

## Generic Security Service Application Program Interface

### Status of this Memo

This RFC specifies an Internet standards track protocol for the Internet community, and requests discussion and suggestions for improvements. Please refer to the current edition of the "Internet Official Protocol Standards" for the standardization state and status of this protocol. Distribution of this memo is unlimited.

### Abstract

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

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## 1. GSS-API Characteristics and Concepts

The operational paradigm in which GSS-API operates 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 (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.) (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 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.

The following paragraphs provide an example illustrating 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. The example assumes 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.

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

#### 1.1.1.2. 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. (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.) 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 (OIDs)) serve to qualify the interpretation of associated tokens. (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)".) 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.

#### 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 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. (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.)

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.

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 conventional interpretations for the contents of channel binding arguments, including address specifiers (with content dependent on communications protocol environment) for context initiators and acceptors. (These conventions are being incorporated into related documents.) 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_NAME_TYPE	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

#### 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 accommodated 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.

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 granularity 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 than a message already processed on the context. [Note: 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.]

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.

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:

- o desired\_name INTERNAL NAME, -NULL requests locally-determined default
- o lifetime\_req INTEGER, -in seconds; 0 requests default
- o desired\_mechs SET OF OBJECT IDENTIFIER, -empty set requests system-selected default
- o cred\_usage INTEGER-0=INITIATE-AND-ACCEPT, 1=INITIATE-ONLY, 2=ACCEPT-ONLY

#### Outputs:

- o major\_status INTEGER,
- o minor\_status INTEGER,
- o output\_cred\_handle OCTET STRING,
- o actual\_mechs SET OF OBJECT IDENTIFIER,
- o lifetime\_rec INTEGER -in seconds, or reserved value for INDEFINITE

Return major\_status codes:

- o 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.
- o GSS\_BAD\_MECH indicates that a mech\_type unsupported by the GSS-API implementation type was requested, causing the credential establishment operation to fail.
- o GSS\_BAD\_NAME\_TYPE 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.
- o 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.
- o 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. 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.

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, or can request credentials with a default validity interval. (Requests for postdated credentials are not supported within the GSS-API.) 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:

- o `cred_handle` OCTET STRING-NULL specifies default credentials

Outputs:

- o `major_status` INTEGER,
- o `minor_status` INTEGER

Return `major_status` codes:

- o `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.

- o 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.
- o 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:

- o cred\_handle OCTET STRING -NULL specifies default credentials

Outputs:

- o major\_status INTEGER,
- o minor\_status INTEGER,
- o cred\_name INTERNAL NAME,
- o lifetime\_rec INTEGER -in seconds, or reserved value for INDEFINITE
- o cred\_usage INTEGER, -0=INITIATE-AND-ACCEPT, 1=INITIATE-ONLY, 2=ACCEPT-ONLY
- o mech\_set SET OF OBJECT IDENTIFIER

Return major\_status codes:

- o 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.

- o 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.
- o 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:

- o claimant\_cred\_handle OCTET STRING, -NULL specifies "use default"
- o input\_context\_handle INTEGER, -0 specifies "none assigned yet"
- o targ\_name INTERNAL NAME,
- o mech\_type OBJECT IDENTIFIER, -NULL parameter specifies "use default"
- o deleg\_req\_flag BOOLEAN,

- o mutual\_req\_flag BOOLEAN,
- o replay\_det\_req\_flag BOOLEAN,
- o sequence\_req\_flag BOOLEAN,
- o lifetime\_req INTEGER,-0 specifies default lifetime
- o chan\_bindings OCTET STRING,
- o input\_token OCTET STRING-NULL or token received from target

Outputs:

- o major\_status INTEGER,
- o minor\_status INTEGER,
- o output\_context\_handle INTEGER,
- o mech\_type OBJECT IDENTIFIER, -actual mechanism always indicated, never NULL
- o output\_token OCTET STRING, -NULL or token to pass to context target
- o deleg\_state BOOLEAN,
- o mutual\_state BOOLEAN,
- o replay\_det\_state BOOLEAN,
- o sequence\_state BOOLEAN,
- o conf\_avail BOOLEAN,
- o integ\_avail BOOLEAN,
- o 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:

- o 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.
- o 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.
- o GSS\_DEFECTIVE\_TOKEN indicates that consistency checks performed on the input\_token failed, preventing further processing from being performed based on that token.
- o 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.
- o GSS\_BAD\_SIG indicates that the received input\_token contains an incorrect signature, so context setup cannot be accomplished.
- o 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.
- o 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.
- o 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.)
- o 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.
- o GSS\_BAD\_NAME\_TYPE 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.

- o 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.
- o 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:

- o acceptor\_cred\_handle OCTET STRING, -NULL specifies "use default"
- o input\_context\_handle INTEGER, -0 specifies "not yet assigned"
- o chan\_bindings OCTET STRING,
- o input\_token OCTET STRING

##### Outputs:

- o major\_status INTEGER,
- o minor\_status INTEGER,
- o src\_name INTERNAL NAME,
- o mech\_type OBJECT IDENTIFIER,
- o output\_context\_handle INTEGER,
- o deleg\_state BOOLEAN,
- o mutual\_state BOOLEAN,
- o replay\_det\_state BOOLEAN,
- o sequence\_state BOOLEAN,
- o conf\_avail BOOLEAN,
- o integ\_avail BOOLEAN,
- o lifetime\_rec INTEGER, - in seconds, or reserved value for INDEFINITE
- o delegated\_cred\_handle OCTET STRING,
- o 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:

- o 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.
- o 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.
- o GSS\_DEFECTIVE\_TOKEN indicates that consistency checks performed on the input\_token failed, preventing further processing from being performed based on that token.
- o 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.
- o GSS\_BAD\_SIG indicates that the received input\_token contains an incorrect signature, so context setup cannot be accomplished.
- o 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.
- o 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.
- o 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.

- o 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.
- o 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.
- o 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.
- o 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:

- o `context_handle` INTEGER

Outputs:

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

Return `major_status` codes:

- o 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.
- o GSS\_NO\_CONTEXT indicates that no valid context was recognized for the input context\_handle provide, so no deletion was performed.
- o 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:

- o context\_handle INTEGER,
- o input\_context\_token OCTET STRING

Outputs:

- o major\_status INTEGER,
- o minor\_status INTEGER,

Return major\_status codes:

- o GSS\_COMPLETE indicates that the input\_context\_token was successfully processed in conjunction with the context referenced by context\_handle.
- o GSS\_DEFECTIVE\_TOKEN indicates that consistency checks performed on the received context\_token failed, preventing further processing

from being performed with that token.

- o GSS\_NO\_CONTEXT indicates that no valid context was recognized for the input context\_handle provided.
- o 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:

- o context\_handle INTEGER,

Outputs:

- o major\_status INTEGER,
- o minor\_status INTEGER,
- o lifetime\_rec INTEGER - in seconds, or reserved value for INDEFINITE

Return major\_status codes:

- o GSS\_COMPLETE indicates that the referenced context is valid, and will remain valid for the amount of time indicated in lifetime\_rec.
- o GSS\_CONTEXT\_EXPIRED indicates that data items related to the referenced context have expired.
- o GSS\_CREDENTIALS\_EXPIRED indicates that the context is recognized, but that its associated credentials have expired.
- o GSS\_NO\_CONTEXT indicates that no valid context was recognized for the input context\_handle provided.

- o 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:

- o context\_handle INTEGER,
- o qop\_req INTEGER, -0 specifies default QOP
- o message OCTET STRING

Outputs:

- o major\_status INTEGER,

- o minor\_status INTEGER,
- o per\_msg\_token OCTET STRING

Return major\_status codes:

- o 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.
- o GSS\_CONTEXT\_EXPIRED indicates that context-related data items have expired, so that the requested operation cannot be performed.
- o GSS\_CREDENTIALS\_EXPIRED indicates that the context is recognized, but that its associated credentials have expired, so that the requested operation cannot be performed.
- o GSS\_NO\_CONTEXT indicates that no valid context was recognized for the input context\_handle provided.
- o 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:

- o context\_handle INTEGER,
- o message OCTET STRING,
- o per\_msg\_token OCTET STRING

## Outputs:

- o qop\_state INTEGER,
- o major\_status INTEGER,
- o minor\_status INTEGER,

## Return major\_status codes:

- o GSS\_COMPLETE indicates that the message was successfully verified.
- o GSS\_DEFECTIVE\_TOKEN indicates that consistency checks performed on the received per\_msg\_token failed, preventing further processing from being performed with that token.
- o GSS\_BAD\_SIG indicates that the received per\_msg\_token contains an incorrect signature for the message.
- o 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.
- o GSS\_CONTEXT\_EXPIRED indicates that context-related data items have expired, so that the requested operation cannot be performed.
- o GSS\_CREDENTIALS\_EXPIRED indicates that the context is recognized, but that its associated credentials have expired, so that the requested operation cannot be performed.
- o GSS\_NO\_CONTEXT indicates that no valid context was recognized for the input context\_handle provided.
- o 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:

- o context\_handle INTEGER,
- o conf\_req\_flag BOOLEAN,
- o qop\_req INTEGER, -0 specifies default QOP
- o input\_message OCTET STRING

#### Outputs:

- o major\_status INTEGER,
- o minor\_status INTEGER,
- o conf\_state BOOLEAN,
- o output\_message OCTET STRING

#### Return major\_status codes:

- o GSS\_COMPLETE indicates that the input\_message was successfully processed and that the output\_message is ready for transmission.
- o GSS\_CONTEXT\_EXPIRED indicates that context-related data items have expired, so that the requested operation cannot be performed.
- o GSS\_CREDENTIALS\_EXPIRED indicates that the context is recognized, but that its associated credentials have expired, so that the requested operation cannot be performed.
- o GSS\_NO\_CONTEXT indicates that no valid context was recognized for the input context\_handle provided.
- o 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:

- o `context_handle` INTEGER,
- o `input_message` OCTET STRING

##### Outputs:

- o `conf_state` BOOLEAN,
- o `qop_state` INTEGER,
- o `major_status` INTEGER,
- o `minor_status` INTEGER,
- o `output_message` OCTET STRING

##### Return `major_status` codes:

- o `GSS_COMPLETE` indicates that the `input_message` was successfully processed and that the resulting `output_message` is available.
- o `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.
- o `GSS_BAD_SIG` indicates that an incorrect signature was detected for the message.
- o `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.
- o `GSS_CONTEXT_EXPIRED` indicates that context-related data items have expired, so that the requested operation cannot be performed.
- o `GSS_CREDENTIALS_EXPIRED` indicates that the context is recognized, but that its associated credentials have expired, so that the requested operation cannot be performed.

- o GSS\_NO\_CONTEXT indicates that no valid context was recognized for the input context\_handle provided.
- o 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:

- o status\_value INTEGER, -GSS-API major\_status or minor\_status return value
- o status\_type INTEGER, -1 if major\_status, 2 if minor\_status
- o mech\_type OBJECT IDENTIFIER-mech\_type to be used for minor\_status translation

Outputs:

- o major\_status INTEGER,
- o minor\_status INTEGER,
- o status\_string\_set SET OF OCTET STRING

Return major\_status codes:

- o 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`.

- o `GSS_BAD_MECH` indicates that translation in accordance with an unsupported `mech_type` was requested, so translation could not be performed.
- o `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.
- o `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:

- o (none)

Outputs:

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

Return major\_status codes:

- o `GSS_COMPLETE` indicates that a set of available mechanisms has been returned in `mech_set`.
- o `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:

- o name1 INTERNAL NAME,
- o name2 INTERNAL NAME

Outputs:

- o major\_status INTEGER,
- o minor\_status INTEGER,
- o name\_equal BOOLEAN

Return major\_status codes:

- o GSS\_COMPLETE indicates that name1 and name2 were comparable, and that the name\_equal result indicates whether name1 and name2 were equal or unequal.
- o GSS\_BAD\_NAME\_TYPE 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.
- o 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.
- o 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:

- o name INTERNAL NAME

Outputs:

- o major\_status INTEGER,
- o minor\_status INTEGER,
- o name\_string OCTET STRING,

- o name\_type OBJECT IDENTIFIER

Return major\_status codes:

- o GSS\_COMPLETE indicates that a valid printable name representation is available in the returned name\_string.
- o GSS\_BAD\_NAME\_TYPE indicates that the provided name was of a type uninterpretable by the supporting GSS-API implementation, so no printable representation could be generated.
- o 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.
- o 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:

- o input\_name\_string OCTET STRING,
- o input\_name\_type OBJECT IDENTIFIER

Outputs:

- o major\_status INTEGER,
- o minor\_status INTEGER,
- o output\_name INTERNAL NAME

Return major\_status codes:

- o GSS\_COMPLETE indicates that a valid name representation is output in output\_name and described by the type value in output\_name\_type.
- o GSS\_BAD\_NAME\_TYPE indicates that the input\_name\_type is unsupported by the GSS-API implementation, so the import operation could not be completed.

- o 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.
- o 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:

- o name INTERNAL NAME

Outputs:

- o major\_status INTEGER,
- o minor\_status INTEGER

Return major\_status codes:

- o GSS\_COMPLETE indicates that the storage associated with the input name was successfully released.
- o GSS\_BAD\_NAME indicates that the input name argument did not contain a valid name.
- o 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:

- o buffer OCTET STRING

Outputs:

- o major\_status INTEGER,

- o minor\_status INTEGER

Return major\_status codes:

- o GSS\_COMPLETE indicates that the storage associated with the input buffer was successfully released.
- o 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:

- o buffer SET OF OBJECT IDENTIFIER

Outputs:

- o major\_status INTEGER,
- o minor\_status INTEGER

Return major\_status codes:

- o GSS\_COMPLETE indicates that the storage associated with the input object identifier set was successfully released.
- o 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`, 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. Note: 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 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.

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

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 RFC.

## 5. Acknowledgments

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## 6. Security Considerations

Security issues are discussed throughout this memo.

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## 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
```

## APPENDIX C

## MECHANISM DESIGN CONSTRAINTS

The following constraints on GSS-API mechanism designs are adopted in response to observed caller protocol requirements, and adherence thereto is anticipated in subsequent descriptions of GSS-API mechanisms to be documented in standards-track Internet specifications.

Use of the approach defined in Appendix B of this specification, applying a mechanism type tag to the InitialContextToken, is required.

It is strongly recommended that mechanisms offering per-message protection services also offer at least one of the replay detection and sequencing services, as mechanisms offering neither of the latter will fail to satisfy recognized requirements of certain candidate caller protocols.