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Identifiers and Test Vectors for HMAC-SHA-224, HMAC-SHA-256, HMAC-SHA-384, and HMAC-SHA-512

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Abstract

This document provides test vectors for the HMAC-SHA-224, HMAC-SHA-256, HMAC-SHA-384, and HMAC-SHA-512 message authentication schemes. It also provides ASN.1 object identifiers and Uniform Resource Identifiers (URIs) to identify use of these schemes in protocols. The test vectors provided in this document may be used for conformance testing.

Table of Contents

1. Introduction

This document provides test vectors for the HMAC-SHA-224, HMAC-SHA-256, HMAC-SHA-384, and HMAC-SHA-512 message authentication schemes. It also provides ASN.1 object identifiers and URIs to identify use of these schemes in protocols using ASN.1 constructs (such as those built on Secure/Multipurpose Internet Mail Extensions (S/MIME) [4]) or protocols based on XML constructs (such as those leveraging XML Digital Signatures [5]).

HMAC-SHA-224 is the realization of the HMAC message authentication code [1] using the SHA-224 hash function, HMAC-SHA-256 is the realization of the HMAC message authentication code using the SHA-256 hash function, HMAC-SHA-384 is the realization of the HMAC message authentication code using the SHA-384 hash function, and HMAC-SHA-512 is the realization of the HMAC message authentication code using the SHA-512 hash function. SHA-224, SHA-256, SHA-384, and SHA-512 are all described in [2].

2. Conventions Used in This Document

The key word "SHOULD" in this document is to be interpreted as described in RFC 2119 [3].

3. Scheme Identifiers

3.1. ASN.1 Object Identifiers

The following ASN.1 object identifiers have been allocated for these schemes:

```
rsadsi OBJECT IDENTIFIER ::=
    {iso(1) member-body(2) us(840) rsadsi(113549)}

digestAlgorithm   OBJECT IDENTIFIER ::= {rsadsi 2}

id-hmacWithSHA224 OBJECT IDENTIFIER ::= {digestAlgorithm 8}
id-hmacWithSHA256 OBJECT IDENTIFIER ::= {digestAlgorithm 9}
id-hmacWithSHA384 OBJECT IDENTIFIER ::= {digestAlgorithm 10}
id-hmacWithSHA512 OBJECT IDENTIFIER ::= {digestAlgorithm 11}
```

When the "algorithm" component in a value of ASN.1 type AlgorithmIdentifier (see, e.g., [4], Section 10) identifies one of these schemes, the "parameter" component SHOULD be present but have type NULL.

3.2. Algorithm URIs

The following URIs have been allocated for these schemes:

```
http://www.rsasecurity.com/rsalabs/pkcs/schemas/pkcs-5#hmac-sha-224
http://www.rsasecurity.com/rsalabs/pkcs/schemas/pkcs-5#hmac-sha-256
http://www.rsasecurity.com/rsalabs/pkcs/schemas/pkcs-5#hmac-sha-384
http://www.rsasecurity.com/rsalabs/pkcs/schemas/pkcs-5#hmac-sha-512
```

As usual, when used in the context of [5], the <ds:HMACOutputLength> element may specify the truncated length of the scheme output.

4. Test Vectors

4.1. Introduction

The test vectors in this document have been cross-verified by three independent implementations. An implementation that concurs with the results provided in this document should be interoperable with other similar implementations.

Keys, data, and digests are provided in hex.

4.2. Test Case 1

```
Key =           0b0b0b0b0b0b0b0b0b0b0b0b0b0b0b0b
                0b0b0b0b                          (20 bytes)
Data =          4869205468657265                  ("Hi There")

HMAC-SHA-224 = 896fb1128abbdf196832107cd49df33f
                47b4b1169912ba4f53684b22
HMAC-SHA-256 = b0344c61d8db38535ca8afceaf0bf12b
                881dc200c9833da726e9376c2e32cff7
HMAC-SHA-384 = afd03944d84895626b0825f4ab46907f
                15f9dadbe4101ec682aa034c7cebc59c
                faea9ea9076ede7f4af152e8b2fa9cb6
HMAC-SHA-512 = 87aa7cdea5ef619d4ff0b4241a1d6cb0
                2379f4e2ce4ec2787ad0b30545e17cde
                daa833b7d6b8a702038b274eaea3f4e4
                be9d914eeb61f1702e696c203a126854
```

4.3. Test Case 2

Test with a key shorter than the length of the HMAC output.

```
Key =           4a656665                          ("Jefe")
Data =          7768617420646f2079612077616e7420   ("what do ya want ")
                666f72206e6f7468696e673f          ("for nothing?")

HMAC-SHA-224 = a30e01098bc6dbbf45690f3a7e9e6d0f
                8bbea2a39e6148008fd05e44
HMAC-SHA-256 = 5bdcc146bf60754e6a042426089575c7
                5a003f089d2739839dec58b964ec3843
HMAC-SHA-384 = af45d2e376484031617f78d2b58a6b1b
                9c7ef464f5a01b47e42ec3736322445e
                8e2240ca5e69e2c78b3239ecfab21649
HMAC-SHA-512 = 164b7a7bfcf819e2e395fbe73b56e0a3
                87bd64222e831fd610270cd7ea250554
                9758bf75c05a994a6d034f65f8f0e6fd
                caeab1a34d4a6b4b636e070a38bce737
```

4.4. Test Case 3

Test with a combined length of key and data that is larger than 64 bytes (= block-size of SHA-224 and SHA-256).

```
Key             aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
                aaaaaaaa                            (20 bytes)
Data =          dddddddddddddddddddddddddddddddd
                dddddddddddddddddddddddddddddddd
                dddddddddddddddddddddddddddddddd
                dddd                                (50 bytes)

HMAC-SHA-224 = 7fb3cb3588c6c1f6ffa9694d7d6ad264
                 9365b0c1f65d69d1ec8333ea
HMAC-SHA-256 = 773ea91e36800e46854db8ebd09181a7
                 2959098b3ef8c122d9635514ced565fe
HMAC-SHA-384 = 88062608d3e6ad8a0aa2ace014c8a86f
                 0aa635d947ac9febe83ef4e55966144b
                 2a5ab39dc13814b94e3ab6e101a34f27
HMAC-SHA-512 = fa73b0089d56a284efb0f0756c890be9
                 b1b5dbdd8ee81a3655f83e33b2279d39
                 bf3e848279a722c806b485a47e67c807
                 b946a337bee8942674278859e13292fb
```

4.5. Test Case 4

Test with a combined length of key and data that is larger than 64 bytes (= block-size of SHA-224 and SHA-256).

```
Key =           0102030405060708090a0b0c0d0e0f10
                111213141516171819                  (25 bytes)
Data =          cdcdcdcdcdcdcdcdcdcdcdcdcdcdcdcd
                cdcdcdcdcdcdcdcdcdcdcdcdcdcdcdcd
                cdcdcdcdcdcdcdcdcdcdcdcdcdcdcdcd
                cdcd                                (50 bytes)

HMAC-SHA-224 = 6c11506874013cac6a2abc1bb382627c
                 ec6a90d86efc012de7afec5a
HMAC-SHA-256 = 82558a389a443c0ea4cc819899f2083a
                 85f0faa3e578f8077a2e3ff46729665b
HMAC-SHA-384 = 3e8a69b7783c25851933ab6290af6ca7
                 7a9981480850009cc5577c6e1f573b4e
                 6801dd23c4a7d679ccf8a386c674cffb
HMAC-SHA-512 = b0ba465637458c6990e5a8c5f61d4af7
                 e576d97ff94b872de76f8050361ee3db
                 a91ca5c11aa25eb4d679275cc5788063
                 a5f19741120c4f2de2adebeb10a298dd
```

4.6. Test Case 5

Test with a truncation of output to 128 bits.

```
Key =          0c0c0c0c0c0c0c0c0c0c0c0c0c0c0c0c
               0c0c0c0c                          (20 bytes)
Data =         546573742057697468205472756e6361  ("Test With Trunca")
               74696f6e                          ("tion")

HMAC-SHA-224 = 0e2aea68a90c8d37c988bcdb9fca6fa8
HMAC-SHA-256 = a3b6167473100ee06e0c796c2955552b
HMAC-SHA-384 = 3abf34c3503b2a23a46efc619baef897
HMAC-SHA-512 = 415fad6271580a531d4179bc891d87a6
```

4.7. Test Case 6

Test with a key larger than 128 bytes (= block-size of SHA-384 and SHA-512).

```
Key =          aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
               aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
               aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
               aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
               aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
               aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
               aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
               aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
               aaaaaa                            (131 bytes)
Data =         546573742057696e67204c61726765    ("Test Using Large")
               72205468616e20426c6f636b2d53697a  ("r Than Block-Siz")
               65204b6579202d2048617368204b6579  ("e Key - Hash Key")
               204669727374                      (" First")

HMAC-SHA-224 = 95e9a0db962095adaebe9b2d6f0dbce2
               d499f112f2d2b7273fa6870e
HMAC-SHA-256 = 60e431591ee0b67f0d8a26aacbf5b77f
               8e0bc6213728c5140546040f0ee37f54
HMAC-SHA-384 = 4ece084485813e9088d2c63a041bc5b4
               4f9ef1012a2b588f3cd11f05033ac4c6
               0c2ef6ab4030fe8296248df163f44952
HMAC-SHA-512 = 80b24263c7c1a3ebb71493c1dd7be8b4
               9b46d1f41b4aeec1121b013783f8f352
               6b56d037e05f2598bd0fd2215d6a1e52
               95e64f73f63f0aec8b915a985d786598
```

4.8. Test Case 7

Test with a key and data that is larger than 128 bytes (= block-size of SHA-384 and SHA-512).

```
Key =          aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
               aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
               aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
               aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
               aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
               aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
               aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa
               aaaaaa                                (131 bytes)
Data =         5468697320697320612074657374207 5  ("This is a test u")
               73696e672061206c6172676572207468  ("sing a larger th")
               616e20626c6f636b2d73697a65206b65  ("an block-size ke")
               7920616e642061206c61726765722074  ("y and a larger t")
               68616e20626c6f636b2d73697a652064  ("han block-size d")
               6174612e20546865206b6579206e6565  ("ata. The key nee")
               647320746f2062652068617368656420  ("ds to be hashed ")
               6265666f7265206265696e6720757365  ("before being use")
               642062792074686520484d414320616c  ("d by the HMAC al")
               676f726974686d2e                  ("gorithm.")

HMAC-SHA-224 = 3a854166ac5d9f023f54d517d0b39dbd
               946770db9c2b95c9f6f565d1
HMAC-SHA-256 = 9b09ffa71b942fcb27635fbcd5b0e944
               bfdc63644f0713938a7f51535c3a35e2
HMAC-SHA-384 = 6617178e941f020d351e2f254e8fd32c
               602420feb0b8fb9adccebb82461e99c5
               a678cc31e799176d3860e6110c46523e
HMAC-SHA-512 = e37b6a775dc87dbaa4dfa9f96e5e3ffd
               debd71f8867289865df5a32d20cdc944
               b6022cac3c4982b10d5eeb55c3e4de15
               134676fb6de0446065c97440fa8c6a58
```

5. Security Considerations

This document is intended to provide the identifications and test vectors for the four identified message authentication code schemes to the Internet community. No assertion of the security of these message authentication code schemes for any particular use is intended. The reader is referred to [1] for a discussion of the general security of the HMAC construction.

6. Acknowledgements

The test cases in this document are derived from the test cases in [6], although the keys and data are slightly different.

Thanks to Jim Schaad and Brad Hards for assistance in verifying the results.

7. References

7.1. Normative References

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

[2] National Institute of Standards and Technology, "Secure Hash Standard", FIPS 180-2, August 2002, with Change Notice 1 dated February 2004.

[3] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, March 1997.

7.2. Informative References

[4] Housley, R., "Cryptographic Message Syntax (CMS)", RFC 3852, July 2004.

[5] Eastlake 3rd, D., Reagle, J., and D. Solo, "(Extensible Markup Language) XML-Signature Syntax and Processing", RFC 3275, March 2002.

[6] Cheng, P. and R. Glenn, "Test Cases for HMAC-MD5 and HMAC-SHA-1", RFC 2202, September 1997.

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