

LURK  
Internet-Draft  
Intended status: Standards Track  
Expires: 27 January 2022

D. Migault  
Ericsson  
I. Boureau  
University of Surrey  
26 July 2021

LURK Extension version 1 for (D)TLS 1.2 Authentication  
draft-mglt-lurk-tls12-05

## Abstract

This document describes the LURK Extension 'tls12' which enables interactions between a LURK Client and a LURK Server in a context of authentication with (D)TLS 1.2.

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Internet-Draft

LURK/TLS 1.2

July 2021

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## [1.](#) Introduction

This document describes the LURK Extension for TLS 1.2 so the LURK Server can implement a Cryptographic Service in a TLS 1.2 [[RFC5246](#)] and DTLS 1.2 [[RFC6347](#)] context.

More specifically, the LURK Server will be in charge of performing the cryptographic operations associated to the private key of the TLS Server, while other aspects of the termination of the TLS session is handled by other services in the same administrative domain or in a different administrative domain. Most Cryptographic Operations are related to the TLS authentication and the current document limits the Cryptographic Operations to the following authentication methods: RSA and ECDHE\_RSA defined in [[RFC5246](#)], [[RFC6347](#)] as well as ECDHE\_ECDSA defined in [[RFC8422](#)].

A more detailed description of some use cases foreseen in a TLS context can be found in [[I-D.mglt-lurk-tls-use-cases](#)].

HTTPS delegation has been the main concern of the Content Delivery Networks Interconnection (cdni) Working Group and several mechanisms have been designed to delegate the load from an upstream entity to a downstream entity. Entities can be of different nature and may designated differently according to the context. Typically designations includes Content Owner, CDN Provider, Domain Name Owner for example. [[I-D.fieau-cdni-https-delegation](#)] provides a details comparison of the various mechanisms applies to the CDN Interconnection, and the remaining of this section positions these mechanisms at a very high level view.

STAR [[I-D.ietf-acme-star](#)], [[I-D.sheffer-acme-star-request](#)] describes a methods where the domain name owner or the content owner orchestrates the refreshing process between a CA and the CDN (terminating the TLS session). The CDN refreshes regularly and automatically its certificates using [[I-D.ietf-acme-acme](#)], which allows the use of short term certificates.

Delegated credentials [[I-D.rescorla-tls-subcerts](#)] consists having a certificate that enables the servers to generate some "delegated credentials".

STAR and "delegated credentials" both require some changes performed by the CA - new certificate type for the delegated credentials and new interfaces for the delegated and delegating entity for STAR. In both cases the TLS Client authenticates the delegated entity. While STAR does not require changes on the TLS Client, the "delegated credential" solution does. In both cases, the delegation is controlled by limiting in time (7 days), which is also the limit of

use of a stolen key or a rogue server. Such delegation provides a high scalability of the architecture and prevents additional delays when a TLS session is established.

The LURK Architecture [[I-D.mglt-lurk-lurk](#)] and the LURK Extension 'tls12' do not proceed to the delegation of the HTTPS delegation by delegating the entire TLS termination. Instead, the TLS termination is split into sub services, for example one associated to the networking part and one associated to the cryptographic operation. While micro services associated to the networking part are delegated, the micro service associated to the cryptographic operation may not be delegated. As a result, LURK Architecture is focused on the protection of the Cryptographic Material and prevents leakage of the Cryptographic Material for example by avoiding node exposed to the Internet to host the Cryptographic Material. In addition, LURK provides means to instantaneously suspend the delegation with a suspicious node. On the other hand the LURK Extension 'tls12' introduces some latency, and is not as scalable as STAR or delegated credential solutions.

The LURK Extension 'tls12' is seen as a complementary to the STAR and "delegated credentials". The LURK Extension 'tls12' is a backend solution that does not require any modifications from TLS Client or the CA. It is also aimed at protecting the Cryptographic Material.

LURK may also be deployed within an administrative domain in order to provide a more controlled deployment of TLS Servers.

## [2.](#) Terminology and Acronyms

This document re-uses the terminology defined in [\[I-D.mglt-lurk-lurk\]](#).

### 3. LURK Header

LURK / TLS 1.2 is a LURK Extension that introduces a new designation "tls12". This document assumes that Extension is defined with designation set to "tls12" and version set to 1. The LURK Extension extends the LURKHeader structure defined in [\[I-D.mglt-lurk-lurk\]](#) as follows:

```
enum {  
    tls12 (1), (255)  
} Designation;
```

```
enum {  
    capabilities (0), ping (1), rsa_master (2),  
    rsa_master_with_poh (3), rsa_extended_master (4),  
    rsa_extended_master_with_poh (5), ecdhe (6), (255)  
} TLS12Type;
```

```
enum {  
    // generic values reserved or aligned with the  
    // LURK Protocol  
    request (0), success (1), undefined_error (2),  
    invalid_payload_format (3),  
  
    // code points for rsa authentication  
    invalid_key_id_type (4), invalid_key_id (5),  
    invalid_tls_random (6), invalid_freshness_func (7),  
    invalid_encrypted_premaster (8), invalid_finished (9)
```

```

        //code points for ecdhe authentication
        invalid_ec_type (10), invalid_ec_curve (11),
        invalid_poo_prf (12), invalid_poo (13), (255)
    }TLS12Status

    struct {
        Designation designation = "tls12";
        int8 version = 1;
    } Extension;

    struct {
        Extension extension;
        select( Extension ){
            case ("tls12", 1):
                TLS12Type;
        } type;
        select( Extension ){
            case ("tls12", 1):
                TLS12Status;
        } status;
        uint64 id;
        uint32 length;
    } LURKHeader;

```

#### [4.](#) `rsa_master`, `rsa_master_with_poh`

An exchange of type `"rsa_master"` or `"rsa_master_with_poh"` enables the LURK Client to delegate the RSA Key Exchange and authentication as defined in [\[RFC5246\]](#). The LURK Server returns the master secret.

`"rsa_master"` provides the necessary parameters and details to generate the master secret, as well as to hinder replaying of old handshake messages by a corrupt LURK Client. I.e., some attestation of message-freshness is acquired by the LURK Server.

In addition, the `"rsa_master_with_poh"` provides a proof of handshake (PoH). The proof of handshake consists in providing the Finished message of the TLS Client to the LURK Server, so that latter can perform more checks than in the `"rsa_master"` mode. Notably, herein,

the LURK Server also checks that the LURK request is performed in a context of a TLS handshake.

While "rsa\_master" and "rsa\_master\_with\_poh" exchange have respectively different requests, the response is the same. The motivation for having different type is that the parameters provided to the LURK Server are provided using different format. "rsa\_master" provides them explicitly, while "rsa\_master\_with\_poh" provides them via handshake messages.

#### [4.1.](#) Request Payload

A rsa\_master request payload has the following structure:

```
enum {
    sha256_32 (0), (255)
}KeyPairIdType;

struct {
    KeyPairIdType type;
    opaque data; // length defined by the type
} KeyPairID;
```

```

enum{
    sha256 (0), (255)
} FreshnessFunct

enum{
    sha256 (0), sha384(1), sha512(2), (255)
} PRFHash

struct {
    KeyPairID key_id;
    FreshnessFunct freshness_funct;
    PRFHash prf_hash;
    Random client_random;          // see RFC5246 section 7.4.1.2
    Random server_random;
    EncryptedPreMasterSecret pre_master;
                                // see RFC5246 section 7.4.7.1
                                // Length depends on the key.
}
} TLS12RSAMasterRequestPayload;

```

**key\_id** The identifier of the public key. This document defines sha256\_32 format which takes the 32 first bits of the hash of the binary ASN.1 DER representation of the public key using sha256. The binary representation of RSA keys is described in [[RFC8017](#)]. The binary representation of ECC keys is the subjectPublicKeyInfo structure defined in [[RFC5480](#)].

**freshness\_funct** the one-way hash function (OWHF) used by LURK to implement Perfect Forward Secrecy.

**prf\_hash** the one way hash function used by the Pseudo Random Function (PRF) to generate the master secret. PRF and hash function are defined in {[RFC5246](#)} [Section 5](#).

**client\_random** the random value associated to the TLS Client as defined in [RFC5246](#) [Section 7.4.1.2](#).

**server\_random:** the random value associated to the TLS Server as defined in [RFC5246](#) [Section 7.4.1.2](#).

**EncryptedPreMasterSecret** : The encrypted master secret as defined in



[\[RFC5246\] Section 7.4.7.1.](#)

A `rsa_master_with_poh` request payload has the following structure:

```
struct {  
    KeyPairID key_id;  
    FreshnessFunct freshness_func;  
    opaque handshake_messages<2...2^16-2>  
        // see RFC5246 section 7.4.9  
    Finished finished  
} TLS12RSAMasterWithPoHRequestPayload;
```

`key_id`, `freshness_func` are defined above

`handshake_messages` provides the necessary handshake messages to compute the Finished message of the TLS Client as defined in [\[RFC5246\] section 7.4.9](#).

`finished` the TLS Client Finished message as defined by [\[RFC5246\] section 7.4.9](#).

#### [4.1.1.](#) Perfect Forward Secrecy

This document defines a mechanism which uses a function called `freshness_func`, to prevent an attacker to send a request to the LURK Server in such a way that the said attacker can obtain back the mastersecret for an old handshake. In other words, the use of this function helps prevent a forward-secrecy attack on an old TLS session, where the attack would make use that session's handshake-data observed by the adversary.

This design achieves PFS with `freshness_func` being a collision-resistant hash function (CHRF). By CHRF, we mean a one-way hash function (OWHF) which also has collision resistance; the latter means that it is computationally infeasible to find any two inputs  $x_1$  and  $x_2$  such that `freshness_func( $x_1$ ) = freshness_func( $x_2$ )`. By one-way hash function (OWHF) we mean, as standard, a hash function `freshness_func` that satisfies preimage resistance and 2nd-preimage resistance. That is, given a hash value  $y$ , it is computationally infeasible to find an  $x$  such that `freshness_func( $x$ ) =  $y$` , and respectively-- given a value  $x_1$  and its hash `freshness_func( $x_1$ )`, it is computationally infeasible to find another  $x_2$  such that `freshness_func( $x_2$ ) = freshness_func( $x_1$ )`.

For the concrete use of our `freshness_func` functions, let  $S$  be a fresh, randomly picked value generated by the LURK Client. The value of `server_random` in the TLS exchange is then equal to

freshness\_func( $S$ ), i.e.,  $\text{server\_random} = \text{freshness\_func}(S)$ . Between the TLS Client and the LURK Server only  $\text{server\_random}$  is exchanged. The LURK Client sends  $S$  to the Key Server, in the query. Note that the latter SHOULD happen over a secure channel.

A man-in-the-middle attacker observing the (plaintext) TLS handshake between a TLS Client and the LURK Client does not see  $S$ , but only  $\text{server\_random}$ . The preimage resistance guaranteed by the  $\text{freshness\_func}$  makes it such that this man-in-the-middle cannot retrieve  $S$  out of the observed  $\text{server\_random}$ . As such, this man-in-the-middle attacker cannot query the  $S$  corresponding to an (old) observed handshake to the Key Server. Moreover, the collision resistance guaranteed by the  $\text{freshness\_func}$  makes it such that if the aforementioned man-in-the-middle cannot find  $S'$  such that  $\text{freshness\_func}(S) = \text{freshness\_func}(S')$ .

As discussed in [Section 9](#), PFS may be achieved in other ways (i.e., not using a CRHF and the aforementioned exchanges but other cryptographic primitives and other exchanges). These may offer better computational efficiency. These may be standardized in future versions of the LURK extension "tls12".

The  $\text{server\_random}$  MUST follow the structure of [\[RFC5246\] section 7.4.1.2](#), which carries the  $\text{gmt\_unix\_time}$  in the first four bytes. So, the  $\text{ServerHello.random}$  of the TLS exchange is derived from the  $\text{server\_random}$  of the LURK exchange as defined below:

```
gmt_unix_time = server_random[0..3];
ServerHello.random = freshness_func( server_random + "tls12 pfs" );
ServerHello.random[0..3] = gmt_unix_time;
```

The operation MUST be performed by the LURK Server as well as the TLS Server, upon receiving the master secret or the signature of the  $\text{ecdhe\_params}$  from the LURK Client.

#### [4.2.](#) Response Payload

The "rsa\_master" response payload contains the master secret and has the following structure:

```
struct {
    opaque master[0..47];
} TLS12RSAMasterResponsePayload;
```

### [4.3.](#) LURK Client Behavior

A LURK Client initiates an `rsa_master` or an `rsa_master_with_poh` exchange in order to retrieve the master secret. The LURK exchange happens on the TLS Server side (Edge Server). Upon receipt of the `master_secret` the Edge Server generates the session keys and finish the TLS key exchange protocol.

A LURK Client MAY use the `rsa_master_with_poh` to provide the LURK Server evidences that the LURK exchange is performed in the context of a TLS handshake. The Proof of TLS Handshake (POH) helps the LURK Server to audit the context associated to the query.

The LURK Client MUST ensure that the transmitted values for `server_random` is `S` such as `server_random = freshness_func( S )`.

### [4.4.](#) LURK Server Behavior

Upon receipt of a `rsa_master` or a `rsa_master_with_poh` request, the LURK Server proceeds according to the following steps:

1. The LURK Server checks the RSA key pair is available (`key_id`). If the format of the key pair identifier is not understood, an `"invalid_key_id_type"` error is returned. If the designated key pair is not available an `"invalid_key_id"` error is returned.
2. The LURK Server checks the `freshness_func`. If it does not support the `FreshnessFunc`, an `"invalid_freshness_func"` error is returned.
3. The LURK Server collects the `client_random`, `server_random` and `pre_master` parameters either provided explicitly (`rsa_master`) or within the handshake (`rsa_master_with_poh`).
4. The LURK Server MUST check the format of the `server_random` and more specifically checks the `gmt_unix_time` associated to the random is acceptable. Otherwise it SHOULD return an `"invalid_tls_random"` error. The value of the time window is implementation dependent and SHOULD be a configurable

parameters. The LURK Server MAY also check the `client_random`. This should be considered cautiously as such check may prevent TLS Clients to set a TLS session. `client_random` is generated by the TLS Client whose clock might not be synchronized with the one of the LURK Server or that might have a TLS implementations that does not generate random based on `gmt_unix_time`.

5. The LURK Server computes the necessary `ServerHello.random` from the `server_random` when applicable as described in [Section 4.1.1](#). When option is set to "finished" the `ServerHello.random` in the handshake is replaced by its new value.
6. The LURK Server checks the length of the encrypted premaster secret and returns an "invalid\_payload\_format" error if the length differs from the length of binary representation of the RSA modulus.
7. The LURK Server decrypts the encrypted premaster secret as described in [\[RFC5246\] section 7.4.7.1](#). When a PKCS1.5 format error is detected, or a mismatch between the TLS versions provided as input and the one indicated in the encrypted premaster secret, the Key Server returns a randomly generated master secret.
8. The LURK Server generates the master secret as described in [\[RFC5246\] section 8.1](#) using the `client_random`, and the `server_random` provided by the LURK Client.
9. With a `rsa_master_with_poh`, the LURK Server checks the Finished message is checked as defined in [\[RFC5246\] section 7.4.9](#). In case of mismatch returns an "invalid\_finished" error.
10. The LURK Server returns a master secret in a `TLS12RSAMasterResponsePayload`.
11. Error are expected to provide the LURK Client an indication of the cause that resulted in the error. When an error occurs the LURK Server MAY ignore the request, or provide more generic error codes such as "undefined\_error" or "invalid\_format".

## [5.](#) `rsa_extended_master`, `rss_extended_master_with_poh`

A exchange of type "`rsa_extended_master`" enables the LURK Client to delegate the RSA Key Exchange and authentication. The LURK Server returns the extended master secret as defined in [[RFC7627](#)].

### [5.1.](#) Request Payload

The "`rsa_extended_master`" request has the following structure:

```
enum { sha256 (0), (255) } FreshnessFunct
```

```
enum { null(0), sha256_128(1), sha256_256(2),  
(255) }POOPRF
```

```
struct {  
    KeyPairID key_id  
    FreshnessFunct freshness_funct          // see RFC5246 section 6.1  
    opaque handshake_messages<2...2^16-2> // see RFC7627 section 4  
}TLS12ExtendedMasterRSARequestPayload;
```

The "`rsa_extended_master_with_poh`" request has the following structure:

```
struct {  
    KeyPairID key_id  
    FreshnessFunct freshness_funct          // see RFC5246 section 6.1  
    opaque handshake_messages<2...2^16-2>  
                                         // see RFC5246 section 7.4.9  
    Finished finished  
}  
}TLS12ExtendedMasterRSAWithPoHRequestPayload;
```

`key_id`, `freshness_funct`, `option`, `handshake`, `finished` are defined in [Section 4.1](#).

handshake\_messages With a the handshake message includes are those necessary to generate a extended master secret as defined in [\[RFC7627\] section 4](#).

## [5.2](#). Response Payload

rsa\_extended\_master response payload has a similar structure as the rsa\_master response payload [Section 4.2](#).

## [5.3](#). LURK Client Behavior

The LURK Client proceeds as described in [Section 4.3](#). The main difference is that the necessary element to generate the master secret are included in the handshake and or not provided separately.

## [5.4](#). LURK Server Behavior

The LURK Server proceeds as described in [Section 4.4](#) except that the generation of the extended master is processed as described in [\[RFC7627\]](#).

## [6](#). ecdhe"

A exchange of type "ecdhe" enables the LURK Client to delegate the ECDHE\_RSA [\[RFC5246\]](#) or the ECDHE\_ECDSA [\[RFC8422\]](#) authentication.

### [6.1](#). Request Payload

The "ecdhe" request payload has the following structure:

```
enum { null(0), sha256_128(1), sha256_256(2),
(255) }POOPRF

struct {
    POOPRF poo_prf;
    select( poo_prf ) {
        case ( "null" ):
        case ( "sha256_128" )
            ECPoint vG; //RFC8422 section 5.4
```

```

        opaque R[16] r;
    case ( "sha256_256" ):
        ECPPoint vG; //RFC8422 section 5.4
        opaque R[32] r;
    }
} TLS12P00Params;

struct {
    KeyPairID key_id;
    FreshnessFunct freshness_funct;
    Random client_random; // see RFC5246 section 7.4.1.2
    Random server_random;
    SignatureAndHashAlgorithm sig_and_hash //RFC 5246 section 4.7
    ServerECDHParams ecdhe_params; // RFC8422 section 5.4
    POOParams poo_params;
} TLS12ECDHERequestPayload;

```

key\_id, freshness\_funct, client\_random, server\_random is defined in [Section 4.1](#).

ecdhe\_params contains as defined in [\[RFC8422\] section 5.4](#), the elliptic curve domain parameters associated with the ECDH public key (defined by the ECPParameters structure) and the ephemeral ECDH public key (defined by the ECPPoint structure). The public key is also noted in this document bG with b is a random secret generated by the LURK Client and G the base point of the curve.

poo\_params defines the necessary parameters to provide a proof of

ownership of the ECDHE private key. This option is intended to prevent the LURK Server to sign bytes that do not correspond to a ECDHE public key.

poo\_prf pseudo random function used to generate the necessary randoms to proof ownership of the private key. This document defines sha256\_128 and sha256\_256 which apply the sha256 hash function and respectively return the 128 or 256 first bits of the resulting hash.

vG are the necessary points to generate the proof of ownership.

$r$  necessary value to create the proof of ownership.

The proof of ownership (PoO) consists in the LURK Client proving the knowledge of the private random  $b$ , while not disclosing  $b$ . With  $G$  the base point,  $bG$  represents the public value. The PoO is based on the non-interactive variant of the three-pass Schnorr identification scheme (NIZR) also designated as the Fiat-Shamir transformation described in [RFC8235]. More specifically, the LURK Client randomly generates  $v$  and then derive  $c$  and  $r = v - b \cdot c$ . The LURK Client provides  $bG$ ,  $vG$ , and  $r$  to the LURK Servers. The LURK Server first checks  $bG$  is on the curve. Then it computes  $c$  similarly to the LURK Client as well  $S = rG + (bG)c$ . This latest value  $S$  is compared to  $vG$ . The equality between  $S$  and  $vG$  proves the ownership of  $b$ .

$v$  is randomly generated by the LURK Client.  $v$  MUST remain non-predictable with a length equivalent to the expected level of security, that is 128 bit length (resp. 256 bit length) for a 128 (resp 256) bit security level. Given  $b$ , we RECOMMEND  $v$  to be at least half the size of  $b$ .

$c$  is computed by the LURK Client and the LURK Server as described in [RFC8235]. UserID is defined by the concatenation of the client\_random and the server\_random. OtherInfo is defined as the concatenation of key\_id, freshness\_funct, sig\_and\_hash, ecdhe\_params, "tls12 poo". Each concatenated item is prefixed with a 4-byte integer that represents the byte length of the item.

```
UserID = client_random || server_random
OtherInfo = key_id || freshness_funct || sig_and_hash ||
            ecdhe_params || "tls12 poo"
c = poo_prf(G || vG || bG || UserID || OtherInfo)
```

The LURK Client provides  $bG$  in ecdhe\_params and  $vG$  as well as  $r$  in poo\_params.

With X25519 or X448,  $b$  and  $r$  MUST be clamped and  $vG$  MUST use the Curve25519 (resp. Curve448).  $bG$  MAY also use the Curve25519 or Curve448 representation, or the LURK Server MAY derive  $bG$  values from the provided xlined value in ecdhe\_params.



## [6.2.](#) Response Payload

The "ecdhe" response payload has the following structure:

```
struct {  
    Signature signed_params; // RFC8422 section 5.4  
} TLS12ECDHEResponsePayload;
```

signed\_params signature applied to the hash of the ecdhe\_params as well as client\_random and server\_random as described in

[RFC8422] [section 5.4](#).

## [6.3.](#) LURK Client Behavior

The LURK Client builds the base as described in [Section 4.1](#) and in [Section 6.1](#).

Upon receiving the response payload, the LURK Client MAY check the signature. If the signature does not match an error SHOULD be reported.

## [6.4.](#) LURK Server Behavior

Upon receiving an ecdhe request, the LURK Server proceeds as follows:

1. perform steps 1 - 6 as described in [Section 4.4](#)
2. The LURK Server performs some format check of the ecdhe\_params before signing them. If the ecdhe\_params does not follow the expected structure. With the notations from [[RFC8422](#)], if curve\_type is not set to "named\_curve", the LURK Server SHOULD respond with an "invalid\_ec\_type" error. If the curve or namedcurve is not supported the LURK Server SHOULD be able to respond with an "invalid\_ec\_curve" error.
3. The LURK Server processes the poo\_params. If the poo\_prf is not supported, the LURK Extension returns a "invalid\_poo\_prf" status. If poo\_prf is supported and different from "null", the LURK Server proceeds to the proof of ownership as described in [Section 6.1](#). If the proof is not properly verified, the LURK Extension returns a "invalid\_poo" status.

4. The LURK Server processes the base structure as described in [Section 4.4](#)
5. The LURK Server generates the signed\_params.

Error are expected to provide the LURK Client an indication of the cause that resulted in the error. When an error occurs the LURK Server MAY ignore the request, or provide more generic error codes such as "undefined\_error" or "invalid\_format".

## [7.](#) capabilities

A exchange of type "capabilities" enables the LURK Client to be informed of the supported operations performed by the LURK Server. The supported parameters are provided on a per type basis.

### [7.1.](#) Request Payload

A LURK "capabilities" request has no payload.

### [7.2.](#) Response Payload

The "capabilities" response payload lists for each supported type, the supported certificates, the supported signatures and hash associated. The "capabilities" payload has the following structure:

```
struct{
    CertificateType certificate_type // RFC8442 section 4.4.2
    select (certificate_type) {
        case RawPublicKey:
            /* From RFC 7250 ASN.1_subjectPublicKeyInfo */
            opaque ASN1_subjectPublicKeyInfo<1..2^24-1>;
        case X509:
            opaque cert_data<1..2^24-1>;
    };
} TypedCertificate;

struct {
    KeyPairID key_id_type_list<0..255>;
    TypedCertificate typed_certificate_list<0..255>
    FreshnessFuncList freshness_func_list<0..255>
    CipherSuites cipher_suite_list<0..255>
    PRFHash prf_hash_list<0..255>
} TLS12RSACapability;
```

```
struct {
```

```
    KeyPairID key_id_type_list<0..255>;
    TypedCertificate typed_certificate_list<0..255>
    FreshnessFuncList freshness_func_list<0..255>
    CipherSuites cipher_suite_list<0..255>
    SignatureAndHashAlgorithm sig_and_hash_list<0..255>
    NameCurve ecdsa_curves_list<0..255>;
    NameCurve ecdhe_curves_list<0..255>
    POOPRF poo_prf_list<0..255>
} TLS12ECDHECapability;

struct {
    uint32 length;
    TLS12Type type
    Select( type ) {
        case rsa_master : TLS12RSACapability,
        case rsa_master_with_poh : TLS12RSACapability,
        case rsa_extended_master : TLS12RSACapability,
        case rsa_extended_master_with_poh : TLS12RSACapability,
        case ecdhe : TLS12ECDHECapability
    } capability ;
} TLS12Capability
```

```
struct {
    TLS12Capability capability_list;
    opaque state<32>;
} TLS12CapabilitiesResponsePayload;
```

typed\_certificate enables to contain authentication credentials of various type, such as X09 certificate or raw public key. While different, the structure is similar of CertificateEntry defined in [\[RFC8446\] section 4.4.2](#) as well as the Certificate structure defined in [\[RFC7250\]](#).

key\_id\_type\_list the supported key\_id\_type.

freshness\_func\_list designates the list of freshness\_func ( see [Section 4.1](#)).

certificate\_list designates the certificates associated to message

type. The format is similar but different from the CertificateEntry defined in [\[RFC8446\]](#) in [section 4.4.2](#) and [\[RFC7250\] section 1](#). The CertificateBis format enables the use of X509 as well as Raw Public key, while the Certificate structure defined in [\[RFC5246\] section 7.4.2](#) does not.

sig\_and\_hash\_list designates supported signature algorithms as well

as PRF used for the different operations. The format is defined in [\[RFC5246\] section 7.4.1.4.1](#).

ecdsa\_curves\_list the supported signatures

ecdhe\_curves\_list the supported curves for ECHDE parameters.

poo\_prf\_list the supported message type poo\_prf ( see [Section 6.1](#). to be used with the proof of ownership.

type\_list the supported message type of the LURK extension.

state characterizes the configuration associated to 'tls12' on the LURK Server..

### [7.3.](#) LURK Client Behavior

The LURK Client performs a capability request in order to determine the possible operations.

The LURK Client is expected to keep the state value to be able to detect a change in the LURK Server configuration when an error occurs.

### [7.4.](#) LURK Server Behavior"

Upon receiving a capabilities request, the LURK Extension MUST return the capabilities payload associated to a "success" status to the LURK Server. These information are then forwarded by the LURK Server to the LURK Client.

## [8.](#) ping

A exchange of type "ping" enables the LURK Client to check the reachability in a context of the defined LURK Extension.

#### [8.1.](#) Request Payload

A "ping" request has no payload.

#### [8.2.](#) Response Payload

A "ping" response has no payload.

#### [8.3.](#) LURK Client Behavior

The LURK Client sends a "ping" request to test the reachability of the LURK Server. The reachability is performed for the tls12 LURK Extension.

#### [8.4.](#) LURK Server Behavior

Upon receiving a ping request, the LURK Extension MUST return the ping response associated with a "success" status to the LURK Server. These information are then forwarded by the LURK Server to the LURK Client.

### [9.](#) Security Considerations

The security considerations defined in [[I-D.mgmt-lurk-lurk](#)] applies to the LURK Extension "tls12" defined in this document.

Anti-replay mechanisms rely in part on the security of channel between the LURK Client and the LURK Server. As such the channel between the LURK Client and the LURK Server MUST be ensuring confidentiality and integrity. More specifically, the exchanges between the LURK Client and the LURK Server MUST be an encrypted with authentication encryption, and the two parties had previously mutually authenticated.

The LURK Extension "tls12" is expected to have response smaller than the request or at least not significantly larger, which makes "tls12" relatively robust to amplification attacks. This is especially matters when LURK is using UDP. The use of an authenticated channel reduces also the risk of amplification attacks even when UDP is being used.

The LURK Client and the LURK Server use time in their way to generate the server\_random. Care MUST be taken so the LURK Client and LURK Server remain synchronized.

### [9.1.](#) RSA

The rsa\_master and rsa\_extended\_master returns the master\_secret instead of the premaster. The additional hashing operation necessary to generate the master secret is expected to improve the protection of the RSA private key against cryptographic analysis based on the observation of a set of clear text and corresponding encrypted text.

The standard TLS1.2 is robust against Bleichenbacher attack as it provides no means to detect if the error comes from a TLS version mismatch or from the premaster format. This properties remain with LURK, and so LURK does not present vulnerabilities toward Bleichenbacher attack, and cannot be used as a decryption oracle.

### [9.2.](#) ECDHE

A passive attacker observing the ecdhe exchange may collect a sufficient amount of clear text and corresponding signature to perform a cryptographic analysis or to reuse the signature for other purposes. As a result, it remains important to encrypt the ecdhe exchange between the LURK Client and the LURK Server. Note that this vulnerability is present in TLS 1.2 as a TLS Client can accumulate these data as well. The difference with LURK is by listening the LURK Server, the accumulation is achieved for all TLS Clients.

As previously mentioned, the LURK Server may be used as signing oracle for the specific string:

```
SHA(ClientHello.random + ServerHello.random +  
    ServerKeyExchange.params);
```

More specifically, the ECDHE\_RSA and ECDHE\_DSA mechanisms does not associate the signature to a TLS1.2 context. As a result, an attacker could re-used the signature in another context.

The attack may operate by collecting a large collection of clear text and their corresponding signature. When the attacker want to provide a signature, it checks in its database, a match occurs between the two contents to be signed. The probability of a collision increases with number of available hashes. The attack is related the pre-image and collision resistance properties of the hash function.

The attacker may also given a clear text to be signed, generate a collision such that a collision occurs which provides is related to the second pre-image and collision resistance property of the hash function.

The surface of attack is limited by:

- \* limiting the possibility of aggregating a collection of clear text and their corresponding signatures. This could be achieved by using multiple LURK Clients using an encrypted channel between the LURK Client and the LURK Server.

- \* increasing the checks and ensure that signature is performed in a TLS 1.2 context. For that purpose it is RECOMMENDED the LURK Server checks the consistency of its input parameters. This includes the proof of ownership as well as the format of the randoms and ecdhe\_params for example.
- \* limiting the usage of a Cryptographic material to a single usage, in our case serving TLS 1.2.

### [9.3.](#) Perfect Foward Secrecy

This document uses sha256 as the freshness\_funct, in order to achieve

PFS [Section 4.1.1](#) as described above. By construction of the `server_random`, of the output of `freshness_funct` we will keep only the last 28 bytes. The PFS property is in place as long as this truncated version of `freshness_funct` can be considered a CRHF and that the 28 bytes of randomness carried by the `server_random` are sufficient. Otherwise, the mechanism described in this document will not be considered as safe.

Details on the truncation will be added. Alternatively, we could use a hash function like SHA3 (or, more explicitly SHAKE) which considers variable output length as part of its design. The SHAKE functions allow arbitrary output lengths and the PFS-input `S` can be of arbitrary length too. However, for SHAKE128-d, if the truncated output is of length `d` as low as 224 bits (28 bytes), then one only gets  $224/2=112$  bits security w.r.t. collision-resistance,  $> 112$  bits w.r.t. preimage resistance and 112 bits security w.r.t. second preimage resistance.

One reason why we have the hash-based solution to is to reduce communication costs between the LURK Client and the LURK Server, whilst still getting more than some security w.r.t. a MiM corrupting a LURK Client and then attempting a PFS attack.

But, if we disregard the overhaed on communication costs, we can consider other mechanisms not based on CRHF for attaining PFS security. See I and II below.

I. For example, as `freshness_funct`, one can use an instance of a pseudo random function (PRF), keyed on a key `K` that the LURK Server already shares with the LURK Client. I.e., `server_random=freshness_funct(S;K)`. In this case, the mechanisms to achieve PFS are as follows: 1. The LURK Client and the LURK Server run a key-establishment protocol before every LURK session to establish such a new key `K` for every LURK session. Alternatively, the export this key of the key-establishment run to secure the channel. The time-to-live of `K` is one session only. 2. The LURK

Server generates the value `S` on its side and send the `server_random` to the LURK Client. 3. The LURK Client uses this `server_random` with the TLS Client 4. The LURK Server checks the correctness of the use of the said `server_random` when the query for the `master_secret` is made, with the messages forwarded therein;



II. In fact, since the channel between the LURK Client and the LURK Server MUST be encrypted by default, all for 2 steps in point I above can be combined into 1 step (without the need of a specially executed key-establishment): a. the LURK Server sends the server\_random to the LURK Client. b. the LURK Client uses this server\_random with the TLS Client c. the LURK Server checks the correctness of the use of the said server\_random when the query for the master\_secret is made, with the messages forwarded therein;

Yet, option I and option II are more expensive on the communication than the version achieving PFS with a hash function. I.e., in I and II, the LURK Server needs to be involved on the first part of the TLS handshake to produce the S or server\_random for the LURK Client. However, note that the LURK Client no longer queries S, hence the risk of a man-in-the-middle querying an old S is eliminated by design.

Option II above is akin to what "Content delivery over TLS: a cryptographic analysis of keyless SSL," by K. Bhargavan, I. Boureanu, P. A. Fouque, C. Onete and B. Richard at 2017 IEEE European Symposium on Security and Privacy (EuroS&P), Paris, 2017, pp. 1-16, suggested in order to amend (forward-secrecy) attacks on Keyless SSL.

## 10. IANA Considerations

The requested information is defined in [[I-D.mglt-lurk-lurk](#)].

LURK Extension Designation: tls12 LURK Extension Reference: [RFD-TBD]  
LURK Extension Description: RSA, ECDHE\_RSA and ECDHE\_ECDSA for (D)TLS 1.2.

## LURK tls12 Extension Status

Value	Description	Reference
-----		
0 - 1	Reserved	[RFC-TBD-LURK]
2	undefined_error	[RFC-TBD]
3	invalid_payload_format	[RFC-TBD]
4	invalid_key_id_type	[RFC-TBD]
5	invalid_key_id	[RFC-TBD]
6	invalid_tls_random	[RFC-TBD]
7	invalid_freshness_funct	[RFC-TBD]
8	invalid_encrypted_premaster	[RFC-TBD]
9	invalid_finished	[RFC-TBD]
10	invalid_ec_type	[RFC-TBD]
11	invalid_ec_curve	[RFC-TBD]
12	invalid_poo_prf	[RFC-TBD]
13	invalid_poo	[RFC-TBD]
14	invalid_cipher_or_prf_hash	[RFC-TBD]
15 - 255	UNASSIGNED	

## LURK tls12 Extension Type

Value	Description	Reference
-----		
0	capabilities	[RFC-TBD]
1	ping	[RFC-TBD]
2	rsa_master	[RFC-TBD]
2	rsa_master_with_poh	[RFC-TBD]
3	rsa_extended_master	[RFC-TBD]
3	rsa_extended_master_with_poh	[RFC-TBD]
4	ecdhe	[RFC-TBD]
16 - 255	UNASSIGNED	

## 11. Acknowledgments

We would like to thank for their very useful feed backs: Yaron Sheffer, Yoav Nir, Stephen Farrell, Eric Burger, Thomas Fossati, Eric Rescorla, Mat Naslung, Rich Salz, Ilari Liusvaara, Scott Fluhrer. Many ideas in this document are from [[I-D.erb-lurk-rsalg](#)].

We would also like to thank those that have supported LURK or raised interesting discussions. This includes among others Robert Skog, Hans Spaak, Salvatore Loreto, John Mattsson, Alexei Tumarkin, Richard Brunner, Stephane Dault, Dan Kahn Gillmor, Joe Hildebrand, Kelsey Cairns.

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## [12.](#) Apendix

## LURK Exchange for TLS RSA Master Secret

TLS Client	Edge Server	Key Server
------------	-------------	------------

ClientHello

server\_version  
client\_random  
cipher\_suite  
TLS\_RSA\_\*, ...

----->

S = server\_random  
server\_random = freshness\_func( S )

ServerHello

tls\_version  
server\_random  
Cipher\_suite=TLS\_RSA  
Certificate  
RSA Public Key  
ServerHelloDone

<-----

ClientKeyExchange

EncryptedPremasterSecret

[\[ChangeCipherSpec\]](#)

Finished

----->

TLS12 Request Header

TLS12MasterRSARequestPayload

key\_id  
freshness\_func  
prf\_hash  
client\_random  
S  
EncryptedPremasterSecret

----->

server\_random = freshness\_func( S )

```

master_secret = PRF(\
pre_master_secret + \
"master secret" +\
client_random +\
server_random)[0..47];

```

```

TLS12 Response Header
TLS12MasterResponsePayload
    master
<-----

```

```

[ChangeCipherSpec]
    Finished
<-----

```

Application Data

<----->

Application Data

## [12.1.](#) LURK Exchange for TLS RSA Master Secret with Proof of Handshake

TLS Client

Edge Server

Key Server

```

ClientHello
    server_version
    client_random
    cipher_suite
        TLS_RSA_*, ...
----->

```

```

S = server_random
server_random = freshness_funct( S )

```

```

ServerHello
    tls_version
    server_random
    Cipher_suite=TLS_RSA
Certificate
    RSA Public Key
ServerHelloDone
<-----

```

```

ClientKeyExchange
    EncryptedPremasterSecret
\[ChangeCipherSpec\]

```

Finished  
----->

TLS12 Request Header  
TLS12MasterRSAWithPoHRequestPayload  
    key\_id  
    freshness\_funct  
    handshake\_messages  
    finished  
----->

server\_random = freshness\_funct( S )

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master\_secret = PRF(\  
pre\_master\_secret + \  
"master secret" +\  
client\_random +\  
server\_random)[0..47];

TLS12 Response Header  
TLS12MasterResponsePayload  
    master  
<-----

[ChangeCipherSpec]  
Finished

<-----

Application Data

<----->

Application Data

## [12.2.](#) LURK Exchange for TLS RSA Extended Master Secret

TLS Client

Edge Server

Key Server

ClientHello

tls\_version

cipher\_suite

TLS\_RSA\_\*, ...

Extension 0x0017

-----&gt;

ServerHello

edge\_server\_version

cipher\_suite=TLS\_RSA

Extension 0x0017

Certificate

RSA Public Key

ServerHelloDone

&lt;-----

ClientKeyExchange

EncryptedPremasterSecret

[\[ChangeCipherSpec\]](#)

Finished

----->

TLS12 Request Header  
TLS12ExtendedMasterRSARequestPayload  
    key\_id  
    freshness\_funct  
    handshake\_messages  
    EncryptedPreMasterSecret  
----->

1. Computing Master Secret  
master\_secret = master\_prf(  
pre\_master\_secret +\  
"extended master secret" +\  
session\_hash)[0..47]

TLS12 Response Header  
TLS12MasterPayload  
    master  
<-----

[ChangeCipherSpec]  
    Finished  
<-----

Application Data

<----->

Application Data

TLS Client

Edge Server

Key Server

ClientHello

tls\_version

cipher\_suite

TLS\_RSA\_\*, ...

Extension 0x0017



----->

ServerHello  
    edge\_server\_version  
    cipher\_suite=TLS\_RSA  
    Extension 0x0017  
Certificate  
    RSA Public Key  
ServerHelloDone  
<-----

ClientKeyExchange  
    EncryptedPremasterSecret  
    [ChangeCipherSpec]  
Finished  
----->

TLS12 Request Header  
TLS12ExtendedMasterWithPoHRequestPayload  
    key\_id  
    freshness\_func  
    handshake\_messages  
    finished  
----->

1. Computing Master Secret  
master\_secret = master\_prf(  
pre\_master\_secret +\  
"extended master secret" +\  
session\_hash)[0..47]

TLS12 Response Header  
TLS12MasterPayload  
    master  
<-----

[ChangeCipherSpec]  
Finished

<-----

Application Data

<----->

Application Data

#### 12.4. LURK Exchange for TLS ECDHE Signature

TLS Client	Edge Server	Key Server
ClientHello		
tls_version		
client_random		
cipher_suite		
TLS_ECDHE_ECDSA_*, TLS_ECDHE_RSA_*, ...		
Extension Supported EC, Supported Point Format		
----->		
	S = server_random	
	server_random = freshness_funcnt( S )	
	TLS12 Request Header	
	TLS12ECDHEInputPayload	
	key_id	
	client_random	
	S	
	ecdhe_params	
	----->	
		server_random = freshness_funcnt( S )
		signature = ECDSA( client_random + \
		server_random + ecdhe_params )
		TLS12 Response Header
		TLS12DigitallySignedPayloads
		signature
		<-----
	ServerHello	
	tls_version	
	server_random	
	Cipher_suite=TLS_ECDHE_ECDSA	
	Extension Supported EC,	
	Supported Point Format	
	Certificate	
	ECDSA Public Key	
	ServerKeyExchange	
	ecdhe_params	
	signature	
	ServerHelloDone	
	<-----	
ClientKeyExchange		
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Finished  
----->

[[ChangeCipherSpec](#)]

Finished  
<-----

Application Data

&lt;-----&gt;

Application Data

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#### Authors' Addresses

Daniel Migault  
Ericsson  
8275 Trans Canada Route  
Saint Laurent, QC 4S 0B6  
Canada

Email: [daniel.migault@ericsson.com](mailto:daniel.migault@ericsson.com)

Ioana Boureanu  
University of Surrey  
Stag Hill Campus  
Guildford  
GU2 7XH  
United Kingdom

Email: [i.boureanu@surrey.ac.uk](mailto:i.boureanu@surrey.ac.uk)