

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 [7]. 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. The length of each field is 40 bits, 34 of which is the sum of the integer (9) and fractional (25) bits, plus 6 bits of resolution.

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 22 bits of integer part and 8 bits of fractional part. 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; [6] 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 begins with an accuracy sub-field of 6 bits, indicating the number of bits of resolution. This resolution sub-field accommodates the desire 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.

2. DHC Location Configuration Information Elements

DHCP is a binary Protocol; using protocols of LCI are likely to be text based. Since most coordinate systems translate 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 LCI format is as follows:

```

      0                1                2                3
      0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
| Code 123 |   16   | LaRes | Latitude |
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
|           | Latitude (cont'd) |           | LoRes |
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
|           | Longitude |           |
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
| AT | AltRes |           | Altitude |
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
| Alt (cont'd) | Datum |
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+

```

2.1. Elements of the Location Configuration Information

Code 123: The code for this DHCP option.

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 sender.

The examples in the appendix illustrate that a smaller value in the resolution field increases the area within which the device is located.

LaRes does not define Geographic Privacy policy.

Values above decimal 34 are undefined and reserved.

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. Positive numbers are north of the equator and negative numbers are 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 (in the first example of the appendix). A value of 34 in the LaRes field indicates a precision of about 3.11 mm in Latitude at the equator.

Polk, et al. Standards Track [Page 5]
 RFC 3825 DHCP Option for Coordinate LCI July 2004

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 sender.

LoRes does not define Geographic Privacy policy.

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. Positive values are East of the prime meridian and negative (2s complement) numbers are West of the prime meridian.

A value of 2 in the LoRes field indicates precision of no greater than 1/6th that of the globe (see first example of the appendix). 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 (better precision) 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 Geographic Privacy policy.

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

Polk, et al. Standards Track [Page 6]
 RFC 3825 DHCP Option for Coordinate LCI July 2004

To minimize the unintended exposure of location information, the LCI option SHOULD be returned by DHCP servers only when the DHCP client has included this option in its 'parameter request list' (section 3.5 [1]).

When implementing a DHC server that will serve clients across an uncontrolled network, one should consider the potential security risks.

4. IANA Considerations

IANA has assigned a DHCP option code of 123 for the GeoConf option defined in this document.

The GeoConf Option defines two fields for which IANA maintains a registry: The Altitude (AT) field (see Section 2) and the Datum field (see Section 2). The datum indicator MUST include specification of both horizontal and vertical datum. New values for the Altitude (AT) field are assigned through "Standards Action" [RFC 2434]. The initial values of the Altitude registry are as follows:

Polk, et al.	Standards Track	[Page 8]
☐		
RFC 3825	DHCP Option for Coordinate LCI	July 2004

AT = 1 meters of Altitude defined by the vertical datum specified.

AT = 2 building Floors of Altitude.

Datum = 1 denotes 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 denotes 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

Datum = 3 denotes 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

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

5. Acknowledgements

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Polk, et al.	Standards Track	[Page 9]
☐		
RFC 3825	DHCP Option for Coordinate LCI	July 2004

Appendix: Calculations of Imprecision Possible with the DHC LCI

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

Polk, et al. Standards Track [Page 11]

RFC 3825 DHCP Option for Coordinate LCI July 2004

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 [8] 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 requested 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.

A.2. Location Configuration Information of "Sears Tower" (Example 2)

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

Polk, et al. Standards Track [Page 12]

RFC 3825 DHCP Option for Coordinate LCI July 2004

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

Polk, et al. Standards Track [Page 14]
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RFC 3825 DHCP Option for Coordinate LCI July 2004

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Polk, et al. Standards Track [Page 15]
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