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Dynamic Host Configuration Protocol Option for
Location Configuration Information for GEOPRIV

Aug 21st, 2003

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Abstract

This document specifies a Dynamic Host Configuration Protocol Option for the geographic location of the client. The Location Configuration Information (LCI) includes latitude, longitude, and altitude, with resolution indicators for each. The reference datum for these values is also included.

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DHCP LCI for Geopriv

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[1.](#) Introduction

This document specifies a Dynamic Host Configuration Protocol [[1](#)] Option for the geographic location of the client, to be provided by the server.

The DHCP server is assumed to have determined the location from the Circuit-ID Relay Agent Information Option (RAIO) defined (as SubOpt 1) in [[2](#)]. In order to translate the circuit (switch port identifier) into a location, the DHCP server is assumed to have access to a service that maps from circuit-ID to the location at which the circuit connected to that port terminates in the building; for example, the location of the wall jack.

An important feature of this specification is that location information is completely under control of the end device rather than stored in an outside service for retrieval by the end device. Storage outside the end device during times of emergency can cause unnecessary delay, or failure during communication.

Another important feature of this LCI is its inclusion of a

resolution parameter for each of the dimensions of location. The GEOPRIV working group has a stated requirement [3] to enable decreasing the precision of a location element. Because this resolution parameter need not apply to all dimensions equally, a resolution value is included for each of the 3 location elements.

This resolution method provides a natural ability for the device to hide from the center point of the bounding area as this resolution method is determined via the inherent effects of binary

representation.

Resolution does not define how Geographic Privacy policy should

The resulting location information using this resolution method is a small fixed length Configuration Information that can be easily carried in protocols, such as DHCP, which have limited packet size because this LCI is only 18 bytes long.

Finally, in the appendix this document provides some arithmetic examples of just how the imprecision can be introduced in any or all of the La/Lo/Alt values without the IP device needing to be preprogrammed with bogus location information, and just how imprecise the La/Lo/Alt values can be.

This document does not cover any policy regarding the use of this other than a few as potential suggestions to convey the meaning intended by the document.

1.1 Conventions used in this document

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 [4].

1.2 Motivation

As applications such as IP Telephony are replacing conventional telephony, users are expecting the same (or greater) level of services with the new technology. One service offered by conventional telephony that is missing, in any standardized fashion, within IP Telephony is for a user to be automatically located by

emergency responders, in a timely fashion, when the user summons help (by dialing 911 in North America, for example). Unless strict administrative rules are followed, the mobility of a wired Ethernet device within a campus negates any opportunity for an emergency responder to locate the device with any degree of expediency. Users do not want to give up the mobility IP Telephony offers. Informing the host device of its geo-location at host configuration time will allow the device to utilize this geo-location information to inform others of it's current geo-location, if the user and/or application so desires.

The goal of this option is to enable a wired Ethernet host to provide its location to an emergency responder, as one example.

Wireless hosts can utilize this option to gain knowledge of the location of the radio access point used during host configuration,

but will need some more exotic mechanisms, maybe GPS, or maybe a future DHCP option, which includes a list of geo-locations like that defined here, which has the locations of the radio access points that are close to the client.

1.3 Rationale

Within the LCI described here, Latitude and Longitude are represented in fixed-point 2s-complement binary degrees, for the economy of a smaller option size compared to a string encoding of digits in [5]. The integer parts of these fields are 9 bits long to accommodate +/- 180 degrees. The fractional part is 25 bits long, better than the precision of 7 decimal digits. Each parameter is 40 bits total, in length.

Altitude is determined by the Altitude Type (AT) indicated by the AT field, which is 4 bits long. Two Altitude Types are defined here, meters (code=1) and floors (code=2), both of which are 2s-complement fixed-point with 8 bits of fraction. Additional Altitude Types MAY be assigned by IANA. The "floors" Altitude Type is provided because altitude in meters may not be known within a building, and a floor indication may be more useful.

GPS systems today can use WGS84 for horizontal and vertical datums, [9] defines WGS84 as a three-dimensional datum. For other datum values that do not include a vertical component, both the horizontal

and vertical datum of reference will be specified in the IANA record.

Each of these 3 elements is preceded by an accuracy sub-field of 6 bits, indicating the number of bits of resolution. This resolution sub-field accommodates the GEOPRIV requirement [3] to easily adjust the precision of a reported location. Contents beyond the claimed resolution MAY be randomized to obscure greater precision that might be available.

[1.4](#) Changes from version -00

Here is a list of changes to version -01 from -00:

- inadvertently left out the Acknowledgements section; corrected that error
- added the NAD83 Datum to the list in [section 2.1](#), and to the list put forth for IANA registration

Here is a list of changes to version -02 from -01:

- changed Measurement Unit to Altitude Type to relieve some

confusion regarding the use of Floors in this field

- added some text explaining GPS uses of WGS 84
- Clarified the text to eliminate pairing of datum, but requiring both horizontal and vertical where the reference datum is not 3-D, as it is in WGS 84.
- added a line to each *Res description section that it isn't to be used to provide or enforce policy by the domain (which is contradictory to Geopriv requirements of a single point of policy injection)
- Split the Datum NAD83 into two different datum registries: One adding a vertical datum (NVAD88) for land (not near Tidal water), and added a new NAD83 datum pair (currently #5) to include NAD83 when used on the water/sea/ocean - with a vertical datum of MLLW
- Deleted all text regarding policy (through the use of the *Res

field values) not being injected at two places (Geopriv requirements state this should only occur at one location)

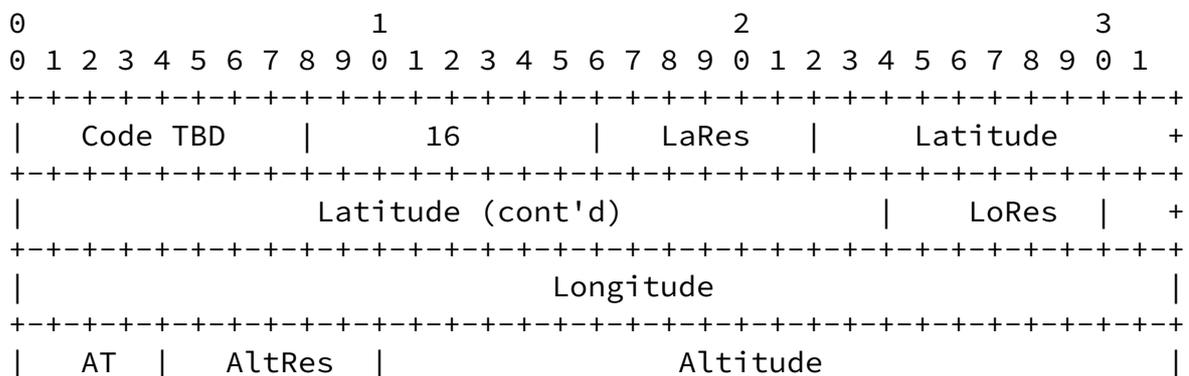
- augmented the IANA section to include the Horizontal and Vertical Datum pairings for #s 1, 2 & 3
- Deleted the all references to datums ED50 and ED87 because Carl Reed established that neither has a "well known" vertical datum to pair either with

2. DHC Location Configuration Information Elements

DHCP is a binary Protocol; GEOPRIV is text-based. Since most coordinate systems translate fairly easily between binary-based and text-based location output (even emergency services within the US), translation/conversion is a non-issue with DHCP's binary format.

This binary format provides a fortunate benefit in a mechanism for making a true/correct location coordinate imprecise. It further provides the capability to have this binary representation be deterministically imprecise.

The proposed LCI format is:



```

+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+
| Alt (cont'd) | Datum |
+-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+

```

2.1 Elements of the Location Configuration Information

Code TBD: The code for this DHCP option is TBD by IANA.

16: The length of this option is 16 bytes.

LaRes: Latitude resolution. 6 bits indicating the number of valid bits in the fixed-point value of Latitude.

This value is the number of high-order Latitude bits that should be considered valid. Any bits entered to the right of this limit should not be considered valid and might be purposely false, or zeroed by the sending.

The examples below in [section 4.0](#), are to illustrate that a smaller value in the resolution field increases the area within which the device is located (without deception).

LaRes does not define how Geographic Privacy policy should relate to precision.

Values of resolution above decimal 34 are Undefined and reserved because that is the largest number of bits in the Latitude field.

Latitude: a 34 bit fixed point value consisting of 9 bits of integer and 25 bits of fraction. Latitude SHOULD be normalized to within +/- 90 degrees. Geo-location formats provide for positive numbers to be north of the equator and negative numbers to be south of the equator.

A value of 2 in the LaRes field indicates a precision of no greater than 1/6th that of the globe (detailed in the first example in [section 4.0](#)). A value of 34 in the LaRes field indicates a precision of about 3.11 mm in Latitude.

LoRes: Longitude resolution. 6 bits indicating the number of valid bits in the fixed-point value of Longitude.

This value is the number of high-order Longitude bits that should be considered valid. Any bits entered to the right of this limit should not be considered valid and might be purposely false, or zeroed by the sending.

LoRes does not define how Geographic Privacy policy should relate to precision.

Values above decimal 34 are undefined and reserved.

Longitude: a 34 bit fixed point value consisting of 9 bits of integer and 25 bits of fraction. Longitude SHOULD be normalized to within +/- 180 degrees. Geo-location formats provide for positive numbers to be east of the prime meridian and negative (2s complement) numbers to be west of the prime meridian.

Entering a value of 2 in the LoRes field will result in the precision of no greater than 1/6th that of the globe (see first example in [section 4.0](#) for more here). A value of 34 in the LoRes field indicates a precision of about 2.42 mm in longitude (at the equator). Because lines of longitude converge at the poles, the distance is smaller (resolution greater) for locations away from the equator.

Altitude: A 30 bit value defined by the AT field

AltRes: Altitude resolution. 6 bits indicating the number of valid bits in the altitude. Values above 30 (decimal) are undefined and reserved.

AltRes does not define how Geographic Privacy policy should relate to precision.

AT: Altitude Type for altitude. Codes defined are:

1: Meters - in 2s-complement fixed-point 22-bit integer part with 8-bit fraction

If AT = 1, an AltRes value 0.0 would indicate unknown altitude. The most precise Altitude would have an AltRes value of 30. Many values of AltRes would obscure any variation due to vertical datum differences.

2: Floors - in 2s-complement fixed-point 22-bit integer part with 8-bit fraction

AT = 2 for Floors enables representing altitude in a form more

relevant in buildings which have different floor-to-floor dimensions. An altitude coded as AT=2, AltRes = 30, and Altitude = 0.0 is meaningful even outside a building, and represents ground level at the given latitude and longitude. Inside a building, 0.0 represents the floor level associated with ground level at the main entrance. This document defines a number; one must arrive at the number by counting floors from the floor defined to be 0.0.

The values represented by this AT will be of local significance. Since buildings and floors can vary due to lack of common control, the values chosen to represent the characteristics of an individual building will be derived and agreed upon by the operator of the building and the intended users of the data. Attempting to standardize this type of function is beyond the scope this document.

Sub-floors can be represented by non-integer values. Example: a mezzanine between floor 1 and floor 2 could be represented as a value=1.1. Example: (2) mezzanines between floor 4 and floor 5 could be represented as values=4.1 and 4.2 respectively.

Floors located below ground level could be represented by negative values.

Larger values represent floors that are above (higher in altitude) floors with lower values.

The AltRes field SHOULD be set to maximum precision when AT = 2 (floors) when a floor value is included in the DHCP Reply, or the AT = 0 to denote the floor isn't known.

Any additional Geopriv Altitude Types(s) to be defined for use via this DHC Option MUST be done through a Standards Track RFC.

Datum: The Map Datum used for the coordinates given in this Option

The datum must include both a horizontal and a vertical reference. Since the WGS 84 reference datum is three-dimensional, it includes both. For any additional datum parameters, the datum codepoint must specify both horizontal datum and vertical datum references.

The Datum byte has 255 possibilities, of which 3 are to be registered with IANA by this document (all derived from specification in [8]):

- 1: WGS 84 (Geographical 3D) - World Geodesic System 1984, CRS Code 4327, Prime Meridian Name: Greenwich

2: NAD83 - North American Datum 1983, CRS Code 4269, Prime Meridian Name: Greenwich; The associated vertical datum is the North American Vertical Datum of 1988

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(NAVD88)

This datum pair would be used when referencing locations on land, not near tidal water (which would use Datum = 3 below)

3: NAD83 - North American Datum 1983, CRS Code 4269, Prime Meridian Name: Greenwich; The associated vertical datum is Mean Lower Low Water (MLLW)

This datum pair would be used when referencing locations on water/sea/ocean

Any additional Geopriv datum(s) to be defined for use via this DHC Option MUST be done through a Standards Track RFC.

3. Purpose of Resolution Value per La/Lo/Alt Element

GEOPRIV specified the requirement [[3](#)] that any location expressed from or proxied on behalf of a device through the GEOPRIV Protocol can have the accuracy or precision of that device's location limited. The owner of the device, or the domain of the device determines the policy for divulging how precise the location is for any/all given requesters of that device's location.

As stated in [section 2.1](#), these resolution fields are not intended to specify policy towards the endpoint. However, the *Res fields can provide a quite useful feature by providing to the endpoint the maximum precision of location in the DHCP Reply.

4. Security Considerations

Where critical decisions might be based on the value of this GeoLoc option, DHCP authentication in [[7](#)] SHOULD be used to protect the integrity of the DHCP options.

Since there is no privacy protection for DHCP messages, an

eavesdropper who can monitor the link between the DHCP server and requesting client can discover this LCI.

5. IANA Considerations

The DHCP option code for the GeoLoc option is TBD.

This document calls for the IANA registration of the following:

AT = 1 is meters of Altitude defined by the vertical datum specified. Semantics are included in this document (section

2.1)

AT = 2 is building Floors of Altitude. Semantics are included in this document ([section 2.1](#))

Datum = 1 is denoting the vertical datum WGS 84 as defined by the EPSG as their CRS Code 4327; CRS Code 4327 also specifies WGS 84 as the vertical datum

Datum = 2 is denoting the vertical datum NAD83 as defined by the EPSG as their CRS Code 4269; North American Vertical Datum of 1988 (NAVD88) is the associated vertical datum for NAD83

The semantics of this datum pair (#2) is presented in [section 2.1](#) above

Datum = 3 is denoting the vertical datum NAD83 as defined by the EPSG as their CRS Code 4269; Mean Lower Low Water (MLLW) is the associated vertical datum for NAD83

The semantics of this datum pair (#3) is presented in [section 2.1](#) above

6. Acknowledgements

The authors would like to thank Patrik Falstrom, Ralph Droms, Ted Hardie, Jon Peterson and Nadine Abbott for their inputs and constructive comments regarding this document. Additionally, the authors would like to thank Greg Troxel for the education on vertical datums, and to Carl Reed.

If: LaRes is expressed as value 2 (0x02 or 000010) and LoRes is expressed as value 2 (0x02 or 000010), then it would describe a geo-location region that is north of the equator and extends from -1 degree (west of the meridian) to -128 degrees. This would include the area from approximately 600km south of Saltpond, Ghana, due north to the North Pole and approximately 4400km south-southwest of Los Angeles, CA due north to the North Pole. This would cover an area of about one-sixth of the globe, approximately 20 million square nautical miles (nm).

If: LaRes is expressed as value 3 (0x03 or 000011) and LoRes is expressed as value 3, (0x03 or 000011) then it would describe a geo-location area that is north from the equator to 63 degrees north, and -65 degrees to -128 degrees longitude. This area includes south of a line from Anchorage, AL to eastern Nunavut, CN. and from the Amazons of northern Brazil to approximately 4400km south-southwest of Los Angeles, CA. This area would include North America, Central America, and parts of Venezuela and Columbia, except portions of Alaska and northern and eastern Canada, approximately 10 million square nm.

If: LaRes is expressed as value 5 (0x05 or 000101) and LoRes is expressed as value 5 (0x05 or 000101), then it would describe a geo-location area that is latitude 32 north of the equator to latitude 48 and extends from -64 degrees to -80 degrees longitude. This is approximately an east-west boundary of a time zone, an area of approximately 700,000 square nm.

If: LaRes is expressed as value 9 (0x09 or 001001) and LoRes is expressed as value 9 (0x09 or 001001), which includes all the integer bits, then it would describe a geo-location area that is latitude 38 north of the equator to latitude 39 and extends from -77 degrees to -78 degrees longitude. This is an area of approximately 9600 square km (111.3km x 86.5km).

If: LaRes is expressed as value 18 (0x12 or 010010) and LoRes is expressed as value 18 (0x12 or 010010), then it would describe a geo-location area that is latitude 38.8984375 north to latitude 38.9003906 and extends from -77.0390625 degrees to -77.0371094 degrees longitude. This is an area of approximately 36,600 square meters (169m x 217m).

If: LaRes is expressed as value 22 (0x16 or 010110) and LoRes is expressed as value 22 (0x16 or 010110), then it would describe a geo-location area that is latitude 38.896816 north to latitude 38.8985596 and extends from -77.0372314 degrees to -77.0371094 degrees longitude. This is an area of approximately 143 square meters (10.5m x 13.6m).

If: LaRes is expressed as value 28 (0x1c or 011100) and LoRes is expressed as value 28 (0x1c or 011100), then it would describe a geo-location area that is latitude 38.8986797 north to latitude 38.8986816 and extends from -77.0372314 degrees to -77.0372296 degrees longitude. This is an area of approximately 339 square centimeters (20.9cm x 16.23cm).

If: LaRes is expressed as value 30 (0x1e or 011110) and LoRes is expressed as value 30 (0x1e or 011110), then it would describe a geo-location area that is latitude 38.8986797 north to latitude 38.8986802 and extends from -77.0372300 degrees to -77.0372296 degrees longitude. This is an area of approximately 19.5 square centimeters (50mm x 39mm).

If: LaRes is expressed as value 34 (0x22 or 100010) and LoRes is expressed as value 34 (0x22 or 100010), then it would describe a geo-location area that is latitude 38.8986800 north to latitude 38.8986802 and extends from -77.0372300 degrees to -77.0372296 degrees longitude. This is an area of approximately 7.5 square millimeters (3.11mm x 2.42mm).

In the (White House) example, the requirement of emergency responders in North America via their NENA Model Legislation [6], could be met by a LaRes value of 21 and a LoRes value of 20. This would yield a geo-location that is latitude 38.8984375 north to latitude 38.8988616 north and longitude -77.0371094 to longitude -77.0375977. This is an area of approximately 89 feet by 75 feet or 6669 square feet, which is very close to the 7000 square feet asked for by NENA. In this example a service

provider could enforce that a device send a Location Configuration Information with this minimum amount of resolution for this particular location when calling emergency services.

Postal Address:
Sears Tower
103rd Floor
233 S. Wacker Dr.
Chicago, IL 60606

Viewing the Chicago area from the Observation Deck of the Sears Tower.

Latitude 41.87884 degrees North (or +41.87884 degrees)
Using 2s complement, 34 bit fixed point, 25 bit fraction
Latitude = 0x053c1f751,
Latitude = 0001010011110000011111011101010001

Longitude 87.63602 degrees West (or -87.63602 degrees)
Using 2s complement, 34 bit fixed point, 25 bit fraction
Longitude = 0xf50ba5b97,
Longitude = 1101010000101110100101101110010111

Altitude 103

In this example we are inside a structure, therefore we will assume an altitude value of 103 to indicate the floor we are on. The Altitude Type value is 2 indicating floors. The AltRes field would indicate that all bits in the Altitude field are true, as we want to accurately represent the floor of the structure where we are located.

AltRes = 30, 0x1e, 011110
AT = 2, 0x02, 000010
Altitude = 103, 0x00006700, 0000000000000000110011100000000

For the accuracy of the latitude and longitude, the best information available to us was supplied by a generic mapping service that shows a single geo-loc for all of the Sears Tower. Therefore we are going to show LaRes as value 18 (0x12 or 010010) and LoRes as value 18 (0x12 or 010010). This would be describing a geo-location area that is latitude 41.8769531 to latitude 41.8789062 and extends from -87.6367188 degrees to -87.6347657 degrees longitude. This is an area of approximately 373412 square feet (713.3 ft. x 523.5 ft.).

7. References

- [1] Droms R., "Dynamic Host Configuration Protocol", [RFC 2131](#), March 1997
- [2] Patrick M., "DHCP Relay Agent Information Option", [RFC 3046](#), January 2001
- [3] Cuellar J., Morris J., Mulligan D., "GEOPRIV Requirements", Internet Draft, "Work in Progress", June 2002
- [4] Bradner S., "Key words for use in RFCs to Indicate Requirement Levels", [RFC 2119](#), March 1997
- [5] Farrell C., Schulze M., Pleitner S. and Baldoni D., "DNS Encoding of Geographical Location", [RFC 1712](#), November 1994.
- [6] National Emergency Number Association (NENA) www.nena.org
NENA Technical Information Document on Model Legislation Enhanced 911 for Multi-Line Telephone Systems
(http://www.nena.org/9%2D1%2D1techstandards/TechInfoDocs/MLTS_ModLeg_Nov200.PDF)
- [7] Droms R., "Authentication for DHCP Messages", [RFC 3118](#), June 2001
- [8] European Petroleum Survey Group, <http://www.epsg.org/> and <http://www.ihsenergy.com/epsg/geodetic2.html>
- [9] World Geodetic System 1984 (WGS 84), MIL-STD-2401, <http://164.214.2.59/publications/specs/printed/WGS84/wgs84.html> and <http://www.wgs84.com/>

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