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Compact TLS 1.3
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Abstract

This document specifies a "compact" version of TLS 1.3 and DTLS 1.3. It saves bandwidth by trimming obsolete material, tighter encoding, a template-based specialization technique, and alternative cryptographic techniques. cTLS is not directly interoperable with TLS 1.3 or DTLS 1.3 since the over-the-wire framing is different. A single server can, however, offer cTLS alongside TLS or DTLS.

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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Table of Contents

1. Introduction

This document specifies "compact" versions of TLS [RFC8446] and DTLS [RFC9147], respectively known as "Stream cTLS" and "Datagram cTLS". cTLS provides equivalent security and functionality to TLS and DTLS, but it is designed to take up minimal bandwidth. The space reduction is achieved by five basic techniques:

* Omitting unnecessary values that are a holdover from previous versions of TLS.

* Omitting the fields and handshake messages required for preserving backwards-compatibility with earlier TLS versions.

* More compact encodings.

* A template-based specialization mechanism that allows pre-populating information at both endpoints without the need for negotiation.

* Alternative cryptographic techniques, such as nonce truncation.

For the common (EC)DHE handshake with pre-established certificates, Stream cTLS achieves an overhead of 53 bytes over the minimum required by the cryptovariables. For a PSK handshake, the overhead is 21 bytes. An annotated handshake transcript can be found in Appendix A.

TODO: Make a PSK transcript and check the overhead.

cTLS supports the functionality of TLS and DTLS 1.3, and is forward-compatible to future versions of TLS and DTLS. cTLS itself is versioned by CTLSTemplate.version (currently zero).

The compression of the handshake while preserving the security guarantees of TLS has been formally verified in [Comparse].

2. Conventions and Definitions

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.

Structure definitions listed below override TLS 1.3 definitions; any PDU not internally defined is taken from TLS 1.3.

2.1. Template-based Specialization

A significant transmission overhead in TLS 1.3 is contributed to by two factors:

* the negotiation of algorithm parameters, and extensions, as well as

* the exchange of certificates.

TLS 1.3 supports different credential types and modes that are impacted differently by a compression scheme. For example, TLS supports certificate-based authentication, raw public key-based authentication as well as pre-shared key (PSK)-based authentication. PSK-based authentication can be used with externally configured PSKs or with PSKs established through tickets.

The basic idea of template-based specialization is that we start with the basic TLS 1.3 handshake, which is fully general and then remove degrees of freedom, eliding parts of the handshake which are used to express those degrees of freedom. For example, if we only support one version of TLS, then it is not necessary to have version negotiation and the supported_versions extension can be omitted. Thus, each specialization produces a new protocol that preserves the security guarantees of TLS, but has its own unique handshake.

By assuming that out-of-band agreements took place already prior to the start of the cTLS protocol exchange, the amount of data exchanged can be radically reduced. Because different clients may use different compression templates and because multiple compression templates may be available for use in different deployment environments, a client needs to inform the server about the profile it is planning to use. The profile field in the ClientHello serves this purpose.

Although the template-based specialization mechanisms described here are general, we also include specific mechanism for certificate-based exchanges because those are where the most complexity and size reduction can be obtained. Most of the other exchanges in TLS 1.3 are highly optimized and do not require compression to be used.

The compression profile defining the use of algorithms, algorithm parameters, and extensions is represented by the CTLSTemplate structure:

```
enum {
  profile(0),
  version(1),
  cipher_suite(2),
  dh_group(3),
  signature_algorithm(4),
  random(5),
  mutual_auth(6),
  handshake_framing(7),
  client_hello_extensions(8),
  server_hello_extensions(9),
  encrypted_extensions(10),
  certificate_request_extensions(11),
  known_certificates(12),
  finished_size(13),
  optional(65535)
} CTLSTemplateElementType;

struct {
  CTLSTemplateElementType type;
  opaque data<0..2^32-1>;
} CTLSTemplateElement;

struct {
  uint16 ctls_version = 0;
  CTLSTemplateElement elements<0..2^32-1>
} CTLSTemplate;
```

Elements in a CTLSTemplate MUST appear sorted by the type field in strictly ascending order. The initial elements are defined in the subsections below. Future elements can be added via an IANA registry (Section 6.2). When generating a template, all elements are OPTIONAL to include. When processing a template, all elements are mandatory to understand (but see discussion of optional in Section 2.1.1.11).

For ease of configuration, an equivalent JSON dictionary format is also defined. It consists of a dictionary whose keys are the name of each element type (converted from snake_case to camelCase), and whose values are a type-specific representation of the element intended to maximize legibility. The cTLS version is represented by the key "ctlsVersion", whose value is an integer, defaulting to 0 if omitted.

For example, the following specialization describes a protocol with a single fixed version (TLS 1.3) and a single fixed cipher suite (TLS_AES_128_GCM_SHA256). On the wire, ClientHello.cipher_suites, ServerHello.cipher_suites, and the supported_versions extensions in the ClientHello and ServerHello would be omitted.

```
{
  "ctlsVersion": 0,
  "profile": "0001020304050607",
  "version": 772,
  "cipherSuite": "TLS_AES_128_GCM_SHA256"
}
```

2.1.1. Initial template elements

2.1.1.1. profile

This element identifies the profile being defined. Its binary value is:

```
opaque ProfileID<1..2^8-1>
```

This encodes the profile ID, if one is specified. IDs whose decoded length is 4 bytes or less are reserved (see Section 6.5). When a reserved value is used (including the default value), other keys MUST NOT appear in the template, and a client MUST NOT accept the template unless it recognizes the ID.

In JSON, the profile ID is represented as a hexadecimal-encoded string.

2.1.1.2. version

Value: a single ProtocolVersion ([RFC8446], Section 4.1.2) that both parties agree to use. For TLS 1.3, the ProtocolVersion is 0x0304.

When this element is included, the supported_versions extension is omitted from ClientHello.extensions.

In JSON, the version is represented as an integer (772 = 0x0304 for TLS 1.3).

2.1.1.3. cipher_suite

Value: a single CipherSuite ([RFC8446], Section 4.1.2) that both parties agree to use.

When this element is included, the ClientHello.cipher_suites and ServerHello.cipher_suite fields are omitted.

In JSON, the cipher suite is represented using the "TLS_AEAD_HASH" syntax defined in [RFC8446], Section 8.4.

2.1.1.4. dh_group

Value: a single CTLSKeyShareGroup to use for key establishment.

```
struct {
    NamedGroup group_name;
    uint16 key_share_length;
} CTLSKeyShareGroup;
```

This is equivalent to adding a "supported_groups" extension to every message where that is allowed (i.e. ClientHello and EncryptedExtensions, in TLS 1.3) consisting solely of the group CTLSKeyShareGroup.group_name.

Static vectors (see Section 2.1.2):

* KeyShareClientHello.client_shares

* KeyShareEntry.key_exchange, if CTLSKeyShareGroup.key_share_length is non-zero.

In JSON, this value is represented as a dictionary with two keys:

* groupName: a string containing the code point name from the TLS Supported Groups registry (e.g., "x25519").

* keyShareLength: an integer, defaulting to zero if omitted.

2.1.1.5. signature_algorithm

Value: a single CTLSSignatureAlgorithm to use for authentication.

```
struct {
    SignatureScheme signature_scheme;
    uint16 signature_length;
} CTLSSignatureAlgorithm;
```

This is equivalent to a placing a literal "signature_algorithms" extension consisting solely of CTLSSignatureAlgorithm.signature_scheme in every extensions field where the "signature_algorithms" extension is permitted to appear (i.e. ClientHello and CertificateRequest, in TLS 1.3). When this element is included, CertificateVerify.algorithm is omitted.

Static vectors (see Section 2.1.2):

* CertificateVerify.signature, if CTLSSignatureAlgorithm.signature_length is non-zero.

In JSON, the signature algorithm is listed by the code point name in [RFC8446], Section 4.2.3. (e.g., ecdsa_secp256r1_sha256). In JSON, this value is represented as a dictionary with two keys:

* signatureScheme: a string containing the code point name in the TLS SignatureScheme registry (e.g., "ecdsa_secp256r1_sha256").

* signatureLength: an integer, defaulting to zero if omitted.

2.1.1.6. random

Value: a single uint8.

The ClientHello.Random and ServerHello.Random values are truncated to the given length. Where a 32-byte Random is required, the Random is padded to the right with 0s and the anti-downgrade mechanism in [RFC8446], Section 4.1.3 is disabled. IMPORTANT: Using short Random values can lead to potential attacks. The Random length MUST be less than or equal to 32 bytes.

> OPEN ISSUE: Karthik Bhargavan suggested the idea of hashing ephemeral public keys and to use the result (truncated to 32 bytes) as random values. Such a change would require a security analysis.

In JSON, the length is represented as an integer.

2.1.1.7. mutual_auth

Value: a single uint8, with 1 representing "true" and 0 representing "false". All other values are forbidden.

If set to true, this element indicates that the client must authenticate with a certificate by sending Certificate and a CertificateVerify message. If the CertificateRequest message does not add information not already conveyed in the template, the server SHOULD omit it.

In JSON, this value is represented as true or false.

> TODO: It seems like there was an intent to elide the Certificate.certificate_request_context field, but this is not stated explicitly anywhere.

2.1.1.8. handshake_framing

Value: uint8, with 0 indicating "false" and 1 indicating "true". If true, handshake messages MUST be conveyed inside a Handshake ([RFC8446], Section 4) struct on reliable, ordered transports, or a DTLSHandshake ([RFC9147], Section 5.2) struct otherwise, and MAY be broken into multiple records as in TLS and DTLS. If false, each handshake message is conveyed in a CTLSHandshake or CTLSDatagramHandshake struct (Section 2.3), which MUST be the payload of a single record.

In JSON, this value is represented as true or false.

2.1.1.9. client_hello_extensions, server_hello_extensions, encrypted_extensions, and certificate_request_extensions

Value: a single CTLSExtensionTemplate struct:

```
struct {
  Extension predefined_extensions<0..2^16-1>;
  ExtensionType expected_extensions<0..2^16-1>;
  ExtensionType self_delimiting_extensions<0..2^16-1>;
  uint8 allow_additional;
} CTLSExtensionTemplate;
```

The predefined_extensions field indicates extensions that should be treated as if they were included in the corresponding message. This allows these extensions to be omitted entirely.

The expected_extensions field indicates extensions that must be included in the corresponding message, at the beginning of its extensions field. The types of these extensions are omitted when serializing the extensions field of the corresponding message.

The self_delimiting_extensions field indicates extensions whose data is self-delimiting. The cTLS implementation MUST be able to parse all these extensions, and all extensions listed in Section 4.2 of [RFC8446].

The allow_additional field MUST be 0 (false) or 1 (true), indicating whether additional extensions are allowed here.

predefined_extensions and expected_extensions MUST be in strictly ascending order by ExtensionType, and a single ExtensionType MUST NOT appear in both lists. If the version, dh_group, or signature_algorithm element appears in the template, the corresponding ExtensionType MUST NOT appear here. The pre_shared_key ExtensionType MUST NOT appear in either list.

OPEN ISSUE: Are there other extensions that would benefit from special treatment, as opposed to hex values.

Static vectors (see Section 2.1.2):

* Extension.extension_data for any extension whose type is in self_delimiting_extensions, or is listed in Section 4.2 of [RFC8446] except padding. This applies only to the corresponding message.

* The extensions field of the corresponding message, if allow_additional is false.

In JSON, this value is represented as a dictionary with three keys:

* predefinedExtensions: a dictionary mapping ExtensionType names ([RFC8446], Section 4.2) to values encoded as hexadecimal strings.

* expectedExtensions: an array of ExtensionType names.

* selfDelimitingExtensions: an array of ExtensionType names.

* allowAdditional: true or false.

If predefinedExtensions or expectedExtensions is empty, it MAY be omitted.

OPEN ISSUE: Should we have a certificate_entry_extensions element?

2.1.1.10. finished_size

Value: uint8, indicating that the Finished value is to be truncated to the given length.

OPEN ISSUE: How short should we allow this to be? TLS 1.3 uses the native hash and TLS 1.2 used 12 bytes. More analysis is needed to know the minimum safe Finished size. See [RFC8446], Appendix E.1 for more on this, as well as https://mailarchive.ietf.org/arch/msg/tls/TugB5ddJu3nYg7chcyeIyUqWSbA. The minimum safe size may vary depending on whether the template was learned via a trusted channel.

In JSON, this length is represented as an integer.

2.1.1.11. optional

Value: a CTLSTemplate containing elements that are not required to be understood by the client. Server operators MUST NOT place an element in this section unless the server is able to determine whether the client is using it from the client data it receives. A key MUST NOT appear in both the main template and the optional section.

In JSON, this value is represented in the same way as the CTLSTemplate itself.

2.1.1.12. known_certificates

Value: a CertificateMap struct:

```
struct {
  opaque id<1..2^8-1>;
  opaque cert_data<1..2^16-1>;
} CertificateMapEntry;

struct {
  CertificateMapEntry entries<2..2^24-1>;
} CertificateMap;
```

Entries in the certificate map must appear in strictly ascending lexicographic order by ID.

In JSON, CertificateMap is represented as a dictionary from id to cert_data, which are both represented as hexademical strings:

```
{
  "00": "3082...",
  "01": "3082...",
}
```

Certificates are a major contributor to the size of a TLS handshake. In order to avoid this overhead when the parties to a handshake have already exchanged certificates, a compression profile can specify a dictionary of "known certificates" that effectively acts as a compression dictionary on certificates.

When compressing a Certificate message, the sender examines the cert_data field of each CertificateEntry. If the cert_data matches a value in the known certificates object, then the sender replaces the cert_data with the corresponding key. Decompression works the opposite way, replacing keys with values.

Note that in this scheme, there is no signaling on the wire for whether a given cert_data value is compressed or uncompressed. Known certificates objects SHOULD be constructed in such a way as to avoid a uncompressed object being mistaken for compressed one and erroneously decompressed. For X.509, it is sufficient for the first byte of the compressed value (key) to have a value other than 0x30, since every X.509 certificate starts with this byte.

This element can be used to compress both client and server certificates. However, in most deployments where client certificates are used, it would be inefficient to encode all client certificates into a single profile. Instead, deployments can define a unique profile for each client, distinguished by the profile ID. Note that the profile ID is sent in cleartext, so this strategy has significant privacy implications.

2.1.2. Static vector compression

Some cTLS template elements imply that certain vectors (as defined in [RFC8446], Section 3.4) have a fixed number of elements during the handshake. These template elements note these "static vectors" in their definition. When encoding a "static vector", its length prefix is omitted.

For example, suppose that the cTLS template is:

```
{
  "ctlsVersion": 0,
  "version": 772,
  "dhGroup": {
    "groupName": "x25519",
    "keyShareLength": 32
  },
  "clientHelloExtensions": {
    "expectedExtensions": ["key_share"],
    "allowAdditional": false
  }
}
```

Then, the following structure:

```
   28                // length(extensions)
   33 26             // extension_type = KeyShare
     0024            // length(client_shares)
       001d          // KeyShareEntry.group
       0020          // length(KeyShareEntry.key_exchange)
         a690...af948 // KeyShareEntry.key_exchange
```

is compressed down to:

```
a690...af948 // KeyShareEntry.key_exchange
```

according to the following rationale:

* The length of extensions is omitted because allowAdditional is false, so the number of items in extensions (i.e., 1) is known in advance.

* extension_type is omitted because it is specified by expected_extensions.

* The length of client_shares is omitted because the use of dhGroup implies that there can only be one KeyShareEntry.

* KeyShareEntry.group is omitted because it is specified by dhGroup.

* The length of the key_exchange is omitted because the "x25519" key share has a fixed size (32 bytes).

2.2. Record Layer

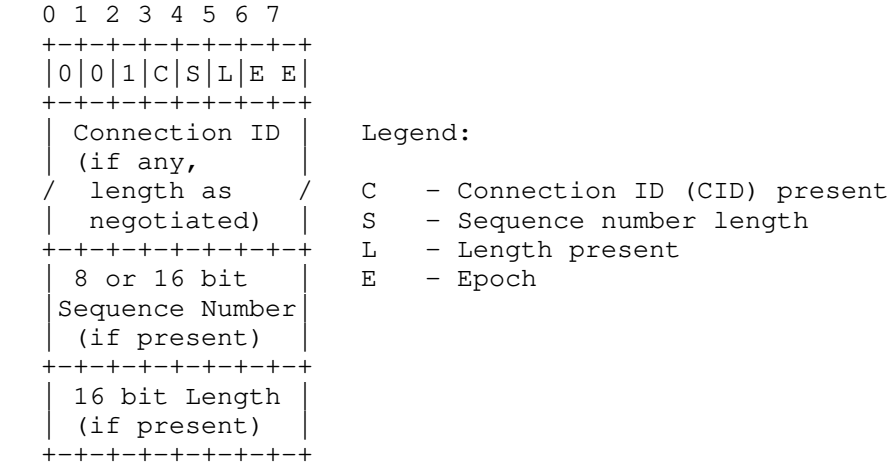
The only cTLS records that are sent in plaintext are handshake records (ClientHello and ServerHello/HRR) and alerts. cTLS alerts are the same as TLS/DTLS alerts and use the same content types. For handshake records, we set the content_type field to a fixed cTLS-specific value to distinguish cTLS plaintext records from encrypted records, TLS/DTLS records, and other protocols using the same 5-tuple.

```
struct {
    ContentType content_type = ctls_handshake;
    opaque profile_id<0..2^8-1>;
    opaque fragment<0..2^16-1>;
} CTLSClientPlaintext;
```

The profile_id field MUST identify the profile that is in use. A zero-length ID corresponds to the cTLS default protocol. The server's reply does not include the profile_id, because the server must be using the same profile indicated by the client.

```
struct {
    ContentType content_type = ctls_handshake;
    opaque fragment<0..2^16-1>;
} CTLSServerPlaintext;
```

Encrypted records use DTLS 1.3 [RFC9147] record framing, comprising a configuration octet followed by optional connection ID, sequence number, and length fields. The encryption process and additional data are also as described in DTLS.




```
struct {
    opaque unified_hdr[variable];
    opaque encrypted_record[length];
} CTLSCiphertext;
```

The presence and size of the connection ID field is negotiated as in DTLS.

As with DTLS, the length field MAY be omitted by clearing the L bit, which means that the record consumes the entire rest of the data in the lower level transport. In this case it is not possible to have multiple DTLSCiphertext format records without length fields in the same datagram. In stream-oriented transports (e.g., TCP), the length field MUST be present. For use over other transports length information may be inferred from the underlying layer.

Normal DTLS does not provide a mechanism for suppressing the sequence number field entirely. When a reliable, ordered transport (e.g., TCP) is in use, the S bit in the configuration octet MUST be cleared and the sequence number MUST be omitted. When an unreliable transport is in use, the S bit has its usual meaning and the sequence number MUST be included.

2.3. cTLS Handshake Layer

The cTLS handshake is modeled in three layers:

1. The Transport layer

2. The Transcript layer

3. The Logical layer

2.3.1. The Transport layer

When template.handshake_framing is false, the cTLS transport layer uses a custom handshake framing that saves space by relying on the record layer for message lengths. (This saves 3 bytes per message compared to TLS, or 9 bytes compared to DTLS.) This compact framing is defined by the CTLSHandshake and CTLSDatagramHandshake structs.

Any handshake type registered in the IANA TLS HandshakeType Registry can be conveyed in a CTLS[Datagram]Handshake, but not all messages are actually allowed on a given connection. This definition shows the messages types supported in CTLSHandshake as of TLS 1.3 and DTLS 1.3, but any future message types are also permitted.

```
struct {
    HandshakeType msg_type;    /* handshake type */
    select (CTLSHandshake.msg_type) {
        case client_hello:          ClientHello;
        case server_hello:          ServerHello;
        case hello_retry_request:   HelloRetryRequest;  /* New */
        case end_of_early_data:     EndOfEarlyData;
        case encrypted_extensions:  EncryptedExtensions;
        case certificate_request:   CertificateRequest;
        case certificate:           Certificate;
        case certificate_verify:    CertificateVerify;
        case finished:              Finished;
        case new_session_ticket:    NewSessionTicket;
        case key_update:            KeyUpdate;
        case request_connection_id: RequestConnectionId;
        case new_connection_id:     NewConnectionId;
    };
} CTLSHandshake;

struct {
    HandshakeType msg_type;    /* handshake type */
    uint16 message_seq;        /* DTLS-required field */
    select (CTLSDatagramHandshake.msg_type) {
      ... /* same as CTLSHandshake */
    };
} CTLSDatagramHandshake;
```

Each CTLSHandshake or CTLSDatagramHandshake MUST be conveyed as a single CTLSClientPlaintext.fragment, CTLSServerPlaintext.fragment, or CTLSCiphertext.encrypted_record, and is therefore limited to a maximum length of 2^16-1 or less. When operating over UDP, large CTLSDatagramHandshake messages will also require the use of IP fragmentation, which is sometimes undesirable. Operators can avoid these concerns by setting template.handshakeFraming = true.

On unreliable transports, the DTLS 1.3 ACK system is used.

2.3.2. The Transcript layer

TLS and DTLS start the handshake with an empty transcript. cTLS is different: it starts the transcript with a "virtual message" whose HandshakeType is ctls_template (Section 6.3) containing the CTLSTemplate used for this connection. This message is included in the transcript even though it is not exchanged during connection setup, in order to ensure that both parties are using the same template. Subsequent messages are appended to the transcript as usual.

When computing the handshake transcript, all handshake messages are represented in TLS Handshake messages, as in DTLS 1.3 ([RFC9147], Section 5.2), regardless of template.handshake_framing.

To ensure that all parties agree about what protocol is in use, and whether records are subject to loss, the Cryptographic Label Prefix used for the handshake SHALL be "Sctls " (for "Stream cTLS") if Handshake or CTLSHandshake transport was used, and "Dctls " (for "Datagram cTLS") otherwise. (This is similar to the prefix substitution in Section 5.9 of [RFC9147]).

2.3.3. The Logical layer

The logical handshake layer consists of handshake messages that are reconstructed following the instructions in the template. At this layer, predefined extensions are reintroduced, truncated Random values are extended, and all information is prepared to enable the cryptographic handshake and any import or export of key material and configuration.

There is no obligation to reconstruct logical handshake messages in any specific format, and client and server do not need to agree on the precise representation of these messages, so long as they agree on their logical contents.

3. Handshake Messages

In general, we retain the basic structure of each individual TLS or DTLS handshake message. However, the following handshake messages have been modified for space reduction and cleaned up to remove pre-TLS 1.3 baggage.

3.1. ClientHello

The cTLS ClientHello is defined as follows.

```
opaque Random[RandomLength];      // variable length

struct {
    Random random;
    CipherSuite cipher_suites<1..2^16-1>;
    Extension extensions<1..2^16-1>;
} ClientHello;
```

3.2. ServerHello

We redefine ServerHello in the following way.

```
        struct {
            Random random;
            CipherSuite cipher_suite;
            Extension extensions<1..2^16-1>;
        } ServerHello;
```

3.3. HelloRetryRequest

In cTLS, the HelloRetryRequest message is a true handshake message instead of a specialization of ServerHello. The HelloRetryRequest has the following format.

```
      struct {
          CipherSuite cipher_suite;
          Extension extensions<2..2^16-1>;
      } HelloRetryRequest;
```

The HelloRetryRequest is the same as the ServerHello above but without the unnecessary sentinel Random value.

> OPEN ISSUE: Should we define a hello_retry_request_extensions template element? Or is this too far off the happy path to be worth optimizing?

4. Examples

This section provides some example specializations.

For this example we use TLS 1.3 only with AES_GCM, x25519, ALPN h2, short random values, and everything else is ordinary TLS 1.3.

```
{
   "ctlsVersion": 0,
   "profile": "0504030201",
   "version" : 772,
   "random": 16,
   "cipherSuite" : "TLS_AES_128_GCM_SHA256",
   "dhGroup": {
     "groupName": "x25519",
     "keyShareLength": 32
   },
   "clientHelloExtensions": {
      "predefinedExtensions": {
          "application_layer_protocol_negotiation" : "030016832",
      },
      "allowAdditional": true
    }
}
```

Version 772 corresponds to the hex representation 0x0304 (i.e. 1.3).

5. Security Considerations

The use of key ids is a new feature introduced in this document, which requires some analysis, especially as it looks like a potential source of identity misbinding. This is, however, entirely separable from the rest of the specification.

Once the handshake has completed, this specification is intended to provide a fully secured connection even if the client initially learned the template through an untrusted channel. However, this security relies on the use of a cryptographically strong Finished message. If the Finished message has not yet been received, or the transcript hash has been truncated by use of a small finished_size template element value, an attacker could be using a forged template to impersonate the other party. This should not impact any ordinary use of TLS, including Early Data (which is secured by the previously completed handshake).

6. IANA Considerations

6.1. Adding a ContentType

This document requests that a code point be allocated from the "TLS ContentType registry. This value must be in the range 0-31 (inclusive). The row to be added in the registry has the following form:

Value	Description	DTLS-OK	Reference
TBD	ctls	Y	RFCXXXX
TBD	ctls_handshake	Y	RFCXXXX

Table 1

RFC EDITOR: Please replace the value TBD with the value assigned by IANA, and the value XXXX to the RFC number assigned for this document.

6.2. Template Keys

This document requests that IANA open a new registry entitled "cTLS Template Keys", on the Transport Layer Security (TLS) Parameters page, with a "Specification Required" registration policy and the following initial contents:

Name	Value	Reference
profile	0	(This document)
version	1	(This document)
cipher_suite	2	(This document)
dh_group	3	(This document)
signature_algorithm	4	(This document)
random	5	(This document)
mutual_auth	6	(This document)
handshake_framing	7	(This document)
client_hello_extensions	8	(This document)
server_hello_extensions	9	(This document)
encrypted_extensions	10	(This document)
certificate_request_extensions	11	(This document)
known_certificates	12	(This document)
finished_size	13	(This document)
optional	65535	(This document)

Table 2

6.3. Adding a cTLS Template message type

IANA is requested to add the following entry to the TLS HandshakeType registry.

* Value: TBD

* Description: ctls_template

* DTLS-OK: Y

* Reference: (This document)

* Comment: Virtual message used in cTLS.

6.4. Activating the HelloRetryRequest MessageType

This document requests that IANA change the name of entry 6 in the TLS HandshakeType Registry from "hello_retry_request_RESERVED" to "hello_retry_request", and set its Reference field to this document.

6.5. Reserved profiles

This document requests that IANA open a new registry entitled "Well-known cTLS Profile IDs", on the Transport Layer Security (TLS) Parameters page, with the following columns:

* ID value: A sequence of 1-4 octets.

* Template: A JSON object.

* Note: An explanation or reference.

The ID values of length 1 are subject to a "Standards Action" registry policy. Values of length 2 are subject to an "RFC Required" policy. Values of length 3 and 4 are subject to a "First Come First Served" policy. Values longer than 4 octets are not subject to registration and MUST NOT appear in this registry.

The initial registry contents are:

ID value	Template	Note
[0x00]	{"version": 772}	cTLS 1.3-only

Table 3

7. References

7.1. Normative References

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7.2. Informative References

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Appendix A. Example Exchange

The follow exchange illustrates a complete cTLS-based exchange supporting mutual authentication using certificates. The digital signatures use Ed25519. The ephemeral Diffie-Hellman uses the X25519 curve and the exchange negotiates TLS-AES-128-CCM8-SHA256. The certificates are exchanged using certificate identifiers.

The resulting byte counts are as follows:

	ECDHE		
	TLS	CTLS	Cryptovariables
ClientHello	132	74	64
ServerHello	90	68	64
ServerFlight	478	92	72
ClientFlight	458	91	72
Total	1158	325	272

The following compression profile was used in this example:

```
   {
     "ctlsVersion": 0,
     "profile": "abcdef1234",
     "version": 772,
     "cipherSuite": "TLS_AES_128_CCM_8_SHA256",
     "dhGroup": {
       "groupName": "x25519",
       "keyShareLength": 32
     },
     "signatureAlgorithm": {
       "signatureScheme": "ed25519",
       "signatureLength": 64
     },
     "finishedSize": 8,
     "clientHelloExtensions": {
       "predefinedExtensions": {
         "server_name": "000e00000b6578616d706c652e636f6d"
       },
       "expectedExtensions": ["key_share"],
       "allowAdditional": false
     },
     "serverHelloExtensions": {
       "expectedExtensions": ["key_share"],
       "allowAdditional": false
     },
     "encryptedExtensions": {
       "allowAdditional": false
     },
     "mutualAuth": true,
     "knownCertificates": {
       "61": "3082...",
       "62": "3082...",
       "63": "...",
       "64": "...",
       ...
     }
   }

   ClientHello: 74 bytes = Profile ID(5) + Random(32) + DH(32) +
   Overhead(5)

 $TBD               // CTLSClientPlaintext.message_type = ctls_handshake
 05 abcdef1234      // CTLSClientPlaintext.profile_id
 0041               // CTLSClientPlaintext.fragment length = 65
   01               // CTLSHandshake.msg_type = client_hello
     5856...c130    //   ClientHello.random (32 bytes)
 // ClientHello.extensions is omitted except for the key share contents.
       a690...f948  //     KeyShareEntry.key_exchange (32 bytes)
```

```
   ServerHello: 68 bytes = Random(32) + DH(32) + Overhead(4)

 $TBD               // CTLSServerPlaintext.message_type = ctls_handshake
 0041               // CTLSServerPlaintext.fragment length
   02               //   CTLSHandshake.msg_type = server_hello
     cff4...9ca8    //     ServerHello.random (32 bytes)
 // ServerHello.extensions is omitted except for the key share contents.
       9fbc...0f49  //       KeyShareEntry.key_exchange (32 bytes)

   Server Flight: 92 = SIG(64) + Finished(8) + MAC(8) + CERTID(1) +
   Overhead(11)

  24                // CTLSCipherText header, L=1, C,S,E=0
  0059              // CTLSCipherText.length = 89

  // BEGIN ENCRYPTED CONTENT

  08                // CTLSHandshake.msg_type = encrypted_extensions

  // The EncryptedExtensions body is omitted because there are no more
  // extensions.  The length is also omitted, because allowAdditional is
  // false.

  // The CertificateRequest message is omitted because "mutualAuth" and
  // "signatureAlgorithm" are specified in the template.

  0b                // CTLSHandshake.msg_type = certificate
    00              //   Certificate.certificate_request_context = ""
    03              //   Certificate.certificate_list length
      01            //     CertificateEntry.cert_data length
        61          //       cert_data = 'a'
      00            //     CertificateEntry.extensions

  0f                // CTLShandshake.msg_type = certificate_verify
    3045...10ce     //   CertificateVerify.signature

  14                // CTLSHandshake.msg_type = finished
    bfc9d66715bb2b04 //   Finished.verify_data

  // END ENCRYPTED CONTENT

  b3d9...0aa7       // CCM-8 MAC (8 bytes)

   Client Flight: 91 bytes = SIG(64) + Finished(8) + MAC(8) + CERTID(1)
   + Overhead(10)
```

```
   24                // CTLSCipherText header, L=1, C,S,E=0
   0058              // CTLSCipherText.length = 88

   // BEGIN ENCRYPTED CONTENT

   0b                // CTLSHandshake.msg_type = certificate
     00              //   Certificate.certificate_request_context = ""
     03              //   Certificate.certificate_list length
       01            //     CertificateEntry.cert_data length
         62          //       cert_data = 'b'
       00            //     CertificateEntry.extensions

   0f                // CTLSHandshake.msg_type = certificate_verify
                     //   CertificateVerify.algorithm is omitted
                     //   CertificateVerify.signature length is omitted
     3045...f60e     //   CertificateVerify.signature (64 bytes)

   14                // CTLSHandshake.msg_type = finished
     35e9c34eec2c5dc1 //   Finished.verify_data

   // END ENCRYPTED CONTENT

   09c5..37b1        // CCM-8 MAC (8 bytes)
```

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