      Synchronizing Service Boundaries and <mapping> Elements Based on the
               Location-to-Service Translation (LoST) Protocol

Abstract

   The Location-to-Service Translation (LoST) protocol is an XML-based
   protocol for mapping service identifiers and geodetic or civic
   location information to service URIs and service boundaries. In
   particular, it can be used to determine the location-appropriate
   Public Safety Answering Point (PSAP) for emergency services.

   The <mapping> element in the LoST protocol specification encapsulates
   information about service boundaries and circumscribes the region
   within which all locations map to the same service Uniform Resource
   Identifier (URI) or set of URIs for a given service.

   This document defines an XML protocol to exchange these mappings
   between two nodes. This mechanism is designed for the exchange of
   authoritative <mapping> elements between two entities. Exchanging
   cached <mapping> elements, i.e., non-authoritative elements, is
   possible but not envisioned. Even though the <mapping> element
   format is reused from the LoST specification, the mechanism in this
   document can be used without the LoST protocol.

Status of This Memo

Copyright Notice

Table of Contents

1. Introduction

   Since the early days of emergency services, there has been a desire
   to route emergency calls to Public Safety Answering Points (PSAPs)
   that are nearest to the location of the emergency caller. For this
   purpose each PSAP discloses one or more service boundaries so that
   this information can be used to select the appropriate PSAP and to
   route the call to it. RFC 5222 [RFC5222] defines this data structure
   in the following way:

      A service boundary circumscribes the region within which all
      locations map to the same service URI or set of URIs for a given
      service. A service boundary may consist of several non-contiguous
      geometric shapes.

   RFC 5222 [RFC5222] also specifies the data structure itself as the
   <mapping> element.

   This document reuses this existing data structure and defines an XML-
   based protocol to exchange authoritative service boundaries between
   two entities, namely, the LoST Sync source and the LoST Sync
   destination. This protocol can be used whether or not the LoST
   protocol is used for querying for service boundary information.

   The rest of the document is structured as follows. Section 3 starts
   with an example usage of the LoST protocol. In Sections 4, 5, 6, and
   7, we describe the protocol semantics, transport considerations, and
   the schema. Finally, we conclude with operational, security, and
   IANA considerations in Sections 8, 9, and 10.

2. Terminology

   The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT",
   "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this
   document are to be interpreted as described in RFC 2119 [RFC2119].

   This document reuses terminology introduced by the mapping
   architecture document [RFC5582], such as 'coverage region', 'forest
   guide', 'mapping', and 'authoritative mapping server'. This document
   also uses the term 'ESRP', defined in [RFC5012].

   Throughout this document, we use the terms 'LoST Sync source' and
   'LoST Sync destination' to denote the protocol endpoints of the
   exchange. The protocol is referred to as 'LoST Sync' within the
   text.

3. A Motivating Example

   The LoST Sync mechanism can, for example, be used in the LoST
   architecture, as specified in [RFC5582]. There, LoST servers
   cooperate to provide an ubiquitous, globally scalable, and resilient
   mapping service. In the LoST mapping architecture, LoST servers can
   peer, i.e., have an ongoing data exchange relationship. Peering
   relationships are set up manually, based on local policies. A LoST
   server may peer with any number of other LoST servers. Forest guides
   peer with other forest guides; authoritative mapping servers peer
   with forest guides and other authoritative servers, either in the
   same cluster or above or below them in the tree. Authoritative
   mapping servers push coverage regions "up" the tree, i.e., from child
   nodes to parent nodes. The child informs the parent of the
   geospatial or civic region that it covers for a specific service.

   Consider a hypothetical deployment of LoST in two countries, for
   example, Austria and Finland. Austria, in our example, runs three
   authoritative mapping servers labeled as 'East', 'West', and
   'Vienna', where the former two cover the entire country except for
   Vienna, which is covered by a separate LoST server. There may be
   other caching LoST servers run by ISPs, universities, and Voice
   Service Providers (VSPs), but they are not relevant for this
   illustration. Finland, on the other hand, decided to only deploy a
   single LoST server that also acts as a forest guide. For this
   simplistic illustration, we assume that only one service is
   available, namely 'urn:service:sos' since otherwise the number of
   stored mappings would have to be multiplied by the number of used
   services.

   Figure 1 shows the example deployment.

```
               +---LoST-Sync-->\\      //<--LoST-Sync----+
               |                 -----                    |
               \/                                         \/
             -----                                      -----
            //    \\                                   //    \\
           /        \                                 /        \
          |  Forest  |                               |  Forest  |
          |  Guide   |                               |  Guide   |
          |  Austria |                               |  Finland |
           \        /                                 \        /
   +-------->\\     //<--------+                        \\    //
   |          -----            |                         -----
   |           /\              |                           |
  LoST         |             LoST                     //------\\
  Sync       LoST           Sync                     |Co-Located|
   |         Sync            |                        |   LoST   |
   \/          |             \/                       |  Server  |
 //----\\      \/          //----\\                    \\------//
|  LoST  |   //----\\     |  LoST  |
|  Server|  |  LoST  |    |  Server|
| 'East' |  |  Server|    |'Vienna'|
 \\----//   | 'West' |     \\----//
            |        |
             \\----//
```

                    Figure 1: LoST Deployment Example

   The nodes are configured as follows:

   Forest Guide Austria: This forest guide contains mappings for the
      three authoritative mapping servers (East, West, and Vienna)
      describing the area for which they are responsible. Note that
      each mapping contains a service URN, and these mappings point to
      LoST servers rather than to PSAPs or Emergency Services Routing
      Proxies (ESRPs).

   LoST Server 'East': This LoST server contains all the mappings to
      PSAPs covering the eastern part of the country.

      Additionally, the LoST server aggregates all the information it
      has and provides an abstracted view towards the forest guide
      indicating that it is responsible for a certain area (for a given
      service and for a given location profile). For our example, the
      structure of a mapping is shown below:

```
<mapping
    xmlns="urn:ietf:params:xml:ns:lost1"
    xmlns:gml="http://www.opengis.net/gml"
    expires="2009-01-01T01:44:33Z"
    lastUpdated="2009-12-01T01:00:00Z"
    source="east-austria.lost-example.com"
    sourceId="e8b05a41d8d1415b80f2cdbb96ccf109">
    <displayName xml:lang="en">LoST Server 'East'</displayName>
    <service>urn:service:sos</service>
    <serviceBoundary profile="geodetic-2d">
        <gml:Polygon srsName="urn:ogc:def::crs:EPSG::4326">
            <gml:exterior>
                <gml:LinearRing>
                    <gml:pos> ... </gml:pos>
                    ..... list of coordinates for
                    boundary of LoST server 'East'
                    <gml:pos> ... </gml:pos>
                </gml:LinearRing>
            </gml:exterior>
        </gml:Polygon>
    </serviceBoundary>
    <uri/>
</mapping>
```
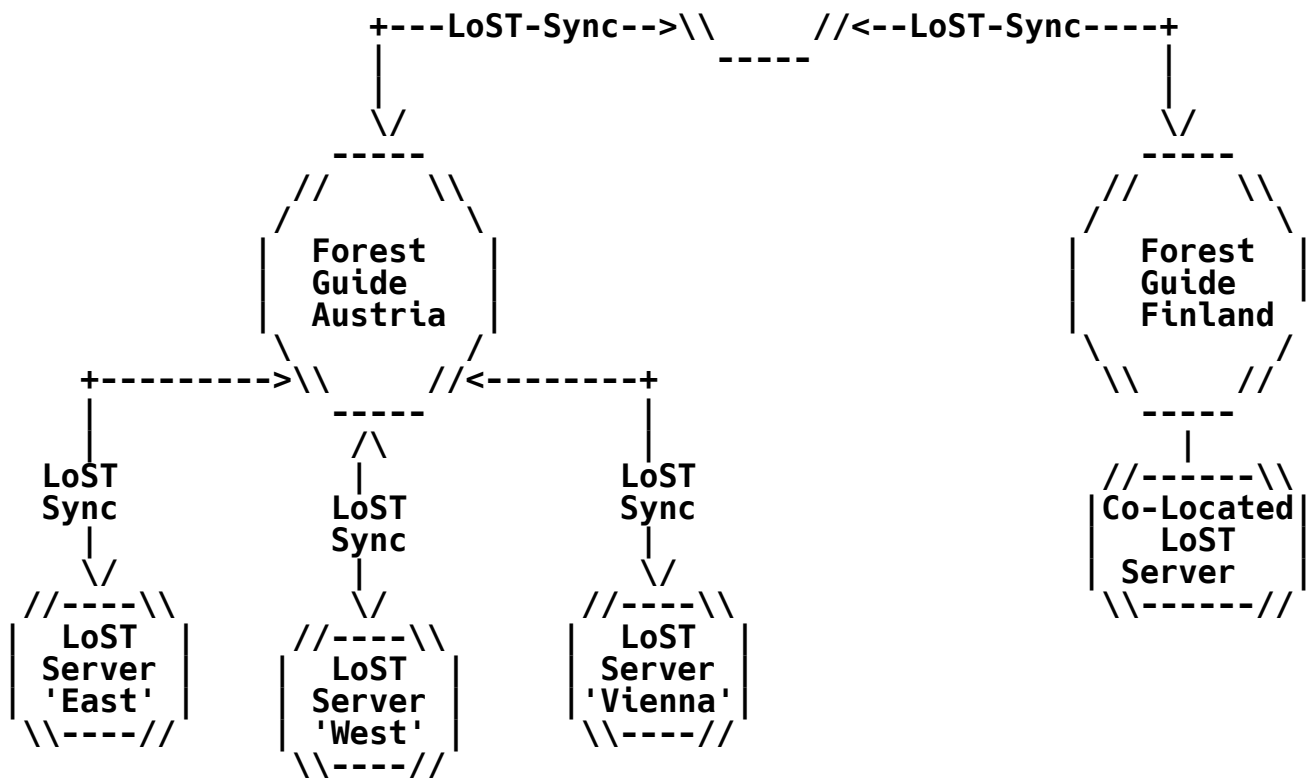
           Figure 2: Forest Guide Austria Mapping XML Snippet

   Note that the XML code snippet in Figure 2 serves illustrative
   purposes only and does not validate. As can be seen in this
   example, the <uri> element is absent, and the 'source' attribute
   identifies the LoST server, namely "east-austria.lost-
   example.com".

   The mapping shown above is what is the LoST server "east-
   austria.lost-example.com" provides to the Austrian forest guide.

LoST Server 'West': This LoST server contains all the mappings to
   PSAPs covering the western half of the country.

LoST Server 'Vienna': This LoST server contains all the mappings to
   PSAPs for the city of Vienna.

Forest Guide Finland: In our example, we assume that Finland deploys
   a single ESRP for the entire country as their IP-based emergency
   services solution. There is only a single LoST server, and it is
   co-located with the forest guide, as shown in Figure 1. The
   mapping data this forest guide (FG) then distributes via LoST Sync
   is shown in Figure 3.

```
<mapping xmlns="urn:ietf:params:xml:ns:lost1"
    expires="2007-01-01T01:44:33Z"
    lastUpdated="2006-11-01T01:00:00Z"
    source="finland.lost-example.com"
    sourceId="7e3f40b098c711dbb6060800200c9a66">
    <displayName xml:lang="en">Finland ESRP</displayName>
    <service>urn:service:sos</service>
    <serviceBoundary profile="civic">
        <civicAddress
            xmlns="urn:ietf:params:xml:ns:pidf:geopriv10:civicAddr">
            <country>FI</country>
        </civicAddress>
    </serviceBoundary>
    <uri/>
</mapping>
```

             Figure 3: Forest Guide Finland Mapping XML Snippet

   An example mapping stored at the co-located LoST server is shown
   in Figure 4.

```
<mapping xmlns="urn:ietf:params:xml:ns:lost1"
    expires="2007-01-01T01:44:33Z"
    lastUpdated="2006-11-01T01:00:00Z"
    source="finland.lost-example.com"
    sourceId="7e3f40b098c711dbb6060800200c9a66">
    <displayName xml:lang="en">Finland ESRP</displayName>
    <service>urn:service:sos</service>
    <serviceBoundary profile="civic">
        <civicAddress
            xmlns="urn:ietf:params:xml:ns:pidf:geopriv10:civicAddr">
            <country>FI</country>
        </civicAddress>
    </serviceBoundary>
    <uri>sip:esrp@finland-example.com</uri>
    <uri>xmpp:esrp@finland-example.com</uri>
    <serviceNumber>112</serviceNumber>
</mapping>
```

        Figure 4: Forest Guide Finland / Co-Located LoST Server Mapping
                               XML Snippet

   The LoST Sync mechanism described in this document can be run between
   the two forest guides. That way, the three mappings stored in the FG
   Austria are sent to the FG Finland, and a single mapping in the FG
   Finland is sent to the FG Austria. Additionally, the three Austrian
   LoST servers could utilize LoST Sync to inform the Austrian FG about
   their boundaries. These three authoritative mapping servers in

Austria would be responsible for maintaining their own mapping
information. Since the amount of data being exchanged is small and
the expected rate of change is low, the nodes are configured to
always exchange all their mapping information whenever a change
happens.

This document defines two types of exchanges, which are best
described by the exchange between two nodes as shown in Figures 5 and
6. The protocol exchange always runs between a LoST Sync source and
a LoST Sync destination. Node A in the examples of Figures 5 and 6
has mappings that Node B is going to retrieve. Node A acts as the
source for the data and Node B is the destination.

The <getMappingsRequest> request allows a LoST Sync source to request
mappings from a LoST Sync destination.

```
   +---------+                    +---------+
   | Node B  |                    | Node A  |
   | acting  |                    | acting  |
   | as      |                    | as      |
   | LoST    |                    | LoST    |
   | Sync    |                    | Sync    |
   | Dest.   |                    | Source  |
   +---------+                    +---------+
        |                              |
        |                              |
        |                              |
        |   <getMappingsRequest>       |
        |----------------------------->|
        |                              |
        |   <getMappingsResponse>      |
        |<-----------------------------|
        |                              |
        |                              |
        |                              |
```
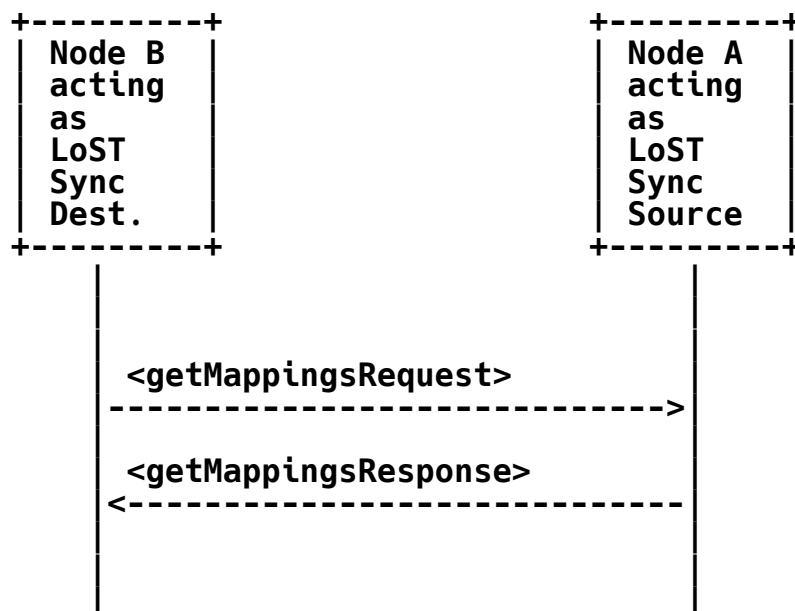
     Figure 5: Querying for Mappings with a <getMappingsRequest> Message

Note that in the exchange illustrated in Figure 5, Node B is issuing
the first request and plays the role of the HTTPS client, and Node A
plays the role of the HTTPS server.

In Figure 6, the <pushMappingsRequest> exchange allows a LoST Sync
source to push mappings to a LoST Sync destination. In this example,
we assume that Node A has been configured maintain state about the
mappings it had pushed to Node B.

This document does not define a publish/subscribe mechanism. Such a
mechanism would allow Node B to tell Node A what mappings it is
interested in. This document also does not define a mechanism for
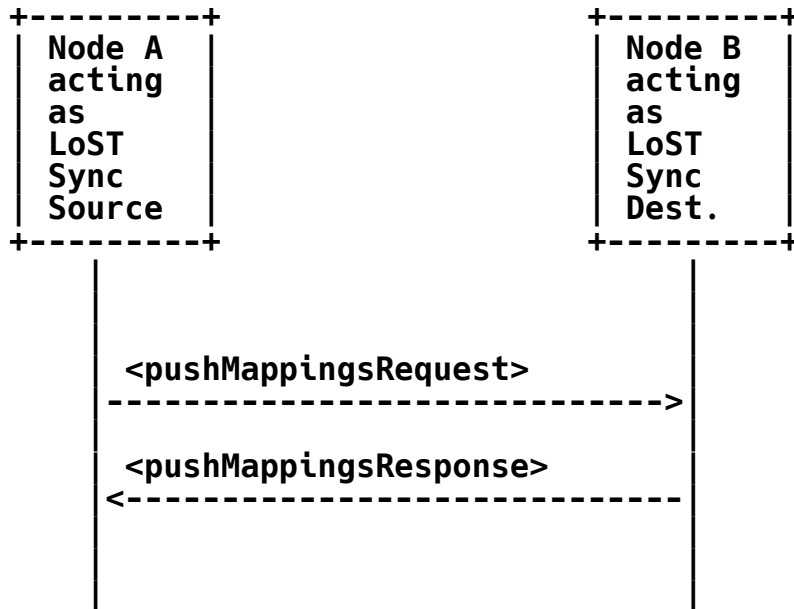nodes to find out to which other entities mappings have to be pushed.

```
       +---------+                      +---------+
       | Node A  |                      | Node B  |
       | acting  |                      | acting  |
       | as      |                      | as      |
       | LoST    |                      | LoST    |
       | Sync    |                      | Sync    |
       | Source  |                      | Dest.   |
       +---------+                      +---------+
            |                                |
            |                                |
            |                                |
            |   <pushMappingsRequest>        |
            |------------------------------->|
            |                                |
            |   <pushMappingsResponse>       |
            |<-------------------------------|
            |                                |
            |                                |
            |                                |
```

        Figure 6: Pushing Mappings with a <pushMappingsRequest> Message

   Node A issuing the first request in Figure 6 plays the role of the
   HTTPS client, and Node B plays the role of the HTTPS server.

4. Querying for Mappings with a <getMappingsRequest>/
    <getMappingsResponse> Exchange

4.1. Behavior of the LoST Sync Destination

   A LoST Sync destination has two ways to retrieve <mapping> elements
   from a LoST Sync source.

   1. When the Lost Sync destination does not have any mappings, it
       submits an empty <getMappingsRequest> message, as shown in
       Figure 7. This indicates that it wishes to retrieve all mappings
       from the LoST Sync source. Note that the request does not
       propagate further to other nodes.

   2. In case a LoST Sync destination node has already obtained
       mappings in previous exchanges, then it may want to check whether
       these mappings have been updated in the meanwhile. The policy
       regarding when to poll for updated mapping information is outside
       the scope of this document. The <getMappingsRequest> message
       with one or more <exists> child element(s) allows the source to
       only return mappings that are missing at the destination or have
       been updated.

   After issuing the <getMappingsRequest> message, the LoST Sync
   destination waits for the <getMappingsResponse> message. In case of
   a successful response, the LoST Sync destination stores the received
   mappings and determines which mappings to update.

4.2. Behavior of the LoST Sync Source

   When a LoST Sync source receives an empty <getMappingsRequest>
   message, then all locally available mappings MUST be returned.

   When a LoST Sync source receives a <getMappingsRequest> message with
   one or more <exists> child element(s), then it MUST consult with the
   local mapping database to determine whether any of the mappings of
   the client is stale and whether there are mappings locally that the
   client does not yet have. The former can be determined by finding
   mappings corresponding to the 'source' and 'sourceID' attributes
   where a mapping with a more recent 'lastUpdated' date exists.

   Processing a <getMappingsRequest> message MAY lead to a successful
   response in the form of a <getMappingsResponse> or an <errors>
   message. Only the <badRequest>, <forbidden>, <internalError>, and
   <serverTimeout> errors, defined in [RFC5222], are used by this
   specification. Neither the <redirect> nor the <warnings> messages
   are reused by this message.

4.3. Examples

   The first example shows an empty <getMappingsRequest> message that
   would retrieve all locally stored mappings at the LoST Sync source.

   <?xml version="1.0" encoding="UTF-8"?>
   <getMappingsRequest xmlns="urn:ietf:params:xml:ns:lostsync1"/>

           Figure 7: Example of Empty <getMappingsRequest> Message

   A further example request is shown in Figure 8, and the corresponding
   response is depicted in Figure 9. In this example, the
   <getMappingsRequest> element contains information about the mapping
   that is locally available to the client inside the

<mapping-fingerprint> element (with
source="authoritative.bar.example",
sourceId="7e3f40b098c711dbb6060800200c9a66", and lastUpdated="2006-
11-01T01:00:00Z"). The query asks for mappings that are more recent
than the available one as well as any missing mapping.

```
<?xml version="1.0" encoding="UTF-8"?>
<getMappingsRequest xmlns="urn:ietf:params:xml:ns:lostsync1">
    <exists>
        <mapping-fingerprint source="authoritative.bar.example"
        sourceId="7e3f40b098c711dbb6060800200c9a66"
        lastUpdated="2006-11-01T01:00:00Z">
        </mapping-fingerprint>
    </exists>
</getMappingsRequest>
```

             Figure 8: Example <getMappingsRequest> Message

The response to the above request is shown in Figure 9. A more
recent mapping was available with the identification of
source="authoritative.bar.example" and
sourceId="7e3f40b098c711dbb6060800200c9a66". Only one missing
mapping, with source "authoritative.foo.example", was found and
returned.

```
<?xml version="1.0" encoding="UTF-8"?>
<sync:getMappingsResponse
    xmlns:sync="urn:ietf:params:xml:ns:lostsync1"
    xmlns="urn:ietf:params:xml:ns:lost1"
    xmlns:gml="http://www.opengis.net/gml">

        <mapping source="authoritative.bar.example"
            sourceId="7e3f40b098c711dbb6060800200c9a66"
            lastUpdated="2008-11-26T01:00:00Z"
            expires="2009-12-26T01:00:00Z">
            <displayName xml:lang="en">Leonia Police Department
            </displayName>
            <service>urn:service:sos.police</service>
            <serviceBoundary
profile="urn:ietf:params:lost:location-profile:basic-civic">
                <civicAddress
xmlns="urn:ietf:params:xml:ns:pidf:geopriv10:civicAddr">
                    <country>US</country>
                    <A1>NJ</A1>
                    <A3>Leonia</A3>
                    <PC>07605</PC>
                </civicAddress>
            </serviceBoundary>
```

```
            <uri>sip:police@leonianj2.example.org</uri>
            <serviceNumber>911</serviceNumber>
        </mapping>

        <mapping expires="2009-01-01T01:44:33Z"
            lastUpdated="2008-11-01T01:00:00Z"
            source="authoritative.foo.example"
            sourceId="7e3f40b098c711dbb606011111111111">
        <displayName xml:lang="en">New York City Police Department
        </displayName>
        <service>urn:service:sos.police</service>
        <serviceBoundary profile="geodetic-2d">
            <gml:Polygon srsName="urn:ogc:def::crs:EPSG::4326">
                <gml:exterior>
                    <gml:LinearRing>
                        <gml:pos>37.775 -122.4194</gml:pos>
                        <gml:pos>37.555 -122.4194</gml:pos>
                        <gml:pos>37.555 -122.4264</gml:pos>
                        <gml:pos>37.775 -122.4264</gml:pos>
                        <gml:pos>37.775 -122.4194</gml:pos>
                    </gml:LinearRing>
                </gml:exterior>
            </gml:Polygon>
        </serviceBoundary>
        <uri>sip:nypd@example.com</uri>
        <uri>xmpp:nypd@example.com</uri>
        <serviceNumber>911</serviceNumber>
        </mapping>

    </sync:getMappingsResponse>
```

            Figure 9: Example <getMappingsResponse> Message

5. Pushing Mappings via <pushMappings> and <pushMappingsResponse>

5.1. Behavior of the LoST Sync Source

   When a LoST Sync source obtains new information that is of interest
   to its peers, it may push the new mappings to its peers.
   Configuration settings at both peers decide whether this
   functionality is used and what mappings are pushed to which other
   peers. New mappings may arrive through various means, such as a
   manual addition to the local mapping database, or through the
   interaction with other entities. Deleting mappings may also trigger
   a protocol interaction.

The LoST Sync source SHOULD keep track of which LoST Sync destination
it has pushed <mapping> elements to. If it does not keep state
information, then it always has to push the complete data set. As
discussed in Section 5.1 of [RFC5222], <mapping> elements are
identified by the 'source', 'sourceID', and 'lastUpdated' attributes.
A mapping is considered the same if these three attributes match.

A <pushMappings> request sent by a LoST Sync source MUST contain one
or more <mapping> elements.

To delete a mapping, the content of the mapping is left empty, i.e.,
the <mapping> element only contains the 'source', 'sourceID',
'lastUpdated', and 'expires' attributes. Figure 10 shows an example
request where the mapping with the source="nj.us.example",
sourceId="123", lastUpdated="2008-11-01T01:00:00Z", and
expires="2008-11-01T01:00:00Z" is requested to be deleted. Note that
the 'expires' attribute is required per the schema definition but
will be ignored in processing the request on the receiving side. A
sync source may want to delete the mapping from its internal mapping
database but has to remember the peers to which it has distributed
this update unless it has other ways to ensure that databases do not
get out of sync.

5.2. Behavior of the LoST Sync Destination

When a LoST Sync destination receives a <pushMappingsRequest>
message, then the cache with the existing mappings is inspected to
determine whether the received mapping should lead to an update of an
already existing mapping, should create a new mapping in the cache,
or should be discarded.

If a newly received mapping has a more recent time in its
'lastUpdated' attribute, it MUST update an existing mapping that has
matching 'source' and 'sourceID' attributes.

If the received mapping does not match with any existing mapping
based on the 'source' and 'sourceId', then it MUST be added to the
local cache as an independent mapping.

If a <pushMappingsRequest> message with an empty <mapping> element is
received, then a corresponding mapping has to be determined based on
the 'source' and the 'sourceID'.

If no mapping can be identified, then an <errors> response MUST be
returned that contains the <notDeleted> child element. The
<notDeleted> element MAY contain a 'message' attribute with an error
description used for debugging purposes. The <notDeleted> element
MUST contain the <mapping> element(s) that caused the error.

The response to a <pushMappingsRequest> request is a
<pushMappingsResponse> message. With this specification, a
successful response message returns no additional elements, whereas
an <errors> response is returned in the response message if the
request failed. Only the <badRequest>, <forbidden>, <internalError>,
or <serverTimeout> errors defined in Section 13.1 of [RFC5222] are
used. The <redirect> and <warnings> messages are not used for this
query/response.

If the set of nodes that are synchronizing their data does not form a
tree, it is possible that the same information arrives through
several other nodes. This is unavoidable but generally only imposes
a modest overhead. (It would be possible to create a spanning tree
in the same fashion as IP multicast, but the complexity does not seem
warranted, given the relatively low volume of data.)

5.3. Example

An example is shown in Figure 10. Imagine a LoST node that obtained
two new mappings identified as follows:

o   source="authoritative.example"
    sourceId="7e3f40b098c711dbb6060800200c9a66"
    lastUpdated="2008-11-26T01:00:00Z"

o   source="authoritative.example"
    sourceId="7e3f40b098c711dbb606011111111111"
    lastUpdated="2008-11-01T01:00:00Z"

These two mappings have to be added to the peer's mapping database.

Additionally, the following mapping has to be deleted:

o   source="nj.us.example"
    sourceId="123"
    lastUpdated="2008-11-01T01:00:00Z"

```
<?xml version="1.0" encoding="UTF-8"?>
<sync:pushMappings
    xmlns:sync="urn:ietf:params:xml:ns:lostsync1"
    xmlns="urn:ietf:params:xml:ns:lost1"
    xmlns:gml="http://www.opengis.net/gml">
```

```
      <mapping source="authoritative.example"
          sourceId="7e3f40b098c711dbb6060800200c9a66"
          lastUpdated="2008-11-26T01:00:00Z"
          expires="2009-12-26T01:00:00Z">
          <displayName xml:lang="en">Leonia Police Department
          </displayName>
          <service>urn:service:sos.police</service>
          <serviceBoundary
   profile="urn:ietf:params:lost:location-profile:basic-civic">
              <civicAddress
   xmlns="urn:ietf:params:xml:ns:pidf:geopriv10:civicAddr">
                  <country>US</country>
                  <A1>NJ</A1>
                  <A3>Leonia</A3>
                  <PC>07605</PC>
              </civicAddress>
          </serviceBoundary>
          <uri>sip:police@leonianj.example.org</uri>
          <serviceNumber>911</serviceNumber>
      </mapping>

      <mapping expires="2009-01-01T01:44:33Z"
          lastUpdated="2008-11-01T01:00:00Z"
          source="authoritative.example"
          sourceId="7e3f40b098c711dbb606011111111111">
          <displayName xml:lang="en">New York City Police Department
          </displayName>
          <service>urn:service:sos.police</service>
          <serviceBoundary profile="geodetic-2d">
              <gml:Polygon srsName="urn:ogc:def::crs:EPSG::4326">
                  <gml:exterior>
                      <gml:LinearRing>
                          <gml:pos>37.775 -122.4194</gml:pos>
                          <gml:pos>37.555 -122.4194</gml:pos>
                          <gml:pos>37.555 -122.4264</gml:pos>
                          <gml:pos>37.775 -122.4264</gml:pos>
                          <gml:pos>37.775 -122.4194</gml:pos>
                      </gml:LinearRing>
                  </gml:exterior>
              </gml:Polygon>
          </serviceBoundary>
          <uri>sip:nypd@example.com</uri>
          <uri>xmpp:nypd@example.com</uri>
          <serviceNumber>911</serviceNumber>
      </mapping>
```

```
        <mapping source="nj.us.example"
            sourceId="123"
            lastUpdated="2008-11-01T01:00:00Z"
            expires="2008-11-01T01:00:00Z"/>

  </sync:pushMappings>
```

                Figure 10: Example <pushMappingsRequest> Message

In response, the peer performs the necessary operations and updates
its mapping database. In particular, it will check whether the other
peer is authorized to perform the update and whether the elements and
attributes contain values that it understands. In our example, a
positive response is returned as shown in Figure 11.

```
<?xml version="1.0" encoding="UTF-8"?>
<pushMappingsResponse xmlns="urn:ietf:params:xml:ns:lostsync1" />
```

                 Figure 11: Example <pushMappingsResponse>

In case a mapping could not be deleted as requested, the following
error response might be returned instead.

```
<?xml version="1.0" encoding="UTF-8"?>
<errors xmlns="urn:ietf:params:xml:ns:lost1"
    xmlns:sync="urn:ietf:params:xml:ns:lostsync1"
    source="nodeA.example.com">

    <sync:notDeleted
        message="Could not delete the indicated mapping."
        xml:lang="en">

        <mapping source="nj.us.example"
            sourceId="123"
            lastUpdated="2008-11-01T01:00:00Z"
            expires="2008-11-01T01:00:00Z"/>
    </sync:notDeleted>
</errors>
```

                   Figure 12: Example <errors> Message

6. Transport

   LoST Sync needs an underlying protocol transport mechanism to carry
   requests and responses. This document uses HTTPS as a transport to
   exchange XML documents. No fallback to HTTP is provided.

When using HTTP over Transport Layer Security (TLS) [RFC2818], LoST
Sync messages use the POST method. Requests MUST use the Cache-
Control response directive "no-cache".

All LoST Sync responses, including those indicating a LoST warning or
error, are carried in 2xx responses, typically 200 (OK). 3xx, 4xx,
and 5xx HTTP response codes indicate that the request itself failed
or was redirected; these responses do not contain any LoST Sync XML
elements.

7. RELAX NG

Note: In order to avoid copying pattern definitions from the LoST
Regular Language for XML Next Generation (RELAX NG) schema [RFC5222]
to this document, we include it as "lost.rng" (XML syntax) in the
RELAX NG schema below.

```
<?xml version="1.0" encoding="utf-8"?>

    <grammar ns="urn:ietf:params:xml:ns:lostsync1"
    xmlns="http://relaxng.org/ns/structure/1.0"
    xmlns:a="http://relaxng.org/ns/compatibility/annotations/1.0"
    datatypeLibrary="http://www.w3.org/2001/XMLSchema-datatypes">

        <include href="lost.rng"/>

        <start combine="choice">

         <a:documentation> Location-to-Service Translation (LoST)
           Synchronization Protocol</a:documentation>

           <choice>
               <ref name="pushMappings"/>
               <ref name="pushMappingsResponse"/>
               <ref name="getMappingsRequest"/>
               <ref name="getMappingsResponse"/>
           </choice>
        </start>


        <define name="pushMappings">
            <element name="pushMappings">
                    <oneOrMore>
                        <ref name="mapping"/>
                    </oneOrMore>

                <ref name="extensionPoint"/>
            </element>
```

```
        </define>

        <define name="pushMappingsResponse">
            <element name="pushMappingsResponse">
                <ref name="extensionPoint"/>
            </element>
        </define>

         <define name="getMappingsRequest">
            <element name="getMappingsRequest">
                <choice>
                    <ref name="exists"></ref>
                    <ref name="extensionPoint"/>
                </choice>
            </element>
        </define>

         <define name="exists">
            <element name="exists">
                <oneOrMore>
                    <element name="mapping-fingerprint">
                        <attribute name="source">
                            <data type="token"/>
                        </attribute>
                        <attribute name="sourceId">
                            <data type="token"/>
                        </attribute>
                        <attribute name="lastUpdated">
                            <data type="dateTime"/>
                        </attribute>
                        <ref name="extensionPoint"/>
                    </element>
                </oneOrMore>
            </element>
         </define>

        <define name="getMappingsResponse">
            <element name="getMappingsResponse">
                <oneOrMore>
                    <ref name="mapping"/>
                </oneOrMore>
                <ref name="extensionPoint"/>
            </element>
        </define>

         <!-- error messages -->

         <define name="notDeleted">
```

```
                    <element name="notDeleted">
                        <ref name="basicException"/>
                        <oneOrMore>
                            <ref name="mapping"/>
                        </oneOrMore>
                    </element>
                </define>
            </grammar>
```

8. Operational Considerations

It is important to avoid loops when more than two LoST servers use
the mechanism described in this document. The example shown in
Figure 13 with three LoST servers A, B, and C (each of them acts as a
sync source and a sync destination) illustrates the challenge in more
detail. A and B synchronize data between each other; the same is
true for A and C, and B and C, respectively.

```
                        A -------- B
                         \        /
                          \      /
                           \    /
                            \  /
                             C
```
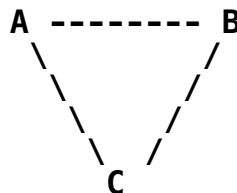
Figure 13: Synchronization Configuration Example

Now, imagine that server A adds a new mapping. This mapping is
uniquely identified by the combination of "source", "sourceid", and
"last updated". Assume that A wants to push this new mapping to B
and C. When B obtains this new mapping, it determines that it has to
distribute it to its peer C. C also needs to distribute the mapping
to its peer B. If the original mapping with the "source",
"sourceid", and "last updated" is not modified by either B or C, then
these two servers would recognize that they already possess the
mapping and can ignore the update.

Implementations MUST NOT modify mappings they receive. An entity
acting maliciously would, however, intentionally modify mappings or
inject bogus mappings. To avoid the possibility of an untrustworthy
member claiming a coverage region for which it is not authorized,
authoritative mapping servers MUST sign mappings they distribute
using an XML digital signature [W3C.REC-xmldsig-core-20020212]. A
recipient MUST verify that the signing entity is indeed authorized to
speak for that region. In many cases, this will require an out-of-
band agreement to be in place to agree on specific entities to take
on this role. Determining who can speak for a particular region is
inherently difficult unless there is a small set of authorizing

entities that participants in the mapping architecture can trust.
Receiving systems should be particularly suspicious if an existing
coverage region is replaced by a new one that contains a different
value in the <uri> element. When mappings are digitally signed, they
cannot be modified by intermediate LoST servers.

9. Security Considerations

This document defines a protocol for exchange of authoritative
mapping information between two entities. Hence, the protocol
operations described in this document require authentication of
neighboring nodes.

The LoST Sync client and servers MUST implement TLS and use TLS.
Which version(s) ought to be implemented will vary over time and
depend on the widespread deployment and known security
vulnerabilities at the time of implementation. At the time of this
writing, TLS version 1.2 [RFC5246] is the most recent version but has
very limited actual deployment and might not be readily available in
implementation tool kits. TLS version 1.0 [RFC2246] is the most
widely deployed version and will give the broadest interoperability.

Mutual authentication between the LoST Sync source and the LoST Sync
destination is not necessarily required in all deployments unless an
emergency service authority wants to enforce access control prior to
the distribution of their <mapping> elements. This may, for example,
be the case when certain emergency services networks distribute
internal mappings that are not meant for public distribution.

An additional threat is caused by compromised or misconfigured LoST
servers. A denial of service could be the consequence of an injected
mapping. If the mapping data contains a URL that does not exist,
then emergency services for the indicated area are not reachable. If
all mapping data contains URLs that point to a single PSAP (rather
than a large number of PSAPs), then this PSAP is likely to experience
overload conditions. If the mapping data contains a URL that points
to a server controlled by the adversary itself, then it might
impersonate PSAPs.

Section 8 discusses this security threat and mandates signed
mappings. For unusual changes to the mapping database, approval by a
system administrator of the emergency services infrastructure (or a
similar expert) may be required before any mappings are installed.

10. IANA Considerations

10.1. Media Type Registration

   This specification requests the registration of a new media type
   according to the procedures of RFC 4288 [RFC4288] and guidelines in
   RFC 3023 [RFC3023].

   Type name: application

   Subtype name: lostsync+xml

   Required parameters: none

   Optional parameters: charset

      Same as charset parameter of application/xml as specified in RFC
      3023 [RFC3023].

   Encoding considerations: Identical to those of "application/xml" as
      described in [RFC3023], Section 3.2.

   Security considerations: This content type is designed to carry LoST
      Synchronization protocol payloads, and the security considerations
      section of RFC 6739 is applicable. In addition, as this media
      type uses the "+xml" convention, it shares the same security
      considerations as described in [RFC3023], Section 10.

   Interoperability considerations: None

   Published specification: RFC 6739

   Applications that use this media type: Emergency and Location-based
      Systems

   Additional information:

      Magic number(s): None

      File extension(s): .lostsyncxml

      Macintosh file type code(s): 'TEXT'

   Person & email address to contact for further information:
      Hannes Tschofenig <Hannes.Tschofenig@gmx.net>

   Intended usage: LIMITED USE

Restrictions on usage: None

Author: Hannes Tschofenig <Hannes.Tschofenig@gmx.net>

Change controller:

   This specification is a work item of the IETF ECRIT working group,
   with mailing list address <ecrit@ietf.org>.

Change controller:

   The IESG <iesg@ietf.org>

10.2. LoST Sync RELAX NG Schema Registration

The schema defined in this document has been registered under the XML
schema registry at
http://www.iana.org/assignments/xml-registry/schema.html

URI: urn:ietf:params:xml:schema:lostsync1

Registrant Contact: IETF ECRIT Working Group, Hannes Tschofenig
   (Hannes.Tschofenig@gmx.net).

RELAX NG Schema: The RELAX NG schema that has been registered is
   contained in Section 7.

10.3. LoST Synchronization Namespace Registration

The namespace defined in this document has been registered under the
XML namespace registry at
http://www.iana.org/assignments/xml-registry/ns.html

URI: urn:ietf:params:xml:ns:lostsync1

Registrant Contact: IETF ECRIT Working Group, Hannes Tschofenig
   (Hannes.Tschofenig@gmx.net).

   XML:

   BEGIN
```
<?xml version="1.0"?>
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML Basic 1.0//EN"
   "http://www.w3.org/TR/xhtml-basic/xhtml-basic10.dtd">
<html xmlns="http://www.w3.org/1999/xhtml">
<head>
   <meta http-equiv="content-type"
         content="text/html;charset=iso-8859-1"/>
   <title>LoST Synchronization Namespace</title>
</head>
<body>
   <h1>Namespace for LoST server synchronization</h1>
   <h2>urn:ietf:params:xml:ns:lostsync1</h2>
<p>See <a href="[URL of published RFC]">RFC 6739
      </a>.</p>
</body>
</html>
```
   END

11. Acknowledgments

   Robins George, Cullen Jennings, Karl Heinz Wolf, Richard Barnes,
   Mayutan Arumaithurai, Alexander Mayrhofer, and Andrew Newton provided
   helpful input. Jari Urpalainen assisted with the RELAX NG schema.
   We would also like to thank our document shepherd Roger Marshall for
   his help with the document.

   We would like to particularly thank Andrew Newton for his timely and
   valuable review of the XML-related content.

   We would like to thank Robert Sparks, Barry Leiba, Stephen Farrell,
   Brian Haberman, Pete Resnick, and Sean Turner for their AD reviews.
   We would also like to thank Bjoern Hoehrmann for his media type
   review, Julian Reschke and Martin Duerst for their applications area
   reviews, and Wassim Haddad for his Gen-ART review.

12. References

12.1. Normative References

   [RFC2119]   Bradner, S., "Key words for use in RFCs to Indicate
               Requirement Levels", BCP 14, RFC 2119, March 1997.

   [RFC2246]   Dierks, T. and C. Allen, "The TLS Protocol Version 1.0",
               RFC 2246, January 1999.

   [RFC2818]   Rescorla, E., "HTTP Over TLS", RFC 2818, May 2000.

   [RFC3023]   Murata, M., St. Laurent, S., and D. Kohn, "XML Media
               Types", RFC 3023, January 2001.

   [RFC4288]   Freed, N. and J. Klensin, "Media Type Specifications and
               Registration Procedures", BCP 13, RFC 4288, December 2005.

   [RFC5222]   Hardie, T., Newton, A., Schulzrinne, H., and H.
               Tschofenig, "LoST: A Location-to-Service Translation
               Protocol", RFC 5222, August 2008.

   [RFC5246]   Dierks, T. and E. Rescorla, "The Transport Layer Security
               (TLS) Protocol Version 1.2", RFC 5246, August 2008.

   [W3C.REC-xmldsig-core-20020212]
               Eastlake, D., Reagle, J., Solo, D., Hirsch, F., and T.
               Roessler, "XML-Signature Syntax and Processing", World
               Wide Web Consortium, Second Edition, REC-xmldsig-core-
               20020212, June 2008.

12.2. Informative References

   [RFC5012]   Schulzrinne, H. and R. Marshall, "Requirements for
               Emergency Context Resolution with Internet Technologies",
               RFC 5012, January 2008.

   [RFC5582]   Schulzrinne, H., "Location-to-URL Mapping Architecture and
               Framework", RFC 5582, September 2009.

Authors' Addresses

     Henning Schulzrinne
     Columbia University
     Department of Computer Science
     450 Computer Science Building
     New York, NY 10027
     USA

     Phone: +1 212 939 7004
     EMail: hgs+ecrit@cs.columbia.edu
     URI: http://www.cs.columbia.edu

     Hannes Tschofenig
     Nokia Siemens Networks
     Linnoitustie 6
     Espoo 02600
     Finland

     Phone: +358 (50) 4871445
     EMail: Hannes.Tschofenig@gmx.net
     URI: http://www.tschofenig.priv.at