Network Working Group
Internet-Draft
Updates: 5246, 6347 (if approved)
Intended status: Standards Track
Expires: June 18, 2016

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December 16, 2015

ChaCha20-Poly1305 Cipher Suites for Transport Layer Security (TLS) draft-ietf-tls-chacha20-poly1305-04

Abstract

This document describes the use of the ChaCha stream cipher and Poly1305 authenticator in the Transport Layer Security (TLS) and Datagram Transport Layer Security (DTLS) protocols.

Status of This Memo

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1. Introduction

This document describes the use of the ChaCha stream cipher and Poly1305 authenticator in version 1.2 or later of the the Transport Layer Security (TLS) [RFC5246] protocol, as well as version 1.2 or later of the Datagram Transport Layer Security (DTLS) protocol [RFC6347].

ChaCha [CHACHA] is a stream cipher developed by D. J. Bernstein in 2008. It is a refinement of Salsa20, which is one of the selected ciphers in the eSTREAM portfolio [ESTREAM], and was used as the core of the SHA-3 finalist, BLAKE.

The variant of ChaCha used in this document has 20 rounds, a 96-bit nonce and a 256-bit key, and will be referred to as ChaCha20. This is the conservative variant (with respect to security) of the ChaCha family and is described in [RFC7539].

Poly1305 [POLY1305] is a Wegman-Carter, one-time authenticator designed by D. J. Bernstein. Poly1305 takes a 256-bit, one-time key and a message, and produces a 16-byte tag that authenticates the message such that an attacker has a negligible chance of producing a valid tag for an inauthentic message. It is also described in [RFC7539].

ChaCha and Poly1305 have both been designed for high performance in

software implementations. They typically admit a compact implementation that uses few resources and inexpensive operations, which makes them suitable on a wide range of architectures. They have also been designed to minimize leakage of information through side channels.

Recent attacks [CBC-ATTACK] have indicated problems with the CBC-mode cipher suites in TLS and DTLS, as well as issues with the only supported stream cipher (RC4) [RC4-ATTACK]. While the existing AEAD cipher suites (based on AES-GCM) address some of these issues, there are concerns about their performance and ease of software implementation.

Therefore, a new stream cipher to replace RC4 and address all the previous issues is needed. It is the purpose of this document to describe a secure stream cipher for both TLS and DTLS that is comparable to RC4 in speed on a wide range of platforms and can be implemented easily without being vulnerable to software side-channel attacks.

2. ChaCha20 Cipher Suites

The ChaCha20 and Poly1305 primitives are built into an AEAD algorithm [RFC5116], AEAD_CHACHA20_POLY1305, as described in [RFC7539]. This AEAD is incorporated into TLS and DTLS as specified in section 6.2.3.3 of [RFC5246].

AEAD_CHACHA20_POLY1305 requires a 96-bit nonce, which is formed as follows:

1. The 64-bit record sequence number is serialized as an 8-byte, big-endian value and padded on the left with four 0x00 bytes.

2. The padded sequence number is XORed with the client_write_IV (when the client is sending) or server_write_IV (when the server is sending).

In DTLS, the 64-bit seq_num is the 16-bit epoch concatenated with the 48-bit seq_num.

This nonce construction is different from the one used with AES-GCM in TLS 1.2 but matches the scheme expected to be used in TLS 1.3.

The nonce is constructed from the record sequence number and shared secret, both of which are known to the recipient. The advantage is that no per-record, explicit nonce need be transmitted, which saves eight bytes per record and prevents implementations from mistakenly using a random nonce. Thus, in the terms of [RFC5246], SecurityParameters.fixed_iv_length is twelve bytes and SecurityParameters.record_iv_length is zero bytes.

The following cipher suites are defined.


```
TLS_ECDHE_RSA_WITH_CHACHA20_POLY1305_SHA256   = {0xTBD, 0xTBD}
TLS_ECDHE_ECDSA_WITH_CHACHA20_POLY1305_SHA256 = {0xTBD, 0xTBD}
TLS_DHE_RSA_WITH_CHACHA20_POLY1305_SHA256     = {0xTBD, 0xTBD}

TLS_PSK_WITH_CHACHA20_POLY1305_SHA256         = {0xTBD, 0xTBD}
TLS_ECDHE_PSK_WITH_CHACHA20_POLY1305_SHA256   = {0xTBD, 0xTBD}
TLS_DHE_PSK_WITH_CHACHA20_POLY1305_SHA256     = {0xTBD, 0xTBD}
TLS_RSA_PSK_WITH_CHACHA20_POLY1305_SHA256     = {0xTBD, 0xTBD}
```

The DHE_RSA, ECDHE_RSA, ECDHE_ECDSA, PSK, ECDHE_PSK, DHE_PSK and RSA_PSK key exchanges for these cipher suites are unaltered and thus are performed as defined in [RFC5246], [RFC4492], and [RFC5489].

The pseudorandom function (PRF) for all the cipher suites defined in this document is the TLS PRF with SHA-256 as the hash function.

3. IANA Considerations

IANA is requested to add the following entries in the TLS Cipher Suite Registry:

```
TLS_ECDHE_RSA_WITH_CHACHA20_POLY1305_SHA256   = {0xTBD, 0xTBD} {0xCC, 0xA8}
TLS_ECDHE_ECDSA_WITH_CHACHA20_POLY1305_SHA256 = {0xTBD, 0xTBD} {0xCC, 0xA9}
TLS_DHE_RSA_WITH_CHACHA20_POLY1305_SHA256     = {0xTBD, 0xTBD} {0xCC, 0xAA}

TLS_PSK_WITH_CHACHA20_POLY1305_SHA256         = {0xTBD, 0xTBD} {0xCC, 0xAB}
TLS_ECDHE_PSK_WITH_CHACHA20_POLY1305_SHA256   = {0xTBD, 0xTBD} {0xCC, 0xAC}
TLS_DHE_PSK_WITH_CHACHA20_POLY1305_SHA256     = {0xTBD, 0xTBD} {0xCC, 0xAD}
TLS_RSA_PSK_WITH_CHACHA20_POLY1305_SHA256     = {0xTBD, 0xTBD} {0xCC, 0xAE}
```

The cipher suite numbers listed in the second column are numbers used for cipher suite interoperability testing and it's suggested that IANA use these values for assignment.

4. Security Considerations

ChaCha20 follows the same basic principle as Salsa20[SALSA20SPEC], a cipher with significant security review [SALSA20-SECURITY][ESTREAM]. At the time of writing this document, there are no known significant security problems with either cipher, and ChaCha20 is shown to be more resistant in certain attacks than Salsa20 [SALSA20-ATTACK]. Furthermore, ChaCha20 was used as the core of the BLAKE hash function, a SHA3 finalist, that has received considerable cryptanalytic attention [NIST-SHA3].

Poly1305 is designed to ensure that forged messages are rejected with a probability of 1-(n/2^107), where n is the maximum length of the

input to Poly1305. In the case of (D)TLS, this means a maximum forgery probability of about 1 in 2^93.

The cipher suites described in this document require that a nonce is never repeated under the same key. The design presented ensures this by using the TLS sequence number, which is unique and does not wrap [RFC5246].

It should be noted that AEADs, such as ChaCha20-Poly1305, are not intended to hide the lengths of plaintexts. When this document speaks of side-channel attacks, it is not considering traffic analysis, but rather timing and cache side-channels. Traffic analysis, while a valid concern, is outside the scope of the AEAD and is being addressed elsewhere in future versions of TLS.

Otherwise, this document should not introduce any additional security considerations other than those that follow from the use of the AEAD_CHACHA20_POLY1305 construction, thus the reader is directed to the Security Considerations section of [RFC7539].

5. Acknowledgements

The authors would like to thank Zooko Wilcox-OHearn, Samuel Neves and Colm MacCarthaigh for their suggestions and guidance.

6. References

6.1. Normative References

[RFC4492] Blake-Wilson, S., Bolyard, N., Gupta, V., Hawk, C., and B. Moeller, "Elliptic Curve Cryptography (ECC) Cipher Suites for Transport Layer Security (TLS)", RFC 4492, DOI 10.17487/RFC4492, May 2006, <http://www.rfc-editor.org/info/rfc4492>.

[RFC5246] Dierks, T. and E. Rescorla, "The Transport Layer Security (TLS) Protocol Version 1.2", RFC 5246, DOI 10.17487/RFC5246, August 2008, <http://www.rfc-editor.org/info/rfc5246>.

[RFC5489] Badra, M. and I. Hajjeh, "ECDHE_PSK Cipher Suites for Transport Layer Security (TLS)", RFC 5489, DOI 10.17487/RFC5489, March 2009, <http://www.rfc-editor.org/info/rfc5489>.

[RFC6347] Rescorla, E. and N. Modadugu, "Datagram Transport Layer Security Version 1.2", RFC 6347, DOI 10.17487/RFC6347, January 2012, <http://www.rfc-editor.org/info/rfc6347>.

[RFC7539] Nir, Y. and A. Langley, "ChaCha20 and Poly1305 for IETF Protocols", RFC 7539, DOI 10.17487/RFC7539, May 2015, <http://www.rfc-editor.org/info/rfc7539>.

6.2. Informative References

[CHACHA] Bernstein, D., "ChaCha, a variant of Salsa20", January 2008, <http://cr.yp.to/chacha/chacha-20080128.pdf>.

[POLY1305] Bernstein, D., "The Poly1305-AES message-authentication code.", March 2005, <http://cr.yp.to/mac/poly1305-20050329.pdf>.

[RFC5116] McGrew, D., "An Interface and Algorithms for Authenticated

Encryption", RFC 5116, DOI 10.17487/RFC5116, January 2008, <http://www.rfc-editor.org/info/rfc5116>.

[SALSA20SPEC]
Bernstein, D., "Salsa20 specification", April 2005, <http://cr.yp.to/snuffle/spec.pdf>.

[SALSA20-SECURITY]
Bernstein, D., "Salsa20 security", April 2005, <http://cr.yp.to/snuffle/security.pdf>.

[ESTREAM] Babbage, S., DeCanniere, C., Cantenaut, A., Cid, C., Gilbert, H., Johansson, T., Parker, M., Preneel, B., Rijmen, V., and M. Robshaw, "The eSTREAM Portfolio (rev. 1)", September 2008, <http://www.ecrypt.eu.org/stream/finallist.html>.

[CBC-ATTACK]
AlFardan, N. and K. Paterson, "Lucky Thirteen: Breaking the TLS and DTLS Record Protocols", IEEE Symposium on Security and Privacy , 2013.

[RC4-ATTACK]
Isobe, T., Ohigashi, T., Watanabe, Y., and M. Morii, "Full Plaintext Recovery Attack on Broadcast RC4", International Workshop on Fast Software Encryption , 2013.

[SALSA20-ATTACK]
Aumasson, J-P., Fischer, S., Khazaei, S., Meier, W., and C. Rechberger, "New Features of Latin Dances: Analysis of Salsa, ChaCha, and Rumba", 2007, <http://eprint.iacr.org/2007/472.pdf>.

[NIST-SHA3]
Chang, S., Burr, W., Kelsey, J., Paul, S., and L. Bassham, "Third-Round Report of the SHA-3 Cryptographic Hash Algorithm Competition", 2012, <http://dx.doi.org/10.6028/NIST.IR.7896>.

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