John Linn
Networking and Communications Architecture
Digital Equipment Corporation
550 King Street, LKG1-2/A19
Littleton, MA 01460
Linn@erlang.enet.dec.com

STATUS OF THIS MEMO

This document is an Internet Draft. Internet Drafts are working documents of the Internet Engineering Task Force (IETF), its Areas, and its Working Groups. Note that other groups may also distribute working documents as Internet Drafts.

Internet Drafts are draft documents valid for a maximum of six months. Internet Drafts may be updated, replaced, or obsoleted by other documents at any time. It is not appropriate to use Internet Drafts as reference material or to cite them other than as a "working draft" or "work in progress."

Please check the I-D abstract listing contained in each Internet Draft directory to learn the current status of this or any other Internet Draft.

Comments on this document should be sent to "cat-ietf@mit.edu", the IETF Common Authentication Technology WG discussion list.

1 GSS-API Characteristics and Concepts

This Generic Security Service Application Program Interface (GSS-API) definition provides security services to callers in a generic fashion, supportable with a range of underlying mechanisms and technologies and hence allowing source-level portability of applications to different environments. This specification defines GSS-API services and primitives at a level independent of underlying mechanism and programming language environment, and is to be complemented by other, related specifications:

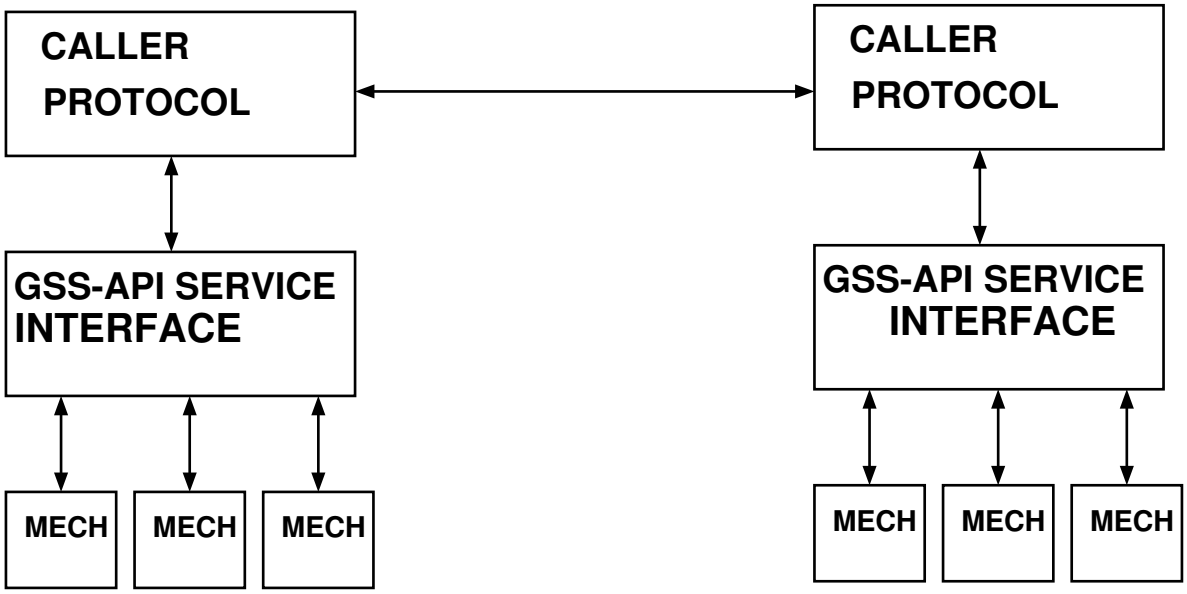
- documents defining specific parameter bindings for particular language environments
- documents defining token formats, protocols, and procedures to be implemented in order to realize GSS-API services atop particular security mechanisms

The operational paradigm in which GSS-API operates (also summarized in Figure 1 in the graphic version of this document) is as follows. A typical GSS-API caller is itself a communications protocol, calling on GSS-API in order to protect its communications with authentication, integrity, and/or confidentiality security services. A GSS-API caller accepts tokens provided to it by its local GSS-API implementation and transfers the tokens to a peer on a remote system; that peer passes the received tokens to its local GSS-API implementation for processing. The security services available through GSS-API in this fashion are implementable (and have been implemented) over a range of underlying mechanisms based on secret-key and public-key cryptographic technologies.

The GSS-API separates the operations of initializing a security context between peers, achieving peer entity authentication[1] (GSS_Init_sec_context( ) and GSS_Accept_sec_context( ) calls), from the operations of providing per-message data origin authentication and data integrity protection (GSS_Sign( ) and GSS_Verify( ) calls) for messages subsequently transferred in conjunction with that context. Per-message

[1] This security service definition, and other definitions used in this document, corresponds to that provided in International Standard ISO 7498-2-1988(E), Security Architecture.

Figure 1: GSS-API Paradigm



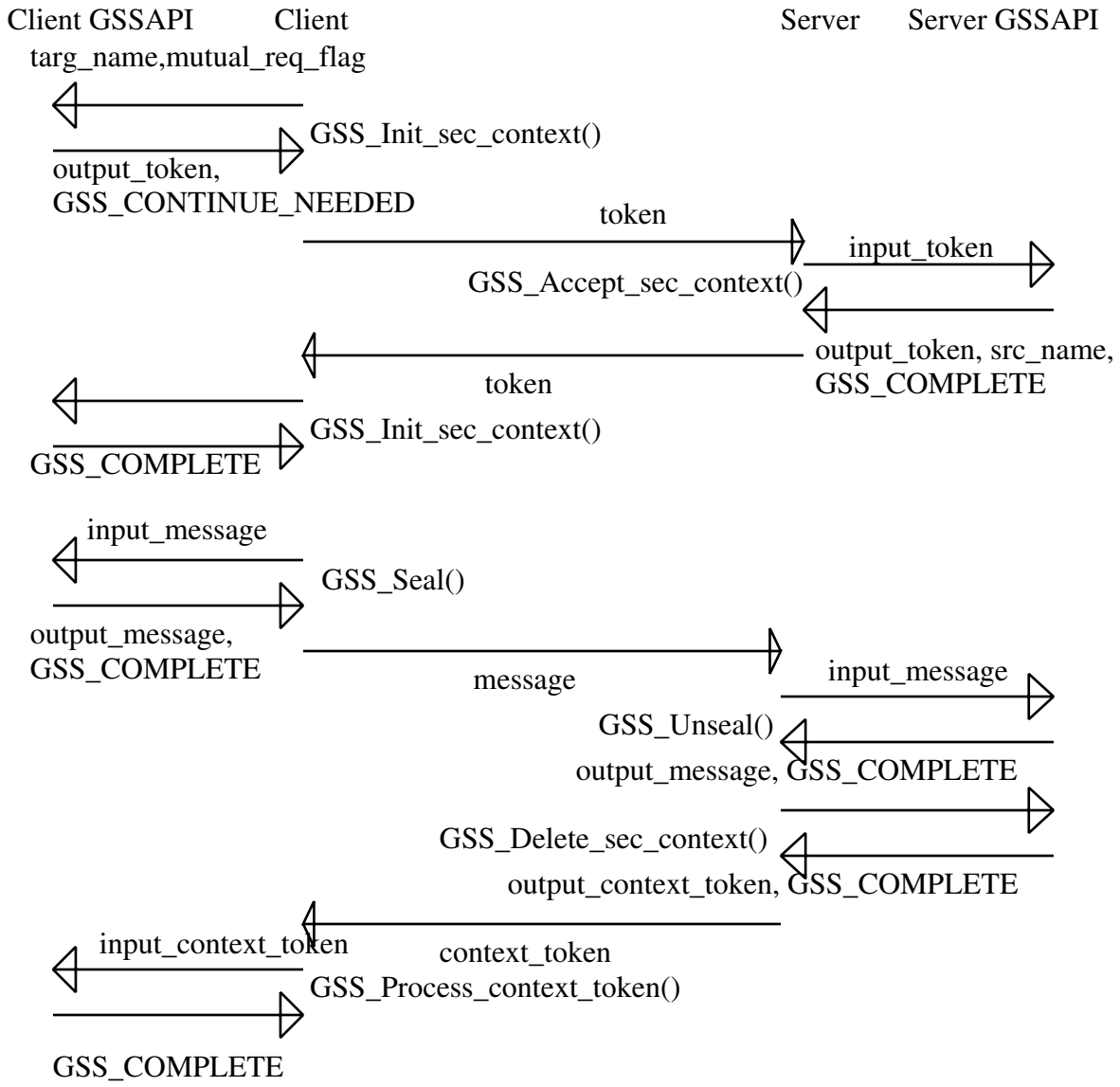
GSS_Seal( ) and GSS_Unseal( ) calls provide the data origin authentication and data integrity services which GSS_Sign( ) and GSS_Verify( ) offer, and also support selection of confidentiality services as a caller option. Additional calls provide supportive functions to the GSS-API's users.

In the graphic version of this document, Figure 2 illustrates the dataflows involved in use of the GSS-API by a client and server in a mechanism-independent fashion, establishing a security context and transferring a protected message. The example assumes that credential acquisition has already been completed. Only a subset of parameter and result values are illustrated, for reasons of clarity in exposition. Further, it is assumed that the underlying authentication technology is capable of authenticating a client to a server using elements carried within a single token, and of authenticating the server to the client (mutual authentication) with a single returned token; this assumption holds for presently-documented CAT mechanisms but is not necessarily true for other cryptographic technologies and associated protocols.

The client calls GSS_Init_sec_context( ) to establish a security context to the server identified by targ_name, and elects to set the mutual_req_flag so that mutual authentication is performed in the course of context establishment. GSS_Init_sec_context( ) returns an output_token to be passed to the server, and indicates GSS_CONTINUE_NEEDED status pending completion of the mutual authentication sequence. Had mutual_req_flag not been set, the initial call to GSS_Init_sec_context( ) would have returned GSS_COMPLETE status. The client sends the output_token to the server.

The server passes the received token as the input_token parameter to GSS_Accept_sec_context( ). GSS_Accept_sec_context indicates GSS_COMPLETE status, provides the client's authenticated identity in the src_name result, and provides an output_token to be passed to the client. The server sends the output_token to the client.

Figure 2: Example Client-Server Scenario



The client passes the received token as the input_token parameter to a successor call to GSS_Init_sec_context( ), which processes data included in the token in order to achieve mutual authentication from the client's viewpoint. This call to GSS_Init_sec_context( ) returns GSS_COMPLETE status, indicating successful mutual authentication and the completion of context establishment for this example.

The client generates a data message and passes it to GSS_Seal( ). GSS_Seal( ) performs data origin authentication, data integrity, and (optionally) confidentiality processing on the message and encapsulates the result into output_message, indicating GSS_COMPLETE status. The client sends the output_message to the server.

The server passes the received message to GSS_Unseal( ). GSS_Unseal inverts the encapsulation performed by GSS_Seal( ), deciphers the message if the optional confidentiality feature was applied, and validates the data origin authentication and data integrity checking quantities. GSS_Unseal( ) indicates successful validation by returning GSS_COMPLETE status along with the resultant output_message.

For purposes of this example, we assume that the server knows by out-of-band means that this context will have no further use after one protected message is transferred from client to server. Given this premise, the server now calls GSS_Delete_sec_context( ) to flush context-level information. GSS_Delete_sec_context returns a context_token for the server to pass to the client.

The client passes the returned context_token to GSS_Process_context_token( ), which returns GSS_COMPLETE status after deleting context-level information at the client system.

The GSS-API design assumes and addresses several basic goals, including:

- Mechanism independence: The GSS-API defines an interface to cryptographically implemented strong authentication and other security services at a generic level which is independent of particular underlying mechanisms. For example, GSS-API-provided services can be implemented by secret-key technologies (e.g., Kerberos) or public-key approaches (e.g., X.509).
- Protocol environment independence: The GSS-API is independent of the communications protocol suites with which it is employed, permitting use in a broad range of protocol environments. In appropriate environments, an intermediate implementation "veneer" which is oriented to a particular communication protocol (e.g., Remote Procedure Call (RPC)) may be interposed between applications which call that protocol and the GSS-API, thereby invoking GSS-API facilities in conjunction with that protocol's communications invocations.
- Protocol association independence: The GSS-API's security context construct is independent of communications protocol association constructs. This characteristic allows a single GSS-API implementation to be utilized by a variety of invoking protocol modules on behalf of those modules' calling applications. GSS-API services can also be invoked directly by applications, wholly independent of protocol associations.
- Suitability to a range of implementation placements: GSS-API clients are not constrained to reside within any Trusted Computing Base (TCB) perimeter defined on a system where the GSS-API is implemented; security services are specified in a manner suitable to both intra-TCB and extra-TCB callers.

1.1 GSS-API Constructs

This section describes the basic elements comprising the GSS-API.

1.1.1 Credentials

Credentials structures provide the prerequisites enabling peers to establish security contexts with each other. A caller may designate that its default credential be used for context establishment calls without presenting an explicit handle to that credential. Alternately, those GSS-API callers which need to make explicit selection of particular credentials structures may make references to those credentials through GSS-API-provided credential handles ("cred_handles").

A single credential structure may be used for initiation of outbound contexts and acceptance of inbound contexts. Callers needing to operate in only one of these modes may designate this fact when credentials are acquired for use, allowing underlying mechanisms to optimize their processing and storage requirements. The credential elements defined by a particular mechanism may contain multiple cryptographic keys, e.g., to enable authentication and message encryption to be performed with different algorithms.

A single credential structure may accommodate credential information associated with multiple underlying mechanisms (mech_types); a credential structure's contents will vary depending on the set of mech_types supported by a particular GSS-API implementation. Commonly, a single mech_type will be used for all security contexts established by a particular initiator to a particular target; the primary motivation for

supporting credential sets representing multiple mech_types is to allow initiators on systems which are equipped to handle multiple types to initiate contexts to targets on other systems which can accommodate only a subset of the set supported at the initiator's system.

It is the responsibility of underlying system-specific mechanisms and OS functions below the GSS-API to ensure that the ability to acquire and use credentials associated with a given identity is constrained to appropriate processes within a system. This responsibility should be taken seriously by implementors, as the ability for an entity to utilize a principal's credentials is equivalent to the entity's ability to successfully assert that principal's identity.

Once a set of GSS-API credentials is established, the transferability of that credentials set to other processes or analogous constructs within a system is a local matter, not defined by the GSS-API. An example local policy would be one in which any credentials received as a result of login to a given user account, or of delegation of rights to that account, are accessible by, or transferable to, processes running under that account.

The credential establishment process (particularly when performed on behalf of users rather than server processes) is likely to require access to passwords or other quantities which should be protected locally and exposed for the shortest time possible. As a result, it will often be appropriate for preliminary credential establishment to be performed through local means at user login time, with the result(s) cached for subsequent reference. These preliminary credentials would be set aside (in a system-specific fashion) for subsequent use, either:

- to be accessed by an invocation of the GSS-API GSS_Acquire_cred( ) call, returning an explicit handle to reference that credential
- as the default credentials installed on behalf of a process

1.1.2 Tokens

Tokens are data elements transferred between GSS-API callers, and are divided into two classes. Context-level tokens are exchanged in order to establish and manage a security context between peers. Per-message tokens are exchanged in conjunction with an established context to provide protective security services for corresponding data messages. The internal contents of both classes of tokens are specific to the particular underlying mechanism used to support the GSS-API; Appendix B of this document provides a uniform recommendation for designers of GSS-API support mechanisms, encapsulating mechanism-specific information along with a globally-interpretable mechanism identifier.

Tokens are opaque from the viewpoint of GSS-API callers. They are generated within the GSS-API implementation at an end system, provided to a GSS-API caller to be transferred to the peer GSS-API caller at a remote end system, and processed by the GSS-API implementation at that remote end system. Tokens may be output by GSS-API primitives (and are to be transferred to GSS-API peers) independent of the status indications which those primitives indicate. Token transfer may take place in an in-band manner, integrated into the same protocol stream used by the GSS-API callers for other data transfers, or in an out-of-band manner across a logically separate channel.

Development of GSS-API support primitives based on a particular underlying cryptographic technique and protocol does not necessarily imply that GSS-API callers invoking that GSS-API mechanism type will be able to interoperate with peers invoking the same technique and protocol outside the GSS-API paradigm. For example, the format of GSS-API tokens defined in conjunction with a particular mechanism, and the techniques used to integrate those tokens into callers' protocols, may not be the same as those used by non-GSS-API callers of the same underlying technique.

1.1.3 Security Contexts

Security contexts are established between peers, using credentials established locally in conjunction with each peer or received by peers via delegation. Multiple contexts may exist simultaneously between a pair of peers, using the same or different sets of credentials. Coexistence of multiple contexts using different credentials allows graceful rollover when credentials expire. Distinction among multiple contexts based on the same credentials serves applications by distinguishing different message streams in a security sense.

The GSS-API is independent of underlying protocols and addressing structure, and depends on its callers to transport GSS-API-provided data elements. As a result of these factors, it is a caller responsibility to parse communicated messages, separating GSS-API-related data elements from caller-provided data. The GSS-API is independent of connection vs. connectionless orientation of the underlying communications service.

No correlation between security context and communications protocol association is dictated[2]. This separation allows the GSS-API to be used in a wide range of communications environments, and also simplifies the calling sequences of the individual calls. In many cases (depending on underlying security protocol, associated mechanism, and availability of cached information), the state information required for context setup can be sent concurrently with initial signed user data, without interposing additional message exchanges.

1.1.4 Mechanism Types

In order to successfully establish a security context with a target peer, it is necessary to identify an appropriate underlying mechanism type (mech_type) which both initiator and target peers support. The definition of a mechanism embodies not only the use of a particular cryptographic technology (or a hybrid or choice among alternative cryptographic technologies), but also definition of the syntax and semantics of data element exchanges which that mechanism will employ in order to support security services.

It is recommended that callers initiating contexts specify the "default" mech_type value, allowing system-specific functions within or invoked by the GSS-API implementation to select the appropriate mech_type, but callers may direct that a particular mech_type be employed when necessary.

The means for identifying a shared mech_type to establish a security context with a peer will vary in different environments and circumstances; examples include (but are not limited to):

- use of a fixed mech_type, defined by configuration, within an environment
- syntactic convention on a target-specific basis, through examination of a target's name
- lookup of a target's name in a naming service or other database in order to identify mech_types supported by that target
- explicit negotiation between GSS-API callers in advance of security context setup

When transferred between GSS-API peers, mech_type specifiers (per Appendix B, represented as Object Identifiers [3](OIDs)) serve to qualify the interpretation of associated tokens. Use of hierarchically structured OIDs serves to preclude ambiguous interpretation of mech_type specifiers. The OID representing the DASS MechType, for example, is 1.3.12.2.1011.7.5.

---

[2] The optional channel binding facility, discussed in Section 1.1.6 of this document, represents an intentional exception to this rule, supporting additional protection features within GSS-API supporting mechanisms.

[3] The structure and encoding of Object Identifiers is defined in ISO/IEC 8824, "Specification of Abstract Syntax Notation One (ASN.1)" and in ISO/IEC 8825, "Specification of Basic Encoding Rules for Abstract Syntax Notation One (ASN.1)".

1.1.5 Naming

The GSS-API avoids prescription of naming structures, treating the names transferred across the interface in order to initiate and accept security contexts as opaque octet string quantities. This approach supports the GSS-API's goal of implementability atop a range of underlying security mechanisms, recognizing the fact that different mechanisms process and authenticate names which are presented in different forms. Generalized services offering translation functions among arbitrary sets of naming environments are outside the scope of the GSS-API; availability and use of local conversion functions to translate among the naming formats supported within a given end system is anticipated.

Two distinct classes of name representations are used in conjunction with different GSS-API parameters:

- a printable form (denoted by OCTET STRING), for acceptance from and presentation to users; printable name forms are accompanied by OID tags identifying the namespace to which they correspond
- an internal form (denoted by INTERNAL NAME), opaque to callers and defined by individual GSS-API implementations; GSS-API implementations supporting multiple namespace types are responsible for maintaining internal tags to disambiguate the interpretation of particular names

Tagging of printable names allows GSS-API callers and underlying GSS-API mechanisms to disambiguate name types and to determine whether an associated name's type is one which they are capable of processing, avoiding aliasing problems which could result from misinterpreting a name of one type as a name of another type.

In addition to providing means for names to be tagged with types, this specification defines primitives to support a level of naming environment independence for certain calling applications. To provide basic services[4] oriented towards the requirements of callers which need not themselves interpret the internal syntax and semantics of names, GSS-API calls for name comparison (GSS_Compare_name( )), human-readable display (GSS_Display_name( )), input conversion (GSS_Import_name( )), and internal name deallocation (GSS_Release_name( )) functions are defined.

GSS_Import_name( ) implementations can, where appropriate, support more than one printable syntax corresponding to a given namespace (e.g., alternative printable representations for X.500 Distinguished Names), allowing flexibility for their callers to select among alternative representations. GSS_Display_name( ) implementations output a printable syntax selected as appropriate to their operational environments; this selection is a local matter. Callers desiring portability across alternative printable syntaxes should refrain from implementing comparisons based on printable name forms and should instead use the GSS_Compare_name( ) call to determine whether or not one internal-format name matches another.

1.1.6 Channel Bindings

The GSS-API accommodates the concept of caller-provided channel binding ("chan_binding") information, used by GSS-API callers to bind the establishment of a security context to relevant characteristics (e.g., addresses, transformed representations of encryption keys) of the underlying communications channel and of protection mechanisms applied to that communications channel. Verification by one peer of chan_binding information provided by the other peer to a context serves to protect against various active attacks. The caller initiating a security context must determine the chan_binding values before making the GSS_Init_sec_context( ) call, and consistent values must be provided by both peers to a context. Callers should not assume that underlying mechanisms provide confidentiality protection for channel binding information.

[4] It is anticipated that these proposed GSS-API calls will be implemented in many end systems based on system-specific name manipulation primitives already extant within those end systems; inclusion within the GSS-API is intended to offer GSS-API callers a portable means to perform specific operations, supportive of authorization and audit requirements, on authenticated names.

Use or non-use of the GSS-API channel binding facility is a caller option, and GSS-API supporting mechanisms can support operation in an environment where NULL channel bindings are presented. When non-NULL channel bindings are used, certain mechanisms will offer enhanced security value by interpreting the bindings' content (rather than simply representing those bindings, or signatures computed on them, within tokens) and will therefore depend on presentation of specific data in a defined format. To this end, agreements among mechanism implementors are defining[5] conventional interpretations for the contents of channel binding arguments, including address specifiers (with content dependent on communications protocol environment) for context initiators and acceptors. In order for GSS-API callers to be portable across multiple mechanisms and achieve the full security functionality available from each mechanism, it is strongly recommended that GSS-API callers provide channel bindings consistent with these conventions and those of the networking environment in which they operate.

1.2 GSS-API Features and Issues

This section describes aspects of GSS-API operations, of the security services which the GSS-API provides, and provides commentary on design issues.

1.2.1 Status Reporting

Each GSS-API call provides two status return values. Major_status values provide a mechanism-independent indication of call status (e.g., GSS_COMPLETE, GSS_FAILURE, GSS_CONTINUE_NEEDED), sufficient to drive normal control flow within the caller in a generic fashion. Table 1 summarizes the defined major_status return codes in tabular fashion.

Table 1: GSS-API Major Status Codes

FATAL ERROR CODES	
GSS_BAD_BINDINGS	channel binding mismatch
GSS_BAD_MECH	unsupported mechanism requested
GSS_BAD_NAME	invalid name provided
GSS_BAD_NAMETYPE	name of unsupported type provided
GSS_BAD_STATUS	invalid input status selector
GSS_BAD_SIG	token had invalid signature
GSS_CONTEXT_EXPIRED	specified security context expired
GSS_CREDENTIALS_EXPIRED	expired credentials detected
GSS_DEFECTIVE_CREDENTIAL	defective credential detected
GSS_DEFECTIVE_TOKEN	defective token detected
GSS_FAILURE	failure, unspecified at GSS-API level
GSS_NO_CONTEXT	no valid security context specified
GSS_NO_CRED	no valid credentials provided

[5] These conventions are being incorporated into related documents.

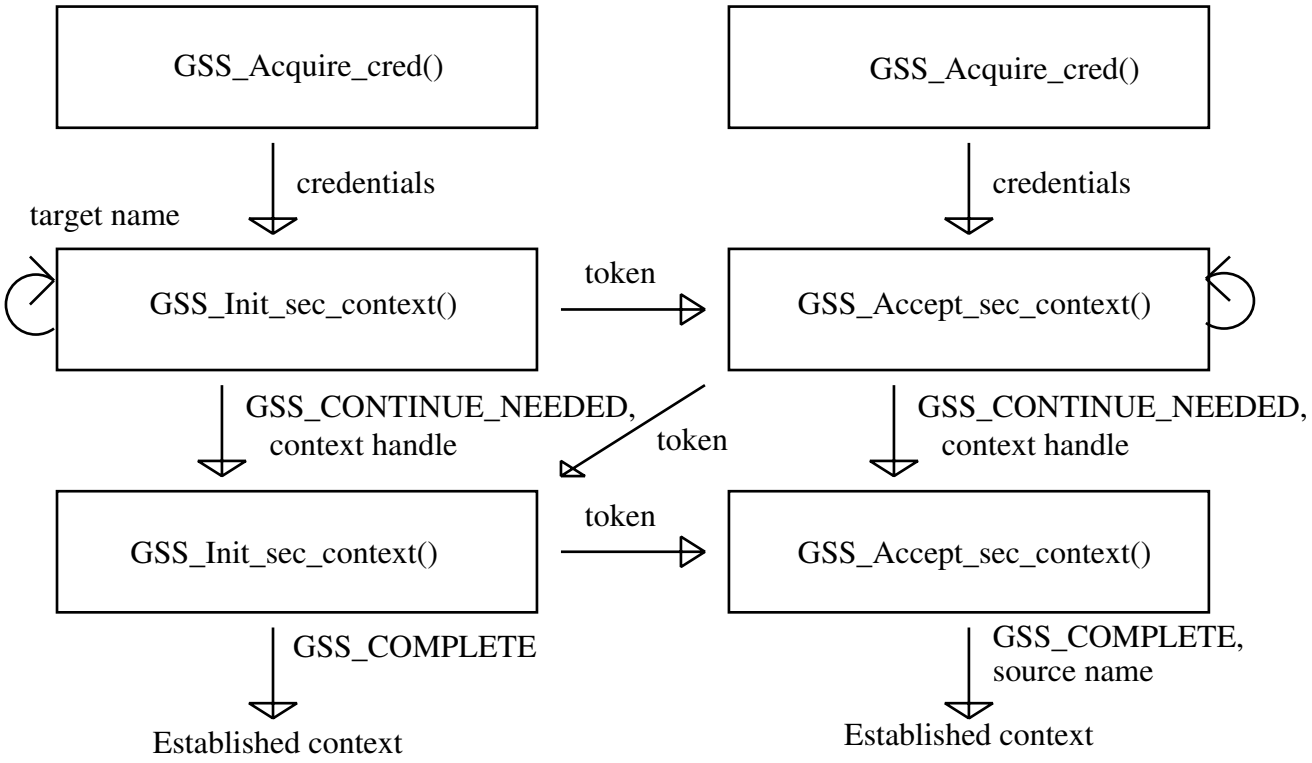
Table 1 (Cont.): GSS-API Major Status Codes

INFORMATORY STATUS CODES	
GSS_COMPLETE	normal completion
GSS_CONTINUE_NEEDED	continuation call to routine required
GSS_DUPLICATE_TOKEN	duplicate per-message token detected
GSS_OLD_TOKEN	timed-out per-message token detected
GSS_UNSEQ_TOKEN	out-of-order per-message token detected

Minor_status provides more detailed status information which may include status codes specific to the underlying security mechanism. Minor_status values are not specified in this document.

GSS_CONTINUE_NEEDED major_status returns, and optional message outputs, are provided in GSS_Init_sec_context( ) and GSS_Accept_sec_context( ) calls so that different mechanisms' employment of different numbers of messages within their authentication sequences need not be reflected in separate code paths within calling applications. Instead, such cases are accomodated with sequences of continuation calls to GSS_Init_sec_context( ) and GSS_Accept_sec_context( ). The same mechanism is used to encapsulate mutual authentication within the GSS-API's context initiation calls. In the graphic version of this document, Figure 3 illustrates a GSS-API continuation scenario.

Figure 3: Example Context Establishment with Continuation



For mech_types which require interactions with third-party servers in order to establish a security context, GSS-API context establishment calls may block pending completion of such third-party interactions. On the other hand, no GSS-API calls pend on serialized interactions with GSS-API peer entities. As a result, local GSS-API status returns cannot reflect unpredictable or asynchronous exceptions occurring at remote peers, and reflection of such status information is a caller responsibility outside the GSS-API.

1.2.2 Per-Message Security Service Availability

When a context is established, two flags are returned to indicate the set of per-message protection security services which will be available on the context:

- the integ_avail flag indicates whether per-message integrity and data origin authentication services are available
- the conf_avail flag indicates whether per-message confidentiality services are available, and will never be returned TRUE unless the integ_avail flag is also returned TRUE

GSS-API callers desiring per-message security services should check the values of these flags at context establishment time, and must be aware that a returned FALSE value for integ_avail means that invocation of GSS_Sign( ) or GSS_Seal( ) primitives on the associated context will apply no cryptographic protection to user data messages.

The GSS-API per-message protection service primitives, as the category name implies, are oriented to operation at the granulatity of protocol data units. They perform cryptographic operations on the data units, transfer cryptographic control information in tokens, and, in the case of GSS_Seal( ), encapsulate the protected data unit. As such, these primitives are not oriented to efficient data protection for stream-paradigm protocols (e.g., Telnet) if cryptography must be applied on an octet-by-octet basis.

1.2.3 Per-Message Replay Detection and Sequencing

Certain underlying mech_types are expected to offer support for replay detection and/or sequencing of messages transferred on the contexts they support. These optionally-selectable protection features are distinct from replay detection and sequencing features applied to the context establishment operation itself; the presence or absence of context-level replay or sequencing features is wholly a function of the underlying mech_type's capabilities, and is not selected or omitted as a caller option.

The caller initiating a context provides flags (replay_det_req_flag and sequence_req_flag) to specify whether the use of per-message replay detection and sequencing features is desired on the context being established. The GSS-API implementation at the initiator system can determine whether these features are supported (and whether they are optionally selectable) as a function of mech_type, without need for bilateral negotiation with the target. When enabled, these features provide recipients with indicators as a result of GSS-API processing of incoming messages, identifying whether those messages were detected as duplicates or out-of-sequence. Detection of such events does not prevent a suspect message from being provided to a recipient; the appropriate course of action on a suspect message is a matter of caller policy.

The semantics of the replay detection and sequencing services applied to received messages, as visible across the interface which the GSS-API provides to its clients, are as follows:

When replay_det_state is TRUE, the possible major_status returns for well-formed and correctly signed messages are as follows:

1. GSS_COMPLETE indicates that the message was within the window (of time or sequence space) allowing replay events to be detected, and that the message was not a replay of a previously-processed message within that window.

2. GSS_DUPLICATE_TOKEN indicates that the signature on the received message was correct, but that the message was recognized as a duplicate of a previously-processed message.
3. GSS_OLD_TOKEN indicates that the signature on the received message was correct, but that the message is too old to be checked for duplication.

When sequence_state is TRUE, the possible major_status returns for well-formed and correctly signed messages are as follows:

1. GSS_COMPLETE indicates that the message was within the window (of time or sequence space) allowing replay events to be detected, and that the message was not a replay of a previously-processed message within that window.
2. GSS_DUPLICATE_TOKEN indicates that the signature on the received message was correct, but that the message was recognized as a duplicate of a previously-processed message.
3. GSS_OLD_TOKEN indicates that the signature on the received message was correct, but that the token is too old to be checked for duplication.
4. GSS_UNSEQ_TOKEN indicates that the signature on the received message was correct, but that it is earlier in a sequenced stream [6] than a message already processed on the context.

As the message stream integrity features (especially sequencing) may interfere with certain applications' intended communications paradigms, and since support for such features is likely to be resource intensive, it is highly recommended that mech_types supporting these features allow them to be activated selectively on initiator request when a context is established. A context initiator and target are provided with corresponding indicators (replay_det_state and sequence_state), signifying whether these features are active on a given context.

An example mech_type supporting per-message replay detection could (when replay_det_state is TRUE) implement the feature as follows: The underlying mechanism would insert timestamps in data elements output by GSS_Sign( ) and GSS_Seal( ), and would maintain (within a time-limited window) a cache (qualified by originator-recipient pair) identifying received data elements processed by GSS_Verify( ) and GSS_Unseal( ). When this feature is active, exception status returns (GSS_DUPLICATE_TOKEN, GSS_OLD_TOKEN) will be provided when GSS_Verify( ) or GSS_Unseal( ) is presented with a message which is either a detected duplicate of a prior message or which is too old to validate against a cache of recently received messages.

1.2.4 Quality of Protection

Some mech_types will provide their users with fine granularity control over the means used to provide per-message protection, allowing callers to trade off security processing overhead dynamically against the protection requirements of particular messages. A per-message quality-of-protection parameter (analogous to quality-of-service, or QOS) selects among different QOP options supported by that mechanism. On context establishment for a multi-QOP mech_type, context-level data provides the prerequisite data for a range of protection qualities.

[6] Mechanisms can be architected to provide a stricter form of sequencing service, delivering particular messages to recipients only after all predecessor messages in an ordered stream have been delivered. This type of support is incompatible with the GSS-API paradigm in which recipients receive all messages, whether in order or not, and provide them (one at a time, without intra-GSS-API message buffering) to GSS-API routines for validation. GSS-API facilities provide supportive functions, aiding clients to achieve strict message stream integrity in an efficient manner in conjunction with sequencing provisions in communications protocols, but the GSS-API does not offer this level of message stream integrity service by itself.

It is expected that the majority of callers will not wish to exert explicit mechanism-specific QOP control and will therefore request selection of a default QOP. Definitions of, and choices among, non-default QOP values are mechanism-specific, and no ordered sequences of QOP values can be assumed equivalent across different mechanisms. Meaningful use of non-default QOP values demands that callers be familiar with the QOP definitions of an underlying mechanism or mechanisms, and is therefore a non-portable construct.

2 Interface Descriptions

This section describes the GSS-API's service interface, dividing the set of calls offered into four groups. Credential management calls are related to the acquisition and release of credentials by principals. Context-level calls are related to the management of security contexts between principals. Per-message calls are related to the protection of individual messages on established security contexts. Support calls provide ancillary functions useful to GSS-API callers. Table 2 groups and summarizes the calls in tabular fashion.

Table 2: GSS-API Calls

CREDENTIAL MANAGEMENT	
GSS_Acquire_cred	acquire credentials for use
GSS_Release_cred	release credentials after use
GSS_Inquire_cred	display information about credentials
CONTEXT-LEVEL CALLS	
GSS_Init_sec_context	initiate outbound security context
GSS_Accept_sec_context	accept inbound security context
GSS_Delete_sec_context	flush context when no longer needed
GSS_Process_context_token	process received control token on context
GSS_Context_time	indicate validity time remaining on context
PER-MESSAGE CALLS	
GSS_Sign	apply signature, receive as token separate from message
GSS_Verify	validate signature token along with message
GSS_Seal	sign, optionally encrypt, encapsulate
GSS_Unseal	decapsulate, decrypt if needed, validate signature
SUPPORT CALLS	
GSS_Display_status	translate status codes to printable form
GSS_Indicate_mechs	indicate mech_types supported on local system
GSS_Compare_name	compare two names for equality
GSS_Display_name	translate name to printable form
GSS_Import_name	convert printable name to normalized form
GSS_Release_name	free storage of normalized-form name
GSS_Release_buffer	free storage of printable name
GSS_Release_oid_set	free storage of OID set object

2.1 Credential management calls

These GSS-API calls provide functions related to the management of credentials. Their characterization with regard to whether or not they may block pending exchanges with other network entities (e.g., directories or authentication servers) depends in part on OS-specific (extra-GSS-API) issues, so is not specified in this document.

The GSS_Acquire_cred( ) call is defined within the GSS-API in support of application portability, with a particular orientation towards support of portable server applications. It is recognized that (for certain systems and mechanisms) credentials for interactive users may be managed differently from credentials for server processes; in such environments, it is the GSS-API implementation's responsibility to distinguish these cases and the procedures for making this distinction are a local matter. The GSS_Release_cred( ) call provides a means for callers to indicate to the GSS-API that use of a credentials structure is no longer required. The GSS_Inquire_cred( ) call allows callers to determine information about a credentials structure.

2.1.1 GSS_Acquire_cred call

Inputs:

- desired_name INTERNAL NAME, —NULL requests locally-determined default
- lifetime_req INTEGER,—in seconds; 0 requests default
- desired_mechs SET OF OBJECT IDENTIFIER,—empty set requests system-selected default
- cred_usage INTEGER—0=INITIATE-AND-ACCEPT, 1=INITIATE-ONLY, 2=ACCEPT-ONLY

Outputs:

- major_status INTEGER,
- minor_status INTEGER,
- output_cred_handle OCTET STRING,
- actual_mechs SET OF OBJECT IDENTIFIER,
- lifetime_rec INTEGER —in seconds, or reserved value for INDEFINITE

Return major_status codes:

- GSS_COMPLETE indicates that requested credentials were successfully established, for the duration indicated in lifetime_rec, suitable for the usage requested in cred_usage, for the set of mech_types indicated in actual_mechs, and that those credentials can be referenced for subsequent use with the handle returned in output_cred_handle.
- GSS_BAD_MECH indicates that a mech_type unsupported by the GSS-API implementation type was requested, causing the credential establishment operation to fail.
- GSS_BAD_NAMETYPE indicates that the provided desired_name is uninterpretable or of a type unsupported by the supporting GSS-API implementation, so no credentials could be established for the accompanying desired_name.
- GSS_BAD_NAME indicates that the provided desired_name is inconsistent in terms of internally-incorporated type specifier information, so no credentials could be established for the accompanying desired_name.

- GSS_FAILURE indicates that credential establishment failed for reasons unspecified at the GSS-API level, including lack of authorization to establish and use credentials associated with the identity named in the input desired_name argument.

GSS_Acquire_cred( ) is used to acquire credentials so that a principal can (as a function of the input cred_usage parameter) initiate and/or accept security contexts under the identity represented by the desired_name input argument. On successful completion, the returned output_cred_handle result provides a handle for subsequent references to the acquired credentials. Typically, single-user client processes using only default credentials for context establishment purposes will have no need to invoke this call.

A caller may provide the value NULL for desired_name, signifying a request for credentials corresponding to a default principal identity. The procedures used by GSS-API implementations to select the appropriate principal identity in response to this form of request are local matters. It is possible that multiple pre-established credentials may exist for the same principal identity (for example, as a result of multiple user login sessions) when GSS_Acquire_cred( ) is called; the means used in such cases to select a specific credential are local matters[7].

The lifetime_rec result indicates the length of time for which the acquired credentials will be valid, as an offset from the present. A mechanism may return a reserved value indicating INDEFINITE if no constraints on credential lifetime are imposed. A caller of GSS_Acquire_cred( ) can request a length of time for which acquired credentials are to be valid (lifetime_req argument), beginning at the present[8], or can request credentials with a default validity interval. Certain mechanisms and implementations may bind in credential validity period specifiers at a point preliminary to invocation of the GSS_Acquire_cred( ) call (e.g., in conjunction with user login procedures). As a result, callers requesting non-default values for lifetime_req must recognize that such requests cannot always be honored and must be prepared to accommodate the use of returned credentials with different lifetimes as indicated in lifetime_rec.

The caller of GSS_Acquire_cred( ) can explicitly specify a set of mech_types which are to be accommodated in the returned credentials (desired_mechs argument), or can request credentials for a system-defined default set of mech_types. Selection of the system-specified default set is recommended in the interests of application portability. The actual_mechs return value may be interrogated by the caller to determine the set of mechanisms with which the returned credentials may be used.

2.1.2 GSS_Release_cred call

Input:

- cred_handle OCTET STRING—NULL specifies default credentials

Outputs:

- major_status INTEGER,
- minor_status INTEGER

Return major_status codes:

- GSS_COMPLETE indicates that the credentials referenced by the input cred_handle were released for purposes of subsequent access by the caller. The effect on other processes which may be authorized shared access to such credentials is a local matter.

[7] The input lifetime_req argument to GSS_Acquire_cred( ) may provide useful information for local GSS-API implementations to employ in making this disambiguation in a manner which will best satisfy a caller's intent.

[8] Requests for postdated credentials are not supported within the GSS-API.

- GSS_NO_CRED indicates that no release operation was performed, either because the input cred_handle was invalid or because the caller lacks authorization to access the referenced credentials.
- GSS_FAILURE indicates that the release operation failed for reasons unspecified at the GSS-API level.

Provides a means for a caller to explicitly request that credentials be released when their use is no longer required. Note that system-specific credential management functions are also likely to exist, for example to assure that credentials shared among processes are properly deleted when all affected processes terminate, even if no explicit release requests are issued by those processes. Given the fact that multiple callers are not precluded from gaining authorized access to the same credentials, invocation of GSS_Release_cred( ) cannot be assumed to delete a particular set of credentials on a system-wide basis.

2.1.3 GSS_Inquire_cred call

Input:

- cred_handle OCTET STRING—NULL specifies default credentials

Outputs:

- major_status INTEGER,
- minor_status INTEGER,
- cred_name INTERNAL NAME,
- lifetime_rec INTEGER—in seconds, or reserved value for INDEFINITE
- cred_usage INTEGER,—0=INITIATE-AND-ACCEPT, 1=INITIATE-ONLY, 2=ACCEPT-ONLY
- mech_set SET OF OBJECT IDENTIFIER

Return major_status codes:

- GSS_COMPLETE indicates that the credentials referenced by the input cred_handle argument were valid, and that the output cred_name, lifetime_rec, and cred_usage values represent, respectively, the credentials' associated principal name, remaining lifetime, suitable usage modes, and supported mechanism types.
- GSS_NO_CRED indicates that no information could be returned about the referenced credentials, either because the input cred_handle was invalid or because the caller lacks authorization to access the referenced credentials.
- GSS_FAILURE indicates that the release operation failed for reasons unspecified at the GSS-API level.

The GSS_Inquire_cred( ) call is defined primarily for the use of those callers which make use of default credentials rather than acquiring credentials explicitly with GSS_Acquire_cred( ). It enables callers to determine a credential structure's associated principal name, remaining validity period, usability for security context initiation and/or acceptance, and supported mechanisms.

2.2 Context-level calls

This group of calls is devoted to the establishment and management of security contexts between peers. A context's initiator calls GSS_Init_sec_context( ), resulting in generation of a token which the caller passes to the target. At the target, that token is passed to GSS_Accept_sec_context( ). Depending on the underlying mech_type and specified options, additional token exchanges may be performed in the course of context establishment; such exchanges are accommodated by GSS_CONTINUE_NEEDED status returns from GSS_Init_sec_context( ) and GSS_Accept_sec_context( ). Either party to an established context may invoke GSS_Delete_sec_context( ) to flush context information when a context is no longer required. GSS_Process_context_token( ) is used to process received tokens carrying context-level control information. GSS_Context_time( ) allows a caller to determine the length of time for which an established context will remain valid.

2.2.1 GSS_Init_sec_context call

Inputs:

- claimant_cred_handle OCTET STRING, —NULL specifies "use default"
- input_context_handle INTEGER, —0 specifies "none assigned yet"
- targ_name INTERNAL NAME,
- mech_type OBJECT IDENTIFIER, —NULL parameter specifies "use default"
- deleg_req_flag BOOLEAN,
- mutual_req_flag BOOLEAN,
- replay_det_req_flag BOOLEAN,
- sequence_req_flag BOOLEAN,
- lifetime_req INTEGER,—0 specifies default lifetime
- chan_bindings OCTET STRING,
- input_token OCTET STRING—NULL or token received from target

Outputs:

- major_status INTEGER,
- minor_status INTEGER,
- output_context_handle INTEGER,
- mech_type OBJECT IDENTIFIER, —actual mechanism always indicated, never NULL
- output_token OCTET STRING, —NULL or token to pass to context target
- deleg_state BOOLEAN,
- mutual_state BOOLEAN,
- replay_det_state BOOLEAN,
- sequence_state BOOLEAN,
- conf_avail BOOLEAN,
- integ_avail BOOLEAN,
- lifetime_rec INTEGER — in seconds, or reserved value for INDEFINITE

This call may block pending network interactions for those mech_types in which an authentication server or other network entity must be consulted on behalf of a context initiator in order to generate an output_ token suitable for presentation to a specified target.

Return major_status codes:

- GSS_COMPLETE indicates that context-level information was successfully initialized, and that the returned output_token will provide sufficient information for the target to perform per-message processing on the newly-established context.
- GSS_CONTINUE_NEEDED indicates that control information in the returned output_token must be sent to the target, and that a reply must be received and passed as the input_token argument to a continuation call to GSS_Init_sec_context( ), before per-message processing can be performed in conjunction with this context.
- GSS_DEFECTIVE_TOKEN indicates that consistency checks performed on the input_token failed, preventing further processing from being performed based on that token.
- GSS_DEFECTIVE_CREDENTIAL indicates that consistency checks performed on the credential structure referenced by claimant_cred_handle failed, preventing further processing from being performed using that credential structure.
- GSS_BAD_SIG indicates that the received input_token contains an incorrect signature, so context setup cannot be accomplished.
- GSS_NO_CRED indicates that no context was established, either because the input cred_handle was invalid, because the referenced credentials are valid for context acceptor use only, or because the caller lacks authorization to access the referenced credentials.
- GSS_CREDENTIALS_EXPIRED indicates that the credentials provided through the input claimant_ cred_handle argument are no longer valid, so context establishment cannot be completed.
- GSS_BAD_BINDINGS indicates that a mismatch between the caller-provided chan_bindings and those extracted from the input_token was detected, signifying a security-relevant event and preventing context establishment. (This result will be returned by GSS_Init_sec_context only for contexts where mutual_state is TRUE.)
- GSS_NO_CONTEXT indicates that no valid context was recognized for the input context_handle provided; this major status will be returned only for successor calls following GSS_CONTINUE_ NEEDED status returns.
- GSS_BAD_NAMETYPE indicates that the provided targ_name is of a type uninterpretable or unsupported by the supporting GSS-API implementation, so context establishment cannot be completed.
- GSS_BAD_NAME indicates that the provided targ_name is inconsistent in terms of internally-incorporated type specifier information, so context establishment cannot be accomplished.
- GSS_FAILURE indicates that context setup could not be accomplished for reasons unspecified at the GSS-API level, and that no interface-defined recovery action is available.

This routine is used by a context initiator, and ordinarily emits one (or, for the case of a multi-step exchange, more than one) output_token suitable for use by the target within the selected mech_type's protocol. Using information in the credentials structure referenced by claimant_cred_handle, GSS_Init_ sec_context( ) initializes the data structures required to establish a security context with target targ_ name. The claimant_cred_handle must correspond to the same valid credentials structure on the initial call to GSS_Init_sec_context( ) and on any successor calls resulting from GSS_CONTINUE_NEEDED status returns; different protocol sequences modeled by the GSS_CONTINUE_NEEDED mechanism will require access to credentials at different points in the context establishment sequence.

The input_context_handle argument is 0, specifying "not yet assigned", on the first GSS_Init_sec_context( ) call relating to a given context. That call returns an output_context_handle for future references to this context. When continuation attempts to GSS_Init_sec_context( ) are needed to perform context establishment, the previously-returned non-zero handle value is entered into the input_context_handle argument and will be echoed in the returned output_context_handle argument. On such continuation attempts (and only on continuation attempts) the input_token value is used, to provide the token returned from the context's target.

The chan_bindings argument is used by the caller to provide information binding the security context to security-related characteristics (e.g., addresses, cryptographic keys) of the underlying communications channel. See Section 1.1.6 of this document for more discussion of this argument's usage.

The input_token argument contains a message received from the target, and is significant only on a call to GSS_Init_sec_context( ) which follows a previous return indicating GSS_CONTINUE_NEEDED major_status.

It is the caller's responsibility to establish a communications path to the target, and to transmit any returned output_token (independent of the accompanying returned major_status value) to the target over that path. The output_token can, however, be transmitted along with the first application-provided input message to be processed by GSS_Sign( ) or GSS_Seal( ) in conjunction with a successfully-established context.

The initiator may request various context-level functions through input flags: the deleg_req_flag requests delegation of access rights, the mutual_req_flag requests mutual authentication, the replay_det_req_flag requests that replay detection features be applied to messages transferred on the established context, and the sequence_req_flag requests that sequencing be enforced. (See Section 1.2.3 for more information on replay detection and sequencing features.)

Not all of the optionally-requestable features will be available in all underlying mech_types; the corresponding return state values (deleg_state, mutual_state, replay_det_state, sequence_state) indicate, as a function of mech_type processing capabilities and initiator-provided input flags, the set of features which will be active on the context. These state indicators' values are undefined unless the routine's major_status indicates COMPLETE. Failure to provide the precise set of features requested by the caller does not cause context establishment to fail; it is the caller's prerogative to delete the context if the feature set provided is unsuitable for the caller's use. The returned mech_type value indicates the specific mechanism employed on the context, and will never indicate the value for "default".

The conf_avail return value indicates whether the context supports per-message confidentiality services, and so informs the caller whether or not a request for encryption through the conf_req_flag input to GSS_Seal( ) can be honored. In similar fashion, the integ_avail return value indicates whether per-message integrity services are available (through either GSS_Sign( ) or GSS_Seal( )) on the established context.

The lifetime_req input specifies a desired upper bound for the lifetime of the context to be established, with a value of 0 used to request a default lifetime. The lifetime_rec return value indicates the length of time for which the context will be valid, expressed as an offset from the present; depending on mechanism capabilities, credential lifetimes, and local policy, it may not correspond to the value requested in lifetime_req. If no constraints on context lifetime are imposed, this may be indicated by returning a reserved value representing INDEFINITE lifetime_req. The values of conf_avail, integ_avail, and lifetime_rec are undefined unless the routine's major_status indicates COMPLETE.

If the mutual_state is TRUE, this fact will be reflected within the output_token. A call to GSS_Accept_sec_context( ) at the target in conjunction with such a context will return a token, to be processed by a continuation call to GSS_Init_sec_context( ), in order to achieve mutual authentication.

2.2.2 GSS_Accept_sec_context call

Inputs:

- acceptor_cred_handle OCTET STRING,—NULL specifies "use default"
- input_context_handle INTEGER, —0 specifies "not yet assigned"
- chan_bindings OCTET STRING,
- input_token OCTET STRING

Outputs:

- major_status INTEGER,
- minor_status INTEGER,
- src_name INTERNAL NAME,
- mech_type OBJECT IDENTIFIER,
- output_context_handle INTEGER,
- deleg_state BOOLEAN,
- mutual_state BOOLEAN,
- replay_det_state BOOLEAN,
- sequence_state BOOLEAN,
- conf_avail BOOLEAN,
- integ_avail BOOLEAN,
- lifetime_rec INTEGER, — in seconds, or reserved value for INDEFINITE
- delegated_cred_handle OCTET STRING,
- output_token OCTET STRING —NULL or token to pass to context initiator

This call may block pending network interactions for those mech_types in which a directory service or other network entity must be consulted on behalf of a context acceptor in order to validate a received input_token.

Return major_status codes:

- GSS_COMPLETE indicates that context-level data structures were successfully initialized, and that per-message processing can now be performed in conjunction with this context.
- GSS_CONTINUE_NEEDED indicates that control information in the returned output_token must be sent to the initiator, and that a response must be received and passed as the input_token argument to a continuation call to GSS_Accept_sec_context( ), before per-message processing can be performed in conjunction with this context.
- GSS_DEFECTIVE_TOKEN indicates that consistency checks performed on the input_token failed, preventing further processing from being performed based on that token.
- GSS_DEFECTIVE_CREDENTIAL indicates that consistency checks performed on the credential structure referenced by acceptor_cred_handle failed, preventing further processing from being performed using that credential structure.
- GSS_BAD_SIG indicates that the received input_token contains an incorrect signature, so context setup cannot be accomplished.

- GSS_DUPLICATE_TOKEN indicates that the signature on the received input_token was correct, but that the input_token was recognized as a duplicate of an input_token already processed. No new context is established.
- GSS_OLD_TOKEN indicates that the signature on the received input_token was correct, but that the input_token is too old to be checked for duplication against previously-processed input_tokens. No new context is established.
- GSS_NO_CRED indicates that no context was established, either because the input cred_handle was invalid, because the referenced credentials are valid for context initiator use only, or because the caller lacks authorization to access the referenced credentials.
- GSS_CREDENTIALS_EXPIRED indicates that the credentials provided through the input acceptor_cred_handle argument are no longer valid, so context establishment cannot be completed.
- GSS_BAD_BINDINGS indicates that a mismatch between the caller-provided chan_bindings and those extracted from the input_token was detected, signifying a security-relevant event and preventing context establishment.
- GSS_NO_CONTEXT indicates that no valid context was recognized for the input context_handle provided; this major status will be returned only for successor calls following GSS_CONTINUE_NEEDED status returns.
- GSS_FAILURE indicates that context setup could not be accomplished for reasons unspecified at the GSS-API level, and that no interface-defined recovery action is available.

The GSS_Accept_sec_context( ) routine is used by a context target. Using information in the credentials structure referenced by the input acceptor_cred_handle, it verifies the incoming input_token and (following the successful completion of a context establishment sequence) returns the authenticated src_name and the mech_type used. The acceptor_cred_handle must correspond to the same valid credentials structure on the initial call to GSS_Accept_sec_context( ) and on any successor calls resulting from GSS_CONTINUE_NEEDED status returns; different protocol sequences modeled by the GSS_CONTINUE_NEEDED mechanism will require access to credentials at different points in the context establishment sequence.

The input_context_handle argument is 0, specifying "not yet assigned", on the first GSS_Accept_sec_context( ) call relating to a given context. That call returns an output_context_handle for future references to this context; when continuation attempts to GSS_Accept_sec_context( ) are needed to perform context establishment, that handle value will be entered into the input_context_handle argument.

The chan_bindings argument is used by the caller to provide information binding the security context to security-related characteristics (e.g., addresses, cryptographic keys) of the underlying communications channel. See Section 1.1.6 of this document for more discussion of this argument's usage.

The returned state results (deleg_state, mutual_state, replay_det_state, and sequence_state) reflect the same context state values as returned to GSS_Init_sec_context( )'s caller at the initiator system.

The conf_avail return value indicates whether the context supports per-message confidentiality services, and so informs the caller whether or not a request for encryption through the conf_req_flag input to GSS_Seal( ) can be honored. In similar fashion, the integ_avail return value indicates whether per-message integrity services are available (through either GSS_Sign( ) or GSS_Seal( )) on the established context.

The lifetime_rec return value indicates the length of time for which the context will be valid, expressed as an offset from the present. The values of deleg_state, mutual_state, replay_det_state, sequence_state, conf_avail, integ_avail, and lifetime_rec are undefined unless the accompanying major_status indicates COMPLETE.

The delegated_cred_handle result is significant only when deleg_state is TRUE, and provides a means for the target to reference the delegated credentials. The output_token result, when non-NULL, provides a context-level token to be returned to the context initiator to continue a multi-step context establishment sequence. As noted with GSS_Init_sec_context( ), any returned token should be transferred to the context's peer (in this case, the context initiator), independent of the value of the accompanying returned major_status.

Note: A target must be able to distinguish a context-level input_token, which is passed to GSS_Accept_sec_context( ), from the per-message data elements passed to GSS_Verify( ) or GSS_Unseal( ). These data elements may arrive in a single application message, and GSS_Accept_sec_context( ) must be performed before per-message processing can be performed successfully.

2.2.3 GSS_Delete_sec_context call

Input:

- context_handle INTEGER

Outputs:

- major_status INTEGER,
- minor_status INTEGER,
- output_context_token OCTET STRING

Return major_status codes:

- GSS_COMPLETE indicates that the context was recognized, that relevant context-specific information was flushed, and that the returned output_context_token is ready for transfer to the context's peer.
- GSS_NO_CONTEXT indicates that no valid context was recognized for the input context_handle provide, so no deletion was performed.
- GSS_FAILURE indicates that the context is recognized, but that the GSS_Delete_sec_context( ) operation could not be performed for reasons unspecified at the GSS-API level.

This call may block pending network interactions for mech_types in which active notification must be made to a central server when a security context is to be deleted.

This call can be made by either peer in a security context, to flush context-specific information and to return an output_context_token which can be passed to the context's peer informing it that the peer's corresponding context information can also be flushed. (Once a context is established, the peers involved are expected to retain cached credential and context-related information until the information's expiration time is reached or until a GSS_Delete_sec_context( ) call is made.) Attempts to perform per-message processing on a deleted context will result in error returns.

2.2.4 GSS_Process_context_token call

Inputs:

- context_handle INTEGER,
- input_context_token OCTET STRING

Outputs:

- major_status INTEGER,

- minor_status INTEGER,

Return major_status codes:

- GSS_COMPLETE indicates that the input_context_token was successfully processed in conjunction with the context referenced by context_handle.
- GSS_DEFECTIVE_TOKEN indicates that consistency checks performed on the received context_token failed, preventing further processing from being performed with that token.
- GSS_NO_CONTEXT indicates that no valid context was recognized for the input context_handle provided.
- GSS_FAILURE indicates that the context is recognized, but that the GSS_Process_context_token( ) operation could not be performed for reasons unspecified at the GSS-API level.

This call is used to process context_tokens received from a peer once a context has been established, with corresponding impact on context-level state information. One use for this facility is processing of the context_tokens generated by GSS_Delete_sec_context( ); GSS_Process_context_token( ) will not block pending network interactions for that purpose. Another use is to process tokens indicating remote-peer context establishment failures after the point where the local GSS-API implementation has already indicated GSS_COMPLETE status.

2.2.5 GSS_Context_time call

Input:

- context_handle INTEGER,

Outputs:

- major_status INTEGER,
- minor_status INTEGER,
- lifetime_rec INTEGER — in seconds, or reserved value for INDEFINITE

Return major_status codes:

- GSS_COMPLETE indicates that the referenced context is valid, and will remain valid for the amount of time indicated in lifetime_rec.
- GSS_CONTEXT_EXPIRED indicates that data items related to the referenced context have expired.
- GSS_CREDENTIALS_EXPIRED indicates that the context is recognized, but that its associated credentials have expired.
- GSS_NO_CONTEXT indicates that no valid context was recognized for the input context_handle provided.
- GSS_FAILURE indicates that the requested operation failed for reasons unspecified at the GSS-API level.

This call is used to determine the amount of time for which a currently established context will remain valid.

2.3 Per-message calls

This group of calls is used to perform per-message protection processing on an established security context. None of these calls block pending network interactions. These calls may be invoked by a context's initiator or by the context's target. The four members of this group should be considered as two pairs; the output from GSS_Sign( ) is properly input to GSS_Verify( ), and the output from GSS_ Seal( ) is properly input to GSS_Unseal( ).

GSS_Sign( ) and GSS_Verify( ) support data origin authentication and data integrity services. When GSS_Sign( ) is invoked on an input message, it yields a per-message token containing data items which allow underlying mechanisms to provide the specified security services. The original message, along with the generated per-message token, is passed to the remote peer; these two data elements are processed by GSS_Verify( ), which validates the message in conjunction with the separate token.

GSS_Seal( ) and GSS_Unseal( ) support caller-requested confidentiality in addition to the data origin authentication and data integrity services offered by GSS_Sign( ) and GSS_Verify( ). GSS_Seal( ) outputs a single data element, encapsulating optionally-enciphered user data as well as associated token data items. The data element output from GSS_Seal( ) is passed to the remote peer and processed by GSS_Unseal( ) at that system. GSS_Unseal( ) combines decipherment (as required) with validation of data items related to authentication and integrity.

2.3.1 GSS_Sign call

Inputs:

- context_handle INTEGER,
- qop_req INTEGER,—0 specifies default QOP
- message OCTET STRING

Outputs:

- major_status INTEGER,
- minor_status INTEGER,
- per_msg_token OCTET STRING

Return major_status codes:

- GSS_COMPLETE indicates that a signature, suitable for an established security context, was successfully applied and that the message and corresponding per_msg_token are ready for transmission.
- GSS_CONTEXT_EXPIRED indicates that context-related data items have expired, so that the requested operation cannot be performed.
- GSS_CREDENTIALS_EXPIRED indicates that the context is recognized, but that its associated credentials have expired, so that the requested operation cannot be performed.
- GSS_NO_CONTEXT indicates that no valid context was recognized for the input context_handle provided.
- GSS_FAILURE indicates that the context is recognized, but that the requested operation could not be performed for reasons unspecified at the GSS-API level.

Using the security context referenced by context_handle, apply a signature to the input message (along with timestamps and/or other data included in support of mech_type-specific mechanisms) and return the result in per_msg_token. The qop_req parameter allows quality-of-protection control. The caller passes the message and the per_msg_token to the target.

The GSS_Sign( ) function completes before the message and per_msg_token is sent to the peer; successful application of GSS_Sign( ) does not guarantee that a corresponding GSS_Verify( ) has been (or can necessarily be) performed successfully when the message arrives at the destination.

2.3.2 GSS_Verify call

Inputs:

- context_handle INTEGER,
- message OCTET STRING,
- per_msg_token OCTET STRING

Outputs:

- qop_state INTEGER,
- major_status INTEGER,
- minor_status INTEGER,

Return major_status codes:

- GSS_COMPLETE indicates that the message was successfully verified.
- GSS_DEFECTIVE_TOKEN indicates that consistency checks performed on the received per_msg_token failed, preventing further processing from being performed with that token.
- GSS_BAD_SIG indicates that the received per_msg_token contains an incorrect signature for the message.
- GSS_DUPLICATE_TOKEN, GSS_OLD_TOKEN, and GSS_UNSEQ_TOKEN values appear in conjunction with the optional per-message replay detection features described in Section 1.2.3; their semantics are described in that section.
- GSS_CONTEXT_EXPIRED indicates that context-related data items have expired, so that the requested operation cannot be performed.
- GSS_CREDENTIALS_EXPIRED indicates that the context is recognized, but that its associated credentials have expired, so that the requested operation cannot be performed.
- GSS_NO_CONTEXT indicates that no valid context was recognized for the input context_handle provided.
- GSS_FAILURE indicates that the context is recognized, but that the GSS_Verify( ) operation could not be performed for reasons unspecified at the GSS-API level.

Using the security context referenced by context_handle, verify that the input per_msg_token contains an appropriate signature for the input message, and apply any active replay detection or sequencing features. Return an indication of the quality-of-protection applied to the processed message in the qop_state result.

2.3.3 GSS_Seal call

Inputs:

- context_handle INTEGER,
- conf_req_flag BOOLEAN,
- qop_req INTEGER,—0 specifies default QOP
- input_message OCTET STRING

Outputs:

- major_status INTEGER,
- minor_status INTEGER,
- conf_state BOOLEAN,
- output_message OCTET STRING

Return major_status codes:

- GSS_COMPLETE indicates that the input_message was successfully processed and that the output_message is ready for transmission.
- GSS_CONTEXT_EXPIRED indicates that context-related data items have expired, so that the requested operation cannot be performed.
- GSS_CREDENTIALS_EXPIRED indicates that the context is recognized, but that its associated credentials have expired, so that the requested operation cannot be performed.
- GSS_NO_CONTEXT indicates that no valid context was recognized for the input context_handle provided.
- GSS_FAILURE indicates that the context is recognized, but that the GSS_Seal( ) operation could not be performed for reasons unspecified at the GSS-API level.

Performs the data origin authentication and data integrity functions of GSS_Sign( ). If the input conf_req_flag is TRUE, requests that confidentiality be applied to the input_message. Confidentiality may not be supported in all mech_types or by all implementations; the returned conf_state flag indicates whether confidentiality was provided for the input_message. The qop_req parameter allows quality-of-protection control.

In all cases, the GSS_Seal( ) call yields a single output_message data element containing (optionally enciphered) user data as well as control information.

2.3.4 GSS_Unseal call

Inputs:

- context_handle INTEGER,
- input_message OCTET STRING

Outputs:

- conf_state BOOLEAN,
- qop_state INTEGER,
- major_status INTEGER,

- minor_status INTEGER,
- output_message OCTET STRING

Return major_status codes:

- GSS_COMPLETE indicates that the input_message was successfully processed and that the resulting output_message is available.
- GSS_DEFECTIVE_TOKEN indicates that consistency checks performed on the per_msg_token extracted from the input_message failed, preventing further processing from being performed.
- GSS_BAD_SIG indicates that an incorrect signature was detected for the message.
- GSS_DUPLICATE_TOKEN, GSS_OLD_TOKEN, and GSS_UNSEQ_TOKEN values appear in conjunction with the optional per-message replay detection features described in Section 1.2.3; their semantics are described in that section.
- GSS_CONTEXT_EXPIRED indicates that context-related data items have expired, so that the requested operation cannot be performed.
- GSS_CREDENTIALS_EXPIRED indicates that the context is recognized, but that its associated credentials have expired, so that the requested operation cannot be performed.
- GSS_NO_CONTEXT indicates that no valid context was recognized for the input context_handle provided.
- GSS_FAILURE indicates that the context is recognized, but that the GSS_Unseal( ) operation could not be performed for reasons unspecified at the GSS-API level.

Processes a data element generated (and optionally enciphered) by GSS_Seal( ), provided as input_message. The returned conf_state value indicates whether confidentiality was applied to the input_message. If conf_state is TRUE, GSS_Unseal( ) deciphers the input_message. Returns an indication of the quality-of-protection applied to the processed message in the qop_state result. GSS_Seal( ) performs the data integrity and data origin authentication checking functions of GSS_Verify( ) on the plaintext data. Plaintext data is returned in output_message.

2.4 Support calls

This group of calls provides support functions useful to GSS-API callers, independent of the state of established contexts. Their characterization with regard to blocking or non-blocking status in terms of network interactions is unspecified.

2.4.1 GSS_Display_status call

Inputs:

- status_value INTEGER,—GSS-API major_status or minor_status return value
- status_type INTEGER,—1 if major_status, 2 if minor_status
- mech_type OBJECT IDENTIFIER—mech_type to be used for minor_status translation

Outputs:

- major_status INTEGER,
- minor_status INTEGER,

- status_string_set SET OF OCTET STRING

Return major_status codes:

- GSS_COMPLETE indicates that a valid printable status representation (possibly representing more than one status event encoded within the status_value) is available in the returned status_string_set.
- GSS_BAD_MECH indicates that translation in accordance with an unsupported mech_type was requested, so translation could not be performed.
- GSS_BAD_STATUS indicates that the input status_value was invalid, or that the input status_type carried a value other than 1 or 2, so translation could not be performed.
- GSS_FAILURE indicates that the requested operation could not be performed for reasons unspecified at the GSS-API level.

Provides a means for callers to translate GSS-API-returned major and minor status codes into printable string representations.

2.4.2 GSS_Indicate_mechs call

Input:

- (none)

Outputs:

- major_status INTEGER,
- minor_status INTEGER,
- mech_set SET OF OBJECT IDENTIFIER

Return major_status codes:

- GSS_COMPLETE indicates that a set of available mechanisms has been returned in mech_set.
- GSS_FAILURE indicates that the requested operation could not be performed for reasons unspecified at the GSS-API level.

Allows callers to determine the set of mechanism types available on the local system. This call is intended for support of specialized callers who need to request non-default mech_type sets from GSS_ Acquire_cred( ), and should not be needed by other callers.

2.4.3 GSS_Compare_name call

Inputs:

- name1 INTERNAL NAME,
- name2 INTERNAL NAME

Outputs:

- major_status INTEGER,
- minor_status INTEGER,
- name_equal BOOLEAN

Return major_status codes:

- GSS_COMPLETE indicates that name1 and name2 were comparable, and that the name_equal result indicates whether name1 and name2 were equal or unequal.
- GSS_BAD_NAMETYPE indicates that one or both of name1 and name2 contained internal type specifiers uninterpretable by the supporting GSS-API implementation, or that the two names' types are different and incomparable, so the equality comparison could not be completed.
- GSS_BAD_NAME indicates that one or both of the input names was ill-formed in terms of its internal type specifier, so the equality comparison could not be completed.
- GSS_FAILURE indicates that the requested operation could not be performed for reasons unspecified at the GSS-API level.

Allows callers to compare two internal name representations for equality.

2.4.4 GSS_Display_name call

Inputs:

- name INTERNAL NAME

Outputs:

- major_status INTEGER,
- minor_status INTEGER,
- name_string OCTET STRING,
- name_type OBJECT IDENTIFIER

Return major_status codes:

- GSS_COMPLETE indicates that a valid printable name representation is available in the returned name_string.
- GSS_BAD_NAMETYPE indicates that the provided name was of a type uninterpretable by the supporting GSS-API implementation, so no printable representation could be generated.
- GSS_BAD_NAME indicates that the contents of the provided name were inconsistent with the internally-indicated name type, so no printable representation could be generated.
- GSS_FAILURE indicates that the requested operation could not be performed for reasons unspecified at the GSS-API level.

Allows callers to translate an internal name representation into a printable form with associated namespace type descriptor. The syntax of the printable form is a local matter.

2.4.5 GSS_Import_name call

Inputs:

- input_name_string OCTET STRING,
- input_name_type OBJECT IDENTIFIER

Outputs:

- major_status INTEGER,
- minor_status INTEGER,

- output_name INTERNAL NAME

Return major_status codes:

- GSS_COMPLETE indicates that a valid name representation is output in output_name and described by the type value in output_name_type.
- GSS_BAD_NAMETYPE indicates that the input_name_type is unsupported by the GSS-API implementation, so the import operation could not be completed.
- GSS_BAD_NAME indicates that the provided input_name_string is ill-formed in terms of the input_name_type, so the import operation could not be completed.
- GSS_FAILURE indicates that the requested operation could not be performed for reasons unspecified at the GSS-API level.

Allows callers to provide a printable name representation, designate the type of namespace in conjunction with which it should be parsed, and convert that printable representation to an internal form suitable for input to other GSS-API routines. The syntax of the input_name is a local matter.

2.4.6 GSS_Release_name call

Inputs:

- name INTERNAL NAME

Outputs:

- major_status INTEGER,
- minor_status INTEGER

Return major_status codes:

- GSS_COMPLETE indicates that the storage associated with the input name was successfully released.
- GSS_BAD_NAME indicates that the input name argument did not contain a valid name.
- GSS_FAILURE indicates that the requested operation could not be performed for reasons unspecified at the GSS-API level.

Allows callers to release the storage associated with an internal name representation.

2.4.7 GSS_Release_buffer call

Inputs:

- buffer OCTET STRING

Outputs:

- major_status INTEGER,
- minor_status INTEGER

Return major_status codes:

- GSS_COMPLETE indicates that the storage associated with the input buffer was successfully released.

- GSS_FAILURE indicates that the requested operation could not be performed for reasons unspecified at the GSS-API level.

Allows callers to release the storage associated with an OCTET STRING buffer allocated by another GSS-API call.

2.4.8 GSS_Release_oid_set call

Inputs:

- buffer SET OF OBJECT IDENTIFIER

Outputs:

- major_status INTEGER,
- minor_status INTEGER

Return major_status codes:

- GSS_COMPLETE indicates that the storage associated with the input object identifier set was successfully released.
- GSS_FAILURE indicates that the requested operation could not be performed for reasons unspecified at the GSS-API level.

Allows callers to release the storage associated with an object identifier set object allocated by another GSS-API call.

3 Mechanism-Specific Example Scenarios

This section provides illustrative overviews of the use of various candidate mechanism types to support the GSS-API. These discussions are intended primarily for readers familiar with specific security technologies, demonstrating how GSS-API functions can be used and implemented by candidate underlying mechanisms. They should not be regarded as constrictive to implementations or as defining the only means through which GSS-API functions can be realized with a particular underlying technology, and do not demonstrate all GSS-API features with each technology.

3.1 Kerberos V5, single-TGT

OS-specific login functions yield a TGT to the local realm Kerberos server; TGT is placed in a credentials structure for the client. Client calls GSS_Acquire_cred( ) to acquire a cred_handle in order to reference the credentials for use in establishing security contexts.

Client calls GSS_Init_sec_context( ). If the requested service is located in a different realm, GSS_Init_sec_context( ) gets the necessary TGT/key pairs needed to traverse the path from local to target realm; these data are placed in the owner's TGT cache. After any needed remote realm resolution, GSS_Init_sec_context( ) yields a service ticket to the requested service with a corresponding session key; these data are stored in conjunction with the context. GSS-API code sends KRB_TGS_REQ request(s) and receives KRB_TGS_REP response(s) (in the successful case) or KRB_ERROR.

Assuming success, GSS_Init_sec_context( ) builds a Kerberos-formatted KRB_AP_REQ message, and returns it in output_token. The client sends the output_token to the service.

The service passes the received token as the input_token argument to GSS_Accept_sec_context( ), which verifies the authenticator, provides the service with the client's authenticated name, and returns an output_context_handle.

Both parties now hold the session key associated with the service ticket, and can use this key in subsequent GSS_Sign( ), GSS_Verify( ), GSS_Seal( ), and GSS_Unseal( ) operations.

3.2 Kerberos V5, double-TGT

TGT acquisition as above.

Note: To avoid unnecessary frequent invocations of error paths when implementing the GSS-API atop Kerberos V5, it seems appropriate to represent "single-TGT K-V5" and "double-TGT K-V5" with separate mech_types, and this discussion makes that assumption.

Based on the (specified or defaulted) mech_type, GSS_Init_sec_context( ) determines that the double-TGT protocol should be employed for the specified target. GSS_Init_sec_context( ) returns GSS_CONTINUE_NEEDED major_status[9], and its returned output_token contains a request to the service for the service's TGT. (If a service TGT with suitably long remaining lifetime already exists in a cache, it may be usable, obviating the need for this step.) The client passes the output_token to the service.

The service passes the received token as the input_token argument to GSS_Accept_sec_context( ), which recognizes it as a request for TGT. (Note that current Kerberos V5 defines no intra-protocol mechanism to represent such a request.) GSS_Accept_sec_context( ) returns GSS_CONTINUE_NEEDED major_status and provides the service's TGT in its output_token. The service sends the output_token to the client.

The client passes the received token as the input_token argument to a continuation of GSS_Init_sec_context( ). GSS_Init_sec_context( ) caches the received service TGT and uses it as part of a service ticket request to the Kerberos authentication server, storing the returned service ticket and session key in conjunction with the context. GSS_Init_sec_context( ) builds a Kerberos-formatted authenticator, and returns it in output_token along with GSS_COMPLETE return major_status. The client sends the output_token to the service.

Service passes the received token as the input_token argument to a continuation call to GSS_Accept_sec_context( ). GSS_Accept_sec_context( ) verifies the authenticator, provides the service with the client's authenticated name, and returns major_status GSS_COMPLETE.

GSS_Sign( ), GSS_Verify( ), GSS_Seal( ), and GSS_Unseal( ) as above.

3.3 X.509 Authentication Framework

This example illustrates use of the GSS-API in conjunction with public-key mechanisms, consistent with the X.509 Directory Authentication Framework.

The GSS_Acquire_cred( ) call establishes a credentials structure, making the client's private key accessible for use on behalf of the client.

The client calls GSS_Init_sec_context( ), which interrogates the Directory to acquire (and validate) a chain of public-key certificates, thereby collecting the public key of the service. The certificate validation operation determines that suitable signatures were applied by trusted authorities and that those certificates have not expired. GSS_Init_sec_context( ) generates a secret key for use in per-message protection operations on the context, and enciphers that secret key under the service's public key.

[9] This scenario illustrates a different use for the GSS_CONTINUE_NEEDED status return facility than for support of mutual authentication; note that both uses can coexist as successive operations within a single context establishment operation.

The enciphered secret key, along with an authenticator quantity signed with the client's private key, is included in the output_token from GSS_Init_sec_context( ). The output_token also carries a certification path, consisting of a certificate chain leading from the service to the client; a variant approach would defer this path resolution to be performed by the service instead of being asserted by the client. The client application sends the output_token to the service.

The service passes the received token as the input_token argument to GSS_Accept_sec_context( ). GSS_Accept_sec_context( ) validates the certification path, and as a result determines a certified binding between the client's distinguished name and the client's public key. Given that public key, GSS_Accept_sec_context( ) can process the input_token's authenticator quantity and verify that the client's private key was used to sign the input_token. At this point, the client is authenticated to the service. The service uses its private key to decipher the enciphered secret key provided to it for per-message protection operations on the context.

The client calls GSS_Sign( ) or GSS_Seal( ) on a data message, which causes per-message authentication, integrity, and (optional) confidentiality facilities to be applied to that message. The service uses the context's shared secret key to perform corresponding GSS_Verify( ) and GSS_Unseal( ) calls.

4 Related Activities

In order to implement the GSS-API atop existing, emerging, and future security mechanisms:

- object identifiers must be assigned to candidate GSS-API mechanisms and the name types which they support
- concrete data element formats must be defined for candidate mechanisms (encapsulation within the mechanism-independent token format definition in Appendix B of this document is recommended to mechanism designers)

Calling applications must implement formatting conventions which will enable them to distinguish GSS-API tokens from other data carried in their application protocols.

Concrete language bindings are required for the programming environments in which the GSS-API is to be employed; such bindings for the C language are available in an associated Internet-Draft.

5 Acknowledgments

This proposal is the result of a collaborative effort. Acknowledgments are due to the many members of the IETF Security Area Advisory Group (SAAG) and the Common Authentication Technology (CAT) Working Group for their contributions at meetings and by electronic mail. Acknowledgments are also due to Kannan Alagappan, Doug Barlow, Bill Brown, Cliff Kahn, Charlie Kaufman, Butler Lampson, Richard Pitkin, Joe Tardo, and John Wray of Digital Equipment Corporation, and John Carr, John Kohl, Jon Rochlis, Jeff Schiller, and Ted T'so of MIT and Project Athena. Joe Pato and Bill Sommerfeld of HP/Apollo, Walt Tuvell of OSF, and Bill Griffith and Mike Merritt of AT&T, provided inputs which helped to focus and clarify directions. Precursor work by Richard Pitkin, presented to meetings of the Trusted Systems Interoperability Group (TSIG), helped to demonstrate the value of a generic, mechanism-independent security service API.

APPENDIX A

PACS AND AUTHORIZATION SERVICES

Consideration has been given to modifying the GSS-API service interface to recognize and manipulate Privilege Attribute Certificates (PACs) as in ECMA 138, carrying authorization data as a side effect of establishing a security context, but no such modifications have been incorporated at this time. This appendix provides rationale for this decision and discusses compatibility alternatives between PACs and the GSS-API which do not require that PACs be made visible to GSS-API callers.

Existing candidate mechanism types such as Kerberos and X.509 do not incorporate PAC manipulation features, and exclusion of such mechanisms from the set of candidates equipped to fully support the GSS-API seems inappropriate. Inclusion (and GSS-API visibility) of a feature supported by only a limited number of mechanisms could encourage the development of ostensibly portable applications which would in fact have only limited portability.

The status quo, in which PACs are not visible across the GSS-API interface, does not preclude implementations in which PACs are carried transparently, within the tokens defined and used for certain mech_types, and stored within peers' credentials and context-level data structures. While invisible to API callers, such PACs could be used by operating system or other local functions as inputs in the course of mediating access requests made by callers. This course of action allows dynamic selection of PAC contents, if such selection is administratively-directed rather than caller-directed.

In a distributed computing environment, authentication must span different systems; the need for such authentication provides motivation for GSS-API definition and usage. Heterogeneous systems in a network can intercommunicate, with globally authenticated names comprising the common bond between locally defined access control policies. Access control policies to which authentication provides inputs are often local, or specific to particular operating systems or environments. If the GSS-API made particular authorization models visible across its service interface, its scope of application would become less general. The current GSS-API paradigm is consistent with the precedent set by Kerberos, neither defining the interpretation of authorization-related data nor enforcing access controls based on such data.

The GSS-API is a general interface, whose callers may reside inside or outside any defined TCB or NTCB boundaries. Given this characteristic, it appears more realistic to provide facilities which provide "value-added" security services to its callers than to offer facilities which enforce restrictions on those callers. Authorization decisions must often be mediated below the GSS-API level in a local manner against (or in spite of) applications, and cannot be selectively invoked or omitted at those applications' discretion. Given that the GSS-API's placement prevents it from providing a comprehensive solution to the authorization issue, the value of a partial contribution specific to particular authorization models is debatable.

APPENDIX B

MECHANISM-INDEPENDENT TOKEN FORMAT

This appendix specifies a mechanism-independent level of encapsulating representation for the initial token of a GSS-API context establishment sequence, incorporating an identifier of the mechanism type to be used on that context. Use of this format (with ASN.1-encoded data elements represented in BER, constrained in the interests of parsing simplicity to the Distinguished Encoding Rule (DER) BER subset defined in X.509, clause 8.7) is recommended to the designers of GSS-API implementations based on various mechanisms, so that tokens can be interpreted unambiguously at GSS-API peers. There is no requirement that the mechanism-specific innerContextToken, innerMsgToken, and sealedUserData data elements be encoded in ASN.1 BER.

```
-- optional top-level token definitions to
-- frame different mechanisms

GSS-API DEFINITIONS ::=

BEGIN

MechType ::= OBJECT IDENTIFIER
-- data structure definitions

-- callers must be able to distinguish among
-- InitialContextToken, SubsequentContextToken,
-- PerMsgToken, and SealedMessage data elements
-- based on the usage in which they occur

InitialContextToken ::=
-- option indication (delegation, etc.) indicated within
-- mechanism-specific token
[APPLICATION 0] IMPLICIT SEQUENCE {
        thisMech MechType,
        innerContextToken ANY DEFINED BY thisMech
           -- contents mechanism-specific
        }

SubsequentContextToken ::= innerContextToken ANY
-- interpretation based on predecessor InitialContextToken

PerMsgToken ::=
-- as emitted by GSS_Sign and processed by GSS_Verify
        innerMsgToken ANY

SealedMessage ::=
-- as emitted by GSS_Seal and processed by GSS_Unseal
-- includes internal, mechanism-defined indicator
-- of whether or not encrypted
        sealedUserData ANY

END
```