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Author: N. Aviram

RFC 10015
Deprecating Obsolete Key Exchange Methods in TLS 1.2 and DTLS 1.2

Abstract

For (D)TLS 1.2, this document deprecates the use of two key exchanges, namely Diffie-Hellman (DH) over a finite field and RSA. It also discourages the use of static Elliptic Curve Diffie-Hellman (ECDH) cipher suites.

These prescriptions apply only to (D)TLS 1.2, since (D)TLS 1.0 and TLS 1.1 are deprecated by RFC 8996 and (D)TLS 1.3 either does not use the affected algorithms or does not share the relevant configuration options. (There is no DTLS version 1.1.)

This document updates RFCs 4162, 4279, 4346, 4785, 5246, 5288, 5289, 5469, 5487, 5932, 6209, 6347, 6367, 6655, 7905, 8422, and 9325 to either deprecate or discourage the use of cipher suites using the above key exchange methods in (D)TLS 1.2 connections.

Status of This Memo

This is an Internet Standards Track document.

This document is a product of the Internet Engineering Task Force (IETF). It represents the consensus of the IETF community. It has received public review and has been approved for publication by the Internet Engineering Steering Group (IESG). Further information on Internet Standards is available in Section 2 of RFC 7841.

Information about the current status of this document, any errata, and how to provide feedback on it may be obtained at https://www.rfc-editor.org/info/rfc10015.

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1. Introduction

(D)TLS 1.2 supports a variety of key exchange algorithms, including RSA, Diffie-Hellman (DH) over a finite field, and Elliptic Curve Diffie-Hellman (ECDH).

DH key exchange, over any group, comes in ephemeral and non-ephemeral varieties. Non-ephemeral DH algorithms use static DH public keys included in the authenticating peer's certificate; see [RFC4492] for discussion. In contrast, ephemeral DH algorithms use ephemeral DH public keys sent in the handshake and authenticated by the peer's certificate. Ephemeral and non-ephemeral finite field DH algorithms are called DHE and DH (or FFDHE and FFDH), respectively, and ephemeral and non-ephemeral elliptic curve DH algorithms are called ECDHE and ECDH, respectively [RFC4492].

In general, non-ephemeral cipher suites are not recommended due to their lack of forward secrecy. Moreover, as demonstrated by the Raccoon attack [RACCOON] on finite field DH, public key reuse (either via non-ephemeral cipher suites or reused keys with ephemeral cipher suites) can lead to timing side channels that may leak connection secrets. For ECDH, invalid curve attacks similarly exploit secret reuse in order to break security [ICA], further demonstrating the risk of reusing public keys. While both side channels can be avoided in implementations, experience shows that in practice, implementations may fail to thwart such attacks due to the complexity and number of the required mitigations.

Additionally, RSA key exchange suffers from security problems that are independent of implementation choices as well as problems that stem purely from the difficulty of implementing security countermeasures correctly.

At a rough glance, the problems affecting FFDHE in (D)TLS 1.2 are as follows:

1. FFDHE suffers from interoperability problems because there is no mechanism for negotiating the group, and some implementations only support small group sizes (see [RFC7919], Section 1).
2. FFDHE groups may have small subgroups, which enables several attacks [SUBGROUPS]. When presented with a custom, non-standardized FFDHE group, a handshaking client cannot practically verify that the group chosen by the server does not suffer from this problem. There is also no mechanism for such handshakes to fall back to other key exchange parameters that are acceptable to the client. Custom FFDHE groups are widespread (as a result of advice based on [WEAK-DH]). Therefore, clients cannot simply reject handshakes that present custom, and thus potentially dangerous, groups.
3. In practice, some operators use 1024-bit FFDHE groups since this is the maximum size that ensures wide support (see [RFC7919], Section 1). This size leaves only a small security margin versus the current discrete log record, which stands at 795 bits [DLOG795].
4. Expanding on the previous point, just a handful of very large computations allow an attacker to cheaply decrypt a relatively large fraction of FFDHE traffic (namely, traffic encrypted using particular standardized groups) [WEAK-DH].
5. When secrets are not fully ephemeral, FFDHE suffers from the Raccoon side-channel attack [RACCOON]. (Note that FFDH is inherently vulnerable to the Raccoon attack unless constant-time mitigations are employed.)

The problems affecting RSA key exchange in (D)TLS 1.2 are as follows:

1. RSA key exchange offers no forward secrecy, by construction.

2. RSA key exchange may be vulnerable to Bleichenbacher's attack [BLEI]. Experience shows that variants of this attack arise every few years because implementing the relevant countermeasure correctly is difficult (see [ROBOT], [NEW-BLEI], and [DROWN]).
3. In addition to the above point, there is no convenient mechanism in (D)TLS 1.2 for the domain separation of keys. Therefore, a single endpoint that is vulnerable to Bleichenbacher's attack would affect all endpoints sharing the same RSA key (see [XPROT] and [DROWN]).

This document updates [RFC4162], [RFC4279], [RFC4346], [RFC4785], [RFC5246], [RFC5288], [RFC5289], [RFC5469], [RFC5487], [RFC5932], [RFC6209], [RFC6347], [RFC6367], [RFC6655], [RFC7905], [RFC8422], and [RFC9325] to remediate the above problems, by deprecating and discouraging the use of affected cipher suites, as listed in Sections 5.2, 5.3, 5.4, and 5.5.

BCP 195 [RFC8996] [RFC9325] contains the latest IETF recommendations for users of the (D)TLS protocol (and specifically, (D)TLS 1.2), and this document updates [RFC9325] in several points. Section 6 details the exact differences. All other recommendations in the BCP documents remain valid.

1.1. Requirements Language

The key words "**MUST**", "**MUST NOT**", "**REQUIRED**", "**SHALL**", "**SHALL NOT**", "**SHOULD**", "**SHOULD NOT**", "**RECOMMENDED**", "**NOT RECOMMENDED**", "**MAY**", and "**OPTIONAL**" in this document are to be interpreted as described in BCP 14 [RFC2119] [RFC8174] when, and only when, they appear in all capitals, as shown here.

2. Non-Ephemeral Diffie-Hellman

Clients **MUST NOT** offer and servers **MUST NOT** select non-ephemeral FFDH cipher suites in (D)TLS 1.2 connections. (Note that (D)TLS 1.0 and TLS 1.1 are deprecated by [RFC8996], and (D)TLS 1.3 does not support FFDH [RFC9846] [RFC9147].) This includes all cipher suites listed in Table 1 in Section 5.1.

Clients **SHOULD NOT** offer and servers **SHOULD NOT** select non-ephemeral ECDH cipher suites in (D)TLS 1.2 connections. (This requirement is already present in [RFC9325]. Note that (D)TLS 1.0 and TLS 1.1 are deprecated by [RFC8996], and (D)TLS 1.3 does not support ECDH [RFC9846] [RFC9147].) This includes all cipher suites listed in Table 2 in Section 5.2.

In addition, to avoid the use of non-ephemeral DH, clients **SHOULD NOT** use and servers **SHOULD NOT** accept certificates with fixed DH parameters. These certificate types are rsa_fixed_dh, dss_fixed_dh, rsa_fixed_ecdh, and ecdsa_fixed_ecdh as listed in Section 5.5. These values only apply to (D)TLS versions of 1.2 and below.

3. Ephemeral Finite Field Diffie-Hellman

Clients **MUST NOT** offer and servers **MUST NOT** select FFDHE cipher suites in (D)TLS 1.2 connections. This includes all cipher suites listed in Table 3 in Section 5.3. (Note that (D)TLS 1.0 and TLS 1.1 are deprecated by [RFC8996].) FFDHE cipher suites in (D)TLS 1.3 do not suffer from the problems presented in Section 1; see [RFC9846] and [RFC9147]. Therefore, clients and servers **MAY** offer FFDHE cipher suites in (D)TLS 1.3 connections.

4. RSA

Clients **MUST NOT** offer and servers **MUST NOT** select RSA cipher suites in (D)TLS 1.2 connections. (Note that (D)TLS 1.0 and TLS 1.1 are deprecated by [RFC8996], and (D)TLS 1.3 does not support static RSA [RFC9846] [RFC9147].) This includes all cipher suites listed in Table 4 in Section 5.4. Note that these cipher suites were previously marked as not recommended in the "TLS Cipher Suites" registry [TLS-REGISTRY].

5. Updates to Cipher Suites and TLS ClientCertificateType Identifiers

The following subsections mention the use of "D" in the "Recommended" column of the "TLS Cipher Suites" and "TLS ClientCertificateType Identifiers" registries [TLS-REGISTRY]. See [RFC9847] for information on the use of the "D".

5.1. DH Cipher Suites Deprecated by This Document

IANA has set the "Recommended" column to "D" and added this document as a reference for the following entries in the "TLS Cipher Suites" registry [TLS-REGISTRY]:

Cipher Suite	Reference
TLS_DH_DSS_EXPORT_WITH_DES40_CBC_SHA	[RFC4346]
TLS_DH_DSS_WITH_DES_CBC_SHA	[RFC8996]
TLS_DH_DSS_WITH_3DES_EDE_CBC_SHA	[RFC5246]
TLS_DH_RSA_EXPORT_WITH_DES40_CBC_SHA	[RFC4346]
TLS_DH_RSA_WITH_DES_CBC_SHA	[RFC8996]
TLS_DH_RSA_WITH_3DES_EDE_CBC_SHA	[RFC5246]
TLS_DH_anon_EXPORT_WITH_RC4_40_MD5	[RFC4346] [RFC6347]
TLS_DH_anon_WITH_RC4_128_MD5	[RFC5246] [RFC6347]

Cipher Suite	Reference
TLS_DH_anon_EXPORT_WITH_DES40_CBC_SHA	[RFC4346]
TLS_DH_anon_WITH_DES_CBC_SHA	[RFC8996]
TLS_DH_anon_WITH_3DES_EDE_CBC_SHA	[RFC5246]
TLS_DH_DSS_WITH_AES_128_CBC_SHA	[RFC5246]
TLS_DH_RSA_WITH_AES_128_CBC_SHA	[RFC5246]
TLS_DH_anon_WITH_AES_128_CBC_SHA	[RFC5246]
TLS_DH_DSS_WITH_AES_256_CBC_SHA	[RFC5246]
TLS_DH_RSA_WITH_AES_256_CBC_SHA	[RFC5246]
TLS_DH_anon_WITH_AES_256_CBC_SHA	[RFC5246]
TLS_DH_DSS_WITH_AES_128_CBC_SHA256	[RFC5246]
TLS_DH_RSA_WITH_AES_128_CBC_SHA256	[RFC5246]
TLS_DH_DSS_WITH_CAMELLIA_128_CBC_SHA	[RFC5932]
TLS_DH_RSA_WITH_CAMELLIA_128_CBC_SHA	[RFC5932]
TLS_DH_anon_WITH_CAMELLIA_128_CBC_SHA	[RFC5932]
TLS_DH_DSS_WITH_AES_256_CBC_SHA256	[RFC5246]
TLS_DH_RSA_WITH_AES_256_CBC_SHA256	[RFC5246]
TLS_DH_anon_WITH_AES_128_CBC_SHA256	[RFC5246]
TLS_DH_anon_WITH_AES_256_CBC_SHA256	[RFC5246]
TLS_DH_DSS_WITH_CAMELLIA_256_CBC_SHA	[RFC5932]
TLS_DH_RSA_WITH_CAMELLIA_256_CBC_SHA	[RFC5932]
TLS_DH_anon_WITH_CAMELLIA_256_CBC_SHA	[RFC5932]
TLS_DH_DSS_WITH_SEED_CBC_SHA	[RFC4162]
TLS_DH_RSA_WITH_SEED_CBC_SHA	[RFC4162]
TLS_DH_anon_WITH_SEED_CBC_SHA	[RFC4162]

Cipher Suite	Reference
TLS_DH_RSA_WITH_AES_128_GCM_SHA256	[RFC5288]
TLS_DH_RSA_WITH_AES_256_GCM_SHA384	[RFC5288]
TLS_DH_DSS_WITH_AES_128_GCM_SHA256	[RFC5288]
TLS_DH_DSS_WITH_AES_256_GCM_SHA384	[RFC5288]
TLS_DH_anon_WITH_AES_128_GCM_SHA256	[RFC5288]
TLS_DH_anon_WITH_AES_256_GCM_SHA384	[RFC5288]
TLS_DH_DSS_WITH_CAMELLIA_128_CBC_SHA256	[RFC5932]
TLS_DH_RSA_WITH_CAMELLIA_128_CBC_SHA256	[RFC5932]
TLS_DH_anon_WITH_CAMELLIA_128_CBC_SHA256	[RFC5932]
TLS_DH_DSS_WITH_CAMELLIA_256_CBC_SHA256	[RFC5932]
TLS_DH_RSA_WITH_CAMELLIA_256_CBC_SHA256	[RFC5932]
TLS_DH_anon_WITH_CAMELLIA_256_CBC_SHA256	[RFC5932]
TLS_DH_DSS_WITH_ARIA_128_CBC_SHA256	[RFC6209]
TLS_DH_DSS_WITH_ARIA_256_CBC_SHA384	[RFC6209]
TLS_DH_RSA_WITH_ARIA_128_CBC_SHA256	[RFC6209]
TLS_DH_RSA_WITH_ARIA_256_CBC_SHA384	[RFC6209]
TLS_DH_anon_WITH_ARIA_128_CBC_SHA256	[RFC6209]
TLS_DH_anon_WITH_ARIA_256_CBC_SHA384	[RFC6209]
TLS_DH_RSA_WITH_ARIA_128_GCM_SHA256	[RFC6209]
TLS_DH_RSA_WITH_ARIA_256_GCM_SHA384	[RFC6209]
TLS_DH_DSS_WITH_ARIA_128_GCM_SHA256	[RFC6209]
TLS_DH_DSS_WITH_ARIA_256_GCM_SHA384	[RFC6209]
TLS_DH_anon_WITH_ARIA_128_GCM_SHA256	[RFC6209]
TLS_DH_anon_WITH_ARIA_256_GCM_SHA384	[RFC6209]

Cipher Suite	Reference
TLS_DH_RSA_WITH_CAMELLIA_128_GCM_SHA256	[RFC6367]
TLS_DH_RSA_WITH_CAMELLIA_256_GCM_SHA384	[RFC6367]
TLS_DH_DSS_WITH_CAMELLIA_128_GCM_SHA256	[RFC6367]
TLS_DH_DSS_WITH_CAMELLIA_256_GCM_SHA384	[RFC6367]
TLS_DH_anon_WITH_CAMELLIA_128_GCM_SHA256	[RFC6367]
TLS_DH_anon_WITH_CAMELLIA_256_GCM_SHA384	[RFC6367]

Table 1

5.2. ECDH Cipher Suites Whose Use Is Discouraged by This Document

[RFC9325] specifies that implementations **SHOULD NOT** negotiate the following cipher suites; accordingly, they appeared with "N" in the "Recommended" column in the IANA "TLS Cipher Suites" registry [TLS-REGISTRY]. Per this document, IANA has updated them to have "D" in the "Recommended" column to align with [RFC9847] (and added this document as a reference for each). This document also records the rationale for discouraging use of these cipher suites, and it cites prior analyses and attacks that demonstrate the associated risks (see Section 8).

Cipher Suite	Reference
TLS_ECDH_ECDSA_WITH_NULL_SHA	[RFC8422]
TLS_ECDH_ECDSA_WITH_RC4_128_SHA	[RFC8422] [RFC6347]
TLS_ECDH_ECDSA_WITH_3DES_EDE_CBC_SHA	[RFC8422]
TLS_ECDH_ECDSA_WITH_AES_128_CBC_SHA	[RFC8422]
TLS_ECDH_ECDSA_WITH_AES_256_CBC_SHA	[RFC8422]
TLS_ECDH_RSA_WITH_NULL_SHA	[RFC8422]
TLS_ECDH_RSA_WITH_RC4_128_SHA	[RFC8422] [RFC6347]
TLS_ECDH_RSA_WITH_3DES_EDE_CBC_SHA	[RFC8422]
TLS_ECDH_RSA_WITH_AES_128_CBC_SHA	[RFC8422]
TLS_ECDH_RSA_WITH_AES_256_CBC_SHA	[RFC8422]
TLS_ECDH_anon_WITH_NULL_SHA	[RFC8422]

Cipher Suite	Reference
TLS_ECDH_anon_WITH_RC4_128_SHA	[RFC8422] [RFC6347]
TLS_ECDH_anon_WITH_3DES_EDE_CBC_SHA	[RFC8422]
TLS_ECDH_anon_WITH_AES_128_CBC_SHA	[RFC8422]
TLS_ECDH_anon_WITH_AES_256_CBC_SHA	[RFC8422]
TLS_ECDH_ECDSA_WITH_AES_128_CBC_SHA256	[RFC5289]
TLS_ECDH_ECDSA_WITH_AES_256_CBC_SHA384	[RFC5289]
TLS_ECDH_RSA_WITH_AES_128_CBC_SHA256	[RFC5289]
TLS_ECDH_RSA_WITH_AES_256_CBC_SHA384	[RFC5289]
TLS_ECDH_ECDSA_WITH_AES_128_GCM_SHA256	[RFC5289]
TLS_ECDH_ECDSA_WITH_AES_256_GCM_SHA384	[RFC5289]
TLS_ECDH_RSA_WITH_AES_128_GCM_SHA256	[RFC5289]
TLS_ECDH_RSA_WITH_AES_256_GCM_SHA384	[RFC5289]
TLS_ECDH_ECDSA_WITH_ARIA_128_CBC_SHA256	[RFC6209]
TLS_ECDH_ECDSA_WITH_ARIA_256_CBC_SHA384	[RFC6209]
TLS_ECDH_RSA_WITH_ARIA_128_CBC_SHA256	[RFC6209]
TLS_ECDH_RSA_WITH_ARIA_256_CBC_SHA384	[RFC6209]
TLS_ECDH_ECDSA_WITH_ARIA_128_GCM_SHA256	[RFC6209]
TLS_ECDH_ECDSA_WITH_ARIA_256_GCM_SHA384	[RFC6209]
TLS_ECDH_RSA_WITH_ARIA_128_GCM_SHA256	[RFC6209]
TLS_ECDH_RSA_WITH_ARIA_256_GCM_SHA384	[RFC6209]
TLS_ECDH_ECDSA_WITH_CAMELLIA_128_CBC_SHA256	[RFC6367]
TLS_ECDH_ECDSA_WITH_CAMELLIA_256_CBC_SHA384	[RFC6367]
TLS_ECDH_RSA_WITH_CAMELLIA_128_CBC_SHA256	[RFC6367]
TLS_ECDH_RSA_WITH_CAMELLIA_256_CBC_SHA384	[RFC6367]

Cipher Suite	Reference
TLS_ECDH_ECDSA_WITH_CAMELLIA_128_GCM_SHA256	[RFC6367]
TLS_ECDH_ECDSA_WITH_CAMELLIA_256_GCM_SHA384	[RFC6367]
TLS_ECDH_RSA_WITH_CAMELLIA_128_GCM_SHA256	[RFC6367]
TLS_ECDH_RSA_WITH_CAMELLIA_256_GCM_SHA384	[RFC6367]

Table 2

5.3. DHE Cipher Suites Deprecated by This Document

IANA has set the "Recommended" column to "D" and added this document as a reference for the following entries in the "TLS Cipher Suites" registry [TLS-REGISTRY]:

Cipher Suite	Reference
TLS_DHE_DSS_EXPORT_WITH_DES40_CBC_SHA	[RFC4346]
TLS_DHE_DSS_WITH_DES_CBC_SHA	[RFC8996]
TLS_DHE_DSS_WITH_3DES_EDE_CBC_SHA	[RFC5246]
TLS_DHE_RSA_EXPORT_WITH_DES40_CBC_SHA	[RFC4346]
TLS_DHE_RSA_WITH_DES_CBC_SHA	[RFC8996]
TLS_DHE_RSA_WITH_3DES_EDE_CBC_SHA	[RFC5246]
TLS_DHE_PSK_WITH_NULL_SHA	[RFC4785]
TLS_DHE_DSS_WITH_AES_128_CBC_SHA	[RFC5246]
TLS_DHE_RSA_WITH_AES_128_CBC_SHA	[RFC5246]
TLS_DHE_DSS_WITH_AES_256_CBC_SHA	[RFC5246]
TLS_DHE_RSA_WITH_AES_256_CBC_SHA	[RFC5246]
TLS_DHE_DSS_WITH_AES_128_CBC_SHA256	[RFC5246]
TLS_DHE_DSS_WITH_CAMELLIA_128_CBC_SHA	[RFC5932]
TLS_DHE_RSA_WITH_CAMELLIA_128_CBC_SHA	[RFC5932]
TLS_DHE_RSA_WITH_AES_128_CBC_SHA256	[RFC5246]
TLS_DHE_DSS_WITH_AES_256_CBC_SHA256	[RFC5246]

Cipher Suite	Reference
TLS_DHE_RSA_WITH_AES_256_CBC_SHA256	[RFC5246]
TLS_DHE_DSS_WITH_CAMELLIA_256_CBC_SHA	[RFC5932]
TLS_DHE_RSA_WITH_CAMELLIA_256_CBC_SHA	[RFC5932]
TLS_DHE_PSK_WITH_RC4_128_SHA	[RFC4279] [RFC6347]
TLS_DHE_PSK_WITH_3DES_EDE_CBC_SHA	[RFC4279]
TLS_DHE_PSK_WITH_AES_128_CBC_SHA	[RFC4279]
TLS_DHE_PSK_WITH_AES_256_CBC_SHA	[RFC4279]
TLS_DHE_DSS_WITH_SEED_CBC_SHA	[RFC4162]
TLS_DHE_RSA_WITH_SEED_CBC_SHA	[RFC4162]
TLS_DHE_RSA_WITH_AES_128_GCM_SHA256	[RFC5288]
TLS_DHE_RSA_WITH_AES_256_GCM_SHA384	[RFC5288]
TLS_DHE_DSS_WITH_AES_128_GCM_SHA256	[RFC5288]
TLS_DHE_DSS_WITH_AES_256_GCM_SHA384	[RFC5288]
TLS_DHE_PSK_WITH_AES_128_GCM_SHA256	[RFC5487]
TLS_DHE_PSK_WITH_AES_256_GCM_SHA384	[RFC5487]
TLS_DHE_PSK_WITH_AES_128_CBC_SHA256	[RFC5487]
TLS_DHE_PSK_WITH_AES_256_CBC_SHA384	[RFC5487]
TLS_DHE_PSK_WITH_NULL_SHA256	[RFC5487]
TLS_DHE_PSK_WITH_NULL_SHA384	[RFC5487]
TLS_DHE_DSS_WITH_CAMELLIA_128_CBC_SHA256	[RFC5932]
TLS_DHE_RSA_WITH_CAMELLIA_128_CBC_SHA256	[RFC5932]
TLS_DHE_DSS_WITH_CAMELLIA_256_CBC_SHA256	[RFC5932]
TLS_DHE_RSA_WITH_CAMELLIA_256_CBC_SHA256	[RFC5932]
TLS_DHE_DSS_WITH_ARIA_128_CBC_SHA256	[RFC6209]

Cipher Suite	Reference
TLS_DHE_DSS_WITH_ARIA_256_CBC_SHA384	[RFC6209]
TLS_DHE_RSA_WITH_ARIA_128_CBC_SHA256	[RFC6209]
TLS_DHE_RSA_WITH_ARIA_256_CBC_SHA384	[RFC6209]
TLS_DHE_RSA_WITH_ARIA_128_GCM_SHA256	[RFC6209]
TLS_DHE_RSA_WITH_ARIA_256_GCM_SHA384	[RFC6209]
TLS_DHE_DSS_WITH_ARIA_128_GCM_SHA256	[RFC6209]
TLS_DHE_DSS_WITH_ARIA_256_GCM_SHA384	[RFC6209]
TLS_DHE_PSK_WITH_ARIA_128_CBC_SHA256	[RFC6209]
TLS_DHE_PSK_WITH_ARIA_256_CBC_SHA384	[RFC6209]
TLS_DHE_PSK_WITH_ARIA_128_GCM_SHA256	[RFC6209]
TLS_DHE_PSK_WITH_ARIA_256_GCM_SHA384	[RFC6209]
TLS_DHE_RSA_WITH_CAMELLIA_128_GCM_SHA256	[RFC6367]
TLS_DHE_RSA_WITH_CAMELLIA_256_GCM_SHA384	[RFC6367]
TLS_DHE_DSS_WITH_CAMELLIA_128_GCM_SHA256	[RFC6367]
TLS_DHE_DSS_WITH_CAMELLIA_256_GCM_SHA384	[RFC6367]
TLS_DHE_PSK_WITH_CAMELLIA_128_GCM_SHA256	[RFC6367]
TLS_DHE_PSK_WITH_CAMELLIA_256_GCM_SHA384	[RFC6367]
TLS_DHE_PSK_WITH_CAMELLIA_128_CBC_SHA256	[RFC6367]
TLS_DHE_PSK_WITH_CAMELLIA_256_CBC_SHA384	[RFC6367]
TLS_DHE_RSA_WITH_AES_128_CCM	[RFC6655]
TLS_DHE_RSA_WITH_AES_256_CCM	[RFC6655]
TLS_DHE_RSA_WITH_AES_128_CCM_8	[RFC6655]
TLS_DHE_RSA_WITH_AES_256_CCM_8	[RFC6655]
TLS_DHE_PSK_WITH_AES_128_CCM	[RFC6655]

Cipher Suite	Reference
TLS_DHE_PSK_WITH_AES_256_CCM	[RFC6655]
TLS_DHE_RSA_WITH_CHACHA20_POLY1305_SHA256	[RFC7905]
TLS_DHE_PSK_WITH_CHACHA20_POLY1305_SHA256	[RFC7905]
TLS_PSK_DHE_WITH_AES_128_CCM_8	[RFC6655]
TLS_PSK_DHE_WITH_AES_256_CCM_8	[RFC6655]

Table 3

5.4. RSA Cipher Suites Deprecated by This Document

IANA has set the "Recommended" column to "D" and added this document as a reference for the following entries in the "TLS Cipher Suites" registry [TLS-REGISTRY]:

Cipher Suite	Reference
TLS_RSA_WITH_NULL_MD5	[RFC5246]
TLS_RSA_WITH_NULL_SHA	[RFC5246]
TLS_RSA_EXPORT_WITH_RC4_40_MD5	[RFC4346] [RFC6347]
TLS_RSA_WITH_RC4_128_MD5	[RFC5246] [RFC6347]
TLS_RSA_WITH_RC4_128_SHA	[RFC5246] [RFC6347]
TLS_RSA_EXPORT_WITH_RC2_CBC_40_MD5	[RFC4346]
TLS_RSA_WITH_IDEA_CBC_SHA	[RFC8996]
TLS_RSA_EXPORT_WITH_DES40_CBC_SHA	[RFC4346]
TLS_RSA_WITH_DES_CBC_SHA	[RFC8996]
TLS_RSA_WITH_3DES_EDE_CBC_SHA	[RFC5246]
TLS_RSA_PSK_WITH_NULL_SHA	[RFC4785]
TLS_RSA_WITH_AES_128_CBC_SHA	[RFC5246]
TLS_RSA_WITH_AES_256_CBC_SHA	[RFC5246]
TLS_RSA_WITH_NULL_SHA256	[RFC5246]
TLS_RSA_WITH_AES_128_CBC_SHA256	[RFC5246]

Cipher Suite	Reference
TLS_RSA_WITH_AES_256_CBC_SHA256	[RFC5246]
TLS_RSA_WITH_CAMELLIA_128_CBC_SHA	[RFC5932]
TLS_RSA_WITH_CAMELLIA_256_CBC_SHA	[RFC5932]
TLS_RSA_PSK_WITH_RC4_128_SHA	[RFC4279] [RFC6347]
TLS_RSA_PSK_WITH_3DES_EDE_CBC_SHA	[RFC4279]
TLS_RSA_PSK_WITH_AES_128_CBC_SHA	[RFC4279]
TLS_RSA_PSK_WITH_AES_256_CBC_SHA	[RFC4279]
TLS_RSA_WITH_SEED_CBC_SHA	[RFC4162]
TLS_RSA_WITH_AES_128_GCM_SHA256	[RFC5288]
TLS_RSA_WITH_AES_256_GCM_SHA384	[RFC5288]
TLS_RSA_PSK_WITH_AES_128_GCM_SHA256	[RFC5487]
TLS_RSA_PSK_WITH_AES_256_GCM_SHA384	[RFC5487]
TLS_RSA_PSK_WITH_AES_128_CBC_SHA256	[RFC5487]
TLS_RSA_PSK_WITH_AES_256_CBC_SHA384	[RFC5487]
TLS_RSA_PSK_WITH_NULL_SHA256	[RFC5487]
TLS_RSA_PSK_WITH_NULL_SHA384	[RFC5487]
TLS_RSA_WITH_CAMELLIA_128_CBC_SHA256	[RFC5932]
TLS_RSA_WITH_CAMELLIA_256_CBC_SHA256	[RFC5932]
TLS_RSA_WITH_ARIA_128_CBC_SHA256	[RFC6209]
TLS_RSA_WITH_ARIA_256_CBC_SHA384	[RFC6209]
TLS_RSA_WITH_ARIA_128_GCM_SHA256	[RFC6209]
TLS_RSA_WITH_ARIA_256_GCM_SHA384	[RFC6209]
TLS_RSA_PSK_WITH_ARIA_128_CBC_SHA256	[RFC6209]
TLS_RSA_PSK_WITH_ARIA_256_CBC_SHA384	[RFC6209]

Cipher Suite	Reference
TLS_RSA_PSK_WITH_ARIA_128_GCM_SHA256	[RFC6209]
TLS_RSA_PSK_WITH_ARIA_256_GCM_SHA384	[RFC6209]
TLS_RSA_WITH_CAMELLIA_128_GCM_SHA256	[RFC6367]
TLS_RSA_WITH_CAMELLIA_256_GCM_SHA384	[RFC6367]
TLS_RSA_PSK_WITH_CAMELLIA_128_GCM_SHA256	[RFC6367]
TLS_RSA_PSK_WITH_CAMELLIA_256_GCM_SHA384	[RFC6367]
TLS_RSA_PSK_WITH_CAMELLIA_128_CBC_SHA256	[RFC6367]
TLS_RSA_PSK_WITH_CAMELLIA_256_CBC_SHA384	[RFC6367]
TLS_RSA_WITH_AES_128_CCM	[RFC6655]
TLS_RSA_WITH_AES_256_CCM	[RFC6655]
TLS_RSA_WITH_AES_128_CCM_8	[RFC6655]
TLS_RSA_WITH_AES_256_CCM_8	[RFC6655]
TLS_RSA_PSK_WITH_CHACHA20_POLY1305_SHA256	[RFC7905]

Table 4

5.5. TLS ClientCertificateType Identifiers Deprecated by This Document

IANA has set the "Recommended" column to "D" and added this document as a reference for the following entries in the "TLS ClientCertificateType Identifiers" registry [TLS-REGISTRY]:

Certificate Type	Reference
rsa_fixed_dh (3)	[RFC5246] [RFC9847]
dss_fixed_dh (4)	[RFC5246] [RFC9847]
rsa_fixed_ecdh (65)	[RFC8422] [RFC9847]
ecdsa_fixed_ecdh (66)	[RFC8422] [RFC9847]

Table 5

6. Updates to RFC 9325

This document updates [RFC9325] with respect to the use of (D)TLS 1.2, and Table 6 lists the exact changes. All of these changes are made in Section 4.1 of [RFC9325].

	RFC 9325	RFC 10015
Non-ephemeral FFDH	**SHOULD NOT**	**MUST NOT**
Non-ephemeral ECDH	**SHOULD NOT**	No change
Fixed DH certificate types	Unspecified	**SHOULD NOT**
Ephemeral FFDH	**SHOULD NOT**	**MUST NOT**
Static RSA	**SHOULD NOT**	**MUST NOT**

Table 6

7. IANA Considerations

The "TLS Cipher Suites" and "TLS ClientCertificateType Identifiers" registries both appear within the "Transport Layer Security (TLS) Parameters" registry group [TLS-REGISTRY]. IANA has updated entries in the "TLS Cipher Suites" registry [TLS-REGISTRY] as indicated in Sections 5.1, 5.2, 5.3, and 5.4. IANA has also updated entries in the "TLS ClientCertificateType Identifiers" registry as indicated in Section 5.5.

For each entry listed in Sections 5.1, 5.2, 5.3, 5.4, and 5.5, IANA has set the "Recommended" column to "D" and updated the entry's Reference column to refer to this document. For information about the use of "D" in the "Recommended" column, see [RFC9847].

8. Security Considerations

Non-ephemeral finite field DH cipher suites (TLS_DH_*), as well as ephemeral key reuse for finite field DH cipher suites, are prohibited due to the Raccoon attack [RACCOON]. Both are already considered bad practice since they do not provide forward secrecy. However, the Raccoon attack revealed that timing side channels in processing TLS premaster secrets may be exploited to reveal the encrypted premaster secret.

As for non-ephemeral ECDH cipher suites (TLS_ECDH_*), forgoing forward secrecy not only allows retroactive decryption in the event of key compromise but may also enable a broad category of attacks where the attacker exploits key reuse to repeatedly query a cryptographic secret.

This category includes, but is not necessarily limited to, the following examples:

1. Invalid curve attacks, where the attacker exploits key reuse to repeatedly query and eventually learn the key itself. These attacks have been shown to be practical against real-world TLS implementations [ICA].
2. Side-channel attacks, where the attacker exploits key reuse and an additional side channel to learn a cryptographic secret. For an example of such an attack, refer to [MAY4].
3. Fault attacks, where the attacker exploits key reuse and incorrect calculations to learn a cryptographic secret. For an example of such an attack, see [PARIS256].

Such attacks are often implementation-dependent, including the above examples. However, these examples demonstrate that building a system that reuses keys and avoids this category of attacks is difficult in practice. In contrast, avoiding key reuse not only prevents decryption in the event of key compromise, but it also precludes this category of attacks altogether. Therefore, this document discourages the reuse of ECDH public keys.

As for ephemeral finite field DH in (D)TLS 1.2 (TLS_DHE_* and TLS_PSK_DHE_*), as explained above, clients have no practical way to support these cipher suites while ensuring they only negotiate security parameters that are acceptable to them. In (D)TLS 1.2, the server chooses the DH group, and custom groups are prevalent. Therefore, once the client includes these cipher suites in its handshake and the server presents a custom group, the client cannot complete the handshake while ensuring security. Verifying the group structure is prohibitively expensive for the client. Using a safelist of known-good groups is also impractical, since server operators were encouraged to generate their own custom group. Further, there is no mechanism for the handshake to fall back to other parameters that are acceptable to both the client and server.

9. References

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Author's Address

Nimrod Aviram
Email: nimrod.aviram@gmail.com