonymous realm, absent other information any realm in the authentication path is allowed by the cross-realm policy check.

5. Interoperability Requirements

Conforming implementations MUST support the anonymous principal with a non-anonymous realm, and they MAY support the anonymous principal with the anonymous realm using anonymous PKINIT.

6. GSS-API Implementation Notes

GSS-API defines the name_type GSS_C_NT_ANONYMOUS [RFC2743] to represent the anonymous identity. In addition, Section 2.1.1 of [RFC1964] defines the single string representation of a Kerberos

principal name with the name_type GSS_KRB5_NT_PRINCIPAL_NAME. The anonymous principal with the anonymous realm corresponds to the GSS-API anonymous principal. A principal with the anonymous principal name and a non-anonymous realm is an authenticated principal; hence, such a principal does not correspond to the anonymous principal in GSS-API with the GSS_C_NT_ANONYMOUS name type. The [RFC1964] name syntax for GSS_KRB5_NT_PRINCIPAL_NAME MUST be used for importing the anonymous principal name with a non-anonymous realm name and for displaying and exporting these names. In addition, this syntax must be used along with the name type GSS_C_NT_ANONYMOUS for displaying and exporting the anonymous principal with the anonymous realm.

At the GSS-API [RFC2743] level, an initiator/client requests the use of an anonymous principal with the anonymous realm by asserting the "anonymous" flag when calling GSS_Init_Sec_Context(). The GSS-API implementation MAY provide implementation-specific means for requesting the use of an anonymous principal with a non-anonymous realm.

GSS-API does not know or define "anonymous credentials", so the (printable) name of the anonymous principal will rarely be used by or relevant for the initiator/client. The printable name is relevant for the acceptor/server when performing an authorization decision based on the initiator name that is returned from the acceptor side upon the successful security context establishment.

A GSS-API initiator MUST carefully check the resulting context attributes from the initial call to GSS_Init_Sec_Context() when requesting anonymity, because (as in the GSS-API tradition and for backwards compatibility) anonymity is just another optional context attribute. It could be that the mechanism doesn’t recognize the attribute at all or that anonymity is not available for some other reasons -- and in that case the initiator MUST NOT send the initial security context token to the acceptor, because it will likely reveal the initiators identity to the acceptor, something that can rarely be "un-done".

Portable initiators are RECOMMENDED to use default credentials whenever possible, and request anonymity only through the input anon_req_flag [RFC2743] to GSS_Init_Sec_Context().

7. PKINIT Client Contribution to the Ticket Session Key

The definition in this section was motivated by protocol analysis of anonymous PKINIT (defined in this document) in building secure channels [RFC6113] and subsequent channel bindings [RFC5056]. In order to enable applications of anonymous PKINIT to form secure channels, all implementations of anonymous PKINIT need to meet the

requirements of this section. There is otherwise no connection to the rest of this document.

PKINIT is useful for constructing secure channels. To ensure that an active attacker cannot create separate channels to the client and KDC with the same known key, it is desirable that neither the KDC nor the client unilaterally determine the ticket session key. The specific reason why the ticket session key is derived jointly is discussed at the end of this section. To achieve that end, a KDC conforming to this definition MUST encrypt a randomly generated key, called the KDC contribution key, in the PA_PKINIT_KX padata (defined next in this section). The KDC contribution key is then combined with the reply key to form the ticket session key of the returned ticket. These two keys are then combined using the KRB-FX-CF2 operation defined in Section 7.1, where K1 is the KDC contribution key, K2 is the reply key, the input pepper1 is American Standard Code for Information Interchange (ASCII) [ASAX34] string "PKINIT", and the input pepper2 is ASCII string "KEYEXCHANGE".

```
PA_PKINIT_KX      147
  -- padata for PKINIT that contains an encrypted
  -- KDC contribution key.

PA-PKINIT-KX  ::= EncryptedData -- EncryptionKey
  -- Contains an encrypted key randomly
  -- generated by the KDC (known as the KDC contribution key).
  -- Both EncryptedData and EncryptionKey are defined in [RFC4120]
```

The PA_PKINIT_KX padata MUST be included in the KDC reply when anonymous PKINIT is used; it SHOULD be included if PKINIT is used with the Diffie-Hellman key exchange but the client is not anonymous; it MUST NOT be included otherwise (e.g., when PKINIT is used with the public key encryption as the key exchange).

The padata-value field of the PA-PKINIT-KX type padata contains the DER [X.680] [X.690] encoding of the Abstract Syntax Notation One (ASN.1) type PA-PKINIT-KX. The PA-PKINIT-KX structure is an EncryptedData. The cleartext data being encrypted is the DER-encoded KDC contribution key randomly generated by the KDC. The encryption key is the reply key and the key usage number is KEY_USAGE_PA_PKINIT_KX (44).

The client then decrypts the KDC contribution key and verifies the ticket session key in the returned ticket is the combined key of the KDC contribution key and the reply key as described above. A conforming client MUST reject anonymous PKINIT authentication if the PA_PKINIT_KX padata is not present in the KDC reply or if the ticket session key of the returned ticket is not the combined key of the KDC

contribution key and the reply key when PA-PKINIT-KX is present in the KDC reply.

This protocol provides a binding between the party which generated the session key and the DH exchange used to generate the reply key. Hypothetically, if the KDC did not use PA-PKINIT-KX, the client and KDC would perform a DH key exchange to determine a shared key, and that key would be used as a reply key. The KDC would then generate a ticket with a session key encrypting the reply with the DH agreement. A MITM attacker would just decrypt the session key and ticket using the DH key from the attacker-KDC DH exchange, and re-encrypt it using the key from the attacker-client DH exchange, while keeping a copy of the session key and ticket. This protocol binds the ticket to the DH exchange and prevents the MITM attack by requiring the session key to be created in a way that can be verified by the client.

7.1. Combining Two Protocol Keys

KRB-FX-CF2() combines two protocol keys based on the pseudo-random() function defined in [RFC3961].

Given two input keys, K1 and K2, where K1 and K2 can be of two different enctypes, the output key of KRB-FX-CF2(), K3, is derived as follows:

```
 KRB-FX-CF2(protocol key, protocol key, octet string,
           octet string)  ->  (protocol key)

 PRF+(K1, pepper1) -> octet-string-1
 PRF+(K2, pepper2) -> octet-string-2
 KRB-FX-CF2(K1, K2, pepper1, pepper2) ->
        random-to-key(octet-string-1 ^ octet-string-2)
```

Where ^ denotes the exclusive-OR operation. PRF+() is defined as follows:

```
PRF+(protocol key, octet string) -> (octet string)

PRF+(key, shared-info) -> pseudo-random( key,  1 || shared-info ) ||
             pseudo-random( key, 2 || shared-info ) ||
             pseudo-random( key, 3 || shared-info ) || ...
```

Here the counter value 1, 2, 3, and so on are encoded as a one-octet integer. The pseudo-random() operation is specified by the enctype of the protocol key. PRF+() uses the counter to generate enough bits as needed by the random-to-key() [RFC3961] function for the encryption type specified for the resulting key; unneeded bits are removed from the tail.

8. Security Considerations

Since KDCs ignore unknown options, a client requiring anonymous communication needs to make sure that the returned ticket is actually anonymous. This is because a KDC that does not understand the anonymous option would not return an anonymous ticket.

By using the mechanism defined in this specification, the client does not reveal the client's identity to the server but the client identity may be revealed to the KDC of the server principal (when the server principal is in a different realm than that of the client), and any KDC on the cross-realm authentication path. The Kerberos client MUST verify the ticket being used is indeed anonymous before communicating with the server, otherwise, the client's identity may be revealed unintentionally.

In cases where specific server principals must not have access to the client's identity (for example, an anonymous poll service), the KDC can define server-principal-specific policy that ensures any normal service ticket can NEVER be issued to any of these server principals.

If the KDC that issued an anonymous ticket were to maintain records of the association of identities to an anonymous ticket, then someone obtaining such records could breach the anonymity. Additionally, the implementations of most (for now all) KDC's respond to requests at the time that they are received. Traffic analysis on the connection to the KDC will allow an attacker to match client identities to anonymous tickets issued. Because there are plaintext parts of the tickets that are exposed on the wire, such matching by a third-party observer is relatively straightforward. A service that is authenticated by the anonymous principals may be able to infer the identity of the client by examining and linking quasi-static protocol information such as the IP address from which a request is received, or by linking multiple uses of the same anonymous ticket.

Two mechanisms, the FAST facility with the hide-client-names option in [RFC6113] and the Kerberos5 starttls option [STARTTLS], protect the client identity so that an attacker would never be able to observe the client identity sent to the KDC. Transport or network layer security between the client and the server will help prevent tracking of a particular ticket to link a ticket to a user. In addition, clients can limit how often a ticket is reused to minimize ticket linking.

The client's real identity is not revealed when the client is authenticated as the anonymous principal. Application servers MAY reject the authentication in order to, for example, prevent information disclosure or as part of Denial of Service (DoS)

prevention. Application servers MUST avoid accepting anonymous credentials in situations where they must record the client's identity; for example, when there must be an audit trail.

9. Acknowledgments

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10. IANA Considerations

This document defines an 'anonymous' Kerberos well-known name and an 'anonymous' Kerberos well-known realm based on [RFC6111]. IANA has added these two values to the Kerberos naming registries that are created in [RFC6111].

Note to IANA: Please update the following Kerberos Parameters registries:

- Well-Known Kerberos Principal Names
- Well-Known Kerberos Realm Names
- Pre-authentication and Typed Data

to reference this document instead of RFC6112.

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11.2. Informative References

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[RFC6113] Hartman, S. and L. Zhu, "A Generalized Framework for Kerberos Pre-Authentication", RFC 6113, April 2011.

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SAML Enhanced Client SASL and GSS-API Mechanisms
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Abstract

Security Assertion Markup Language (SAML) 2.0 is a generalized framework for the exchange of security-related information between asserting and relying parties. Simple Authentication and Security Layer (SASL) and the Generic Security Service Application Program Interface (GSS-API) are application frameworks to facilitate an extensible authentication model. This document specifies a SASL and GSS-API mechanism for SAML 2.0 that leverages the capabilities of a SAML-aware "enhanced client" to address significant barriers to federated authentication in a manner that encourages reuse of existing SAML bindings and profiles designed for non-browser scenarios.

Status of This Memo

This Internet-Draft is submitted in full conformance with the provisions of BCP 78 and BCP 79.

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This Internet-Draft will expire on October 26, 2018.

Table of Contents

1. Introduction

Security Assertion Markup Language (SAML) 2.0 [OASIS.saml-core-2.0-os] is a modular specification that provides various means for a user to be identified to a relying party (RP) through the exchange of (typically signed) assertions issued by an identity provider (IdP). It includes a number of protocols, protocol bindings [OASIS.saml-bindings-2.0-os], and interoperability profiles [OASIS.saml-profiles-2.0-os] designed for different use cases. Additional profiles and extensions are also routinely developed and published.

Simple Authentication and Security Layer (SASL) [RFC4422] is a generalized mechanism for identifying and authenticating a user and for optionally negotiating a security layer for subsequent protocol interactions. SASL is used by application protocols like IMAP, POP and XMPP [RFC3920]. The effect is to make authentication modular, so that newer authentication mechanisms can be added as needed.

The Generic Security Service Application Program Interface (GSS-API) [RFC2743] provides a framework for applications to support multiple authentication mechanisms through a unified programming interface. This document defines a pure SASL mechanism for SAML, but it conforms to the bridge between SASL and the GSS-API called GS2 [RFC5801]. This means that this document defines both a SASL mechanism and a GSS-API mechanism. The GSS-API interface is optional for SASL implementers, and the GSS-API considerations can be avoided in environments that use SASL directly without GSS-API.

The mechanisms specified in this document allow a SASL- or GSS-API-enabled server to act as a SAML relying party, or service provider (SP), by advertising this mechanism as an option for SASL or GSS-API clients that support the use of SAML to communicate identity and attribute information. Clients supporting this mechanism are termed "enhanced clients" in SAML terminology because they understand the federated authentication model and have specific knowledge of the IdP(s) associated with the user. This knowledge, and the ability to act on it, addresses a significant problem with browser-based SAML profiles known as the "discovery", or "where are you from?" (WAYF) problem. In a "dumb" client such as a web browser, various intrusive user interface techniques are used to determine the appropriate IdP to use because the request to the IdP is generated as an HTTP redirect by the RP, which does not generally have prior knowledge of the IdP to use. Obviating the need for the RP to interact with the client to determine the right IdP (and its network location) is both a user interface and security improvement.

The SAML mechanism described in this document is an adaptation of an existing SAML profile, the Enhanced Client or Proxy (ECP) Profile (V2.0) [SAMLECP20].

Figure 1 describes the interworking between SAML and SASL: this document requires enhancements to the RP and to the client (as the two SASL communication endpoints) but no changes to the SAML IdP are assumed apart from its support for the applicable SAML profile. To accomplish this, a SAML protocol exchange between the RP and the IdP, brokered by the client, is tunneled within SASL. There is no assumed communication between the RP and the IdP, but such communication may occur in conjunction with additional SAML-related profiles not in scope for this document.

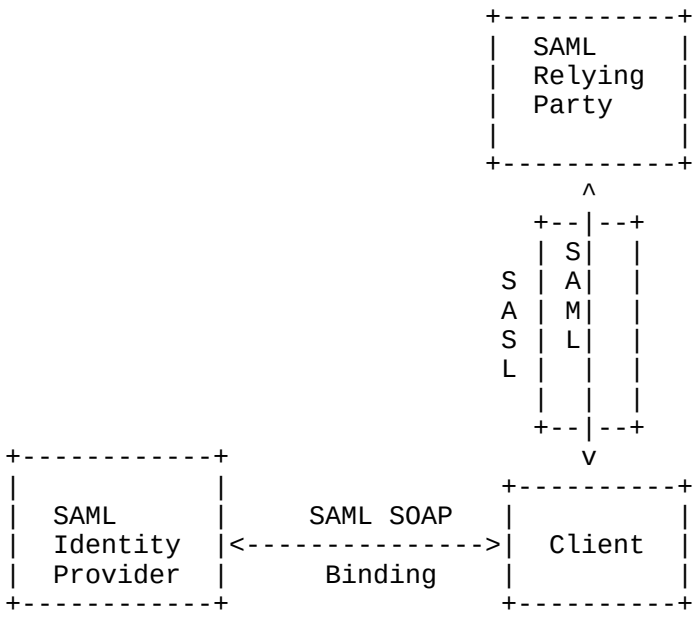

Figure 1: Interworking Architecture

2. Terminology

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in RFC 2119 [RFC2119].

The reader is also assumed to be familiar with the terms used in the SAML 2.0 specification, and an understanding of the Enhanced Client or Proxy (ECP) Profile (V2.0) [SAMLECP20] is necessary, as part of this mechanism explicitly reuses and references it.

This document can be implemented without knowledge of GSS-API since the normative aspects of the GS2 protocol syntax have been duplicated in this document. The document may also be implemented to provide a GSS-API mechanism, and then knowledge of GSS-API is essential. To faciliate these two variants, the references has been split into two parts, one part that provides normative references for all readers, and one part that adds additional normative references required for implementers that wish to implement the GSS-API portion.

3. Applicability for Non-HTTP Use Cases

While SAML is designed to support a variety of application scenarios, the profiles for authentication defined in the original standard are designed around HTTP [RFC2616] applications. They are not, however, limited to browsers, because it was recognized that browsers suffer from a variety of functional and security deficiencies that would be useful to avoid where possible. Specifically, the notion of an "Enhanced Client" (or a proxy acting as one on behalf of a browser, thus the term "ECP") was specified for a software component that acts somewhat like a browser from an application perspective, but includes limited, but sufficient, awareness of SAML to play a more conscious role in the authentication exchange between the RP and the IdP. What follows is an outline of the Enhanced Client or Proxy (ECP) Profile (V2.0) [SAMLECP20], as applied to the web/HTTP service use case:

1. The Enhanced Client requests a resource of a Relying Party (RP) (via an HTTP request). In doing so, it advertises its "enhanced" capability using HTTP headers.

2. The RP, desiring SAML authentication and noting the client’s capabilities, responds not with an HTTP redirect or form, but with a SOAP [W3C.soap11] envelope containing a SAML <AuthnRequest> along with some supporting headers. This request identifies the RP (and may be signed), and may provide hints to the client as to what IdPs the RP finds acceptable, but the choice of IdP is generally left to the client.

3. The client is then responsible for delivering the body of the SOAP message to the IdP it is instructed to use (often via configuration ahead of time). The user authenticates to the IdP ahead of, during, or after the delivery of this message, and perhaps explicitly authorizes the response to the RP.

4. Whether authentication succeeds or fails, the IdP responds with its own SOAP envelope, generally containing a SAML <Response> message for delivery to the RP. In a successful case, the message will include one or more SAML <Assertion> elements containing authentication, and possibly attribute, statements about the subject. Either the response or each assertion is signed, and the assertion(s) may be encrypted to a key negotiated with or known to belong to the RP.

5. The client then delivers the SOAP envelope containing the <Response> to the RP at a location the IdP directs (which acts as an additional, though limited, defense against MITM attacks). This completes the SAML exchange.

6. The RP now has sufficient identity information to approve the original HTTP request or not, and acts accordingly. Everything between the original request and this response can be thought of as an "interruption" of the original HTTP exchange.

When considering this flow in the context of an arbitrary application protocol and SASL, the RP and the client both must change their code to implement this SASL mechanism, but the IdP can remain unmodified. The existing RP/client exchange that is tunneled through HTTP maps well to the tunneling of that same exchange in SASL. In the parlance of SASL [RFC4422], this mechanism is "client-first" for consistency with GS2. The steps are shown below:

1. The server MAY advertise the SAML20EC and/or SAML20EC-PLUS mechanisms.

2. The client initiates a SASL authentication with SAML20EC or SAML20EC-PLUS.

3. The server sends the client a challenge consisting of a SOAP envelope containing its SAML <AuthnRequest>.

4. The SASL client unpacks the SOAP message and communicates with its chosen IdP to relay the SAML <AuthnRequest> to it. This communication, and the authentication with the IdP, proceeds separately from the SASL process.

5. Upon completion of the exchange with the IdP, the client responds to the SASL server with a SOAP envelope containing the SAML <Response> it obtained, or a SOAP fault, as warranted.

6. The SASL Server indicates success or failure.

Note: The details of the SAML processing, which are consistent with the Enhanced Client or Proxy (ECP) Profile (V2.0) [SAMLECP20], are such that the client MUST interact with the IdP in order to complete any SASL exchange with the RP. The assertions issued by the IdP for the purposes of the profile, and by extension this SASL mechanism, are short lived, and therefore cannot be cached by the client for later use.

Encompassed in step four is the client-driven selection of the IdP, authentication to it, and the acquisition of a response to provide to the SASL server. These processes are all external to SASL.

Note also that unlike an HTTP-based profile, the IdP cannot participate in the selection of, or evaluation of, the location to which the SASL Client Response will be delivered by the client. The use of GSS-API Channel Binding is an important mitigation of the risk of a "Man in the Middle" attack between the client and RP, as is the use of a negotiated or derived session key in whatever protocol is secured by this mechanism.

With all of this in mind, the typical flow appears as follows:

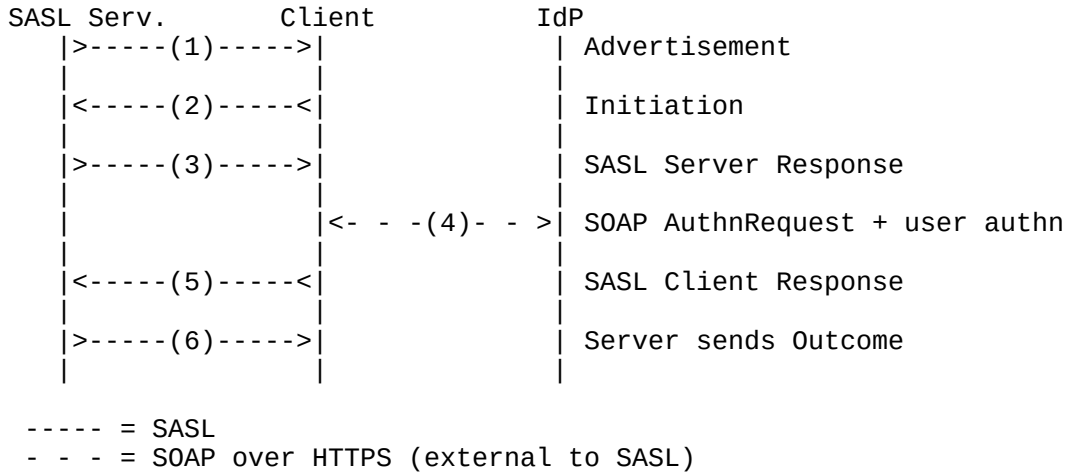

Figure 2: Authentication flow

4. SAML Enhanced Client SASL Mechanism Specification

Based on the previous figures, the following operations are defined by the SAML SASL mechanism:

4.1. Advertisement

To advertise that a server supports this mechanism, during application session initiation, it displays the name "SAML20EC" and/or "SAML20EC-PLUS" in the list of supported SASL mechanisms.

In accordance with [RFC5801] the "-PLUS" variant indicates that the server supports channel binding and would be selected by a client with that capability.

4.2. Initiation

A client initiates "SAML20EC" or "SAML20EC-PLUS" authentication. If supported by the application protocol, the client MAY include an initial response, otherwise it waits until the server has issued an empty challenge (because the mechanism is client-first).

The format of the initial client response ("initresp") is as follows:

```
hok = "urn:oasis:names:tc:SAML:2.0:cm:holder-of-key"

mut = "urn:oasis:names:tc:SAML:2.0:profiles:SSO:ecp:2.0:" \
  "WantAuthnRequestsSigned"

del = "urn:oasis:names:tc:SAML:2.0:conditions:delegation"

initresp = gs2-cb-flag "," [gs2-authzid] "," [hok] "," [mut] "," [del]
```

The gs2-cb-flag flag MUST be set as defined in [RFC5801] to indicate whether the client supports channel binding. This takes the place of the PAOS HTTP header extension used in [SAMLECP20] to indicate channel binding support.

The optional "gs2-authzid" field holds the authorization identity, as requested by the client.

The optional "hok" field is a constant that signals the client’s support for stronger security by means of a locally held key. This takes the place of the PAOS HTTP header extension used in [SAMLECP20] to indicate "holder of key" support.

The optional "mut" field is a constant that signals the client’s desire for mutual authentication. If set, the SASL server MUST

digitally sign its SAML <AuthnRequest> message. The URN constant above is a single string; the linefeed is shown for RFC formatting reasons.

The optional "del" field is a constant that signals the client's desire for the acceptor to request an assertion usable for delegation of the client's identity to the acceptor.

4.3. Server Response

The SASL server responds with a SOAP envelope constructed in accordance with section 2.3.2 of [SAMLECP20]. This includes adhering to the SOAP header requirements of the SAML PAOS Binding [OASIS.saml-bindings-2.0-os], for compatibility with the existing profile. Various SOAP headers are also consumed by the client in exactly the same manner prescribed by that section.

4.4. User Authentication with Identity Provider

Upon receipt of the Server Response (Section 4.3), the steps described in sections 2.3.3 through 2.3.6 of [SAMLECP20] are performed between the client and the chosen IdP. The means by which the client determines the IdP to use, and where it is located, are out of scope of this mechanism.

The exact means of authentication to the IdP are also out of scope, but clients supporting this mechanism MUST support HTTP Basic Authentication as defined in [RFC2617] and TLS client authentication as defined in [RFC5246].

4.5. Client Response

Assuming a response is obtained from the IdP, the client responds to the SASL server with a SOAP envelope constructed in accordance with section 2.3.7 of [SAMLECP20]. This includes adhering to the SOAP header requirements of the SAML PAOS Binding [OASIS.saml-bindings-2.0-os], for compatibility with the existing profile. If the client is unable to obtain a response from the IdP, or must otherwise signal failure, it responds to the SASL server with a SOAP envelope containing a SOAP fault.

4.6. Outcome

The SAML protocol exchange having completed, the SASL server will transmit the outcome to the client depending on local validation of the client responses. This outcome is transmitted in accordance with the application protocol in use.

4.7. Additional Notes

Because this mechanism is an adaptation of an HTTP-based profile, there are a few requirements outlined in [SAMLECP20] that make reference to a response URL that is normally used to regulate where the client returns information to the RP. There are also security-related checks built into the profile that involve this location.

For compatibility with existing IdP and profile behavior, and to provide for mutual authentication, the SASL server MUST populate the responseConsumerURL and AssertionConsumerServiceURL attributes with its service name. As discussed in Section 5.6.2, most SASL profiles rely on a service name format of "service@host", but regardless of the form, the service name is used directly rather than transformed into an absolute URI if it is not already one, and MUST be percent-encoded per [RFC3986].

The IdP MUST securely associate the service name with the SAML entityID claimed by the SASL server, such as through the use of SAML metadata [OASIS.saml-metadata-2.0-os]. If metadata is used, a SASL service's <SPSSODescriptor> role MUST contain a corresponding <AssertionConsumerService> whose Location attribute contains the appropriate service name, as described above. The Binding attribute MUST be one of "urn:ietf:params:xml:ns:samlec" (RECOMMENDED) or "urn:oasis:names:tc:SAML:2.0:bindings:PAOS" (for compatibility with older implementations of the ECP profile in existing identity provider software).

Finally, note that the use of HTTP status signaling between the RP and client mandated by [SAMLECP20] may not be applicable.

5. SAML EC GSS-API Mechanism Specification

This section and its sub-sections and all normative references of it not referenced elsewhere in this document are INFORMATIONAL for SASL implementors, but they are NORMATIVE for GSS-API implementors.

The SAML Enhanced Client SASL mechanism is also a GSS-API mechanism. The messages are the same, but a) the GS2 [RFC5801] header on the client's first message is excluded when SAML EC is used as a GSS-API mechanism, and b) the [RFC2743] section 3.1 initial context token header is prefixed to the client's first authentication message (context token).

The GSS-API mechanism OID for SAML EC is OID-TBD (IANA to assign: see IANA considerations). The DER encoding of the OID is TBD.

The mutual_state request flag (GSS_C_MUTUAL_FLAG) MAY be set to TRUE, resulting in the "mut" option set in the initial client response. The security context mutual_state flag is set to TRUE only if the server digitally signs its SAML <AuthnRequest> message and the signature and signing credential are appropriately verified by the identity provider. The identity provider signals this to the client in an <ecp:RequestAuthenticated> SOAP header block.

The lifetime of a security context established with this mechanism SHOULD be limited by the value of a SessionNotOnOrAfter attribute, if any, in the <AuthnStatement> element(s) of the SAML assertion(s) received by the RP. By convention, in the rare case that multiple valid/confirmed assertions containing <AuthnStatement> elements are received, the most restrictive SessionNotOnOrAfter is generally applied.

5.1. GSS-API Credential Delegation

This mechanism can support credential delegation through the issuance of SAML assertions that an identity provider will accept as proof of authentication by a service on behalf of a subject. An initiator may request delegation of its credentials by setting the "del" option field in the initial client response to "urn:oasis:names:tc:SAML:2.0:conditions:delegation".

An acceptor, upon receipt of this constant, requests a delegated assertion by including in its <AuthnRequest> message a <Conditions> element containing an <AudienceRestriction> identifying the IdP as a desired audience for the assertion(s) to be issued. In the event that the specific identity provider to be used is unknown, the constant "urn:oasis:names:tc:SAML:2.0:conditions:delegation" may be used as a stand-in, per Section 2.3.2 of [SAMLECP20].

Upon receipt of an assertion satisfying this property, and containing a <SubjectConfirmation> element that the acceptor can satisfy, the security context may have its deleg_state flag (GSS_C_DELEG_FLAG) set to TRUE.

The identity provider, if it issues a delegated assertion to the acceptor, MUST include in the SOAP response to the initiator a <samlec:Delegated> SOAP header block, indicating that delegation was enabled. It has no content, other than mandatory SOAP attributes (an example follows):

```
<samlec:Delegated xmlns:samlec="urn:ietf:params:xml:ns:samlec"
    xmlns:S="http://schemas.xmlsoap.org/soap/envelope/"
    S:mustUnderstand="1"
    S:actor="http://schemas.xmlsoap.org/soap/actor/next" />
```

Upon receipt of such a header block, the initiator MUST fail the establishment of the security context if it did not request delegation in its initial client response to the acceptor. It SHOULD signal this failure to the acceptor with a SOAP fault message in its final client response.

As noted previously, the exact means of client authentication to the IdP is formally out of scope of this mechanism. This extends to the use of a delegation assertion as a means of authentication by an acceptor acting as an initiator. In practice, some profile of [WSS-SAML] is used to attach the assertion and a confirmation proof to the SOAP message from the client to the IdP.

5.2. GSS-API Channel Binding

GSS-API channel binding [RFC5554] is a protected facility for exchanging a cryptographic name for an enclosing channel between the initiator and acceptor. The initiator sends channel binding data and the acceptor confirms that channel binding data has been checked.

The acceptor SHOULD accept any channel binding provided by the initiator if null channel bindings are passed into gss_accept_sec_context. Protocols such as HTTP Negotiate [RFC4559] depend on this behavior of some Kerberos implementations.

The exchange and verification of channel binding information is described by [SAMLECP20].

5.3. Session Key Derivation

Some GSS-API features (discussed in the following sections) require a session key be established as a result of security context establishment. In the common case of a "bearer" assertion in SAML, a mechanism is defined to communicate a key to both parties via the identity provider. In other cases such as assertions based on "holder of key" confirmation bound to a client-controlled key, there may be additional methods defined in the future, and extension points are provided for this purpose.

Information defining or describing the session key, or a process for deriving one, is communicated between the initiator and acceptor using a <samlec:SessionKey> element, defined by the XML schema in

Appendix A. This element is a SOAP header block. The content of the element further depends on the specific use in the mechanism. The Algorithm XML attribute identifies a mechanism for key derivation. It is omitted to identify the use of an Identity Provider-generated key (see following section) or will contain a URI value identifying a derivation mechanism defined outside this specification. Each header block's mustUnderstand and actor attributes MUST be set to "1" and "http://schemas.xmlsoap.org/soap/actor/next" respectively.

In the acceptor's first response message containing its SAML request, one or more <samlec:SessionKey> SOAP header blocks MUST be included. The element MUST contain one or more <EncType> elements containing the number of a supported encryption type defined in accordance with [RFC3961]. Encryption types should be provided in order of preference by the acceptor.

In the final client response message, a single <samlec:SessionKey> SOAP header block MUST be included. A single <EncType> element MUST be included to identify the chosen encryption type used by the initiator.

All parties MUST support the "aes128-cts-hmac-sha1-96" encryption type, number 17, defined by [RFC3962].

Further details depend on the mechanism used, one of which is described in the following section.

5.3.1. Generated by Identity Provider

The identity provider, if issuing a bearer assertion for use with this mechanism, SHOULD provide a generated key for use by the initiator and acceptor. This key is used as pseudorandom input to the "random-to-key" function for a specific encryption type defined in accordance with [RFC3961]. The key is base64-encoded and placed inside a <samlec:GeneratedKey> element. The identity provider does not participate in the selection of the encryption type and simply generates enough pseudorandom bits to supply key material to the other parties.

The resulting <samlec:GeneratedKey> element is placed within the <saml:Advice> element of the assertion issued. The identity provider MUST encrypt the assertion (implying that it MUST have the means to do so, typically knowledge of a key associated with the RP). If multiple assertions are issued (allowed, but not typical), the element need only be included in one of the assertions issued for use by the relying party.

A copy of the element is also added as a SOAP header block in the response from the identity provider to the client (and then removed when constructing the response to the acceptor).

If this mechanism is used by the initiator, then the <samlec:SessionKey> SOAP header block attached to the final client response message will identify this via the omission of the Algorithm attribute and will identify the chosen encryption type using the <samlec:EncType> element:

```
<samlec:SessionKey xmlns:samlec="urn:ietf:params:xml:ns:samlec"
    xmlns:S="http://schemas.xmlsoap.org/soap/envelope/"
    S:mustUnderstand="1"
    S:actor="http://schemas.xmlsoap.org/soap/actor/next">
  <samlec:EncType>17</samlec:EncType>
<samlec:SessionKey>
```

Both the initiator and acceptor MUST execute the chosen encryption type's random-to-key function over the pseudorandom value provided by the <samlec:GeneratedKey> element. The result of that function is used as the protocol and session key. Support for subkeys from the initiator or acceptor is not specified.

5.3.2. Alternate Key Derivation Mechanisms

In the event that a client is proving possession of a secret or private key, a formal key agreement algorithm might be supported. This specification does not define such a mechanism, but the <samlec:SessionKey> element is extensible to allow for future work in this space by means of the Algorithm attribute and an optional <ds:KeyInfo> child element to carry extensible content related to key establishment.

However a key is derived, the <samlec:EncType> element will identify the chosen encrytion type, and both the initiator and acceptor MUST execute the encryption type's random-to-key function over the result of the key agreement or derivation process. The result of that function is used as the protocol key.

5.4. Per-Message Tokens

The per-message tokens SHALL be the same as those for the Kerberos V5 GSS-API mechanism [RFC4121] (see Section 4.2 and sub-sections).

The replay_det_state (GSS_C_REPLAY_FLAG), sequence_state (GSS_C_SEQUENCE_FLAG), conf_avail (GSS_C_CONF_FLAG) and integ_avail (GSS_C_INTEG_FLAG) security context flags are always set to TRUE.

The "protocol key" SHALL be a key established in a manner described in the previous section. "Specific keys" are then derived as usual as described in Section 2 of [RFC4121], [RFC3961], and [RFC3962].

The terms "protocol key" and "specific key" are Kerberos V5 terms [RFC3961].

SAML20EC is PROT_READY as soon as the SAML response message has been seen.

5.5. Pseudo-Random Function (PRF)

The GSS-API has been extended with a Pseudo-Random Function (PRF) interface in [RFC4401]. The purpose is to enable applications to derive a cryptographic key from an established GSS-API security context. This section defines a GSS_Pseudo_random that is applicable for the SAML20EC GSS-API mechanism.

The GSS_Pseudo_random() [RFC4401] SHALL be the same as for the Kerberos V5 GSS-API mechanism [RFC4402]. There is no acceptor-asserted sub-session key, thus GSS_C_PRF_KEY_FULL and GSS_C_PRF_KEY_PARTIAL are equivalent. The protocol key to be used for the GSS_Pseudo_random() SHALL be the same as the key defined in the previous section.

5.6. GSS-API Principal Name Types for SAML EC

Services that act as SAML relying parties are typically identified by means of a URI called an "entityID". Clients that are named in the <Subject> element of a SAML assertion are typically identified by means of a <NameID> element, which is an extensible XML structure containing, at minimum, an element value that names the subject and a Format attribute.

In practice, a GSS-API client and server are unlikely to know in advance the name of the initiator as it will be expressed by the SAML identity provider upon completion of authentication. It is also generally incorrect to assume that a particular acceptor name will directly map into a particular RP entityID, because there is often a layer of naming indirection between particular services on hosts and the identity of a relying party in SAML terms.

To avoid complexity, and avoid unnecessary use of XML within the naming layer, the SAML EC mechanism relies on the common/expected

name types used for acceptors and initiators, GSS_C_NT_HOSTBASED_SERVICE and GSS_C_NT_USER_NAME. The mechanism provides for validation of the host-based service name in conjunction with the SAML exchange. It does not attempt to solve the problem of mapping between an initiator "username", the user's identity while authenticating to the identity provider, and the information supplied by the identity provider to the acceptor. These relationships must be managed through local policy at the initiator and acceptor.

SAML-based information associated with the initiator SHOULD be expressed to the acceptor using GSS-API naming extensions [RFC6680], in accordance with [RFC7056].

5.6.1. User Naming Considerations

The GSS_C_NT_USER_NAME form represents the name of an individual user. Clients often rely on this value to determine the appropriate credentials to use in authenticating to the identity provider, and supply it to the server for use by the acceptor.

Upon successful completion of this mechanism, the server MUST construct the authenticated initiator name based on the <saml:NameID> element in the assertion it successfully validated. The name is constructed as a UTF-8 string in the following form:

```
name = element-value "!" Format  "!" NameQualifier
    "!" SPNameQualifier "!" SPProvidedID
```

The "element-value" token refers to the content of the <saml:NameID> element. The other tokens refer to the identically named XML attributes defined for use with the element. If an attribute is not present, which is common, it is omitted (i.e., replaced with the empty string). The Format value is never omitted; if not present, the SAML-equivalent value of "urn:oasis:names:tc:SAML:1.1:nameid-format:unspecified" is used.

Not all SAML assertions contain a <saml:NameID> element. In the event that no such element is present, including the exceptional cases of a <saml:BaseID> element or a <saml:EncryptedID> element that cannot be decrypted, the GSS_C_NT_ANONYMOUS name type MUST be used for the initiator name.

As noted in the previous section, it is expected that most applications able to rely on SAML authentication would make use of naming extensions to obtain additional information about the user based on the assertion. This is particularly true in the anonymous case, or in cases in which the SAML name is pseudonymous or transient in nature. The ability to express the SAML name in

GSS_C_NT_USER_NAME form is intended for compatibility with applications that cannot make use of additional information.

5.6.2. Service Naming Considerations

The GSS_C_NT_HOSTBASED_SERVICE name form represents a service running on a host; it is textually represented as "service@host". This name form is required by most SASL profiles and is used by many existing applications that use the Kerberos GSS-API mechanism. As described in in the SASL mechanism's Section 4.7, such a name is used directly by this mechanism as the effective AssertionConsumerService "location" associated with the service and applied in IdP verification of the request against the claimed SAML entityID.

6. Example

Suppose the user has an identity at the SAML IdP saml.example.org and a Jabber Identifier (jid) "somenode@example.com", and wishes to authenticate his XMPP connection to xmpp.example.com (and example.com and example.org have established a SAML-capable trust relationship). The authentication on the wire would then look something like the following:

Step 1: Client initiates stream to server:

```
<stream:stream xmlns='jabber:client'
xmlns:stream='http://etherx.jabber.org/streams'
to='example.com' version='1.0'>
```

Step 2: Server responds with a stream tag sent to client:

```
<stream:stream
xmlns='jabber:client' xmlns:stream='http://etherx.jabber.org/streams'
id='some_id' from='example.com' version='1.0'>
```

Step 3: Server informs client of available authentication mechanisms:

```
<stream:features>
 <mechanisms xmlns='urn:ietf:params:xml:ns:xmpp-sasl'>
  <mechanism>DIGEST-MD5</mechanism>
  <mechanism>PLAIN</mechanism>
  <mechanism>SAML20EC</mechanism>
 </mechanisms>
</stream:features>
```

Step 4: Client selects an authentication mechanism and sends the initial client response (it is base64 encoded as specified by the XMPP SASL protocol profile):

```
<auth xmlns='urn:ietf:params:xml:ns:xmpp-sasl' mechanism='SAML20EC'>
biwsLCw=
</auth>
```

The initial response is "n,,,," which signals that channel binding is not used, there is no authorization identity, and the client does not support key-based confirmation, or want mutual authentication or delegation.

Step 5: Server sends a challenge to client in the form of a SOAP envelope containing its SAML <AuthnRequest>:

```
<challenge xmlns='urn:ietf:params:xml:ns:xmpp-sasl'>
PFM6RW52ZWxvcGUKICAgIHhtbG5zOnNhbWw9InVybjpvYXNpczpuYW1lczp0YzpT
QU1MOjIuMDphc3NlcnRpb24iCiAgICB4bWxuczpzYW1scD0idXJuOm9hc2lzOm5h
bWVzOnRjOlNBTUw6Mi4wOnByb3RvY29sIgogICAgeG1sbnM6Uz0iaHR0cDovL3Nj
aGVtYXMueG1sc29hcC5vcmcvc29hcC9lbnZlbG9wZS8iPgogIDxTOkhlYWRlcj4K
ICAgIDxwYW9zOlJlcXVlc3QgeG1sbnM6cGFvcz0idXJuOmxpYmVydHk6cGFvczoy
MDAzLTA4IgogICAgICBtZXNzYWdlSUQ9ImMzYTRmOGI5YzJkIiBTOm11c3RVbmRl
cnN0YW5kPSIxIgogICAgICBTOmFjdG9yPSJodHRwOi8vc2NoZW1hcy54bWxzb2Fw
Lm9yZy9zb2FwL2FjdG9yL25leHQiCiAgICAgIHJlc3BvbnNlQ29uc3VtZXJVUkw9
InhtcHBAeG1wcC5leGFtcGxlLmNvbSIKICAgICAgc2VydmljZT0idXJuOm9hc2lz
Om5hbWVzOnRjOlNBTUw6Mi4wOnByb2ZpbGVzOlNTTzplY3AiLz4KICAgIDxlY3A6
UmVxdWVzdAogICAgICB4bWxuczplY3A9InVybjpvYXNpczpuYW1lczp0YzpTQU1M
OjIuMDpwcm9maWxlczpTU086ZWNwIgogICAgICBTOmFjdG9yPSJodHRwOi8vc2No
ZW1hcy54bWxzb2FwLm9yZy9zb2FwL2FjdG9yL25leHQiCiAgICAgIFM6bXVzdFVu
ZGVyc3RhbmQ9IjEiIFByb3ZpZGVyTmFtZT0iSmFiYmVyIGF0IGV4YW1wbGUuY29t
Ij4KICAgICAgPHNhbWw6SXNzdWVyPmh0dHBzOi8veG1wcC5leGFtcGxlLmNvbTwv
c2FtbDpJc3N1ZXI+CiAgICA8L2VjcDpSZXF1ZXN0PgogICAgPHNhbWxwOlJlcXVl
aW9uS2V5IHhtbG5zOnNhbWxlYz0idXJuOmlldGY6cGFyYW1zOnhtbDpuczpzYW1s
ZWMiCiAgICAgIHhtbG5zOlM9Imh0dHA6Ly9zY2hlbWFzLnhtbHNvYXAub3JnL3Nv
YXAvZW52ZWxvcGUvIgogICAgICBTOm11c3RVbmRlcnN0YW5kPSIxIgogICAgICBT
OmFjdG9yPSJodHRwOi8vc2NoZW1hcy54bWxzb2FwLm9yZy9zb2FwL2FjdG9yL25l
eHQiPgogICAgICA8c2FtbGVjOkVuY1R5cGU+MTc8L3NhbWxlYzpFbmNUeXBlPgog
ICAgICA8c2FtbGVjOkVuY1R5cGU+MTg8L3NhbWxlYzpFbmNUeXBlPgogICAgPHNh
bWxlYzpTZXNzaW9uS2V5PgogIDwvUzpFQXI+CiAgPFM6RW5jcnlwdGVkRGF0YSB4
bWxuczpTPSJodHRwOi8vd3d3LnczLm9yZy8yMDAxLzA0L3htbGVuYyMiIFM6bXVz
dFVuZGVyc3RhbmQ9IjEiPgogICAgPFM6RW5jcnlwdGVkS2V5PgogICAgICA8UzpF
bmNyeXB0aW9uTWV0aG9kIFM6QWxnb3JpdGhtPSJodHRwOi8vd3d3LnczLm9yZy8y
MDAxLzA0L3htbGVuYyNyc2EtMV8xNSI+CiAgICAgIDxTOkRpZ2VzdE1ldGhvZCBT
OkFsZ29yaXRobT0iaHR0cDovL3d3dy53My5vcmcvMjAwMS8wNC94bWxkc2lnI3No
YTI1NiIvPgogICAgICA8UzpDaXBoZXJEYXRhPgogICAgICAgIDxTOkNpcGhlclZh
bHVlPgogICAgICAgICAgcm46b2FzaXM6bmFtZXM6dGM6U0FNTDoyLjA6bmFtZWlkLWZvcm1hdDpwZXJzaXN0
ZW50Ii8+CiAgICAgICAgPC9TOkNpcGhlclZhbHVlPgogICAgICA8L1M6Q2lwaGVy
aXNvbj0iZXhhY3QiPgogICAgICAgPHNhbWw6QXV0aG5Db250ZXh0Q2xhc3NSZWY+
CiAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAg
YXNzd29yZFByb3RlY3RlZFRyYW5zcG9ydAogICAgICAgICAgICAgICAgICAgICAg
dGV4dENsYXNzUmVmPgogICAgICA8L3NhbWxwOlJlcXVlc3RlZEF1dGhuQ29udGV4
dD4gCiAgICA8L3NhbWxwOkF1dGhuUmVxdWVzdD4KPC9TOkVuY3J5cHRlZERhdGE+
dmVsb3BlPgo=
</challenge>
```

The Base64 [RFC4648] decoded envelope:

```
<S:Envelope
    xmlns:saml="urn:oasis:names:tc:SAML:2.0:assertion"
    xmlns:samlp="urn:oasis:names:tc:SAML:2.0:protocol"
    xmlns:S="http://schemas.xmlsoap.org/soap/envelope/">
  <S:Header>
    <paos:Request xmlns:paos="urn:liberty:paos:2003-08"
      messageID="c3a4f8b9c2d" S:mustUnderstand="1"
      S:actor="http://schemas.xmlsoap.org/soap/actor/next"
      responseConsumerURL="xmpp@xmpp.example.com"
      service="urn:oasis:names:tc:SAML:2.0:profiles:SSO:ecp"/>
    <ecp:Request
      xmlns:ecp="urn:oasis:names:tc:SAML:2.0:profiles:SSO:ecp"
      S:actor="http://schemas.xmlsoap.org/soap/actor/next"
      S:mustUnderstand="1" ProviderName="Jabber at example.com">
      <saml:Issuer>https://xmpp.example.com</saml:Issuer>
    </ecp:Request>
    <samlec:SessionKey xmlns:samlec="urn:ietf:params:xml:ns:samlec"
      xmlns:S="http://schemas.xmlsoap.org/soap/envelope/"
      S:mustUnderstand="1"
      S:actor="http://schemas.xmlsoap.org/soap/actor/next">
      <samlec:EncType>17</samlec:EncType>
      <samlec:EncType>18</samlec:EncType>
    <samlec:SessionKey>
  </S:Header>
  <S:Body>
    <samlp:AuthnRequest
      ID="c3a4f8b9c2d" Version="2.0" IssueInstant="2007-12-10T11:39:34Z"
      AssertionConsumerServiceURL="xmpp@xmpp.example.com">
      <saml:Issuer xmlns:saml="urn:oasis:names:tc:SAML:2.0:assertion">
       https://xmpp.example.com
      </saml:Issuer>
      <samlp:NameIDPolicy AllowCreate="true"
        Format="urn:oasis:names:tc:SAML:2.0:nameid-format:persistent"/>
      <samlp:RequestedAuthnContext Comparison="exact">
       <saml:AuthnContextClassRef>
       urn:oasis:names:tc:SAML:2.0:ac:classes:PasswordProtectedTransport
       </saml:AuthnContextClassRef>
      </samlp:RequestedAuthnContext>
    </samlp:AuthnRequest>
  </S:Body>
</S:Envelope>
```

Step 5 (alt): Server returns error to client:

```
<failure xmlns='urn:ietf:params:xml:ns:xmpp-sasl'>
 <incorrect-encoding/>
</failure>
</stream:stream>
```

Step 6: Client relays the request to IdP in a SOAP message transmitted over HTTP (over TLS). HTTP portion not shown, use of Basic Authentication is assumed. The body of the SOAP envelope is exactly the same as received in the previous step.

```
<S:Envelope
    xmlns:saml="urn:oasis:names:tc:SAML:2.0:assertion"
    xmlns:samlp="urn:oasis:names:tc:SAML:2.0:protocol"
    xmlns:S="http://schemas.xmlsoap.org/soap/envelope/">
    <S:Body>
        <samlp:AuthnRequest>
        <!-- same as above -->
        </samlp:AuthnRequest>
    </S:Body>
</S:Envelope>
```

Step 7: IdP responds to client with a SOAP response containing a SAML <Response> containing a short-lived SSO assertion (shown as an encrypted variant in the example). A generated key is included in the assertion and in a header for the client.

```
<S:Envelope
    xmlns:saml="urn:oasis:names:tc:SAML:2.0:assertion"
    xmlns:samlp="urn:oasis:names:tc:SAML:2.0:protocol"
    xmlns:S="http://schemas.xmlsoap.org/soap/envelope/">
  <S:Header>
    <ecp:Response S:mustUnderstand="1"
      S:actor="http://schemas.xmlsoap.org/soap/actor/next"
      AssertionConsumerServiceURL="xmpp@xmpp.example.com"/>
    <samlec:GeneratedKey xmlns:samlec="urn:ietf:params:xml:ns:samlec">
      3w1wSBKUosRLsU69xGK7dg==
    </samlec:GeneratedKey>
  </S:Header>
  <S:Body>
    <samlp:Response ID="d43h94r389309r" Version="2.0"
        IssueInstant="2007-12-10T11:42:34Z" InResponseTo="c3a4f8b9c2d"
        Destination="xmpp@xmpp.example.com">
      <saml:Issuer>https://saml.example.org</saml:Issuer>
      <samlp:Status>
        <samlp:StatusCode
            Value="urn:oasis:names:tc:SAML:2.0:status:Success"/>
      </samlp:Status>
      <saml:EncryptedAssertion>
        <!-- contents elided, copy of samlec:GeneratedKey in Advice -->
      </saml:EncryptedAssertion>
    </samlp:Response>
  </S:Body>
</S:Envelope>
```

Step 8: Client sends SOAP envelope containing the SAML <Response> as a response to the SASL server’s challenge:

```
<response xmlns='urn:ietf:params:xml:ns:xmpp-sasl'>
PFM6RW52ZWxvcGUKICAgIHhtbG5zOnNhbWw9InVybjpvYXNpczpuYW1lczp0YzpT
QU1MOjIuMDphc3NlcnRpb24iCiAgICB4bWxuczpzYW1scD0idXJuOm9hc2lzOm5h
bWVzOnRjOlNBTUw6Mi4wOnByb3RvY29sIgogICAgeG1sbnM6Uz0iaHR0cDovL3Nj
aGVtYXMueG1sc29hcC5vcmcvc29hcC9lbnZlbG9wZS8iPgogIDxTOkhlYWRlcj4K
ICAgIDxwYW9zOlJlc3BvbnNlIHhtbG5zOnBhb3M9InVybjpsaWJlcnR5OnBhb3M6
MjAwMy0wOCIKICAgICAgUzphY3Rvcj0iaHR0cDovL3NjaGVtYXMueG1sc29hcC5v
cmcvc29hcC9hY3Rvci9uZXh0IgogICAgICBTOm11c3RVbmRlcnN0YW5kPSIxIiBy
ZWZUb01lc3NhZ2VJRD0iNmMzYTRmOGI5YzJkIi8+CiAgICA8c2FtbGVjOlNlc3Np
b25LZXkgeG1sbnM6c2FtbGVjPSJ1cm46aWV0ZjpwYXJhbXM6eG1sOm5zOnNhbWxl
YyIKICAgICAgeG1sbnM6Uz0iaHR0cDovL3NjaGVtYXMueG1sc29hcC5vcmcvc29h
cC9lbnZlbG9wZS8iCiAgICAgIFM6bXVzdFVuZGVyc3RhbmQ9IjEiCiAgICAgIFM6
YWN0b3I9Imh0dHA6Ly9zY2hlbWFzLnhtbHNvYXAub3JnL3NvYXAvYWN0b3IvbmV4
dCI+CiAgICAgIDxzYW1sZWM6RW5jVHlwZT5hZXMxMjgtY3RzLWhtYWMtc2hhMS05
Njwvc2FtbGVjOkVuY1R5cGU+CiAgICA8c2FtbGVjOlNlc3Npb25LZXk+CiAgPC9T
OkhlYWRlcj4KICA8UzpCb2R5PgogICAgPHNhbWxwOlJlc3BvbnNlIElEPSJkNDNo
OTRyMzg5MzA5ciIgVmVyc2lvbj0iMi4wIgogICAgICAgIElzc3VlSW5zdGFudD0i
MjAwNy0xMi0xMTo0MjozNFoiIEluUmVzcG9uc2VUbz0iYzNhNGY4YjljMmQi
CiAgICAgICAgRGVzdGluYXRpb249InhtcHBAeG1wcC5leGFtcGxlLmNvbSI+CiAg
ICAgIDxzYW1sOklzc3Vlcj5odHRwczovL3NhbWwuZXhhbXBsZS5vcmc8L3NhbWw6
SXNzdWVyPgogICAgICA8c2FtbHA6U3RhdHVzPgogICAgICAgIDxzYW1scDpTdGF0
dXNDb2RlCiAgICAgICAgICAgIFZhbHVlPSJ1cm46b2FzaXM6bmFtZXM6dGM6U0FN
TDoyLjA6c3RhdHVzOlN1Y2Nlc3MiLz4KICAgICAgPC9zYW1scDpTdGF0dXM+CiAg
ICAgIDxzYW1sOkVuY3J5cHRlZEFzc2VydGlvbj4KICAgICAgICA8IS0tIGNvbnRl
bnRzIGVsaWRlZCwgY29weSBvZiBzYW1sZWM6R2VuZXJhdGVkS2V5IGluIEFkdmlj
ZSAtLT4KICAgICAgPC9zYW1sOkVuY3J5cHRlZEFzc2VydGlvbj4KICAgIDwvc2Ft
bHA6UmVzcG9uc2U+CiAgPC9TOkJvZHk+CjwvUzpFbnZlbG9wZT4K
</response>
```

The Base64 [RFC4648] decoded envelope:

```
 <S:Envelope
     xmlns:saml="urn:oasis:names:tc:SAML:2.0:assertion"
     xmlns:samlp="urn:oasis:names:tc:SAML:2.0:protocol"
     xmlns:S="http://schemas.xmlsoap.org/soap/envelope/">
   <S:Header>
     <paos:Response xmlns:paos="urn:liberty:paos:2003-08"
       S:actor="http://schemas.xmlsoap.org/soap/actor/next"
       S:mustUnderstand="1" refToMessageID="6c3a4f8b9c2d"/>
     <samlec:SessionKey xmlns:samlec="urn:ietf:params:xml:ns:samlec"
       xmlns:S="http://schemas.xmlsoap.org/soap/envelope/"
       S:mustUnderstand="1"
       S:actor="http://schemas.xmlsoap.org/soap/actor/next">
       <samlec:EncType>17</samlec:EncType>
     <samlec:SessionKey>
   </S:Header>
   <S:Body>
     <samlp:Response ID="d43h94r389309r" Version="2.0"
         IssueInstant="2007-12-10T11:42:34Z" InResponseTo="c3a4f8b9c2d"
         Destination="xmpp@xmpp.example.com">
       <saml:Issuer>https://saml.example.org</saml:Issuer>
       <samlp:Status>
         <samlp:StatusCode
             Value="urn:oasis:names:tc:SAML:2.0:status:Success"/>
       </samlp:Status>
       <saml:EncryptedAssertion>
         <!-- contents elided, copy of samlec:GeneratedKey in Advice -->
       </saml:EncryptedAssertion>
     </samlp:Response>
   </S:Body>
 </S:Envelope>
```

Step 9: Server informs client of successful authentication:

```
<success xmlns='urn:ietf:params:xml:ns:xmpp-sasl'/>
```

Step 9 (alt): Server informs client of failed authentication:

```
<failure xmlns='urn:ietf:params:xml:ns:xmpp-sasl'>
 <temporary-auth-failure/>
</failure>
</stream:stream>
```

Step 10: Client initiates a new stream to server:

```
<stream:stream xmlns='jabber:client'
xmlns:stream='http://etherx.jabber.org/streams'
to='example.com' version='1.0'>
```

Step 11: Server responds by sending a stream header to client along with any additional features (or an empty features element):

```
<stream:stream xmlns='jabber:client'
xmlns:stream='http://etherx.jabber.org/streams'
id='c2s_345' from='example.com' version='1.0'>
<stream:features>
 <bind xmlns='urn:ietf:params:xml:ns:xmpp-bind'/>
 <session xmlns='urn:ietf:params:xml:ns:xmpp-session'/>
</stream:features>
```

Step 12: Client binds a resource:

```
   <iq type='set' id='bind_1'>
     <bind xmlns='urn:ietf:params:xml:ns:xmpp-bind'>
       <resource>someresource</resource>
     </bind>
   </iq>
```

Step 13: Server informs client of successful resource binding:

```
   <iq type='result' id='bind_1'>
     <bind xmlns='urn:ietf:params:xml:ns:xmpp-bind'>
       <jid>somenode@example.com/someresource</jid>
     </bind>
   </iq>
```

Please note: line breaks were added to the base64 for clarity.

7. Security Considerations

This section will address only security considerations associated with the use of SAML with SASL applications. For considerations relating to SAML in general, the reader is referred to the SAML specification and to other literature. Similarly, for general SASL Security Considerations, the reader is referred to that specification.

Version 2.0 of the Enhanced Client or Proxy Profile [SAMLECP20] adds optional support for channel binding and use of "Holder of Key" subject confirmation. The former is strongly recommended for use with this mechanism to detect "Man in the Middle" attacks between the client and the RP without relying on flawed commercial TLS infrastructure. The latter may be impractical in many cases, but is a valuable way of strengthening client authentication, protecting against phishing, and improving the overall mechanism.

7.1. Risks Left Unaddressed

The adaptation of a web-based profile that is largely designed around security-oblivious clients and a bearer model for security token validation results in a number of basic security exposures that should be weighed against the compatibility and client simplification benefits of this mechanism.

When channel binding is not used, protection against "Man in the Middle" attacks is left to lower layer protocols such as TLS, and the development of user interfaces able to implement that has not been effectively demonstrated. Failure to detect a MITM can result in phishing of the user’s credentials if the attacker is between the client and IdP, or the theft and misuse of a short-lived credential (the SAML assertion) if the attacker is able to impersonate a RP. SAML allows for source address checking as a minor mitigation to the latter threat, but this is often impractical. IdPs can mitigate to some extent the exposure of personal information to RP attackers by encrypting assertions with authenticated keys.

7.2. User Privacy

The IdP is aware of each RP that a user logs into. There is nothing in the protocol to hide this information from the IdP. It is not a requirement to track the activity, but there is nothing technically that prohibits the collection of this information. Servers should be aware that SAML IdPs will track - to some extent - user access to their services. This exposure extends to the use of session keys generated by the IdP to secure messages between the parties, but note that when bearer assertions are involved, the IdP can freely impersonate the user to any relying party in any case.

It is also out of scope of the mechanism to determine under what conditions an IdP will release particular information to a relying party, and it is generally unclear in what fashion user consent could be established in real time for the release of particular information. The SOAP exchange with the IdP does not preclude such interaction, but neither does it define that interoperably.

7.3. Collusion between RPs

Depending on the information supplied by the IdP, it may be possible for RPs to correlate data that they have collected. By using the same identifier to log into every RP, collusion between RPs is possible. SAML supports the notion of pairwise, or targeted/directed, identity. This allows the IdP to manage opaque, pairwise identifiers for each user that are specific to each RP. However, correlation is often possible based on other attributes supplied, and is generally a topic that is beyond the scope of this mechanism. It is sufficient to say that this mechanism does not introduce new correlation opportunities over and above the use of SAML in web-based use cases.

8. IANA Considerations

8.1. GSS-API and SASL Mechanism Registration

The IANA is requested to assign a new entry for this GSS mechanism in the sub-registry for SMI Security for Mechanism Codes, whose prefix is iso.org.dod.internet.security.mechanisms (1.3.6.1.5.5) and to reference this specification in the registry.

The IANA is requested to register the following SASL profile:

SASL mechanism profiles: SAML20EC and SAML20EC-PLUS

Security Considerations: See this document

Published Specification: See this document

For further information: Contact the authors of this document.

Owner/Change controller: the IETF

Note: None

8.2. XML Namespace Name for SAML-EC

A URN sub-namespace for XML constructs introduced by this mechanism is defined as follows:

URI: urn:ietf:params:xml:ns:samlec

Specification: See Appendix A of this document.

Description: This is the XML namespace name for XML constructs introduced by the SAML Enhanced Client SASL and GSS-API Mechanisms.

Registrant Contact: the IESG

9. References

9.1. Normative References

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9.2. Normative References for GSS-API Implementers

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Appendix A. XML Schema

The following schema formally defines the "urn:ietf:params:xml:ns:samlec" namespace used in this document, in conformance with [W3C.REC-xmlschema-1] While XML validation is optional, the schema that follows is the normative definition of the constructs it defines. Where the schema differs from any prose in this specification, the schema takes precedence.

```
   <schema
     targetNamespace="urn:ietf:params:xml:ns:samlec"
     xmlns="http://www.w3.org/2001/XMLSchema"
     xmlns:ds="http://www.w3.org/2000/09/xmldsig#"
     xmlns:S="http://schemas.xmlsoap.org/soap/envelope/"
     xmlns:samlec="urn:ietf:params:xml:ns:samlec"
     elementFormDefault="unqualified"
     attributeFormDefault="unqualified"
     blockDefault="substitution"
     version="1.0">

     <import namespace="http://www.w3.org/2000/09/xmldsig#"/>
     <import namespace="http://schemas.xmlsoap.org/soap/envelope/"/>

     <element name="SessionKey" type="samlec:SessionKeyType"/>
     <complexType name="SessionKeyType">
       <sequence>
         <element ref="samlec:EncType" maxOccurs="unbounded"/>
         <element ref="ds:KeyInfo" minOccurs="0"/>
       </sequence>
       <attribute ref="S:mustUnderstand" use="required"/>
       <attribute ref="S:actor" use="required"/>
       <attribute name="Algorithm"/>
     </complexType>

     <element name="EncType" type="integer"/>

     <element name="GeneratedKey" type="samlec:GeneratedKeyType"/>
     <complexType name="GeneratedKeyType">
       <simpleContent>
         <extension base="base64Binary">
           <attribute ref="S:mustUnderstand"/>
           <attribute ref="S:actor"/>
         </extension>
       </simpleContent>
     </complexType>

     <element name="Delegated" type="samlec:DelegatedType"/>
     <complexType name="DelegatedType">
       <sequence/>
       <attribute ref="S:mustUnderstand" use="required"/>
       <attribute ref="S:actor" use="required"/>
     </complexType>

   </schema>
```

Appendix B. Acknowledgments

The authors would like to thank Klaas Wierenga, Sam Hartman, Nico Williams, Jim Basney, and Venkat Yekkirala for their contributions.

Appendix C. Changes

This section to be removed prior to publication.

- 15,16,17, avoid expiration
- 14, address some minor comments
- 13, clarify SAML metadata usage, adding a recommended Binding value alongside the backward-compatibility usage of PAOS
- 12, clarifying comments based on WG feedback, with a normative change to use enctype numbers instead of names
- 11, update EAP Naming reference to RFC
- 10, update SAML ECP reference to final CS
- 09, align delegation signaling to updated ECP draft
- 08, more corrections, added a delegation signaling header
- 07, corrections, revised section on delegation
- 06, simplified session key schema, moved responsibility for random-to-key to the endpoints, and defined advertisement of session key algorithm and enctypes by acceptor
- 05, revised session key material, added requirement for random-to-key, revised XML schema to capture enctype name, updated GSS naming reference
- 04, stripped down the session key material to simplify it, and define an IdP-brokered keying approach, moved session key XML constructs from OASIS draft into this one
- 03, added TLS key export as a session key option, revised GSS naming material based on list discussion
- 02, major revision of GSS-API material and updated references
- 01, SSH language added, noted non-assumption of HTTP error handling, added guidance on life of security context.

- 00, Initial Revision, first WG-adopted draft. Removed support for unsolicited SAML responses.

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M. Short
Microsoft Corporation

March 30, 2017

Deprecate 3DES and RC4 in Kerberos
draft-kaduk-kitten-des-des-des-die-die-die-01

Abstract

The 3DES and RC4 encryption types are steadily weakening in cryptographic strength, and the deprecation process should be begun for their use in Kerberos.

Status of This Memo

This Internet-Draft is submitted in full conformance with the provisions of BCP 78 and BCP 79.

Internet-Drafts are working documents of the Internet Engineering Task Force (IETF). Note that other groups may also distribute working documents as Internet-Drafts. The list of current Internet-Drafts is at http://datatracker.ietf.org/drafts/current/.

Internet-Drafts are draft documents valid for a maximum of six months and may be updated, replaced, or obsoleted by other documents at any time. It is inappropriate to use Internet-Drafts as reference material or to cite them other than as "work in progress."

This Internet-Draft will expire on October 1, 2017.

Copyright Notice

Table of Contents

1. Introduction

The 3DES and RC4 encryption types are steadily weakening in cryptographic strength, and the deprecation process should be begun for their use in Kerberos.

2. Requirements Notation

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [RFC2119].

3. Affected Specifications

The RC4 Kerberos encryption types are specified in [RFC4757], which is moved to historic.

The des3-cbc-sha1-kd encryption type is specified in [RFC3961]. Additional 3DES encryption types are in use with no formal specification, in particular des3-cbc-md5 and des3-cbc-sha1. These unspecified encryption types are also deprecated by this document.

4. Affected Encryption Types

The following encryption types are deprecated. The numbers are the official identifiers; the names are only for convenience.

enctype number	enctype convenience name
5	des3-cbc-md5
7	des3-cbc-sha1
16	des3-cbc-sha1-kd
23	rc4-hmac

5. RC4 Weakness

RC4's weakness as a TLS cipher due to statistical biases in the keystream has been well-publicized [RFC7465], and these statistical biases cause concern for any consumer of the RC4 cipher. However, the RC4 Kerberos enctypes have additional flaws which reduce the security of applications using them, including the weakness of the password hashing algorithm, the reuse of key material across protocols, and the lack of a salt when hashing the password.

5.1. Statistical Biases

The RC4 stream cipher is known to have statistical biases in its output, which have led to practical attacks against protocols using RC4, such as TLS ([RFC7465]). These attacks seem to rely on repeated encryptions of thousands of copies of the same plaintext; whereas it is easy for malicious javascript in a website to cause such traffic, it is unclear that there is an easy way to induce a kerberized application to generate such repeated encryptions. The statistical biases are most pronounced for earlier bits in the output stream, which is somewhat mitigated by the use of a confounder in kerberos messages -- the first 64 bits of plaintext are a random confounder, and are thus of no use to an attacker who can retrieve them.

Nonetheless, the statistical biases in the RC4 keystream extend well past 64 bits, and provide potential attack surface to an attacker. Continuing to use a known weak algorithm is inviting further development of attacks.

5.2. Password Hash

Kerberos long-term keys can either be random (as might be used in a service's keytab) or derived from a password (usable for individual users to authenticate to a system). The specification for a Kerberos encryption type must include a "string2key" algorithm for generating a raw crypto key from a string (i.e., password). Modern encryption types such as those using the AES and Camellia block ciphers use a string2key function based on the PBKDF2 algorithm, which involves many iterations of a cryptographic hash function, designed to increase the computational effort required to perform a brute-force password-guessing attack. There is an additional option to specify an increased iteration count for a given principal, providing some modicum of adaptability for increases in computing power.

It is also best practice when deriving cryptographic secrets from user passwords, to include a value which is unique to both the user and the realm of authentication as input to the has function; this user-specific input is known as a "salt". The default salt for Kerberos principals includes both the name of the principal and the name of the realm, in accordance with these best practices. However, the RC4 encryption types ignore the salt input to the string2key function, which is a single iteration of the MD4 HMAC function applied to the UTF-16 encoded password, with no salt at all. The MD4 hash function is very old, and is considered to be weak and unsuitable for new cryptographic applications at this time. [RFC6150]

The omission of a salt input to the hash is contrary to cryptographic best practices, and allows an attacker to construct a "rainbow table" of password hashes, which are applicable to all principals in all Kerberos realms. Given the prevalance of poor-quality user-selected password, it is likely that a rainbow table derived from a database of common passwords would be able to compromise a sizable number of Kerberos principals in any realm using RC4 encryption types for password-derived keys.

5.3. Cross-Protocol Key Reuse

The selection of unsalted MD4 as the Kerberos string2key function was deliberate, since it allowed systems to be converted in-place from the old NTLM logon protocol [MS-NLMP] to use Kerberos.

Unfortunately, there still exist systems using NTLM for authentication to applications, which can result in application servers possessing the NT password hash of user passwords. Because the RC4 string2key was chosen to be compatible with the NTLM scheme, this means that these application servers also possess the long-term

Kerberos key for those users (even though the password is unknown). The cross-protocol use of the long-term key/password hash was convenient for migrating to Kerberos, but now provides a vulnerability in Kerberos as NTLM continues to be used.

5.4. Interoperability Concerns

The RC4 Kerberos encryption type remains in use in many environments because of interoperability requirements -- in those sites, RC4 is the strongest enctype which allows two parties to use Kerberos to communicate. In particular, the Kerberos implementions included with Windows XP and Windows Server 2003 support only single-DES and RC4. Since single-DES is deprecated ([RFC6649]), machines running those operating systems must use RC4.

Similarly, there are cross-realm situations where the cross-realm key was initially established when one peer only supported RC4, or where machines only supporting RC4 will need to obtain a cross-realm TGT. It can be difficult to inventory all clients in a Kerberos realm and know what implementations will be used by those client principals; this leads to concerns that disabling RC4 will cause breakage on machines that are unknown to the realm administrators.

However, both Windows XP and Windows Server 2003 are already out of their official support periods. It is now believed that all machines that might be broken by disabling RC4 are unsupported, and concerns about breaking them will be reduced. That should facilitate the removal of RC4 from common use.

6. 3DES Weakness

The flaws in triple-DES as used for Kerberos are not quite as damning as those in RC4, but there is still ample justification for deprecating their use. As is the case for the RC4 enctypes, the string2key algorithm is weak. Additionally, the 3DES encryption types were never implemented in all Kerberos implementations, and the 64-bit blocksize may be problematic in some environments.

6.1. Password-based Keys

The string2key function used by the des-cbc-sha1-kd encryption type is essentially just the same n-fold algorithm used by the single-DES family of enctypes. It is known to not provide effective mixing of the input bits, and is computationally easy to evaluate. As such, it does not slow down brute-force attacks in the way that the computationally demanding PBKDF2 algorithm used by more modern encryption types does. The salt is used by des-cbc-sha1-kd’s

string2key, in contrast to RC4, but a brute-force dictionary attack on common passwords may still be feasible.

6.2. Interoperability

The triple-DES encryption types were implemented by MIT Kerberos early in its development, but encryption types 17 and 18 (AES) quickly followed, so there are only a small number of such deployments which support 3DES but not AES. Similarly, the Heimdal Kerberos implementation provided 3DES shortly followed by AES, and has provided AES for nearly ten years.

The Kerberos implementation in Microsoft Windows does not currently and has never implemented the 3DES encryption type. Support for AES was introduced with Windows Vista and Windows Server 2008; older versions such as Windows XP and Windows Server 2003 only supported the RC4 encryption types.

The 3DES encryption type offers very slow encryption, especially compared to the performance of AES using the hardware accelleration available in modern CPUs. There are no areas where it offers advantages over other encryption types except in the rare case where AES is not available.

6.3. Block Size

Because triple-DES is based on the single-DES primitive, just using additional key material and nested encryption, it inherits the 64-bit cipher block size from single-DES. As a result, an attacker who can collect approximately 2**32 blocks of ciphertext has a good chance of finding a cipher block collision (the "birthday attack"), which would potentially reveal a couple blocks of plaintext.

A cipher block collision would not necessarily cause the key itself to be leaked, so the plaintext revealed by such a collision would be limited. For some sites, that may be an acceptable risk, but it is still considered a weakness in the encryption type.

7. Recommendations

This document hereby removes the following RECOMMENDED types from [RFC4120]:

Encryption: DES3-CBC-SHA1-KD

Checksum: HMAC-SHA1-DES3-KD

Kerberos implementations and deployments SHOULD NOT implement or deploy the following triple-DES encryption types: DES3-CBC-MD5(5), DES3-CBC-SHA1(7), and DES3-CBC-SHA1-KD(16) (updates [RFC4120]).

Kerberos implementations and deployments SHOULD NOT implement or deploy the RC4 encryption type RC4-HMAC(23).

Kerberos implementations and deployments SHOULD NOT implement or deploy the following checksum types: RSA-MD5(7), RSA-MD5-DES3(9), HMAC-SHA1-DES3-KD(12), and HMAC-SHA1-DES3(13) (updates [RFC4120]).

Kerberos GSS mechanism implementations and deployments SHOULD NOT implement or deploy the following SGN_ALGs: HMAC MD5(1100) and HMAC SHA1 DES3 KD (updates [RFC4757]).

Kerberos GSS mechanism implementations and deployments SHOULD NOT implement or deploy the following SEAL_ALGs: RC4(1000) and DES3KD(0400).

This document recommends the reclassification of [RFC4757] as Historic.

8. Security Considerations

This document is entirely about security considerations, namely that the use of the 3DES and RC4 Kerberos encryption types is not secure, and they should not be used.

9. IANA Considerations

IANA is requested to update the registry of Kerberos Encryption Type Numbers to note that encryption types 1, 2, 3, and 24 are deprecated, with RFC 6649 ([RFC6649]) as the reference, and that encryption types 5, 7, 16, and 23 are deprecated, with this document as the reference.

Similarly, IANA Is requested to update the registry of Kerberos Checksum Type Numbers to note that checksum types 1, 2, 3, 4, 5, 6, and 8 are deprecated, with RFC 6649 as the reference, and that checksum types 7, 12, and 13 are deprecated, with this document as the reference.

10. References

10.1. Normative References

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Appendix A. Acknowledgements

Many people have contributed to the understanding of the weaknesses of these encryption types over the years, and they cannot all be named here.

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Kerberos Service Discovery using DNS
draft-mccallum-kitten-krb-service-discovery-03

Abstract

This document proposes defines a new mechanism for discovering Kerberos services using DNS. This new mechanism extends the mechanism already defined in Kerberos V5 [RFC4120] and has four goals. First, reduce the number of DNS queries required to discover a Kerberos KDC. Second, provide DNS administrators more control over client behavior. Third, provide support for discovery of the MS-KKDCP transport. Fourth, define a discovery procedure for Kerberos password services.

Status of This Memo

This Internet-Draft is submitted in full conformance with the provisions of BCP 78 and BCP 79.

Internet-Drafts are working documents of the Internet Engineering Task Force (IETF). Note that other groups may also distribute working documents as Internet-Drafts. The list of current Internet-Drafts is at http://datatracker.ietf.org/drafts/current/.

Internet-Drafts are draft documents valid for a maximum of six months and may be updated, replaced, or obsoleted by other documents at any time. It is inappropriate to use Internet-Drafts as reference material or to cite them other than as "work in progress."

This Internet-Draft will expire on March 27, 2017.

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1. Introduction

Section 7.2.3 of Kerberos V5 [RFC4120] defines a procedure for discovering a KDC based on DNS SRV records. This method has three drawbacks. First, two DNS queries are required to locate a single service (one for UDP and one for TCP). Second, specifying UDP and TCP in separate records means that the DNS administrator has no control over client preferences for TCP or UDP. Third, any new transports for reaching the KDC (such as MS-KKDCP) will require new records and additional DNS queries.

The Kerberos Password [RFC3244] protocol has no defined procedure for discovery similar to the KDC method described above. Implementations have largely chosen a similar method to section 7.2.3 of Kerberos V5 [RFC4120], inheriting the same drawbacks outlined above.

This RFC defines three new URI DNS records [RFC7553]; one each for KDC, Kerberos Password, and Kerberos Admin service discovery.

2. Document Conventions

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in RFC 2119 [RFC2119].

3. Realm to Domain Translation

This document does not define a new mechanism for translating Kerberos realms to DNS domains. The existing mechanism as defined in section 7.2.3.1 of Kerberos V5 [RFC4120] MUST be followed.

4. Required URI Format

The following URI format MUST be supported by clients.

The URI format is comprised of text fields delimited by a colon (":") character.

krb5srv:[flags]:transport:residual

See the Appendix for examples.

4.1. Scheme

This field identifies the URI scheme. Its value MUST be the string "krb5srv".

4.2. Flags

This field contains a sequence of zero or more case-insensitive characters used individually to convey server attributes or feature support (eg. "XYZ" indicates support for features X, Y, and Z.) for the purpose of organizing the lookup results.

This field MUST be present even when no flags are provided, appearing as two colons seperating the scheme and transport fields (eg. "krb5srv::tcp:host").

Flags are not considered critical, therefore flags that are not used or unknown to the implementation SHOULD be ignored.

4.2.1. Master Flag

The "m" flag signifies that the discovered server is a master server. The client SHOULD consider this server as one that would immediately see password changes and use it as a fallback for incorrect password errors.

4.3. Transport

This field contains a string to indicate the transport method to use when contacting the host specified in the URI.

4.4. Residual

This field contains information specific to the transport. It may contain sub-fields where such are defined in the transport specification.

5. Kerberos V5 KDC Service Discovery

In order to discover a KDC service location, the client MUST query the following URI DNS [RFC7553] record (REALM indicates the translation of the Kerberos realm to a DNS domain):

_kerberos.REALM

TTL, Class, URI, Priority, Weight and Target have the standard meanings as defined in RFC 2782 [RFC2782] and the URI DNS record type [RFC7553]. Target SHOULD contain one of the URI formats specified in this document.

6. Kerberos Password Service Discovery

In order to discover a password service location, the client MUST query the following URI DNS [RFC7553] record (REALM indicates the translation of the Kerberos realm to a DNS domain):

_kpasswd.REALM

TTL, Class, URI, Priority, Weight and Target have the standard meanings as defined in RFC 2782 [RFC2782] and the URI DNS record type [RFC7553]. Target SHOULD contain one of the URI formats specified in this document.

7. Kerberos Admin Service Discovery

In order to discover an admin service location, the client MUST query the following URI DNS [RFC7553] record (REALM indicates the translation of the Kerberos realm to a DNS domain):

_kerberos-adm.REALM

TTL, Class, URI, Priority, Weight and Target have the standard meanings as defined in RFC 2782 [RFC2782] and the URI DNS record type [RFC7553]. Target SHOULD contain one of the URI formats specified in this document.

8. Relationship to Existing Mechanism

If an existing discovery protocol is supported by a client, the client SHOULD perform the URI lookup as defined in this document first. If no URI record is found, the client MAY attempt discovery using another protocol.

9. IANA Considerations

This document establishes two registries with the following procedure, in accordance with [RFC5226]:

Registry entries are to be evaluated using the Specification Required method. All specifications must be be published prior to entry inclusion in the registry. There will be a three-week review period by Designated Experts on the kitten@ietf.org mailing list. Prior to the end of the review, the Designated Experts must approve or deny the request. This decision is to be conveyed to both the IANA and the list, and should include reasonably detailed explanation in the case of a denial as well as whether the request can be resubmitted.

9.1. Kerberos Server Discovery Flags

This section species the IANA "Kerberos Server Discovery Flags" registry. This registry records the value and description for each flag.

9.1.1. Registration Template

Value: A single unique ASCII character that identifies the entry, excluding the colon character (":") since it is used as a field delimiter in the scheme outlined in this document.

Description: A brief description of the meaning of the value when it appears in the flags field.

Reference: A reference to the details of the flag.

9.1.2. Initial Registry Contents

- Value: m
- Description: The target is a master server.
- Reference: TBD

9.2. Kerberos Server Discovery Transport Types

This section specifies the IANA "Kerberos Server Discovery Transport Types" registry. This registry records the value, description, residual format, case-sensitive residual elements, default ports, and a reference for each type.

9.2.1. Registration Template

Value: A unique value to identify the transport type within the transport field.

Description: The name or description of the transport type.

Residual Format: The format of the residual field that specifies the discovered target URL. Optional parts of the URL are enclosed in brackets.

Case Sensitive: If any part of the residual format is case-sensitive, it is specified here.

Default KDC Port: A number in the range of 1-65535 as the port used to contact the target URL when no port is specified and the lookup result is for a Kerberos server.

Default Admin Service Port: A number in the range of 1-65535 as the port used to contact the target URL when no port is specified and the lookup result is for a Kerberos Admin server.

Default Password Service Port: A number in the range of 1-65535 as the port used to contact the target URL when no port is specified and the lookup result is for a Kerberos Password server.

Reference: A reference to the details of the transport type.

9.2.2. Initial Registry Contents

- Value: "udp"
- Description: User Datagram Protocol
- Residual Format: "host[:port]"
- Case Sensitive: None
- Default KDC Port: 88
- Default Admin Service Port: 749
- Default Password Service Port: 464
- Reference: [RFC0768]

- Value: "tcp"
- Description: Transport Control Protocol
- Residual Format: "host[:port]"
- Case Sensitive: None
- Default KDC Port: 88
- Default Admin Service Port: 749
- Default Password Service Port: 464
- Reference: [RFC0793]

- Value: "kkdcp"
- Description: Kerberos Key Distribution Center Proxy Protocol
- Residual Format: https://host[:port][/path]
- Case Sensitive: [/path]
- Default KDC Port: 443
- Default Admin Service Port: 443
- Default Password Service Port: 443
- Reference: [MS-KKDCP]

10. Appendix

10.1. URI Format Examples

- krb5srv:m:kkdcp:https://kdc.example.com:8080/path
- krb5srv:m:udp:kdc.example.com
- krb5srv::kkdcp:https://kdc2.example.com/path
- krb5srv::tcp:192.168.1.20:1000

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Appendix A. Acknowledgements

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SPAKE Pre-Authentication
draft-mccallum-kitten-krb-spake-preauth-01

Abstract

This document defines a new pre-authentication mechanism for the Kerberos protocol that uses a password authenticated key exchange. This document has three goals. First, increase the security of Kerberos pre-authentication exchanges by making offline brute-force attacks infeasible. Second, enable the use of secure second factor authentication without relying on FAST. This is achived using the existing trust relationship established by the shared first factor. Third, make Kerberos pre-authentication more resilient against time synchronization errors by removing the need to transfer an encrypted timestamp from the client.

Status of This Memo

This Internet-Draft is submitted in full conformance with the provisions of BCP 78 and BCP 79.

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1. Introduction

The most widely deployed Kerberos pre-authentication method, PA-ENC-TIMESTAMP, encrypts a timestamp in the client principal's long-term secret. When a client uses this method, a passive attacker can perform an offline brute-force attack against the transferred ciphertext. When the client principal's long-term key is based on a password, especially a weak password, offline dictionary attacks can successfully recover the key.

1.1. Properties of PAKE

Password authenticated key exchange (PAKE) algorithms provide several properties which are useful to overcome this problem and make them ideal for use as a Kerberos pre-authentication mechanism.

1. Each side of the exchange contributes entropy.

2. Passive attackers cannot determine the shared key.

3. Active attackers cannot perform a man-in-the-middle attack.

4. Either side can store a password or password equivalent.

These properties of PAKE allow us to establish high-entropy encryption keys resistant to offline brute force attack, even when the passwords used are weak (low-entropy).

1.2. Which PAKE?

Diffie-Hellman Encrypted Key Exchange (DH-EKE) is the earliest widely deployed PAKE. It works by encrypting the public keys of a Diffie-Hellman key exchange with a shared secret. However, it requires both that unauthenticated encryption be used and that the public keys be indistinguishable from random data. This last requirement makes it impossible to use this form of PAKE with elliptic curve cryptography. For these reasons, DH-EKE is not a good fit.

Password authenticated key exchange by juggling (JPAKE) permits the use of elliptic curve cryptography. However, it too has drawbacks. First, the additional computation required for the algorithm makes it resource intensive for servers under load. Second, it requires an additional network round-trip, increasing latency and load on the network.

SPAKE is a variant of the technique used by DH-EKE which ensures that all public key encryption and decryption operations result in a member of the underlying group. This property allows SPAKE to be

used with elliptic curve cryptography, permitting the use of markedly smaller key sizes with equivalent security to a finite-field Diffie-Hellman key exchange. Additionally, SPAKE can complete the key exchange in just a single round-trip. These properties make SPAKE an ideal PAKE to use for Kerberos pre-authentication.

1.3. PAKE and Two-Factor Authentication

Using PAKE in a pre-authentication mechanism also has another benefit when coupled with two-factor authentication (2FA). 2FA methods often require the secure transfer of plaintext material to the KDC for verification. This includes one-time passwords, challenge/response signatures and biometric data. Attempting to encrypt this data using the long-term secret results in packets that are vulnerable to offline brute-force attack if either authenticated encryption is used or if the plaintext is distinguishable from random data. This is a problem that PAKE solves for first factor authentication. So a similar technique can be used with PAKE to encrypt second-factor data.

In the OTP pre-authentication [RFC6560] specification, this problem has been mitigated by using FAST, which uses a secondary trust relationship to create a secure encryption channel within which pre-authentication data can be sent. However, the requirement for a secondary trust relationship has proven to be cumbersome to deploy and often introduces third parties into the trust chain (such as certification authorities). These requirements lead to a scenario where FAST cannot be enabled by default without sufficient configuration. SPAKE pre-authentication, instead, can create a secure encryption channel implicitly, using the key exchange to negotiate a high-entropy encryption key. This key can then be used to securely encrypt 2FA plaintext data without the need for a secondary trust relationship. Further, if the second factor verifiers are sent at the same time as the first factor verifier, and the KDC is careful to prevent timing attacks, then an online brute-force attack cannot be used to attack the factors separately.

For these reasons, this draft departs from the advice given in Section 1 of RFC 6113 [RFC6113] which states that "Mechanism designers should design FAST factors, instead of new pre-authentication mechanisms outside of FAST." However, this pre-authentication mechanism does not intend to replace FAST, and may be used with it to further conceal the metadata of the Kerberos messages.

1.4. SPAKE Overview

The SPAKE algorithm can be broadly described in a series of four steps:

1. Calculation and exchange of the public key

2. Calculation of the shared secret (K)

3. Derivation of an encryption key (K')

4. Verification of the derived encryption key (K')

Higher level protocols must define their own verification step. In the case of this mechanism, verification happens implicitly by a successful decryption of the 2FA data.

This mechanism also provides its own method of deriving encryption keys from the calculated shared secret K, for several reasons: to fit within the framework of [RFC3961], to ensure negotiation integrity using a transcript hash, to derive different keys for each use, and to bind the KDC-REQ-BODY to the pre-authentication exchange.

2. Document Conventions

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [RFC2119].

This document refers to numerous terms and protocol messages defined in [RFC4120].

The terms "encryption type", "required checksum mechanism", and "get_mic" are defined in [RFC3961].

The terms "FAST", "PA-FX-COOKIE", "KDC_ERR_PREAUTH_EXPIRED", "KDC_ERR_MORE_PREAUTH_DATA_REQUIRED", "pre-authentication facility", and "authentication set" are defined in [RFC6113].

The [SPAKE] paper defines SPAKE as a family of two key exchange algorithms differing only in derivation of the final key. This mechanism uses a derivation similar to the second algorithm (SPAKE2) with differences in detail. For simplicity, this document refers to the algorithm as "SPAKE". The normative reference for this algorithm is [I-D.irtf-cfrg-spake2].

The terms "ASN.1" and "DER" are defined in [CCITT.X680.2002] and [CCITT.X690.2002].

3. Prerequisites

3.1. PA-ETYPE-INFO2

This mechanism requires the initial KDC pre-authentication state to contain a singular reply key. Therefore, a KDC which offers SPAKE pre-authentication as a stand-alone mechanism MUST supply a PA-ETYPE-INFO2 value containing a single ETYPE-INFO2-ENTRY, as described in [RFC6113] section 2.1.

3.2. Cookie Support

KDCs which implement SPAKE pre-authentication MUST have some secure mechanism for retaining state between AS-REQs. For stateless KDC implementations, this method will most commonly be an encrypted PA-FX-COOKIE. Clients which implement SPAKE pre-authentication MUST support PA-FX-COOKIE.

3.3. More Pre-Authentication Data Required

Both KDCs and clients which implement SPAKE pre-authentication MUST support the use of KDC_ERR_MORE_PREAUTH_DATA_REQUIRED.

4. SPAKE Pre-Authentication Message Protocol

This mechanism uses the reply key and provides the Client Authentication and Strengthening Reply Key pre-authentication facilities. When the mechanism completes successfully, the client will have proved knowledge of the original reply key and possibly a second factor, and the reply key will be strengthened to a more uniform distribution based on the PAKE exchange. This mechanism also ensures the integrity of the KDC-REQ-BODY contents. This mechanism can be used in an authentication set; no pa-hint value is required or defined.

This section will describe the flow of messages when performing SPAKE pre-authentication. We will begin by explaining the most verbose version of the protocol which all implementations MUST support. Then we will describe several optional optimizations to reduce round-trips.

Mechanism messages are communicated using PA-DATA elements within the padata field of KDC-REQ messages or within the METHOD-DATA in the e-data field of KRB-ERROR messages. All PA-DATA elements for this mechanism MUST use the following padata-type:

PA-SPAKE TBD

The padata-value for all PA-SPAKE PA-DATA values MUST be empty or contain a DER encoding for the ASN.1 type PA-SPAKE.

```
PA-SPAKE ::= CHOICE {
    support     [0] SPAKESupport,
    challenge   [1] SPAKEChallenge,
    response    [2] SPAKEResponse,
    encdata     [3] EncryptedData,
    ...
}
```

4.1. First Pass

The SPAKE pre-authentication exchange begins when the client sends an initial authentication service request (AS-REQ) without pre-authentication data. Upon receipt of this AS-REQ, a KDC which requires pre-authentication and supports SPAKE SHOULD reply with a KDC_ERR_PREAUTH_REQUIRED error, with METHOD-DATA containing an empty PA-SPAKE PA-DATA element. This message indicates to the client that the KDC supports SPAKE pre-authentication.

4.2. Second Pass

Once the client knows that the KDC supports SPAKE pre-authentication and the client desires to use it, the client will generate a new AS-REQ message containing a PA-SPAKE PA-DATA element using the support choice. This message indicates to the KDC which groups the client prefers for the SPAKE operation. The group numbers are defined in the IANA "Kerberos SPAKE Groups" registry created by this document. The groups sequence is ordered from the most preferred group to the least preferred group.

```
SPAKESupport ::= SEQUENCE {
    groups      [0] SEQUENCE (SIZE(1..MAX)) OF Int32,
    ...
}
```

The client and KDC initialize a transcript checksum (Section 6) and update it with the DER-encoded PA-SPAKE message.

Upon receipt of the support message, the KDC will select a group. The KDC SHOULD choose a group from the groups provided by the support message. However, if the support message does not contain any group that is supported by the KDC, the KDC MAY select another group in hopes that the client might support it.

Once the KDC has selected a group, the KDC will reply to the client with a KDC_ERR_MORE_PREAUTH_DATA_REQUIRED error containing a PA-SPAKE

PA-DATA element using the challenge choice. The client and KDC update the transcript checksum with the DER-encoded PA-SPAKE message.

```
SPAKEChallenge ::= SEQUENCE {
    group       [0] Int32,
    pubkey      [1] OCTET STRING,
    factors     [2] SEQUENCE (SIZE(1..MAX)) OF SPAKESecondFactor,
    ...
}
```

The group field indicates the KDC-selected group used for all SPAKE calculations as defined in the IANA "Kerberos SPAKE Groups" registry created by this document.

The pubkey field indicates the KDC's public key generated using the M constant in the SPAKE algorithm, with inputs and conversions as specified in Section 5.

The factors field contains an unordered list of second factors which can be used to complete the authentication. Each second factor is represented by a SPAKESecondFactor.

```
SPAKESecondFactor ::= SEQUENCE {
    type        [0] Int32,
    data        [1] OCTET STRING OPTIONAL
}
```

The type field is a unique integer which identifies the second factor type. The factors field of SPAKEChallenge MUST NOT contain more than one SPAKESecondFactor with the same type value.

The data field contains optional challenge data. The contents in this field will depend upon the second factor type chosen.

4.3. Third Pass

Upon receipt of the challenge message, the client will complete its part of of the SPAKE process, resulting in the shared secret K.

Next, the client chooses one of the second factor types listed in the factors field of the challenge message and gathers whatever data is required for this second factor type; possibly using the challenge data for this second factor type. Finally, the client sends an AS-REQ containing a PA-SPAKE PA-DATA element using the response choice.

```
SPAKEResponse ::= SEQUENCE {
    pubkey      [0] OCTET STRING,
    factor      [1] EncryptedData, -- SPAKESecondFactor
    ...
}
```

The client and KDC update the transcript checksum with the pubkey value, and use the resulting checksum for all encryption key derivations.

The pubkey field indicates the client's public key generated using the N constant in the SPAKE algorithm, with inputs and conversions as specified in Section 5.

The factor field indicates the client's chosen second factor data. The key for this field is K'[1] as specified in Section 7. The key usage number for the encryption is KEY_USAGE_SPAKE_FACTOR. The plain text inside the EncryptedData is an encoding of SPAKESecondFactor. Once decoded, the SPAKESecondFactor contains the type of the second factor and any optional data used. The contents of the data field will depend on the second factor type chosen. The client MUST NOT send a response containing a second factor type which was not listed in the factors field of the challenge message.

When the KDC receives the response message from the client, it will use the pubkey to compute the SPAKE result, derive K'[1], and decrypt the factors field. If decryption is successful, the first factor is successfully validated. The KDC then validates the second factor. If either factor fails to validate, the KDC responds with an appropriate KRB-ERROR message.

If validation of the second factor requires further round-trips, the KDC MUST reply to the client with KDC_ERR_MORE_PREAUTH_DATA_REQUIRED containing a PA-SPAKE PA-DATA element using the encdata choice. The key for the EncryptedData value is K'[2] as specified in Section 7, and the key usage number is KEY_USAGE_SPAKE_FACTOR. The plain text of this message contains a DER-encoded SPAKESecondFactor message. As before, the type field of this message will contain the second factor type, and the data field will optionally contain second factor type specific data.

KEY_USAGE_SPAKE_FACTOR	TBD

4.4. Subsequent Passes

Any number of additional round trips may occur using the encdata choice. The contents of the plaintexts are specific to the second factor type. If a client receives a PA-SPAKE PA-DATA element using

the encdata choice from the KDC, it MUST reply with a subsequent AS-REQ with a PA-SPAKE PA-DATA using the encdata choice, or abort the AS exchange.

The key for client-originated encdata messages in subsequent passes is K'[3] as specified in Section 7 for the first subsequent pass, K'[5] for the second, and so on. The key for KDC-originated encdata messages is K'[4] for the first subsequent pass, K'[6] for the second, and so on.

4.5. Reply Key Strengthening

When the KDC has successfully validated both factors, the reply key is strengthened and the mechanism is complete. To strengthen the reply key, the client and KDC replace it with K'[0] as specified in Section 7. The KDC then replies with a KDC-REP message, or continues on to the next mechanism in the authentication set. There is no final PA-SPAKE PA-DATA message from the KDC to the client.

Reply key strengthening occurs only once at the end of the exchange. The client and KDC MUST use the initial reply key as the base key for all K'[n] derivations.

4.6. Optimizations

The full protocol has two possible optimizations.

First, the KDC MAY reply to the initial AS-REQ (containing no pre-authentication data) with a PA-SPAKE PA-DATA element using the challenge choice, instead of an empty padata-value. In this case, the KDC optimistically selects a group which the client may not support. If the group chosen by the challenge message is supported by the client, the client MUST skip to the third pass by issuing an AS-REQ with a PA-SPAKE message using the response choice. If the KDC's chosen group is not supported by the client, the client MUST initialize and update the transcript hash with the KDC's challenge message, and then continue to the second pass. Clients MUST support this optimization.

Second, clients MAY skip the first pass and send an AS-REQ with a PA-SPAKE PA-DATA element using the support choice. KDCs MUST support this optimization.

5. SPAKE Parameters and Conversions

Group elements are converted to octet strings for the SPAKEChallenge and SPAKEResponse pubkey fields and for key derivation using the

serialization method defined in the IANA "Kerberos SPAKE Groups" registry created by this document.

The SPAKE algorithm requires constants M and N for each group. These constants are defined in the IANA "Kerberos SPAKE Groups" registry created by this document.

The SPAKE algorithm requires a shared secret input w to be used as a scalar multiplier (see [I-D.irtf-cfrg-spake2] section 2). This value MUST be produced from the initial reply key as follows:

1. Determine the length of the multiplier octet string defined in the IANA "Kerberos SPAKE Groups" registry created by this document.

2. Produce an octet string of the above length using PRF+(K, "SPAKEsecret"), where K is the initial reply key and PRF+ is defined in [RFC6113] section 5.1.

3. Convert the octet array to a multiplier scalar using the multiplier conversion method defined in the IANA "Kerberos SPAKE Groups" registry created by this document.

The KDC chooses a secret scalar value x and the client chooses a secret scalar value y. As required by the SPAKE algorithm, these values are chosen randomly and uniformly. The KDC and client MUST NOT reuse x or y values for authentications involving different initial reply keys.

6. Transcript Checksum

The transcript checksum is an octet string of length equal to the output length of the required checksum type of the encryption type of the initial reply key. It initially contains all zero values.

When the transcript checksum is updated with an octet string input, the new value is the get_mic result computed over the concatenation of the old value and the input, for the required checksum type of the initial reply key's encryption type, using the initial reply key and the key usage number KEY_USAGE_SPAKE_TRANSCRIPT.

In the normal message flow or with the second optimization described in Section 4.6, the transcript checksum is first updated with the client's support message, then the KDC's challenge message, and finally with the client's pubkey value. It therefore incorporates the client's supported groups, the KDC's chosen group, the KDC's initial second-factor messages, and the client and KDC public values.

If the first optimization described in Section 4.6 is used successfully, the transcript checksum is updated only with the KDC's challenge message and the client's pubkey value.

If first optimization is used unsuccessfully (i.e. the client does not accept the KDC's selected group), the transcript checksum is updated with the KDC's optimistic challenge message, then with the client's support message, then the KDC's second challenge message, and finally with the client's pubkey value.

KEY_USAGE_SPAKE_TRANSCRIPT TBD

7. Key Derivation

Implementations MUST NOT use the SPAKE result (denoted by K in Section 2 of SPAKE [I-D.irtf-cfrg-spake2]) directly for any cryptographic operation. Instead, the SPAKE result is used to derive keys K'[n] as defined in this section. This method differs slightly from the method used to generate K' in Section 3 of SPAKE [I-D.irtf-cfrg-spake2].

A PRF+ input string is assembled by concatenating the following values:

- The fixed string "SPAKEKey".
- The SPAKE result K, converted to an octet string as specified in Section 5.
- The transcript checksum.
- The KDC-REQ-BODY encoding for the request being sent or responded to. Within a FAST channel, the inner KDC-REQ-BODY encoding MUST be used.
- The value n as a big-endian four-byte unsigned binary number.

The derived key K'[n] has the same encryption type as the initial reply key, and has the value random-to-key(PRF+(initial-reply-key, input-string)). PRF+ is defined in [RFC6113] section 5.1.

8. Second Factor Types

This document defines one second factor type:

SF-NONE 1

This second factor type indicates that no second factor is used. Whenever a SPAKESecondFactor is used with SF-NONE, the data field MUST be omitted. The SF-NONE second factor always successfully validates.

9. Security Considerations

All of the security considerations from SPAKE [I-D.irtf-cfrg-spake2] apply here as well.

This mechanism includes unauthenticated plaintext in the support and challenge messages. Beginning with the third pass, the integrity of this plaintext is ensured by incorporating the transcript checksum into the derivation of the final reply key and second factor encryption keys. Downgrade attacks on support and challenge messages will result in the client and KDC deriving different reply keys and EncryptedData keys. The KDC-REQ-BODY contents are also incorporated into key derivation, ensuring their integrity. The unauthenticated plaintext in the KDC-REP message is not protected by this mechanism.

Unless FAST is used, the factors field of a challenge message is not integrity-protected until the response is verified. Second factor types MUST account for this when specifying the semantics of the data field. Second factor data in the challenge should not be included in user prompts, as it could be modified by an attacker to contain misleading or offensive information.

Subsequent factor data, including the data in the response, are encrypted in a derivative of the shared secret K. Therefore, it is not possible to exploit the untrustworthiness of challenge to turn the client into an encryption or signing oracle, unless the attacker knows the client’s long-term key.

An implementation of this pre-authentication mechanism can have the property of indistinguishability, meaning that an attacker who guesses a long-term key and a second factor value cannot determine whether one of the factors was correct unless both are correct. Indistinguishability is only maintained if the second factor can be validated solely based on the data in the response; the use of additional round trips will reveal to the attacker whether the long-term key is correct. Indistinguishability also requires that there are no side channels. When processing a response message, whether or not the KDC successfully decrypts the factor field, it must reply with the same error fields, take the same amount of time, and make the same observable communications to other servers.

Given that each EncryptedData will begin a new encryption context, a failure to properly derive the encryption keys will result in a situation where the risk of compromise is non-negligible.

Weak checksums present a risk to the transcript hash. Any etype with a checksum based on one of the following algorithms MUST NOT be used:

- CRC32
- MD4
- MD5

Both the size of the EncryptedData and the number of EncryptedData messages may reveal information about the second factor used in an authentication. Care should be taken to keep second factor messages as small and as few as possible.

A stateless KDC implementation generally must use a PA-FX-COOKIE value to remember its private scalar value x and the transcript checksum. The KDC MUST maintain confidentiality and integrity of the cookie value, perhaps by encrypting it in a key known only to the realm's KDCs. Cookie values may be replayed by attackers. The KDC SHOULD limit the time window of replays using a timestamp, and SHOULD prevent cookie values from being applied to other pre-authentication mechanisms or other client principals. Within the validity period of a cookie, an attacker can replay the final message of a pre-authentication exchange to any of the realm's KDCs and make it appear that the client has authenticated.

Any side channels in the creation of the shared secret input w, or in the multiplications wM and wN, could allow an attacker to recover the client long-term key. Implementations MUST take care to avoid side channels, particularly timing channels. Generation of the secret scalar values x and y need not take constant time, but the amount of time taken MUST NOT provide information about the resulting value.

If an x or y value is reused for pre-authentications involving two different client long-term keys, an attacker who observes both authentications and knows one of the long-term keys can conduct an offline dictionary attack to recover the other one.

This pre-authentication mechanism is not designed to provide forward secrecy. Nevertheless, some measure of forward secrecy may result depending on implementation choices. A passive attacker who determines the client long-term key after the exchange generally will not be able to recover the ticket session key; however, an attacker who also determines the PA-FX-COOKIE encryption key (if the KDC uses

an encrypted cookie) will be able to recover the ticket session key. The KDC can mitigate this risk by periodically rotating the cookie encryption key. If the KDC or client retains the x or y value for reuse with the same client long-term key, an attacker who recovers the x or y value and the long-term key will be able to recover the ticket session key.

Although this pre-authentication mechanism is designed to prevent an offline dictionary attack by an active attacker posing as the KDC, such an attacker can attempt to downgrade the client to encrypted timestamp. Client implementations SHOULD provide a configuration option to disable encrypted timestamp on a per-realm basis to mitigate this attack.

Like any other pre-authentication mechanism using the client long-term key, this pre-authentication mechanism does not prevent online password guessing attacks. The KDC is made aware of unsuccessful guesses, and can apply facilities such as password lockout to mitigate the risk of online attacks.

Elliptic curve group operations are more computationally expensive than secret-key operations. As a result, the use of this mechanism may affect the KDC's performance under normal load and its resistance to denial of service attacks.

The selected group's resistance to offline brute-force attacks may not correspond to the brute-force resistance of the secret key encryption type. For performance reasons, a KDC MAY select a group whose brute-force resistance is weaker than the secret key. A passive attacker who solves the group discrete logarithm problem after the exchange will be able to conduct an offline attack against the client long-term key. Although the use of password policies and costly, salted string-to-key functions may increase the cost of such an attack, the resulting cost will likely not be higher than the cost of solving the group discrete logarithm.

This mechanism does not directly provide the KDC Authentication pre-authentication facility, because it does not send a key confirmation from the KDC to the client. When used as a stand-alone mechanism, the traditional KDC authentication provided by the KDC-REP enc-part still applies.

The conversion of the scalar multiplier for the SPAKE w parameter may produce a multiplier that is larger than the order of the group. Some group implementations may be unable to handle such a multiplier. Others may silently accept such a multiplier, but proceed to perform multiplication that is not constant time. This is a minor risk in all known groups, but is a major risk for P-521 due to the extra

seven high bits in the input octet string. A common solution to this problem is achieved by reducing the multiplier modulo the group order, taking care to ensure constant time operation.

10. Assigned Constants

The following key usage values are assigned for this mechanism:

KEY_USAGE_SPAKE_TRANSCRIPT	TBD
KEY_USAGE_SPAKE_FACTOR	TBD

11. IANA Considerations

This document establishes two registries with the following procedure, in accordance with [RFC5226]:

Registry entries are to be evaluated using the Specification Required method. All specifications must be be published prior to entry inclusion in the registry. There will be a three-week review period by Designated Experts on the krb5-spake-review@ietf.org mailing list. Prior to the end of the review, the Designated Experts must approve or deny the request. This decision is to be conveyed to both the IANA and the list, and should include reasonably detailed explanation in the case of a denial as well as whether the request can be resubmitted.

11.1. Kerberos Second Factor Types

This section species the IANA "Kerberos Second Factor Types" registry. This registry records the number, name, implementation requirements and reference for each second factor protocol.

11.1.1. Registration Template

ID Number: This is a value that uniquely identifies this entry. It is a signed integer in range -2147483648 to 2147483647, inclusive. Positive values must be assigned only for algorithms specified in accordance with these rules for use with Kerberos and related protocols. Negative values should be used for private and experimental algorithms only. Zero is reserved and must not be assigned.

Name: Brief, unique, human-readable name for this algorithm.

Implementation Requirements: The second factor implementation requirements, which must be one of the words Required, Recommended, Optional, Deprecated, or Prohibited.

Reference: URI or otherwise unique identifier for where the details of this algorithm can be found. It should be as specific as reasonably possible.

11.1.2. Initial Registry Contents

- ID Number: 1
- Name: NONE
- Implementation Requirements: Required
- Reference: this draft.

11.2. Kerberos SPAKE Groups

This section specifies the IANA "Kerberos SPAKE Groups" registry. This registry records the number, name, implementation requirements, specification, serialization, multiplier length, multiplier conversion, SPAKE M constant and SPAKE N constant.

11.2.1. Registration Template

ID Number: This is a value that uniquely identifies this entry. It is a signed integer in range -2147483648 to 2147483647, inclusive. Positive values must be assigned only for algorithms specified in accordance with these rules for use with Kerberos and related protocols. Negative values should be used for private and experimental use only. Zero is reserved and must not be assigned. Values should be assigned in increasing order.

Name: Brief, unique, human readable name for this entry.

Implementation Requirements: The group implementation requirements, which must be one of the words Required, Recommended, Optional, Deprecated, or Prohibited.

Specification: Reference to the definition of the group parameters and operations.

Serialization: Reference to the definition of the method used to serialize group elements.

Multiplier Length: The length of the input octet string to multiplication operations.

Multiplier Conversion: Reference to the definition of the method used to convert an octet string to a multiplier scalar.

SPAKE M Constant: The serialized value of the SPAKE M constant in hexadecimal notation.

SPAKE N Constant: The serialized value of the SPAKE N constant in hexadecimal notation.

11.2.2. Initial Registry Contents

- ID Number: 1
- Name: P-256
- Implementation Requirements: Required
- Specification: [SEC2] section 2.4.2
- Serialization: [SEC1] section 2.3.3 (compressed).
- Multiplier Length: 32
- Multiplier Conversion: [SEC1] section 2.3.8.
- SPAKE M Constant:
  02886e2f97ace46e55ba9dd7242579f2993b64e16ef3dcab95afd497333d8fa12f
- SPAKE N Constant:
  03d8bbd6c639c62937b04d997f38c3770719c629d7014d49a24b4f98baa1292b49

- ID Number: 2
- Name: P-384
- Implementation Requirements: Optional
- Specification: [SEC2] section 2.5.1
- Serialization: [SEC1] section 2.3.3 (compressed).
- Multiplier Length: 48
- Multiplier Conversion: [SEC1] section 2.3.8.
- SPAKE M Constant:
  030ff0895ae5ebf6187080a82d82b42e2765e3b2f8749c7e05eba3664
  34b363d3dc36f15314739074d2eb8613fceec2853
- SPAKE N Constant:
  02c72cf2e390853a1c1c4ad816a62fd15824f56078918f43f922ca215
  18f9c543bb252c5490214cf9aa3f0baab4b665c10

- ID Number: 3
- Name: P-521
- Implementation Requirements: Optional
- Specification: [SEC2] section 2.6.1
- Serialization: [SEC1] section 2.3.3 (compressed).
- Multiplier Length: 66
- Multiplier Conversion: [SEC1] section 2.3.8.
- SPAKE M Constant:
  02003f06f38131b2ba2600791e82488e8d20ab889af753a41806c5db1
  8d37d85608cfae06b82e4a72cd744c719193562a653ea1f119eef9356907edc9b5
  6979962d7aa
- SPAKE N Constant:
  0200c7924b9ec017f3094562894336a53c50167ba8c5963876880542b
  c669e494b2532d76c5b53dfb349fdf69154b9e0048c58a42e8ed04cef052a3bc34
  9d95575cd25

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12.1. Normative References

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12.2. Non-normative References

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[SPAKE] Abdalla, M. and D. Pointcheval, "Simple Password-Based Encrypted Key Exchange Protocols", February 2005.

Appendix A. ASN.1 Module

```
KerberosV5SPAKE {
        iso(1) identified-organization(3) dod(6) internet(1)
        security(5) kerberosV5(2) modules(4) spake(8)
} DEFINITIONS EXPLICIT TAGS ::= BEGIN

IMPORTS
    EncryptedData, Int32
      FROM KerberosV5Spec2 { iso(1) identified-organization(3)
        dod(6) internet(1) security(5) kerberosV5(2) modules(4)
        krb5spec2(2) };
        -- as defined in RFC 4120.

SPAKESupport ::= SEQUENCE {
    groups      [0] SEQUENCE (SIZE(1..MAX)) OF Int32,
    ...
}

SPAKEChallenge ::= SEQUENCE {
    group       [0] Int32,
    pubkey      [1] OCTET STRING,
    factors     [2] SEQUENCE (SIZE(1..MAX)) OF SPAKESecondFactor,
    ...
}

SPAKESecondFactor ::= SEQUENCE {
    type        [0] Int32,
    data        [1] OCTET STRING OPTIONAL
}

SPAKEResponse ::= SEQUENCE {
    pubkey      [0] OCTET STRING,
    factor      [1] EncryptedData, -- SPAKESecondFactor
    ...
}

PA-SPAKE ::= CHOICE {
    support     [0] SPAKESupport,
    challenge   [1] SPAKEChallenge,
    response    [2] SPAKEResponse,
    encdata     [3] EncryptedData,
    ...
}

END
```

Appendix B. Acknowledgements

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Declaring Kerberos Realm Names in DNS (_kerberos TXT)
draft-vanrein-dnstxt-krb1-09

Abstract

This specification defines a method to determine Kerberos realm names for services that are known by their DNS name. Currently, such information can only be found in static mappings or through educated guesses. DNS can make this process more flexible, provided that DNSSEC is used to assure authenticity of resource records.

Status of This Memo

This Internet-Draft is submitted in full conformance with the provisions of BCP 78 and BCP 79.

Internet-Drafts are working documents of the Internet Engineering Task Force (IETF). Note that other groups may also distribute working documents as Internet-Drafts. The list of current Internet-Drafts is at http://datatracker.ietf.org/drafts/current/.

Internet-Drafts are draft documents valid for a maximum of six months and may be updated, replaced, or obsoleted by other documents at any time. It is inappropriate to use Internet-Drafts as reference material or to cite them other than as "work in progress."

This Internet-Draft will expire on April 27, 2017.

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Table of Contents

1. Introduction

When a Kerberos client contacts a service, it needs to acquire a service ticket, and for that it needs to contact the KDC for a realm under which the service is run. To map a service name into a realm name and then into a KDC, clients tend to use static mappings or educated guesses; the client's KDC may or may not be involved in this process. Through DNS, the static mappings could be replaced by dynamic lookups, and migrate from local client configuration into the hands of the party administrating a server's presence in DNS. This brings improved flexibility and centralisation, which is operationally desirable.

Two mappings are needed for a client to contact a service. One is a mapping from the FQDN of a service to its realm name; the other is a mapping from the realm name to the Kerberos-specific services such as the KDC. The latter mapping is published in SRV records [RFC4120] and such traffic is usually protected by Kerberos itself. The first mapping however, has hitherto not been standardised and is ill-advised over unsecured DNS because the published information is then neither validated by DNS nor does it lead to a protocol that could provide end-to-end validation for it.

With the recent uprise of DNSSEC, it is now possible to make a reliable judgement on the authenticity of data in DNS, which enables the standardisation of the first mapping in the form of resource records under DNSSEC.

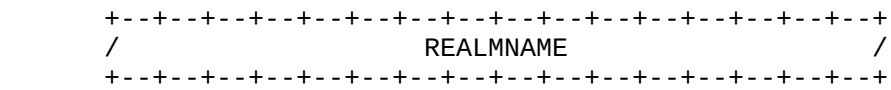
This specification defines a method to publish and process Kerberos realm names in TXT resource records. These records hold a case-sensitive string with the realm name. This has been informally

described and practiced, but generally considered insecure; adding DNSSEC means that much of this existing practice can now be trusted.

It is suggested to use the name "_kerberos TXT" to informally refer to the style of using DNS that is introduced in this specification.

2. Defining _kerberos TXT Resource Records

This specification uses the TXT resource record type in DNS to represent a Kerberos realm name. The corresponding RDATA format is as follows:



The REALMNAME is represented as a <character-string> [RFC1035] which starts with a single-byte length, followed by as many bytes of realm name as the length byte's value. The RDATA field therefore has a length of 1 up to 256 bytes, to hold a realm name of 0 up to 255 bytes. For instance, a realm EXAMPLE.ORG would be represented with the following RDATA, written in the notation for unkonwn resource record types [RFC3597]:

```
\# 12 ( 0b 45 58 41 4d 50 4c 45 2e 4f 52 47 )
```

The REALMNAME represents a Kerberos realm name [Section 6.1 of [RFC4120]], not a DNS name; invalid names SHOULD be ignored. The empty string is considered an invalid REALMNAME, and it should be noted that a REALMNAME may exceed the size constraints of a DNS name.

The TXT record can hold one or more <character-string> values in an ordered sequence, and implementations of this specification MUST NOT reject TXT records with multiple <character-string>s. This specification only describes the meaning of the first <character-string> as a REALMNAME, and leaves the interpretation of further <character-string>s to future specifications. Until these specifications are adopted, master zone files SHOULD NOT introduce these extra <character-string>s. If such future specifications intend to specify Kerberos aspects that do not include a realm name, then they can mention an invalid realm name such as an empty <character-string>.

Though any style of realm name may be published as _kerberos TXT, it is common for realm names in Kerberos to follow the domain style [Section 6.1 of [RFC4120]], in which case they look like DNS names but are case sensitive; unlike the DNS names used as lookup keys in the DNS hierarchy, the REALMNAME format follows the <character-

string> format in being case-sensitive. Even for domain-style realm names, there is no required relationship (such as partial overlap) between the realm name and the DNS name at which a TXT record is found.

In fact, the <character-string> format is a binary format, and DNS notation \DDD [Section 5.1 of [RFC1035]] exists to put arbitrary bytes in the string notation. This binary format leaves the door ajar for future internationalisation of Kerberos realm names. Realm names are defined with the KerberosString type [Section 5.2.1 of [RFC4120]] which is an ASN.1 GeneralString, but its specification currently advises to constrain the use of this string type to an IA5String (basically using only the first 128 codes of the ASCII table) to avoid interoperability problems. After the <character-string>'s length byte, the REALMNAME holds the value of the GeneralString, but not its preceding ASN.1 tag and length.

It is worth noting that the ESC "%" "G" prefix [TODO:xref target="ISO2022"/] can be used to introduce an UTF8String in a GeneralString, and that implementations exist that insert UTF8String values in KerberosString fields without even that escape. All this precedes formal standardisation of internationalisation, but it suggests that the RDATA definition for TXT can be supportive of future internationalisation of realm names, even if the current advised use is limited to the value of an IA5String.

It is possible to create a TXT record for any _kerberos-prefixed DNS name, but this specification only provides query procedures for host names and domain names. The use with a domain name has the additional use of denoting the precise spelling for a realm name under its DNS-mapped name. DNS-mapped names currently would not modify more than the case of a DNS name, and even that is only done as the result of DNS compression [RFC4343]; but in a future with internationalised realm names there might be more to reconstruct, in which case this facility is likely to be helpful.

The format for the resource data in master zone files is standard for DNS [RFC1035]. The TXT record is a general record and was not especially designed for this purpose. The reason to use it nonetheless is that it is an existing practice; the particular use specified here is distinguished from comments in TXT records by always prefixing a _kerberos label to a DNS name. An example declaration of realm name EXAMPLE.ORG for a server named imap.example.org would be:

```
imap.example.org.            IN AAAA  2001:db8::143
_kerberos.imap.example.org.  IN TXT   "EXAMPLE.ORG"
```

The RDATA for this TXT record is shown above, in the generic RDATA section notation.

3. Publishing Kerberos Realm Names

Zones that intend to provide applications with Kerberos realm names through _kerberos TXT records SHOULD protect them with DNSSEC.

Operators SHOULD NOT define more than one valid realm name for a given domain or host name.

Note that _kerberos TXT records with wildcard names will not work. All host names and most domain names define at least one resource record (of any type) with the name that the wildcard should cover. These defined names cause the wildcards to be suppressed [RFC4592] from DNS responses, even when querying a non-existent TXT record.

4. Querying Kerberos Realm Names

This section defines a procedure for determining the Kerberos realm names for a server with a given host name or domain name, as well as for a DNS-mapped realm name. This specification does not impose any restriction on the additional use of other-than-DNS methods for for obtaining a realm name.

When applications know their server host name, perhaps because it is mentioned in a URL or in a ticket as a service principal name, or when applications know a domain name for which they intend to learn the realm name, they resolve the TXT record in DNS at the server host name, prefixed with a _kerberos label.

Since DNS in general cannot be considered secure, the client MUST validate DNSSEC and it MUST dismiss any DNS responses that are Insecure, Bogus or Indeterminate [Section 5 of [RFC4033]]. Only the remaining Secure responses are to be taken into account. This specification does not require that the DNS client validates the responses by itself, but a deployment of _kerberos TXT records SHOULD NOT accept DNS responses from a trusted validating DNS resolver over untrusted communication channels.

In addition to the above, the absense of a _kerberos DNS record may be meaningful for security decisions. If such cases, the only denial of existence of the _kerberos TXT records MUST be authenticated denial.

Only the first lt;character-string> of a _kerberos TXT record is considered; any further ones are silently ignored under this

specification. In addition, invalid realm names such as they empty string are silently ignored.

To give one possible implementation, a Kerberos client or its KDC may send DNS queries with the Authentic Data (AD) bit set to enable DNSSEC [Section 5.7 of [RFC6840]], and thereby request that the Authenticated Data bit is set in the response to indicate [RFC3655] the Secure state for answer and authority sections of the response. When the DNS traffic to and from the validating resolver is protected, for instance because the validating resolver is reached over a loopback interface, then the Kerberos client or its KDC has implemented the requirements for Secure use of the answer and authority sections in DNS responses.

When no Secure DNS responses are received when the DNS query times out, then the TXT query MUST be terminated without extracting realm names from DNS. This termination MAY be done immediately upon receiving Secure denial for the requested TXT record. TXT query termination need not be fatal; non-DNS procedures may exist to find a realm name, including the current practice of static mappings and educated guessing.

5. Efficiency Considerations

The lookup of _kerberos TXT records can be done by the Ticket Granting Service of a KDC, which can respond with a Server Referral [Section 8 of [RFC6806]] to Kerberos clients that enable canonicalization. This can be used for clients that are not setup to query DNS as specified above, and that will assume that a service is running under the client’s realm. The caching of DNS records, their validation and possibly realm-crossover caching at the KDC can all benefit the response time for future lookups by other Kerberos clients.

6. Privacy Considerations

This specification barely publishes new information in DNS, with the exception of markation of Kerberised services. When this is considered unattractive from a privacy viewpoint, it may be better to rely on the existing static tables for spreading this information in a more controlled manner.

7. Security Considerations

There is no restriction for _kerberos TXT records to mention realm names that map back to DNS names in a disjoint part of the DNS hierarcy. The records could therefore specify realm names for a service even if the service is not recognised by the realm. The KDC

for the appointed realm would be very clear about that when trying to procure a service ticket, so there is no anticipated security issue with such misguided use of _kerberos TXT records.

The general point is that the use of DNSSEC makes Kerberos accept authentic information from the party that publishes the _kerberos TXT record, and that party could specify improper realm names or drop realm names that are vital to the client. This is not expected to be a security risk either; the party publishing the _kerberos TXT record is the same party that publishes the service's records, namely its DNS operator. By publishing the service's record in DNS, this operator already has potential control over service denial and other man-in-the-middle attacks, so the _kerberos TXT record does not add any new powers of abuse.

When an external attacker would be permitted to spoof a _kerberos TXT record in a victim's DNS, then it could be possible for that attacker to convince the client that the attacker is the authentic provider for the service. Additional spoofing of host name references could then complete the attack. This has been mitigated by strictly requiring Secure validation results from a DNSSEC-aware resolver for all _kerberos TXT records.

8. IANA Considerations

None.

9. References

9.1. Normative References

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Appendix A. Acknowledgements

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Pseudonymity Support for Kerberos
draft-vanrein-kitten-krb-pseudonymity-01

Abstract

Kerberos either retains client identity in all its ticket transformations, or it applies rigorous anonymity. When crossing over to another realm, an intermediate privacy measure is often desired, namely pseudonymity, as described in this specification.

Status of This Memo

This Internet-Draft is submitted in full conformance with the provisions of BCP 78 and BCP 79.

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1. Introduction

Kerberos' privacy model is not always well-suited for connections to other realms, especially when these are previously unencountered realms that have not earned the client's trust with respect to privacy. Normally, the client identity as obtained during an AS exchange is always retained by Kerberos. There is one exception, and that is anonymity [RFC6112], which completely conceals the client's principal name and possibly also its realm.

Where anonymity is obvious in concealing the client identity, this specification describes a more covert alternative based on pseudonymity. By using a pseudonym, the ticket changes to another client identity, and the chosen identity may be selected specifically for dealing with a particular remote realm. As a result, that remote realm can distinguish return visits without knowing what login name was used by the client, and what pseudonym it used when accessing other realms and/or services. As far as the remote realm is concerned, the pseudonym is just a client identity. As far as the client is concerned, the pseudonym may be specific for that one remote realm, or for a particular group of realms.

Pseudonyms can be useful to replace a personal login with that of a group or role, in which case a client can act on behalf of an entity for which it has been authorised and for which the service has established access rights. This is in the interest of the remote realm, which is given a more concise view on the client than a mere personally identifying name of an individual client. For instance, a remote realm may authorise a client named purchasing@EXAMPLE.COM and it is up to the administrators of EXAMPLE.COM which of its individual users are permitted to change their client identity to that pseudonym (or, informally, which users belong to the purchasing group). This separate administration of group membership and authorisation is often a desirable distribution of responsibilities.

2. Principles and Definitions

TODO: Typical phases: (1) after AS, cliream==tgtrealm and ticket flag is set; KDC may change the realm to something local and may pull client along to stay in this state without clearing the ticket flag; (2) after realm crossover, clirealm!=tgtrealm and ticket flag set; skip this phase is ticket flag is reset; remote KDC may change cliname, will then also pull in clirealm but MUST clear the ticket flag; (3) clirealm==tgtream and ticket flag is cleared; client is user of remote realm; remote KDC may change cliname but not clirealm.

Pseudonymity is applied during a TGS exchange. The client requests or permits the KDC to change its identity supplied in the TGT into another identity in the returned ticket. Without pseudonymity (or anonymity) the KDC falls back to its default behaviour, which usually [RFC4120] means that it copies this identity from the TGT to the returned ticket.

Clients can make implicit or explicit requests for a new client identity. An implicit request permits the KDC to apply whatever policies it has for a TGS, and an explicit request asks the KDC to set a particular client principal name. Explicit pseudonymity requests can be used with restrictive KDC policies, such as demanding a client identity to be selected from a set of possibilities.

The application of pseudonymity can be realm-neutral or realm-changing. Realm-neutral means that the realm of the TGT included in the TGS-REQ is the same as the client identity’s realm. Realm-changing means that those realms differ. When applying pseudonymity, the client realm is replaced with the TGT realm, which only has an impact in the realm-changing case. It is not permitted to apply prealm-changing seudonimity more than once, to avoid arbitrary proxying between realms; a remote realm shall only welcome a client identity from its login realm and a client shall not accept arbitrary relaying of its identity to realms beyond the ones it uses directly. There is no restriction on realm-neutral pseudonymity, neither before nor after realm-changing pseudonymity.

TODO: Consider distinguishing local / foreign realm changes, and only constrain foreign realm changes to once. Local means that the TGT service realm and TGT client realm are the same while the ticket flag on the TGT is set. A local realm changes is permitted with or without clearing the ticket flag; foreign realm changes MUST clear the ticket flag and MUST move to the TGT service realm. This permits setting a realm to something spontaneous internally, such as john@EXAMPLE.COM to purchasing@PUBLIC.EXAMPLE.COM where the realm is a side-effect change of user john becoming group purchasing. Perhaps a better name for a foreign realm change is "pulling the client into

a foreign realm", which may be done only once, and MUST therefore reset the ticket flag.

To test whether a KDC is willing to support pseudonymity, the client may set the "pseudonymity" flag in the kdc-options field of its AS-REQ. When the KDC produces a ticket, it MAY respond to this KDC option by setting the "pseudonymity" ticket flag; if it does, it is a statement that the KDC is supportive of pseudonymity.

To request that pseudonymity is applied by the KDC, a client can set the "pseudonymity" flag in a TGS-REQ.

For explicit pseudonymity, the requested client principal name is included in the optional cname field of the TGS-REQ; this field is not normally included in this message, but may be used after assuring that the KDC supports pseudonyms. Explicit requests are unacceptable after applying realm-changing pseudonymity; this leaves room for a last realm-neutral change of the client identity just before crossing over to anoter realm, namely when a TGS-REQ returns a server referral.

3. Procedures and Requirements

TODO:PLACE: The server SHOULD welcome TGS exchanges that are only meant to change the client identity; these would request a service that matches the existing TGT, for instance the one originally obtained by the client, but possibly also aimed at another service realm.

A client MAY always send a TGS-REQ with a "pseudonymity" KDC option, even when there is no "pseudonymity" ticket flag. KDCs unsupportive of pseudonymity will silently ignore the unknown KDC option.

The KDC MUST NOT apply pseudonymity without "pseudonymity" KDC Options in the TGS-REQ; however, if pseudonymity is required by local policy, it MAY return a KRB-ERROR with code TODO to indicate that the client should retry with the "pseudonymity" flag set.

A number of rules MUST be applied by the KDC if it receives a TGS-REQ with the "pseudonymity" KDC option:

1. For explicit pseudonymity, so when the cname field is included in the TGS-REQ, the TGT must have the "pseudonymity" flag set; if not, the KDC responds like a KDC without pseudonymity support.

2. For realm-changing pseudonymity, the TGT must have the "pseudonymity" flag set; otherwise, the KDC respondes like a KDC without pseudonymity support.

3. The KDC may apply local policy; for implicit pseudonymity, it silently ignores disapproved requests; for explict pseudonymity, it responds to disapproved requests with KRB-ERROR code KDC_ERR_C_PRINCIPAL_UNKNOWN if policy forbids the use of pseudonymity, or KDC_ERR_PRINCIPAL_NOT_UNIQUE (TODO:e-data) if it is permitted but lacks guidance on what to choose. The latter error message may also be generated if zero or one potential principals were found, but other things stop it, such as an explicit confirmation of setup by the end user through an external mechanism.

4. As a special case of the foregoing, external pseudonymity with the special name of type NT-UNKNOWN and zero components in the name string is permitted by default policy and cannot be setup with a pseudonym by the user, so it always triggers the aforementioned KDC_ERR_PRINCIPAL_NOT_UNIQUE error reply.

5. TODO: Define special error codes for pseudonymity; overloading existing ones isn’t proper

6. When the KDC applies realm-changing pseudonymity, it MUST clear the "pseudonymity" flag in the returned ticket. This serves two purposes. First, it drops the knowledge of KDC-supported pseudonymity for the new realm. Second, it ensures that realm-changing pseudonymity is applied at most once. In all other cases, when the KDC returns a ticket it MUST copy the "pseudonymity" ticket flag from the TGT in the TGS-REQ.

Clients supportive of pseudonymity MUST ensure that the "pseudonymity" flag in a TGS-REP is never set by the KDC unless the "pseudonymity" KDC option was set in the corresponding TGS-REQ.

Clients supportive of pseudonymity SHOULD process the "pseudonymity" flag in the TGS-REP. When it is set, the client identity in the TGS-REP may have changed, and give rise to somewhat different handling of the returned ticket. (TODO:WHY? Those clients MUST also verify that the client identity is unchanged when the "pseudonymity" flag in the TGS-REP is not set.)

Clients supportive of pseudonymity MUST notice realm-changing pseudonymity in a TGS-REP, and then ensure that the "pseudonymity" ticket flag is reset on the returned ticket; they MUST NOT accept realm-changing pseudonymity based on TGTs without "pseudonymity" ticket flag, and they MUST NOT request explicit pseudonymity based on TGTs without "pseudonymity" ticket flag. They could request realm-changing implicit pseudonymity based on TGTs without "pseudonymity" ticket flag, but this will be silently ignored by the KDC.

These specifications permit arbitrary rewrites of client principal names within the local realm to which the client signed up, always at the initiative of the client, with a principal provided by the client KDC. This means that a database of pseudonyms can be set up in the client and/or the KDC. The KDC is probably most useful when it applies pseudonymity during a request for a service ticket, especially when it finds that realm crossover is involved in procuring that ticket.

There are two situations in which the KDC explicitly lists pseudonyms that are acceptable for a request, as part of an error message KDC_ERR_PRINCIPAL_NOT_UNIQUE with an e-data field containing an ASN.1 SEQUENCE OF PrincipalName in DER encoding. TODO: encryption? This reply can be sent when the client needs it, to which end it sends an explicit pseudonymity request with a cname holding an NT-UNKNOWN name type. Alternatively, the KDC may generate this message when its policy requires pseudonymity but lacks policies to select one pseudonym; this requires that the "pseudonymity" KDC option is set in the TGS-REQ; it is especially of interest when the KDC is about to release a realm crossover ticket from the client's realm to a service realm. The e-data may hold an empty sequence to indicate that no options exist; it may contain one or more PrincipalNames when its policy is not sufficiently deterministic to make a choice.

Although it may seem unnatural to offer pseudonymity to foreign realms, it can actually be quite helpful. First, since it is always implicit pseudonymity, the remote KDC cannot create a "more unique" representation of the client identity; it is however able to group clients. Think of time-constrained test rides in public or free-trial accounts, or think of (temporary) gold or silver service. This sort of use case enables the service to provide previews without demanding clients to setup accounts upfront. This provides a friendlier, and more useful way to explore new services. The service profits from this mechanism by not accruing a long list of one-time users that never return because they don't like the functionality on offer. With this in mind, it is recommended to continue to send the "pseudonymity" KDC option on any TGS-REQ to a remote realm, so long as the TGT has the "pseudonymity" flag set.

TODO: Use Anonymous Kerberos [RFC6112] as a checklist, for instance refer to it for its handling of AuthorizationData.

4. Efficiency Considerations

TODO:WRITE; lightweight mechanism, choice of central setup in KDC

5. Privacy Considerations

TODO:WRITE; pseudonym appears like the right person; identities tailored to targeted service; choice of decentral setup in client; remote realm cannot run away and make us move from realm to realm; remote realm can hardly store interesting information in the tickets

Foreign realms may hide information in the tickets that they return, but this is not likely to be very useful; tickets are not constantly updated during use, and they are discarded after a brief usage period. These properties makes them far less potent than other privacy alerts, such as browser cookies.

6. Security Considerations

TODO:WRITE; impersonation guarded by KDC (TODO: spec); remote realm might do this in hidden ticket info anyway, or may use another identity, which seems harmless?

7. IANA Considerations

TODO:WRITE; "pseudonymity" KDC option; "pseudonymity" ticket flag

8. Normative References

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October 27, 2014

Generic Naming Attributes for the Generic Security Services Application Programming Interface (GSS-API)
draft-williams-kitten-generic-naming-attributes-02

Abstract

This document specifies several useful generic naming attributes for use with the Generic Security Services Application Programming Interface (GSS-API) Naming Extensions specified in RFC6680.

These attributes allow applications to extract discrete components of a GSS-API "mechanism name" (MN) object: issuer (e.g., realm name, domain name, certification authority name), service and host names (for host-based service names), user names, and others.

Status of this Memo

This Internet-Draft is submitted in full conformance with the provisions of BCP 78 and BCP 79.

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1. Introduction and Motivation

The Generic Security Services Application Programming Interface (GSS-API) [RFC2743] allows applications -and application protocol specifications- to use various security mechanisms in a generic way. There are some shortcomings of this API that preclude a fully-generic treatment of security mechanisms. This document builds on the naming extensions to the GSS-API [RFC6680] to correct some of those shortcomings.

In RFC6680 we introduced an interface by which to access "attributes" of names, but we did not specify any attributes. This document specifies some such attributes. Some of the new attributes are specifically intended to make it possible to use the GSS-API in a mechanism-generic way in common use cases where it is otherwise not possible to do so.

For example, some applications need to be able to observe the discrete elements of a peer principal's host-based service name, but they generally could only do so by parsing mechanism-specific display syntaxes or exported name token formats. Such applications are inherently not generic: they can only function correctly when used with security mechanism whose principal naming conventions/formats the applications understand.

More generally, we use the the extended naming interface to introduce an attribute model of principal naming.

1.1. Naming Constraints

This document also introduces a notion of naming constraints, not unlike PKIX's [RFC5280]. Naming constraints apply to "issuers" of principal names and/or their attributes. For example, to Kerberos [RFC4120] realms, to PKIX certification authorities, to identity providers (IdPs), and so on. The goal is allow specification of policies which constrain the set of principal names that a given issuer can issue credentials for.

For example, the Kerberos realm FOO.EXAMPLE would generally not be expected to issue credentials to host-based principals in domains other than "foo.example".

For each concrete attribute specified below there are several ways to inquire a NAME's value for that attribute:

1. with naming constraint checking, providing no output if naming constraints are violated;

2. with naming constraint checking, providing an output indicator of naming constraint violations;

3. without naming constraint checking;

4. any of the above with "fast" (no slow I/O involved) naming constraint checking.

(1) is the default behavior. The others are obtained by adding an appropriate prefix to the attribute name.

Existing security mechanisms may not have any formal notion of naming constraints, but it is common to have some naming constraint conventions nonetheless. For example, Kerberos realm naming conventions are that realm names should mirror Domain Name System (DNS) [RFC1035] domain names, and that hostnames embedded in Kerberos principal names should a) be fully-qualified, b) within the domain corresponding to the DNS domain name derived from the realm's name. Or a Kerberos implementation might lookup a host's realm and check that it matches the principal's realm. Naming constraints should be formalized for all GSS-API security mechanisms.

1.2. Conventions used in this document

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [RFC2119].

2. Generic Attributes

We add a number of generic name attributes, to be used via the GSS-API extended naming facility [RFC6680]. Some of these attributes can be used as prefixes of other attributes, that is, they can be used to modify the semantics of other attributes (see section 6 of RFC6680).

We also provide C bindings for these attributes, namely, the same symbolic names that we provide for the generic attributes.

Note: in all cases the display form of each attribute SHALL consist of text using the character set, codeset, and encoding from the caller's locale.

2.1. Concrete Attributes

These attributes generally have a single value each. Only one of these attributes can also be used a prefix: the issuer name attribute.

2.1.1. Issuer Name

We add an attribute by which to obtain a name of an issuer of a mechanism name (MN) or of an attribute of an MN. The API name for this attribute is GSS_C_ATTR_GENERIC_ISSUERNAME, and it's actual attribute name is "urn:ietf:id:ietf-kitten-name-attrs-00-issuername".

The display form of issuer names is mechanism-specific.

The non-display form of issuer names SHALL be the exported name token form of the issuer's name. Not all mechanisms will support issuer names as MNs, therefore implementations MAY output a null non-display value.

For example, for the Kerberos mechanism [RFC4121] an issuer name would generally (but not always!) be a Kerberos realm name, probably displayed as just the realm name. (But note that there is not yet a Kerberos realm name as MN specification. We will specify one separately.)

This attribute can be used as prefix of other attributes. When used as a prefix, this attribute indicates that the application wishes to know the name of the issuer of the prefixed attribute of the given MN.

2.1.2. Trust Validation Path

We add an attribute by which to obtain the trust validation path for a given authenticated MN. The API for this attribute is GSS_C_ATTR_GENERIC_TRUST_PATH, and its actual attribute name is urn:ietf:id:ietf-kitten-name-attrs-01-trust-path".

This attribute has zero or more ordered values. The interpretation of the trust validation path will vary somewhat by mechanism. For PKIX-based mechanisms this is the list of issuers in the trust validation path for the given MN's cert. For Kerberos this is the list of realms traversed from the MN to the local name of a security context. The MN's immediate issuer is not included. In the case of Kerberos, the issuer of the local MN is also not included. For Kerberos the trust validation path is the realm transit path of the Ticket used to establish a security context, but may also include PKIX trust validation paths (e.g., if PKINIT is used).

The display and non-display forms of trust validation path values is as for issuer names; see Section 2.1.1.

2.1.3. User Name

We add an attribute by which to obtain the component of an MN naming a user. The API name for this attribute is GSS_C_ATTR_GENERIC_USERNAME, and it's actual attribute name is "urn:ietf:id:ietf-kitten-name-attrs-00-username".

The display form of user names is mechanism-specific.

The non-display form of user names is mechanism-specific.

2.1.4. Service Name

We add an attribute by which to obtain the component of an MN naming a service as part of a host- or domain-based service name. The API name for this attribute is GSS_C_ATTR_GENERIC_SERVICENAME, and it's actual attribute name is "urn:ietf:id:ietf-kitten-name-attrs-00-servicename".

The non-display form of the service name SHALL be the UTF-8 encoding of the service name.

2.1.5. Host Name

We add an attribute by which to obtain the component of an MN naming a host as part of a host- or domain-based service name. The API name for this attribute is GSS_C_ATTR_GENERIC_HOSTNAME, and it's actual

attribute name is "urn:ietf:id:ietf-kitten-name-attrs-00-hostname".

The display form of a host name MAY be stylized and SHOULD NOT be A-labels. [RFC5890].

The non-display form of host names SHOULD be a character string as described in [RFC1123], and SHOULD NOT be U-labels [RFC5890].

2.1.6. Domain Name

We add an attribute by which to obtain the component of an MN naming a domain as part of a domain-based service name. The API name for this attribute is GSS_C_ATTR_GENERIC_DOMAINNAME, and it's actual attribute name is "urn:ietf:id:ietf-kitten-name-attrs-00-domainname".

The display form of a domain name MAY be stylized and SHOULD NOT be A-labels. [RFC5890].

The non-display form of domain names SHOULD be a character string as described in [RFC1123], and SHOULD NOT be U-labels [RFC5890].

2.2. Prefix Attributes

GSS_Get_name_attribute() using attributes described in the preceding section SHALL fail if there are any name constraints that can be applied to the issuers of those names and, in applying those constraints, it is discovered that the issuer was not permitted to issue credentials for the MN.

For example, a Kerberos realm named "FOO.EXAMPLE" might not be expected to issue credentials (tickets, keys) to host-based service names for hosts not ending in ".foo.example" or which are not "foo.example".

Several generic attribute prefixes are described below for overriding this behavior.

2.2.1. GSS_C_ATTR_GENERIC_UNCONSTRAINED

This attribute prefix, named GSS_C_ATTR_GENERIC_UNCONSTRAINED in the API, and with an actual name of "urn:ietf:id:ietf-kitten-name-attrs-00-gen-unconstrained", indicates that the application wants the value of the prefixed attribute without any name constraint checking.

2.2.2. GSS_C_ATTR_GENERIC_UNCONSTRAINED_OK

This attribute prefix, named GSS_C_ATTR_GENERIC_UNCONSTRAINED_OK in the API, and with an actual name of "urn:ietf:id:ietf-kitten-name-attrs-00-gen-unconstrained-ok", indicates that the application wants the value of the prefixed attribute regardless of any applicable naming constraints, but to indicate the name constraint status via the 'authenticated' output parameter of the GSS_Get_name_attribute() interface.

2.2.3. GSS_C_ATTR_GENERIC_FAST

This attribute prefix, named GSS_C_ATTR_GENERIC_FAST in the API, and with an actual name of "urn:ietf:id:ietf-kitten-name-attrs-00-gen-fast", indicates that the application requires that the mechanism not perform any slow operations (e.g., connecting to a directory for the purposes of name constraint validation) in obtaining the prefixed attribute of the given MN.

3. Local Name Attributes

Normally an Internet specification would not be expected to specify any local name attributes of GSS names. However, there is one common and very useful local name attribute, which we specify below. Implementations are free to use different names for this attribute or exclude it altogether -- it is a local name attribute, after all.

3.1. GSS_C_ATTR_LOCAL_LOGIN_USER

This attribute, with suggested API symbolic name GSS_C_ATTR_LOCAL_LOGIN_USER, and suggested actual name "local-login-user", requests a local user name corresponding to the given MN, if any.

Obtaining the local user name corresponding to an MN may require complex name mapping or lookup operations that are completely implementation-defined.

4. Suggested Mechanism-Specific Name Attributes (INFORMATIONAL)

[[anchor1: This section should really be split out into separate Internet-Drafts. It is here only because the author lacks the time at the moment of writing to create such separate I-Ds.]]

[[anchor2: Actually, we should probably make this section normative. It's easier than publishing a larger number of RFCs...]]

4.1. Suggested Kerberos-Specific Name Attributes

- realm (corresponding to issuer name)
- component 0 (first component of a principal name)
- component 1 (second component of a principal name)
- ..
- component 9 (tenth component of a principal name; ten is enough)
- components (ordered set of all components of a principal name)
- specific authorization data elements
- PKINIT client certificate
- session key enctype
- enctypes involved in transit path (this would only be available to initiators)

4.1.1. Kerberos Transit Path Constraint Semantics

For initiator MNs obtained by acceptors from established security contexts, the trust path SHALL be the uncompressed domain- and X.500-style realm names from the initiator's Ticket's 'transited' field, plus the issuer names from the AD-INITIAL-VERIFIED-CAS authorization-data element (if it's in an AD-KDC-ISSUED or similar) if PKINIT [RFC4556] was used.

For acceptor MNs obtained by initiators from established security contexts, the trust path SHALL be the realms traversed -including realms issuing referrals- to obtain a service ticket for the target acceptor.

For MNs for the local end of a security context, the trust path SHALL be empty. This means that GSS_Get_name_attribute() will return empty

value sets; for the C bindings the gss_get_name_attribute() function will return zero in the 'more' output parameter and empty values.

For initiator MNs as seen by acceptors, if the initiator's Ticket has the TRANSIT-POLICY-CHECKED flag set, and if local transit path policy is missing, then the GSS_C_ATTR_GENERIC_TRUST_PATH attribute will be considered authenticated -- the trust path will be considered to meet constraints.

Otherwise, if the acceptor has local transit path policy then the GSS_C_ATTR_GENERIC_TRUST_PATH attribute will be considered authenticated -- the trust path will be considered to meet constraints.

In all other cases the GSS_C_ATTR_GENERIC_TRUST_PATH attribute will be considered not authenticated.

4.2. Suggested PKU2U-Specific Name Attributes

[[anchor3: Add reference to PKU2U.]]

- issuer CA name
- certificate trust validation path to a trust anchor
- certificate
- certificate subject public key
- certificate subject public key algorithm
- certificate subject name
- certificate subject alternate names
- specific certificate extensions
- certificate algorithm names
- session key enctype

5. Generic Issuer Name Type

We add a GSS name-type for use in representing issuer names, designated symbolically as GSS_C_NT_ISSUER. Its query syntax is unspecified and mechanism-specific.

At least initially the common use of this name-type will be for representation of issuer names using the GSS_C_ATTR_GENERIC_ISSUERNAME GSS name attribute (see Section 2.1.1).

5.1. Kerberos Realm Name Type

No name-type is needed in the Kerberos protocol for realm names. Because all three forms of Kerberos realm-names (DOMAIN, X.500, and OTHER) and unambiguously distinguishable from each other, we also do not add a Kerberos-specific GSS name-type.

The query and display syntax of GSS_C_NT_ISSUER names for Kerberos is just a realm name prefixed with an '@'. We prefix the realm name with '@' to take advantage of an otherwise useless ambiguity in the query and display form of Kerberos mechanism principal names [RFC1964], namely that zero-component, and one-zero-length component principal names display identically, therefore those are useless name forms in Kerberos (they would be useless anyways); we appropriate this otherwise useless name form as the query and display syntax of Kerberos realm names. For example, "@FOO.EXAMPLE".

In the unlikely event that a name of GSS_C_NT_ISSUER type is used as a GSS initiator or acceptor principal, the actual Kerberos principal name should be an appropriate TGS principal name. More specific information for such use-cases will be provided by any future application protocol specifications that use them.

5.2. PKIX Issuer Name Type

[[anchor4: A name type for PKIX issuers is needed, even when dealing with Kerberos, since X.500-style realm names may be involved, as well as real PKIX CA names from PKINIT/PKCROSS. We'll need a mechanism OID for a generic PKIX mechanism (even if it isn't specified!) for the exported name tokens! One that Kerberos, PKU2U and other PKIX mechanisms can share.]]

6. Security Considerations

[Add text regarding name constraint checking and explaining the default-to-safe design of the generic name attributes defined in section 2.]

7. IANA Considerations

[Add text regarding the registration and assignment of the name attributes described in the preceding sections. In particular we should want these attributes' names to not reflect an Internet-Draft name, but an RFC number.]

8. References

8.1. Normative References

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, March 1997.

[RFC1035] Mockapetris, P., "Domain names - implementation and specification", STD 13, RFC 1035, November 1987.

[RFC1123] Braden, R., "Requirements for Internet Hosts - Application and Support", STD 3, RFC 1123, October 1989.

[RFC1964] Linn, J., "The Kerberos Version 5 GSS-API Mechanism", RFC 1964, June 1996.

[RFC2743] Linn, J., "Generic Security Service Application Program Interface Version 2, Update 1", RFC 2743, January 2000.

[RFC4556] Zhu, L. and B. Tung, "Public Key Cryptography for Initial Authentication in Kerberos (PKINIT)", RFC 4556, June 2006.

[RFC5890] Klensin, J., "Internationalized Domain Names for Applications (IDNA): Definitions and Document Framework", RFC 5890, August 2010.

[RFC6680] Williams, N., Johansson, L., Hartman, S., and S. Josefsson, "Generic Security Service Application Programming Interface (GSS-API) Naming Extensions", RFC 6680, August 2012.

8.2. Informative References

[RFC4120] Neuman, C., Yu, T., Hartman, S., and K. Raeburn, "The Kerberos Network Authentication Service (V5)", RFC 4120, July 2005.

[RFC4121] Zhu, L., Jaganathan, K., and S. Hartman, "The Kerberos Version 5 Generic Security Service Application Program Interface (GSS-API) Mechanism: Version 2", RFC 4121, July 2005.

[RFC5280] Cooper, D., Santesson, S., Farrell, S., Boeyen, S., Housley, R., and W. Polk, "Internet X.509 Public Key Infrastructure Certificate and Certificate Revocation List (CRL) Profile", RFC 5280, May 2008.

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Negotiation of Extra Security Context Tokens for Kerberos V5 Generic Security Services Mechanism
draft-williams-kitten-krb5-extra-rt-04

Abstract

This Internet-Draft proposes an extension to the Kerberos V5 security mechanism for the Generic Security Services Application Programming Interface (GSS-API) for using extra security context tokens in order to recover from certain errors. Other benefits include: user-to-user authentication, authenticated errors, replay cache avoidance, and others.

Status of this Memo

This Internet-Draft is submitted in full conformance with the provisions of BCP 78 and BCP 79.

Internet-Drafts are working documents of the Internet Engineering Task Force (IETF). Note that other groups may also distribute working documents as Internet-Drafts. The list of current Internet-Drafts is at http://datatracker.ietf.org/drafts/current/.

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This Internet-Draft will expire on May 25, 2015.

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1. Introduction

The Kerberos V5 [RFC4120] AP protocol, and therefore the Kerberos V5 GSS-API [RFC2743] mechanism [RFC4121] security context token exchange, is a one-round trip protocol. Occasionally there are errors that the protocol could recover from by using an additional round trip, but until now there was no way to execute such an additional round trip. For many application protocols the failure of the Kerberos AP protocol is fatal, requiring closing TCP connections and starting over; often there is no automatic recovery.

This document proposes a negotiation of additional security context tokens for automatic recovery from certain errors. This is done in a backwards-compatible way, thus retaining the existing mechanism OID for the Kerberos V5 GSS mechanism. This also enables other new features.

New features enabled by this extension include:

- error recovery (see Section 5)
- user-to-user authentication (see Section 7)
- some authenticated errors (see Section 5.1)
- replay cache avoidance (see Section 6)
- acceptor clock skew correction (see Section 8)
- symmetric authorization data flows

No new interfaces are needed for GSS-API applications to use the features added in this document.

1.1. Conventions used in this document

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [RFC2119].

2. New Protocol Elements

We introduce the following new protocol elements. A partial ASN.1 [CCITT.X680.2002] module (for inclusion in the base Kerberos ASN.1 module) is given in Section 4, and references to its contents are made below.

- a new ap-options flag for use in the clear-text part of AP-REQs to indicate the desire for an extra round trip if need be;
- a new authorization data (AD) element for integrity protection of ap-options;
- a new AD element for use in Authenticators for quoting back a challenge from the acceptor;
- a new PDU: KRB-ERROR2, also known as AP-REP2, with additional fields and support for integrity- (and confidentiality-)protected errors and optional _key confirmation_ :
  - a flag is used to indicate which key is used to encrypt the KRB-ERROR2's private part, as in some cases there can be two keys to choose from;
  - when no key available for encrypting the private part of a KRB-ERROR2, the null enctype is used.

These elements are used to construct security context token exchanges with potentially more than two context tokens.

All context tokens are to be prefixed with the InitialContextToken pseudo-ASN.1/DER header from RFC2743, section 3.1, just as RFCs 1964 and 4121 require of the first two context tokens.

2.1. Fields of KRB-ERROR2

The new KRB-ERROR2 PDU is defined in Section 4. The fields of the KRB-ERROR2 encrypted part have the following purpose/semantics:

continue-challenge A challenge to be quoted back in any subsequent context tokens.

stime The acceptor's current time.

susec Microsecond portion of the acceptor's current time.

subkey The acceptor's sub-session key. This MUST be absent when the KRB-ERROR2 enc-part is "encrypted" in the null enctype and key or when the acceptor failed to decrypt the initiator's Authenticator (but, obviously, succeeded at decrypting the Ticket); otherwise it MUST be present.

seq-number The acceptor's initial per-message token sequence number. This MUST be absent when the subkey is absent; otherwise it MUST be present.

error-code When zero-valued, the KRB-ERROR2 is not an error token, but a key-confirmation that requires continuation with an additional AP-REQ.

e-flags Indicates whether the KRB-ERROR2 is final (error token) or not.

e-text A human-readable string (in any language and script) description of the error, if any.

e-data Currently unused but specified for extensibility reasons. SHOULD be absent and MUST be ignored.

e-typed-data TYPED-DATA; see [RFC4120]. Currently unused but specified for extensibility reasons. SHOULD be absent and MUST be ignored.

your-addresses The initiator's network address(es) as seen on the acceptor side. Currently unused due to insufficient GSS-API interfaces, but specified for extensibility reasons. SHOULD be absent, MUST be ignored.

ad-data Authorization-data. This is intended for symmetry, so that acceptors can assert authorization data to the initiator just as the initiator can assert authorization data to the acceptor. (For example, this might be useful in user-to-user authentication.) When present this has the same semantics as in the AP-REQ's Authenticator, but in the opposite direction.

tgt A TGT for use in user-to-user authentication.

2.2. Distinction between KRB-ERROR2 and AP-REP2 PDUs

The ASN.1 does not distinguish between KRB-ERROR2 and AP-REP2 PDUs. A KRB-ERROR2 can serve either or both, the purpose of conveying error information, as well as the purpose of completing the acceptor's side of the context token exchange and providing key confirmation. We could have used three distinct PDUs instead of one.

It is true that a KRB-ERROR2 that only serves the purpose of final key confirmation without continuation could have a different ASN.1 type for its encrypted part, and a different application tag, however, there seems to be little value in this. Distinguishing between errors with and without key confirmation is even less valuable. Therefore we do not distinguish these three possible PDUs.

3. Negotiation and Use of Extra Context Tokens

In the following text "initiator" refers to the mechanism's initiator functionality (invoked via GSS_Init_sec_context()), and "acceptor" refers to the mechanism's acceptor functionality (invoked via GSS_Accept_sec_context()).

To use this feature, the Kerberos GSS mechanism MUST act as follows:

- To request this feature, initiators SHALL add the new ap-options flag to their AP-REQs.
  - And the initiators SHALL repeat the ap-options in the new AD-AP-OPTIONS AD type in the Authenticator.
- Acceptors that wish to request an additional security context token can only do so when initiators indicate support for it, and MUST do so by returning a KRB-ERROR2. The encrypted part of the KRB-ERROR2 SHALL be encrypted in a key derived (with key usage <TBD>) from one of the following keys: the sub-session key from the AP-REQ's Authenticator (use-initiator-subkey) if it could be decrypted, else the session key from the Ticket (use-ticket-session-key), if it could be decrypted, else the null enc-type/key (use-null-enctype).
- Any KRB-ERROR2 emitted by the acceptor SHALL have the continue-needed e-flag set when the GSS_Accept_sec_context() returns GSS_S_CONTINUE_NEEDED to the application, and in this case the token ID SHALL be 02 00 (KRB_AP_REP, even though the token isn't actually an AP-REP) (see [RFC4121] section 4.1).
- When it consumes a KRB-ERROR2, GSS_Init_sec_context() can return an error (GSS_S_FAILURE) and optionally output an error token, or it can attempt recovery (see Section 5) and output a new AP-REQ security context token.
  - Any error token output by GSS_Init_sec_context() MUST be a KRB-ERROR2, and GSS_Init_sec_context() MUST return GSS_S_FAILURE.
  - The initiator MUST quote the challenge from the KRB-ERROR2 using an AD-CONTINUE-CHALLENGE (see below) authorization data element in any AP-REQ or KRB-ERROR2 response to the acceptor's KRB-ERROR2.
  - When GSS_Init_sec_context() outputs a new AP-REQ security context token, it SHALL return GSS_S_CONTINUE_NEEDED if the application requested mutual authentication and the previous acceptor security context token was a recoverable error (rather

than a request for one more AP-REQ), else it SHALL return GSS_S_COMPLETE.

* When GSS_Init_sec_context() returns an error and the acceptor is awaiting a security context token, GSS_Init_sec_context() MAY generate a KRB-ERROR2 or KRB-ERROR to send to the acceptor.

- Acceptors MUST reject additional AP-REQs which do not have a challenge response nonce matching the one sent by the acceptor in the previous KRB-ERROR2.

- Acceptors MUST reject initial security context tokens that contain a challenge response nonce.

- When GSS_Accept_sec_context() returns an error and outputs an error token, the token MUST be either a KRB-ERROR or a KRB-ERROR2, with the latter having the continue-needed flag cleared.

All non-recoverable KRB-ERROR2 tokens SHALL use the token ID 03 00.

Additional AP-REQs produced by the authenticator MUST have the mutual-required ap-options flag set when a) the application requested mutual authentication, and b) the acceptor's KRB-ERROR2 did not supply the required key confirmation. The acceptor MUST respond to the client's last AP-REQ with an AP-REP when the mutual-required ap-options flag is set or when the GSS_C_MUTUAL_FLAG is set in the "checksum 0x8003", otherwise GSS_Accept_sec_context() MUST NOT produce a response token when it returns GSS_S_COMPLETE.

3.1. Number of Security Context Tokens

The first AP-REQ may well result in an error; the second generally should not. Therefore acceptors SHOULD return a fatal error when a second error results in one security context establishment attempt, except when the first error is that the initiator should use user-to-user authentication. This limits the maximum number of round trips to two (not user-to-user) or three (user-to-user).

The mechanism SHOULD impose some limit on the maximum number of security context tokens. For the time being that limit is six.

Note that in the user-to-user cases (see Section 7) it's possible to have up to three round trips under normal conditions if, for example, the acceptor wishes to avoid the use of replay caches (see Section 6), or if the initiator's clock is too skewed, for example.

3.2. Possible Context Token Sequences

The following successful security context token exchange sequences are possible:

- One token (per-RFC4121; mutual authentication not requested): AP-REQ.
  - In principle this can yield an error token in the case of errors, per-RFC2743.
- Two tokens (per-RFC4121; mutual authentication requested): AP-REQ and AP-REP.
- Two tokens (per-RFC4121; mutual authentication requested): AP-REQ and KRB-ERROR.
- Two tokens (per-RFC4121; mutual authentication requested): AP-REQ and KRB-ERROR2 (non-recoverable error, or recoverable error but the acceptor mechanism is configured to not continue).
- Two tokens (per-RFC4121; mutual authentication requested): AP-REQ and KRB-ERROR2 (recoverable error for the acceptor, but not for the initiator, or the initiator application abandons the partially-established security context).
- Three tokens: AP-REQ, KRB-ERROR2 (recoverable error), AP-REQ.
  - The initiator indicates it supports multiple round trips, and a recoverable error results on the acceptor side.
  - Either the initiator did not request mutual authentication, or the KRB-ERROR2 supplied the necessary key confirmation.
- Three tokens: AP-REQ, KRB-ERROR2 (no error, continue needed), AP-REQ.
  - The initiator indicates it supports multiple round trips, and its Authenticator and Ticket decrypt correctly on the acceptor side, but the acceptor wants to continue, e.g., to avoid the need for a replay cache (see Section 6).
  - This can happen in any recoverable error case where the initiator’s Authenticator (and Ticket) decrypt successfully on the acceptor side.

- Four tokens: AP-REQ, KRB-ERROR2 (recoverable error), AP-REQ, AP-REP.
  - The initiator wanted mutual authentication and a recoverable error occurred where the KRB-ERROR2 could not provide key confirmation, leading to the second round trip.
  - This can happen in any recoverable error case where the initiator's Authenticator did not decrypt successfully.
  - This can also happen in the user-to-user case.
  - This case provides replay cache avoidance without a fifth token because the acceptor provides a challenge in its first (KRB-ERROR2) token and the initiator completes the challenges in its second token.
- Five tokens: AP-REQ, KRB-ERROR2 (with user-to-user TGT), AP-REQ, KRB-ERROR2 (recoverable error), AP-REQ.
  - The initiator does not want mutual authentication, the acceptor wants user-to-user authentication, and the initiator's second AP-REQ elicits a recoverable error.
- Six tokens: AP-REQ, KRB-ERROR2 (with user-to-user TGT), AP-REQ, KRB-ERROR2 (recoverable error), AP-REQ, AP-REP.
  - The initiator wants mutual authentication, the acceptor wants user-to-user authentication, and the initiator's second AP-REQ elicits a recoverable error; none of the KRB-ERROR2 tokens was a key-confirmation token.

Other context token sequences might be possible in the future.

In the above sequences the AP-REP tokens can be AP-REP2 tokens as well.

3.3. Per-Message Token Sequence Numbers

It is REQUIRED that each real AP-REQ in a single security token exchange specify the same start sequence number as preceding AP-REQs in the same security context token exchange.

3.4. Early PROT_READY State

The GSS-API allows security mechanisms to support the use of per-message tokens prior to full security context establishment. In this section we'll call this "early PROT_READY". Early PROT_READY is

optional for the GSS-API and for implementations of mechanisms that support it.

The Kerberos V GSS mechanism supports this in the two-token exchange, with the initiator being PROT_READY before consuming the AP-REP. This extension also supports early PROT_READY, which works as follows:

1. The initiator asserts a sub-session key in each AP-REQ that does not follow a key-confirmation KRB-ERROR2, and GSS_Init_sec_context() sets the prot_ready_state return flag on the first call.

    1. If there are multiple such AP-REQs in a security context token exchange, then each such AP-REQ must assert the same sub-session key.

    2. Subsequent AP-REQs need not carry a sub-session key; acceptors MUST ignore sub-session keys from subsequent AP-REQs.

2. GSS_Accept_sec_context() MUST NOT set the prot_ready_state return flag until it has successfully decrypted an AP-REQ's Ticket and Authenticator from the initiator. If the acceptor requests additional context tokens and signals PROT_READY at that point, then it too will be PROT_READY.

Replay protection for early prot_ready per-message tokens depends on the initiator always generating a fresh sub-session key for every security context's initial context token, on the acceptor always generating a fresh sub-session key for its key confirmation token, and on either a replay cache or the challenge/response token provided for in this document:

- An attacker cannot replay an early per-message token without also replaying the corresponding initial security context token (as otherwise the initiator-asserted sub-session keys won't match), and replay protection for the initial security context token provides replay protection for any subsequent early per-message tokens.

- Per-message tokens made after full security context establishment are protected against replay by the use of the acceptor's sub-session key hierarchy (since the initiator must then use that key).

- AP-REPs and key-confirmation KRB-ERROR2s are protected against replays to initiators by the use of the initiator's sub-session

key.

- o Initial security context tokens (and error-recovery AP-REQs) are protected against replay either by a replay cache on the acceptor side, or by the use of additional context tokens for challenge/response replay cache avoidance (see Section 6).

3.5. Other Requirements, Recommendations, and Non-Requirements

All error PDUs in an AP exchange where the AP-REQ has the continue-needed-ok ap-options flag MUST be KRB-ERROR2 PDUs.

Whenever an acceptor is able to decrypt the Ticket from an AP-REQ and yet wishes or has to output a KRB-ERROR2, then the enc-part of the KRB-ERROR2 MUST be encrypted in either the initiator's sub-session key (from the Authenticator) or the Ticket's session key (if the acceptor could not decrypt the Authenticator).

4. ASN.1 Module for New Protocol Elements

A partial ASN.1 module appears below. This ASN.1 is to be used as if it were part of the base Kerberos ASN.1 module (see RFC4120), therefore the encoding rules to be used are the Distinguished Encoding Rules (DER) [CCITT.X690.2002], and the environment is one of explicit tagging.

```
KerberosExtraContextTokens DEFINITIONS ::=
BEGIN
EXPORTS ad-continue-challenge,
        AD-CONTINUE-CHALLENGE,
        KrbErrorEncPartFlags,
        KRB-ERROR2,
        ErrorFlags;
IMPORTS UInt32, Int32, KerberosTime,
        Microseconds, KerberosFlags,
        Checksum, EncryptedData,
        EncryptionKey, KerberosString,
        AuthorizationData, TYPED-DATA,
        HostAddresses, Ticket FROM KERBEROS5;

APOptions       ::= KerberosFlags
        -- reserved(0),
        -- use-session-key(1),
        -- mutual-required(2),
        -- continue-needed-ok(TBD)

-- Challenge (for use in Authenticator)
ad-continue-challenge     Int32 ::= -5 -- <TBD>
AD-CONTINUE-CHALLENGE ::= OCTET STRING

-- AP options, integrity-protected
ad-ap-options             Int32 ::= -6 -- <TBD>
AD-AP-OPTIONS         ::= KerberosFlags

KrbErrorEncPartFlags ::= ENUMERATED {
        use-null-enctype(0),
        use-initiator-subkey(1),
        use-ticket-session-key(2),
        ...
}

-- Application tag TBD
KRB-ERROR2          ::= [APPLICATION 55] SEQUENCE {
        pvno            [0] INTEGER (5),
        msg-type        [1] INTEGER (55), -- TBD
        enc-part-key    [2] KrbErrorEncPartFlags,
```

```
        enc-part        [3] EncryptedData -- EncKRBErrorPart
    }

    -- Alias type name
    AP-REP2             ::= KRB-ERROR2

    ErrorFlags ::= ENUMERATED {
            final(0),
            continue-needed(1),
            ...
    }

    -- Application tag TBD
    EncKRBErrorPart    ::= [APPLICATION 56] SEQUENCE {
            continue-challenge  [0]  AD-CHALLENGE-RESPONSE,
            stime               [1]  KerberosTime,
            susec               [2]  Microseconds,
            subkey              [3]  EncryptionKey OPTIONAL,
            seq-number          [4]  UInt32 OPTIONAL,
            error-code          [5]  Int32,
            e-flags             [6]  ErrorFlags,
            e-text              [7]  UTF8String OPTIONAL,
            e-data              [8]  OCTET STRING OPTIONAL,
            e-typed-data        [9]  TYPED-DATA OPTIONAL,
            -- For recovery from KRB_AP_ERR_BADADDR:
            your-addresses      [10] HostAddresses OPTIONAL,
            ad-data             [11] AuthorizationData OPTIONAL,
            tgt                 [12] Ticket OPTIONAL, -- for user2user
            ...
    }

    END
```

Figure 1: ASN.1 module (with explicit tagging)

5. Recoverable Errors and Error Recovery

The following Kerberos errors can be recovered from automatically using this protocol:

- KRB_AP_ERR_TKT_EXPIRED: the initiator should get a new service ticket;
- KRB_AP_ERR_TKT_NYV: the initiator should get a new service ticket;
- KRB_AP_ERR_REPEAT: the initiator should build a new AP-REQ;
- KRB_AP_ERR_SKEW: see Section 8;
- KRB_AP_ERR_BADKEYVER: the initiator should get a new service ticket;
- KRB_AP_PATH_NOT_ACCEPTED: the initiator should get a new service ticket using a different transit path;
- KRB_AP_ERR_INAPP_CKSUM: the initiator should try again with a different checksum type.

Error codes that denote PDU corruption (and/or an active attack) can also be recovered from by attempting a new AP-REQ, though subsequent AP-REQs may fail for the same reason:

- KRB_AP_ERR_BAD_INTEGRITY
- KRB_AP_ERR_BADVERSION
- KRB_AP_ERR_BADMATCH
- KRB_AP_ERR_MSG_TYPE
- KRB_AP_ERR_MODIFIED

Other error codes that may be recovered from:

- KRB_AP_ERR_BADADDR: the acceptor SHOULD include a list of one or more client network addresses as reported by the operating system, but if the acceptor does not then the continue-needed e-flag MUST NOT be included and the error must be final.

5.1. Authenticated Errors

The following errors, at least, can be authenticated in AP exchanges:

- KRB_AP_ERR_TKT_EXPIRED
- KRB_AP_ERR_TKT_NYV
- KRB_AP_ERR_REPEAT
- KRB_AP_ERR_SKEW
- KRB_AP_PATH_NOT_ACCEPTED
- KRB_AP_ERR_INAPP_CKSUM
- KRB_AP_ERR_BADADDR

6. Replay Cache Avoidance

By using an additional AP-REQ and a challenge/response nonce, this protocol is immune to replays of AP-REQ PDUs and does not need a replay cache. Acceptor implementations MUST not insert Authenticators from extra round trips into a replay cache when there are no other old implementations on the same host (and with access to the same acceptor credentials) that ignore critical authorization data or which don't know to reject initial AP-REQs that contain a challenge response nonce.

In the replay cache avoidance case where there's no actual error (e.g., time skew) the acceptor's KRB-ERROR2 will have KDC_ERR_NONE as the error code, with the continue-needed e-flag.

6.1. Replay Cache Avoidance without Extensions

Many Kerberos services can avoid the use of a replay cache altogether, but it's tricky to know when it's safe to do so. For Kerberos it's safe to not use a replay cache for AP-REQs/ Authenticators when either:

- the application doesn't require replay detection at all and
  - no other acceptor/service application shares the same long-term service keys for its service principal

or

- the application protocol always has the initiator/client send the first per-message token (or KRB-SAFE/PRIV PDU) which can then function as a challenge response, and
  - no other acceptor/service application shares the same long-term service keys for its service principal

It is difficult to establish the second part of the above conjunctions programmatically. In practice this is best left as a local configuration matted on a per-service name basis.

For example, it's generally safe for NFSv4 [RFC3530] to not use a replay cache for the Kerberos GSS mechanism, but it is possible for multiple Kerberos host-based service principals on the same host to share the same keys, therefore in practice, the analysis for NFSv4 requires more analysis. The same is true for SSHv2 [RFC4251] (SSHv2 implementations share the same service principal as other non-GSS Kerberos applications that do sometimes need a replay cache).

7. User-to-User Authentication

There are two user2user authentication cases:

1. the KDC only allows a service principal to use user2user authentication,

2. the service principal does not know its long-term keys or otherwise wants to use user2user authentication even though the KDC vended a service ticket.

In the first case the initiator knows this because the KDC returns KDC_ERR_MUST_USE_USER2USER. The initiator cannot make a valid AP-REQ in this case, yet it must send some sort of initial security context token! For this case we propose that the initiator make an AP-REQ with a Ticket with zero-length enc-part (and null enctype) and a zero-length authenticator (and null enctype). The acceptor will fail to process the AP-REQ, of course, and SHOULD respond with a continue-needed KRB-ERROR2 (using the null enc-type for the enc-part) that includes a TGT for the acceptor.

In the second case the initiator does manage to get a real service ticket for the acceptor but the acceptor nonetheless wishes to use user2user authentication.

In both cases the acceptor responds with a KRB-ERROR2 with the KRB_AP_ERR_USER_TO_USER_REQUIRED error code and including a TGT for itself.

In both cases the initiator then does a TGS request with a second ticket to get a new, user2user Ticket. Then the initiator makes a new AP-REQ using the new Ticket, and proceeds.

8. Acceptor Clock Skew Correction

An initiator in possession of a (short-lived) valid service ticket for a given service principal... must have had little clock skew relative to the service principal's realm's KDC(s), or the initiator must have been able to correct its local clock skew. But the acceptor's clock might be skewed, yielding a KRB_AP_ERR_SKEW error with a challenge. The client could recover from this by requesting a new service ticket with this challenge as an authorization data element. The acceptor should be able to verify this in the subsequent AP-REQ, and then it should be able to detect that its clock is skewed and to estimate by how much.

9. Security Considerations

This document deals with security.

The new KRB-ERROR2 PDU is cryptographically distinguished from the original mechanism's acceptor success security context token (AP-REQ).

Not every KRB-ERROR2 can be integrity protected. This is unavoidable.

Because in the base Kerberos V5 GSS-API security mechanism all errors are unauthenticated, and because even with this specification some elements are unauthenticated, it is possible for an attacker to cause one peer to think that the security context token exchange has failed while the other thinks it will continue. This can cause an acceptor to waste resources while waiting for additional security context tokens from the initiator. This is not really a new problem, however: acceptor applications should already have suitable timeouts on security context establishment.

There is a binding of preceding security context tokens in each additional AP-REQ, via the challenge-response nonce. This binding is weak, and does not detect all modifications of unauthenticated plaintext in preceding security context tokens.

[[anchor1: We could use the GSS_EXTS_FINISHED extension from draft-ietf-kitten-iakerb to implement a strong binding of all context tokens.]]

Early prot_ready per-message tokens have security considerations that are beyond the scope of this document and which are not exhaustively described elsewhere yet. Use only with care.

10. IANA Considerations

[[anchor2: Various allocations are required...]]

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11.1. Normative References

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Public Key-Based Kerberos Cross Realm Path Traversal Protocol Using Kerberized Certification Authorities (kx509) and PKINIT
draft-williams-kitten-krb5-pkcross-05

Abstract

This document specifies a protocol for obtaining cross-realm Kerberos tickets using existing, related protocols: kerberized certification authorities (kx509) and public key cryptography initial authentication in Kerberos (PKINIT). The resulting protocol has a number of desirable properties, primarily that it allows Kerberos to scale to large numbers of realms.

Status of this Memo

This Internet-Draft is submitted in full conformance with the provisions of BCP 78 and BCP 79.

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Table of Contents

1. Introduction

Kerberos [RFC4120] supports meshes of many realms. The individual relationships between realms must be manually keyed, usually with keys derived from passwords. A full mesh wouldn't scale, therefore the protocol calls for hierarchical trust universes. In practice non-hierarchical but also non-fully-meshed relationships are used, and these generally require distribution of trust routing information to clients, services, and KDCs. With referrals it is possible to reduce the need for client-side trust routing information, but KDCs still need it, as do services (unless they accept KDC trust path policy and the KDC applies it via the TRANSITED-POLICY-CHECKED ticket flag).

These manually-exchanged keys are very difficult to rollover safely, and when they are changed the result is often outages -- controlled outages where foreseen, but outages nonetheless.

Manual cross-realm keying does not scale, and has very poor security properties. We seek to remediate this using public key cryptography, building on existing Kerberos specifications.

Distribution of trust routing (traditionally known as "capaths") and trust path validation (also "capaths") information is difficult; there is no standard protocol for it. Maintenance of it is a thoroughly manual process.

Many years ago there was a proposal for exchanging cross-realm keys using a public key infrastructure (PKI) [RFC5280]; that proposal went by the name "PKCROSS". We appropriate that long-dead proposal's name, but the protocol specified here is very different from the original proposal.

PKCROSS can make Kerberos scale to large numbers of realms, will remove the need for manual keying of cross-realm TGS principals, will further reduce the need for maintenance and distribution of trust routing information, and will tend to reduce the complexity of trust path validation.

1.1. Conventions used in this document

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [RFC2119].

2. The PKCROSS Protocol

We provide two variants of the PKCROSS protocol: one that is client-driven, and another that is driven by a Ticket Granting Service (TGS) on behalf of its clients. The latter is based on the former, with the TGS acting as a client. We begin with the client-driven case. DNS-Based Authentication of Named Entities (DANE) [RFC6698] can and should be used for realm CA certificate validation.

2.1. Client-Driven PKCROSS

A Kerberos client in with a ticket-granting ticket (TGT) for any one source realm (usually but not necessarily the client's own realm) wishing to acquire a TGT for a destination realm may use this protocol instead of the traditional cross-realm ticket-granting service (TGS) exchanges as follows:

1. Generate private key to a public key cryptosystem;

2. Request a certificate from the kx509 [RFC6717] service run by the source realm;

3. Request a TGT from the destination realm using PKINIT [RFC4556] and the client certificate obtained in step #2.

If the destination realm issues the requested Ticket then it SHOULD include the client's certificate in an AD-CLIENT-CERTIFICATE authorization-data element, and it MUST do so if it does not validate the client's certificate to an acceptable trust anchor. The AD-CLIENT-CERTIFICATE authorization-data MUST be in a KDC-signed authorization-data container [XXX add reference to CAMMAC].

[[anchor1: QUESTION: Should the PKINIT request in step #3 be a TGS-REQ with PKINIT pre-auth data?]]

[[anchor2: QUESTION: Should the PKINIT request in step #3 be required to be used within a FAST tunnel?]]

2.2. TGS-Driven PKCROSS

A TGS can bootstrap ephemeral cross-realm trust principals on behalf of its clients. This allows the cost of PKCROSS to be amortized over many clients, and it allows participation by clients that do not support client-driven PKCROSS (or whose PKCROSS requests are rejected by the target).

In this mode the TGS uses the client-driven PKCROSS protocol, modified as follows:

- the TGS's client certificate MUST have an id-pkinit-san Subject Alternative Name (SAN) identifying the source TGS as krbtgt/SOURCE@SOURCE

- the TGS's client certificate MUST have an Extended Key Usage (EKU) of id-pkcross-issuer (TBD)

The resulting TGT -which we shall term an "issuer TGT" (ITGT)- and its session key can then be used by the source TGS to create cross-realm TGTs for the source-to-target trust principal ("krbtgt/TARGET@SOURCE").

This ITGT will be used to mint tickets as described below.

2.2.1. Issuing cross-realm TGTs issued for PKCROSS-keyed cross-realm TGS principals

Cross-realm TGTs issued by a source TGS using an ITGT will not be quite like normal Kerberos Tickets: their encrypted part contains an AP-REQ using the ITGT acquired by the source TGS, and this AP-REQ is "encrypted" with the null enctype, The AP-REQ's Authenitcator MUST contain an authorization-data element that carries a) the name of the client principal, b) the session key that the client should be using with the cross-realm TGTs issued.

```
 AD-PKCROSS-TGT-INFO ::= SEQUENCE {
     cname [0] Principal,    -- the client's realm is the
                             -- crealm from the ITGT's EncTicketPart
     key   [1] EncryptionKey
 }
```

Figure 1: AD-PKCROSS-TGT-INFO

2.2.2. Handling impatient clients

Because the process of acquiring an ITGT might be slow, a TGS doing so on behalf of a client could use a mechanism for instructing the client to be patient. Existing clients would not handler a new error code by waiting, therefore there is not much that can be done to keep an impatient client from retrying at another KDC.

The existing KDC_ERR_SVC_UNAVAILABLE error code cannot be used as often this causes the client to immediately retry the request at another KDC. A new error code for indicating estimated time to completion of request would be handy, but out of scope for this document.

Note that there is a denial of service (DoS) attack by clients on

willing source KDCs: the clients can ask the KDCs to acquire cross-realm ITGTs for many target realms. Ideally the quality of service for the Kerberos authentication service (AS) with PKINIT (and/or other slow pre-authentication mechanisms) should be separate from that of the Kerberos TGS co-located with it, and the PKCROSS-capable TGS as well, so as to be able to throttle low-priority requests when under load.

2.3. Stapled DANE

[[anchor3: TBD. We should use Google's serialization of DNS RRsets needed for DANE validation. We will need a label for the TLSA RRs for kx509 issuers.]]

2.4. Validation

KDCs processing PKINIT requests crossing realms MUST apply either or both of:

- PKIX certificate validation
- DANE certificate validation

KDCs MUST reject PKINIT requests from clients of foreign realms whose certificates cannot be validated, unless the client request the anonymous principal name in the target's realm.

2.5. Transit Path

The combined Kerberos/PKIX/DNSSEC transit path MUST be represented in any tickets issued using PKCROSS (see below). As usual, each realm's KDCs in the mix can set the transit policy checked flag if a client's transit path is acceptable per the realm's KDCs' local policy.

Two validation mechanisms are available: all PKIX [RFC5280] validation methods, and DANE [RFC6698]. DANE validation records SHOULD be stapled onto the client certificates by the issuing kx509 CA; alternatively, clients can staple <http://src.chromium.org/viewvc/chrome/trunk/src/net/base/dnssec_chain_verifier.cc?pathrev=167227> onto their PKINIT requests using an authorization-data element, AD-PKINIT-CLIENT-DANE.

Additionally, when PKIX certificate validation is used, the trust path should be encoded in an AD-INITIAL-VERIFIED-CAS authorization data element, per-PKINIT.

2.5.1. Transit path representation

The notional transit path for a ticket issued by a target realm's KDCs includes:

- the source realm (never expressed in the 'transited' field of Kerberos Tickets)
- all realms in the ITGT's transited field (in the TGS-driven PKCROSS case)
- all issuers in the validation path for the kx509-issued certificate, which are
  - all issuers in the certificate's PKIX validation path when PKIX validation is used
  - all DNS zone domainnames transited from the source realm's domainname to the root zone
- the target realm (also never expressed in the 'transited' field)

When using DANE for validation of the issuer's certificate the target SHOULD represent the transit path as hierarchical from the source realm's domain to the root domain, then direct from there to the target's realm.

The notional transit path for a given client principal MUST be encoded as usual, using the Kerberos X.500 and domain-style representations of PKIX issuer names and DNS domainnames as faithfully to the original as possible.

[[anchor4: QUESTION: Do we need a 100% faithful representation of the transit path?]]

2.6. Exchange of Long-Term Cross-Realm Symmetric Keys

A KDC can acquire a TGT using PKCROSS whose session key then becomes the long-lived, persistent symmetric key for a cross-realm principal from the source realm to the target realm ("krbtgt/TARGET@SOURCE").

To do this the KDC MUST set the USE-SESSION-KEY-AS-REALM-KEY KDCOptions flag (TBD) in its request for an ITGT from the target realm. As usual, the target realm's KDC MUST validate the client principal's certificate. The target realm's KDC MUST NOT return a TGS-REP until the new principal is committed to its principal database, and MUST set the endtime of the ITGT to the time at which the source realm may begin using the new symmetrically-keyed

principal.

The source realm’s KDC MUST commit the new principal to its principal database and MUST NOT begin using the new principal’s long-term keys until the new principal is available to all KDCs for the source realm and the endtime of the ITGT passes.

Target KDCs SHOULD require manual pre-approval of such new cross-realm principals. In small, isolated environments a KDC MAY be configured to pre-approve all such new principals.

By default, source KDCs SHOULD NOT automatically request long-term keying of cross-realm principals.

3. Security Properties

The proposed PKCROSS protocol has several useful properties described below.

3.1. Automatic Cross-Realm Keying

No more manual keying of cross-realm principals via exchanging passwords in-person on a telephone call (or similar).

3.2. Scalability

Kerberos with commonplace symmetrically-keyed hierarchical cross-real trusts can scale to a large universe of realms, but only if there are top-level realms that are willing to pair-wise trust and "child" realms. Such top-level realms do not exist in practice, leading to an O(N^2) scaling problem for most two-label realms.

Leveraging a PKI, such as a PKIX PKI [RFC5280] or a DNSSEC PKI [RFC4033] removes the need for either top-level realms (which are not likely to ever be operated as commercial or even non-profit entities) or O(N^2) pair-wise cross-realm symmetric keying.

The cost of this is having to add PKI trust paths to Kerberos trust paths (though the resulting trust path length need not be much different than before).

3.2.1. Simplified trust routing

For clients, relying on referrals (and TGS-driven PKCROSS) and/or client-driven PKCROSS will greatly reduce the need for client-side trust routing information.

Even KDCs won’t need trust routing information.

3.2.2. Simplified trust path validation

For services that accept hierarchical trust paths, PKCROSS will greatly reduce the complexity of trust path / transit validation. Such services that also trust DANE/DNSSEC will need no trust path validation information for any clients using PKCROSS to reach the service. In many cases a very simple policy expressed in terms of whitelists of top-level domains (TLDs) or near top-level domains traversed, trust anchor sets, and trust of all zero-length transit paths, will suffice.

3.3. Privacy Protection relative to home realm

This protocol protects the privacy of client principals vis-a-vis their home realms, when the clients use the client-driven PKCROSS protocol.

This feature is generally and naturally available in PKI, and as this protocol is based on a kerberized certification authority, this protocol inherits this privacy feature from PKI.

The realms visited by the client may, of course, inform the client's home realm, but in the event that they don't, the client does gain this small measure of privacy. Of course, the privacy-conscious client SHOULD attach an OCSP Response [RFC6960] to its PKINIT request, per [RFC4557].

4. Application Programming Interface Considerations

Improved scalability for Kerberos realm traversal implies larger Kerberos universes, and the larger a universe of trust the more important it is to have useful and expressive local policy for evaluating the trustworthiness of any given transit path. Because in most applications local policy should be a component external to the application, there is mostly no impact on APIs here. However, an implementation may wish to provide applications with interfaces for specifying policies, either named or by value.

4.1. GSS-API Considerations

The naming attributes [RFC6680] defined in [I-D.williams-kitten-generic-naming-attributes] provide access to information about transit paths.

Note that information about how PKCROSS was used to establish symmetrically-keyed cross-realm principals is lost and will not appear in the transit path in tickets issued by KDCs reached via such cross-realm principals.

5. Security Considerations

[[anchor5: All the security considerations of Kerberos and PKI apply. Security considerations are discussed throughout this document.]]

Scaling up the universe of realms reachable via any trust path necessarily dilutes trust overall, but not for specific paths. On the other hand, by shortening transit path lengths trust can be improved, though some short transit paths will have been symmetrically keyed using this PKCROSS protocol and therefore will be longer than they appear to be. These are subjective notions of trust, of course.

5.1. Loss of Cross-Realm Principal Trust Establishment Information

Once a cross-realm principal is symmetrically keyed the transit path used to automatically key that principal will no longer appear in subsequent cross-realm tickets issued by the target.

The Kerberos transit path encodes only realm names (including X.500-style names, thus PKIX certificate subject and issuer names), and lacks any public key information that might be useful for pinning. However, the certificate validation path for each realm in a transit path SHOULD be included in the transit path.

5.2. On the Need for a Common Transit Path Policy Language

There are no standard ways to express authorization policies for trust transit paths for either Kerberos nor PKI. A standard language for this would be extremely useful. Such a language should allow for the expression of policies for both, clients and services. Such a language should allow for the expression of complex realm/domain/other naming, and should allow for HSTS-style pinning [add references -Nico]. Such a language should allow for multiple paths where desired, and should allow for more than path rejection: it should also allow for reducing the entitlements assigned to a peer/realm for authorization purposes.

The need for a standard transit path policy expression language is not new, and such a language is broadly and generally needed. Therefore such a language is outside this document’s scope.

PKCROSS can greatly simplify the process of validating a ticket’s trust path, first by shortening the number of realms involved to two (in the typical case), maybe three, second by making the actual trust path (PKI or DANE) hierarchical, thus hopefully leaving much less policy to express in a transit path policy language: whitelists of domains and sub-domains, perhaps. But a common language would still

be desirable.

5.3. On the Need for Trust Routing

A common language for trust routing is not necessary in a purely hierarchical world, as in DANE. But since it’s likely that there will be some non-hierarchical, non-zero-length transit paths in many deployments for a long time to come, a common language for trust routing would be desirable as well. Routing protocols normally used for network addresses could be used for discovery and distribution of trust routing information as well. But note that there are subtle differences between trust routing and trust path validation, even though in traditional Kerberos deployments the same information is used for both, with the trust validation policy effectively being that the client must have taken the shortest, highest-priority path specified in "capaths" configutation.

6. IANA Considerations

[[anchor6: Allocate the new KDCOptions flag (USE-SESSION-KEY-AS-REALM-KEY) and authorization-data element (AD-CLIENT-CERTIFICATE), as well as the new EKU id-pkcross-issuer.]]

7. TODO

- Provide a normative reference for DANE stapling.

8. Acknowledgements

Although the author arrived at this "kx509 + PKINIT == PKCROSS" idea independently, it is not an original idea. Henry Hotz and Jeffrey Altman each conceived the same idea years earlier. It is a relatively obvious idea when taking into account efforts to bridge disparate security mechanisms and credentials infrastructures.

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