                          MD2 to Historic Status

Abstract

   This document retires MD2 and discusses the reasons for doing so.
   This document moves RFC 1319 to Historic status.

Status of This Memo

   This document is not an Internet Standards Track specification; it is
   published for informational purposes.

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1. Introduction

   MD2 [MD2] is a message digest algorithm that takes as input a message
   of arbitrary length and produces as output a 128-bit "fingerprint" or
   "message digest" of the input. This document retires MD2.
   Specifically, this document moves RFC 1319 [MD2] to Historic status.
   The reasons for taking this action are discussed.

   [HASH-Attack] summarizes the use of hashes in many protocols and
   discusses how attacks against a message digest algorithm's one-way
   and collision-free properties affect and do not affect Internet
   protocols. Familiarity with [HASH-Attack] is assumed.

2. Rationale

   MD2 was published in 1992 as an Informational RFC. Since its
   publication, MD2 has been shown to not be collision-free [ROCH1995]
   [KNMA2005] [ROCH1997], albeit successful collision attacks for
   properly implemented MD2 are not that damaging. Successful pre-image
   and second pre-image attacks against MD2 have been shown [KNMA2005]
   [MULL2004] [KMM2010].

3. Documents that Reference RFC 1319

   Use of MD2 has been specified in the following RFCs:

   Proposed Standard (PS):

   o [RFC3279] Algorithms and Identifiers for the Internet X.509 Public
               Key Infrastructure Certificate and Certificate Revocation
               List (CRL) Profile.

   o [RFC4572] Connection-Oriented Media Transport over the Transport
               Layer Security (TLS) Protocol in the Session Description
               Protocol (SDP).

   Informational:

   o [RFC1983] Internet Users' Glossary.

   o [RFC2315] PKCS #7: Cryptographic Message Syntax Version 1.5.

   o [RFC2898] PKCS #5: Password-Based Cryptography Specification
               Version 2.0.

   o [RFC3447] Public-Key Cryptography Standards (PKCS) #1: RSA
               Cryptography Specifications Version 2.1.

Experimental:

o [RFC2660] The Secure HyperText Transfer Protocol.

There are other RFCs that refer to MD2, but they have been either
moved to Historic status or obsoleted by a later RFC. References and
discussions about these RFCs are omitted. The exceptions are:

o [RFC2313] PKCS #1: RSA Encryption Version 1.5.

o [RFC2437] PKCS #1: RSA Cryptography Specifications Version 2.0.

4. Impact on Moving MD2 to Historic

The impact of moving MD2 to Historic on the RFCs specified in Section
3 is minimal, as described below.

Regarding PS RFCs:

o MD2 support in TLS was dropped in TLS 1.1.

o MD2 support is optional in [RFC4572], and SHA-1 is specified as the
  preferred algorithm.

o MD2 is included in the original PKIX certificate profile and the
  PKIX algorithm document [RFC3279] for compatibility with older
  applications, but its use is discouraged. SHA-1 is identified as
  the preferred algorithm for the Internet PKI.

Regarding Informational RFCs:

o The Internet Users' Guide [RFC1983] provided a definition for
  Message Digest and listed MD2 as one example.

o PKCS#1 v1.5 [RFC2313] stated that there are no known attacks
  against MD2. PKCS#1 v2.0 [RFC2437] updated this stance to indicate
  that MD2 should only be supported for backward compatibility and to
  mention the attacks in [ROCH1995]. PKCS#1 [RFC3447] indicates that
  support of MD2 is only retained for compatibility with existing
  applications.

o PKCS#5 [RFC2898] recommends that the Password-Based Encryption
  Scheme (PBES) that uses MD2 not be used for new applications.

o PKCS#7 [RFC2315] was replaced by a series of Standards Track
  publications, "Cryptographic Message Syntax" [RFC2630] [RFC3369]
  [RFC5652] and "Cryptographic Message Syntax (CMS) Algorithms"
  [RFC3370]. Support for MD2 was dropped in [RFC3370].

RFC 2818, "HTTP Over TLS", which does not reference MD2, largely
supplanted implementation of [RFC2660]. [RFC2660] specified MD2 for
use both as a digest algorithm and as a MAC (Message Authentication
Code) algorithm [RFC2104]. Note that this is the only reference to
HMAC-MD2 found in the RFC repository.

5. Other Considerations

MD2 has also fallen out of favor because it is slower than both MD4
[MD4] and MD5 [MD5]. This is because MD2 was optimized for 8-bit
machines, while MD4 and MD5 were optimized for 32-bit machines. MD2
is also slower than the Secure Hash Standard (SHS) [SHS] algorithms:
SHA-1, SHA-224, SHA-256, SHA-384, and SHA-512.

6. Security Considerations

MD2 is different from MD4 and MD5 in that is not a straight Merkle-
Damgaard design. For a padded message with t blocks, it generates a
nonlinear checksum as its t+1 block. The checksum is considered as
the final block input of MD2.

As confirmed in 1997 by Rogier et al. [ROCH1997], the collision
resistance property of MD2 highly depends on the nonlinear checksum.
Without the checksum, a collision can be found in 2^{12} MD2
operations, while with the checksum, the best collision attack takes
$2^{63.3}$ operations with 2^{50} memory complexity [MULL2004], which is
not significantly better than the birthday attack.

Even though collision attacks on MD2 are not significantly more
powerful than the birthday attack, MD2 was found not to be one-way.
In [KMM2010], a pre-image can be found with 2^{104} MD2 operations. In
an improved attack described in [KMM2010], a pre-image can be found
in 2^{73} MD2 operations. Because of this "invertible" property of
MD2, when using MD2 in HMAC, it may leak information of the keys.

Obviously, the pre-image attack can be used to find a second pre-
image. The second pre-image attack is even more severe than a
collision attack to digital signatures. Therefore, MD2 must not be
used for digital signatures.

Some may find the guidance for key lengths and algorithm strengths in
[SP800-57] and [SP800-131] useful.

7. Recommendation

   Despite MD2 seeing some deployment on the Internet, this
   specification recommends obsoleting MD2. MD2 is not a reasonable
   candidate for further standardization and should be deprecated in
   favor of one or more existing hash algorithms (e.g., SHA-256 [SHS]).

   RSA Security considers it appropriate to move the MD2 algorithm to
   Historic status.

   It takes a number of years to deploy crypto and it also takes a
   number of years to withdraw it. Algorithms need to be withdrawn
   before a catastrophic break is discovered. MD2 is clearly showing
   signs of weakness, and implementations should strongly consider
   removing support and migrating to another hash algorithm.

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   all the cryptographers who studied the algorithm. For their
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9. Informative References

   [HASH-Attack] Hoffman, P. and B. Schneier, "Attacks on Cryptographic
                 Hashes in Internet Protocols", RFC 4270, November 2005.

   [KMM2010]   Knudsen, L., Mathiassen, J., Muller, F., and Thomsen,
                 S., "Cryptanalysis of MD2", Journal of Cryptology,
                 23(1):72-90, 2010.

   [KNMA2005]   Knudsen, L., and J. Mathiassen, "Preimage and Collision
                 Attacks on MD2", FSE 2005.

   [MD2]   Kaliski, B., "The MD2 Message-Digest Algorithm", RFC
                 1319, April 1992.

   [MD4]   Rivest, R., "The MD4 Message-Digest Algorithm", RFC
                 1320, April 1992.

   [MD5]   Rivest, R., "The MD5 Message-Digest Algorithm", RFC
                 1321, April 1992.

   [MULL2004]   Muller, F., "The MD2 Hash Function Is Not One-Way",
                 ASIACRYPT, LNCS 3329, pp. 214-229, Springer, 2004.

   [RFC1983]   Malkin, G., Ed., "Internet Users' Glossary", FYI 18,
                  RFC 1983, August 1996.

   [RFC2104]   Krawczyk, H., Bellare, M., and R. Canetti, "HMAC:
                  Keyed-Hashing for Message Authentication", RFC 2104,
                  February 1997.

   [RFC2313]   Kaliski, B., "PKCS #1: RSA Encryption Version 1.5", RFC
                  2313, March 1998.

   [RFC2315]   Kaliski, B., "PKCS #7: Cryptographic Message Syntax
                  Version 1.5", RFC 2315, March 1998.

   [RFC2437]   Kaliski, B. and J. Staddon, "PKCS #1: RSA Cryptography
                  Specifications Version 2.0", RFC 2437, October 1998.

   [RFC2630]   Housley, R., "Cryptographic Message Syntax", RFC 2630,
                  June 1999.

   [RFC2660]   Rescorla, E. and A. Schiffman, "The Secure HyperText
                  Transfer Protocol", RFC 2660, August 1999.

   [RFC2898]   Kaliski, B., "PKCS #5: Password-Based Cryptography
                  Specification Version 2.0", RFC 2898, September 2000.

   [RFC3279]   Bassham, L., Polk, W., and R. Housley, "Algorithms and
                  Identifiers for the Internet X.509 Public Key
                  Infrastructure Certificate and Certificate Revocation
                  List (CRL) Profile", RFC 3279, April 2002.

   [RFC3369]   Housley, R., "Cryptographic Message Syntax (CMS)", RFC
                  3369, August 2002.

   [RFC3370]   Housley, R., "Cryptographic Message Syntax (CMS)
                  Algorithms", RFC 3370, August 2002.

   [RFC3447]   Jonsson, J. and B. Kaliski, "Public-Key Cryptography
                  Standards (PKCS) #1: RSA Cryptography Specifications
                  Version 2.1", RFC 3447, February 2003.

   [RFC4572]   Lennox, J., "Connection-Oriented Media Transport over
                  the Transport Layer Security (TLS) Protocol in the
                  Session Description Protocol (SDP)", RFC 4572, July
                  2006.

   [RFC5652]   Housley, R., "Cryptographic Message Syntax (CMS)", STD
                  70, RFC 5652, September 2009.

   [ROCH1995]   Rogier, N., and P. Chauvaud, "The compression function
                 of MD2 is not collision free", Presented at Selected
                 Areas in Cryptography '95, Carleton University, Ottawa,
                 Canada. May 18-19, 1995.

   [ROCH1997]   Rogier, N. and P. Chauvaud, "MD2 is not secure without
                 the checksum byte", Des. Codes Cryptogr. 12(3), 245-251
                 (1997).

   [SHS]   National Institute of Standards and Technology (NIST),
                 FIPS Publication 180-3: Secure Hash Standard, October
                 2008.

   [SP800-57]   National Institute of Standards and Technology (NIST),
                 Special Publication 800-57: Recommendation for Key
                 Management - Part 1 (Revised), March 2007.

   [SP800-131]   National Institute of Standards and Technology (NIST),
                 Special Publication 800-131: DRAFT Recommendation for
                 the Transitioning of Cryptographic Algorithms and Key
                 Sizes, June 2010.

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