KITTEN
Internet-Draft
Updates: 2743, 2744 (if approved)
Intended status: Standards Track
Expires: August 9, 2019

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February 5, 2019

Channel Binding Signalling for the Generic Security Services Application Programming Interface
draft-ietf-kitten-channel-bound-flag-04

Abstract

Channel binding is a technique that allows applications to use a secure channel at a lower layer without having to use authentication at that lower layer. The concept of channel binding comes from the Generic Security Services Application Programming Interface (GSS-API). It turns out that the semantics commonly implemented are different than those specified in the base GSS-API RFC (RFC2743), and that that specification has a serious bug. This document addresses both the inconsistency as-implemented and the specification bug.

This Internet-Draft proposes the addition of a "channel bound" return flag for the GSS_Init_sec_context() and GSS_Accept_sec_context() functions. Two behaviors are specified: a default, safe behavior reflecting existing implementation deployments, and a behavior that is only safe when the application specifically tells the GSS-API that it (the application) supports the new behavior. Additional API elements related to this are also added, including a new security context establishment API.

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 GSS-API [RFC2743] supports "channel binding" [RFC5056], a technique for detection of man-in-the-middle (MITM) attacks in secure channels at lower network layers. This facility is meant to be all-or-nothing: either both the initiator and acceptor use it and it succeeds, or both must not use it. This has created a negotiation problem when retrofitting the use of channel binding into existing application protocols.

However, GSS-APIv2u1 [RFC2743] does not specify channel binding behavior when only one party provides provides none. In practice, some mechanisms (such as Kerberos [RFC4121]) ignore channel bindings when the acceptor provides none, but not when the initiator provides none. Note that it would be useless to allow security context establishment to succeed when the initiator does not provide channel bindings but the acceptor does, at least as long as there's no outward indication of whether channel binding was used! Since the GSS-APIv2u1 does not provide any such indication, this document corrects that flaw.

Allowing the connection to succeed when an initiator provides bindings but an acceptor does not has helped deployment of channel binding in existing applications: first fix all the initiators, then fix all the acceptors. But even this technique is insufficient when there are many clients to fix, such that fixing them all will take a long time. Additionally, it limits the usefulness of channel bindings, while allowing the acceptor to provide but not enforce would protect against man in the middle attacks (for channel binding aware initiators).

This document proposes a new method for deployment of channel binding that allows the feature to be enabled on the acceptor side before fixing all initiators. If the GSS-API had always had a return flag by which to indicate channel binding state then we could have had a simpler method of deploying channel binding: applications check that return flag and act accordingly (e.g., fail when channel binding is required). We cannot safely introduce this behavior now without an indication of support by the application.

Additionally, there may be applications where it is important for initiators to know that acceptors did use channel binding, and even to know whether a mechanism is capable of indicating as much. We add a request flag and a mechanism attribute for such applications.

1.1. Design and Future directions

The design for signalling application flag support and empty contexts is based on the Java Bindings of the GSS-API [RFC5653]. This document begins introduction of additional context inquiry and mutation functions, which eventually will also allow for simplified stepping to replace the GSS_Init/Accept_sec_context() loop.

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. Channel Binding State Extension

We propose a new return flag for GSS_Init_sec_context() and GSS_Accept_sec_context(), as well as a pair of functions for a) creating "empty" security context handles, b) requesting flags and indicating which flags the application understands. We also add a new mechanism attribute for supporting channel binding confirmation.

C bindings of these extensions are provided along the lines of [RFC2744] and [RFC5587].

In the future we might move more of the many input (and output) arguments to GSS_Init_sec_context() and GSS_Accept_sec_context() into mutators on empty security context handles.

2.1. GSS_Create_sec_context()

Inputs:

- <none>

Outputs:

- major_status INTEGER
- minor_status INTEGER -- note: mostly useless, but we should keep it
- context SECURITY CONTEXT -- "empty" security context

Return major status codes:

- GSS_S_COMPLETE indicates success.
- GSS_S_UNAVAILABLE indicates that memory is not available, for example.
- GSS_S_FAILURE indicates a general failure.

This function creates an "empty" security context handle that can be passed to GSS_Init_sec_context() or GSS_Accept_sec_context() where they expect GSS_C_NO_CONTEXT.

2.1.1. C-Bindings

```
OM_uint32
gss_create_sec_context(OM_uint32 *minor_status,
                       gss_ctx_id_t *context);
```

2.2. GSS_Set_context_flags()

Inputs:

context CONTEXT HANDLE

req_flags FLAGS Requested flags. Applicable to acceptors and initiators.

ret_flags_understood FLAGS The set of return flags understood by the caller.

Outputs:

- major_status INTEGER
- minor_status INTEGER

Return major status codes:

- GSS_S_COMPLETE indicates success.
- GSS_S_FAILURE indicates a general failure.

This function tells the mechanism (when one is eventually chosen and invoked) that the application requests the given req_flags and is prepared to check the flags in the given ret_flags_understood. Mechanisms SHOULD NOT limit flags returned to those in ret_flags_understood, but MAY alter behavior accordingly. Initiators can override the req_flags in their GSS_Init_sec_context() call, but if no flags are requested there then the req_flags set on the empty context will be used. GSS_Accept_sec_context() is not required to perform any action based on req_flags at this time.

NOTE: The abstract GSS-API [RFC2743] uses individual elements--one per-flag--instead of a "FLAGS" type. This is unwieldy, therefore we introduce an abstract type named "FLAGS" to act as a set of all the request/return flags defined for the abstract GSS-API.

2.2.1. C-Bindings

```
OM_uint32
gss_set_context_flags(OM_uint32 *minor_status,
                      gss_ctx_id_t context,
                      uint64_t req_flags,
                      uint64_t ret_flags_understood);
```

2.3. Return Flag for Channel Binding State Signalling

Whenever both the initiator and the acceptor provide matching channel bindings to GSS_Init_sec_context() and GSS_Accept_sec_context(), respectively, then the mechanism SHALL indicate that the context is channel bound via an output flag, ret_channel_bound_flag, for the established context. Note that some mechanisms have no way for the acceptor to signal CB success to the initiator, in which case GSS_Init_sec_context() MUST NOT output the ret_channel_bound_flag.

2.3.1. C-Bindings

```
#define GSS_C_CHANNEL_BOUND_FLAG 2048 /* 0x00000800 */
```

2.4. New Mechanism Attribute

- We add a new mechanism attribute, GSS_C_MA_CBINDING_CONFIRM, to indicate that the initiator can and always does learn whether the acceptor application supplied channel bindings (assuming mutual auth has been requested). Mechanisms advertising this attribute MUST always indicate acceptor channel bound state to the initiator.

OID assignments TBD.

2.5. Request Flag for Acceptor Confirmation of Channel Binding

We add a new request flag for GSS_Init_sec_context(), req_cb_confirmation_flag, to be used by initiators that insist on acceptors providing channel bindings. If set, the mechanism MUST prefer establishment of contexts which provide channel binding confirmation. It SHOULD NOT fail to negotiate just because it cannot provide the GSS_C_MA_CBINDING_CONFIRM attribute.

2.5.1. C-Bindings

Because GSS_C_CHANNEL_BOUND_FLAG is a return flag only, and this flag is a request flag only, and to save on precious flag bits, we use the same flag bit assignment for both flags:

```
#define GSS_C_CB_CONFIRM_FLAG 2048 /* 0x00000800 */
```

2.6. Handling Empty Contexts in Other GSS-API Functions

GSS_Init_sec_context() and GSS_Accept_sec_context() operate on empty security contexts as specified above (i.e., examining flags).

All other GSS-API functions MUST treat empty contexts as they would GSS_C_NO_CONTEXT as well. For most functions, this will result in returning GSS status code GSS_S_NO_CONTEXT.

GSS_Delete_sec_context() MUST NOT output a context deletion token when applied to empty security contexts.

3. Modified Channel Binding Semantics

The channel binding semantics of the base GSS-API are modified as follows:

- Whenever both the initiator and acceptor have provided input_channel_bindings to GSS_Init/Accept_sec_context() and the channel bindings do not match, then the mechanism MUST fail to establish a security context token. (This is a restatement of an existing requirement in the base specification.)

- Whenever the acceptor application has a) provided channel bindings to GSS_Accept_sec_context(), and b) not indicated support for the ret_channel_bound_flag flag, then the mechanism MUST fail to establish a security context if the initiator did not provide channel bindings data. This requirement is critical for security purposes, to make applications predating this document secure, and this requirement reflects actual implementations as deployed.

- Whenever the initiator application has a) provided channel bindings to GSS_Init_sec_context(), and b) not indicated support for the ret_channel_bound_flag flag, then the mechanism SHOULD NOT fail to establish a security context just because the acceptor failed to provide channel bindings data. This strong sugestion is for interoperability purposes, and reflects actual implementations that have been deployed.

- Whenever the application has a) provided channel bindings to GSS_Init_sec_context() or GSS_Accept_sec_context(), and b) indicated support for the ret_channel_bound_flag flag, then the mechanism SHOULD NOT fail to establish a security context just because the peer did not provide channel bindings data. The mechanism MUST output the ret_channel_bound_flag if both peers provided the same input_channel_bindings to GSS_Init_sec_context() and GSS_Accept_sec_context(). The mechanism MUST NOT output the ret_channel_bound_flag if either (or both) peer did not provide input_channel_bindings to GSS_Init/Accept_sec_context(). This requirement restores the original base GSS-API specified behavior, with the addition of the ret_channel_bound_flag flag.

4. Security Considerations

This document deals with security. There are no security considerations that should be documented separately in this section. To recap, this document fixes a significant flaw in the base GSS-API [RFC2743] specification that fortunately has not been implemented, and it adds a feature (that should have been in the base specification) for improved negotiation of use of channel binding [RFC5056].

5. IANA Considerations

The GSS-API mechanism attribute is to be added to the "SMI Security for Mechanism gsscma Codes" registry established by RFC5587 [RFC5587]. See Section 2.4.

6. References

6.1. 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, <https://www.rfc-editor.org/info/rfc2119>.

[RFC2743] Linn, J., "Generic Security Service Application Program Interface Version 2, Update 1", RFC 2743, DOI 10.17487/RFC2743, January 2000, <https://www.rfc-editor.org/info/rfc2743>.

[RFC2744] Wray, J., "Generic Security Service API Version 2 : C-bindings", RFC 2744, DOI 10.17487/RFC2744, January 2000, <https://www.rfc-editor.org/info/rfc2744>.

[RFC5056] Williams, N., "On the Use of Channel Bindings to Secure Channels", RFC 5056, DOI 10.17487/RFC5056, November 2007, <https://www.rfc-editor.org/info/rfc5056>.

[RFC5587] Williams, N., "Extended Generic Security Service Mechanism Inquiry APIs", RFC 5587, DOI 10.17487/RFC5587, July 2009, <https://www.rfc-editor.org/info/rfc5587>.

6.2. Informative References

[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, DOI 10.17487/RFC4121, July 2005, <https://www.rfc-editor.org/info/rfc4121>.

[RFC5653] Upadhyay, M. and S. Malkani, "Generic Security Service API Version 2: Java Bindings Update", RFC 5653, DOI 10.17487/RFC5653, August 2009, <https://www.rfc-editor.org/info/rfc5653>.

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Network Working Group
Internet-Draft
Intended status: Informational
Expires: August 23, 2015

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February 19, 2015

Structure of the GSS Negotiation Loop
draft-ietf-kitten-gss-loop-05

Abstract

This document specifies the generic structure of the negotiation loop to establish a GSS security context between initiator and acceptor. The control flow of the loop is indicated for both parties, including error conditions, and indications are given for where application-specific behavior must be specified.

Status of This Memo

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1. Introduction

The Generic Security Service Application Program Interface version 2 [RFC2743] provides a generic interface for security services, in the form of an abstraction layer over the underlying security mechanisms that an application may use. A GSS initiator and acceptor exchange messages, called tokens, until a security context is established. Such a security context allows for each party to authenticate the other, the passing of confidential and/or integrity-protected messages between the initiator and acceptor, the generation of identical pseudo-random bit strings by both participants [RFC4401], and more.

During context establishment, security context tokens are exchanged synchronously, one at a time; the initiator sends the first context token. The number of tokens which must be exchanged between initiator and acceptor in order to establish the security context is dependent on the underlying mechanism as well as the desired properties of the security context, and is in general not known to the application. Accordingly, the application's control flow must include a loop within which GSS security context tokens are

exchanged, which terminates upon successful establishment of a security context or an error condition. The GSS-API, together with its security mechanisms, specifies the format and encoding of the context tokens themselves, but the application protocol must specify the necessary framing for the application to determine what octet strings constitute GSS security context tokens and pass them into the GSS-API implementation as appropriate.

The GSS-API C bindings [RFC2744] provide some example code for such a negotiation loop, but this code does not specify the application's behavior on unexpected or error conditions. As such, individual application protocol specifications have had to specify the structure of their GSS negotiation loops, including error handling, on a per-protocol basis. [RFC4462], [RFC3645], [RFC5801], [RFC4752], [RFC2203] This represents a substantial duplication of effort, and the various specifications go into different levels of detail and describe different possible error conditions. It is therefore preferable to have the structure of the GSS negotiation loop, including error conditions and token passing, described in a single specification, which can then be referred to from other documents in lieu of repeating the structure of the loop each time. This document will perform that role.

The necessary requirements for correctly performing a GSS negotiation loop are essentially all included in [RFC2743], but they are scattered in many different places. This document brings all the requirements together into one place for the convenience of implementors, even though the normative requirements remain in [RFC2743]. In a few places, this document notes additional behavior which is useful for applications but is not mandated by [RFC2743].

2. Application Protocol Requirements

Part of the purpose of this document is to guide the development of new application protocols using the GSS-API, as well as the development of new application software using such protocols. The following list is features which are necessary or useful in such an application protocol:

- A way to frame and identify security context negotiation tokens in the loop.
- Error tokens should generally also get special framing, as the recipient may have no other way to distinguish unexpected error context tokens from per-message tokens.
- Failing that, a way to indicate error status from one peer to the other, possibly accompanied by a descriptive string.

- o A protocol may use the negotiated GSS security context for per-message operations; in such cases, the protocol will need a way to frame and identify those per-message tokens and the nature of their contents. For example, a protocol message may be accompanied by the output of GSS_GetMIC() over that message; the protocol must identify the location and size of that MIC token, and indicate that it is a MIC token and what cleartext it corresponds to.

- o Applications are responsible for authorization of the authenticated peer principal names which are supplied by the GSS-API. Such names are mechanism-specific, and may come from a different portion of a federated identity scheme. Application protocols may need to supply additional information to support the authorization of access to a given resource, such as the SSHv2 "username" parameter.

3. Loop Structure

The loop is begun by the appropriately named initiator, which calls GSS_Init_sec_context() with an empty (zero-length) input_token and a fixed set of input flags containing the desired attributes for the security context. The initiator should not change any of the input parameters to GSS_Init_sec_context() between calls to it during the loop, with the exception of the input_token parameter, which will contain a message from the acceptor after the initial call, and the input_context_handle, which must be the result returned in the output_context_handle of the previous call to GSS_Init_sec_context() (GSS_C_NO_CONTEXT for the first call). (In the C bindings, there is only a single read/modify context_handle argument, so the same variable should be passed for each call in the loop.) RFC 2743 only requires that the claimant_cred_handle argument remain constant over all calls in the loop, but the other non-excepted arguments should also remain fixed for reliable operation.

The following subsections will describe the various steps of the loop, without special consideration to whether a call to GSS_Init_sec_context() or GSS_Accept_sec_context() is the first such call in the loop.

3.1. Anonymous Initiators

If the initiator is requesting anonymity by setting the anon_req_flag input to GSS_Init_sec_context(), then on non-error returns from GSS_Init_sec_context() (that is, when the major status is GSS_S_COMPLETE or GSS_S_CONTINUE_NEEDED), the initiator must verify that the output value of anon_state from GSS_Init_sec_context() is true before sending the security context token to the acceptor.

Failing to perform this check could cause the initiator to lose anonymity.

3.2. GSS_Init_sec_context

The initiator calls GSS_Init_sec_context(), using the input_context_handle for the current security context being established and its fixed set of input parameters, and the input_token received from the acceptor (if this is not the first iteration of the loop). The presence or absence of a nonempty output_token and the value of the major status code are the indicators for how to proceed:

- If the major status code is GSS_S_COMPLETE and the output_token is empty, then the context negotiation is fully complete and ready for use by the initiator with no further actions.

- If the major status code is GSS_S_COMPLETE and the output_token is nonempty, then the initiator's portion of the security context negotiation is complete but the acceptor's is not. The initiator must send the output_token to the acceptor so that the acceptor can establish its half of the security context.

- If the major status code is GSS_S_CONTINUE_NEEDED and the output_token is nonempty, the context negotiation is incomplete. The initiator must send the output_token to the acceptor and await another input_token from the acceptor.

- If the major status code is GSS_S_CONTINUE_NEEDED and the output_token is empty, the mechanism has produced an output which is not compliant with [RFC2743]. However, there are some known implementations of certain mechanisms such as NTLMSSP [NTLMSSP] which do produce empty context negotiation tokens. For maximum interoperability, applications should be prepared to accept such tokens, and should transmit them to the acceptor if they are generated.

- If the major status code is any other value, the context negotiation has failed. If the output_token is nonempty, it is an error token, and the initiator should send it to the acceptor. If the output_token is empty, then the initiator should indicate the failure to the acceptor if an appropriate application-protocol channel to do so is available.

3.3. Sending from Initiator to Acceptor

The establishment of a GSS security context between initiator and acceptor requires some communication channel by which to exchange the context negotiation tokens. The nature of this channel is not specified by the GSS specification -- it could be a dedicated TCP channel, a UDP-based RPC protocol, or any other sort of channel. In many cases, the channel will be multiplexed with non-GSS application data; the application protocol must always provide some means by which the GSS context tokens can be identified (e.g., length and start location) and passed through to the mechanism accordingly. The application protocol may also include a facility for indicating errors from one party to the other, which can be used to convey errors resulting from GSS-API calls, when appropriate (such as when no error token was generated by the GSS-API implementation). Note that GSS major and minor status codes are specified by language bindings, not the abstract API; sending a major status code and optionally the display form of the two error codes may be the best that can be done in this case.

However, even the presence of a communication channel does not necessarily indicate that it is appropriate for the initiator to indicate such errors. For example, if the acceptor is a stateless or near-stateless UDP server, there is probably no need for the initiator to explicitly indicate its failure to the acceptor. Conditions such as this can be treated in individual application protocol specifications.

If a regular security context output_token is produced by the call to GSS_Init_sec_context(), the initiator must transmit this token to the acceptor over the application's communication channel. If the call to GSS_Init_sec_context() returns an error token as output_token, it is recommended that the initiator transmit this token to the acceptor over the application's communication channel.

3.4. Acceptor Sanity Checking

The acceptor's half of the negotiation loop is triggered by the receipt of a context token from the initiator. Before calling GSS_Accept_sec_context(), the acceptor may find it useful to perform some sanity checks on the state of the negotiation loop.

If the acceptor receives a context token but was not expecting such a token (for example, if the acceptor's previous call to GSS_Accept_sec_context() returned GSS_S_COMPLETE), this is probably an error condition indicating that the initiator's state is invalid. See Section 4.3 for some exceptional cases. It is likely appropriate

for the acceptor to report this error condition to the initiator via the application's communication channel.

If the acceptor is expecting a context token (e.g., if the previous call to GSS_Accept_sec_context() returned GSS_S_CONTINUE_NEEDED), but does not receive such a token within a reasonable amount of time after transmitting the previous output_token to the initiator, the acceptor should assume that the initiator's state is invalid (time out) and fail the GSS negotiation. Again, it is likely appropriate for the acceptor to report this error condition to the initiator via the application's communication channel.

3.5. GSS_Accept_sec_context

The GSS acceptor responds to the actions of an initiator; as such, there should always be a nonempty input_token to calls to GSS_Accept_sec_context(). The input_context_handle parameter will always be given as the output_context_handle from the previous call to GSS_Accept_sec_context() in a given negotiation loop, or GSS_C_NO_CONTEXT on the first call, but the acceptor_cred_handle and chan_bindings arguments should remain fixed over the course of a given GSS negotiation loop. [RFC2743] only requires that the acceptor_cred_handle remain fixed throughout the loop, but the chan_bindings argument should also remain fixed for reliable operation.

The GSS acceptor calls GSS_Accept_sec_context(), using the input_context_handle for the current security context being established and the input_token received from the initiator. The presence or absence of a nonempty output_token and the value of the major status code are the indicators for how to proceed:

- If the major status code is GSS_S_COMPLETE and the output_token is empty, then the context negotiation is fully complete and ready for use by the acceptor with no further actions.

- If the major status code is GSS_S_COMPLETE and the output_token is nonempty, then the acceptor's portion of the security context negotiation is complete but the initiator's is not. The acceptor must send the output_token to the initiator so that the initiator can establish its half of the security context.

- If the major status code is GSS_S_CONTINUE_NEEDED and the output_token is nonempty, the context negotiation is incomplete. The acceptor must send the output_token to the initiator and await another input_token from the initiator.

- If the major status code is GSS_S_CONTINUE_NEEDED and the output_token is empty, the mechanism has produced an output which is not compliant with [RFC2743]. However, there are some known implementations of certain mechanisms such as NTLMSSP [NTLMSSP] which do produce empty context negotiation tokens. For maximum interoperability, applications should be prepared to accept such tokens, and should transmit them to the initiator if they are generated.

- If the major status code is any other value, the context negotiation has failed. If the output_token is nonempty, it is an error token, and the acceptor should send it to the initiator. If the output_token is empty, then the acceptor should indicate the failure to the initiator if an appropriate application-protocol channel to do so is available.

3.6. Sending from Acceptor to Initiator

The mechanism for sending the context token from acceptor to initiator will depend on the nature of the communication channel between the two parties. For a synchronous bidirectional channel, it can be just another piece of data sent over the link, but for a stateless UDP RPC acceptor, the token will probably end up being sent as an RPC output parameter. Application protocol specifications will need to specify the nature of this behavior.

If the application protocol has the initiator driving the application's control flow, it is particularly helpful for the acceptor to indicate a failure to the initiator, as mentioned in some of the above cases conditional on "an appropriate application-protocol channel to do so".

If a regular security context output_token is produced by the call to GSS_Accept_sec_context(), the acceptor must transmit this token to the initiator over the application's communication channel. If the call to GSS_Accept_sec_context() returns an error token as output_token, it is recommended that the acceptor transmit this token to the initiator over the application's communication channel.

3.7. Initiator input validation

The initiator's half of the negotiation loop is triggered (after the first call) by receipt of a context token from the acceptor. Before calling GSS_Init_sec_context(), the initiator may find it useful to perform some sanity checks on the state of the negotiation loop.

If the initiator receives a context token but was not expecting such a token (for example, if the initiator's previous call to

GSS_Init_sec_context() returned GSS_S_COMPLETE), this is probably an error condition indicating that the acceptor's state is invalid. See Section 4.3 for some exceptional cases. It may be appropriate for the initiator to report this error condition to the acceptor via the application's communication channel.

If the initiator is expecting a context token (that is, the previous call to GSS_Init_sec_context() returned GSS_S_CONTINUE_NEEDED), but does not receive such a token within a reasonable amount of time after transmitting the previous output_token to the acceptor, the initiator should assume that the acceptor's state is invalid and fail the GSS negotiation. Again, it may be appropriate for the initiator to report this error condition to the acceptor via the application's communication channel.

3.8. Continue the Loop

If the loop is in neither a success or failure condition, then the loop must continue. Control flow returns to Section 3.2.

4. After Security Context Negotiation

Once a party has completed its half of the security context and fulfilled its obligations to the other party, the context is complete, but it is not necessarily ready and appropriate for use. In particular, the security context flags may not be appropriate for the given application's use. In some cases the context may be ready for use before the negotiation is complete, see Section 4.2.

The initiator specifies as part of its fixed set of inputs to GSS_Init_sec_context() values for all defined request flag booleans, among them: deleg_req_flag, mutual_req_flag, replay_det_req_flag, sequence_req_flag, conf_req_flag, and integ_req_flag. Upon completion of the security context negotiation, the initiator must verify that the values of the deleg_state, mutual_state, replay_det_state, sequence_state, conf_avail, and integ_avail (and any additional flags added by extensions) from the last call to GSS_Init_sec_context() correspond to the requested flags. If a flag was requested but is not available, and that feature is necessary for the appplication protocol, the initiator must destroy the security context and not use the security context for application traffic.

Application protocol specifications citing this document should indicate which context flags are required for their application protocol.

The acceptor receives as output the following booleans: deleg_state, mutual_state, replay_det_state, sequence_state, anon_state,

trans_state, conf_avail, and integ_avail, and any additional flags added by extensions to the GSS-API. The acceptor must verify that any flags necessary for the application protocol are set. If a necessary flag is not set, the acceptor must destroy the security context and not use the security context for application traffic.

4.1. Authorization Checks

The acceptor receives as one of the outputs of GSS_Accept_sec_context() the name of the initiator which has authenticated during the security context negotiation. Applications need to implement authorization checks on this received name ('client_name' in the sample code) before providing access to restricted resources. In particular, security context negotiation can be successful when the client is anonymous or is from a different identity realm than the acceptor, depending on the details of the mechanism used by the GSS-API to establish the security context. Acceptor applications can check which target name was used by the initiator, but the details are out of scope for this document. See [RFC2743] sections 2.2.6 and 1.1.5. Additional information can be available in GSS-API Naming Extensions, [RFC6680].

4.2. Using Partially Complete Security Contexts

For mechanism/flag combinations that require multiple token exchanges, the GSS-API specification [RFC2743] provides a prot_ready_state output value from GSS_Init_sec_context() and GSS_Accept_sec_context(), which indicates when per-message operations are available. However, many mechanism implementations do not provide this functionality, and the analysis of the security consequences of its use is rather complicated, so it is not expected to be useful in most application protocols.

In particular, mutual authentication, replay protection, and other services (if requested) are services which will be active when GSS_S_COMPLETE is returned, but which are not necessarily active before the security context is fully established.

4.3. Additional Context Tokens

Under some conditions, a context token will be received by a party to a security context negotiation after that party has completed the negotiation (i.e., after GSS_Init_sec_context() or GSS_Accept_sec_context() has returned GSS_S_COMPLETE). Such tokens must be passed to GSS_Process_context_token() for processing. It may not always be necessary for a mechanism implementation to generate an error token on the initiator side, or for an initiator application to transmit that token to the acceptor; such decisions are out of scope

for this document. Both peers should always be prepared to process such tokens, and application protocols should provide means by which they can be transmitted.

Such tokens can be security context deletion tokens, emitted when the remote party called GSS_Delete_sec_context() with a non-null output_context_token parameter, or error tokens, emitted when the remote party experiences an error processing the last token in a security context negotiation exchange. Errors experienced when processing tokens earlier in the negotiation would be transmitted as normal security context tokens and processed by GSS_Init_sec_context() or GSS_Accept_sec_context(), as appropriate. With the GSS-API version 2, it is not recommended to use security context deletion tokens, so error tokens are expected to be the most common form of additional context token for new application protocols.

GSS_Process_context_token() may indicate an error in its major_status field if an error is encountered locally during token processing, or to indicate that an error was encountered on the peer and conveyed in an error token. See [RFC2743] Errata #4151. Regardless of the major_status output of GSS_Process_context_token(), GSS_Inquire_context() should be used after processing the extra token, to query the status of the security context and whether it can supply the features necessary for the application protocol.

At present, all tokens which should be handled by GSS_Process_context_token() will lead to the security context being effectively unusable. Future extensions to the GSS-API may allow for applications to continue to function after a call to GSS_Process_context_token(), and it is expected that the outputs of GSS_Inquire_context() will indicate whether it is safe to do so. However, since there are no such extensions at present (error tokens and deletion tokens both result in the security context being essentially unusable), there is no guidance to give to applications regarding this possibility at this time.

Even if GSS_Process_context_token() processes an error or deletion token which renders the context essentially unusable, the resources associated with the context must eventually be freed with a call to GSS_Delete_sec_context(), just as would be needed if GSS_Init_sec_context() or GSS_Accept_sec_context() had returned an error while processing an input context token and the input_context_handle was not GSS_C_NO_CONTEXT. RFC 2743 has some text which is slightly ambiguous in this regard, but the best practice is to always call GSS_Delete_sec_context().

5. Sample Code

This section gives sample code for the GSS negotiation loop, both for a regular application and for an application where the initiator wishes to remain anonymous. Since the code for the two cases is very similar, the anonymous-specific additions are wrapped in a conditional check; that check and the conditional code may be ignored if anonymous processing is not needed.

Since the communication channel between the initiator and acceptor is a matter for individual application protocols, it is inherently unspecified at the GSS-API level, which can lead to examples that are less satisfying than may be desired. For example, the sample code in [RFC2744] uses an unspecified send_token_to_peer() routine. Fully correct and general code to frame and transmit tokens requires a substantial amount of error checking and would detract from the core purpose of this document, so we only present the function signature for one example of what such functions might be, and leave some comments in the otherwise-empty function bodies.

This sample code is written in C, using the GSS-API C bindings [RFC2744]. It uses the macro GSS_ERROR() to help unpack the various sorts of information which can be stored in the major status field; supplementary information does not necessarily indicate an error. Applications written in other languages will need to exercise care that checks against the major status value are written correctly.

This sample code should be compilable as a standalone program, linked against a GSS-API library. In addition to supplying implementations for the token transmission/receipt routines, in order for the program to successfully run when linked against most GSS-API libraries, the initiator will need to specify an explicit target name for the acceptor, which must match the credentials available to the acceptor. A skeleton for how this may be done is provided, using a dummy name.

This sample code assumes v2 of the GSS-API. Applications wishing to remain compatible with v1 of the GSS-API may need to perform additional checks in some locations.

5.1. GSS Application Sample Code

```
#include <unistd.h>
#include <err.h>
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <gssapi/gssapi.h>
```

```
/*
 * This helper is used only on buffers that we allocate ourselves (e.g.,
 * from receive_token()).  Buffers allocated by GSS routines must use
 * gss_release_buffer().
 */
static void
release_buffer(gss_buffer_t buf)
{
    free(buf->value);
    buf->value = NULL;
    buf->length = 0;
}

/*
 * Helper to send a token on the specified fd.
 *
 * If errors are encountered, this routine must not directly cause
 * termination of the process, because compliant GSS applications
 * must release resources allocated by the GSS library before
 * exiting.
 *
 * Returns 0 on success, non-zero on failure.
 */
static int
send_token(int fd, gss_buffer_t token)
{
    /*
     * Supply token framing and transmission code here.
     *
     * It is advisable for the application protocol to specify the
     * length of the token being transmitted, unless the underlying
     * transit does so implicitly.
     *
     * In addition to checking for error returns from whichever
     * syscall(s) are used to send data, applications should have
     * a loop to handle EINTR returns.
     */
    return 1;
}

/*
 * Helper to receive a token on the specified fd.
 *
 * If errors are encountered, this routine must not directly cause
 * termination of the process, because compliant GSS applications
 * must release resources allocated by the GSS library before
 * exiting.
 *
```

```
 * Returns 0 on success, non-zero on failure.
 */
static int
receive_token(int fd, gss_buffer_t token)
{
    /*
     * Supply token framing and transmission code here.
     *
     * In addition to checking for error returns from whichever
     * syscall(s) are used to receive data, applications should have
     * a loop to handle EINTR returns.
     *
     * This routine is assumed to allocate memory for the local copy
     * of the received token, which must be freed with release_buffer().
     */
    return 1;
}

static void
do_initiator(int readfd, int writefd, int anon)
{
    int initiator_established = 0, ret;
    gss_ctx_id_t ctx = GSS_C_NO_CONTEXT;
    OM_uint32 major, minor, req_flags, ret_flags;
    gss_buffer_desc input_token = GSS_C_EMPTY_BUFFER;
    gss_buffer_desc output_token = GSS_C_EMPTY_BUFFER;
    gss_buffer_desc name_buf = GSS_C_EMPTY_BUFFER;
    gss_name_t target_name = GSS_C_NO_NAME;

    /* Applications should set target_name to a real value. */
    name_buf.value = "<service>@<hostname.domain>";
    name_buf.length = strlen(name_buf.value);
    major = gss_import_name(&minor, &name_buf,
                            GSS_C_NT_HOSTBASED_SERVICE, &target_name);
    if (GSS_ERROR(major)) {
        warnx(1, "Could not import name\n");
        goto cleanup;
    }

    /* Mutual authentication will require a token from acceptor to
     * initiator, and thus a second call to gss_init_sec_context(). */
    req_flags = GSS_C_MUTUAL_FLAG | GSS_C_CONF_FLAG | GSS_C_INTEG_FLAG;
    if (anon)
        req_flags |= GSS_C_ANON_FLAG;

    while (!initiator_established) {
        /* The initiator_cred_handle, mech_type, time_req,
         * input_chan_bindings, actual_mech_type, and time_rec
```

```
         * parameters are not needed in many cases.  We pass
         * GSS_C_NO_CREDENTIAL, GSS_C_NO_OID, 0, NULL, NULL, and NULL
         * for them, respectively. */
        major = gss_init_sec_context(&minor, GSS_C_NO_CREDENTIAL, &ctx,
                                     target_name, GSS_C_NO_OID,
                                     req_flags, 0, NULL, &input_token,
                                     NULL, &output_token, &ret_flags,
                                     NULL);
        /* This was allocated by receive_token() and is no longer
         * needed.  Free it now to avoid leaks if the loop continues. */
        release_buffer(&input_token);
        if (anon) {
            /* Initiators which wish to remain anonymous must check
             * whether their request has been honored before sending
             * each token. */
            if (!(ret_flags & GSS_C_ANON_FLAG)) {
                warnx("Anonymous requested but not available\n");
                goto cleanup;
            }
        }
        /* Always send a token if we are expecting another input token
         * (GSS_S_CONTINUE_NEEDED is set) or if it is nonempty. */
        if ((major & GSS_S_CONTINUE_NEEDED) ||
            output_token.length > 0) {
            ret = send_token(writefd, &output_token);
            if (ret != 0)
                goto cleanup;
        }
        /* Check for errors after sending the token so that we will send
         * error tokens. */
        if (GSS_ERROR(major)) {
            warnx("gss_init_sec_context() error major 0x%x\n", major);
            goto cleanup;
        }
        /* Free the output token's storage; we don't need it anymore.
         * gss_release_buffer() is safe to call on the output buffer
         * from gss_int_sec_context(), even if there is no storage
         * associated with that buffer. */
        (void)gss_release_buffer(&minor, &output_token);

        if (major & GSS_S_CONTINUE_NEEDED) {
            ret = receive_token(readfd, &input_token);
            if (ret != 0)
                goto cleanup;
        } else if (major == GSS_S_COMPLETE) {
            initiator_established = 1;
        } else {
            /* This situation is forbidden by RFC 2743.  Bail out. */
```

```
            warnx("major not complete or continue but not error\n");
            goto cleanup;
        }
    }   /* while (!initiator_established) */
    if ((ret_flags & req_flags) != req_flags) {
        warnx("Negotiated context does not support requested flags\n");
        goto cleanup;
    }
    printf("Initiator's context negotiation successful\n");
cleanup:
    /* We are required to release storage for nonzero-length output
     * tokens.  gss_release_buffer() zeros the length, so we are
     * will not attempt to release the same buffer twice. */
    if (output_token.length > 0)
        (void)gss_release_buffer(&minor, &output_token);
    /* Do not request a context deletion token; pass NULL. */
    (void)gss_delete_sec_context(&minor, &ctx, NULL);
    (void)gss_release_name(&minor, &target_name);
}

/*
 * Perform authorization checks on the initiator's GSS name object.
 *
 * Returns 0 on success (the initiator is authorized) and nonzero
 * when the initiator is not authorized.
 */
static int
check_authz(gss_name_t client_name)
{
    /*
     * Supply authorization checking code here.
     *
     * Options include bitwise comparison of the exported name against
     * a local database, and introspection against name attributes.
     */
    return 0;
}

static void
do_acceptor(int readfd, int writefd)
{
    int acceptor_established = 0, ret;
    gss_ctx_id_t ctx = GSS_C_NO_CONTEXT;
    OM_uint32 major, minor, ret_flags;
    gss_buffer_desc input_token = GSS_C_EMPTY_BUFFER;
    gss_buffer_desc output_token = GSS_C_EMPTY_BUFFER;
    gss_name_t client_name;
```

```
    major = GSS_S_CONTINUE_NEEDED;

    while (!acceptor_established) {
        if (major & GSS_S_CONTINUE_NEEDED) {
            ret = receive_token(readfd, &input_token);
            if (ret != 0)
                goto cleanup;
        } else if (major == GSS_S_COMPLETE) {
            acceptor_established = 1;
            break;
        } else {
            /* This situation is forbidden by RFC 2743.  Bail out. */
            warnx("major not complete or continue but not error\n");
            goto cleanup;
        }
        /* We can use the default behavior or do not need the returned
         * information for the parameters acceptor_cred_handle,
         * input_chan_bindings, mech_type, time_rec, and
         * delegated_cred_handle and pass the values
         * GSS_C_NO_CREDENTIAL, NULL, NULL, NULL, and NULL,
         * respectively.  In some cases the src_name will not be
         * needed, but most likely it will be needed for some
         * authorization or logging functionality. */
        major = gss_accept_sec_context(&minor, &ctx,
                                       GSS_C_NO_CREDENTIAL,
                                       &input_token, NULL,
                                       &client_name, NULL,
                                       &output_token, &ret_flags, NULL,
                                       NULL);
        /* This was allocated by receive_token() and is no longer
         * needed.  Free it now to avoid leaks if the loop continues. */
        release_buffer(&input_token);
        /* Always send a token if we are expecting another input token
         * (GSS_S_CONTINUE_NEEDED is set) or if it is nonempty. */
        if ((major & GSS_S_CONTINUE_NEEDED) ||
            output_token.length > 0) {
            ret = send_token(writefd, &output_token);
            if (ret != 0)
                goto cleanup;
        }
        /* Check for errors after sending the token so that we will send
         * error tokens. */
        if (GSS_ERROR(major)) {
            warnx("gss_accept_sec_context() error major 0x%x\n", major);
            goto cleanup;
        }
        /* Free the output token's storage; we don't need it anymore.
         * gss_release_buffer() is safe to call on the output buffer
```

```
         * from gss_accept_sec_context(), even if there is no storage
         * associated with that buffer. */
        (void)gss_release_buffer(&minor, &output_token);
    }   /* while (!acceptor_established) */
    if (!(ret_flags & GSS_C_INTEG_FLAG)) {
        warnx("Negotiated context does not support integrity\n");
        goto cleanup;
    }
    printf("Acceptor's context negotiation successful\n");
    ret = check_authz(client_name);
    if (ret != 0)
        printf("Client is not authorized; rejecting access\n");
cleanup:
    release_buffer(&input_token);
    /* We are required to release storage for nonzero-length output
     * tokens.  gss_release_buffer() zeros the length, so we are
     * will not attempt to release the same buffer twice. */
    if (output_token.length > 0)
        (void)gss_release_buffer(&minor, &output_token);
    /* Do not request a context deletion token, pass NULL. */
    (void)gss_delete_sec_context(&minor, &ctx, NULL);
    (void)gss_release_name(&minor, &client_name);
}

int
main(void)
{
    pid_t pid;
    int fd1 = -1, fd2 = -1;

    /* Create fds for reading/writing here. */
    pid = fork();
    if (pid == 0)
        do_initiator(fd1, fd2, 0);
    else if (pid > 0)
        do_acceptor(fd2, fd1);
    else
        err(1, "fork() failed\n");
    exit(0);
}
```

6. IANA Considerations

This document makes no request of IANA.

7. Security Considerations

This document provides a (reasonably) concise description and example for correct construction of the GSS-API security context negotiation loop. Since everything relating to the construction and use of a GSS security context is security-related, there are security-relevant considerations throughout the document. It is useful to call out a few things in this section, though.

The GSS-API uses a request-and-check model for features. An application using the GSS-API requests certain features (confidentiality protection for messages, or anonymity), but such a request does not require the GSS implementation to provide that feature. The application must check the returned flags to verify whether a requested feature is present; if the feature was non-optional for the application, the application must generate an error. Phrased differently, the GSS-API will not generate an error if it is unable to satisfy the features requested by the application.

In many cases it is convenient for GSS acceptors to accept security contexts using multiple acceptor names (such as by using the default credential set, as happens when GSS_C_NO_CREDENTIAL is passed to GSS_Accept_sec_context()). This allows acceptors to use any credentials to which it has access for accepting security contexts, which may not be the desired behavior for a given application. (For example, sshd may only wish to accept only using GSS_C_NT_HOSTBASED credentials of the form host@<hostname>, and not nfs@<hostname>.) Acceptor applications can check which target name was used by the initiator, but the details are out of scope for this document. See [RFC2743] sections 2.2.6 and 1.1.5.

The C sample code uses the macro GSS_ERROR() to assess the return value of gss_init_sec_context() and gss_accept_sec_context(). This is done to indicate where checks are needed in writing code for other languages and what the nature of those checks might be. The C code could be made simpler by omitting that macro. In applications expecting to receive protected octet streams, this macro should not be used on the result of per-message operations, as it omits checking for supplementary status values such as GSS_S_DUPLICATE_TOKEN, GSS_S_OLD_TOKEN, etc.. Use of the GSS_ERROR() macro on the results of GSS-API per-message operations has resulted in security vulnerabilities in existing software!

The security considerations from RFCs 2743 and 2744 remain applicable to consumers of this document.

8. References

8.1. Normative References

[RFC2743] Linn, J., "Generic Security Service Application Program Interface Version 2, Update 1", RFC 2743, January 2000.

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8.2. Informational References

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Appendix A. Acknowledgements

Thanks to Nico Williams and Jeff Hutzleman for prompting me to write this document.

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NETWORK WORKING GROUP
Internet-Draft
Intended status: Standards Track
Expires: October 1, 2017

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Namespace Considerations and Registries for GSS-API Extensions
draft-ietf-kitten-gssapi-extensions-iana-11.txt

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.

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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

[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>.

[RFC2743] Linn, J., "Generic Security Service Application Program Interface Version 2, Update 1", RFC 2743, DOI 10.17487/RFC2743, January 2000, <http://www.rfc-editor.org/info/rfc2743>.

[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>.

10.2. Informative References

[RFC1964] Linn, J., "The Kerberos Version 5 GSS-API Mechanism", RFC 1964, DOI 10.17487/RFC1964, June 1996, <http://www.rfc-editor.org/info/rfc1964>.

[RFC2744] Wray, J., "Generic Security Service API Version 2 : C-bindings", RFC 2744, DOI 10.17487/RFC2744, January 2000, <http://www.rfc-editor.org/info/rfc2744>.

[RFC2853] Kabat, J. and M. Upadhyay, "Generic Security Service API Version 2 : Java Bindings", RFC 2853, DOI 10.17487/RFC2853, June 2000, <http://www.rfc-editor.org/info/rfc2853>.

[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, DOI 10.17487/RFC4121, July 2005, <http://www.rfc-editor.org/info/rfc4121>.

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NETWORK WORKING GROUP
Internet-Draft
Updates: 4120,4121 (if approved)
Intended status: Standards Track
Expires: October 1, 2017

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March 30, 2017

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.

Copyright Notice

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

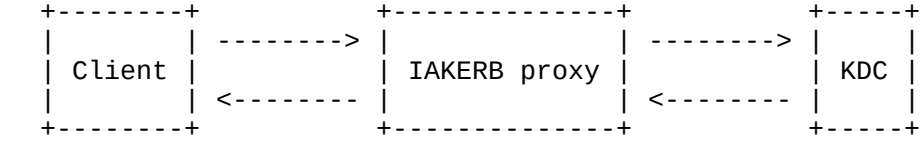
The GSS-API mechanism Objection Identifier (OID) for IAKERB is id-kerberos-iakerb:

```
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

[CCITT.X680.2002]
International Telephone and Telegraph Consultative Committee, "Abstract Syntax Notation One (ASN.1): Specification of basic notation", CCITT Recommendation X.680, July 2002.

[CCITT.X690.2002]
International Telephone and Telegraph Consultative Committee, "ASN.1 encoding rules: Specification of basic encoding Rules (BER), Canonical encoding rules (CER) and Distinguished encoding rules (DER)", CCITT Recommendation X.690, July 2002.

[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>.

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[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>.

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[RFC6542] Emery, S., "Kerberos Version 5 Generic Security Service Application Program Interface (GSS-API) Channel Binding Hash Agility", RFC 6542, DOI 10.17487/RFC6542, March 2012, <http://www.rfc-editor.org/info/rfc6542>.

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[RFC6112] Zhu, L., Leach, P., and S. Hartman, "Anonymity Support for Kerberos", RFC 6112, DOI 10.17487/RFC6112, April 2011, <http://www.rfc-editor.org/info/rfc6112>.

[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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NETWORK WORKING GROUP
Internet-Draft
Obsoletes: 4402 (if approved)
Intended status: Standards Track
Expires: June 13, 2016

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December 11, 2015

A Pseudo-Random Function (PRF) for the Kerberos V Generic Security Service Application Program Interface (GSS-API) Mechanism
draft-ietf-kitten-rfc4402bis-02

Abstract

This document defines the Pseudo-Random Function (PRF) for the Kerberos V mechanism for the Generic Security Service Application Program Interface (GSS-API), based on the PRF defined for the Kerberos V cryptographic framework, for keying application protocols given an established Kerberos V GSS-API security context.

This document obsoletes RFC 4402 and reclassifies that document as historic. RFC 4402 starts the PRF+ counter at 1, however a number of implementations starts the counter at 0. As a result, the original specification would not be interoperable with existing implementations.

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 June 13, 2016.

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1. Introduction

This document specifies the Kerberos V GSS-API mechanism's [RFC4121] pseudo-random function corresponding to [RFC4401]. The function is a "PRF+" style construction. For more information see [RFC4401], [RFC2743], [RFC2744] and [RFC4121].

This document obsoletes RFC 4402 and reclassifies that document as historic. RFC 4402 starts the PRF+ counter at 1, however a number of implementations starts the counter at 0. As a result, the original specification would not be interoperable with existing implementations.

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. Kerberos V GSS Mechanism PRF

The GSS-API PRF [RFC4401] function for the Kerberos V mechanism [RFC4121] shall be the output of a PRF+ function based on the encryption type's PRF function keyed with the negotiated session key of the security context corresponding to the 'prf_key' input parameter of GSS_Pseudo_random().

This PRF+ MUST be keyed with the key indicated by the 'prf_key' input parameter as follows:

- GSS_C_PRF_KEY_FULL -- use the sub-session key asserted by the acceptor, if any exists, or the sub-session asserted by the initiator, if any exists, or the Ticket's session key

- GSS_C_PRF_KEY_PARTIAL -- use the sub-session key asserted by the initiator, if any exists, or the Ticket's session key

The PRF+ function is a simple counter-based extension of the Kerberos V pseudo-random function [RFC3961] for the encryption type of the security context's keys:

```
PRF+(K, L, S) = truncate(L, T0 || T1 || .. || Tn)

Tn = pseudo-random(K, n || S)
```

where K is the key indicated by the 'prf_key' parameter, where '||' is the concatenation operator, 'n' is encoded as a network byte order 32-bit unsigned binary number, truncate(L, S) truncates the input octet string S to length L, and pseudo-random() is the Kerberos V pseudo-random function [RFC3961].

The maximum output size of the Kerberos V mechanism's GSS-API PRF then is, necessarily, 2^32 times the output size of the pseudo-random() function for the encryption type of the given key.

When the input size is longer than 2^14 octets as per [RFC4401] and exceeds an implementation's resources, then the mechanism MUST return GSS_S_FAILURE and GSS_KRB5_S_KG_INPUT_TOO_LONG as the minor status code.

4. IANA Considerations

This document has no IANA considerations currently. If and when a relevant IANA registry of GSS-API symbols and constants is created, then the GSS_KRB5_S_KG_INPUT_TOO_LONG minor status code should be added to such a registry.

5. Security Considerations

Kerberos V encryption types' PRF functions use a key derived from contexts' session keys and should preserve the forward security properties of the mechanisms' key exchanges.

Legacy Kerberos V encryption types may be weak, particularly the single-DES encryption types.

See also [RFC4401] for generic security considerations of GSS_Pseudo_random().

See also [RFC3961] for generic security considerations of the Kerberos V cryptographic framework.

Use of Ticket session keys, rather than sub-session keys, when initiators and acceptors fail to assert sub-session keys, is dangerous as ticket reuse can lead to key reuse; therefore, initiators should assert sub-session keys always, and acceptors should assert sub-session keys at least when initiators fail to do so.

The computational cost of computing this PRF+ may vary depending on the Kerberos V encryption types being used, but generally the computation of this PRF+ gets more expensive as the input and output octet string lengths grow (note that the use of a counter in the PRF+ construction allows for parallelization).

6. Acknowledgements

This document is an update to Nico Williams' RFC. Greg Hudson has provided the test vectors based on MIT's implementation.

7. Normative References

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[RFC4401] Williams, N., "A Pseudo-Random Function (PRF) API Extension for the Generic Security Service Application Program Interface (GSS-API)", RFC 4401, DOI 10.17487/RFC4401, February 2006, <http://www.rfc-editor.org/info/rfc4401>.

Appendix A. Test Vectors

Here are some test vectors from the MIT implementation provided by Greg Hudson. Test cases used include input string lengths of 0 and 61 bytes, and an output length of 44 bytes. 61 bytes of input is just enough to produce a partial second MD5 or SHA1 hash block with the four-byte counter prefix. 44 bytes of output requires two full and one partial RFC 3961 PRF output for all existing enctypes. All keys were randomly generated.

```
Enctype: des-cbc-crc
Key: E607FE9DABB57AE0
Input: (empty string)
Output: 803C4121379FC4B87CE413B67707C4632EBED2C6D6B7
        2A55E878836E35E21600D915D590DED5B6D77BB30A1F

Enctype: des-cbc-crc
Key: 54758316B6257A75
Input: ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz123456789
Output: 279E4105F7ADC9BD6EF28ABE31D89B442FE0058388BA
        33264ACB5729562DC637950F6BD144B654BE7700B2D6

Enctype: des3-cbc-sha1
Key: 70378A19CD64134580C27C0115D6B34A1CF2FEECEF9886A2
Input: (empty string)
Output: 9F8D127C520BB826BFF3E0FE5EF352389C17E0C073D9
        AC4A333D644D21BA3EF24F4A886D143F85AC9F6377FB

Enctype: des3-cbc-sha1
Key: 3452A167DF1094BA1089E0A20E9E51ABEF1525922558B69E
Input: ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz123456789
Output: 6BF24FABC858F8DD9752E4FCD331BB831F238B5BE190
        4EEA42E38F7A60C588F075C5C96A67E7F8B7BD0AECF4

Enctype: rc4-hmac
Key: 3BB3AE288C12B3B9D06B208A4151B3B6
Input: (empty string)
Output: 9AEA11A3BCF3C53F1F91F5A0BA2132E2501ADF5F3C28
        3C8A983AB88757CE865A22132D6100EAD63E9E291AFA

Enctype: rc4-hmac
Key: 6DB7B33A01BD2B72F7655CB7B3D5FA0B
Input: ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz123456789
Output: CDA9A544869FC84873B692663A82AFDA101C8611498B
        A46138B01E927C9B95EEC953B562807434037837DDDF

Enctype: aes128-cts-hmac-sha1-96
Key: 6C742096EB896230312B73972FA28B5D
```

```
   Input: (empty string)
   Output: 94208D982FC1BB7778128BDD77904420B45C9DA699F3
           117BCE66E39602128EF0296611A6D191A5828530F20F

   Enctype: aes128-cts-hmac-sha1-96
   Key: FA61138C109D834A477D24C7311BE6DA
   Input: ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz123456789
   Output: 0FAEDF0F842CC834FEE750487E1B622739286B975FE5
           B7F45AB053143C75CA0DF5D3D4BBB80F6A616C7C9027

   Enctype: aes256-cts-hmac-sha1-96
   Key: 08FCDAFD5832611B73BA7B497FEBFF8C954B4B58031CAD9B977C3B8C25192FD6
   Input: (empty string)
   Output: E627EFC14EF5B6D629F830C7109DEA0D3D7D36E8CD57
           A1F301C5452494A1928F05AFFBEE3360232209D3BE0D

   Enctype: aes256-cts-hmac-sha1-96
   Key: F5B68B7823D8944F33F41541B4E4D38C9B2934F8D16334A796645B066152B4BE
   Input: ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz123456789
   Output: 112F2B2D878590653CCC7DE278E9F0AA46FA5A380B62
           59F774CB7C134FCD37F61A50FD0D9F89BF8FE1A6B593

   Enctype: camellia128-cts-cmac
   Key: 866E0466A178279A32AC0BDA92B72AEB
   Input: (empty string)
   Output: 97FBB354BF341C3A160DCC86A7A910FDA824601DF677
           68797BACEEBF5D250AE929DEC9760772084267F50A54

   Enctype: camellia128-cts-cmac
   Key: D4893FD37DA1A211E12DD1E03E0F03B7
   Input: ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz123456789
   Output: 1DEE2FF126CA563A2A2326B9DD3F0095013257414C83
           FAD4398901013D55F367C82681186B7B2FE62F746BA4

   Enctype: camellia256-cts-cmac
   Key: 203071B1AE77BD3D6FCE70174AF95C225B1CED46B35CF52B6479EFEB47E6B063
   Input: (empty string)
   Output: 9B30020634C10FDA28420CEE7B96B70A90A771CED43A
           D8346554163E5949CBAE2FB8EF36AFB6B32CE75116A0

   Enctype: camellia256-cts-cmac
   Key: A171AD582C1AFBBAD52ABD622EE6B6A14D19BF95C6914B2BA40FFD99A88EC660
   Input: ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz123456789
   Output: A47CBB6E104DCC77E4DB48A7A474B977F2FB6A7A1AB6
           52317D50508AE72B7BE2E4E4BA24164E029CBACF786B
```

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Network Working Group
Internet-Draft
Obsoletes: 5653 (if approved)
Intended status: Standards Track
Expires: August 13, 2018

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Generic Security Service API Version 2: Java Bindings Update
draft-ietf-kitten-rfc5653bis-07

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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Network Working Group
Internet-Draft
Obsoletes: 6112 (if approved)
Updates: 4120, 4121, 4556 (if approved)
Intended status: Standards Track
Expires: May 20, 2017

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November 16, 2016

Anonymity Support for Kerberos
draft-ietf-kitten-rfc6112bis-03

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.

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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

JK Jaganathan helped editing early revisions of this document.

Clifford Neuman contributed the core notions of this document.

Ken Raeburn reviewed the document and provided suggestions for improvements.

Martin Rex wrote the text for GSS-API considerations.

Nicolas Williams reviewed the GSS-API considerations section and suggested ideas for improvements.

Sam Hartman and Nicolas Williams were great champions of this work.

Miguel Garcia and Phillip Hallam-Baker reviewed the document and provided helpful suggestions.

In addition, the following individuals made significant contributions: Jeffrey Altman, Tom Yu, Chaskiel M Grundman, Love Hornquist Astrand, Jeffrey Hutzelman, and Olga Kornievskaia.

Greg Hudson and Robert Sparks had provided helpful text in the bis version of the draft.

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.

11. References

11.1. Normative References

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Network Working Group
Internet-Draft
Intended status: Standards Track
Expires: February 29, 2020

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August 28, 2019

SAML Enhanced Client SASL and GSS-API Mechanisms
draft-ietf-kitten-sasl-saml-ec-19

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 February 29, 2020.

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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 [RFC6120]. 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.

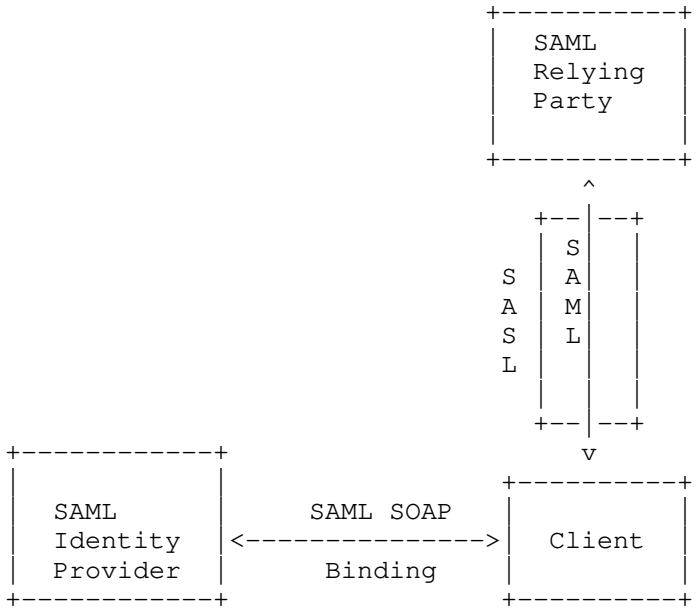

Figure 1: Interworking Architecture

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 [RFC7230] 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:

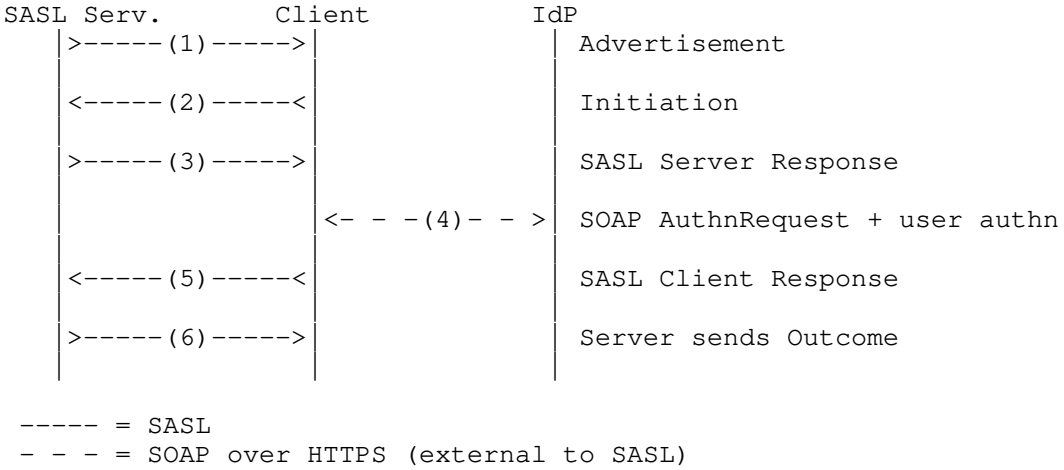

Figure 2: Authentication flow

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 [RFC7617] and TLS 1.3 client authentication as defined in [RFC8446].

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 [RFC7802]. 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
c3QgeG1sbnM6c2FtbD0idXJuOmxldGY6cGFyYW1zOnhtbDpuczpzYW1s
ZWMiCiAgICAgIHhtbG5zOlM9Imh0dHA6Ly9zY2hlbWFzLnhtbHNvYXAub3JnL3Nv
YXAvZW52ZWxvcGUvIgogICAgICBTOm11c3RVbmRlcnN0YW5kPSIxIgogICAgICBT
OmFjdG9yPSJodHRwOi8vc2NoZW1hcy54bWxzb2FwLm9yZy9zb2FwL2FjdG9yL25l
eHQiPgogICAgICA8c2FtbGVjOkVuY1R5cGU+MTc8L3NhbWxlYzpFbmNUeXBlPgog
ICAgICA8c2FtbGVjOkVuY1R5cGU+MTg8L3NhbWxlYzpFbmNUeXBlPgogICAgPHNh
bWxlYzpTZXNzaW9uS2V5PgogIDwvUzpIZWFkZXI+CiAgPFM6Qm9keUT4KICAgIDxz
YW1scDpBdXRoblJlcXVlc3QKICAgICAgSUQ9ImMzYTRmOGI5YzJkIiBWZXJzaW9u
PSIyLjAiIElzc3VlSW5zdGFudD0iMjAwNy0xMi0xMFQxMTozOTozNFoiCiAgICAg
IEFzc2VydGlvbkNvbnN1bWVyU2VydmljZVVSTD0ieG1wcEB4bXBwLmV4YW1wbGUu
Y29tIj4KICAgICAgPHNhbWw6SXNzdWVyIHhtbG5zOnNhbWw9InVybjpvYXNpczpu
YW1lczp0YzpTQU1MOjIuMDphc3NlcnRpb24iPgogICAgICAgaHR0cHM6Ly94bXBw
LmV4YW1wbGUuY29tCiAgICAgIDwvc2FtbDpJc3N1ZXI+CiAgICAgIDxzYW1scDO
YW1lSURQb2xpY3kgQWxsb3dDcmVhdGU9InRydWUiCiAgICAgICAgRm9ybWF0PSJ1
cm46b2FzaXM6bmFtZXM6dGM6U0FNTDoyLjA6bmFtZWlkLWZvcm1hdDpwZXJzaXN0
ZW50Ii8+CiAgICAgIDxzYW1scDpSZXF1ZXN0ZWRBdXRobkNvbnRleHQgQ29tcGFy
aXNvbj0iZXhhY3QiPgogICAgICAgPHNhbWw6QXV0aG5Db250ZXh0Q2xhc3NSZWY+
CiAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAgICAg
YXNzd29yZFByb3RlY3RlZFRyYW5zcG9ydAogICAgICAgPC9zYW1sOkF1dGhuQ29u
dGV4dENsYXNzUmVmPgogICAgICA8L3NhbWxwOlJlcXVlc3RlZEF1dGhuQ29udGV4
dD4gCiAgICA8L3NhbWxwOkF1dGhuUmVxdWVzdD4KPC9TOkVudmVsb3BlPgo=
</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
OkhlYWRlcj4KICA8UzpCb2R5PgogICAgPHNhbWxwOlJlIEElEPSJkNDNo
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

[OASIS.saml-bindings-2.0-os]
Cantor, S., Hirsch, F., Kemp, J., Philpott, R., and E. Maler, "Bindings for the OASIS Security Assertion Markup Language (SAML) V2.0", OASIS Standard saml-bindings-2.0-os, March 2005.

[OASIS.saml-core-2.0-os]
Cantor, S., Kemp, J., Philpott, R., and E. Maler, "Assertions and Protocol for the OASIS Security Assertion Markup Language (SAML) V2.0", OASIS Standard saml-core-2.0-os, March 2005.

[OASIS.saml-profiles-2.0-os]
Hughes, J., Cantor, S., Hodges, J., Hirsch, F., Mishra, P., Philpott, R., and E. Maler, "Profiles for the OASIS Security Assertion Markup Language (SAML) V2.0", OASIS Standard OASIS.saml-profiles-2.0-os, March 2005.

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

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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.

- 19, update obsoleted references
- 15,16,17,18 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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Network Working Group
Internet-Draft
Intended status: Standards Track
Expires: September 4, 2014

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Using Generic Security Service Application Program Interface (GSS-API) Mechanisms in Simple Authentication and Security Layer (SASL): The GS2 Mechanism Family

draft-josefsson-kitten-gs2bis-00

Abstract

This document describes how to use a Generic Security Service Application Program Interface (GSS-API) mechanism in the Simple Authentication and Security Layer (SASL) framework. This is done by defining a new SASL mechanism family, called GS2. This mechanism family offers a number of improvements over the previous "SASL/GSSAPI" mechanism: it is more general, uses fewer messages for the authentication phase in some cases, and supports negotiable use of channel binding. This is an update of RFC 5801 that relaxes the requirement for channel binding support and mutual authentication in the underlying GSS-API mechanism.

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 September 4, 2014.

Table of Contents

1. Introduction

Generic Security Service Application Program Interface (GSS-API) [RFC2743] is a framework that provides security services to applications using a variety of authentication mechanisms. Simple Authentication and Security Layer (SASL) [RFC4422] is a framework to provide authentication and security layers for connection-based protocols, also using a variety of mechanisms. This document describes how to use a GSS-API mechanism as though it were a SASL mechanism. This facility is called GS2 -- a moniker that indicates that this is the second GSS-API->SASL mechanism bridge. The original GSS-API->SASL mechanism bridge was specified by [RFC2222], now [RFC4752]; we shall sometimes refer to the original bridge as GS1 in this document.

All GSS-API mechanisms are implicitly registered for use within SASL by this specification. The SASL mechanisms defined in this document are known as the GS2 family of mechanisms.

The GS1 bridge failed to gain wide deployment for any GSS-API mechanism other than "The Kerberos Version 5 GSS-API Mechanism" [RFC1964] [RFC4121], and has a number of problems that led us to desire a new bridge. Specifically, a) GS1 was not round-trip optimized and b) GS1 did not support channel binding [RFC5056]. These problems and the opportunity to create the next SASL password-based mechanism, "Salted Challenge Response Authentication Mechanism (SCRAM) SASL and GSS-API Mechanisms" [RFC5802], as a GSS-API mechanism used by SASL applications via GS2, provide the motivation for GS2.

In particular, the current consensus of the SASL community appears to be that SASL "security layers" (i.e., confidentiality and integrity protection of application data after authentication) are too complex and redundant because SASL applications tend to have an option to run over a Transport Layer Security (TLS) [RFC5246] channel. Use of SASL security layers is best replaced with channel binding to a TLS channel.

GS2 is designed to be as simple as possible. It adds to GSS-API security context token exchanges only the bare minimum to support SASL semantics and negotiation of use of channel binding. Specifically, GS2 adds a small header (a few bytes plus the length of the client-requested SASL authorization identity) to the initial GSS-API context token and to the application channel binding data. GS2 uses SASL mechanism negotiation to implement channel binding negotiation. Security-relevant GS2 plaintext is protected via the use of GSS-API channel binding. Additionally, to simplify the implementation of GS2 mechanisms for implementors who will not

implement a GSS-API framework, we compress the initial security context token header required by [RFC2743], Section 3.1.

GS2 does not protect any plaintext exchanged outside GS2, such as SASL mechanism negotiation plaintext, or application messages following authentication. But using channel binding to a secure channel over which all SASL and application plaintext is sent will cause all that plaintext to be authenticated.

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].

The document uses many terms and function names defined in [RFC2743], as updated by [RFC5554].

3. Mechanism Name

There are two SASL mechanism names for any GSS-API mechanism used through this facility. One denotes that the server supports channel binding. The other denotes that it does not.

The SASL mechanism name for a GSS-API mechanism is that which is provided by that mechanism when it was specified, if one was specified. This name denotes that the server does not support channel binding. Add the suffix "-PLUS" and the resulting name denotes that the server does support channel binding. SASL implementations can use the GSS_Inquire_SASLname_for_mech call (see below) to query for the SASL mechanism name of a GSS-API mechanism.

If the GSS_Inquire_SASLname_for_mech interface is not used, the GS2 implementation needs some other mechanism to map mechanism Object Identifiers (OIDs) to SASL names internally. In this case, the implementation can only support the mechanisms for which it knows the SASL name. If GSS_Inquire_SASLname_for_mech() fails and the GS2 implementation cannot map the OID to a SASL mechanism name via some other means, then the GS2 implementation MUST NOT use the given GSS-API mechanism.

3.1. Generating SASL Mechanism Names from GSS-API OIDs

For GSS-API mechanisms whose SASL names are not defined together with the GSS-API mechanism or in this document, the SASL mechanism name is concatenation of the string "GS2-" and the Base32 encoding [RFC4648]

(with an uppercase alphabet) of the first 55 bits of the binary SHA-1 hash [FIPS.180-1.1995] string computed over the ASN.1 DER encoding [CCITT.X690.2002], including the tag and length octets, of the GSS-API mechanism's Object Identifier. The Base32 rules on padding characters and characters outside of the Base32 alphabet are not relevant to this use of Base32. If any padding or non-alphabet characters are encountered, the name is not a GS2 family mechanism name. This name denotes that the server does not support channel binding. Add the suffix "-PLUS" and the resulting name denotes that the server does support channel binding.

A GS2 mechanism that has a non-OID-derived SASL mechanism name is said to have a "user-friendly SASL mechanism name".

3.2. Computing Mechanism Names Manually

The hash-derived GS2 SASL mechanism name may be computed manually. This is useful when the set of supported GSS-API mechanisms is known in advance. This eliminates the need to implement Base32, SHA-1, and DER in the SASL mechanism. The computed mechanism name can be used directly in the implementation, and the implementation need not be concerned if the mechanism is part of a mechanism family.

3.3. Examples

The OID for the Simple Public-Key GSS-API Mechanism (SPKM-1) [RFC2025] is 1.3.6.1.5.5.1.1. The ASN.1 DER encoding of the OID, including the tag and length, is (in hex) 06 07 2b 06 01 05 05 01 01. The SHA-1 hash of the ASN.1 DER encoding is (in hex) 1c f8 f4 2b 5a 9f 80 fa e9 f8 31 22 6d 5d 9d 56 27 86 61 ad. Convert the first 7 octets to binary, drop the last bit, and re-group them in groups of 5, and convert them back to decimal, which results in these computations:

hex:
1c f8 f4 2b 5a 9f 80

binary:
00011100 11111000 11110100 00101011 01011010
10011111 1000000

binary in groups of 5:
00011 10011 11100 01111 01000 01010 11010 11010
10011 11110 00000

decimal of each group:
3 19 28 15 8 10 26 26 19 30 0

base32 encoding:
D T 4 P I K 2 2 T 6 A

The last step translates each decimal value using table 3 in Base32 [RFC4648]. Thus, the SASL mechanism name for the SPKM-1 GSSAPI mechanism is "GS2-DT4PIK22T6A".

The OID for the Kerberos V5 GSS-API mechanism [RFC1964] is 1.2.840.113554.1.2.2 and its DER encoding is (in hex) 06 09 2A 86 48 86 F7 12 01 02 02. The SHA-1 hash is 82 d2 73 25 76 6b d6 c8 45 aa 93 25 51 6a fc ff 04 b0 43 60. Convert the 7 octets to binary, drop the last bit, and re-group them in groups of 5, and convert them back to decimal, which results in these computations:

hex:
82 d2 73 25 76 6b d6

binary:
10000010 11010010 01110011 00100101 01110110
01101011 1101011

binary in groups of 5:
10000 01011 01001 00111 00110 01001 01011 10110
01101 01111 01011

decimal of each group:
16 11 9 7 6 9 11 22 13 15 11

base32 encoding:
Q L J H G J L W N P L

The last step translates each decimal value using table 3 in Base32 [RFC4648]. Thus, the SASL mechanism name for the Kerberos V5 GSS-API mechanism would be "GS2-QLJHGJLWNPL" and (because this mechanism

supports channel binding) "GS2-QLJHGJLWNPL-PLUS". Instead, the next section assigns the Kerberos V5 mechanism a non-hash-derived mechanism name.

3.4. Grandfathered Mechanism Names

Some older GSS-API mechanisms were not specified with a SASL GS2 mechanism name. Using a shorter name can be useful, nonetheless. We specify the names "GS2-KRB5" and "GS2-KRB5-PLUS" for the Kerberos V5 mechanism, to be used as if the original specification documented it, see Section 16.

4. SASL Authentication Exchange Message Format

During the SASL authentication exchange for GS2, a number of messages following the following format are sent between the client and server. On success, this number is the same as the number of context tokens that the GSS-API mechanism would normally require in order to establish a security context. On failures, the exchange can be terminated early by any party.

When using a GS2 mechanism the SASL client is always a GSS-API initiator and the SASL server is always a GSS-API acceptor. The client calls GSS_Init_sec_context and the server calls GSS_Accept_sec_context.

All the SASL authentication messages exchanged are exactly the same as the security context tokens of the GSS-API mechanism, except for the initial security context token.

The client and server MAY send GSS-API error tokens (tokens output by GSS_Init_sec_context() or GSS_Accept_sec_context() when the major status code is other than GSS_S_COMPLETE or GSS_S_CONTINUE_NEEDED). As this indicates an error condition, after sending the token, the sending side should fail the authentication.

The initial security context token is modified as follows:

- The initial context token header (see Section 3.1 of [RFC2743]) MUST be removed if present. If the header is not present, the client MUST send a "gs2-nonstd-flag" flag (see below). On the server side, this header MUST be recomputed and restored prior to passing the token to GSS_Accept_sec_context, except when the "gs2-nonstd-flag" is sent.
- A GS2 header MUST be prefixed to the resulting initial context token. This header has the form "gs2-header" given below in ABNF [RFC5234].

The figure below describes the permissible attributes, their use, and the format of their values. All attribute names are single US-ASCII letters and are case sensitive.

```
 UTF8-1-safe    = %x01-2B / %x2D-3C / %x3E-7F
                  ;; As UTF8-1 in RFC 3629 except
                  ;; NUL, "=", and ",".
 UTF8-2         = <as defined in RFC 3629 (STD 63)>
 UTF8-3         = <as defined in RFC 3629 (STD 63)>
 UTF8-4         = <as defined in RFC 3629 (STD 63)>
 UTF8-char-safe = UTF8-1-safe / UTF8-2 / UTF8-3 / UTF8-4

 saslname       = 1*(UTF8-char-safe / "=2C" / "=3D")
 gs2-authzid    = "a=" saslname
                    ;; GS2 has to transport an authzid since
                    ;; the GSS-API has no equivalent
 gs2-nonstd-flag = "F"
                    ;; "F" means the mechanism is not a
                    ;; standard GSS-API mechanism in that the
                    ;; RFC 2743, Section 3.1 header was missing
 cb-name         = 1*(ALPHA / DIGIT / "." / "-")
                    ;; See RFC 5056, Section 7.
 gs2-cb-flag     = ("p=" cb-name) / "n" / "y"
                    ;; GS2 channel binding (CB) flag
                    ;; "p" -> client supports and used CB
                    ;; "n" -> client does not support CB
                    ;; "y" -> client supports CB, thinks the server
                    ;;           does not
 gs2-header = [gs2-nonstd-flag ","] gs2-cb-flag "," [gs2-authzid] ","
                     ;; The GS2 header is gs2-header.
```

When the "gs2-nonstd-flag" flag is present, the client did not find/remove a token header ([RFC2743], Section 3.1) from the initial token returned by GSS_Init_sec_context. This signals to the server that it MUST NOT re-add the data that is normally removed by the client.

The "gs2-cb-flag" signals the channel binding mode. One of "p", "n", or "y" is used. A "p" means the client supports and used a channel binding, and the name of the channel binding type is indicated. An "n" means that the client does not support channel binding. A "y" means the client supports channel binding, but believes the server does not support it, so it did not use a channel binding. See the next section for more details.

The "gs2-authzid" holds the SASL authorization identity. It is encoded using UTF-8 [RFC3629] with three exceptions:

- The NUL character is forbidden as required by section 3.4.1 of [RFC4422].
- The server MUST replace any "," (comma) in the string with "=2C".
- The server MUST replace any "=" (equals) in the string with "=3D".

Upon receipt of this value, the server verifies its correctness according to the used SASL protocol profile. Failed verification results in a failed authentication exchange.

5. Channel Bindings

GS2 supports channel binding to external secure channels, such as TLS. Clients and servers may or may not support channel binding; therefore, the use of channel binding is negotiable. However, GS2 does not provide security layers; therefore, it is imperative that GS2 provide integrity protection for the negotiation of channel binding.

Use of channel binding is negotiated as follows:

- Servers that support the use of channel binding SHOULD advertise both the non-PLUS and PLUS-variant of each GS2 mechanism name. If the server cannot support channel binding, it SHOULD advertise only the non-PLUS-variant. If the server would never succeed in the authentication of the non-PLUS-variant due to policy reasons, it MUST advertise only the PLUS-variant.
- If the client supports channel binding and the server does not appear to (i.e., the client did not see the -PLUS name advertised by the server), then the client MUST NOT use an "n" gs2-cb-flag.
- Clients that support mechanism negotiation and channel binding MUST use a "p" gs2-cb-flag when the server offers the PLUS-variant of the desired GS2 mechanism.
- If the client does not support channel binding, then it MUST use an "n" gs2-cb-flag. Conversely, if the client requires the use of channel binding then it MUST use a "p" gs2-cb-flag. Clients that do not support mechanism negotiation never use a "y" gs2-cb-flag, they use either "p" or "n" according to whether they require and support the use of channel binding or whether they do not, respectively.
- The client generates the chan_bindings input parameter for GSS_Init_sec_context as described below.
- Upon receipt of the initial authentication message, the server checks the gs2-cb-flag in the GS2 header and constructs a chan_bindings parameter for GSS_Accept_sec_context as described below. If the client channel binding flag was "y" and the server did advertise support for channel bindings (by advertising the PLUS-variant of the mechanism chosen by the client), then the server MUST fail authentication. If the client channel binding flag was "p" and the server does not support the indicated channel

binding type, then the server MUST fail authentication.

- If the client used an "n" gs2-cb-flag and the server requires the use of channel binding, then the server MUST fail authentication.

FLAG	CLIENT CB SUPPORT	SERVER CB SUPPORT	DISPOSITION
n	no support	N/A	If server disallows non-channel-bound authentication, then fail
y	Yes, not required	No	Authentication may succeed; CB not used
y	Yes, not required	Yes	Authentication must fail
p	Yes	Yes	Authentication may succeed, with CB used
p	Yes	No	Authentication will fail
N/A	Yes, required	No	Client does not even try

For more discussion of channel bindings, and the syntax of the channel binding data for various security protocols, see [RFC5056].

5.1. Content of GSS-CHANNEL-BINDINGS Structure

The calls to GSS_Init_sec_context and GSS_Accept_sec_context take a chan_bindings parameter. The value is a GSS-CHANNEL-BINDINGS structure [RFC5554].

The initiator-address-type and acceptor-address-type fields of the GSS-CHANNEL-BINDINGS structure MUST be set to 0. The initiator-address and acceptor-address fields MUST be the empty string.

The application-data field MUST be set to the gs2-header, excluding the initial [gs2-nonstd-flag ","] part, concatenated with, when a gs2-cb-flag of "p" is used, the application’s channel binding data.

5.2. Default Channel Binding

A default channel binding type agreement process for all SASL application protocols that do not provide their own channel binding type agreement is provided as follows.

’tls-unique’ is the default channel binding type for any application

that doesn’t specify one.

Servers MUST implement the "tls-unique" [RFC5929] channel binding type, if they implement any channel binding. Clients SHOULD implement the "tls-unique" channel binding type, if they implement any channel binding. Clients and servers SHOULD choose the highest-layer/innermost end-to-end TLS channel as the channel to which to bind.

Servers MUST choose the channel binding type indicated by the client, or fail authentication if they don’t support it.

6. When the mechanism does not support channel binding and/or mutual authentication

Some authentication mechanisms does not offer mutual authentication or is unable to provide channel bindings. This is unfortunate, and usually suggests that the authentication mechanism offers limited authentication functionality. However there are situations when the lack of this functionality can be mitigated with other protection mechanisms, leading to acceptable overall security. Being able to define and use an authentication mechanism as a GSS-API mechanism and then use that GSS-API mechanism in the SASL environment using GS2 has advantages; for example, being able to re-use existing generic GS2 implementations. Further, being able to express all mechanisms that can be expressed as a GSS-API mechanisms as a SASL mechanism (and vice versa) provides design elegance and framework replacability. Therefor, this document relaxes the requirement that the GSS-API mechanism support channel bindings and/or mutual authentication. Implementing and deploying applications that supports those mechanism require some consideration, and this section discuss the relevant areas.

For the discussion it helps to understand what happens with the GS2 bridge when a GSS-API mechanism does not offer channel bindings or mutual authentication. When channel bindings is not supported by the underlying mechanism, GS2 cannot protect its data (essentially: the channel binding flag and the SASL authorization identity). This means that the security of the channel binding mode breaks down and that the other side cannot trust the SASL authorization identity. When mutual authentication is not happening, the client cannot know that it sends its data to the intended server.

It is acceptable to use these mechanisms with GS2 in some situations. For example, if the client uses TLS against a server, and the client verify the server’s certificate properly so that server authentication has occured, then authenticating the client to the

server using a "weak" GSS-API mechanism will technically work. The security properties will not be as good as they would have been if the underlying mechanism supported channel binding or mutual authentication, however they become as good as possible.

This document relaxes the requirements on GSS-API mechanism so that all GSS-API mechanism can be expressed in GS2. For these mechanisms, the "gs2-cb-flag" value MUST always be "n", and the PLUS-variant of the GS2 mechanism name MUST NOT be advertised or negotiated.

The SAML SASL bridge [RFC6595] and the SAML OpenID bridge [RFC6616] are two examples of documents that describe such bridges. These documents did not meet the requirements of the original GS2 bridge, but with the update in this document they are conformant. Note that both documents had discussions describing this aspect and sufficient requirements for safe implementation and deployment.

7. Examples

Example #1: a one round-trip GSS-API context token exchange, no channel binding, optional authzid given.

```
C: Request authentication exchange
S: Empty Challenge
C: n,a=someuser,<initial context token with standard
                 header removed>
S: Send reply context token as is
C: Empty message
S: Outcome of authentication exchange
```

Example #2: a one and one half round-trip GSS-API context token exchange, no channel binding.

```
C: Request authentication exchange
S: Empty Challenge
C: n,,<initial context token with standard
                 header removed>
S: Send reply context token as is
C: Send reply context token as is
S: Outcome of authentication exchange
```

Example #3: a two round-trip GSS-API context token exchange, no channel binding, no standard token header.

```
C: Request authentication exchange
S: Empty Challenge
C: F,n,,<initial context token without
                    standard header>
S: Send reply context token as is
C: Send reply context token as is
S: Send reply context token as is
C: Empty message
S: Outcome of authentication exchange
```

Example #4: using channel binding, optional authzid given.

```
C: Request authentication exchange
S: Empty Challenge
C: p=tls-unique,a=someuser,<initial context token with standard
                        header removed>
S: Send reply context token as is
...
```

Example #5: using channel binding.

```
C: Request authentication exchange
S: Empty Challenge
C: p=tls-unique,,<initial context token with standard
                        header removed>
S: Send reply context token as is
...
```

Example #6: using non-standard channel binding (requires out-of-band negotiation).

```
C: Request authentication exchange
S: Empty Challenge
C: p=tls-server-end-point,,<initial context token with standard
                        header removed>
S: Send reply context token as is
...
```

Example #7: client supports channel bindings but server does not, optional authzid given.

```
C: Request authentication exchange
S: Empty Challenge
C: y,a=someuser,<initial
                  context token with standard header removed>
S: Send reply context token as is
...
```

GSS-API authentication is always initiated by the client. The SASL framework allows either the client or the server to initiate authentication. In GS2, the server will send an initial empty challenge (zero-byte string) if it has not yet received a token from the client. See Section 3 of [RFC4422].

8. Authentication Conditions

Authentication MUST NOT succeed if any one of the following conditions are true:

- If GSS_Init/Accept_sec_context returns anything other than GSS_S_CONTINUE_NEEDED or GSS_S_COMPLETE.
- If the client's initial GS2 header does not match the ABNF.
- In particular, if the initial character of the client message is anything except "F", "p", "n", or "y".
- If the client's GS2 channel binding flag was "y" and the server supports channel bindings.
- If the client's GS2 channel binding flag was "p" and the server does not support the indicated channel binding.
- If the client requires use of channel binding and the server did not advertise support for channel binding.
- If authorization of client principal (i.e., src_name in GSS_Accept_sec_context) to requested authzid failed.
- If the client is not authorized to the requested authzid or an authzid could not be derived from the client's initiator principal name.

9. GSS-API Parameters

GS2 does not use any GSS-API per-message tokens. Therefore, the per-message token ret_flags from GSS_Init_sec_context() and GSS_Accept_sec_context() are irrelevant; implementations SHOULD NOT set the per-message req_flags.

The mutual_req_flag MUST be set. Clients MUST check that the

corresponding ret_flag is set when the context is fully established, else authentication MUST fail.

Use or non-use of deleg_req_flag and anon_req_flag is an implementation-specific detail. SASL and GS2 implementors are encouraged to provide programming interfaces by which clients may choose to delegate credentials and by which servers may receive them. SASL and GS2 implementors are encouraged to provide programming interfaces that provide a good mapping of GSS-API naming options.

10. Naming

There is no requirement that any particular GSS-API name-types be used. However, typically, SASL servers will have host-based acceptor principal names (see [RFC2743], Section 4.1) and clients will typically have username initiator principal names (see [RFC2743], Section 4.2). When a host-based acceptor principal name is used ("service@hostname"), "service" is the service name specified in the protocol's profile and "hostname" is the fully qualified host name of the server.

11. GSS_Inquire_SASLname_for_mech Call

We specify a new GSS-API utility function to allow SASL implementations to more efficiently identify the GSS-API mechanism to which a particular SASL mechanism name refers.

Inputs:

- desired_mech OBJECT IDENTIFIER

Outputs:

- major_status INTEGER
- minor_status INTEGER
- sasl_mech_name UTF-8 STRING -- SASL name for this mechanism; caller must release with GSS_Release_buffer()
- mech_name UTF-8 STRING -- name of this mechanism, possibly localized; caller must release with GSS_Release_buffer()
- mech_description UTF-8 STRING -- possibly localized description of this mechanism; caller must release with GSS_Release_buffer()

Return major_status codes:

- GSS_S_COMPLETE indicates successful completion, and that output parameters holds correct information.
- GSS_S_BAD_MECH indicates that a desired_mech was unsupported by the GSS-API implementation.
- GSS_S_FAILURE indicates that the operation failed for reasons unspecified at the GSS-API level.

The GSS_Inquire_SASLname_for_mech call is used to get the SASL mechanism name for a GSS-API mechanism. It also returns a name and description of the mechanism in user-friendly form.

The output variable sasl_mech_name will hold the IANA registered mechanism name for the GSS-API mechanism, or if none is registered, a mechanism name computed from the OID as described in Section 3.1 of this document.

11.1. gss_inquire_saslname_for_mech

The C binding for the GSS_Inquire_SASLname_for_mech call is as follows.

As mentioned in [RFC2744], routines may return GSS_S_FAILURE, indicating an implementation-specific or mechanism-specific error condition, further details of which are reported via the minor_status parameter.

```
OM_uint32 gss_inquire_saslname_for_mech(
  OM_uint32     *minor_status,
  const gss_OID  desired_mech,
  gss_buffer_t   sasl_mech_name,
  gss_buffer_t   mech_name,
  gss_buffer_t   mech_description
);
```

Purpose:

Output the SASL mechanism name of a GSS-API mechanism.
It also returns a name and description of the mechanism in a
user-friendly form.

Parameters:

minor_status	Integer, modify Mechanism-specific status code.
desired_mech	OID, read Identifies the GSS-API mechanism to query.
sasl_mech_name	buffer, character-string, modify, optional Buffer to receive SASL mechanism name. The application must free storage associated with this name after use with a call to gss_release_buffer().
mech_name	buffer, character-string, modify, optional Buffer to receive human-readable mechanism name. The application must free storage associated with this name after use with a call to gss_release_buffer().
mech_description	buffer, character-string, modify, optional Buffer to receive description of mechanism. The application must free storage associated with this name after use with a call to gss_release_buffer().
Function value:	GSS status code:
GSS_S_COMPLETE	Successful completion.
GSS_S_BAD_MECH	The desired_mech OID is unsupported.

12. GSS_Inquire_mech_for_SASLname Call

To allow SASL clients to more efficiently identify to which GSS-API mechanism a particular SASL mechanism name refers, we specify a new GSS-API utility function for this purpose.

Inputs:

- sasl_mech_name UTF-8 STRING -- SASL name of mechanism.

Outputs:

- major_status INTEGER
- minor_status INTEGER
- mech_type OBJECT IDENTIFIER -- must be explicit mechanism, and not "default" specifier. Caller should treat as read-only and should not attempt to release.

Return major_status codes:

- GSS_S_COMPLETE indicates successful completion, and that output parameters holds correct information.
- GSS_S_BAD_MECH indicates that no supported GSS-API mechanism had the indicated sasl_mech_name.
- GSS_S_FAILURE indicates that the operation failed for reasons unspecified at the GSS-API level.

The GSS_Inquire_mech_for_SASLname call is used to get the GSS-API mechanism OID associated with a SASL mechanism name.

12.1. gss_inquire_mech_for_saslname

The C binding for the GSS_Inquire_mech_for_SASLname call is as follows.

As mentioned in [RFC2744], routines may return GSS_S_FAILURE, indicating an implementation-specific or mechanism-specific error condition, further details of which are reported via the minor_status parameter.

```
OM_uint32 gss_inquire_mech_for_saslname(
  OM_uint32           *minor_status,
  const gss_buffer_t   sasl_mech_name,
  gss_OID             *mech_type
);
```

Purpose:

Output GSS-API mechanism OID of mechanism associated with given sasl_mech_name.

Parameters:

minor_status	Integer, modify Mechanism-specific status code.
sasl_mech_name	buffer, character-string, read Buffer with SASL mechanism name.
mech_type	OID, modify, optional Actual mechanism used. The OID returned via this parameter will be a pointer to static storage that should be treated as read-only. In particular, the application should not attempt to free it. Specify NULL if not required.
Function value:	GSS status code:
GSS_S_COMPLETE	Successful completion.
GSS_S_BAD_MECH	There is no GSS-API mechanism known as sasl_mech_name.

13. Security Layers

GS2 does not support SASL security layers. Applications that need integrity or confidentiality protection can use either channel

binding to a secure external channel or another SASL mechanism that does provide security layers.

14. Interoperability with the SASL GSSAPI Mechanism

The Kerberos V5 GSS-API [RFC1964] mechanism is currently used in SASL under the name GSSAPI, see [RFC4752]. The Kerberos V5 mechanism may also be used with the GS2 family. This causes an interoperability problem, which is discussed and resolved below.

14.1. The Interoperability Problem

The SASL "GSSAPI" mechanism is not wire compatible with the Kerberos V GSS-API mechanism used as a SASL GS2 mechanism.

If a client (or server) only support Kerberos V5 under the "GSSAPI" name, and the server (or client) only support Kerberos V5 under the GS2 family, the mechanism negotiation will fail.

14.2. Resolving the Problem

If the Kerberos V5 mechanism is supported under GS2 in a server, the server SHOULD also support Kerberos V5 through the "GSSAPI" mechanism, to avoid interoperability problems with older clients.

Reasons for violating this recommendation may include security considerations regarding the absent features in the GS2 mechanism. The SASL "GSSAPI" mechanism lacks support for channel bindings, which means that using an external secure channel may not be sufficient protection against active attackers (see [RFC5056] and [MITM]).

14.3. Additional Recommendations

If the application requires SASL security layers, then it MUST use the SASL "GSSAPI" mechanism [RFC4752] instead of "GS2-KRB5" or "GS2-KRB5-PLUS".

If the application can use channel binding to an external channel, then it is RECOMMENDED that it select Kerberos V5 through the GS2 mechanism rather than the "GSSAPI" mechanism.

15. GSS-API Mechanisms That Negotiate Other Mechanisms

A GSS-API mechanism that negotiates other mechanisms will interact badly with the SASL mechanism negotiation. There are two problems. The first is an interoperability problem and the second is a security

concern. The problems are described and resolved below.

15.1. The Interoperability Problem

If a client implements GSS-API mechanism X, potentially negotiated through a GSS-API mechanism Y, and the server also implements GSS-API mechanism X negotiated through a GSS-API mechanism Z, the authentication negotiation will fail.

15.2. Security Problem

If a client's policy is to first prefer GSSAPI mechanism X, then non-GSSAPI mechanism Y, then GSSAPI mechanism Z, and if a server supports mechanisms Y and Z but not X, then if the client attempts to negotiate mechanism X by using a GSS-API mechanism that negotiates other mechanisms (such as Simple and Protected GSS-API Negotiation (SPNEGO) [RFC4178]), it may end up using mechanism Z when it ideally should have used mechanism Y. For this reason, the use of GSS-API mechanisms that negotiate other mechanisms is disallowed under GS2.

15.3. Resolving the Problems

GSS-API mechanisms that negotiate other mechanisms MUST NOT be used with the GS2 SASL mechanism. Specifically, SPNEGO [RFC4178] MUST NOT be used as a GS2 mechanism. To make this easier for SASL implementations, we assign a symbolic SASL mechanism name to the SPNEGO GSS-API mechanism, "SPNEGO". SASL client implementations MUST NOT choose the SPNEGO mechanism under any circumstances.

The GSS_C_MA_MECH_NEGO attribute of GSS_Inquire_attrs_for_mech [RFC5587] can be used to identify such mechanisms.

16. IANA Considerations

The IANA has registered a SASL mechanism family as per [RFC4422] using the following information.

```
Subject: Registration of SASL mechanism family GS2-*
SASL mechanism prefix: GS2-
Security considerations: RFC 5801
Published specification: RFC 5801
Person & email address to contact for further information:
  Simon Josefsson <simon@josefsson.org>
Intended usage: COMMON
Owner/Change controller: iesg@ietf.org
Note: Compare with the GSSAPI and GSS-SPNEGO mechanisms.
```

The IANA is advised that SASL mechanism names starting with "GS2-" are reserved for SASL mechanisms that conform to this document. The IANA has placed a statement to that effect in the SASL Mechanisms registry.

The IANA is further advised that GS2 SASL mechanism names MUST NOT end in "-PLUS" except as a version of another mechanism name simply suffixed with "-PLUS".

The SASL names for the Kerberos V5 GSS-API mechanism [RFC4121] [RFC1964] used via GS2 SHALL be "GS2-KRB5" and "GS2-KRB5-PLUS".

The SASL names for the SPNEGO GSS-API mechanism used via GS2 SHALL be "SPNEGO" and "SPNEGO-PLUS". As described in Section 15, the SASL "SPNEGO" and "SPNEGO-PLUS" MUST NOT be used. These names are provided as a convenience for SASL library implementors.

17. Security Considerations

Security issues are also discussed throughout this memo.

The security provided by a GS2 mechanism depends on the security of the GSS-API mechanism. The GS2 mechanism family depends on channel binding support, so GSS-API mechanisms that do not support channel binding cannot be successfully used as SASL mechanisms via the GS2 bridge.

Because GS2 does not support security layers, it is strongly RECOMMENDED that channel binding to a secure external channel be used. Successful channel binding eliminates the possibility of man-in-the-middle (MITM) attacks, provided that the external channel and its channel binding data are secure and that the GSS-API mechanism used is secure. Authentication failure because of channel binding failure may indicate that an MITM attack was attempted, but note that a real MITM attacker would likely attempt to close the connection to the client or simulate network partition; thus, MITM attack detection is heuristic.

Use of channel binding will also protect the SASL mechanism negotiation -- if there is no MITM, then the external secure channel will have protected the SASL mechanism negotiation.

The channel binding data MAY be sent (by the actual GSS-API mechanism used) without confidentiality protection and knowledge of it is assumed to provide no advantage to an MITM (who can, in any case, compute the channel binding data independently). If the external channel does not provide confidentiality protection and the GSS-API

mechanism does not provide confidentiality protection for the channel binding data, then passive attackers (eavesdroppers) can recover the channel binding data, see [RFC5056].

When constructing the input_name_string for GSS_Import_name with the GSS_C_NT_HOSTBASED_SERVICE name type, the client SHOULD NOT canonicalize the server's fully qualified domain name using an insecure or untrusted directory service, such as the Domain Name System [RFC1034] without DNS Security (DNSSEC) [RFC4033].

SHA-1 is used to derive SASL mechanism names, but no traditional cryptographic properties are required -- the required property is that the truncated output for distinct inputs are different for practical input values. GS2 does not use any other cryptographic algorithm. Therefore, GS2 is "algorithm agile", or, as agile as the GSS-API mechanisms that are available for use in SASL applications via GS2.

GS2 does not protect against downgrade attacks of channel binding types. Negotiation of channel binding type was intentionally left out of scope for this document.

The security considerations of SASL [RFC4422], the GSS-API [RFC2743], channel binding [RFC5056], any external channels (such as TLS, [RFC5246], channel binding types (see the IANA channel binding type registry), and GSS-API mechanisms (such as the Kerberos V5 mechanism [RFC4121] [RFC1964]), also apply.

18. Acknowledgements

The history of GS2 can be traced to the "GSSAPI" mechanism originally specified by RFC 2222. This document was derived from draft-ietf-sasl-gssapi-02 which was prepared by Alexey Melnikov with significant contributions from John G. Myers, although the majority of this document has been rewritten by the current authors.

Contributions of many members of the SASL mailing list are gratefully acknowledged. In particular, ideas and feedback from Pasi Eronen, Sam Hartman, Jeffrey Hutzelman, Alexey Melnikov, and Tom Yu improved the document and the protocol. Other suggestions to the documents were made by Spencer Dawkins, Ralph Droms, Adrian Farrel, Robert Sparks, and Glen Zorn.

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Kitten Working Group
Internet-Draft
Intended status: Standards Track
Expires: April 30, 2015

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Public Key Cryptography for Initial Authentication in Kerberos (PKINIT) Freshness Extension
draft-short-pkinit-freshness-00

Abstract

This document describes how to extend Public Key Cryptography for Initial Authentication in Kerberos (PKINIT) extension [RFC4556] to exchange an opaque data blob which 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 April 30, 2015.

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Table of Contents

1. Introduction

Kerberos PKINIT [RFC4556] defines two schemes to use 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 [RFC5349] only supports Elliptic Curve Diffie-Hellman (ECDH) key agreement.

- Requires certificates with an encryption key which is not deployed on many existing smart cards.

In the Diffie-Hellman exchange, the client uses its private key only to sign the AuthPack specified in Section 3.2.1 of [RFC4556] which 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 the future times. Unless the time is outside the validity period of the client's certificate, the KDC will validate it 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 in advance.

1.1. Kerberos message flow using KRB_AS_REQ without pre-authentication

Today some password-based AS exchanges [RFC4120] depend on the client sending a KRB_AS_REQ without pre-authentication to trigger the KDC to provide the Kerberos client with information needed to complete an AS exchange such as the supported encryption types and salt value (see message flow below):

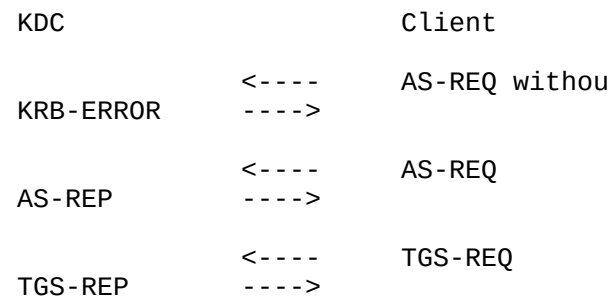

Figure 1

We can use this mechanism in PKInit for KDCs to provide data which the client returns as part of the 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

This 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 with the OPT-HARDWARE-AUTH option specified in Section 2.9.3 [RFC4120] to the KDC.

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] and includes the freshness token 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 [RFC4556] then additionally validates the freshness token.

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

2.1. Generation of KRB_ERROR Message

The KDC will indicate support by adding to the METHOD-DATA object the PA-PK-AS-KDCTOKEN with padata-type is PA_PK_AS_KDCTOKEN.

2.2. Generation of KRB_AS_REQ Message

After the client receives the KRB-ERROR message, when generating the PKInit AS-REQ it extracts PA-PK-AS-KDCTOKEN as an opaque data blob. When generating the PKAuthenticator, the PA-PK-AS-KDCTOKEN SHALL be added as an opaque blob in the kdcToken field so it becomes part of the signed data in the KRB_AS_REQ.

2.3. Receipt of KRB_AS_REQ Message

After validating the PA_PK_AS_REQ message normally, the KDC will validate the PA-PK-AS-KDCTOKEN in an implementation specific way. If the freshness token is not valid, the KDC MUST return KDC_ERR_PREAUTH_FAILED with PA-PK-AS-KDCTOKEN. 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.

3. PreAuthentication Data Types

The following are the new PreAuthentication data types:

Padata and Data Type	Padata-type Value
PA_PK_AS_KDCTOKEN	TBD

4. PA-PK-AS-KDCTOKEN

The PA-PK-AS-KDCTOKEN structure specifies an freshness token. Its structure is defined using ASN.1 notation. The syntax is as follows:

```
PA-PK-AS-KDCTOKEN ::= OCTET STRING
```

5. Extended PKAuthenticator

The PKAuthenticator structure specified in Section 3.2.1 [RFC4556] is extended to include a new kdcToken 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.
   ...,
   kdcToken     [4] PA-PK-AS-KDCTOKEN OPTIONAL,
             -- MUST be present if sent by KDC
   ...
}
```

6. Acknowledgements

Nathan Ide and Magnus Nystrom reviewed the document and provided suggestions for improvements.

7. IANA Considerations

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

Type	Value	Reference
TBD	PA_PK_AS_KDCTOKEN	[This RFC]

8. Security Considerations

The freshness token SHOULD include either signing or sealing data from the KDC to prevent tampering. Kerberos error messages are not integrity protected unless authenticated using Kerberos FAST [RFC6113].

The freshness token SHOULD include signing, encrypting or sealing data from the KDC to determine authenticity. Even if FAST is required to provide integrity protection, a different KDC would not be able to validate freshness tokens without some kind of shared database.

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.

9. References

9.1. Normative References

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, March 1997.

[RFC4120] Neuman, C., Yu, T., Hartman, S., and K. Raeburn, "The Kerberos Network Authentication Service (V5)", RFC 4120, July 2005.

[RFC4556] Zhu, L. and B. Tung, "Public Key Cryptography for Initial Authentication in Kerberos (PKINIT)", RFC 4556, June 2006.

[RFC5349] Zhu, L., Jaganathan, K., and K. Lauter, "Elliptic Curve Cryptography (ECC) Support for Public Key Cryptography for Initial Authentication in Kerberos (PKINIT)", RFC 5349, September 2008.

9.2. Informative References

[RFC6113] Hartman, S. and L. Zhu, "A Generalized Framework for Kerberos Pre-Authentication", RFC 6113, April 2011.

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