        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.

Table of Contents

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:

   o 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.

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

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

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

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

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

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

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

4. IANA Considerations

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

5. Security Considerations

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

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

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

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

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

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

6. Normative References

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

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              Interface Version 2, Update 1", RFC 2743,
              DOI 10.17487/RFC2743, January 2000,
              <http://www.rfc-editor.org/info/rfc2743>.

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

   [RFC3961] Raeburn, K., "Encryption and Checksum Specifications for
              Kerberos 5", RFC 3961, DOI 10.17487/RFC3961, February
              2005, <http://www.rfc-editor.org/info/rfc3961>.

   [RFC4121] Zhu, L., Jaganathan, K., and S. Hartman, "The Kerberos
              Version 5 Generic Security Service Application Program
              Interface (GSS-API) Mechanism: Version 2", RFC 4121,
              DOI 10.17487/RFC4121, July 2005,
              <http://www.rfc-editor.org/info/rfc4121>.

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

Appendix A. Test Vectors

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

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

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

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

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

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

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

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


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


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


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


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


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


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


Enctype: camellia256-cts-cmac
Key: A171AD582C1AFBBAD52ABD622EE6B6A14D19BF95C6914B2BA40FFD99A88EC660
Input: ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz123456789
Output: A47CBB6E104DCC77E4DB48A7A474B977F2FB6A7A1AB6
        52317D50508AE72B7BE2E4E4BA24164E029CBACF786B
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Authors' Addresses

   Shawn Emery
   Oracle Corporation
   500 Eldorado Blvd Bldg 1
   Broomfield, CO 78727
   United States

   EMail: shawn.emery@oracle.com

   Nicolas Williams
   Cryptonector, LLC

   EMail: nico@cryptonector.com