IPSECME
Internet-Draft
Intended status: Standards Track
Expires: September 24, 2018

D. Migault, Ed.
Ericsson
T. Guggemos, Ed.
LMU Munich
Y. Nir
Dell EMC

March 23, 2018

Implicit IV for Counter-based Ciphers in Encapsulating Security Payload (ESP)

draft-ietf-ipsecme-implicit-iv-01

Abstract

Encapsulating Security Payload (ESP) sends an initialization vector (IV) or nonce in each packet. The size of IV depends on the applied transform, being usually 8 or 16 octets for the transforms defined by the time this document is written. Some algorithms such as AES-GCM, AES-CCM, AES-CTR and ChaCha20-Poly1305 require a unique nonce but do not require an unpredictable nonce. When using such algorithms the packet counter value can be used to generate a nonce. This avoids sending the nonce itself, and savec in the case of AES-GCM, AES-CCM, AES-CTR and ChaCha20-Poly1305 8 octets per packet. This document describes how to do this.

Status of This Memo

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

Internet-Drafts are working documents of the Internet Engineering Task Force (IETF). Note that other groups may also distribute working documents as Internet-Drafts. The list of current Internet-Drafts is at https://datatracker.ietf.org/drafts/current/.

Internet-Drafts are draft documents valid for a maximum of six months and may be updated, replaced, or obsoleted by other documents at any time. It is inappropriate to use Internet-Drafts as reference material or to cite them other than as "work in progress."

This Internet-Draft will expire on September 24, 2018.

Copyright Notice

Table of Contents

1. Requirements notation

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].

2. Introduction

Counter-based AES modes of operation such as AES-CTR ([RFC3686]), AES-CCM ([RFC4309]), and AES-GCM ([RFC4106]) require the specification of an nonce for each ESP packet. The same applies for ChaCha20-Poly1305 ([RFC7634]. Currently this nonce is sent in each ESP packet ([RFC4303]). This practice is designated in this document as "explicit nonce".

In some context, such as IoT, it may be preferable to avoid carrying the extra bytes associated to the IV and instead generate it locally on each peer. The local generation of the nonce is designated in this document as "implicit IV".

The size of this nonce depends on the specific algorithm, but all of the algorithms mentioned above take an 8-octet nonce.

This document defines how to compute the nonce locally when it is implicit. It also specifies how peers agree with the Internet Key Exchange version 2 (IKEv2 - [RFC7296]) on using an implicit IV versus an explicit IV.

This document limits its scope to the algorithms mentioned above. Other algorithms with similar properties may later be defined to use this extension.

This document does not consider AES-CBC ([RFC3602]) as AES-CBC requires the IV to be unpredictable. Deriving it directly from the packet counter as described below is insecure as mentioned in Security Consideration of [RFC3602] and has led to real world chosen plain-text attack such as BEAST [BEAST].

3. Terminology

- IoT: Internet of Things.
- IV: Initialization Vector.
- IIV: Implicit Initialization Vector.
- Nonce: a fixed-size octet string used only once. This is similar to IV, except that in common usage there is no implication of non-predictability.

4. Implicit IV

With the algorithms listed in Section 2, the 8 byte nonce MUST NOT repeat. The binding between a ESP packet and its nonce is provided using the Sequence Number or the Extended Sequence Number. Figure 1 and Figure 2 represent the IV with a regular 4-byte Sequence Number and with an 8-byte Extended Sequence Number respectively.

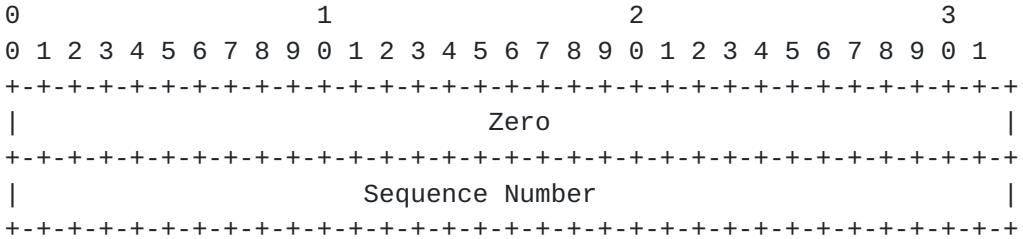

Figure 1: Implicit IV with a 4 byte Sequence Number

- Sequence Number: the 4 byte Sequence Number carried in the ESP packet.

o Zero: a 4 byte array with all bits set to zero.

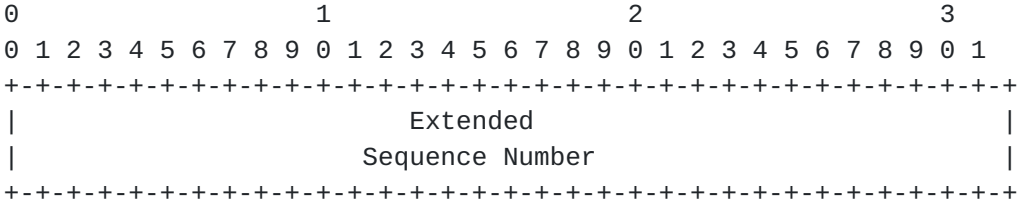

Figure 2: Implicit IV with an 8 byte Extended Sequence Number

o Extended Sequence Number: the 8 byte Extended Sequence Number of the Security Association. The 4 byte low order bytes are carried in the ESP packet.

As the IV MUST NOT repeat for one SPI when Counter-Mode ciphers are used, Implicit IV as described in this document MUST NOT be used in setups with the chance that the Sequence Number overlaps for one SPI. Multicast as described in [RFC5374], [RFC6407] and [I-D.yeung-g-ikev2] is a prominent example, where many senders share one secret and thus one SPI. Section 3.5 of [RFC6407] explains how repetition MAY BE prevented by using a prefix for each group member, which could be prefixed to the Sequence Number. Otherwise, Implicit IV MUST NOT be used in multicast scenarios.

5. Initiator Behavior

An initiator supporting this feature SHOULD propose implicit IV for all relevant algorithms. To facilitate backward compatibility with non-supporting peers the initiator SHOULD also include those same algorithms without Implicit IV (IIV). This may require extra transforms.

6. Responder Behavior

The rules of SA payload processing ensure that the responder will never send an SA payload containing the IIV indicator to an initiator that does not support IIV.

7. Security Consideration

Nonce generation for these algorithms has not been explicitly defined. It has been left to the implementation as long as certain security requirements are met. Typically, for AES-GCM, AES-CCM, AES-CTR and ChaCha20-Poly1305, the IV is not allowed being repeated for one particular key. This document provides an explicit and normative way to generate IVs. The mechanism described in this document meets the IV security requirements of all relevant algorithms.

8. IANA Considerations

AES-CTR, AES-CCM, AES-GCM and ChaCha20-Poly1305 are likely to implement the implicit IV described in this document. This section limits assignment of new code points to the recommended suites provided in [RFC8221], thus the new Transform Type 1 - Encryption Algorithm Transform IDs [IANA] are as defined below:

- ENCR_AES_CCM_8_IIV

- ENCR_AES_GCM_16_IIV

- ENCR_CHACHA20_POLY1305_IIV

These algorithms should be added with this document as ESP Reference and "Not Allowed" for IKEv2 Reference.

9. Acknowledgements

We would like to thanks people Valery Smyslov for their valuable comments, David Schinazi for its implementation, as well as the ipseceme chairs Tero Kivinen and David Waltermire for moving this work forward.

10. References

10.1. 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, <https://www.rfc-editor.org/info/rfc2119>.

[RFC3602] Frankel, S., Glenn, R., and S. Kelly, "The AES-CBC Cipher Algorithm and Its Use with IPsec", RFC 3602, DOI 10.17487/RFC3602, September 2003, <https://www.rfc-editor.org/info/rfc3602>.

[RFC3686] Housley, R., "Using Advanced Encryption Standard (AES) Counter Mode With IPsec Encapsulating Security Payload (ESP)", RFC 3686, DOI 10.17487/RFC3686, January 2004, <https://www.rfc-editor.org/info/rfc3686>.

[RFC4106] Viega, J. and D. McGrew, "The Use of Galois/Counter Mode (GCM) in IPsec Encapsulating Security Payload (ESP)", RFC 4106, DOI 10.17487/RFC4106, June 2005, <https://www.rfc-editor.org/info/rfc4106>.

[RFC4303] Kent, S., "IP Encapsulating Security Payload (ESP)", RFC 4303, DOI 10.17487/RFC4303, December 2005, <https://www.rfc-editor.org/info/rfc4303>.

[RFC4309] Housley, R., "Using Advanced Encryption Standard (AES) CCM Mode with IPsec Encapsulating Security Payload (ESP)", RFC 4309, DOI 10.17487/RFC4309, December 2005, <https://www.rfc-editor.org/info/rfc4309>.

[RFC5374] Weis, B., Gross, G., and D. Ignjatic, "Multicast Extensions to the Security Architecture for the Internet Protocol", RFC 5374, DOI 10.17487/RFC5374, November 2008, <https://www.rfc-editor.org/info/rfc5374>.

[RFC6407] Weis, B., Rowles, S., and T. Hardjono, "The Group Domain of Interpretation", RFC 6407, DOI 10.17487/RFC6407, October 2011, <https://www.rfc-editor.org/info/rfc6407>.

[RFC7296] Kaufman, C., Hoffman, P., Nir, Y., Eronen, P., and T. Kivinen, "Internet Key Exchange Protocol Version 2 (IKEv2)", STD 79, RFC 7296, DOI 10.17487/RFC7296, October 2014, <https://www.rfc-editor.org/info/rfc7296>.

[RFC7634] Nir, Y., "ChaCha20, Poly1305, and Their Use in the Internet Key Exchange Protocol (IKE) and IPsec", RFC 7634, DOI 10.17487/RFC7634, August 2015, <https://www.rfc-editor.org/info/rfc7634>.

[RFC8221] Wouters, P., Migault, D., Mattsson, J., Nir, Y., and T. Kivinen, "Cryptographic Algorithm Implementation Requirements and Usage Guidance for Encapsulating Security Payload (ESP) and Authentication Header (AH)", RFC 8221, DOI 10.17487/RFC8221, October 2017, <https://www.rfc-editor.org/info/rfc8221>.

10.2. Informational References

[BEAST] Thai, T. and J. Juliano, "Here Come The xor Ninjas", , May 2011, <https://www.researchgate.net/publication/266529975_Here_Come_The_Ninjas>.

[I-D.yeung-g-ikev2] Weis, B., Nir, Y., and V. Smyslov, "Group Key Management using IKEv2", draft-yeung-g-ikev2-13 (work in progress), March 2018.

[IANA] "IANA IKEv2 Parameter - Type 1 - Encryption Algorithm Transform IDs", <https://www.iana.org/assignments/ikev2-parameters/ikev2-parameters.xhtml#ikev2-parameters-5>.

Authors' Addresses

Daniel Migault (editor)
Ericsson
8400 boulevard Decarie
Montreal, QC H4P 2N2
Canada

Email: daniel.migault@ericsson.com

Tobias Guggemos (editor)
LMU Munich
Oettingenstr. 67
80538 Munich, Bavaria
Germany

Email: guggemos@mnm-team.org
URI: http://mnm-team.org/~guggemos

Yoav Nir
Dell EMC
9 Andrei Sakharov St
Haifa 3190500
Israel

Email: ynir.ietf@gmail.com