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Layer 3 Discovery and Liveness Signing
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Abstract

The Layer 3 Discovery and Liveness protocol OPEN PDU may contain a key and a certificate, which can be used to verify signatures on subsequent PDUs. This document describes two mechanisms based on digital signatures, one that is Trust On First Use (TOFU), and one that uses certificates to provide authentication as well as session integrity.

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.

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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This Internet-Draft will expire on July 30, 2021.

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1. Introduction

This draft is being published without incorporating changes from an excellent security review. This is being done so a couple of other drafts can reference it. While all comments will, of course, be appreciated, readers may want to wait for the -01 version.

The Layer 3 Discovery and Liveness protocol [I-D.ietf-lsvr-l3dl] OPEN PDU contains an algorithm identifier, a key, and a certificate, which can be used to verify signatures on subsequent PDUs. This document describes two methods of key generation and signing for use by L3DL, Trust On First Use (TOFU) and a PKI-based mechanism to provide authentication as well as session integrity.

The Key in the OPEN PDU SHOULD be the public key of an asymmetric key pair. The sender signs with the private key, of course. The device sending the OPEN may use one key for all links, a different key for each link, or some mix(s) thereof.

In the TOFU method the key sent in the OPEN PDU is generated on the sending device, is believed without question by the receiver, and used to verify all subsequent PDUs from the same sender with the same Key Algorithm.

With the PKI-mechanism, an enrollment step is performed. The public key is put into a certificate [RFC5280], which is signed by the the operational environment's trust anchor. In this way, the relying party can be confident that the public key is under control of the identified L3DL protocol entity.

To the receiver verifying signatures on PDUs, the two methods are indistinguishable; the key provided in the OPEN PDU is used to verify the signatures of subsequent PDUs. The difference that PKI-based keys may be verified against the trust anchor when the OPEN PDU is received.

In the PKI method the OPEN key MUST be verified against the trust anchor for the operational domain. The OPEN key is then used to verify all subsequent PDUs in the session.

2. Trust On First Use Method

There are three parts to using a key: signing PDUs, verifying the OPEN PDU, and verifying subsequent PDUs.

2.1. Signing a PDU

All signed PDUs are generated in the same way:

- Compose the PDU, with all fields including "Sig Algo" and "Signature Length" set, but omitting the trailing "Signature" field itself. The Certificate Length should be zero and the Certificate field should be empty. This is the "message to be signed" for purposes of the signature algorithm.

- Generate the signature as specified for the chosen signature suite, using the private member of the asymmetric key pair. In general this will involve first hashing the "message to be signed" then signing the hash, but the precise details may vary with the specific algorithm. The result will be a sequence of octets, the length of which MUST be equal to the setting of the "Signature Length" field.

- Construct the complete message by appending the signature octets to the otherwise complete message composed above.

In the case of the OPEN PDU, the message to be signed will include the public member of the asymmetric keypair, but as far as the signature algorithm is concerned that's just payload, no different from any other PDU content.

2.2. Verifying the OPEN PDU

The process for verifying an OPEN PDU is slightly different from the process for verifying other PDU types, because the OPEN PDU also establishes the session key.

- Verify that the PDU is syntactically correct, and extract the Auth Type, Key, Sig Type, and Signature fields.

- Verify that Auth Type and Sig Type refer to the same algorithm suite, and that said algorithm suite is one that the implementation understands.

- Construct the "message to be verified" by truncating the PDU to remove the Signature field (in practice this should not require copying any data, just subtract the signature length from the PDU length).

- Verify the message constructed above against the public key using the rules for the specific signature suite.

- Record Auth Type and Key as this sessions's authentication type and session key, for use in verifying subseuqent PDUs.

If any of the above verification steps fail, generate an error using error code 2 ("Authorization failure in OPEN").

2.3. Verifying Other PDUs

The process for verifying non-OPEN PDUs is slightly simpler, but follows the same basic pattern as for OPEN PDUs.

- Verify that the PDU is syntactically correct, and extract the Sig Type and Signature fields.

- Verify that Sig Type refers to the same algorithm suite as the Auth Type recorded during verification of the OPEN PDU.

- Construct the "message to be verified" by truncating the PDU to remove the Signature field.

- Verify the message constructed above against the recorded session key using the rules for the specific signature suite.

If any of the above verification steps fail, generate an error using error code 3 ("Signature failure in PDU").

3. Public Key Infrastructure Method

Using a PKI, [RFC5280], is almost the same as using TOFU, but with one additional step: during verification of an OPEN PDU, after extracting the Key field from the PDU but before attempting to use it to verify the PDU's signature, the receiver MUST verify the received key against the PKI to confirm that it's an authorized key.

Generating an OPEN PDU using the PKI method requires a certificate, which must be supplied via out of band configuration. The certificate is a signature of the public key to be sent in the Key field of the OPEN PDU, signed by the trust anchor private key.

Verifying an OPEN PDU using the PKI method requires the public key of the trust anchor, which the receiver uses to verify the certificate, thereby demonstrating that the supplied is represents an authorized L3DL speaker in this administrative domain.

We use the term "certificate" here in the generic sense. These are not X.509 certificates: X.509 is much more complicated than we need for L3DL. The certificates used here are just signatures of one key (the session key supplied in the Key field of the OPEN PDU) by another key (the trust anchor).

3.1. Signing OPEN PDU with PKI

Generating and signing the OPEN PDU with the PKI method is almost the same as in Section 2.1. The only difference is that the PKI method MUST supply the appropriate certificate in the Certificate field.

Note that the Auth Type field applies to both the Key and Certificate fields. That is: the certificate uses the same certificate suite as the session keys, L3DL does not support cross-algorithm-suite certification.

3.2. Verifying OPEN PDU with PKI

Verifying the OPEN PDU with PKI is similar to verifying with TOFU as described in Section 2.2, but includes one critical extra step:

After extracting the Key field from the PDU but before verifying the Signature, extract the Certificate field and verfiy that the

Certificate is a valid signature of the Key field, according to the rules for the signature suite specified by Auth Type. If this step fails, handle as in Section 2.2.

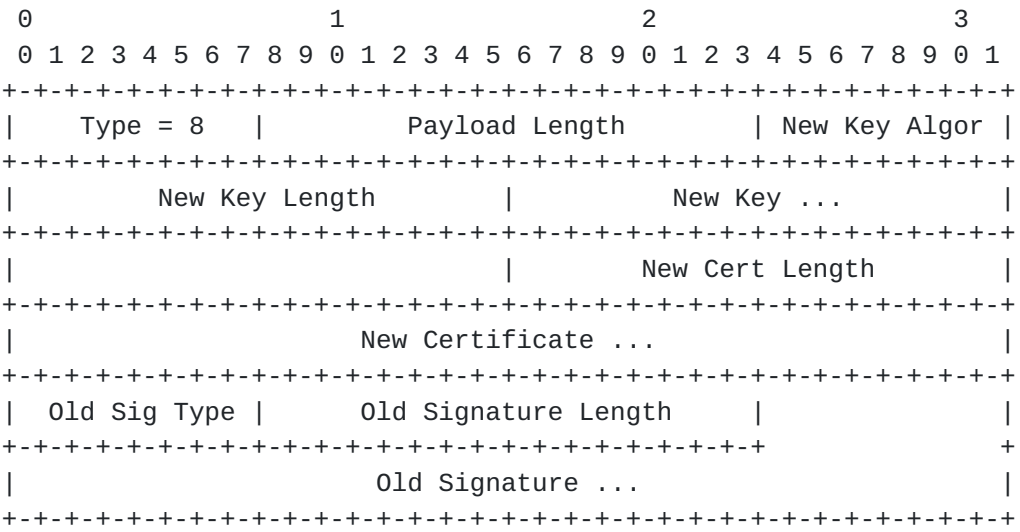
4. Local Policy

Whether to use TOFU, PKI, or no signatures at all is a matter of local policy, to be decided by the operator. The useful policy combinations for Key and Certificate are probably:

- Not signing: sender need not sign, receiver does not check.
- Require TOFU: sender MUST supply key and receiver MUST check, certificate not needed and ignored if sent.
- Allow TOFU: sender must supply key and receiver MUST check, receiver SHOULD check certificate if supplyed by sender.
- Require PKI: sender MUST supply key and certificate, receiver MUST check both.

5. NEWKEY, Key Roll

Modern key management allows for agility in 'rolling' to a new key or even algorithm in case of key expiry, key compromise, or merely prudence. Declaring a new key with an L3DL OPEN PDU would cause serious churn in topology as a new OPEN may cause a withdraw of previously announced encapsulations. Therefore, a gentler rekeying is needed.



The New Key Type, New Key Length, New Key, New Cert Length, and New Certificate field declare the replacement algorithm suite, key, and certificate.

The NEWKEY PDU is signed using the current (soon to be old) algorithm suite and key.

The sender and the receiver should be cautious of algorithm suite downgrade attacks.

To avoid possible race conditions, the receiver SHOULD accept signatures using either the new or old key for a configurable time (default 30 seconds). This is intended to accommodate situations such as senders with high peer out-degree and a single per-device asymmetric key.

If the sender does not receive an ACK in the normal window, including retransmission, then the sender MAY choose to allow a session reset by either issuing a new OPEN or by letting the receiver eventually have a signature failure (error code 3) on a PDU.

The rekeying operation changes the session key and algorithm suite described in Section 2.3. The NEWKEY PDU itself is verified using the old algorithm and session key, subsequent PDUs are verified with the new algorithm and session key recorded after the NEWKEY PDU has been accepted.

6. Security Considerations

The TOFU method requires a leap of faith to accept the key in the OPEN PDU, as it can not be verified against any authority. Hence it is jokingly referred to as Married On First Date. The assurance it does provide is that subsequent signed PDUs are from the same peer. And data integrity is a positive side effect of the signature covering the payload.

The PKI-based method offers assurance that the certificate, and hence the keying material, provided in the OPEN PDU are authorized by a central authority, e.g. the network's network security team. The onward assurance of talking to the same peer and data integrity are the same as in the TOFU method.

With the PKI-based method, automated device provisioning could restrict which certificates are allowed from which peers on a per interface basis. This would complicate key rolls. Where one draws the line between rigidity, flexibility, and security varies.

The REKEY PDU is open to abuse to create an algorithm suite downgrade attack.

7. IANA Considerations

This document requests the IANA create a new entry in the L3DL PDU Type registry as follows:

PDU Code	PDU Name
8	NEWKEY

This document requests the IANA add registry entries for "TOFU - Trust On First Use" and "PKI" to the L3DL-Signature-Type registry as follows:

Number	Name
1	TOFU - Trust On First Use
2	PKI

8. Acknowledgments

The authors thank Russ Housley for advice and reviews.

9. Normative References

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