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## Specifying Holes in Location-to-Service Translation (LoST) Service Boundaries

### Abstract

This document describes how holes can be specified in geodetic service boundaries. One means of implementing a search solution in a service database, such as one might provide with a Location-to-Service Translation (LoST) server, is described.

### Status of This Memo

This is an Internet Standards Track document.

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## 1. Introduction

The LoST protocol [RFC5222] maps service and locations to destination addresses. A LoST server does this by provisioning boundary maps or areas against service URNs. The boundary is a polygon made up of sets of geodetic coordinates specifying an enclosed area. In some circumstances, an area enclosed by a polygon, also known as an exterior polygon, may contain exception areas, or holes, that for the same service must yield a different destination to that described by the larger area.

This document describes a profile of Geographic Markup Language (GML) [ISO-19107] polygons that constrains their representation when used for describing service boundaries. The profile removes a number of permutations that are difficult to process. This allows for simplified implementations that are not capable of handling all potential variations allowed by GML. A fully conformant GML implementation must produce polygons that fit this profile to ensure interoperability.

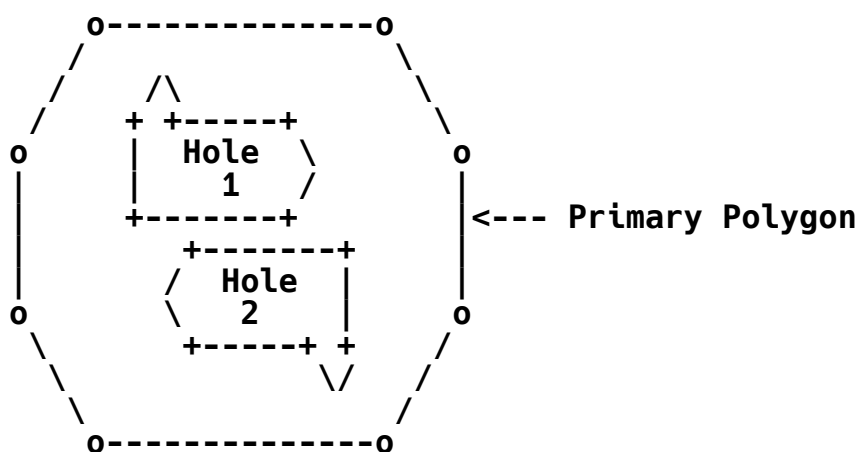


Figure 1: Holes in a Polygon

This document describes a profile of GML [ISO-19107] polygons that constrains their representation when used for describing service boundaries.

The working group considered that the types of regions described in this memo could be represented in various ways as polygons without holes, but concluded on the recommendations here to avoid potential problems with the arbitrary division of regions and to align with existing geospatial system practices.

## 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 [RFC2119].

## 3. Specifying Holes

Holes related to an exterior boundary polygon **MUST** adhere to the following rules:

**Rule 1:** Two holes **MUST NOT** have more than one point of intersection.

If two or more holes overlap or share a common boundary, then these represent a single hole. The internal elements (holes) should have common boundaries removed and a single hole created irrespective of whether the excluded area is itself made up of multiple service boundaries.

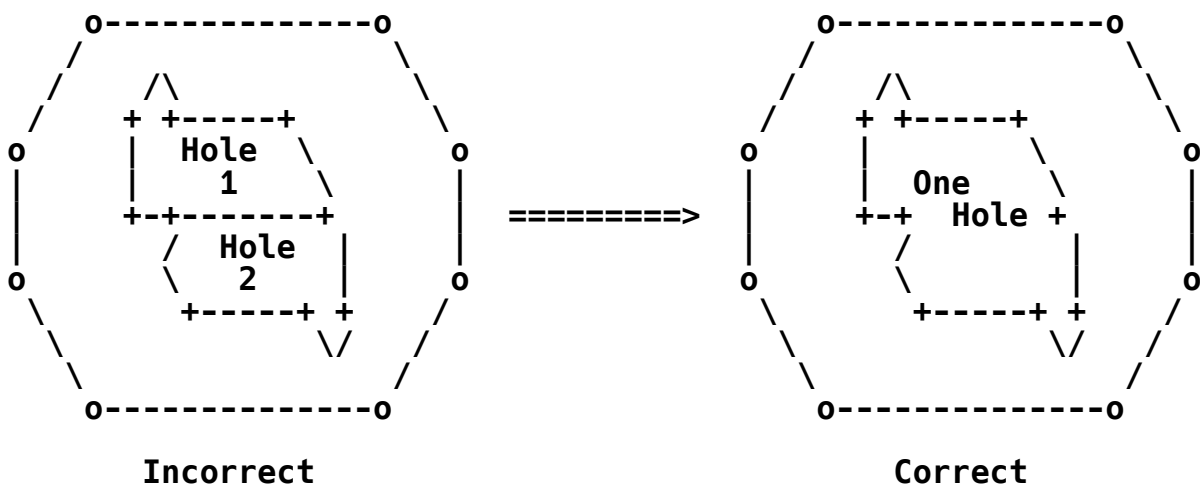


Figure 2: Hole Specification with Boundary Sharing

**Rule 2:** A polygon **MUST** describe a contiguous region.

If a hole overlaps with the outer boundary, or it shares part of a side with the outer boundary, then it has an inlet and it **MUST** be expressed without the hole.

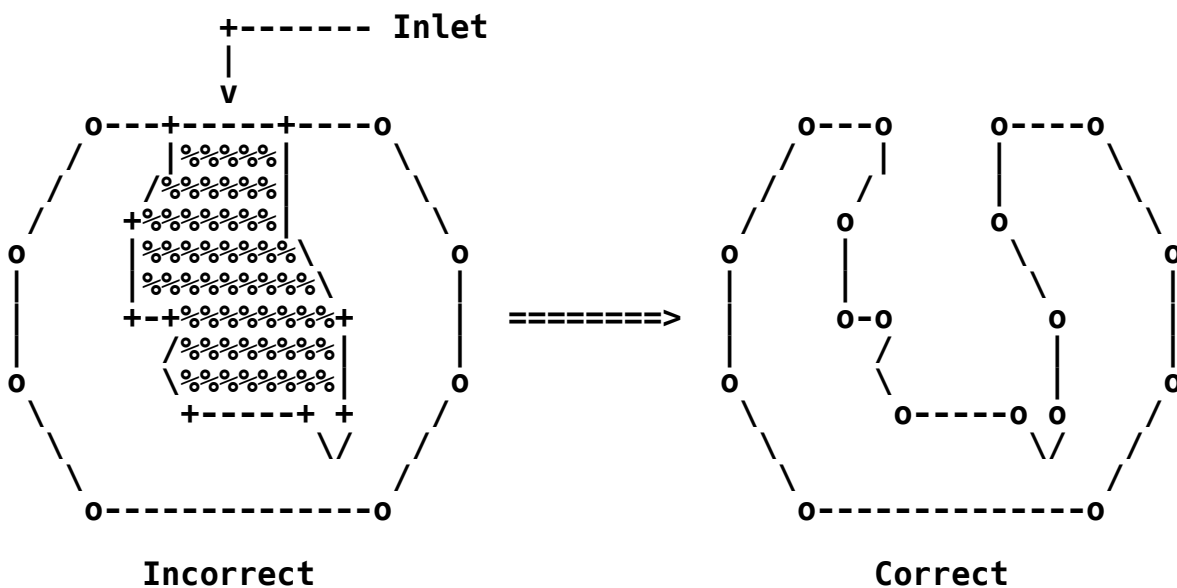


Figure 3: Specification of an Inlet

If a hole touches the outer boundary in two places, the region **MUST** be expressed as two separate polygons.

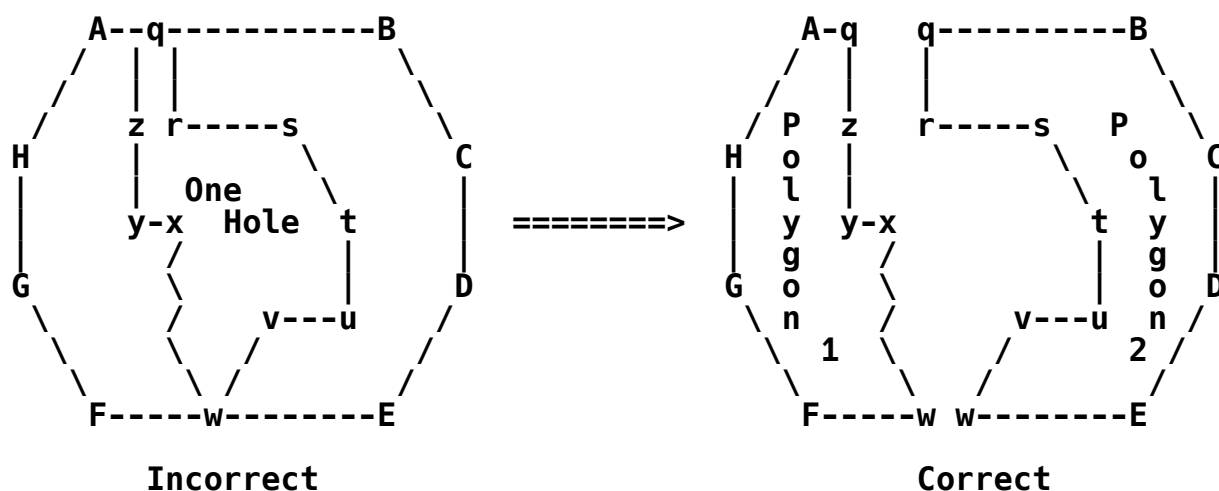


Figure 4: Specification of Hole with Multiple Outer-Boundary Intersections

Similarly, a polygon that is enclosed entirely within a hole from another polygon (i.e., an "island") is a separate polygon.

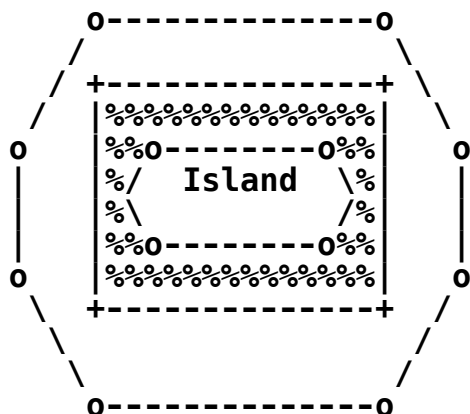


Figure 5: Hole with Enclosed Polygon (Island)

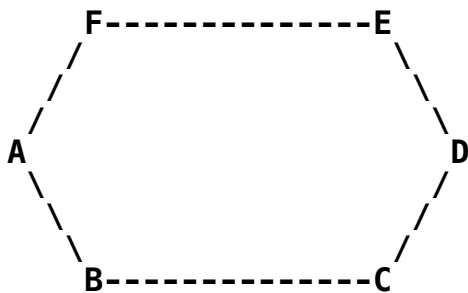
**Rule 3:** A hole **MUST** be formed from a legal linear ring in accordance with [geoshape], except that points are specified in a clockwise direction.

Holes are specified in a clockwise direction so that the upward normal is opposed to the upward normal of the exterior boundary of the polygon. Note that [geoshape] stipulates that exterior boundaries are specified in counterclockwise order.

There is no restriction on the number of points that are used to express the perimeter of either exterior or interior boundaries.

#### 4. GML Polygons

The GML encoding of a polygon defines an enclosed exterior boundary, with the first and last points of boundary being the same. Consider the example in Figure 6.



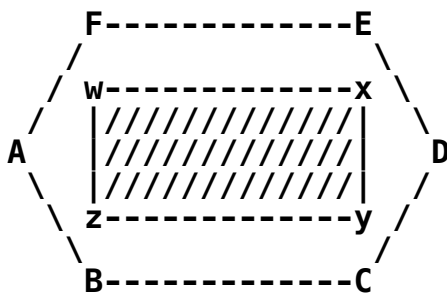
```
<gml:Polygon srsName="urn:ogc:def:crs:EPSG::4326">
  <gml:exterior>
    <gml:LinearRing>
      <gml:pos>43.311 -73.422</gml:pos> <!--A-->
      <gml:pos>43.111 -73.322</gml:pos> <!--B-->
      <gml:pos>43.111 -73.222</gml:pos> <!--C-->
      <gml:pos>43.311 -73.122</gml:pos> <!--D-->
      <gml:pos>43.411 -73.222</gml:pos> <!--E-->
      <gml:pos>43.411 -73.322</gml:pos> <!--F-->
      <gml:pos>43.311 -73.422</gml:pos> <!--A-->
    </gml:LinearRing>
  </gml:exterior>
</gml:Polygon>
```

Figure 6: Hexagon and Associated GML

Note that polygon vertices in Figure 6 are expressed using `<pos>` elements for clarity. The vertices can also be expressed using a `<posList>` element.

#### 5. Holes in GML Polygons

A hole is specified in the polygon by defining an interior boundary. The points defining the internal boundary define the area represented by the hole in the primary (exterior) polygon. The shaded area in Figure 7 is represented by the 4 points of the interior boundary specified by (w,z,y,x).



```

<gml:Polygon srsName="urn:ogc:def:crs:EPSG::4326">
  <gml:exterior>
    <gml:LinearRing>
      <gml:pos>43.311 -73.422</gml:pos> <!--A-->
      <gml:pos>43.111 -73.322</gml:pos> <!--B-->
      <gml:pos>43.111 -73.222</gml:pos> <!--C-->
      <gml:pos>43.311 -73.122</gml:pos> <!--D-->
      <gml:pos>43.511 -73.222</gml:pos> <!--E-->
      <gml:pos>43.511 -73.322</gml:pos> <!--F-->
      <gml:pos>43.311 -73.422</gml:pos> <!--A-->
    </gml:LinearRing>
  </gml:exterior>
  <gml:interior>
    <gml:LinearRing>
      <gml:pos>43.411 -73.322</gml:pos> <!--w-->
      <gml:pos>43.411 -73.222</gml:pos> <!--x-->
      <gml:pos>43.211 -73.222</gml:pos> <!--y-->
      <gml:pos>43.211 -73.322</gml:pos> <!--z-->
      <gml:pos>43.411 -73.322</gml:pos> <!--w-->
    </gml:LinearRing>
  </gml:interior>
</gml:Polygon>

```

Figure 7: Hexagon with Hole

## 6. Service Boundary Specification and Selection Algorithm

A service boundary is represented by a polygon that may have many vertices. The enclosed area of the polygon represents the area in which a service, expressed as a service URN, maps to a single URI.

Figure 7 is used to illustrate two service boundaries. The first service boundary A->F shall be referred to as area-A, and the second service boundary w->z shall be referred to as area-w. Furthermore, area-A is directly represented by the GML encoding provided in Figure 7. Area-w is represented as a hole in area-A by the interior

boundary. Since area-w is also a service boundary, a separate polygon describing this area is also required and is shown in Figure 8 (note the reversal of the vertices).

```
<gml:Polygon srsName="urn:ogc:def:crs:EPSG::4326">
  <gml:exterior>
    <gml:LinearRing>
      <gml:pos>43.411 -73.322</gml:pos> <!--w-->
      <gml:pos>43.211 -73.322</gml:pos> <!--z-->
      <gml:pos>43.211 -73.222</gml:pos> <!--y-->
      <gml:pos>43.411 -73.222</gml:pos> <!--x-->
      <gml:pos>43.411 -73.322</gml:pos> <!--w-->
    </gml:LinearRing>
  </gml:exterior>
</gml:Polygon>
```

Figure 8: GML for Area-w

Service mappings for these boundaries might be provided by a LoST server in the form shown in Figure 9.

```
<mapping xmlns="urn:ietf:params:xml:ns:lost1"
  expires="2010-12-25T09:44:33Z"
  lastUpdated="2010-03-08T03:48:22Z"
  source="authoritative.foo.example"
  sourceId="7e3f40b098c711dbb6060111111111111">
  <displayName xml:lang="en">Outer Area Police</displayName>
  <service>urn:service:sos.police</service>
  <serviceBoundary profile="geodetic-2d">
    <gml:Polygon xmlns:gml="http://www.opengis.net/gml"
      srsName="urn:ogc:def:crs:EPSG::4326">
      <gml:exterior>
        <gml:LinearRing>
          <gml:pos>43.311 -73.422</gml:pos>
          <gml:pos>43.111 -73.322</gml:pos>
          <gml:pos>43.111 -73.222</gml:pos>
          <gml:pos>43.311 -73.122</gml:pos>
          <gml:pos>43.511 -73.222</gml:pos>
          <gml:pos>43.511 -73.322</gml:pos>
          <gml:pos>43.311 -73.422</gml:pos>
        </gml:LinearRing>
      </gml:exterior>
      <!-- this is the service boundary hole -->
      <gml:interior>
        <gml:LinearRing>
          <gml:pos>43.411 -73.322</gml:pos>
          <gml:pos>43.211 -73.322</gml:pos>
          <gml:pos>43.211 -73.222</gml:pos>
```



```

        <gml:pos>43.411 -73.222</gml:pos>
        <gml:pos>43.411 -73.322</gml:pos>
      </gml:LinearRing>
    </gml:interior>
  </gml:Polygon>
</serviceBoundary>
<uri>sip:area-A-pd@example.com</uri>
<uri>xmpp:area-A-pd@example.com</uri>
<serviceNumber>000</serviceNumber>
</mapping>

<mapping xmlns="urn:ietf:params:xml:ns:lost1"
  expires="2010-12-25T09:44:33Z"
  lastUpdated="2010-03-08T03:48:22Z"
  source="authoritative.foo.example"
  sourceId="7e3f40b098c711dbb6060111111111111">
  <displayName xml:lang="en">Inner Area Police</displayName>
  <service>urn:service:sos.police</service>
  <serviceBoundary profile="geodetic-2d">
    <gml:Polygon xmlns:gml="http://www.opengis.net/gml"
      srsName="urn:ogc:def:crs:EPSG::4326">
      <gml:exterior>
        <gml:LinearRing>
          <gml:pos>43.411 -73.322</gml:pos>
          <gml:pos>43.211 -73.322</gml:pos>
          <gml:pos>43.211 -73.222</gml:pos>
          <gml:pos>43.411 -73.222</gml:pos>
          <gml:pos>43.411 -73.322</gml:pos>
        </gml:LinearRing>
      </gml:exterior>
    </gml:Polygon>
  </serviceBoundary>
  <uri>sip:area-w-pd@example.com</uri>
  <uri>xmpp:area-w-pd@example.com</uri>
  <serviceNumber>000</serviceNumber>
</mapping>

```

Figure 9: Service Boundary Specifications

It is considered likely that LoST servers will need to provide responses sufficiently quickly to allow real-time queries to be performed as part of an emergency call routing flow. It is for this reason that databases supporting native geospatial query techniques are desirable and that service boundary specifications that are easily mapped to internal data structures are preferred. Using interior boundaries makes support for this operation easy, while allowing an arbitrary number of holes in a service boundary to be specified.

Each polygon is stored in the geospatial database and mapped to a service URN and destination URI. Many geospatial databases natively support polygons with interior exclusions. Without native support, interior boundaries can be stored against the polygon and can be checked separately. A location falls within the area described by a polygon if it is within the exterior boundary and not within any interior boundary.

In the above example, if a location falls within the interior boundary, it maps to the "Inner Area Police" service; likewise, if a location falls within the exterior boundary, but not within the interior boundary, it maps to the "Outer Area Police" service.

## 7. Security Considerations

Constraining the form of a polygon representation as described in this document does not introduce new security considerations.

## 8. Acknowledgements

Thanks to Carl Reed for input provided to the list some months back and for reviewing this document. Thanks to Michael Haberler for suggesting that such a specification is required. Thanks to Avery Penniston for review and feedback.

## 9. References

### 9.1. Normative References

- [RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, March 1997.
- [RFC5222] Hardie, T., Newton, A., Schulzrinne, H., and H. Tschofenig, "LoST: A Location-to-Service Translation Protocol", RFC 5222, August 2008.
- [geoshape] Thomson, M. and C. Reed, "GML 3.1.1 PIDF-LO Shape Application Schema for use by the Internet Engineering Task Force (IETF)", Candidate OpenGIS Implementation Specification 06-142r1, Version: 1.0, April 2007.

### 9.2. Informative References

- [ISO-19107] ISO, "Geographic information - Spatial Schema", ISO Standard 19107, First Edition, May 2003.

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