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GEOPRIV Presence Information Data Format Location Object (PIDF-LO)
Usage Clarification, Considerations, and Recommendations

Status of This Memo

This document specifies an Internet standards track protocol for the Internet community, and requests discussion and suggestions for improvements. Please refer to the current edition of the "Internet Official Protocol Standards" (STD 1) for the standardization state and status of this protocol. Distribution of this memo is unlimited.

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Abstract

The Presence Information Data Format Location Object (PIDF-LO) specification provides a flexible and versatile means to represent location information. There are, however, circumstances that arise when information needs to be constrained in how it is represented. In these circumstances, the range of options that need to be implemented are reduced. There is growing interest in being able to use location information contained in a PIDF-LO for routing applications. To allow successful interoperability between applications, location information needs to be normative and more tightly constrained than is currently specified in RFC 4119 (PIDF-LO). This document makes recommendations on how to constrain, represent, and interpret locations in a PIDF-LO. It further recommends a subset of Geography Markup Language (GML) 3.1.1 that is mandatory to implement by applications involved in location-based routing.

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1. Introduction

The Presence Information Data Format Location Object (PIDF-LO) [RFC4119] is the recommended way of encoding location information and associated privacy policies. Location information in a PIDF-LO may be described in a geospatial manner based on a subset of Geography Markup Language (GML) 3.1.1 [OGC-GML3.1.1] or as civic location information [RFC5139]. A GML profile for expressing geodetic shapes in a PIDF-LO is described in [GeoShape]. Uses for the PIDF-LO are envisioned in the context of numerous location-based applications. This document makes recommendations for formats and conventions to make interoperability less problematic.

The PIDF-LO provides a general presence format for representing location information, and permits specification of location information relating to a whole range of aspects of a Target. The general presence data model is described in [RFC4479] and caters to a presence document to describe different aspects of the reachability of a presentity. Continuing this approach, a presence document may contain several GEOPRIV objects that specify different locations and aspects of reachability relating to a presentity. This degree of flexibility is important, and recommendations in this document make no attempt to forbid the usage of a PIDF-LO in this manner. This document provides a specific set of guidelines for building presence documents when it is important to unambiguously convey exactly one location.

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].

The definition for "Target" is taken from [RFC3693].

In this document a "discrete location" is defined as a place, point, area, or volume in which a Target can be found.

The term "compound location" is used to describe location information represented by a composite of both civic and geodetic information. An example of compound location might be a geodetic polygon describing the perimeter of a building and a civic element representing the floor in the building.

The term "method" in this document refers to the mechanism used to determine the location of a Target. This may be something employed by a location information server (LIS), or by the Target itself. It

specifically does not refer to the location configuration protocol (LCP) used to deliver location information either to the Target or the Recipient.

The term "source" is used to refer to the LIS, node, or device from which a Recipient (Target or Third-Party) obtains location information.

3. Using Location Information

The PIDF format provides for an unbounded number of <tuple>, <device>, and <person> elements. Each of these elements contains a single <status> element that may contain more than one <geopriv> element as a child. Each <geopriv> element must contain at least the following two child elements: <location-info> element and <usage-rules> element. One or more elements containing location information are contained inside a <location-info> element.

Hence, a single PIDF document may contain an arbitrary number of location objects, some or all of which may be contradictory or complementary. Graphically, the structure of a PIDF-LO document can be depicted as shown in Figure 1.

```

<presence>
  <tuple> -- #1
    <status>
      <geopriv> -- #1
        <location-info>
          location element #1
          location element #2
          ...
          location element #n
        <usage-rules>
      </geopriv>
      <geopriv> -- #2
      <geopriv> -- #3
      ...
      <geopriv> -- #m
    </status>
  </tuple>
  <device>
    <geopriv> -- #1
      <location-info>
        location element(s)
      <usage-rules>
    </geopriv>
    <geopriv> -- #2
    ...
    <geopriv> -- #m
  </device>
  <person>
    <geopriv> -- #1
      <location-info>
        location element(s)
      <usage-rules>
    </geopriv>
    <geopriv> -- #2
    ...
    <geopriv> -- #m
  </person>
  <tuple> -- #2
  <device> -- #2
  <person> -- #2
  ...
  <tuple> -- #o
</presence>

```

Figure 1: Structure of a PIDF-LO Document

All of these potential sources and storage places for location lead to confusion for the generators, conveyors, and consumers of location information. Practical experience within the United States National Emergency Number Association (NENA) in trying to solve these ambiguities led to a set of conventions being adopted. These rules do not have any particular order, but should be followed by creators and consumers of location information contained in a PIDF-LO to ensure that a consistent interpretation of the data can be achieved.

Rule #1: A <geopriv> element MUST describe a discrete location.

Rule #2: Where a discrete location can be uniquely described in more than one way, each location description SHOULD reside in a separate <tuple>, <device>, or <person> element; only one geopriv element per tuple.

Rule #3: Providing more than one <geopriv> element in a single presence document (PIDF) MUST only be done if the locations refer to the same place or are put into different element types. For example, one location in a <tuple>, a second location in a <device> element, and a third location in a <person> element.

This may occur if a Target's location is determined using a series of different techniques or if the Target wishes to represent her location as well as the location of her PC. In general, avoid putting more than one location into a document unless it makes sense to do so.

Rule #4: Providing more than one location chunk in a single <location-info> element SHOULD be avoided where possible. Rule #5 and Rule #6 provide further refinement.

Rule #5: When providing more than one location chunk in a single <location-info> element, the locations MUST be provided by a common source at the same time and by the same location determination method.

Rule #6: Providing more than one location chunk in a single <location-info> element SHOULD only be used for representing compound location referring to the same place.

For example, a geodetic location describing a point, and a civic location indicating the floor in a building.

Rule #7: Where the compound location is provided in a single <location-info> element, the coarse location information MUST be provided first.

For example, a geodetic location describing an area and a civic location indicating the floor should be represented with the area first followed by the civic location.

Rule #8: Where a PIDF document contains more than one <geopriv> element, the priority of interpretation is given to the first <device> element in the document containing a location. If no <device> element containing a location is present in the document, then priority is given to the first <tuple> element containing a location. Locations contained in <person> tuples SHOULD only be used as a last resort.

Rule #9: Where multiple PIDF documents can be sent or received together, say in a multi-part MIME body, and current location information is required by the recipient, then document selection SHOULD be based on document order, with the first document considered first.

The following examples illustrate the application of these rules.

3.1. Single Civic Location Information

Jane is at a coffee shop on the ground floor of a large shopping mall. Jane turns on her laptop and connects to the coffee shop's WiFi hotspot; Jane obtains a complete civic address for her current location, for example, using the DHCP civic mechanism defined in [RFC4776]. A Location Object is constructed consisting of a single PIDF document, with a single <tuple> or <device> element, a single <status> element, a single <geopriv> element, and a single location chunk residing in the <location-info> element. This document is unambiguous, and should be interpreted consistently by receiving nodes if sent over the network.

3.2. Civic and Geospatial Location Information

Mike is visiting his Seattle office and connects his laptop into the Ethernet port in a spare cube. In this case, location information is geodetic location, with the altitude represented as a building floor number. Mike's main location is the point specified by the geodetic coordinates. Further, Mike is on the second floor of the building located at these coordinates. Applying rules #6 and #7, the resulting compound location information is shown in Figure 2.

```

<presence xmlns="urn:ietf:params:xml:ns:pidf"
  xmlns:dm="urn:ietf:params:xml:ns:pidf:data-model"
  xmlns:gp="urn:ietf:params:xml:ns:pidf:geopriv10"
  xmlns:gml="http://www.opengis.net/gml"
  xmlns:cl="urn:ietf:params:xml:ns:pidf:geopriv10:civicAddr"
  entity="pres:mike@seattle.example.com">
  <dm:device id="mikepc">
    <gp:geopriv>
      <gp:location-info>
        <gml:Point srsName="urn:ogc:def:crs:EPSG::4326">
          <gml:pos>-43.5723 153.21760</gml:pos>
        </gml:Point>
        <cl:civicAddress>
          <cl:FLR>2</cl:FLR>
        </cl:civicAddress>
      </gp:location-info>
      <gp:usage-rules/>
      <gp:method>Wiremap</gp:method>
    </gp:geopriv>
    <dm:deviceID>mac:8asd7d7d70cf</dm:deviceID>
    <dm:timestamp>2007-06-22T20:57:29Z</dm:timestamp>
  </dm:device>
</presence>

```

Figure 2: PIDF-LO Containing a Compound Location

3.3. Manual/Automatic Configuration of Location Information

Lorraine has a predefined civic location stored in her laptop, since she normally lives in Sydney, the address is for her Sydney-based apartment. Lorraine decides to visit sunny San Francisco, and when she gets there, she plugs in her laptop and makes a call. Lorraine's laptop receives a new location from the visited network in San Francisco. As this system cannot be sure that the preexisting and new location both describe the same place, Lorraine's computer generates a new PIDF-LO and will use this to represent Lorraine's location. If Lorraine's computer were to add the new location to her existing PIDF location document (breaking rule #3), then the correct information may still be interpreted by the Location Recipient providing Lorraine's system applies rule #9. In this case, the resulting order of location information in the PIDF document should be San Francisco first, followed by Sydney. Since the information is provided by different sources, rule #8 should also be applied and the information placed in different tuples with the tuple containing the San Francisco location first.

3.4. Multiple Location Objects in a Single PIDF-LO

Vanessa has her PC with her at the park, but due to a misconfiguration, her PC reports her location as being in the office. The resulting PIDF-LO will have a <device> element showing the location of Vanessa's PC as the park, and a <person> element saying that Vanessa is in her office.

```
<presence xmlns="urn:ietf:params:xml:ns:pidf"
  xmlns:dm="urn:ietf:params:xml:ns:pidf:data-model"
  xmlns:gp="urn:ietf:params:xml:ns:pidf:geopriv10"
  xmlns:ca="urn:ietf:params:xml:ns:pidf:geopriv10:civicAddr"
  xmlns:gml="http://www.opengis.net/gml"
  xmlns:gs="http://www.opengis.net/pidflo/1.0"
  entity="pres:ness@example.com">
  <dm:device id="nesspc-1">
    <gp:geopriv>
      <gp:location-info>
        <ca:civicAddress xml:lang="en-AU">
          <ca:country>AU</ca:country>
          <ca:A1>NSW</ca:A1>
          <ca:A3>      Wollongong
          </ca:A3><ca:A4>North Wollongong
        </ca:A4>
          <ca:RD>Flinders</ca:RD><ca:STS>Street</ca:STS>
          <ca:RDBR>Campbell Street</ca:RDBR>
          <ca:LMK>
            Gilligan's Island
          </ca:LMK> <ca:LOC>Corner</ca:LOC>
          <ca:NAM> Video Rental Store </ca:NAM>
          <ca:PC>2500</ca:PC>
          <ca:ROOM> Westerns and Classics </ca:ROOM>
          <ca:PLC>store</ca:PLC>
          <ca:POBOX>Private Box 15</ca:POBOX>
        </ca:civicAddress>
      </gp:location-info>
      <gp:usage-rules/>
      <gp:method>GPS</gp:method>
    </gp:geopriv>
    <dm:deviceID>mac:1234567890ab</dm:deviceID>
    <dm:timestamp>2007-06-22T20:57:29Z</dm:timestamp>
  </dm:device>
  <dm:person id="ness">
    <gp:geopriv>
      <gp:location-info>
        <gs:Circle srsName="urn:ogc:def:crs:EPSG::4326">
          <gml:pos>-34.410649 150.87651</gml:pos>
          <gs:radius uom="urn:ogc:def:uom:EPSG::9001">
```

```
        30
        </gs:radius>
    </gs:Circle>
</gp:location-info>
<gp:usage-rules/>
<gp:method>Manual</gp:method>
</gp:geopriv>
<dm:timestamp>2007-06-24T12:28:04Z</dm:timestamp>
</dm:person>
</presence>
```

Figure 3: PIDF-LO Containing Multiple Location Objects

4. Geodetic Coordinate Representation

The geodetic examples provided in RFC 4119 [RFC4119] are illustrated using the `<gml:location>` element, which uses the `<gml:coordinates>` element inside the `<gml:Point>` element, and this representation has several drawbacks. Firstly, it has been deprecated in later versions of GML (3.1 and beyond) making it inadvisable to use for new applications. Secondly, the format of the coordinates type is opaque and so can be difficult to parse and interpret to ensure consistent results, as the same geodetic location can be expressed in a variety of ways. The PIDF-LO Geodetic Shapes specification [GeoShape] provides a specific GML profile for expressing commonly used shapes using simple GML representations. The shapes defined in [GeoShape] are the recommended shapes to ensure interoperability.

5. Geodetic Shape Representation

The cellular mobile world today makes extensive use of geodetic-based location information for emergency and other location-based applications. Generally, these locations are expressed as a point (either in two or three dimensions) and an area or volume of uncertainty around the point. In theory, the area or volume represents a coverage in which the user has a relatively high probability of being found, and the point is a convenient means of defining the centroid for the area or volume. In practice, most systems use the point as an absolute value and ignore the uncertainty. It is difficult to determine if systems have been implemented in this manner for simplicity, and even more difficult to predict if uncertainty will play a more important role in the future. An important decision is whether an uncertainty area should be specified.

The PIDF-LO Geodetic Shapes specification [GeoShape] defines eight shape types, most of which are easily translated into shape definitions used in other applications and protocols, such as the Open Mobile Alliance (OMA) Mobile Location Protocol (MLP). For completeness, the shapes defined in [GeoShape] are listed below:

- o Point (2d and 3d)
- o Polygon (2d)
- o Circle (2d)
- o Ellipse (2d)
- o Arc band (2d)
- o Sphere (3d)
- o Ellipsoid (3d)
- o Prism (3d)

The above-listed shapes MUST be implemented.

The GeoShape specification [GeoShape] also describes a standard set of coordinate reference systems (CRS), unit of measure (UoM) and conventions relating to lines and distances. The use of the world geodetic system 1984 (WGS84) [WGS84] coordinate reference system and the usage of European petroleum survey group (EPSG) code 4326 (as identified by the URN urn:ogc:def:crs:EPSG::4326, [CRS-URN]) for two-dimensional (2d) shape representations and EPSG 4979 (as identified by the URN urn:ogc:def:crs:EPSG::4979) for three-dimensional (3d) volume representations is mandated. Distance and heights are expressed in meters using EPSG 9001 (as identified by the URN urn:ogc:def:uom:EPSG::9001). Angular measures MUST use either degrees or radians. Measures in degrees MUST be identified by the URN urn:ogc:def:uom:EPSG::9102, measures in radians MUST be identified by the URN urn:ogc:def:uom:EPSG::9101. Angles representing bearings are measured in a clockwise direction from Northing, as defined by the WGS84 CRS, not magnetic north.

Implementations MUST specify the CRS using the srsName attribute on the outermost geometry element. The CRS MUST NOT be respecified or changed for any sub-elements. The srsDimension attribute SHOULD be omitted, since the number of dimensions in these CRSs is known. A CRS MUST be specified using the above URN notation only; implementations do not need to support user-defined CRSs.

Numerical values for coordinates and measures are expressed using the lexical representation for "double" defined in [W3C.REC-xmlschema-2-20041028]. Leading zeros and trailing zeros past the decimal point are not significant; for instance "03.07500" is equivalent to "3.075".

It is RECOMMENDED that uncertainty is expressed at a confidence of 95% or higher. Specifying a convention for confidence enables better use of uncertainty values.

5.1. Polygon Restrictions

The polygon shape type defined in [GeoShape] intentionally does not place any constraints on the number of vertices that may be included to define the bounds of a polygon. This allows arbitrarily complex shapes to be defined and conveyed in a PIDF-LO. However, where location information is to be used in real-time processing applications, such as location-dependent routing, having arbitrarily complex shapes consisting of tens or even hundreds of points could result in significant performance impacts. To mitigate this risk, Polygon shapes SHOULD be restricted to a maximum of 15 points (16 including the repeated point) when the location information is intended for use in real-time applications. This limit of 15 points is chosen to allow moderately complex shape definitions while at the same time enabling interoperability with other location transporting protocols such as those defined in the 3rd Generation Partnership Project (3GPP) (see [3GPP.23.032]) and OMA where the 15-point limit is already imposed.

The edges of a polygon are defined by the shortest path between two points in space (not a geodesic curve). Two-dimensional points MAY be interpreted as having a zero value for their altitude component. To avoid significant errors arising from potential geodesic interpolation, the length between adjacent vertices SHOULD be restricted to a maximum of 130 km. More information relating to this restriction is provided in [GeoShape].

A connecting line SHALL NOT cross another connecting line of the same Polygon.

Polygons MUST be defined with the upward normal pointing up. This is accomplished by defining the vertices in a counter-clockwise direction.

Points specified in a polygon using three-dimensional coordinates MUST all have the same altitude.

5.2. Shape Examples

This section provides some examples of where some of the more complex shapes are used, how they are determined, and how they are represented in a PIDF-LO. Complete details on all of the GeoShape types are provided in [GeoShape].

5.2.1. Point

The point shape type is the simplest form of geodetic location information (LI), which is natively supported by GML. The `gml:Point` element is used when there is no known uncertainty. A point also forms part of a number of other geometries. A point may be specified using either WGS 84 (latitude, longitude) or WGS 84 (latitude, longitude, altitude). Figure 4 shows a 2d point:

```
<presence xmlns="urn:ietf:params:xml:ns:pidf"
  xmlns:dm="urn:ietf:params:xml:ns:pidf:data-model"
  xmlns:gp="urn:ietf:params:xml:ns:pidf:geopriv10"
  xmlns:cl="urn:ietf:params:xml:ns:pidf:geopriv10:civicAddr"
  xmlns:gml="http://www.opengis.net/gml"
  entity="pres:point2d@example.com">
  <dm:device id="point2d">
    <gp:geopriv>
      <gp:location-info>
        <gml:Point srsName="urn:ogc:def:crs:EPSG::4326">
          <gml:pos>-34.407 150.883</gml:pos>
        </gml:Point>
      </gp:location-info>
      <gp:usage-rules/>
      <gp:method>Wiremap</gp:method>
    </gp:geopriv>
    <dm:deviceID>mac:1234567890ab</dm:deviceID>
    <dm:timestamp>2007-06-22T20:57:29Z</dm:timestamp>
  </dm:device>
</presence>
```

Figure 4: PIDF-LO Containing a Two-Dimensional Point

Figure 5 shows a 3d point:

```
<presence xmlns="urn:ietf:params:xml:ns:pidf"
  xmlns:dm="urn:ietf:params:xml:ns:pidf:data-model"
  xmlns:gp="urn:ietf:params:xml:ns:pidf:geopriv10"
  xmlns:gml="http://www.opengis.net/gml"
  entity="pres:point3d@example.com">
  <dm:device id="point3d">
    <gp:geopriv>
      <gp:location-info>
        <gml:Point srsName="urn:ogc:def:crs:EPSG::4979"
          xmlns:gml="http://www.opengis.net/gml">
          <gml:pos>-34.407 150.883 24.8</gml:pos>
        </gml:Point>
      </gp:location-info>
      <gp:usage-rules/>
      <gp:method>Wiremap</gp:method>
    </gp:geopriv>
    <dm:deviceID>mac:1234567890ab</dm:deviceID>
    <dm:timestamp>2007-06-22T20:57:29Z</dm:timestamp>
  </dm:device>
</presence>
```

Figure 5: PIDF-LO Containing a Three-Dimensional Point

5.2.2. Polygon

The polygon shape type may be used to represent a building outline or coverage area. The first and last points of the polygon have to be the same. For example, looking at the hexagon in Figure 6 with vertices, A, B, C, D, E, and F. The resulting polygon will be defined with 7 points, with the first and last points both having the coordinates of point A.

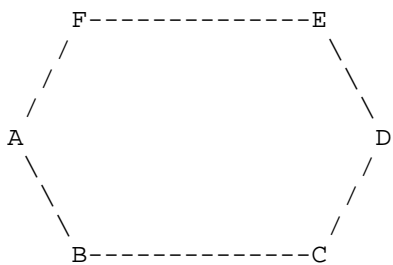


Figure 6: Example of a Polygon

```

<presence xmlns="urn:ietf:params:xml:ns:pidf"
  xmlns:gp="urn:ietf:params:xml:ns:pidf:geopriv10"
  xmlns:gml="http://www.opengis.net/gml"
  entity="pres:hexagon@example.com">
  <tuple id="polygon-pos">
    <status>
      <gp:geopriv>
        <gp:location-info>
          <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> <!--F-->
                <gml:pos>43.111 -73.222</gml:pos> <!--E-->
                <gml:pos>43.311 -73.122</gml:pos> <!--D-->
                <gml:pos>43.411 -73.222</gml:pos> <!--C-->
                <gml:pos>43.411 -73.322</gml:pos> <!--B-->
                <gml:pos>43.311 -73.422</gml:pos> <!--A-->
              </gml:LinearRing>
            </gml:exterior>
          </gml:Polygon>
        </gp:location-info>
        <gp:usage-rules/>
        <gp:method>Wiremap</gp:method>
      </gp:geopriv>
    </status>
    <timestamp>2007-06-22T20:57:29Z</timestamp>
  </tuple>
</presence>

```

Figure 7: PIDF-LO Containing a Polygon

In addition to the form shown in Figure 7, GML supports a `posList` that provides a more compact representation for the coordinates of the Polygon vertices than the discrete `pos` elements. The more compact form is shown in Figure 8. Both forms are permitted.

```
<presence xmlns="urn:ietf:params:xml:ns:pidf"
  xmlns:gp="urn:ietf:params:xml:ns:pidf:geopriv10"
  xmlns:gml="http://www.opengis.net/gml"
  entity="pres:hexagon@example.com">
  <tuple id="polygon-poslist">
    <status>
      <gp:geopriv>
        <gp:location-info>
          <gml:Polygon srsName="urn:ogc:def:crs:EPSG::4326">
            <gml:exterior>
              <gml:LinearRing>
                <gml:posList>
                  43.311 -73.422 43.111 -73.322
                  43.111 -73.222 43.311 -73.122
                  43.411 -73.222 43.411 -73.322
                  43.311 -73.422
                </gml:posList>
              </gml:LinearRing>
            </gml:exterior>
          </gml:Polygon>
        </gp:location-info>
        <gp:usage-rules/>
        <gp:method>Wiremap</gp:method>
      </gp:geopriv>
    </status>
    <timestamp>2007-06-22T20:57:29Z</timestamp>
  </tuple>
</presence>
```

Figure 8: Compact Form of a Polygon Expressed in a PIDF-LO

5.2.3. Circle

The circular area is used for coordinates in two-dimensional CRSs to describe uncertainty about a point. The definition is based on the one-dimensional geometry in GML, `gml:CircleByCenterPoint`. The center point of a circular area is specified by using a two-dimensional CRS; in three dimensions, the orientation of the circle cannot be specified correctly using this representation. A point with uncertainty that is specified in three dimensions should use the sphere shape type.

```
<presence xmlns="urn:ietf:params:xml:ns:pidf"
  xmlns:gp="urn:ietf:params:xml:ns:pidf:geopriv10"
  xmlns:gml="http://www.opengis.net/gml"
  xmlns:gs="http://www.opengis.net/pidflo/1.0"
  entity="pres:circle@example.com">
  <tuple id="circle">
    <status>
      <gp:geopriv>
        <gp:location-info>
          <gs:Circle srsName="urn:ogc:def:crs:EPSG::4326">
            <gml:pos>42.5463 -73.2512</gml:pos>
            <gs:radius uom="urn:ogc:def:uom:EPSG::9001">
              850.24
            </gs:radius>
          </gs:Circle>
        </gp:location-info>
        <gp:usage-rules/>
        <gp:method>OTDOA</gp:method>
      </gp:geopriv>
    </status>
  </tuple>
</presence>
```

Figure 9: PIDF-LO Containing a Circle

5.2.4. Ellipse

An elliptical area describes an ellipse in two-dimensional space. The ellipse is described by a center point, the length of its semi-major and semi-minor axes, and the orientation of the semi-major axis. Like the circular area (Circle), the ellipse MUST be specified using the two-dimensional CRS.

```

<presence xmlns="urn:ietf:params:xml:ns:pidf"
  xmlns:gp="urn:ietf:params:xml:ns:pidf:geopriv10"
  xmlns:gml="http://www.opengis.net/gml"
  xmlns:gs="http://www.opengis.net/pidflo/1.0"
  entity="pres:Ellipse@somecell.example.com">
  <tuple id="ellipse">
    <status>
      <gp:geopriv>
        <gp:location-info>
          <gs:Ellipse srsName="urn:ogc:def:crs:EPSG::4326">
            <gml:pos>42.5463 -73.2512</gml:pos>
            <gs:semiMajorAxis uom="urn:ogc:def:uom:EPSG::9001">
              1275
            </gs:semiMajorAxis>
            <gs:semiMinorAxis uom="urn:ogc:def:uom:EPSG::9001">
              670
            </gs:semiMinorAxis>
            <gs:orientation uom="urn:ogc:def:uom:EPSG::9102">
              43.2
            </gs:orientation>
          </gs:Ellipse>
        </gp:location-info>
        <gp:usage-rules/>
        <gp:method>Device-Assisted_A-GPS</gp:method>
      </gp:geopriv>
    </status>
    <timestamp>2007-06-22T20:57:29Z</timestamp>
  </tuple>
</presence>

```

Figure 10: PIDF-LO Containing an Ellipse

The `gml:pos` element indicates the position of the center, or origin, of the ellipse. The `gs:semiMajorAxis` and `gs:semiMinorAxis` elements are the length of the semi-major and semi-minor axes, respectively. The `gs:orientation` element is the angle by which the semi-major axis is rotated from the first axis of the CRS towards the second axis. For WGS 84, the orientation indicates rotation from Northing to Easting, which, if specified in degrees, is roughly equivalent to a compass bearing (if magnetic north were the same as the WGS north pole). Note: An ellipse with equal major and minor axis lengths is a circle.

5.2.5. Arc Band

The arc band shape type is commonly generated in wireless systems where timing advance or code offsets sequences are used to compensate for distances between handsets and the access point. The arc band is represented as two radii emanating from a central point, and two angles that represent the starting angle and the opening angle of the arc. In a cellular environment, the central point is nominally the location of the cell tower, the two radii are determined by the extent of the timing advance, and the two angles are generally provisioned information.

For example, Paul is using a cellular wireless device and is 7 timing advance symbols away from the cell tower. For a GSM-based network, this would place Paul roughly between 3,594 meters and 4,148 meters from the cell tower, providing the inner and outer radius values. If the start angle is 20 degrees from north, and the opening angle is 120 degrees, an arc band representing Paul's location would look similar to Figure 11.

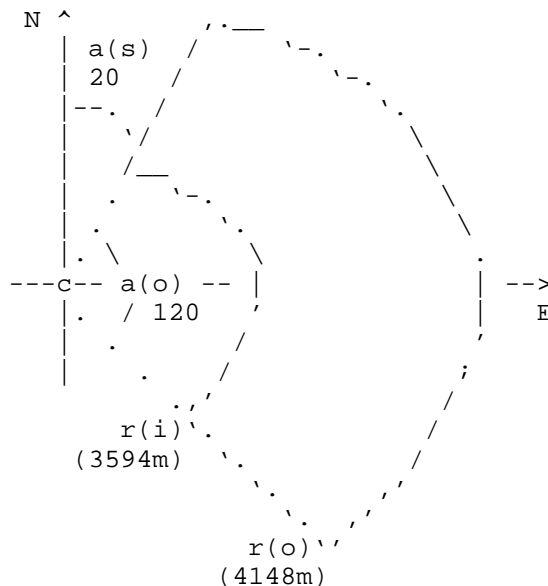


Figure 11: Example of an Arc Band

The resulting PIDF-LO is shown in Figure 12.

```

<presence xmlns="urn:ietf:params:xml:ns:pidf"
  xmlns:gp="urn:ietf:params:xml:ns:pidf:geopriv10"
  xmlns:gml="http://www.opengis.net/gml"
  xmlns:gs="http://www.opengis.net/pidflo/1.0"
  entity="pres:paul@somecell.example.com">
  <tuple id="arcband">
    <status>
      <gp:geopriv>
        <gp:location-info>
          <gs:ArcBand srsName="urn:ogc:def:crs:EPSG::4326">
            <gml:pos>-43.5723 153.21760</gml:pos>
            <gs:innerRadius uom="urn:ogc:def:uom:EPSG::9001">
              3594
            </gs:innerRadius>
            <gs:outerRadius uom="urn:ogc:def:uom:EPSG::9001">
              4148
            </gs:outerRadius>
            <gs:startAngle uom="urn:ogc:def:uom:EPSG::9102">
              20
            </gs:startAngle>
            <gs:openingAngle uom="urn:ogc:def:uom:EPSG::9102">
              20
            </gs:openingAngle>
          </gs:ArcBand>
        </gp:location-info>
        <gp:usage-rules/>
        <gp:method>TA-NMR</gp:method>
      </gp:geopriv>
    </status>
    <timestamp>2007-06-22T20:57:29Z</timestamp>
  </tuple>
</presence>

```

Figure 12: PIDF-LO Containing an Arc Band

An important note to make on the arc band is that the center point used in the definition of the shape is not included in resulting enclosed area, and that Target may be anywhere in the defined area of the arc band.

5.2.6. Sphere

The sphere is a volume that provides the same information as a circle in three dimensions. The sphere has to be specified using a three-dimensional CRS. Figure 13 shows the sphere shape type, which is identical to the circle example, except for the addition of an altitude in the provided coordinates.

```
<presence xmlns="urn:ietf:params:xml:ns:pidf"
  xmlns:gp="urn:ietf:params:xml:ns:pidf:geopriv10"
  xmlns:gml="http://www.opengis.net/gml"
  xmlns:gs="http://www.opengis.net/pidflo/1.0"
  entity="pres:sphere@example.com">
  <tuple id="sphere">
    <status>
      <gp:geopriv>
        <gp:location-info>
          <gs:Sphere srsName="urn:ogc:def:crs:EPSG::4979">
            <gml:pos>42.5463 -73.2512 26.3</gml:pos>
            <gs:radius uom="urn:ogc:def:uom:EPSG::9001">
              850.24
            </gs:radius>
          </gs:Sphere>
        </gp:location-info>
        <gp:usage-rules/>
        <gp:method>Device-Based_A-GPS</gp:method>
      </gp:geopriv>
    </status>
  </tuple>
</presence>
```

Figure 13: PIDF-LO Containing a Sphere

5.2.7. Ellipsoid

The ellipsoid is the volume most commonly produced by GPS systems. It is used extensively in navigation systems and wireless location networks. The ellipsoid is constructed around a central point specified in three dimensions, and three axes perpendicular to one another are extended outwards from this point. These axes are defined as the semi-major (M) axis, the semi-minor (m) axis, and the vertical (v) axis, respectively. An angle is used to express the orientation of the ellipsoid. The orientation angle is measured in degrees from north, and represents the direction of the semi-major axis from the center point.

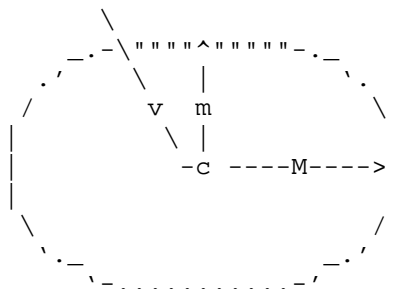


Figure 14: Example of an Ellipsoid

A PIDF-LO containing an ellipsoid appears as shown in Figure 15.

```
<presence xmlns="urn:ietf:params:xml:ns:pidf"
  xmlns:gp="urn:ietf:params:xml:ns:pidf:geopriv10"
  xmlns:gml="http://www.opengis.net/gml"
  xmlns:gs="http://www.opengis.net/pidflo/1.0"
  entity="pres:somone@gpsreceiver.example.com">
  <tuple id="ellipsoid">
    <status>
      <gp:geopriv>
        <gp:location-info>
          <gs:Ellipsoid srsName="urn:ogc:def:crs:EPSG::4979">
            <gml:pos>42.5463 -73.2512 26.3</gml:pos>
            <gs:semiMajorAxis uom="urn:ogc:def:uom:EPSG::9001">
              7.7156
            </gs:semiMajorAxis>
            <gs:semiMinorAxis uom="urn:ogc:def:uom:EPSG::9001">
              3.31
            </gs:semiMinorAxis>
            <gs:verticalAxis uom="urn:ogc:def:uom:EPSG::9001">
              28.7
            </gs:verticalAxis>
            <gs:orientation uom="urn:ogc:def:uom:EPSG::9102">
              90
            </gs:orientation>
          </gs:Ellipsoid>
        </gp:location-info>
        <gp:usage-rules/>
        <gp:method>Hybrid_A-GPS</gp:method>
      </gp:geopriv>
    </status>
    <timestamp>2007-06-22T20:57:29Z</timestamp>
  </tuple>
</presence>
```

Figure 15: PIDF-LO Containing an Ellipsoid

5.2.8. Prism

A prism may be used to represent a section of a building or range of floors of building. The prism extrudes a polygon by providing a height element. It consists of a base made up of coplanar points defined in 3 dimensions all at the same altitude. The prism is then an extrusion from this base to the value specified in the height element. The height of the Prism MUST be a positive value. The first and last points of the polygon have to be the same.

For example, looking at the cube in Figure 16: if the prism is extruded from the bottom up, then the polygon forming the base of the prism is defined with the points A, B, C, D, A. The height of the prism is the distance between point A and point E in meters.

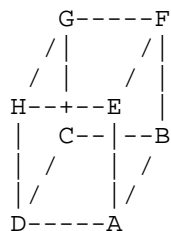


Figure 16: Example of a Prism

The resulting PIDF-LO is shown in Figure 17.

```

<presence xmlns="urn:ietf:params:xml:ns:pidf"
  xmlns:gp="urn:ietf:params:xml:ns:pidf:geopriv10"
  xmlns:gml="http://www.opengis.net/gml"
  xmlns:gs="http://www.opengis.net/pidflo/1.0"
  entity="pres:mike@someprism.example.com">
  <tuple id="prism">
    <status>
      <gp:geopriv>
        <gp:location-info>
          <gs:Prism srsName="urn:ogc:def:crs:EPSG::4979">
            <gs:base>
              <gml:Polygon>
                <gml:exterior>
                  <gml:LinearRing>
                    <gml:posList>
                      42.556844 -73.248157 36.6 <!--A-->
                      42.656844 -73.248157 36.6 <!--B-->
                      42.656844 -73.348157 36.6 <!--C-->
                      42.556844 -73.348157 36.6 <!--D-->
                      42.556844 -73.248157 36.6 <!--A-->
                    </gml:posList>
                  </gml:LinearRing>
                </gml:exterior>
              </gml:Polygon>
            </gs:base>
            <gs:height uom="urn:ogc:def:uom:EPSG::9001">
              2.4
            </gs:height>
          </gs:Prism>
        </gp:location-info>
        <gp:usage-rules/>
        <gp:method>Wiremap</gp:method>
      </gp:geopriv>
    </status>
    <timestamp>2007-06-22T20:57:29Z</timestamp>
  </tuple>
</presence>

```

Figure 17: PIDF-LO Containing a Prism

6. Security Considerations

The primary security considerations relate to how location information is conveyed and used, which are outside the scope of this document. This document is intended to serve only as a set of guidelines as to which elements MUST or SHOULD be implemented by systems wishing to perform location dependent routing. The ramification of such recommendations is that they extend to devices and clients that wish to make use of such services.

7. Acknowledgments

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