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

Abstract

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

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

Status of This Memo

This is an Internet Standards Track document.

This document is a product of the Internet Engineering Task Force (IETF). It represents the consensus of the IETF community. It has received public review and has been approved for publication by the Internet Engineering Steering Group (IESG). Further information on Internet Standards is available in Section 2 of RFC 5741.

Information about the current status of this document, any errata, and how to provide feedback on it may be obtained at http://www.rfc-editor.org/info/rfc7802.
1. Introduction

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

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

2. Conventions Used in This Document

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [RFC2119].
3. Kerberos V GSS Mechanism PRF

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

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

- **GSS_C_PRF_KEY_FULL** -- use the sub-session key asserted by the acceptor (if any exists), or the sub-session asserted by the initiator (if any exists), or the Ticket’s session key.

- **GSS_C_PRF_KEY_PARTIAL** -- use the sub-session key asserted by the initiator (if any exists) or the Ticket’s session key.

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

\[
PRF+(K, L, S) = \text{truncate}(L, T0 \mid T1 \mid \ldots \mid Tn)
\]

\[
Tn = \text{pseudo-random}(K, n \mid S)
\]

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

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

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

4. IANA Considerations

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

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

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

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

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

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

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

6. Normative References


Appendix A. Test Vectors

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

Enctype: des-cbc-crc
Key: E607FE9DAB57AE0
Input: (empty string)
Output: 803C4121379FC4B87CE413B67707C4632E6ED2C6D6B72A55E878836E35E21600D915D590DED5B6D77BB30A1F

Enctype: des-cbc-crc
Key: 54758316B6257A75
Input: ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz123456789
Output: 279E4105F7ADC9BD6EF28ABE31DB89B442FE0058388BA33264ACB5729562DC637950F6BD144B654BE7700B2D6

Enctype: des3-cbc-sha1
Key: 70378A19CD64134580C27C0115D6B34A1CF2FECEF9886A2
Input: (empty string)
Output: 9F8D127C520BB826B7F0E5EF352389C17E0C073D9AC4A333D644D21BA3EF24F4A886D143F85AC9F6377FB

Enctype: des3-cbc-sha1
Key: 3452A167DF1094BA1089E0A20E9E51ABEF1525922558B69E
Input: ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz123456789
Output: 6BF24FABC858F8DD9752E4FCD331BB831F2B85BE1904EEA42E38F7A60C588F075C5C96A67E7F8B7BD0AE5F4

Enctype: rc4-hmac
Key: 3BB3AE288C12B39D6B208A415B3B6
Input: (empty string)
Output: 9EA9A13ABCFC3C531F91F5A0BA2132E2501ADF5F3C283C8A985AB8757CE865A22132D6100EAD63E9E291AFA

Enctype: rc4-hmac
Key: 6DB7B3A01BD72F655CB7B3D5FA0B
Input: ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz123456789
Output: CDA9A544869FC84873B692663A82AFDA101C8611498B4A46138B01E927C9B95EEC953B56280743037837D3DF
Enctype: aes128-cts-hmac-sha1-96
Key: 6C742096EB896230312B73972FA28B5D
Input: (empty string)
Output: 94208D982FC1BB7778128BDD77904420B45C9DA699F3
117BCE66E39602128EF0296611A6D191A5828530F20F

Enctype: aes128-cts-hmac-sha1-96
Key: FA61138C109D834A477D24C7311BE6DA
Input: ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz123456789
Output: 9FAEDF0F842CC834FEE750487E1B622739286B975FE5
B7F45AB053143C75CA0DF5D3D4BBB80F6A616C7C9027

Enctype: aes256-cts-hmac-sha1-96
Key: 08FCDAFD5832611B73BA7B497FEBF8C954B4B58031CAD9B77C3B8C25192FD6
Input: (empty string)
Output: E627EFC14EF5B6D629F830C7109DEAAD3D73D6E8CD57
A1F301C5452494A1928F05AFFBEE3360232209D3BE0D

Enctype: camellia128-cts-cmac
Key: 866E0466A178279A32AC08DA92B72AEB
Input: (empty string)
Output: 97FBB354BF341C3A160DCC86A7A910FDA824601DF677
68797BACEEBF5D250AE929DEC97607720842675F0A54

Enctype: camellia128-cts-cmac
Key: D4893FD7DA1A211E12DD1E03E0F03B7
Input: ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz123456789
Output: 1DEE2FF126CA563A2A2326B9DD3F009501325741A338
FAD4398901013D5F367C826811867B2FE62F746BA4

Enctype: camellia256-cts-cmac
Key: 203071BAE77BD63FCE70174AF95C225B1CED46B35CF2B6479EFEB47E6B063
Input: (empty string)
Output: 9B30020634C10FDA28420CE7B96B70A90A71CDED43A
D8346554163E5949CBAE2F8EF36AFB6B32CE75116A0

Enctype: camellia256-cts-cmac
Key: A171AD582C1AFBBAD52ABD622EE6B6A14D19BF95C6914B2BA40FFD99A88EC60
Input: ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz123456789
Output: A47CBB6E104DCC77E4DB48A7A474B977F2FB6A7A1AB6
52317D50508AE72B7BE24E4BA24164E029CBACF786B
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