Layer 3 Discovery and Liveness Signing
draft-ymbk-lsvr-l3dl-signing-00

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

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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 [old ref because new
   draft not yet pushed] [I-D.ietf-lsvr-l3dl] OPEN PDU contains an
   algorithm specifier, 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 aggregation(s) thereof.

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

With the PKI-mechanism, an enrollment step is performed. The public
key is put into a certificate, 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. It 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:

o Compose the PDU, with all fields including "Sig Type" 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.

o 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.

   o 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.

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

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

   o 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).

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

   o 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.

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

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

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

o 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 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 I3DL. 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.
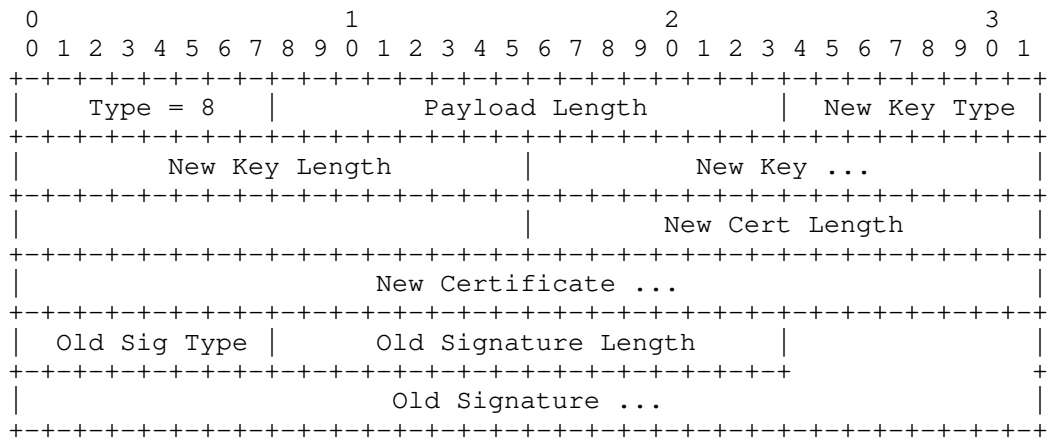
4. Local Policy

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:

o Not signing: sender need not sign, receiver does not check.

o Require TOFU: sender MUST supply key and receiver MUST check, certificate not needed and ignored if sent.

o Allow TOFU: sender must supply key and receiver MUST check, receiver SHOULD check certificate if supplyed by sender.

o 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.

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|   Type = 8    |          Payload Length       | New Key Type  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|        New Key Length          |          New Key ...         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                               |          New Cert Length      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                       New Certificate ...                     |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Old Sig Type  |     Old Signature Length      |              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+              +
|                        Old Signature ...                     |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

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 a registry entry for "TOFU - Trust On First Use" to the L3DL-Signature-Type registry as follows:

          Number   Name
          ------   ------------------
             1   TOFU - Trust On First Use
             2   PKI

8. Acknowledgments

   The authors than Russ Housley for advice and review.

9. Normative References

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