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HTTP Enabled Location Delivery (HELD)
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Abstract

A Layer 7 Location Configuration Protocol (L7 LCP) is described that is used for retrieving location information from a server within an access network. The protocol includes options for retrieving location information either by-value or by-reference. The protocol supports mobile and nomadic devices through Location URIs. The protocol is an application-layer protocol that is independent of

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session-layer; an HTTP, web services binding is specified.

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[1.](#) Introduction

The location of a Device is information that is useful for a number of applications. The L7 LCP problem statement and requirements document [\[11\]](#) provides some scenarios in which a Device might rely on its access network to provide the location information, such as such as fixed environments (e.g., DSL/Cable), mobile networks and wireless access networks. This document describes a protocol that can be used to acquire Location Information (LI) from a service within an access network. The service within an access network is assumed to be provided by a Location Configuration Server (LCS), as introduced in the L7 LCP problem statement and requirements document.

This specification identifies two methods for acquiring LI. Location may be retrieved from a Location Configuration Server (LCS) by-value, that is, the Device may acquire LI directly. Alternatively, the Device may request that the LCS provide a location URI so that LI can be distributed by-reference. Both of these methods are compatible, and both can be provided concurrently from the same LCS so that application needs can be addressed individually.

This specification defines an XML-based protocol that enables the retrieval of LI from a LCS by a Device. This protocol can be bound to any session-layer protocol, particularly those capable of MIME transport; an HTTP binding is included as a minimum requirement.

[2.](#) Conventions

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 [1].

3. Terminology

This document uses the terms (and their acronym forms) Access Provider (AP), Location Information (LI), Location Object (LO), Device, Target, Location Server (LS), Location Generator (LG), Location Recipient (LR), Rule Maker (RM) and Rule Holder (RH) as defined in [7]. This document also includes definitions for the terms, Civic Location/Address, Geodetic Location, and Location Configuration Server, used within this document. These definitions may differ slightly from those used in other GEOPRIV documents, but the concepts are the same.

For convenience, abbreviated versions of [RFC 3693](#) [7] definitions are included. Notes are included following some of the definitions to

clarify the context in which these terms are used in this document:

Access Network Provider: See Access Provider (AP).

Access Provider (AP): An organization that provides physical network connectivity to its customers or users, e.g., through digital subscriber lines, cable TV plants, Ethernet, leased lines or radio frequencies. Examples of such organizations include telecommunication carriers, municipal utilities, larger enterprises with their own network infrastructure, and government organizations such as the military.

Note: this definition differs from that in [7] by the use of the more generic 'organization' rather than 'domain' - the general concept is the same. This term is used interchangeably with Access Network Provider in this document.

Civic Location/Address: A location expressed in a form that is defined by civic demarcations. Civic addresses can be specialized for jurisdictional (general use) or postal (message delivery) purposes, or they can apply to either.

Device: The technical device whereby the location is tracked as a

proxy for the location of a Target.

Geodetic Location: A location expressed in coordinate form.

Location Configuration Server (LCS): The entity within the Access Provider's network that provides location information to clients. This term is introduced in [\[11\]](#) and it provides the location information that is generated and maintained by the LG and LS functional elements respectively. The details of the interactions between an LG and LS and in particular how the LCS uses these to obtain location information is outside the scope of this document since it is very deployment specific.

Location Generator (LG): The entity that initially determines or gathers the location of the Target and creates Location Objects describing that location.

Location Information (LI): The data that describes the location of a Device. The term LI does not include the representation of this data.

Note: this term is not officially defined in [\[7\]](#), but rather is assumed from the general usage throughout that document and within the GEOPRIV WG.

Location Object (LO): An object conveying Location Information (and possibly privacy rules) to which Geopriv security mechanisms and privacy rules are to be applied.

Note: this is a specific by-value representation of Location Information (LI). In this document, LO refers to PIDF-LO [\[8\]](#).

Location Server (LS): The LS is an element that receives publications of Location Objects from Location Generators and may receive subscriptions from Location Recipients. The LS applies the rules (which it learns from the Rule Holder) to LOs it receives from LGs, and then notifies LR of resulting LOs as necessary.

Note: This definition varies from that defined in [\[7\]](#) by defining the roles of the functional elements more explicitly. In some specifications the Location Server is referred to as a Location

Information Server or LIS. In this context, the Location Server is distinct from what is alternatively referred to as a Registrar in other contexts.

Location Recipient (LR): The entity that receives Location Information (LI).

Rule Holder (RH): The entity that provides the rules associated with a particular target for the distribution of Location Information (LI).

Rule Maker (RM): The authority that creates rules governing access to location information for a target (typically, this is the Target themselves).

Target: A person or other entity whose location is communicated by a GEOPRIV Location Object (LO).

[4.](#) Overview and Scope

This document describes an interface between a Device and a Location Configuration Server (LCS). The LCS is a service present within the same administrative domain as the Device (the access network). An Access Provider (AP) operates the LCS service so that Devices (and Targets) can retrieve LI. The LCS exists because not all Devices are capable of determining LI, and because, even if a device is able to determine its own LI, it may be more efficient with assistance. This document does not specify how LI is derived.

This document is based on the attribution of the LI to a device and not specifically a person (end user) or Target, based on the premise

that location determination technologies are generally designed to locate a device and not a person. It is expected that, for most applications, LI for the device can be used as an adequate substitute for the end user's LI. Since revealing the location of the device almost invariably reveals some information about the location of the user of the device, the same level of privacy protection demanded by a user is required for the device. This approach may require either some additional assurances about the link between device and target,

or an acceptance of the limitation that unless the device requires active user authentication, there is no guarantee that any particular individual is using the device at that instant.

This document identifies two methods for acquiring LI. Location may be retrieved from a Location Configuration Server (LCS) by-value, that is, the device may acquire LI directly. Alternatively, the Device may request that the LCS provide a location URI so that LI can be distributed by-reference. Providing LI by-reference implies that a server is able to provide the device with a public, globally-addressable URI.

The following diagram shows the logical configuration of some of the functional elements identified in [7] and the LCS defined in [11] and where this protocol applies, with the Rule Maker and Target represented by the role of the Device.

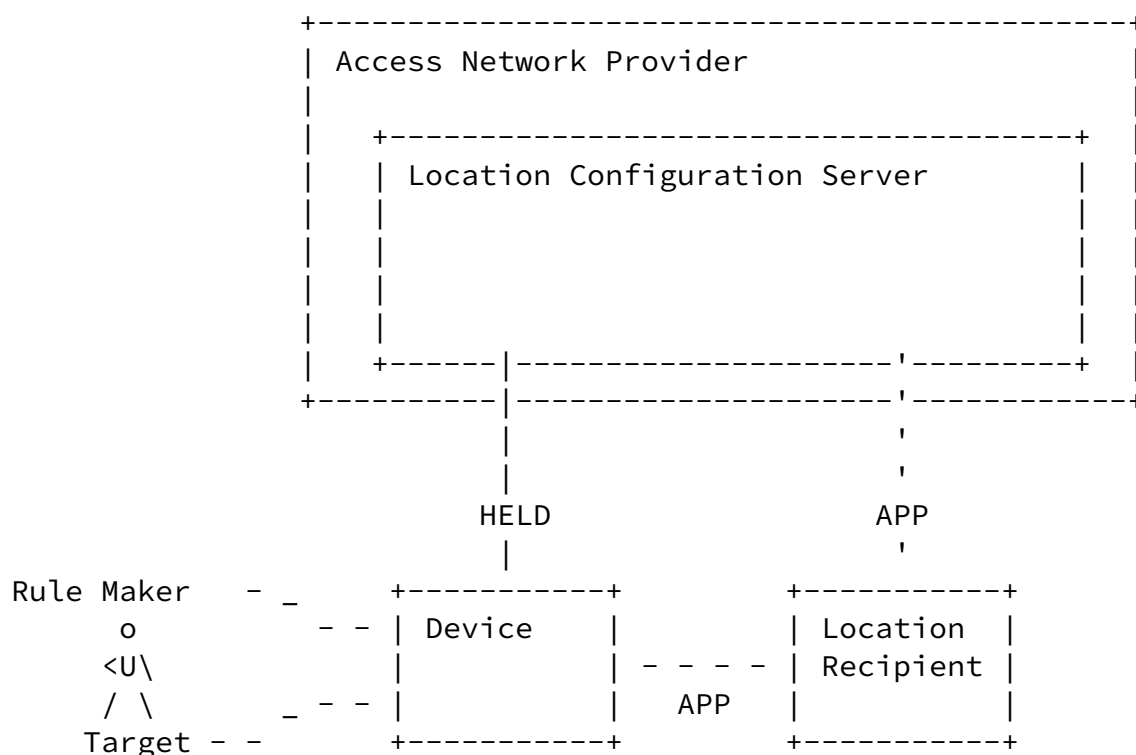


Figure 1: Significant Roles

and/or LCS is application specific, as indicated by the APP annotation in the diagram and it is outside the scope of the document. An example of an APP interface between a device and LR can be found in the SIP Location Conveyance document [24].

5. Protocol Overview

The HELD protocol facilitates retrieval of LI either by-value, as a PIDF-LO document, or by-reference, as a Location URI. The policy that describes to whom, and how, LI is granted is outside the scope of this document and maybe specified in separate specifications as required. The Device must first discover the URI for the LCS for sending the HELD protocol requests as identified by the requirement in the L7 LCP problem statement and requirements [11]. The discovery methods are specified in [15].

Where a Device requires LI directly, it can request that the LCS create a PIDF-LO document. This approach fits well with a configuration whereby the device directly makes use of the provided PIDF-LO document. With this approach, the LCS needs to uniquely identify the Device within the access network. The source address of the request message is sufficient in most cases. Once the Device is identified, the LCS uses network domain-specific information to determine the location of the Device.

The details on the information that may be included in the PIDF-LO MUST follow the subset of those rules relating to the construction of the "location-info" element in [10]. The PIDF-LO generated by the LCS in this case MUST follow the rules in [10]. In addition, the default values for <retransmission allowed> and <retention expires> as specified in [8] MUST be applied. A default value of "no" SHALL be used for the <retransmission-allowed> element. A default value of 24 hours SHALL be used for <retention-expires> value of any generated PDIF-LO documents.

Requesting location directly does not always address the requirements of an application. A Device can request a location URI instead of literal location. A Location URI is a URI [23] of any scheme, which a Location Recipient (LR) can use to retrieve LI. A location URI provided by an LCS can be assumed to be globally-addressable; that is, anyone in possession of the URI can access the LCS. This does not in any way suggest that the LCS is bound to reveal the location associated with the location URI. This issue is deemed out of scope for this document. The merits and drawbacks of using a Location URI approach are discussed in [16].

[6.](#) Protocol Description

As discussed in [Section 5](#), this protocol provides for the retrieval of a Location or a Location URI from an LCS. Three messages are defined to support the location retrieval: locationRequest, heldResponse and error. Messages are defined as XML documents.

The Location Request (locationRequest) message is described in [Section 6.2](#). A Location Request from a Device indicates whether a Location (and the specific type of location) and/or a Location URI should be returned. The LCS replies with a response (heldResponse), including a PIDF-LO document and/or one or more Location URIs in case of success, or an error message in case of an error.

A MIME type "application/held+xml" is registered in [Section 12.6](#) to distinguish HELD messages from other XML document bodies. This specification follows the recommendations and conventions described in [\[20\]](#), including the naming convention of the type ('+xml' suffix) and the usage of the 'charset' parameter.

[Section 7](#) contains a more thorough description of the protocol parameters, valid values, and how each should be handled. [Section 8](#) contains a more specific definition of the structure of these messages in the form of an XML Schema [\[12\]](#).

[6.1.](#) Protocol Binding

The HELD protocol is an application-layer protocol that is defined independently of any lower layers. This means that any protocol can be used to transport this protocol providing that it can provide a few basic features:

- o The protocol must have acknowledged delivery.
- o The protocol must be able to correlate a response with a request.
- o The protocol must provide authentication, privacy and protection against modification.

Candidate protocols that could be used to address these purposes include: TCP [\[17\]](#), TLS [\[2\]](#), SASL [\[18\]](#), HTTP [\[3\]](#), SIP [\[22\]](#), BEEP [\[21\]](#) and SOAP [\[25\]](#) [\[26\]](#). This document includes a binding that uses a combination of HTTP, TLS and TCP in [Section 9](#).

[6.2.](#) Location Request

A location request is sent from the Device to the LCS when it requires LI. This request MUST include the type of location being requested such as civic location, location URI, etc. The type of LI that a Device requests is determined by the type of LI that is

included in the "locationType" element.

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The location request is made by sending a document formed of a "locationRequest" element. The successful response to a location request is a document formed of a "heldResponse" element, unless the request fails, in which case the LCS SHOULD provide an error indication document.

[6.3.](#) Held Response

The response to a Location request MUST contain either a PIDF-LO and/or Location URI(s), depending upon the requested "locationType". The "heldResponse" element MUST include a "code" attribute with a value of 200. A set of predefined error codes are included in [Section 7.4](#). The response is in error if there is a value other than 200, since those MUST be sent using the error message [Section 6.4](#).

A Location URI MUST NOT contain any information that could be used to identify the Device or Target. It is RECOMMENDED that a Location URI contain a public address for the LCS and a random sequence of characters that the LCS can use to identify a particular context.

[6.4.](#) Indicating Errors

In the event of an error, the LCS SHOULD respond to the Device with an error document. The error response applies to all request types and SHOULD also be sent in response to any unrecognized request.

An error indication document consists of an "error" element. The "error" element MUST include a "code" attribute that indicates the type of error. A set of predefined error codes are included in [Section 7.4](#).

Error responses MAY also include a "message" attribute that can include additional information. This information SHOULD be for diagnostic purposes only, and MAY be in any language. The language of the message SHOULD be indicated with an "xml:lang" attribute.

[7.](#) Protocol Parameters

This section describes, in detail the parameters that are used for this protocol. Table 1 lists the top-level components used within the protocol and where they are mandatory or optional for each of the messages.

Parameter	Location Request	HELD Response	Error
responseTime (Section 7.1)	o		
locationType (Section 7.2)	m		
exact (Section 7.2.1)	o		
options (Section 7.3)	o		
code (Section 7.4)		m	m
message (Section 7.5)		o	o
locationURI (Section 7.6)		o	
expires (Section 7.6.1)		m	

Table1: Message Parameter Usage

[7.1.](#) "responseTime" Parameter

The "responseTime" attribute indicates to the LCS how long the Device is prepared to wait for a response. This attribute MAY be added to a Location request message. The value of this attribute is indicative only, the LCS is under no obligation to strictly adhere to the time limit implied; any enforcement of the time limit is left to the requesting Device.

This attribute is expressed with a decimal seconds value, which may include a decimal point. It is RECOMMENDED that systems support millisecond precision for this parameter.

The LCS MUST provide the most accurate LI that can be determined within the specified interval. This parameter could be used as input when selecting the method of location determination, where multiple such methods exist. If this parameter is absent, then the LCS MUST return the most precise LI it is capable of determining.

[7.2.](#) "locationType" Parameter

The "locationType" element is included in a location request. It contains a list of LI types that are requested by the Device. The following list describes the possible values:

any: The LCS SHOULD attempt to provide LI in all forms available to it. This value MUST be assumed as the default if no "locationType" is specified. The LCS SHOULD return location information in a form that is suited for routing and responding to an emergency call in its jurisdiction.

geodetic: The LCS SHOULD return a geodetic location for the Target.

civic: The LCS SHOULD return a civic address for the Target. Any type of civic address may be returned. The LCS SHOULD ignore this value if a request for jurisdictional or postal civic address has been made and can be satisfied.

jurisdictionalCivic: The LCS SHOULD return a jurisdictional civic address for the Target.

postalCivic: The LCS SHOULD return a postal civic address for the Target.

locationURI: The LCS SHOULD return a location URI for the Target.

The LCS SHOULD return the requested location type or types. The LCS MAY provide additional location types, or it MAY provide alternative types if the request cannot be satisfied for a requested location type. If the "exact" attribute is present and set to "true" in a location request, then a successful LCS response MUST provide the requested location type only, with no additional location information. The "exact" attribute has no effect when this element is set to "any".

The "SHOULD"-strength requirement on this parameter is included to allow for soft-failover. This enables a fixed client configuration that prefers a specific location type without causing location requests to fail when that location type is unavailable. Unless the "exact" attribute is set, the LCS MUST provide LI in any available

form if it is unable to comply with the request.

For example, a notebook computer could be configured to retrieve civic addresses, which is usually available from typical home or work situations. However, when using a wireless modem, the LCS might be unable to provide a civic address.

[7.2.1.](#) "exact" Parameter

When the "exact" attribute is set to "true", it indicates to the LCS that the contents of the "locationType" parameter MUST be strictly followed. The default value of "false" allows the LCS the option of returning something beyond what is specified, such as a location URI when only a civic location was requested.

A value of "true" indicates that the LCS MUST provide a location of the requested type or types or MUST provide an error. The LCS MUST provide the requested types only and these types SHOULD be specified in the same order as they were requested. The LCS SHOULD handle an exact request that includes a "locationType" element set to "any" as if the "exact" attribute were set to "false".

[7.3.](#) "options" Parameter

The "options" attribute provides for extensibility, allowing for the definition of future optional extensions to the location request message without the need to create a new namespace. If multiple options are used, they MUST be separated by a semicolon (;), such as "optionOne=1;optionTwo=2;Option3=3". Options MUST be registered with IANA per [Section 12.2](#).

[7.4.](#) "code" Parameter

All responses MUST contain a response code. The "code" attribute applies to the "error" and "heldResponse" messages.

The following response codes follow a three decimal form similar to that in HTTP [\[3\]](#) and SIP [\[22\]](#):

200 (Success): This code indicates that the request was successful. This code MUST not be used for an error response.

400 (Request Error): This code indicates that the request was badly formed in some fashion.

401 (XML Error): This code indicates that the XML content of the request was either badly formed or invalid.

402 (Authentication Error): This code indicates that the request either did not contain authentication information, or the authentication provided was not accepted.

500 (General LCS Error): This code indicates that an unspecified error occurred at the LCS.

501 (Location Unknown): This code indicates that the LCS could not determine the location of the Device.

502 (Unsupported Message): This code indicates that the request was not supported or understood by the LCS.

503 (Timeout): This code indicates that the LCS could not satisfy the request within the time specified in the "responseTime" parameter.

504 (Cannot Provide LI Type): This code indicates that the LCS was unable to provide LI of the type or types requested. This code is used when the "exact" attribute on the "locationType" parameter is set to "true".

Additional response codes within the x00 to x79 range MUST be specified in published RFCs; the range from x80 to x99 is reserved for private usage.

[7.5.](#) "message" Parameter

The "heldResponse" and "error" messages MAY include a "message" attribute to convey some additional, human-readable information about the result of the request. This message MAY be included in any language, which SHOULD be indicated by the "xml:lang", attribute.

The default language is assumed to be English.

[7.6.](#) "locationURI" Parameter

The "locationURI" element includes a single Location URI. Each Location URI that is allocated by the LCS is unique to the device that is requesting it.

A "heldResponse" message MAY contain any number of "locationURI" elements. It is RECOMMENDED that the LCS allocate a Location URI for each scheme that it supports and that each scheme is present only

once. URI schemes and their secure variants such as http and https should be regarded as two separate schemes.

[7.6.1.](#) "expires" Parameter

The "expires" attribute indicates the time at which the Location URI provided by the LCS will expire. This attribute is included in the "heldResponse" message only.

Responses to Locations requests for Location URIs MUST include the expiry time of the Location URI.

[8.](#) XML Schema

This section gives the XML Schema Definition [[12](#)] of the "application/held+xml" format. This is presented as a formal definition of the "application/held+xml" format. Note that the XML Schema definition is not intended to be used with on-the-fly validation of the presence XML document.

```
<?xml version="1.0"?>
<xs:schema
  targetNamespace="urn:ietf:params:xml:ns:geopriv:held"
  xmlns:xs="http://www.w3.org/2001/XMLSchema"
  xmlns:held="urn:ietf:params:xml:ns:geopriv:held"
  xmlns:gp="urn:ietf:params:xml:ns:pidf:geopriv10"
  xmlns:ca="urn:ietf:params:xml:ns:pidf:geopriv10:civicAddr"
  xmlns:cp="urn:ietf:params:xml:ns:common-policy"
  xmlns:gml="http://www.opengis.net/gml"
  xmlns:xml="http://www.w3.org/XML/1998/namespace"
  elementFormDefault="qualified"
  attributeFormDefault="unqualified">

  <xs:annotation>
    <xs:documentation source="http://www.ietf.org/rfc/rfcXXXX.txt">
<!-- [[NOTE TO RFC-EDITOR: Please replace above URL with URL of
```

```
    published RFC and remove this note.]] -->
    This document defines HELD messages.
  </xs:documentation>
</xs:annotation>
```



```

<xs:import namespace="http://www.w3.org/XML/1998/namespace"
           schemaLocation="xml.xsd"/>
<xs:import namespace="urn:ietf:params:xml:ns:pidf:geopriv10"
           schemaLocation="geopriv10.xsd"/>
<xs:import
  namespace="urn:ietf:params:xml:ns:pidf:geopriv10:civicAddr"
  schemaLocation="civicAddress.xsd"/>
<xs:import namespace="urn:ietf:params:xml:ns:common-policy"
           schemaLocation="common-policy.xsd"/>
<xs:import namespace="http://www.opengis.net/gml"
           schemaLocation="GML-3.1.1/base/geometryBasic2d.xsd"/>

<!-- Context Information -->
<xs:complexType name="returnContextType">
  <xs:complexContent>
    <xs:restriction base="xs:anyType">
      <xs:sequence>
        <xs:element name="locationURI" type="xs:anyURI"
                     maxOccurs="unbounded"/>
      </xs:sequence>
      <xs:attribute name="expires" type="xs:dateTime"
                     use="required"/>
    </xs:restriction>
  </xs:complexContent>
</xs:complexType>

<!-- Duration Type -->
<xs:simpleType name="durationType">
  <xs:restriction base="xs:decimal">
    <xs:minInclusive value="0.0"/>
  </xs:restriction>
</xs:simpleType>

<!-- Location Type -->
<xs:simpleType name="locationTypeBase">
  <xs:union>
    <xs:simpleType>
      <xs:restriction base="xs:token">
        <xs:enumeration value="any"/>
      </xs:restriction>
    </xs:simpleType>
  </xs:union>
</xs:simpleType>

```

```
<xs:simpleType>
  <xs:list>
    <xs:simpleType>
      <xs:restriction base="xs:token">
        <xs:enumeration value="civic"/>
        <xs:enumeration value="geodetic"/>
        <xs:enumeration value="postalCivic"/>
        <xs:enumeration value="jurisdictionalCivic"/>
        <xs:enumeration value="locationURI"/>
      </xs:restriction>
    </xs:simpleType>
  </xs:list>
</xs:simpleType>
</xs:union>
</xs:simpleType>

<xs:complexType name="locationTypeType">
  <xs:simpleContent>
    <xs:extension base="held:locationTypeBase">
      <xs:attribute name="exact" type="xs:boolean"
        use="optional" default="false"/>
    </xs:extension>
  </xs:simpleContent>
</xs:complexType>

<!-- Response code -->
<xs:simpleType name="codeType">
  <xs:restriction base="xs:nonNegativeInteger">
    <xs:pattern value="[0-5][0-9][0-9]"/>
  </xs:restriction>
</xs:simpleType>

<!-- Message Definitions -->
<xs:complexType name="baseRequestType">
  <xs:complexContent>
    <xs:restriction base="xs:anyType">
      <xs:sequence/>
      <xs:attribute name="responseTime" type="held:durationType"
        use="optional"/>
    </xs:restriction>
  </xs:complexContent>
</xs:complexType>

<xs:complexType name="baseResponseType">
  <xs:complexContent>
    <xs:restriction base="xs:anyType">
      <xs:sequence/>
    </xs:restriction>
  </xs:complexContent>
</xs:complexType>
```

```
<xs:attribute name="code" type="held:codeType"
```

```
        use="required"/>
    <xs:attribute name="message" type="xs:token"
        use="optional"/>
    <xs:attribute ref="xml:lang" use="optional"/>
</xs:restriction>
</xs:complexContent>
</xs:complexType>

<xs:element name="error" type="held:baseResponseType"/>

<!-- Context Response -->
<xs:complexType name="contextResponseType">
    <xs:complexContent>
        <xs:extension base="held:baseResponseType">
            <xs:sequence>
                <xs:element name="locationUriSet"
                    type="held:returnContextType"
                    minOccurs="0"/>
                <xs:any namespace="##other" processContents="lax"
                    minOccurs="0" maxOccurs="unbounded"/>
            </xs:sequence>
        </xs:extension>
    </xs:complexContent>
</xs:complexType>

<xs:element name="heldResponse"
    type="held:contextResponseType"/>

<!-- Location Request -->

<xs:complexType name="locationRequestType">
    <xs:complexContent>
        <xs:extension base="held:baseRequestType">
            <xs:sequence>
                <xs:element name="locationType"
                    type="held:locationTypeType"
                    minOccurs="0"/>
                <xs:any namespace="##other" processContents="lax"
                    minOccurs="0" maxOccurs="unbounded"/>
            </xs:sequence>
        </xs:extension>
    </xs:complexContent>
</xs:complexType>
```

```

        </xs:sequence>
        <xs:attribute name="options" type="xs:token"
                      use="optional"/>
    </xs:extension>
</xs:complexContent>
</xs:complexType>

<xs:element name="locationRequest"

```

```

        type="held:locationRequestType"/>

</xs:schema>

```

9. HTTP Binding

This section defines an HTTP [3] binding for this protocol, which all conforming implementations MUST support. This binding takes the form of a Web Service (WS) that can be described by the Web Services Description Language (WSDL) document in [Section 9.1](#).

The request is carried in this binding as the body of an HTTP POST request. The MIME type of both request and response bodies should be "application/held+xml".

The LCS populates the HTTP headers so that they are consistent with the contents of the message. In particular, the "expires" and cache control headers are used to control the caching of any PIDF-LO document or Location URIs. The HTTP status code SHOULD have the same first digit as any "heldResponse" or "error" body included, and it SHOULD indicate a 2xx series response when a PIDF-LO document or Location URI is included.

This binding also includes a default behaviour, which is triggered by a GET request, or a POST with no request body. If either of these queries are received, the LCS MUST attempt to provide either a PIDF-LO document or a Location URI, as if the request was a location request.

This binding MUST use TLS as described in [4]. TLS provides message integrity and privacy between Device and LCS. The LCS MUST use the server authentication method described in [4]; the Device MUST fail a

request if server authentication fails, except in the event of an emergency.

[9.1.](#) HTTP Binding WSDL

The following WSDL 2.0 [\[27\]](#) document describes the HTTP binding for this protocol. Actual service instances MUST provide a "service" with at least one "endpoint" that implements the "heldHTTP" binding. A service description document MAY include this schema directly or by using the "import" or "include" directives.

```
<?xml version="1.0"?>
<wsdl:definitions
  xmlns:wsdl="http://www.w3.org/2005/05/wsdl"
  xmlns:whttp="http://www.w3.org/2005/05/wsdl/http">
```

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```
  xmlns:held="urn:ietf:params:xml:ns:geopriv:held"
  xmlns:pidf="urn:ietf:params:xml:ns:pidf"
  xmlns:heldhttp="urn:ietf:params:xml:ns:geopriv:held:http"
  targetNamespace="urn:ietf:params:xml:ns:geopriv:held:http"
  type="http://www.w3.org/2005/05/wsdl/http">
```

```
<wsdl:documentation>
```

```
  This document describes the basic HELD sighting web service.
  Please refer to RFCXXXX for details.
```

```
  [[NOTE TO RFC-EDITOR: Please replace XXXX with the RFC number
  for this specification and remove this note.]]
```

```
</wsdl:documentation>
```

```
<wsdl:types>
```

```
  <xsd:schema xmlns:xsd="http://www.w3.org/2001/XMLSchema">
```

```
    <xsd:import namespace="urn:ietf:params:xml:ns:geopriv:held"
      schemaLocation="held.xsd"/>
```

```
    <xsd:import namespace="urn:ietf:params:xml:ns:pidf"/>
```

```
  </xsd:schema>
```

```
</wsdl:types>
```

```
<wsdl:interface name="held">
```

```
  <wsdl:operation name="locationRequest" method="POST">
```

```
    <wsdl:input message="held:locationRequest"/>
```

```
    <wsdl:output message="held:heldResponse"/>
```

```

        <wsdl:fault message="held:error"/>
    </wsdl:operation>

    <wsdl:operation
        name="getLocation" method="GET"
        pattern="http://www.w3.org/2004/08/wsdl/out-only">
        <wsdl:output message="held:heldResponse"/>
        <wsdl:fault message="held:error"/>
    </wsdl:operation>

</wsdl:interface>

<!-- Note that the by default the HTTP binding uses:
    whttp:inputSerialization="application/xml"
    whttp:outputSerialization="application/xml"
    whttp:faultSerialization="application/xml"
    whttp:location=""
-->

<wsdl:binding name="heldHTTP" whttp:defaultMethod="POST">
    <wsdl:operation ref="heldhttp:locationRequest"/>
    <wsdl:operation ref="heldhttp:getLocation" whttp:method="GET"/>

```

```

    </wsdl:binding>

</wsdl:definitions>

```

[10.](#) Security Considerations

The threat model for this protocol assumes that the LCS exists within the same administrative domain as the Device. The LCS requires access to network information so that it can determine Location. Therefore, the LCS can use network information to protect against a number of the possible attacks.

Specific requirements and security considerations for location acquisition protocols are provided in [\[11\]](#) including that the LCP MUST NOT assume prior network access authentication, which is addressed in [Section 10.2](#)

An in-depth discussion of the security considerations applicable to the use of Location URIs and by-reference provision of LI is included in [16].

10.1. Return Routability

It is RECOMMENDED that Location Configuration Servers use return routability rather than requiring Device authentication. Device authentication SHOULD NOT be required due to the administrative challenge of issuing and managing of client credentials, particularly when networks allow visiting users to attach devices. However, the LCS MAY require any form of authentication as long as these factors are considered.

Addressing information used in a request to the LCS is used to determine the identity of the Device, and to address a response. This ensures that a Device can only request its own LI.

A temporary spoofing of IP address could mean that a device could request a Location URI that would result in another Device's location. One or more of the follow approaches are RECOMMENDED to limit this exposure:

- o Location URIs SHOULD have a limited lifetime, as reflected by the value for the expires element ([Section 7.6.1](#)).
- o The network SHOULD have mechanisms that protect against IP address spoofing.
- o The LCS SHOULD ensure that requests can only originate from within its administrative domain.

- o The LCS and network SHOULD be configured so that the LCS is made aware of Device movement within the network and addressing changes. If the LCS detects a change in the network, then all location URIs MUST be invalidated.

The above measures are dependent on network configuration and SHOULD be considered with circumstances in mind. For instance, in a fixed internet access, providers may be able to restrict the allocation of IP addresses to a single physical line, ensuring that spoofing is not possible; in such an environment, other measures may not be necessary.

[10.2.](#) Transaction Layer Security

All bindings for this protocol MUST ensure that messages are adequately protected against eavesdropping and modification. Bindings MUST also provide a means of authenticating the LCS.

It is RECOMMENDED that all bindings also use TLS [\[2\]](#).

For the HTTP binding, TLS MUST be used. TLS provides protection against eavesdropping and modification. The server authentication methods described in HTTP on TLS [\[4\]](#) MUST be used.

[11.](#) Examples

[11.1.](#) Simple HTTP Binding Example Messages

The examples in this section show a complete HTTP message that includes the HELD request or response document.

This example shows the most basic request for a LO. This uses the GET feature described by the HTTP binding. This example assumes that the LCS service exists at the URL "https://lcs.example.com/location".

```
GET /location HTTP/1.1
Host: lcs.example.com
Accept: application/pidf+xml,application/held+xml,
        application/xml;q=0.8,
        text/xml;q=0.7
Accept-Charset: UTF-8,*
```

The GET request is exactly identical to a minimal POST request that includes an empty "locationRequest" element.

```
POST /location HTTP/1.1
Host: lcs.example.com
```


Accept: application/pidf+xml,application/held+xml,
application/xml;q=0.8,
text/xml;q=0.7

Accept-Charset: UTF-8,*

Content-Type: application/held+xml

Content-Length: 87

<?xml version="1.0"?>

<locationRequest xmlns="urn:ietf:params:xml:ns:geopriv:held"/>

The successful response to either of these requests is a PIDF-L0 document. The following response shows a minimal PIDF-L0 response.

```
HTTP/1.x 200 OK
Server: Example LCS
Date: Tue, 10 Jan 2006 03:42:29 GMT
Expires: Tue, 10 Jan 2006 03:42:29 GMT
Cache-control: private
Content-Type: application/pidf+xml
Content-Length: 594

<?xml version="1.0"?>
<heldResponse xmlns="urn:ietf:params:xml:ns:geopriv:held"
               code="200"
               message="OK">
  <presence xmlns="urn:ietf:params:xml:ns:pidf"
            entity="pres:3650n87934c@ls.example.com">
    <tuple id="3b650sf789nd">
      <status>
        <geopriv xmlns="urn:ietf:params:xml:ns:pidf:geopriv10">
          <location-info>
            <Point xmlns="http://www.opengis.net/gml"
                  srsName="urn:ogc:def:crs:EPSG::4326">
              <pos>-34.407 150.88001</pos>
            </Point>
          </location-info>
          <usage-rules>
            <retention-expires>
              2006-01-11T03:42:28+00:00</retention-expires>
            </usage-rules>
          </geopriv>
        </status>
        <timestamp>2006-01-10T03:42:28+00:00</timestamp>
      </tuple>
    </presence>
  </heldResponse>
```

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The error response to either of these requests is an error document. The following response shows an example error response.

```
HTTP/1.x 500 Server Error
Server: Example LCS
Expires: Tue, 10 Jan 2006 03:49:20 GMT
Cache-control: private
Content-Type: application/held+xml
Content-Length: 135

<?xml version="1.0"?>
<error xmlns="urn:ietf:params:xml:ns:geopriv:held" code="501"
      message="Unable to determine location"/>
```

Note: To focus on important portions of messages, all examples following this note do not show HTTP headers or the XML prologue. In addition, sections of XML not relevant to the example are replaced with comments.

[11.2.](#) Simple Location Request Example

The location request shown below doesn't specify any location types or response time.

```
<locationRequest xmlns="urn:ietf:params:xml:ns:geopriv:held"/>
```

The response to this location request is a list of Location URIs.

```
<heldResponse xmlns="urn:ietf:params:xml:ns:geopriv:held"
              code="200" message="OK">
  <locationUriSet expires="2006-01-01T13:00:00">
    <locationURI>https://ls.example.com:9768/357yc6s64ceyoiuy5ax3o
    </locationURI>
    <locationURI>sips:9769+357yc6s64ceyoiuy5ax3o@ls.example.com
    </locationURI>
  </locationUriSet>
</heldResponse>
```

An error response to this location request is shown below:

```
<error xmlns="urn:ietf:params:xml:ns:geopriv:held" code="450"
      message="Location not available"/>
```

[11.3.](#) Location Request Example with options

The location request shown below specifies a response time and an option, but doesn't specify any location type.

```
<locationRequest xmlns="urn:ietf:params:xml:ns:geopriv:held"
      responseTime="2"
      options="optionOne=1;"/>
```

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The corresponding HELD response shown below includes a PIDF-L0.

```
<heldResponse xmlns="urn:ietf:params:xml:ns:geopriv:held"
               code="200" message="OK">
  <presence xmlns="urn:ietf:params:xml:ns:pidf:geopriv10"
            entity="pres:ae3be8585902e2253ce2@10.102.23.9">
    <tuple id="lisLocation">
      <status>
        <geopriv>
          <location-info>
            <gs:Circle
              xmlns:gs="urn:ietf:params:xml:ns:pidf:geopriv10:geoShape"
              xmlns:gml="http://www.opengis.net/gml"
              srsName="urn:ogc:def:crs:EPSG::4326">
              <gml:pos>-34.407242 150.882518</gml:pos>
              <gs:radius uom="urn:ogc:def:uom:EPSG::9001">30
              </gs:radius>
            </gs:Circle>
            <ca:civicAddress
              xmlns:ca="urn:ietf:params:xml:ns:pidf:geopriv10:civicAddr"
              xml:lang="en-au">
              <ca:country>AU</ca:country>
              <ca:A1>NSW</ca:A1>
              <ca:A3>Wollongong</ca:A3>
              <ca:A4>Gwynneville</ca:A4>
              <ca:STS>Northfield Avenue</ca:STS>
              <ca:LMK>University of Wollongong</ca:LMK>
              <ca:FLR>2</ca:FLR>
```

```

    <ca:NAM>Andrew Corporation</ca:NAM>
    <ca:PC>2500</ca:PC>
    <ca:BLD>39</ca:BLD>
    <ca:SEAT>WS-183</ca:SEAT>
    <ca:POBOX>U40</ca:POBOX>
  </ca:civicAddress>
</location-info>
<usage-rules>
  <retransmission-allowed>false</retransmission-allowed>
  <retention-expires>2007-05-25T12:35:02+10:00
  </retention-expires>
</usage-rules>
<method>Wiremap</method>
</geopriv>
</status>
<timestamp>2007-05-24T12:35:02+10:00</timestamp>
</tuple>
</presence>
</heldResponse>

```

A corresponding HELD response with Location URIs.

```

<heldResponse xmlns="urn:ietf:params:xml:ns:geopriv:held"
               code="200" message="OK">
  <locationUriSet expires="2006-01-01T13:00:00">
    <locationURI>https://ls.example.com:9768/357yc6s64ceyoiuy5ax3o
    </locationURI>
    <locationURI>sips:9769+357yc6s64ceyoiuy5ax3o@ls.example.com:
    </locationURI>
  </locationUriSet>
</heldResponse>

```

[11.4.](#) Location Request Example for Multiple Location Types

The following Location Request message includes a request for geodetic, jurisdictional civic and any Location URIs.

```

<locationRequest xmlns="urn:ietf:params:xml:ns:geopriv:held">
  <locationType exact="true">

```

```

    geodetic
    jurisdictionalCivic
    locationURI
  </locationType>
</locationRequest>

```

The corresponding HELD Response message includes the requested location information, including two location URIs.

```

<heldResponse xmlns="urn:ietf:params:xml:ns:geopriv:held"
               code="200" message="OK">
  <locationUriSet expires="2006-01-01T13:00:00">
    <locationURI>https://ls.example.com:9768/357yc6s64ceyoiuy5ax3o
    </locationURI>
    <locationURI>sips:9769+357yc6s64ceyoiuy5ax3o@ls.example.com:
    </locationURI>
  </locationUriSet>
  <presence xmlns="urn:ietf:params:xml:ns:pidf:geopriv10"
            entity="pres:ae3be8585902e2253ce2@10.102.23.9">
    <tuple id="lisLocation">
      <status>
      <geopriv>
        <location-info>
          <gs:Circle
            xmlns:gs="urn:ietf:params:xml:ns:pidf:geopriv10:geoShape"

```

```

    xmlns:gml="http://www.opengis.net/gml"
    srsName="urn:ogc:def:crs:EPSG::4326">
  <gml:pos>-34.407242 150.882518</gml:pos>
  <gs:radius uom="urn:ogc:def:uom:EPSG::9001">30
  </gs:radius>
</gs:Circle>
<ca:civicAddress
  xmlns:ca="urn:ietf:params:xml:ns:pidf:geopriv10:civicAddr"
  xml:lang="en-au">
  <ca:country>AU</ca:country>
  <ca:A1>NSW</ca:A1>
  <ca:A3>Wollongong</ca:A3>
  <ca:A4>Gwynneville</ca:A4>
  <ca:STS>Northfield Avenue</ca:STS>

```

```

    <ca:LMK>University of Wollongong</ca:LMK>
    <ca:FLR>2</ca:FLR>
    <ca:NAM>Andrew Corporation</ca:NAM>
    <ca:PC>2500</ca:PC>
    <ca:BLD>39</ca:BLD>
    <ca:SEAT>WS-183</ca:SEAT>
    <ca:POBOX>U40</ca:POBOX>
    </ca:civicAddress>
  </location-info>
  <usage-rules>
    <retransmission-allowed>>false</retransmission-allowed>
    <retention-expires>2007-05-25T12:35:02+10:00
    </retention-expires>
  </usage-rules>
  <method>Wiremap</method>
</geopriv>
</status>
<timestamp>2007-05-24T12:35:02+10:00</timestamp>
</tuple>
</presence>
</heldResponse>

```

[11.5.](#) Sample LCS WSDL Document

The following WSDL document demonstrates how a WSDL document can be created for a specific service, in this case, a service at the URI "https://lcs.example.com/location".

```
<?xml version="1.0"?>
```



```

<wsdl:definitions
  xmlns:wsdl="http://www.w3.org/2005/05/wsdl"
  xmlns:heldhttp="urn:ietf:params:xml:ns:geopriv:held:http"
  targetNamespace="http://lcs.example.com/ws/held">

  <wsdl:import
    namespace="urn:ietf:params:xml:ns:geopriv:held:http"/>

  <wsdl:service name="sample-held-svc" interface="heldhttp:held">
    <wsdl:endpoint name="sample-held-ep"
      binding="heldhttp:heldHTTP"
      address="https://lcs.example.com/location"/>
  </wsdl:service>

</wsdl:definitions>

```

[12.](#) IANA Considerations

According to the guidelines in [\[6\]](#), this document calls for an IANA registry for result codes and a registry for options in the locationRequest. This document also registers an XML namespace and schema and the "application/held+xml" MIME type.

[12.1.](#) IANA Registry for HELD Result Codes

IANA will establish and maintain a registry of HELD result codes. Additional values are registered based on the "specification required" option in [\[6\]](#).

Specifications MUST specify the following information when registering new values in this registry:

Code Value: A three-digit value from 000 to 679. The last 20 codes in each block of 100 (from x80 to x99) are reserved for private or experimental use and cannot be registered.

Short Message: A brief message that describes the general reason for the code.

Publication: A reference to any relevant publication or specification.

Description and Usage: A longer description of the code and the circumstances where it applies. This description does not need to be exhaustive.

The values in [Section 7.4](#) are pre-registered in this registry.

[12.2.](#) IANA Registry for HELD Location Request Options

IANA will establish and maintain a registry of HELD Location Request options to allow for extensibility of the request. Values are registered based on the "specification required" option in [\[6\]](#).

Specifications MUST specify the following information when registering new values in this registry:

Option: Name of the option.

Short Message: A brief message that describes the general reason for the option and valid values and ranges.

Publication: A reference to any relevant publication or specification.

Description and Usage: A longer description of the option and the circumstances where it applies. This description does not need to be exhaustive.

[12.3.](#) URN Sub-Namespace Registration for urn:ietf:params:xml:ns:geopriv:held

This section registers a new XML namespace,
"urn:ietf:params:xml:ns:geopriv:held", as per the guidelines in [\[6\]](#).

URI: urn:ietf:params:xml:ns:geopriv:held

Registrant Contact: IETF, GEOPRIV working group,
(geopriv@ietf.org), Mary Barnes (mary.barnes@nortel.com).

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```
BEGIN
  <?xml version="1.0"?>
  <!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Strict//EN"
    "http://www.w3.org/TR/xhtml1/DTD/xhtml1-strict.dtd">
  <html xmlns="http://www.w3.org/1999/xhtml" xml:lang="en">
    <head>
      <title>HELD Messages</title>
    </head>
    <body>
      <h1>Namespace for HELD Messages</h1>
      <h2>urn:ietf:params:xml:ns:geopriv:held</h2>
      [[NOTE TO IANA/RFC-EDITOR: Please update RFC URL and replace XXXX
        with the RFC number for this specification.]]
      <p>See <a href="[[RFC URL]]">RFCXXXX</a>.</p>
    </body>
  </html>
END
```

[12.4.](#) XML Schema Registration

This section registers an XML schema as per the guidelines in [\[6\]](#).

URI: urn:ietf:params:xml:schema:geopriv:held

Registrant Contact: IETF, GEOPRIV working group, (geopriv@ietf.org),
Mary Barnes (mary.barnes@nortel.com).

Schema: The XML for this schema can be found as the entirety of
[Section 8](#) of this document.

[12.5.](#) URN Sub-Namespace Registration for urn:ietf:params:xml:ns:geopriv:held:http

This section registers a new XML namespace,
"urn:ietf:params:xml:ns:geopriv:held:http", as per the guidelines in
[\[6\]](#).

URI: urn:ietf:params:xml:ns:geopriv:held:http

Registrant Contact: IETF, GEOPRIV working group,
(geopriv@ietf.org), Mary Barnes (mary.barnes@nortel.com).

XML:

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BEGIN

```
<?xml version="1.0"?>
<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0 Strict//EN"
  "http://www.w3.org/TR/xhtml1/DTD/xhtml1-strict.dtd">
<html xmlns="http://www.w3.org/1999/xhtml" xml:lang="en">
  <head>
    <title>HELD HTTP Binding WS</title>
  </head>
  <body>
    <h1>Namespace for HELD HTTP Binding WS</h1>
    <h2>urn:ietf:params:xml:ns:geopriv:held:http</h2>
    [[NOTE TO IANA/RFC-EDITOR: Please update RFC URL and replace XXXX
      with the RFC number for this specification.]]
    <p>See <a href="[[RFC URL]]">RFCXXXX</a>.</p>
  </body>
</html>
```

END

[12.6.](#) MIME Media Type Registration for 'application/held+xml'

This section registers the "application/held+xml" MIME type.

To: ietf-types@iana.org

Subject: Registration of MIME media type application/held+xml

MIME media type name: application

MIME subtype name: held+xml

Required parameters: (none)

Optional parameters: charset

Indicates the character encoding of enclosed XML. Default is UTF-8.

Encoding considerations: Uses XML, which can employ 8-bit characters, depending on the character encoding used. See [RFC 3023](#) [20], section 3.2.

Security considerations: This content type is designed to carry protocol data related to the location of an entity, which could include information that is considered private. Appropriate precautions should be taken to limit disclosure of this

information.
Interoperability considerations: This content type provides a basis for a protocol
Published specification: RFC XXXX [[NOTE TO IANA/RFC-EDITOR: Please replace XXXX with the RFC number for this specification.]]
Applications which use this media type: Location information providers and consumers.
Additional Information: Magic Number(s): (none)
File extension(s): .xml
Macintosh File Type Code(s): (none)

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Person & email address to contact for further information: Mary Barnes <mary.barnes@nortel.com>
Intended usage: LIMITED USE
Author/Change controller: This specification is TBD
Other information: This media type is a specialization of application/xml [20], and many of the considerations described there also apply to application/held+xml.

[13.](#) Contributors

James Winterbottom, Martin Thomson and Barbara Stark are the authors of the original document, from which this WG document was derived. Their contact information is included in the Author's address section.

[14.](#) Acknowledgements

The author/contributors would like to thank the following people for their constructive input to this document (in alphabetical order): Nadine Abbott, Guy Caron, Martin Dawson, Jerome Grenier, Neil Justusson, Tat Lam, Patti McCalmont, Perry Prozeniuk, John Schnizlein, Henning Schulzrinne, Ed Shrum, and Hannes Tschofenig.

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[Appendix A](#). HELD Compliance to IETF LCP requirements

This appendix describes HELD's compliance to the requirements

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specified in the [\[11\]](#).

[A.1](#). L7-1: Identifier Choice

"The LIS MUST be presented with a unique identifier of its own addressing realm associated in some way with the physical location of the end host."

COMPLY

The identifier used may be the source address of the request packet and/or additional client identifier values relevant to the scope of the access network provided within the request. Mapping an IP address into lower-level attachment data is access network dependent and is the responsibility the LIS.

[A.2.](#) L7-2: Mobility Support

"The GEOPRIV Layer 7 Location Configuration Protocol MUST support a broad range of mobility from devices that can only move between reboots, to devices that can change attachment points with the impact that their IP address is changed, to devices that do not change their IP address while roaming, to devices that continuously move by being attached to the same network attachment point."

COMPLY

Mobility support is inherently a characteristic of the access network technology and HELD is designed to be access network agnostic. Consequently HELD complies with this requirement. In addition HELD provides specific support for mobile environments by providing an optional responseTime attribute in location request messages. Wireless networks often have several different mechanisms at their disposal for position determination (e.g. Assisted GPS versus location based on serving base station identity), each providing different degrees of accuracy and taking different amounts of time to yield a result. The responseTime parameter provides the LIS with a criterion which it can use to select a location determination technique.

[A.3.](#) L7-3: Layer 7 and Layer 2/3 Provider Relationship

"The design of the GEOPRIV Layer 7 Location Configuration Protocol MUST NOT assume a business or trust relationship between the provider of application layer (e.g., SIP, XMPP, H.323) provider and the access network provider operating the LIS."

COMPLY

dependencies on how location is used once it has been acquired. Location acquisition using HELD is subject to the restrictions described in [Section 10](#).

[A.4.](#) L7-4: Layer 2 and Layer 3 Provider Relationship

"The design of the GEOPRIV Layer 7 Location Configuration Protocol MUST assume that there is a trust and business relationship between the L2 and the L3 provider. The L3 provider operates the LIS and needs to obtain location information from the L2 provider since this one is closest to the end host. If the L2 and L3 provider for the same host are different entities, they cooperate for the purposes needed to determine end system locations."

COMPLY

HELD was specifically designed with this model in mind and readily allows itself to chaining requests between operators without a change in protocol being required. HELD is a webservicess protocol it can be bound to transports other than HTTP, such as BEEP. Using a transport like BEEP for HELD offers the option of high request throughput over a dedicated connection between an L3 provider and an L2 provider without incurring the serial restriction imposed by HTTP. This is less easy to do with protocols that do not decouple themselves from the transport.

[A.5.](#) L7-5: Legacy Device Considerations

"The design of the GEOPRIV Layer 7 Location Configuration Protocol MUST consider legacy residential NAT devices and NTEs in an DSL environment that cannot be upgraded to support additional protocols, for example to pass additional information through DHCP."

COMPLY

HELD is an application protocol and operates on top of IP. A HELD request from a host behind a residential NAT will traverse the NAT acquiring the external address of the home router. The location provided to the host therefore will be the address of the home router in this circumstance. No changes are required to the home router in order to support this function, HELD was designed specifically to address this deployment scenario.

[A.6.](#) L7-6: VPN Awareness

"The design of the GEOPRIV Layer 7 Location Configuration Protocol MUST assume that at least one end of a VPN is aware of the VPN

functionality. In an enterprise scenario, the enterprise side will provide the LIS used by the client and can thereby detect whether the LIS request was initiated through a VPN tunnel."

COMPLY

HELD does not preclude a LIS on the far end of a VPN tunnel being aware that the client request is occurring over that tunnel. It also does not preclude a client device from accessing a LIS serving the local physical network and subsequently using the location information with an application that is accessed over a VPN tunnel.

[A.7.](#) L7-7: Network Access Authentication

"The design of the GEOPRIV Layer 7 Location Configuration Protocol MUST NOT assume prior network access authentication."

COMPLY

HELD makes no assumptions about prior network access authentication. HELD strongly recommends the use of TLS with server-side certificates for communication between the end-point and the LIS. There is no requirement for the end-point to authenticate with the LIS.

[A.8.](#) L7-8: Network Topology Unawareness

"The design of the GEOPRIV Layer 7 Location Configuration Protocol MUST NOT assume end systems being aware of the access network topology. End systems are, however, able to determine their public IP address(es) via mechanisms such as STUN or NSIS NATFW NSLP."

COMPLY

HELD makes no assumption about the network topology. HELD doesn't require that the device know its external IP address, except where that is required for discovery of the LCS.

[A.9.](#) L7-9: Discovery Mechanism

"The L7 LCP MUST define a single mandatory to implement discovery mechanism."

COMPLY

HELD uses the discovery mechanism in [\[15\]](#).

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