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## GSS Algorithm for TSIG (GSS-TSIG)

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### Abstract

The TSIG protocol provides transaction level authentication for DNS. TSIG is extensible through the definition of new algorithms. This document specifies an algorithm based on the Generic Security Service Application Program Interface (GSS-API) ([RFC2743](#)). This document updates [RFC 2845](#).

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## [1. Introduction](#)

The Secret Key Transaction Authentication for DNS (TSIG) [[RFC2845](#)] protocol was developed to provide a lightweight authentication and integrity of messages between two DNS entities, such as client and server or server and server. TSIG can be used to protect dynamic update messages, authenticate regular message or to off-load complicated DNSSEC [[RFC2535](#)] processing from a client to a server and still allow the client to be assured of the integrity of the answers.

The TSIG protocol [[RFC2845](#)] is extensible through the definition of new algorithms. This document specifies an algorithm based on the Generic Security Service Application Program Interface (GSS-API) [[RFC2743](#)]. GSS-API is a framework that provides an abstraction of security to the application protocol developer. The security services offered can include authentication, integrity, and confidentiality.

The GSS-API framework has several benefits:

- \* Mechanism and protocol independence. The underlying mechanisms that

realize the security services can be negotiated on the fly and varied over time. For example, a client and server MAY use Kerberos [[RFC1964](#)] for one transaction, whereas that same server MAY use SPKM [[RFC2025](#)] with a different client.

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\* The protocol developer is removed from the responsibility of creating and managing a security infrastructure. For example, the developer does not need to create new key distribution or key management systems. Instead the developer relies on the security service mechanism to manage this on its behalf.

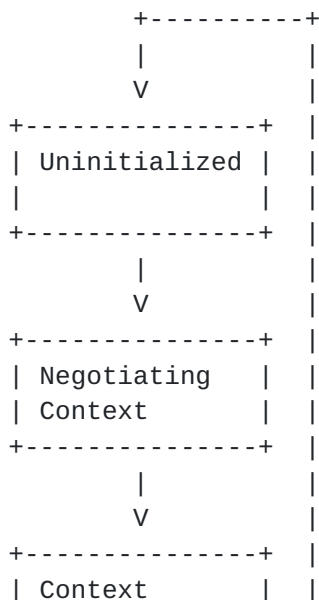
The scope of this document is limited to the description of an authentication mechanism only. It does not discuss and/or propose an authorization mechanism. Readers that are unfamiliar with GSS-API concepts are encouraged to read the characteristics and concepts section of [[RFC2743](#)] before examining this protocol in detail. It is also assumed that the reader is familiar with [[RFC2845](#)], [[RFC2930](#)], [[RFC1034](#)] and [[RFC1035](#)].

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

## 2. Algorithm Overview

In GSS, client and server interact to create a "security context". The security context can be used to create and verify transaction signatures on messages between the two parties. A unique security context is required for each unique connection between client and server.

Creating a security context involves a negotiation between client and server. Once a context has been established, it has a finite lifetime for which it can be used to secure messages. Thus there are three states of a context associated with a connection:



	Established		
+-----+			
	+-----+		

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Every connection begins in the uninitialized state.

## **2.1 GSS Details**

Client and server MUST be locally authenticated and have acquired default credentials before using this protocol as specified in [Section 1.1.1 "Credentials"](#) in [RFC 2743](#) [[RFC2743](#)].

The GSS-TSIG algorithm consists of two stages:

**I. Establish security context. The Client and Server use the** GSS\_Init\_sec\_context and GSS\_Accept\_sec\_context APIs to generate the tokens that they pass to each other using [[RFC2930](#)] as a transport mechanism.

II. Once the security context is established it is used to generate and verify signatures using GSS\_GetMIC and GSS\_VerifyMIC APIs. These signatures are exchanged by the Client and Server as a part of the TSIG records exchanged in DNS messages sent between the Client and Server, as described in [[RFC2845](#)].

## **2.2 Modifications to the TSIG protocol ([RFC 2845](#))**

Modification to [RFC 2845](#) allows use of TSIG through signing server's response in an explicitly specified place in multi message exchange between two DNS entities even if client's request wasn't signed.

Specifically [Section 4.2 of RFC 2845](#) MUST be modified as follows.

Replace:

"The server MUST not generate a signed response to an unsigned request."

With:

"The server MUST not generate a signed response to an unsigned request, except in case of response to client's unsigned TKEY query if secret key is established on server side after server processed client's query. Signing responses to unsigned TKEY queries MUST be explicitly specified in the description of an individual secret key establishment algorithm."

## **3. Client Protocol Details**

A unique context is required for each server to which the client sends secure messages. A context is identified by a context handle. A

client maintains a mapping of servers to handles,

(target\_name, key\_name, context\_handle)

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The value `key_name` also identifies a context handle. The `key_name` is the owner name of the TKEY and TSIG records sent between a client and a server to indicate to each other which context MUST be used to process the current request.

DNS client and server MAY use various underlying security mechanisms to establish security context as described in sections 3 and 4. At the same time, in order to guarantee interoperability between DNS clients and servers that support GSS-TSIG it is REQUIRED that security mechanism used by client enables use of Kerberos v5 (see [Section 9](#) for more information).

### **3.1 Negotiating Context**

In GSS, establishing a security context involves the passing of opaque tokens between the client and the server. The client generates the initial token and sends it to the server. The server processes the token and if necessary, returns a subsequent token to the client. The client processes this token, and so on, until the negotiation is complete. The number of times the client and server exchange tokens depends on the underlying security mechanism. A completed negotiation results in a context handle.

The TKEY resource record [[RFC2930](#)] is used as the vehicle to transfer tokens between client and server. The TKEY record is a general mechanism for establishing secret keys for use with TSIG. For more information, see [[RFC2930](#)].

#### **3.1.1 Call GSS\_Init\_sec\_context**

To obtain the first token to be sent to a server, a client MUST call `GSS_Init_sec_context` API.

The following input parameters MUST be used. The outcome of the call is indicated with the output values below. Consult Sections [2.2.1](#) "GSS\_Init\_sec\_context call" of [[RFC2743](#)] for syntax definitions.

##### **INPUTS**

CREDENTIAL HANDLE `claimant_cred_handle` = NULL (NULL specifies "use default"). Client MAY instead specify some other valid handle to its credentials.

CONTEXT HANDLE `input_context_handle` = 0

INTERNAL NAME `targ_name` = "DNS@<target\_server\_name>"

OBJECT IDENTIFIER `mech_type` = Underlying security mechanism chosen by implementers. To guarantee interoperability of the implementations of the GSS-TSIG mechanism client MUST specify a valid underlying security mechanism that enables use of Kerberos v5 (see [Section 9](#) for

```
more information).  
OCTET STRING    input_token      = NULL  
BOOLEAN         replay_det_req_flag = TRUE
```

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BOOLEAN        mutual\_req\_flag        = TRUE  
BOOLEAN        deleg\_req\_flag        = TRUE  
BOOLEAN        sequence\_req\_flag      = TRUE  
BOOLEAN        anon\_req\_flag        = FALSE  
BOOLEAN        integ\_req\_flag        = TRUE  
INTEGER        lifetime\_req        = 0 (0 requests a default  
              value). Client MAY instead specify another upper bound for the  
              lifetime of the context to be established in seconds.  
OCTET STRING   chan\_bindings        = Any valid channel bindings  
              as specified in [Section 1.1.6](#) "Channel Bindings" in [[RFC2743](#)]

## OUTPUTS

INTEGER        major\_status  
CONTEXT HANDLE output\_context\_handle  
OCTET STRING   output\_token  
BOOLEAN        replay\_det\_state  
BOOLEAN        mutual\_state  
INTEGER        minor\_status  
OBJECT IDENTIFIER mech\_type  
BOOLEAN        deleg\_state  
BOOLEAN        sequence\_state  
BOOLEAN        anon\_state  
BOOLEAN        trans\_state  
BOOLEAN        prot\_ready\_state  
BOOLEAN        conf\_avail  
BOOLEAN        integ\_avail  
INTEGER        lifetime\_rec

If returned major\_status is set to one of the following errors

GSS\_S\_DEFECTIVE\_TOKEN  
GSS\_S\_DEFECTIVE\_CREDENTIAL  
GSS\_S\_BAD\_SIG (GSS\_S\_BAD\_MIC)  
GSS\_S\_NO\_CRED  
GSS\_S\_CREDENTIALS\_EXPIRED  
GSS\_S\_BAD\_BINDINGS  
GSS\_S\_OLD\_TOKEN  
GSS\_S\_DUPLICATE\_TOKEN  
GSS\_S\_NO\_CONTEXT  
GSS\_S\_BAD\_NAME  
GSS\_S\_BAD\_NAME  
GSS\_S\_BAD\_MECH  
GSS\_S\_FAILURE

then the the client MUST abandon the algorithm and MUST NOT use the GSS-TSIG algorithm to establish this security context. This document does not prescribe which other mechanism could be used to establish a security context. Next time when this client needs to establish security context, the client MAY use GSS-TSIG algorithm.

Success values of major\_status are GSS\_S\_CONTINUE\_NEEDED and GSS\_S\_COMPLETE. The exact success code is important during later processing.

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The values of `replay_det_state` and `mutual_state` indicate if the security package provides replay detection and mutual authentication, respectively. If returned `major_status` is `GSS_S_COMPLETE` AND one or both of these values are `FALSE`, the client MUST abandon this algorithm.

Client's behavior MAY depend on other `OUTPUT` parameters according to the policy local to the client.

The handle `output_context_handle` is unique to this negotiation and is stored in the client's mapping table as the `context_handle` that maps to `target_name`.

### **3.1.2 Send TKEY Query to Server**

An opaque `output_token` returned by `GSS_Init_sec_context` is transmitted to the server in a query request with `QTYPE=TKEY`. The token itself will be placed in a Key Data field of the RDATA field in the TKEY resource record in the additional records section of the query. The owner name of the TKEY resource record set queried for and the owner name of the supplied TKEY resource record in the additional records section MUST be the same. This name uniquely identifies the security context to both the client and server, and thus the client SHOULD use a value which is globally unique as described in [\[RFC2930\]](#). To achieve global uniqueness, the name MAY contain a UUID/GUID [\[ISO11578\]](#).

#### TKEY Record

NAME = client-generated globally unique domain name string  
(as described in [\[RFC2930\]](#))

#### RDATA

Algorithm Name	= gss-tsig
Mode	= 3 (GSS-API negotiation - per <a href="#">[RFC2930]</a> )
Key Size	= size of <code>output_token</code> in octets
Key Data	= <code>output_token</code>

The remaining fields in the TKEY RDATA, i.e. Inception, Expiration, Error, Other Size and Data Fields, MUST be set according to [\[RFC2930\]](#).

The query is transmitted to the server.

Note: if the original client call to `GSS_Init_sec_context` returned any `major_status` other than `GSS_S_CONTINUE_NEEDED` or `GSS_S_COMPLETE`, then the client MUST NOT send TKEY query. Client's behavior in this case is described above in [Section 3.1.1](#).

### **3.1.3 Receive TKEY Query-Response from Server**

Upon the reception of the TKEY query DNS server MUST respond according to the description in [Section 4](#). This Section specifies the behavior of the client after it receives the matching response to its query.

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The next processing step depends on the value of `major_status` from the most recent call that client performed to `GSS_Init_sec_context`: either `GSS_S_COMPLETE` or `GSS_S_CONTINUE`.

#### **3.1.3.1 Value of `major_status` == `GSS_S_COMPLETE`**

If the last call to `GSS_Init_sec_context` yielded a `major_status` value of `GSS_S_COMPLETE` and a non-NULL `output_token` was sent to the server, then the client side component of the negotiation is complete and the client is awaiting confirmation from the server.

Confirmation is in the form of a query response with `RCODE=NOERROR` and with the last client supplied TKEY record in the answer section of the query. The response MUST be signed with a TSIG record. Note that server is allowed to sign a response to unsigned client's query due to modification to the [RFC 2845](#) specified in [Section 2.2](#) above. The signature in the TSIG record MUST be verified using the procedure detailed in [section 5](#), Sending and Verifying Signed Messages. If the response is not signed, OR if the response is signed but signature is invalid, then an attacker has tampered with the message in transit or has attempted to send the client a false response. In this case the client MAY continue waiting for a response to its last TKEY query until the time period since the client sent last TKEY query expires. Such a time period is specified by the policy local to the client. This is a new option that allows DNS client to accept multiple answers for one query ID and select one (not necessarily the first one) based on some criteria.

If the signature is verified the context state is advanced to Context Established. Proceed to [section 3.2](#) for usage of the security context.

#### **3.1.3.2 Value of `major_status` == `GSS_S_CONTINUE`**

If the last call to `GSS_Init_sec_context` yielded a `major_status` value of `GSS_S_CONTINUE`, then the negotiation is not yet complete. The server will return to the client a query-response with a TKEY record in the Answer section. If the DNS message error is not `NO_ERROR` or error field in the TKEY record is not 0 (i.e. no error), then the client MUST abandon this negotiation sequence. The client MUST delete an active context by calling `GSS_Delete_sec_context` providing the associated `context_handle`. The client MAY repeat the negotiation sequence starting with the uninitialized state as described in [section 3.1](#). To prevent infinite looping the number of attempts to establish a security context MUST be limited to ten or less.

If the DNS message error is `NO_ERROR` and error field in the TKEY record is 0 (i.e. no error), then the client MUST pass a token specified in the Key Data field in the TKEY resource record to `GSS_Init_sec_context`

using the same parameters values as in previous call except values for  
CONTEXT HANDLE input\_context\_handle and OCTET STRING input\_token as  
described below:

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## INPUTS

CONTEXT HANDLE input\_context\_handle = context\_handle (this is the context\_handle corresponding to the key\_name which is the owner name of the TKEY record in the answer section in the TKEY query response)

OCTET STRING input\_token = token from Key field of TKEY record

Depending on the following OUTPUT values of GSS\_Init\_sec\_context

INTEGER major\_status

OCTET STRING output\_token

the client MUST take one of the following actions:

If OUTPUT major\_status is set to one of the following values

GSS\_S\_DEFECTIVE\_TOKEN

GSS\_S\_DEFECTIVE\_CREDENTIAL

GSS\_S\_BAD\_SIG (GSS\_S\_BAD\_MIC)

GSS\_S\_NO\_CRED

GSS\_S\_CREDENTIALS\_EXPIRED

GSS\_S\_BAD\_BINDINGS

GSS\_S\_OLD\_TOKEN

GSS\_S\_DUPLICATE\_TOKEN

GSS\_S\_NO\_CONTEXT

GSS\_S\_BAD\_NAME

GSS\_S\_BAD\_NAME

GSS\_S\_BAD\_MECH

GSS\_S\_FAILURE

the client MUST abandon this negotiation sequence. This means that the client MUST delete an active context by calling GSS\_Delete\_sec\_context providing the associated context\_handle. The client MAY repeat the negotiation sequence starting with the uninitialized state as described in [section 3.1](#). To prevent infinite looping the number of attempts to establish a security context MUST be limited to ten or less.

If OUTPUT major\_status is GSS\_S\_CONTINUE\_NEEDED OR GSS\_S\_COMPLETE then client MUST act as described below.

If the response from the server was signed, and the OUTPUT major\_status is GSS\_S\_COMPLETE, then the signature in the TSIG record MUST be verified using the procedure detailed in [section 5](#), Sending and Verifying Signed Messages. If the signature is invalid, then the client MUST abandon this negotiation sequence. This means that the client MUST delete an active context by calling GSS\_Delete\_sec\_context providing the associated context\_handle. The client MAY repeat the negotiation sequence starting with the uninitialized state as described in [section 3.1](#). To prevent infinite looping the number of attempts to establish a security context MUST be limited to ten or less.

If major\_status is GSS\_S\_CONTINUE\_NEEDED the negotiation is not yet finished. The token output\_token MUST be passed to the server in a TKEY record by repeating the negotiation sequence beginning with section

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**[3.1.2.](#)** The client **MUST** place a limit on the number of continuations in a context negotiation to prevent endless looping. Such limit **SHOULD NOT** exceed value of 10.

If major\_status is GSS\_S\_COMPLETE and output\_token is non-NULL, the client-side component of the negotiation is complete but the token output\_token **MUST** be passed to the server by repeating the negotiation sequence beginning with [section 3.1.2.](#)

If major\_status is GSS\_S\_COMPLETE and output\_token is NULL, context negotiation is complete. The context state is advanced to Context Established. Proceed to [section 3.2](#) for usage of the security context.

## **[3.2](#) Context Established**

When context negotiation is complete, the handle context\_handle **MUST** be used for the generation and verification of transaction signatures.

The procedures for sending and receiving signed messages are described in [section 5](#), Sending and Verifying Signed Messages.

### **[3.2.1](#) Terminating a Context**

When the client is not intended to continue using the established security context, the client **SHOULD** delete an active context by calling GSS\_Delete\_sec\_context providing the associated context\_handle, **AND** client **SHOULD** delete the established context on the DNS server by using TKEY RR with the Mode field set to 5, i.e. "key deletion" [[RFC2930](#)].

## **[4.](#) Server Protocol Details**

As on the client-side, the result of a successful context negotiation is a context handle used in future generation and verification of the transaction signatures.

A server **MAY** be managing several contexts with several clients. Clients identify their contexts by providing a key name in their request. The server maintains a mapping of key names to handles:

(key\_name, context\_handle)

### **[4.1](#) Negotiating Context**

A server MUST recognize TKEY queries as security context negotiation messages.

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#### [4.1.1](#) Receive TKEY Query from Client

Upon receiving a query with QTYPE = TKEY, the server MUST examine whether the Mode and Algorithm Name fields of the TKEY record in the additional records section of the message contain values of 3 and gss-tsig, respectively. If they do, then the (key\_name, context\_handle) mapping table is searched for the key\_name matching the owner name of the TKEY record in the additional records section of the query. If the name is found in the table and the security context for this name is established and not expired, then the server MUST respond to the query with BADNAME error in the TKEY error field. If the name is found in the table and the security context is not established, the corresponding context\_handle is used in subsequent GSS operations. If the name is found but the security context is expired, then the server deletes this security context, as described in [Section 4.2.1](#), and interprets this query as a start of new security context negotiation and performs operations described in [Section 4.1.2](#) and 4.1.3. If the name is not found, then the server interprets this query as a start of new security context negotiation and performs operations described in [Section 4.1.2](#) and 4.1.3.

#### [4.1.2](#) Call GSS\_Accept\_sec\_context

The server performs its side of a context negotiation by calling GSS\_Accept\_sec\_context. The following input parameters MUST be used. The outcome of the call is indicated with the output values below. Consult Sections [2.2.2](#) "GSS\_Accept\_sec\_context call" of the [RFC 2743](#)[\[RFC2743\]](#) for syntax definitions.

##### INPUTS

CONTEXT\_HANDLE input\_context\_handle = 0 if new negotiation,  
context\_handle matching  
key\_name if ongoing negotiation

OCTET STRING input\_token = token specified in the Key  
field from TKEY RR (from Additional records Section of  
the client's query)

CREDENTIAL\_HANDLE acceptor\_cred\_handle = NULL (NULL specifies "use  
default"). Server MAY instead specify some other valid handle  
to its credentials.

OCTET STRING chan\_bindings = Any valid channel bindings  
as specified in [Section 1.1.6](#) "Channel Bindings" in [\[RFC2743\]](#)

##### OUTPUTS

INTEGER major\_status

CONTEXT\_HANDLE output\_context\_handle

OCTET STRING output\_token

INTEGER	minor_status
INTERNAL NAME	src_name
OBJECT IDENTIFIER	mech_type
BOOLEAN	deleg_state

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BOOLEAN	mutual_state
BOOLEAN	replay_det_state
BOOLEAN	sequence_state
BOOLEAN	anon_state
BOOLEAN	trans_state
BOOLEAN	prot_ready_state
BOOLEAN	conf_avail
BOOLEAN	integ_avail
INTEGER	lifetime_rec
CONTEXT_HANDLE	delegated_cred_handle

If this is the first call to GSS\_Accept\_sec\_context in a new negotiation, then output\_context\_handle is stored in the server's key-mapping table as the context\_handle that maps to the name of the TKEY record.

#### **4.1.3 Send TKEY Query-Response to Client**

The server MUST respond to the client with a TKEY query response with RCODE = NOERROR, that contains a TKEY record in the answer section.

If OUTPUT major\_status is one of the following errors the error field in the TKEY record set to BADKEY.

- GSS\_S\_DEFECTIVE\_TOKEN
- GSS\_S\_DEFECTIVE\_CREDENTIAL
- GSS\_S\_BAD\_SIG (GSS\_S\_BAD\_MIC)
- GSS\_S\_DUPLICATE\_TOKEN
- GSS\_S\_OLD\_TOKEN
- GSS\_S\_NO\_CRED
- GSS\_S\_CREDENTIALS\_EXPIRED
- GSS\_S\_BAD\_BINDINGS
- GSS\_S\_NO\_CONTEXT
- GSS\_S\_BAD\_MECH
- GSS\_S\_FAILURE

If OUTPUT major\_status is set to GSS\_S\_COMPLETE or GSS\_S\_CONTINUE\_NEEDED then server MUST act as described below.

If major\_status is GSS\_S\_COMPLETE the server component of the negotiation is finished. If output\_token is non-NULL, then it MUST be returned to the client in a Key Data field of the RDATA in TKEY. The error field in the TKEY record is set to NOERROR. The message MUST be signed with a TSIG record as described in [section 5](#), Sending and Verifying Signed Messages. Note that server is allowed to sign a response to unsigned client's query due to modification to the RFC [2845](#) specified in [Section 2.2](#) above. The context state is advanced to Context Established. [Section 4.2](#) discusses the usage of the security

context.

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If `major_status` is `GSS_S_COMPLETE` and `output_token` is `NULL`, then the TKEY record received from the client MUST be returned in the Answer section of the response. The message MUST be signed with a TSIG record as described in [section 5](#), Sending and Verifying Signed Messages. Note that server is allowed to sign a response to unsigned client's query due to modification to the [RFC 2845](#) specified in [section 2.2](#) above. The context state is advanced to Context Established. [Section 4.2](#) discusses the usage of the security context.

If `major_status` is `GSS_S_CONTINUE`, the server component of the negotiation is not yet finished. The server responds to the TKEY query with a standard query response, placing in the answer section a TKEY record containing `output_token` in the Key Data RDATA field. The error field in the TKEY record is set to `NOERROR`. The server MUST limit the number of times that a given context is allowed to repeat, to prevent endless looping. Such limit SHOULD NOT exceed value of 10.

In all cases except if `major_status` is `GSS_S_COMPLETE` and `output_token` is `NULL` other TKEY record fields MUST contain the following values:

NAME = `key_name`

RDATA

Algorithm Name = `gss-tsig`

Mode = 3 (GSS-API negotiation - per [\[RFC2930\]](#))

Key Size = size of `output_token` in octets

The remaining fields in the TKEY RDATA, i.e. Inception, Expiration, Error, Other Size and Data Fields, MUST be set according to [\[RFC2930\]](#).

## [4.2](#) Context Established

When context negotiation is complete, the handle `context_handle` is used for the generation and verification of transaction signatures. The handle is valid for a finite amount of time determined by the underlying security mechanism. A server MAY unilaterally terminate a context at any time (see [section 4.2.1](#)).

Server SHOULD limit the amount of memory used to cache established contexts.

The procedures for sending and receiving signed messages are given in [section 5](#), Sending and Verifying Signed Messages.

### [4.2.1](#) Terminating a Context

A server can terminate any established context at any time. The server MAY hint to the client that the context is being deleted by including a TKEY RR in a response with the Mode field set to 5, i.e.

"key deletion" [[RFC2930](#)].

An active context is deleted by calling GSS\_Delete\_sec\_context providing the associated context\_handle.

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## 5. Sending and Verifying Signed Messages

### 5.1 Sending a Signed Message - Call GSS\_GetMIC

The procedure for sending a signature-protected message is specified in [\[RFC2845\]](#). The data to be passed to the signature routine includes the whole DNS message with specific TSIG variables appended. For the exact format, see [\[RFC2845\]](#). For this protocol, use the following TSIG variable values:

```
TSIG Record
  NAME = key_name that identifies this context
  RDATA
    Algorithm Name = gss-tsig
```

Assign the remaining fields in the TSIG RDATA appropriate values as described in [\[RFC2845\]](#).

The signature is generated by calling GSS\_GetMIC. The following input parameters MUST be used. The outcome of the call is indicated with the output values specified below. Consult Sections [2.3.1](#) "GSS\_GetMIC call" of the [RFC 2743](#)[\[RFC2743\]](#) for syntax definitions.

#### INPUTS

```
CONTEXT HANDLE context_handle = context_handle for key_name
OCTET STRING   message       = outgoing message plus TSIG
                                variables (per \[RFC2845\])
INTEGER qop_req           = 0 (0 requests a default
                             value). Caller MAY instead specify other valid value (for
                             details see Section 1.2.4 in \[RFC2743\])
```

#### OUTPUTS

```
INTEGER      major_status
INTEGER      minor_status
OCTET STRING per_msg_token
```

If major\_status is GSS\_S\_COMPLETE, then signature generation succeeded. The signature in per\_msg\_token is inserted into the Signature field of the TSIG RR and the message is transmitted.

If major\_status is GSS\_S\_CONTEXT\_EXPIRED, GSS\_S\_CREDENTIALS\_EXPIRED or GSS\_S\_FAILURE the caller MUST delete the security context, return to the uninitialized state and SHOULD negotiate a new security context, as described above in [Section 3.1](#)

If major\_status is GSS\_S\_NO\_CONTEXT, the caller MUST remove the entry for key\_name from the (target\_name, key\_name, context\_handle) mapping table, return to the uninitialized state and SHOULD negotiate a new security context, as described above in [Section 3.1](#)

If major\_status is GSS\_S\_BAD\_QOP, the caller SHOULD repeat the GSS\_GetMIC call with allowed QOP value. The number of such repetitions MUST be limited to prevent infinite loops.

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## 5.2 Verifying a Signed Message - Call GSS\_VerifyMIC

The procedure for verifying a signature-protected message is specified in [\[RFC2845\]](#).

The NAME of the TSIG record determines which context\_handle maps to the context that MUST be used to verify the signature. If the NAME does not map to an established context, the server MUST send a standard TSIG error response to the client indicating BADKEY in the TSIG error field (as described in [\[RFC2845\]](#)).

For the GSS algorithm, a signature is verified by using GSS\_VerifyMIC:

### INPUTS

CONTEXT HANDLE	context_handle	= context_handle for key_name
OCTET STRING	message	= incoming message plus TSIG variables (per <a href="#">[RFC2845]</a> )
OCTET STRING	per_msg_token	= Signature field from TSIG RR

### OUTPUTS

INTEGER	major_status
INTEGER	minor_status
INTEGER	qop_state

If major\_status is GSS\_S\_COMPLETE, the signature is authentic and the message was delivered intact. Per [\[RFC2845\]](#), the timer values of the TSIG record MUST also be valid before considering the message to be authentic. The caller MUST not act on the request or response in the message until these checks are verified.

When a server is processing a client request, the server MUST send a standard TSIG error response to the client indicating BADKEY in the TSIG error field as described in [\[RFC2845\]](#), if major\_status is set to one of the following values

- GSS\_S\_DEFECTIVE\_TOKEN
- GSS\_S\_BAD\_SIG (GSS\_S\_BAD\_MIC)
- GSS\_S\_DUPLICATE\_TOKEN
- GSS\_S\_OLD\_TOKEN
- GSS\_S\_UNSEQ\_TOKEN
- GSS\_S\_GAP\_TOKEN
- GSS\_S\_CONTEXT\_EXPIRED
- GSS\_S\_NO\_CONTEXT
- GSS\_S\_FAILURE

If the timer values of the TSIG record are invalid, the message MUST NOT be considered authentic. If this error checking fails when a server is processing a client request, the appropriate error response MUST be sent to the client according to [\[RFC2845\]](#).

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## 6. Example usage of GSS-TSIG algorithm

This Section describes an example where a Client, client.example.com, and a Server, server.example.com, establish a security context according to the algorithm described above.

### I. Client initializes security context negotiation

To establish a security context with a server, server.example.com, the Client calls GSS\_Init\_sec\_context with the following parameters (Note that some INPUT and OUTPUT parameters not critical for this algorithm are not described in this example)

```
CONTEXT_HANDLE input_context_handle = 0
INTERNAL_NAME  targ_name             = "DNS@server.example.com"
OCTET STRING   input_token           = NULL
BOOLEAN        replay_det_req_flag   = TRUE
BOOLEAN        mutual_req_flag       = TRUE
```

The OUTPUTS parameters returned by GSS\_Init\_sec\_context include

```
INTEGER        major_status = GSS_S_CONTINUE_NEEDED
CONTEXT_HANDLE output_context_handle context_handle
OCTET STRING   output_token output_token
BOOLEAN        replay_det_state = TRUE
BOOLEAN        mutual_state = TRUE
```

Client verifies that replay\_det\_state and mutual\_state values are TRUE. Since the major\_status is GSS\_S\_CONTINUE\_NEEDED, which is a success OUTPUT major\_status value, client stores context\_handle that maps to "DNS@server.example.com" and proceeds to the next step.

### II. Client sends a query with QTYPE = TKEY to server

Client sends a query with QTYPE = TKEY for a client-generated globally unique domain name string, 789.client.example.com.server.example.com. Query contains a TKEY record in its Additional records section with the following fields (Note that some fields not specific to this algorithm are not specified)

```
NAME = 789.client.example.com.server.example.com.
RDATA
  Algorithm Name    = gss-tsig
  Mode              = 3 (GSS-API negotiation - per RFC2930)
  Key Size          = size of output_token in octets
  Key Data          = output_token
```

After the key\_name 789.client.example.com.server.example.com. is generated it is stored in the client's (target\_name, key\_name, context\_handle) mapping table.

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### III. Server receives a query with QTYPE = TKEY

When server receives a query with QTYPE = TKEY, the server verifies that Mode and Algorithm fields in the TKEY record in the Additional records section of the query are set to 3 and "gss-tsig" respectively. It finds that the key\_name 789.client.example.com.server.example.com. is not listed in its (key\_name, context\_handle) mapping table.

### IV. Server calls GSS\_Accept\_sec\_context

To continue security context negotiation server calls GSS\_Accept\_sec\_context with the following parameters (Note that some INPUT and OUTPUT parameters not critical for this algorithm are not described in this example)

#### INPUTS

CONTEXT HANDLE input\_context\_handle = 0  
OCTET STRING input\_token = token specified in the Key field from TKEY RR (from Additional records section of the client's query)

The OUTPUTS parameters returned by GSS\_Accept\_sec\_context include

INTEGER major\_status = GSS\_S\_CONTINUE\_NEEDED  
CONTEXT\_HANDLE output\_context\_handle context\_handle  
OCTET STRING output\_token output\_token

Server stores the mapping of the 789.client.example.com.server.example.com. to OUTPUT context\_handle in its (key\_name, context\_handle) mapping table.

### V. Server responds to the TKEY query

Since the major\_status = GSS\_S\_CONTINUE\_NEEDED in the last server's call to GSS\_Accept\_sec\_context, the server responds to the TKEY query placing in the answer section a TKEY record containing output\_token in the Key Data RDATA field. The error field in the TKEY record is set to 0. The RCODE in the query response is set to NOERROR.

### VI. Client processes token returned by server

When the client receives the TKEY query response from the server, the client calls GSS\_Init\_sec\_context with the following parameters (Note that some INPUT and OUTPUT parameters not critical for this algorithm are not described in this example)

CONTEXT HANDLE input\_context\_handle = the context\_handle stored in the client's mapping table entry (DNS@server.example.com., 789.client.example.com.server.example.com., context\_handle)  
INTERNAL NAME targ\_name = "DNS@server.example.com"  
OCTET STRING input\_token = token from Key field of TKEY record from the Answer section of the server's response  
BOOLEAN replay\_det\_req\_flag = TRUE  
BOOLEAN mutual\_req\_flag = TRUE

The OUTPUTS parameters returned by GSS\_Init\_sec\_context include  
INTEGER           major\_status = GSS\_S\_COMPLETE

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```
CONTEXT HANDLE output_context_handle = context_handle
OCTET STRING   output_token = output_token
BOOLEAN        replay_det_state = TRUE
BOOLEAN        mutual_state = TRUE
```

Since the major\_status is set to GSS\_S\_COMPLETE the client side security context is established, but since the output\_token is not NULL client MUST send a TKEY query to the server as described below.

VII. Client sends a query with QTYPE = TKEY to server

Client sends to the server a TKEY query for the

789.client.example.com.server.example.com. name. Query contains a TKEY record in its Additional records section with the following fields (Note that some INPUT and OUTPUT parameters not critical to this algorithm are not described in this example)

```
NAME = 789.client.example.com.server.example.com.
```

```
RDATA
```

```
Algorithm Name    = gss-tsig
Mode              = 3 (GSS-API negotiation - per [RFC2930])
Key Size          = size of output_token in octets
Key Data          = output_token
```

VIII. Server receives a TKEY query

When the server receives a TKEY query, the server verifies that Mode and Algorithm fields in the TKEY record in the Additional records section of the query are set to 3 and gss-tsig, respectively. It finds that the key\_name 789.client.example.com.server.example.com. is listed in its (key\_name, context\_handle) mapping table.

IX. Server calls GSS\_Accept\_sec\_context

To continue security context negotiation server calls

GSS\_Accept\_sec\_context with the following parameters (Note that some INPUT and OUTPUT parameters not critical for this algorithm are not described in this example)

```
INPUTS
```

```
CONTEXT HANDLE input_context_handle = context_handle from the
    (789.client.example.com.server.example.com., context_handle)
    entry in the server's mapping table
OCTET STRING   input_token          = token specified in the Key
    field of TKEY RR (from Additional records Section of
    the client's query)
```

The OUTPUTS parameters returned by GSS\_Accept\_sec\_context include

```
INTEGER        major_status = GSS_S_COMPLETE
CONTEXT_HANDLE output_context_handle = context_handle
OCTET STRING   output_token = NULL
```

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Since `major_status = GSS_S_COMPLETE`, the security context on the server side is established, but the server still needs to respond to the client's TKEY query, as described below. The security context state is advanced to Context Established.

#### X. Server responds to the TKEY query

Since the `major_status = GSS_S_COMPLETE` in the last server's call to `GSS_Accept_sec_context` and the `output_token` is `NULL`, the server responds to the TKEY query placing in the answer section a TKEY record that was sent by the client in the Additional records section of the client's latest TKEY query. In addition to this server places a TSIG record in additional records section of its response. Server calls `GSS_GetMIC` to generate a signature to include it in the TSIG record. The server specifies the following `GSS_GetMIC` INPUT parameters:

```
CONTEXT HANDLE context_handle = context_handle from the
                               (789.client.example.com.server.example.com., context_handle)
                               entry in the server's mapping table
OCTET STRING   message         = outgoing message plus TSIG
                               variables (as described in [RFC2845])
```

The OUTPUTS parameters returned by `GSS_GetMIC` include

```
INTEGER        major_status = GSS_S_COMPLETE
OCTET STRING   per_msg_token
```

Signature field in the TSIG record is set to `per_msg_token`.

#### XI. Client processes token returned by server

Client receives the TKEY query response from the server. Since the `major_status` was `GSS_S_COMPLETE` in the last client's call to `GSS_Init_sec_context`, the client verifies that the server's response is signed. To validate the signature client calls `GSS_VerifyMIC` with the following parameters:

##### INPUTS

```
CONTEXT HANDLE context_handle = context_handle for
                               789.client.example.com.server.example.com. key_name
OCTET STRING   message         = incoming message plus TSIG
                               variables (as described in [RFC2845])
OCTET STRING   per_msg_token   = Signature field from TSIG RR
                               included in the server's query response
```

Since the OUTPUTS parameter `major_status = GSS_S_COMPLETE`, the signature is validated, security negotiation is complete and the security context state is advanced to Context Established. These client and server will use the established security context to sign and validate the signatures when they exchange packets with each

other until the context expires.

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## **7. Security Considerations**

This document describes a protocol for DNS security using GSS-API. The security provided by this protocol is only as effective as the security provided by the underlying GSS mechanisms.

All the security considerations from [RFC2845](#), [RFC2930](#) and [RFC 2743](#) apply to the protocol described in this document.

## **8. IANA Considerations**

The authors request that the IANA reserve the TSIG Algorithm name gss-tsig for the use in the Algorithm fields of TKEY and TSIG resource records. This Algorithm name refers to the algorithm described in this document. The requirement to have this name registered with IANA is specified in [RFC 2845](#).

## **9. Conformance**

The GSS API using SPNEGO [[RFC2478](#)] provides maximum flexibility to choose the underlying security mechanisms that enables security context negotiation. GSS API using SPNEGO [[RFC2478](#)] enables client and server to negotiate and choose such underlying security mechanisms on the fly. To support such flexibility, DNS clients and servers SHOULD specify SPNEGO mech\_type in their GSS API calls. At the same time, in order to guarantee interoperability between DNS clients and servers that support GSS-TSIG it is required that

- DNS servers specify SPNEGO mech\_type
- GSS APIs called by DNS client support Kerberos v5
- GSS APIs called by DNS server support SPNEGO [[RFC2478](#)] and Kerberos v5.

In addition to these, GSS APIs used by DNS client and server MAY also support other underlying security mechanisms.

## **10. Acknowledgements**

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