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Request for Comments: 2847   Zambeel
Category: Standards Track   June 2000

LIPKEY - A Low Infrastructure Public Key Mechanism Using SPKM

Status of this Memo

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Abstract

This memorandum describes a method whereby one can use GSS-API [RFC2078] to supply a secure channel between a client and server, authenticating the client with a password, and a server with a public key certificate. As such, it is analogous to the common low infrastructure usage of the Transport Layer Security (TLS) protocol [RFC2246].

The method leverages the existing Simple Public Key Mechanism (SPKM) [RFC2025], and is specified as a separate GSS-API mechanism (LIPKEY) layered above SPKM.

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1. Introduction

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 memorandum describes a new security mechanism under the GSS-API called the Low Infrastructure Public Key Mechanism (LIPKEY). GSS-API provides a way for an application protocol to implement authentication, integrity, and privacy. TLS is another way. While TLS is in many ways simpler for an application to incorporate than GSS-API, there are situations where GSS-API might be more suitable. Certainly this is the case with application protocols that run over connectionless protocols. It is also the case with application protocols such as ONC RPC [RFC1831] [RFC2203], which have their own security architecture, and so do not easily mesh with a protocol like TLS that is implemented as a layer that encapsulates the upper layer application protocol. GSS-API allows the application protocol to encapsulate as much of the application protocol as necessary.

Despite the flexibility of GSS-API, it compares unfavorably with TLS with respect to the perception of the amount of infrastructure required to deploy it. The better known GSS-API mechanisms, Kerberos V5 [RFC1964] and SPKM require a great deal of infrastructure to set up. Compare this to the typical TLS deployment scenario, which consists of a client with no public key certificate accessing a server with a public key certificate. The client:

* obtains the server's certificate,

* verifies that it was signed by a trusted Certification Authority (CA),

* generates a random session symmetric key,

* encrypts the session key with the server's public key, and

* sends the encrypted session key to the server.

At this point, the client and server have a secure channel. The client can then provide a user name and password to the server to authenticate the client. For example, when TLS is being used with the http protocol, once there is a secure channel, the http server will present the client with an html page that prompts for a user name and password. This information is then encrypted with the session key and sent to the server. The server then authenticates the client.

Note that the client is not required to have a certificate for itself to identify and authenticate it to the server. In addition to a TLS implementation, the required security infrastructure includes a public key certificate and password database on the server, and a list of trusted CAs and their public keys on the client. Most operating systems that the http server would run on already have a native password database, so the net additional infrastructure is a server certificate and CA list. Hence the term "low infrastructure security model" to identify this typical TLS deployment scenario.

By using unilateral authentication, and using a mechanism resembling the SPKM-1 mechanism type, SPKM can offer many aspects of the previously described low infrastructure security model. An application that uses GSS-API is certainly free to use GSS-API's GSS_Wrap() routine to encrypt a user name and password and send them to the server, for it to decrypt and verify.

Applications often have application protocols associated with them, and there might not be any provision in the protocol to specify a password. Layering a thin GSS-API mechanism over a mechanism resembling SPKM-1 can mitigate this problem. This can be a useful approach to avoid modifying applications that have already bound to GSS-API, assuming the applications are not statically bound to specific GSS-API mechanisms. The remainder of this memorandum defines the thin mechanism: the Low Infrastructure Public Key Mechanism (LIPKEY).

2. LIPKEY's Requirements of SPKM

SPKM-1 with unilateral authentication is close to the desired low infrastructure model described earlier. This section describes some additional changes to how SPKM-1 operates in order to realize the low infrastructure model. These changes include some minor changes in semantics. While it would be possible to implement these semantic changes within an SPKM-1 implementation (including using the same mechanism type Object Identifier (OID) as SPKM-1), the set of changes stretch the interpretation of RFC 2025 to the point where compatibility would be in danger. A new mechanism type, called SPKM-3, is warranted. LIPKEY requires that the SPKM implementation support SPKM-3. SPKM-3 is equivalent to SPKM-1, except as described in the remainder of this section.

2.1. Mechanism Type

SPKM-3 has a different mechanism type OID from SPKM-1.

```
spkm-3 OBJECT IDENTIFIER ::=
   {iso(1)identified-organization(3)dod(6)internet(1)security(5)
   mechanisms(5)spkm(1)spkm-3(3)}
```

2.2. Name Type

RFC 2025 defines no required name types of SPKM. LIPKEY requires that the SPKM-3 implementation support all the mechanism independent name types in RFC 2078.

2.3. Algorithms

2.3.1. MANDATORY Algorithms

RFC 2025 defines various algorithms for integrity, confidentiality, key establishment, and subkey derivation. Except for md5WithRSAEncryption, the REQUIRED Key Establishment (K-ALG), Integrity (I-ALG) and One-Way Functions for Subkey Derivation (O-ALG) algorithms listed in RFC 2025 continue to be REQUIRED.

SPKM is designed to be extensible with regard to new algorithms. In order for LIPKEY to work correctly and securely, the following algorithms MUST be implemented in SPKM-3:

* Integrity algorithms (I-ALG)

NULL-MAC
: Because the initiator may not have a certificate for itself, nor for the target, it is not possible for it to calculate an Integrity value in the initiator's REQ-TOKEN that is sent to the target. So we define, in ASN.1 [CCITT] syntax, a null I-ALG that returns a zero length bit string regardless of the input passed to it:

```
NULL-MAC OBJECT IDENTIFIER ::=
   {iso(1)identified-organization(3)dod(6)internet(1)security(5)
   integrity(3)NULL-MAC(3)}
```

id-dsa-with-sha1
: This is the signature algorithm as defined in Section 7.2.2 of [RFC2459]. As noted in RFC 2459, the ASN.1 OID used to identify this signature algorithm is:

```
id-dsa-with-sha1 OBJECT IDENTIFIER ::= {
        iso(1) member-body(2) us(840) x9-57(10040)
                x9cm(4) 3
}
```

Note that there is a work-in-progress [PKIX] to obsolete RFC 2459. However that work-in-progress does not change the definition of id-dsa-with-sha1.

HMAC-MD5
: A consequence of the SPKM-3 initiator not having a certificate is that it cannot use a digital signature algorithm like md5WithRSAEncryption, id-dsa-with-sha1, or sha1WithRSAEncryption once the context is established. Instead, a message authentication code (MAC) algorithm is

required. DES-MAC is specified as recommended in [RFC2025]. Since the security of 56 bit DES has been shown to be inadequate [EFF], SPKM-3 needs a stronger MAC. Thus, SPKM-3 MUST support the HMAC-MD5 algorithm [RFC2104], with this OID:

```
HMAC-MD5 OBJECT IDENTIFIER ::= {
        iso(1) org(3) dod(6) internet(1) security(5)
                mechanisms(5) ipsec(8) isakmpOakley(1)
                1
}
```

The reference for the algorithm OID of HMAC-MD5 is [IANA]. The reference for the HMAC-MD5 algorithm is [RFC2104].

The HMAC-SHA1 algorithm is not a mandatory SPKM-3 I-ALG MAC because SHA-1 is about half the speed of MD5 [Young]. A MAC based on an encryption algorithm like cast5CBC, DES EDE3, or RC4 is not mandatory because MD5 is 31 percent faster than the fastest of the three encryption algorithms [Young].

* Confidentiality algorithm (C-ALG).

  RFC 2025 does not have a MANDATORY confidentiality algorithm, and instead has RECOMMENDED a 56 bit DES algorithm. Since the LIPKEY initiator needs to send a password to the target, and since 56 bit DES has been demonstrated as inadequate [EFF], LIPKEY needs stronger encryption. Thus, SPKM-3 MUST support this algorithm:

```
cast5CBC OBJECT IDENTIFIER ::= {
        iso(1) memberBody(2) usa(840) nt(113533) nsn(7)
                algorithms(66) 10
}

Parameters ::= SEQUENCE {
        iv OCTET STRING DEFAULT 0, -- Initialization vector
        keyLength INTEGER          -- Key length, in bits
}
```

  The reference for the OID and description of the cast5CBC algorithm is [RFC2144]. The keyLength in the Parameters MUST be set to 128 bits.

  A triple DES (DES EDE3) algorithm is not a mandatory SPKM-3 C-ALG because it is much slower than cast5CBC. One set of measurements [Young] on a Pentium Pro 200 megahertz processor using the SSLeay code, showed that DES EDE3 performed as high as 1,646,210 bytes per second, using 1024 byte blocks. The same test bed yielded performance of 7,147,760 bytes per second for cast5CBC, and 22,419,840 bytes per second for RC4. Most TLS sessions negotiate the RC4 cipher. Given that LIPKEY is targeted at environments similar to that where TLS is deployed, selecting a cipher that is over 13 times slower (and over 13 times more CPU intensive) than RC4 would severely impede the usefulness of LIPKEY. For performance reasons, RC4 would be the preferred mandatory algorithm for SPKM-3. Due to intellectual property considerations with RC4 [Schneier], the combination of cast5CBC's reasonable performance, and its royalty-free licensing terms [RFC2144] make cast5CBC the optimal choice among DES EDE3, RC4, and cast5CBC.

* Key Establishment Algorithm (K-ALG)

RFC 2025 lists dhKeyAgreement [PKCS-3] as an apparently optional algorithm. As will be described later, the RSAEncryption key establishment algorithm is of no use for a low infrastructure security mechanism as defined by this memorandum. Hence, in SPKM-3, dhKeyAgreement is a REQUIRED key establishment algorithm:

```
dhKeyAgreement OBJECT IDENTIFIER ::= {
        iso(1) member-body(2) US(840) rsadsi(113549) pkcs(1)
        pkcs-3(3) 1
}
```

* One-Way Function for Subkey Derivation Algorithm (O-ALG)

RFC 2025 lists MD5 as a mandatory algorithm. Since MD5 has been found to have weaknesses when used as a hash [Dobbertin], id-sha1 is a MANDATORY O-ALG in SPKM-3:

```
id-sha1 OBJECT IDENTIFIER ::= {
        iso(1) identified-organization(3) oiw(14)
        secsig(3) algorithms(2) 26
}
```

The reference for the algorithm OID of id-sha1 is [RFC2437]. The reference for SHA-1 algorithm corresponding to id-sha1 is [FIPS].

2.3.2. RECOMMENDED Integrity Algorithms (I-ALG)

md5WithRSAEncryption
The md5WithRSAEncryption integrity algorithm is listed in [RFC2025] as mandatory. Due to intellectual property considerations [RSA-IP], SPKM-3 implementations cannot be

required to implement it. However, given the proliferation of certificates using RSA public keys, md5WithRSAEncryption is strongly RECOMMENDED. Otherwise, the opportunities for LIPKEY to leverage existing public key infrastructure will be limited.

sha1WithRSAEncryption
For reasons similar to that for md5WithRSAEncryption, sha1WithRSAEncryption is a RECOMMENDED algorithm. The sha1WithRSAEncryption algorithm is listed in addition to md5WithRSAEncryption due to weaknesses in the MD5 hash algorithm [Dobbertin]. The OID for sha1WithRSAEncryption is:

```
sha1WithRSAEncryption  OBJECT IDENTIFIER ::= {
        iso(1) member-body(2) US(840) rsadsi(113549) pkcs(1)
        pkcs-1(1) 5
}
```

The reference for the algorithm OID and description of sha1WithRSAEncryption is [RFC2437].

2.4. Context Establishment Tokens

RFC 2025 sets up a context with an initiator first token (REQ-TOKEN), a target reply (REP-TI-TOKEN), and finally an initiator second token (REP-IT-TOKEN) to reply to the target's reply. Since LIPKEY uses SPKM-3 with unilateral authentication, the REP-IT-TOKEN is not used. LIPKEY has certain requirements on the contents of the REQ-TOKEN and REP-TI-TOKEN, but the syntax of the SPKM-3 tokens is not different from RFC 2025's SPKM-1 tokens.

2.4.1. REQ-TOKEN Content Requirements

2.4.1.1. algId and req-integrity

If the SPKM-3 initiator cannot calculate a req-integrity field due to the lack of a target certificate, it MUST use the NULL-MAC I-ALG described earlier in this memorandum. This will produce a zero length bit string in the Integrity field.

2.4.1.2. Req-contents

Because RFC 2025 requires that the RSAEncryption K-ALG be present, SPKM-1 must be able to map the target (targ-name) to its public key certificate, and thus SPKM can use the RSAEncryption algorithm to fill in the key-estb-req field. Because LIPKEY assumes a low infrastructure deployment, SPKM-3 MUST be prepared to be unable to map the targ-name field of the Req-contents field. This is a contradiction which is resolved by requiring SPKM-3 to support the dhKeyAgreement algorithm. Note that if an SPKM-3 implementation tries to map the target to a certificate, and succeeds, it is free to use the RSAEncryption K-ALG algorithm. It is also free to use an algID other than NULL-MAC in the REQ-TOKEN type.

2.4.1.2.1. Options

SPKM-3 implementations MUST set the target-certif-data-required bit to 1 if the only K-ALG in the key-estb-set field of Req-contents is dhKeyAgreement. This would normally occur if the SPKM-3 implementation cannot resolve the target name to a certificate.

2.4.1.2.2. Conf-Algs

If the SPKM-3 implementation supports an algorithm weaker than cast5CBC, cast5CBC MUST be listed before the weaker algorithm to encourage the target to negotiate the stronger algorithm.

2.4.1.2.3. Intg-Algs

Because the initiator will be anonymous (at the SPKM-3 level) and will not have a certificate for itself, the initiator cannot use an integrity algorithm that supports non-repudiation; it must use a MAC algorithm. If the SPKM-3 implementation supports an algorithm weaker than HMAC-MD5, HMAC-MD5 MUST be listed before the weaker algorithm to encourage the target to negotiate the stronger algorithm.

2.4.2. REP-TI-TOKEN Content Requirements

With the previously described requirements on REQ-TOKEN, the contents of SPKM-3's REP-TI-TOKEN can for the most part be derived from the specification in RFC 2025. The exceptions are the algId and rep-ti-integ fields.

2.4.2.1. algId

The SPKM-3 target MUST NOT use a NULL-MAC I-ALG; it MUST use a signature algorithm like id-dsa-with-sha1, md5WithRSAEncryption, or sha1WithRSAEncryption.

2.4.2.2. rep-ti-integ

If the req-token has an algId of NULL-MAC, then the target MUST compute the rep-ti-integ on the concatenation of the req-contents and rep-ti-contents.

2.5. Quality of Protection (QOP)

The SPKM-3 initiator and target negotiate the set of algorithms they mutually support, using the procedure defined in Section 5.2 of RFC 2025. If a QOP of zero is specified, then the initiator and target will use the first C-ALG (privacy), and I-ALG (integrity) algorithms negotiated.

SPKM breaks the QOP into several fields, as reproduced here from Section 5.2 of RFC 2025:

```
    Confidentiality                    Integrity
    31 (MSB)                        16 15                 (LSB) 0
   -------------------------------|-------------------------------
   | TS(5) | U(3) | IA(4) | MA(4) | TS(5) | U(3) | IA(4) | MA(4) |
   -------------------------------|-------------------------------
```

The MA subfields enumerate mechanism-defined algorithms. Since this memorandum introduces a new mechanism, SPKM-3, within the SPKM family, it is appropriate to add algorithms to the MA subfields of the respective Confidentiality and Integrity fields.

The complete set of Confidentiality MA algorithms is thus:

```
0001 (1) = DES-CBC
0010 (2) = cast5CBC
```

Where "0001" and "0010" are in base 2. An SPKM peer that negotiates a confidentiality MA algorithm value of "0010" MUST use a 128 bit key, i.e. set the keyLength values in the cast5CBC Parameters to 128 bits.

The complete set of Integrity MA algorithms is thus:

```
0001 (1) = md5WithRSAEncryption
0010 (2) = DES-MAC
0011 (3) = id-dsa-with-sha1
0100 (4) = HMAC-MD5
0101 (5) = sha1WithRSAEncryption
```

Where "0001" through "0101" are in base 2.

Adding support for cast5CBC, id-dsa-with-sha1, HMAC-MD5, and sha1WithRSAEncryption in the above manner to SPKM-1 and SPKM-2 does not impair SPKM-1 and SPKM-2 backward compatibility because, as noted previously, SPKM negotiates algorithms. An older SPKM-1 or SPKM-2 that does not recognize MA values for cast5CBC, id-dsa-with-sha1, HMAC-MD5, or sha1WithRSAEncryption will not select them.

3. How LIPKEY Uses SPKM

3.1. Tokens

LIPKEY will invoke SPKM-3 to produce SPKM tokens. Since the mechanism that the application uses is LIPKEY, LIPKEY will wrap some of the SPKM-3 tokens with LIPKEY prefixes. The exact definition of the tokens is described later in this memorandum.

3.2. Initiator

3.2.1. GSS_Import_name

The initiator uses GSS_Import_name to import the target's name, typically, but not necessarily, using the GSS_C_NT_HOSTBASED_SERVICE name type. Ultimately, the output of GSS_Import_name will apply to an SPKM-3 mechanism type because a LIPKEY target is an SPKM-3 target.

3.2.2. GSS_Acquire_cred

The initiator calls GSS_Acquire_cred. The credentials that are acquired are LIPKEY credentials, a user name and password. How the user name and password is acquired is dependent upon the operating environment. A application that invokes GSS_Acquire_cred() while the application's user has a graphical user interface running might trigger the appearance of a pop up window that prompts for the information. A application embedded into the operating system, such as an NFS [Sandberg] client implemented as a native file system might broadcast a message to the user's terminals telling him to invoke a command that prompts for the information.

Because the credentials will not be used until GSS_Init_sec_context is called, the LIPKEY implementation will need to safeguard the credentials. If this is a problem, the implementation may instead defer actual acquisition of the user name and password until GSS_init_sec_context is ready to send the user name and password to the target. In that event, the output_cred_handle argument of GSS_Acquire_cred would simply be a reference that mapped to the principal corresponding to the desired_name argument. A subsequent GSS_Init_sec_context call would consider the mapping of claimant_cred_handle to principal when it acquires the user name and password. For example, the aforementioned pop up window might fill in the user name portion of the dialog with a default value that maps to the principal referred to in claimant_cred_handle.

3.2.3. GSS_Init_sec_context

When a program invokes GSS_Init_sec_context on the LIPKEY mechanism type, if the context handle is NULL, the LIPKEY mechanism will in turn invoke GSS_Init_sec_context on an SPKM-3 mechanism implemented according to the requirements described previously. This call to SPKM-3 MUST have the following attributes:

* claimant_cred_handle is NULL

* mutual_req_flag is FALSE

* anon_req_flag is TRUE

* input_token is NULL

* mech_type is the OID of the SPKM-3 mechanism

Keep in mind the above attributes are in the GSS_Init_sec_context call from the LIPKEY mechanism down to the SPKM-3 mechanism. There are no special restrictions placed on the application invoking LIPKEY's GSS_Init_sec_context routine. All other arguments are derived from the LIPKEY GSS_Init_sec_context arguments.

The call to the SPKM-3 GSS_Init_sec_context will create an SPKM-3 context handle. The remainder of the description of the LIPKEY GSS_Init_sec_context call depends on whether the caller of the LIPKEY GSS_Init_sec_context sets anon_req_flag to TRUE or FALSE.

3.2.3.1. LIPKEY Caller Specified anon_req_flag as TRUE

If the caller of LIPKEY's GSS_Init_sec_context sets anon_req_flag to TRUE, it MUST return to the LIPKEY caller all the outputs from the SPKM-3 GSS_Init_sec_context call, including the output_context_handle, output_token, and mech_type. In this way, LIPKEY now "gets out of the way" of GSS-API processing between the application and SPKM-3, because nothing in the returned outputs relates to LIPKEY. This is necessary, because LIPKEY context tokens do not have provision for specifying anonymous initiators. This is because SPKM-3 is sufficient for purpose of supporting anonymous initiators in a low infrastructure environment.

Clearly, when the LIPKEY caller desires anonymous authentication, LIPKEY does not add any value, but it is simpler to support the feature, than to insist the caller directly use SPKM-3.

If all goes well, the caller of LIPKEY will be returned a major_status of GSS_S_CONTINUE_NEEDED via SPKM-3, and so the caller of LIPKEY will send the output_token to the target. The caller of LIPKEY then receives the response token from the target, and directly invokes the SPKM-3 GSS_Init_sec_context. Upon return, the major_status should be GSS_S_COMPLETE.

3.2.3.2. LIPKEY Caller Specified anon_req_flag as FALSE

The LIPKEY mechanism will need to allocate a context handle for itself, and record in the LIPKEY context handle the SPKM-3 context handle that was returned in the output_context_handle parameter from the call to the SPKM-3 GSS_Init_sec_context routine. The LIPKEY GSS_Init_sec_context routine will return in output_context_handle the LIPKEY context handle, and in mech_type, the LIPKEY mechanism type. The output_token is as defined later in this memorandum, in the subsection entitled "Context Tokens Prior to SPKM-3 Context Establishment." All the other returned outputs will be those that the SPKM-3 GSS_Init_sec_context routine returned to LIPKEY. If all went well, the SPKM-3 mechanism will have returned a major_status of GSS_S_CONTINUE_NEEDED.

The caller of the LIPKEY GSS_Init_sec_context routine will see a major_status of GSS_S_CONTINUE_NEEDED, and so the caller of LIPKEY will send the output_token to the target. The caller of LIPKEY then receives the target's response token, and invokes the LIPKEY GSS_Init_sec_context routine for a second time. LIPKEY then invokes the SPKM-3 GSS_Init_sec_context for a second time and upon return, the major_status should be GSS_S_COMPLETE.

While SPKM-3's context establishment is now complete, LIPKEY's context establishment is not yet complete, because the initiator must send to the target the user name and password that were passed to it via the claimant_cred_handle on the first call to the LIPKEY GSS_Init_sec_context routine. LIPKEY uses the established SPKM-3 context handle as the input to GSS_Wrap (with conf_req_flag set to TRUE) to encrypt what the claimant_cred_handle refers to (user name and password), and returns that as the output_token to the caller of LIPKEY (provided the conf_state output from the call to SPKM-3's GSS_Wrap is TRUE), along with a major_status of GSS_S_CONTINUE_NEEDED.

The caller of LIPKEY sends its second context establishment token to the target, and waits for a token provided by the target's GSS_Accept_sec_context routine. The target's LIPKEY GSS_Accept_sec_context routine invokes the SPKM-3 GSS_Unwrap routine on the token, and validates the user name and password. The target then invokes SPKM-3's GSS_Wrap routine on a boolean indicating whether or not the user name and password were accepted, and returns the output_message result from GSS_Wrap as the output_token result for GSS_Accept_sec_context.

The caller of LIPKEY receives the target's response token, and passes this via the input_token parameter to the LIPKEY GSS_Init_sec_context routine. LIPKEY then invokes GSS_Unwrap to get the boolean acceptance indication, and maps this to a major_status of either GSS_S_COMPLETE indicating successful (the boolean was TRUE) and completed LIPKEY context establishment, or GSS_S_FAILURE, indicating that context establishment failed. GSS_S_CONTINUE_NEEDED will not be returned.

Note that the mutual_req_flag parameter is ignored because unilateral authentication is impossible. The initiator must authenticate the target via SPKM-3 in order to create a secure channel to transmit the user name and password. The target must authenticate the initiator when it receives the user name and password.

The SPKM-3 context remains established while the LIPKEY context is established. If the SPKM-3 context expires before the LIPKEY context is destroyed, the LIPKEY implementation should expire the LIPKEY context and return the appropriate error on the next GSS-API operation.

3.2.4. Other operations

For other operations, the LIPKEY context acts as a pass through to the SPKM-3 context. Operations that affect or inquire context state, such as GSS_Delete_sec_context, GSS_Export_sec_context, GSS_Import_sec_context, and GSS_Inquire_context will require a pass through to the SPKM-3 context and a state modification of the LIPKEY context.

3.3. Target

3.3.1. GSS_Import_name

As with the initiator, the imported name will be that of the target.

3.3.2. GSS_Acquire_cred

The target calls the LIPKEY GSS_Acquire_cred routine to get a credential for an SPKM-3 target, via the SPKM-3 GSS_Acquire_cred routine. The desired_name is the output_name from GSS_Import_name.

3.3.3. GSS_Accept_sec_context

When a program invokes GSS_Accept_sec_context on the LIPKEY mechanism type, if the context handle is NULL, the LIPKEY mechanism will in turn invoke GSS_Accept_sec_context on an SPKM-3 mechanism implemented according the requirements described previously. This call to SPKM-3 is no different than what one would expect for a layered call to GSS_Accept_sec_context.

If all goes well, the SPKM-3 GSS_Accept_sec_context call succeeds with GSS_S_COMPLETE, and the LIPKEY GSS_Accept_sec_context call returns the output_token to the caller, but with a major_status of GSS_S_CONTINUE_NEEDED because the LIPKEY initiator is still expected to send the user name and password.

Once the SPKM-3 context is in a GSS_S_COMPLETE state, the next token the target receives will contain the user name and password, wrapped by the output of an SPKM-3 GSS_Wrap call. The target invokes the LIPKEY GSS_Accept_sec_context, which in turn invokes the SPKM-3 GSS_Unwrap routine. The LIPKEY GSS_Accept_sec_context routine then compares the user name and password with its user name name and password database. If the initiator's user name and password are valid, GSS_S_COMPLETE is returned to the caller. Otherwise GSS_S_FAILURE is returned. In either case, an output_token - equal to the output_message result from an SPKM-3 GSS_Wrap call on a boolean value - is returned to the caller. The boolean value is set to TRUE if the the user name and password were valid, FALSE otherwise. The target expects no more context establishment tokens from caller.

4. LIPKEY Description

4.1. Mechanism Type

```
lipkey OBJECT IDENTIFIER ::=
   {iso(1)identified-organization(3)dod(6)internet(1)security(5)
   mechanisms(5)lipkey(9)}
```

4.2. Name Types

LIPKEY uses only the mechanism independent name types defined in RFC 2078. All the name types defined in RFC 2078 are REQUIRED.

4.3. Token Formats

4.3.1. Context Tokens

GSS-API defines the context tokens as:

```
InitialContextToken ::=
-- option indication (delegation, etc.) indicated within
-- mechanism-specific token
[APPLICATION 0] IMPLICIT SEQUENCE {
       thisMech MechType,
       innerContextToken ANY DEFINED BY thisMech
          -- contents mechanism-specific
          -- ASN.1 structure not required
}

SubsequentContextToken ::= innerContextToken ANY
-- interpretation based on predecessor InitialContextToken
-- ASN.1 structure not required
```

The contents of the innerContextToken depend on whether the SPKM-3 context is established or not.

4.3.1.1. Context Tokens Prior to SPKM-3 Context Establishment

In a LIPKEY InitialContextToken, thisMech will be the Object identifier for LIPKEY. However, as long as LIPKEY has not established the SPKM-3 mechanism, the innerContextToken for both the InitialContextToken and the SubsequentContextToken will be the output of an SPKM-3 GSS_Init_sec_context or GSS_Accept_sec_context. So the LIPKEY innerContextToken would be either:

* An InitialContextToken, with thisMech set to the object identifier for SPKM-3, with innerContextToken defined to be an SPKMInnerContextToken, as defined in RFC 2025.

* A SubsequentContextToken, with innerContextToken defined to be SPKMInnerContextToken

4.3.1.2. Post-SPKM-3 Context Establishment Tokens

Once the SPKM-3 context is established, there is just one token sent from the initiator to the target, and one token returned to initiator.

4.3.1.2.1. From LIPKEY Initiator

The LIPKEY initiator generates a token that is the the result of a GSS_Wrap (conf_req is set to TRUE) of a user name and password by the SPKM-3 context. The input_message argument of GSS_Wrap refers to an instance of the UserName-Password type defined below:

```
UserName-Password ::= SEQUENCE {
        user-name       OCTET STRING,
                                -- each octet is an octet of a
                                -- UTF-8 [RFC2279] string
        password        OCTET STRING
                                -- each octet is an octet of a
                                -- UTF-8 [RFC2279] string
}
```

4.3.1.2.2. From LIPKEY Target

The target validates the user name and password token from the initiator, and generates a response token that is the output_message result of an SPKM-3 GSS_Wrap (conf_req may or may not be set to TRUE) call on an indication of validation success. The input_message argument of GSS_Wrap refers to an instance of the Valid-UNP type defined below:

```
Valid-UNP ::= BOOLEAN
                -- If TRUE, user name/password pair was valid.
```

4.3.2. Tokens from GSS_GetMIC and GSS_Wrap

RFC 2078 defines the token emitted by GSS_GetMIC and GSS_Wrap as:

```
          PerMsgToken ::=
          -- as emitted by GSS_GetMIC and processed by GSS_VerifyMIC
          -- ASN.1 structure not required
                  innerMsgToken ANY

          SealedMessage ::=
          -- as emitted by GSS_Wrap and processed by GSS_Unwrap
          -- includes internal, mechanism-defined indicator
          -- of whether or not encrypted
          -- ASN.1 structure not required
                  sealedUserData ANY
```

As one can see, there are no mechanism independent prefixes in PerMSGToken or SealedMessage, and no explicit mechanism specific information. Since LIPKEY does not add any value to GSS_GetMIC and

GSS_Wrap other than passing the message to the SPKM-3 GSS_GetMIC and GSS_Wrap, LIPKEY's PerMsgToken and SealedMessage tokens are exactly what SPKM-3's GSS_GetMIC and GSS_Wrap routines produce.

4.4. Quality of Protection

LIPKEY, being a pass through for GSS_Wrap and GSS_GetMIC to SPKM-3, does not interpret or alter the QOPs passed to the aforementioned routines or received from their complements, GSS_Unwrap, and GSS_VerifyMIC. Thus, LIPKEY supports the same set of QOPs as SPKM-3.

5. Security Considerations

5.1. Password Management

LIPKEY sends the clear text password encrypted by 128 bit cast5CBC so the risk in this approach is in how the target manages the password after it is done with it. The approach should be safe, provided the target clears the memory (primary and secondary, such as disk) buffers that contained the password, and any hash of the password immediately after it has validated the user's password.

5.2. Certification Authorities

The initiator must have a list of trusted Certification Authorities in order to verify the checksum (rep-ti-integ) on the SPKM-3 target's context reply token. If it encounters a certificate signed by an unknown and/or untrusted certificate authority, the initiator MUST NOT silently accept the certificate. If it does wish to accept the certificate, it MUST get confirmation from the user running the application that is using GSS-API.

5.3. HMAC-MD5 and MD5 Weaknesses

While the MD5 hash algorithm has been found to have weaknesses [Dobbertin], the weaknesses do not impact the security of HMAC-MD5 [Dobbertin].

5.4. Security of cast5CBC

The cast5CBC encryption algorithm is relatively new compared to established algorithms like triple DES, and RC4. Nonetheless, the choice of cast5CBC as the MANDATORY C-ALG for SPKM-3 is advisable. The cast5CBC algorithm is a 128 bit algorithm that the 256 bit cast6CBC [RFC2612] algorithm is based upon. The cast6CBC algorithm was judged by the U.S. National Institute of Standards and Technology (NIST) to have no known major or minor "security gaps," and to have a "high security margin" [AES]. NIST did note some vulnerabilities related to smart card implementations, but many other algorithms NIST analyzed shared the vulnerabilities, and in any case, LIPKEY is by definition not aimed at smart cards.

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Acknowledgments

The author thanks and acknowledges:

* Jack Kabat for his patient explanation of the intricacies of SPKM, excellent suggestions, and review comments.

* Denis Pinkas for his review comments.

* Carlisle Adams for his review comments.

* John Linn for his review comments.

* Martin Rex for his review comments.

* This memorandum includes ASN.1 definitions for GSS-API tokens from RFC 2078, which was authored by John Linn.

* This memorandum includes ASN.1 definitions and other text from the SPKM definition in RFC 2025, which was authored by Carlisle Adams.

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Acknowledgement

Funding for the RFC Editor function is currently provided by the Internet Society.