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IP Encapsulating Security Payload (ESP)

Status of this Memo

ABSTRACT

This document describes the IP Encapsulating Security Payload (ESP). ESP is a mechanism for providing integrity and confidentiality to IP datagrams. In some circumstances it can also provide authentication to IP datagrams. The mechanism works with both IPv4 and IPv6.

1. INTRODUCTION

ESP is a mechanism for providing integrity and confidentiality to IP datagrams. It may also provide authentication, depending on which algorithm and algorithm mode are used. Non-repudiation and protection from traffic analysis are not provided by ESP. The IP Authentication Header (AH) might provide non-repudiation if used with certain authentication algorithms [Atk95b]. The IP Authentication Header may be used in conjunction with ESP to provide authentication. Users desiring integrity and authentication without confidentiality should use the IP Authentication Header (AH) instead of ESP. This document assumes that the reader is familiar with the related document "IP Security Architecture", which defines the overall Internet-layer security architecture for IPv4 and IPv6 and provides important background for this specification [Atk95a].

1.1 Overview

The IP Encapsulating Security Payload (ESP) seeks to provide confidentiality and integrity by encrypting data to be protected and placing the encrypted data in the data portion of the IP Encapsulating Security Payload. Depending on the user's security requirements, this mechanism may be used to encrypt either a transport-layer segment (e.g., TCP, UDP, ICMP, IGMP) or an entire IP datagram. Encapsulating the protected data is necessary to provide confidentiality for the entire original datagram.

Use of this specification will increase the IP protocol processing costs in participating systems and will also increase the communications latency. The increased latency is primarily due to the encryption and decryption required for each IP datagram containing an Encapsulating Security Payload.

In Tunnel-mode ESP, the original IP datagram is placed in the encrypted portion of the Encapsulating Security Payload and that entire ESP frame is placed within a datagram having unencrypted IP headers. The information in the unencrypted IP headers is used to route the secure datagram from origin to destination. An unencrypted IP Routing Header might be included between the IP Header and the Encapsulating Security Payload.

In Transport-mode ESP, the ESP header is inserted into the IP datagram immediately prior to the transport-layer protocol header (e.g., TCP, UDP, or ICMP). In this mode bandwidth is conserved because there are no encrypted IP headers or IP options.

In the case of IP, an IP Authentication Header may be present as a header of an unencrypted IP packet, as a header after the IP header and before the ESP header in a Transport-mode ESP packet, and also as a header within the encrypted portion of a Tunnel-mode ESP packet. When AH is present both in the cleartext IP header and also inside a Tunnel-mode ESP header of a single packet, the unencrypted IPv6 Authentication Header is primarily used to provide protection for the contents of the unencrypted IP headers and the encrypted Authentication Header is used to provide authentication only for the encrypted IP packet. This is discussed in more detail later in this document.

The Encapsulating Security Payload is structured a bit differently than other IP payloads. The first component of the ESP payload consist of the unencrypted field(s) of the payload. The second component consists of encrypted data. The field(s) of the unencrypted ESP header inform the intended receiver how to properly decrypt and process the encrypted data. The encrypted data component includes protected fields for the security protocol and also the encrypted encapsulated IP datagram.

The concept of a "Security Association" is fundamental to ESP. It is described in detail in the companion document "Security Architecture for the Internet Protocol" which is incorporated here by reference [Atk95a]. Implementors should read that document before reading this one.

1.2 Requirements Terminology

In this document, the words that are used to define the significance of each particular requirement are usually capitalised. These words are:

- MUST

  This word or the adjective "REQUIRED" means that the item is an absolute requirement of the specification.

- SHOULD

  This word or the adjective "RECOMMENDED" means that there might exist valid reasons in particular circumstances to ignore this item, but the full implications should be understood and the case carefully weighed before taking a different course.

- MAY

  This word or the adjective "OPTIONAL" means that this item is truly optional. One vendor might choose to include the item because a particular marketplace requires it or because it enhances the product, for example; another vendor may omit the same item.

2. KEY MANAGEMENT

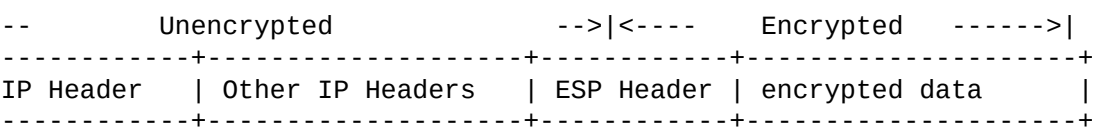
Key management is an important part of the IP security architecture. However, a specific key management protocol is not included in this specification because of a long history in the public literature of subtle flaws in key management algorithms and protocols. IP tries to decouple the key management mechanisms from the security protocol mechanisms. The only coupling between the key management protocol and the security protocol is with the Security Parameter Index (SPI), which is described in more detail below. This decoupling permits several different key management mechanisms to be used. More importantly, it permits the key management protocol to be changed or corrected without unduly impacting the security protocol implementations. Thus, a key management protocol for IP is not specified within this memo. The IP Security Architecture describes key management in more detail and specifies the key management requirements for IP. Those key management requirements are incorporated here by reference [Atk95a].

The key management mechanism is used to negotiate a number of parameters for each security association, including not only the keys but other information (e.g., the cryptographic algorithms and modes,

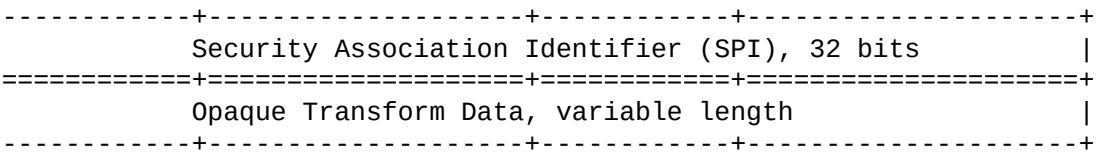
security classification level, if any) used by the communicating parties. The key management protocol implementation usually creates and maintains a logical table containing the several parameters for each current security association. An ESP implementation normally needs to read that security parameter table to determine how to process each datagram containing an ESP (e.g., which algorithm/mode and key to use).

3. ENCAPSULATING SECURITY PAYLOAD SYNTAX

The Encapsulating Security Payload (ESP) may appear anywhere after the IP header and before the final transport-layer protocol. The Internet Assigned Numbers Authority has assigned Protocol Number 50 to ESP [STD-2]. The header immediately preceding an ESP header will always contain the value 50 in its Next Header (IPv6) or Protocol (IPv4) field. ESP consists of an unencrypted header followed by encrypted data. The encrypted data includes both the protected ESP header fields and the protected user data, which is either an entire IP datagram or an upper-layer protocol frame (e.g., TCP or UDP). A high-level diagram of a secure IP datagram follows.



A more detailed diagram of the ESP Header follows below.



Encryption and authentication algorithms, and the precise format of the Opaque Transform Data associated with them are known as "transforms". The ESP format is designed to support new transforms in the future to support new or additional cryptographic algorithms. The transforms are specified by themselves rather than in the main body of this specification. The mandatory transform for use with IP is defined in a separate document [KMS95]. Other optional transforms exist in other separate specifications and additional transforms might be defined in the future.

3.1 Fields of the Encapsulating Security Payload

The SPI is a 32-bit pseudo-random value identifying the security association for this datagram. If no security association has been established, the value of the SPI field shall be 0x00000000. An SPI is similar to the SAID used in other security protocols. The name has been changed because the semantics used here are not exactly the same as those used in other security protocols.

The set of SPI values in the range 0x00000001 though 0x000000FF are reserved to the Internet Assigned Numbers Authority (IANA) for future use. A reserved SPI value will not normally be assigned by IANA unless the use of that particular assigned SPI value is openly specified in an RFC.

The SPI is the only mandatory transform-independent field. Particular transforms may have other fields unique to the transform. Transforms are not specified in this document.

3.2 Security Labeling with ESP

The encrypted IP datagram need not and does not normally contain any explicit Security Label because the SPI indicates the sensitivity level. This is an improvement over the current practices with IPv4 where an explicit Sensitivity Label is normally used with Compartmented Mode Workstations and other systems requiring Security Labels [Ken91] [DIA]. In some situations, users MAY choose to carry explicit labels (for example, IPSO labels as defined by RFC-1108 might be used with IPv4) in addition to using the implicit labels provided by ESP. Explicit label options could be defined for use with IPv6 (e.g., using the IPv6 End-to-End Options Header or the IPv6 Hop-by-Hop Options Header). Implementations MAY support explicit labels in addition to implicit labels, but implementations are not required to support explicit labels. Implementations of ESP in systems claiming to provide multi-level security MUST support implicit labels.

4. ENCAPSULATING SECURITY PROTOCOL PROCESSING

This section describes the steps taken when ESP is in use between two communicating parties. Multicast is different from unicast only in the area of key management (See the definition of the SPI, above, for more detail on this). There are two modes of use for ESP. The first mode, which is called "Tunnel-mode", encapsulates an entire IP datagram inside ESP. The second mode, which is called "Transport-Mode", encapsulates a transport-layer (e.g., UDP, TCP) frame inside ESP. The term "Transport-mode" must not be misconstrued as restricting its use to TCP and UDP. For example, an ICMP message MAY

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