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Summary of Cryptographic Authentication Algorithm Implementation Requirements for Routing Protocols
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Abstract

The routing protocols Open Shortest Path First version 2 (OSPFv2), Intermediate System to Intermediate System (IS-IS) and Routing Information Protocol (RIP) currently define cleartext and MD5 (Message Digest 5) methods for authenticating protocol packets. Recently effort has been made to add support for the SHA (Secure Hash Algorithm) family of hash functions for the purpose of authenticating routing protocol packets for RIP, IS-IS and OSPF.

To encourage interoperability between disparate implementations, it is imperative that we specify the expected minimal set of algorithms thereby ensuring that there is at least one algorithm that all implementations will have in common.

Similarly RIPng and OSPFv3 support IPSec algorithms for authenticating their protocol packets.

This document examines the current set of available algorithms with interoperability and effective cryptographic authentication protection being the principle considerations. Cryptographic authentication of these routing protocols requires the availability of the same algorithms in disparate implementations. It is desirable that newly specified algorithms should be implemented and available in routing protocol implementations because they may be promoted to requirements at some future time.

Status of this Memo

This Internet-Draft is submitted in full conformance with the provisions of BCP 78 and BCP 79.

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1. Introduction

Most routing protocols include three different types of authentication schemes: Null authentication, cleartext Password and a Cryptographic Authentication scheme. Null authentication is equivalent to having no authentication scheme at all.

In a cleartext scheme, also known as, simple password scheme, the password is exchanged completely unprotected and anyone with physical access to the network can learn the password and compromise the integrity of the routing domain. The simple password scheme protects from accidental establishment of routing sessions in a given domain, but beyond that it offers no additional protection.

In a cryptographic authentication scheme, routers share a secret key which is used to generate a message authentication code for each of the protocol packets. Today, routing protocols that implement message authentication codes often use a keyed MD5 [RFC1321] digest. The recent escalating series of attacks on MD5 raise concerns about its remaining useful lifetime.

These attacks may not necessarily result in direct vulnerabilities for keyed MD5 digests as message authentication codes because the colliding message may not correspond to a syntactically correct protocol packet. The known collision, pre-image, and second pre-image attacks [RFC4270] on MD5 may not increase the effectiveness of the key recovery attacks on HMAC-MD5. Regardless, there is a need felt to deprecated MD5 [RFC1321] as the basis for the HMAC algorithm in favor of stronger digest algorithms.

In light of these considerations, there are proposals to replace HMAC-MD5 with keyed HMAC-SHA [SHS] digests where HMAC-MD5 is currently mandated in RIPv2 [RFC2453] and IS-IS [ISO] [RFC1195] and keyed-MD5 in OSPFv2 [RFC2328].

OSPFv3 [RFC5340] and RIPng [RFC2080] rely on the IPv6 Authentication Header (AH) [RFC4302] and IPv6 Encapsulating Security Payload (ESP) [RFC4303] in order to provide integrity, authentication, and/or confidentiality.

However, the nature of cryptography is that algorithmic improvement is an ongoing process and as is the exploration and refinement of attack vectors. An algorithm believed to be strong today may be demonstrated to be weak tomorrow. Given this, the choice of preferred algorithm should favor the minimization of the likelihood of it being compromised quickly.

It should be recognized that preferred algorithm(s) will change over

time to adapt to the evolving threats. At any particular time, the mandatory to implement algorithm(s) might not be specified in the base protocol specification. As protocols are extended the preference for presently stronger algorithms presents a problem both on the question of interoperability of existing and future implementations with respect to standards and operational preference for the configuration as deployed.

It is expected an implementation should support changing of security (authentication) keys. Changing the symmetric key used in any HMAC algorithm on a periodic basis is good security practice. Operators need to plan for this.

Implementations can support in-service key change so that no control packets are lost. During an in-service/in-band key change more than one key can be active for receiving packets for a session. Some protocols support a key identifier which allows the two peers of a session to have multiple keys simultaneously for a session.

However, these protocols currently manage keys manually (i.e., operator intervention) or dynamically based on some timer or security protocol.

2. Intermediate System to Intermediate System (IS-IS)

The IS-IS specification allows for authentication of its Protocol Data Units (PDUs) via the authentication TLV (TLV 10) in the PDU. The base specification [ISO] had provisions only for cleartext passwords. [RFC5304] extends the authentication capabilities by providing cryptographic authentication for IS-IS PDUs. It mandates support for HMAC-MD5.

[RFC5310] adds support for the use of any cryptographic hash function for authenticating IS-IS PDUs. It in addition to this, also details how IS-IS can use HMAC construct along with the Secure Hash Algorithm (SHA) family of cryptographic hash functions to secure IS-IS PDUs.

2.1. Authentication Scheme Selection

In order for IS-IS implementations to securely interoperate, they must support one or more authentication schemes in common. This section specifies the preference for standards conformant IS-IS implementations, which desire to utilize the security feature.

The earliest interoperability requirement for authentication as stated by [ISO] [RFC1195] required all implementations to support cleartext Password. This authentication scheme's utility is limited to precluding the accidental introduction of a new IS into a broadcast domain. Operators should not use this scheme as it provides no protection against an attacker with access to the broadcast domain as anyone can determine the secret password through inspection of the PDU. This mechanism does not provide any significant level of security and should be avoided.

[RFC5304] defined the cryptographic authentication scheme for IS-IS. HMAC-MD5 was the only algorithm specified, hence it is mandated. [RFC5310] defined a generic cryptographic scheme and added support for additional algorithms. Implementations should support [RFC5310] as it defines the generic cryptographic authentication scheme.

2.2. Authentication Algorithm Selection

For IS-IS implementations to securely interoperate, they must have support for one or more authentication algorithms in common.

This section details the authentication algorithm requirements for standards conformant IS-IS implementations.

The following are the available options for authentication algorithms:

- [RFC5304] mandates the use of HMAC-MD5.
- [RFC5310] does not require a particular algorithm but instead supports any digest algorithm (i.e., cryptographic hash function).

As noted earlier, there is a desire to deprecate the use of MD5. IS-IS implementations will likely migrate to an authentication scheme supported by [RFC5310] because it is algorithm agnostic. Possible

digest algorithms included: SHA-1, SHA-256, SHA-384, and SHA-512. Picking at least one mandatory-to-implement algorithms is imperative to ensuring interoperability.

3. Open Shortest Path First Version 2(OSPFv2)

[RFC2328] includes three different types of authentication schemes: Null authentication, cleartext password (defined as simple password in [RFC2328]) and cryptographic authentication. Null authentication is semantically equivalent to no authentication.

In the cryptographic authentication scheme, the OSPFv2 routers on a common network/subnet are configured with a shared secret which is used to generate a keyed MD5 digest for each packet. A monotonically increasing sequence number scheme is used to protect against replay attacks.

[RFC5709] adds support for the use of the SHA family of hash algorithms for authentication of OSPFv2 packets.

3.1. Authentication Scheme Selection

For OSPF implementations to securely interoperate, they must have one or more authentication schemes in common.

While all implementations will have NULL auth since it's mandated by [RFC2328], its use is not appropriate in any context where the operator wishes to authenticate OSPFv2 packets in their network.

While all implementations will also have Cleartext Password since it's mandated by [RFC2328], its use is only appropriate for use when the operator wants to preclude the accidental introduction of a router into the domain. This scheme is patently not useful when an operator wants to authenticate the OSPFv2 packets.

Cryptographic Authentication is a mandatory scheme defined in [RFC2328] and all conformant implementations must support this.

3.2. Authentication Algorithm Selection

For OSPFv2 implementations to securely interoperate, they must support one or more cryptographic authentication algorithms in common.

The following are the available options for authentication algorithms:

- [RFC2328] specifies the use of HMAC-MD5.

- [RFC5709] specifies the use of HMAC-SHA1, HMAC-SHA224, HMAC-SHA256, HMAC-SHA384, and HAMC-512 and mandates support for HMAC-SHA256 (HMAC-SHA1 is optional).

As noted earlier, there is a desired to deprecate the use MD5. Some alternatives for MD5 are listed in [RFC5709].

Possible digest algorithms included: SHA-1, SHA-224, SHA-256, SHA-384, and SHA-512. Picking one mandatory-to-implement algorithms is imperative to ensuring interoperability.

4. Open Shortest Path First Version 3 (OSPFv3)

OSPFv3 [RFC5340] relies on the IPv6 Authentication Header (AH) [RFC4302] and IPv6 Encapsulating Security Payload (ESP) [RFC4303] in order to provide integrity, authentication, and/or confidentiality.

[RFC4522] mandates the use of ESP for authenticating OSPFv3 packets. The implementations could also provide support for using AH to protect these packets.

The algorithm requirements for AH and ESP are described in [RFC4835] as follows:

- [RFC2404] mandates HMAC-SHA1-96.
- [RFC3566] indicates AES-XCBC-MAC-96 as a should, but its likely that this will be mandated at some future time.

5. Routing Information Protocol Version 2 (RIPv2)

RIPv2, originally specified in [RFC1388], then [RFC1723], has been updated and published as STD56 [RFC2453]. If the Address Family Identifier of the first (and only the first) entry in the RIPv2 message is 0xFFFF, then the remainder of the entry contains the authentication information. The [RFC2453] version of the protocol provides for authenticating packets using a cleartext password (defined as "simple password" in [RFC2453]) not more than 16 octets in length.

[RFC2082] added support for Keyed MD5 authentication, where a digest is appended to the end of the RIP packet. [RFC4822] obsoleted [RFC2082] and added the SHA family of hash algorithms to the list of cryptographic authentications that can be used to protect RIPv2, whereas [RFC2082] previously specified only the use of Keyed MD5.

5.1. Authentication Scheme Selection

For RIPv2 implementations to securely interoperate they must support one or more authentication schemes in common.

While all implementations will support cleartext password since it's mandated by [RFC2453], its use is only appropriate for use when the operator wants to preclude the accidental introduction of a router into the domain. This scheme is patently not useful when an operator wants to authenticate the RIPv2 packets.

[RFC2082] mandates the use of an authentication scheme that uses Keyed MD5. However, [RFC2082] has been obsoleted by [RFC4822] Cryptographic Authentication. Compliant implementations must provide support for an authentication scheme that uses Keyed MD5 but should

recognize that this is superseded by Cryptographic Authentication as defined in [RFC4822].

Implementations should provide support for [RFC4822] as it specifies the RIPv2 Cryptographic Authentication schemes.

5.2. Authentication Algorithm Selection

For RIPv2 implementations to securely interoperate they must support one or more authentication algorithms in common.

The following are the available options for authentication algorithms:

- [RFC2082] specifies the use of keyed MD5.

- [RFC4822] specifies the use of HMAC-MD5, HMAC-SHA1, HMAC-SHA224, HMAC- SHA256, HMAC-SHA384 and HMAC-SHA512.

As noted earlier, there is a desire to deprecate the use MD5. Some alternatives for MD5 are listed in [RFC4822]. Possible digest algorithms included: SHA-1, SHA-224, SHA-256, SHA-384, and SHA-512. Picking one mandatory-to-implement algorithms is imperative to ensuring interoperability.

6. Routing Information Protocol for IPv6 (RIPng)

RIPng [RFC2080] relies on the IPv6 Authentication Header (AH) [RFC4302] and IPv6 Encapsulating Security Payload (ESP) [RFC4303] in order to provide integrity, authentication, and/or confidentiality.

The algorithm requirements for AH and ESP are described in [RFC4835] as follows:

- [RFC2404] mandates HMAC-SHA1-96.
- [RFC3566] indicates AES-XCBC-MAC-96 as a should, but its likely that this will be mandated at some future time.

7. Security Considerations

The cryptographic mechanisms referenced in this document provide only authentication algorithms. These algorithms do not provide confidentiality. Encrypting the content of the packet and thereby providing confidentiality is not considered in the definition of the routing protocols.

The cryptographic strength of the HMAC depends upon the cryptographic strength of the underlying hash function and on the size and quality of the key. The feasibility of attacking the integrity of routing

protocol messages protected by keyed digests may be significantly more limited than that of other data, however preference for one family of algorithms over another may also change independently of the perceived risk to a particular protocol.

To ensure greater security, the keys used should be changed periodically and implementations must be able to store and use more than one key at the same time. Operational experience suggests that the lack of periodic rekeying is a source of significant exposure and that the lifespan of shared keys in the network is frequently measured in years.

While simple password schemes are well represented in the document series and in conformant implementations of the protocols, the inability to offer either integrity or identity protection are sufficient reason to strongly discourage their use.

This document concerns itself with the selection of cryptographic algorithms for use in the authentication of routing protocol packets being exchanged between adjacent routing processes. The cryptographic algorithms identified in this document are not known to be broken at the current time, and ongoing cryptographic research so far leads us to believe that they will likely remain secure in the foreseeable future. We expect that new revisions of this document will be issued in the future to reflect current thinking on the algorithms various routing protocols should employ to ensure interoperability between disparate implementations.

8. IANA Considerations

This document has no actions for IANA.

9. Acknowledgements

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