Interoperability testing of the ALTO Protocol
draft-roome-interop-ietf93-00

Abstract

The Application-Layer Traffic Optimization (ALTO) protocol is designed to allow entities with knowledge about the network infrastructure to export such information to applications that need to choose one or more endpoints to connect to among large sets of logically equivalent ones. This document defines a data set that may be used to test the functionality and interoperability of ALTO clients and servers.

Status of this Memo

This Internet-Draft is submitted in full conformance with the provisions of BCP 78 and BCP 79.

Internet-Drafts are working documents of the Internet Engineering Task Force (IETF). Note that other groups may also distribute working documents as Internet-Drafts. The list of current Internet-Drafts is at http://datatracker.ietf.org/drafts/current/.

Internet-Drafts are draft documents valid for a maximum of six months and may be updated, replaced, or obsoleted by other documents at any time. It is inappropriate to use Internet-Drafts as reference material or to cite them other than as "work in progress."

This Internet-Draft will expire on December 6, 2015.

Copyright Notice

Copyright (c) 2015 IETF Trust and the persons identified as the document authors. All rights reserved.

This document is subject to BCP 78 and the IETF Trust’s Legal Provisions Relating to IETF Documents (http://trustee.ietf.org/license-info) in effect on the date of publication of this document. Please review these documents carefully, as they describe your rights and restrictions with respect to this document. Code Components extracted from this document must include Simplified BSD License text as described in Section 4.e of
1. Overview

The Application-Layer Traffic Optimization (ALTO) protocol is designed to allow entities with knowledge about the network infrastructure to export such information to applications that need to choose one or more endpoints to connect to among large sets of logically equivalent ones.

This document defines procedures to test the functionality and interoperability of ALTO clients and servers.

This document is informational and is NOT NORMATIVE on any aspects of the ALTO protocol. The normative behavior of ALTO entities is prescribed in [RFC7285].

Section 2 defines the network maps, cost maps and other data necessary to provision an ALTO server. This ensures that all tested servers will return the same results, so a client may verify that a server is operating correctly. Section 3 defines the required and optional resources for an ALTO server to provide. Section 4 describes the actions expected from a client. Section 5 describes a set of invalid client requests, to verify that a server can respond correctly to client errors.

While every effort has been made to catalogue representative test cases, this document does not attempt to codify every test case that arises in ALTO. The aim of the document is to focus on areas that highlight the key offerings of the ALTO protocol.

2. Server Data

This section defines the data necessary to provision a tested ALTO server in a uniform manner. First it defines a default network map, and associated cost maps for the "routingcost" and "hopcount" metrics. Next it defines an optional alternate network map, along with "routingcost" and "hopcount" costs for that map. Finally it defines a set of optional endpoint properties.

Appendix A gives network and cost map data defined in this section formatted in JSON.

2.1. Default Network Map And Cost Maps

Every tested ALTO server MUST provide a default network map with the PIDs defined below:
Each ALTO server MUST provide a cost map for the "routingcost" metric. The following table presents the numerical values for those costs. If a server provides a numerical-mode cost map, it MUST use these values. If a server provides an ordinal-mode cost map, the server may use whatever values it wants, provided the ordinal values preserve the order of the numerical values.

```
default 1.0 75.0 75.0 75.0 75.0 75.0 - - - -
mine 75.0 1.0 15.0 15.0 15.0 15.0 30.0 25.0 40.0 45.0
mine1 75.0 15.0 2.0 2.5 5.0 7.0 20.0 25.0 40.0 45.0
mine1a 75.0 15.0 2.0 1.0 7.0 9.0 22.0 24.0 42.0 48.0
mine2 75.0 15.0 2.0 7.0 1.0 6.0 23.0 25.0 43.0 46.0
mine3 75.0 15.0 7.0 9.0 6.0 1.0 25.0 28.0 45.0 49.0
peer1 - 30.0 20.0 22.0 23.0 25.0 1.0 - - -
peer2 - 30.0 25.0 24.0 25.0 28.0 - 1.0 - -
tran1 - 50.0 40.0 42.0 43.0 45.0 - - 1.0 -
tran2 - 50.0 45.0 48.0 46.0 49.0 - - - 1.0
```

Note that this is a partial cost map, in that it does not define a cost for every source and destination PID.

Each ALTO server MAY provide a cost map for the "hopcount" metric. The following table gives the numerical values. As with
"routingcost", a numerical-mode cost map MUST use these values, and an ordinal-mode cost map may use any values consistent with this ordering.

\[
\begin{array}{ccccccccccc}
\text{default} & \text{mine} & \text{mine1} & \text{mine1a} & \text{mine2} & \text{mine3} & \text{peer1} & \text{peer2} & \text{tran1} & \text{tran2} \\
\text{default} & 1.0 & 10.0 & 10.0 & 10.0 & 10.0 & - & - & - & - \\
\text{mine} & 10.0 & 1.0 & 3.0 & 3.0 & 3.0 & 5.0 & 6.0 & 8.0 & 8.0 \\
\text{mine1} & 10.0 & 3.0 & 1.0 & 2.0 & 2.0 & 2.0 & 4.0 & 5.0 & 6.0 & 7.0 \\
\text{mine1a} & 10.0 & 3.0 & 2.0 & 1.0 & 2.0 & 3.0 & 5.0 & 6.0 & 7.0 & 8.0 \\
\text{mine2} & 10.0 & 3.0 & 2.0 & 2.0 & 1.0 & 2.0 & 4.0 & 5.0 & 6.0 & 7.0 \\
\text{mine3} & 10.0 & 3.0 & 2.0 & 3.0 & 2.0 & 1.0 & 4.0 & 5.0 & 6.0 & 7.0 \\
\text{peer1} & - & 5.0 & 4.0 & 5.0 & 4.0 & 4.0 & 1.0 & - & - & - \\
\text{peer2} & - & 6.0 & 5.0 & 6.0 & 5.0 & 5.0 & - & 1.0 & - & - \\
\text{tran1} & - & 8.0 & 6.0 & 7.0 & 6.0 & 6.0 & - & - & 1.0 & - \\
\text{tran2} & - & 8.0 & 7.0 & 8.0 & 7.0 & 7.0 & - & - & - & 1.0 \\
\end{array}
\]

Figure 3: "hopcount" Numerical Cost Map

2.2. Alternate Network Map And Cost Maps

Every tested ALTO server MAY provide an alternate, or secondary, network map with the PIDs defined below:

<table>
<thead>
<tr>
<th>PID</th>
<th>IP Address Block</th>
</tr>
</thead>
<tbody>
<tr>
<td>dc1</td>
<td>101.0.0.0/16</td>
</tr>
<tr>
<td>dc2</td>
<td>102.0.0.0/16</td>
</tr>
<tr>
<td>dc3</td>
<td>103.0.0.0/16</td>
</tr>
<tr>
<td>dc4</td>
<td>104.0.0.0/16</td>
</tr>
<tr>
<td>user1</td>
<td>201.0.0.0/16</td>
</tr>
<tr>
<td>user2</td>
<td>202.0.0.0/16</td>
</tr>
<tr>
<td>user3</td>
<td>203.0.0.0/16</td>
</tr>
<tr>
<td>user4</td>
<td>204.0.0.0/16</td>
</tr>
<tr>
<td>default</td>
<td>0.0.0.0/0, ::0/0</td>
</tr>
<tr>
<td>loopback</td>
<td>127.0.0.0/8, ::1/128</td>
</tr>
<tr>
<td>linklocal</td>
<td>169.254.0.0/16, ff80::/10</td>
</tr>
<tr>
<td>private</td>
<td>10.0.0.0/8, 172.16.0.0/12,</td>
</tr>
<tr>
<td></td>
<td>192.168.0.0/16, fc00::/7</td>
</tr>
</tbody>
</table>

Figure 4: Alternate Network Map

Each ALTO server MAY provide a cost map for the "routingcost" metric for the alternate network map. The following table presents the numerical values for those costs. If a server provides a numerical-mode cost map, it MUST use these values. If a server provides an ordinal-mode cost map, the server may use whatever values it wants,
provided the ordinal values preserve the order of the numerical values.

```
<table>
<thead>
<tr>
<th></th>
<th>dc1</th>
<th>dc2</th>
<th>dc3</th>
<th>dc4</th>
<th>default</th>
<th>user1</th>
<th>user2</th>
<th>user3</th>
<th>user4</th>
</tr>
</thead>
<tbody>
<tr>
<td>dc1</td>
<td>0.0</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
<td>50.0</td>
<td>10.0</td>
<td>20.0</td>
<td>30.0</td>
<td>40.0</td>
</tr>
<tr>
<td>dc2</td>
<td>5.0</td>
<td>0.0</td>
<td>5.0</td>
<td>5.0</td>
<td>50.0</td>
<td>20.0</td>
<td>10.0</td>
<td>20.0</td>
<td>30.0</td>
</tr>
<tr>
<td>dc3</td>
<td>5.0</td>
<td>5.0</td>
<td>0.0</td>
<td>5.0</td>
<td>50.0</td>
<td>30.0</td>
<td>20.0</td>
<td>10.0</td>
<td>20.0</td>
</tr>
<tr>
<td>dc4</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
<td>0.0</td>
<td>50.0</td>
<td>40.0</td>
<td>30.0</td>
<td>20.0</td>
<td>10.0</td>
</tr>
<tr>
<td>default</td>
<td>50.0</td>
<td>50.0</td>
<td>50.0</td>
<td>50.0</td>
<td>0.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>user1</td>
<td>10.0</td>
<td>20.0</td>
<td>30.0</td>
<td>40.0</td>
<td></td>
<td>0.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>user2</td>
<td>20.0</td>
<td>10.0</td>
<td>20.0</td>
<td>30.0</td>
<td></td>
<td></td>
<td>0.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>user3</td>
<td>30.0</td>
<td>20.0</td>
<td>10.0</td>
<td>20.0</td>
<td></td>
<td></td>
<td></td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>user4</td>
<td>40.0</td>
<td>30.0</td>
<td>20.0</td>
<td>10.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.0</td>
</tr>
</tbody>
</table>
```

Figure 5: "routingcost" Numerical Cost Map

Note that this is a partial cost map, in that it does not define a cost for every source and destination PID.

Each ALTO server MAY provide a cost map for the "hopcount" metric. The following table gives the numerical values. As with "routingcost", a numerical-mode cost map MUST use these values, and an ordinal-mode cost map may use any values consistent with this ordering.

```
<table>
<thead>
<tr>
<th></th>
<th>dc1</th>
<th>dc2</th>
<th>dc3</th>
<th>dc4</th>
<th>default</th>
<th>user1</th>
<th>user2</th>
<th>user3</th>
<th>user4</th>
</tr>
</thead>
<tbody>
<tr>
<td>dc1</td>
<td>0.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>8.0</td>
<td>3.0</td>
<td>4.0</td>
<td>5.0</td>
<td>6.0</td>
</tr>
<tr>
<td>dc2</td>
<td>1.0</td>
<td>0.0</td>
<td>1.0</td>
<td>1.0</td>
<td>8.0</td>
<td>4.0</td>
<td>3.0</td>
<td>4.0</td>
<td>5.0</td>
</tr>
<tr>
<td>dc3</td>
<td>1.0</td>
<td>1.0</td>
<td>0.0</td>
<td>1.0</td>
<td>8.0</td>
<td>5.0</td>
<td>4.0</td>
<td>3.0</td>
<td>4.0</td>
</tr>
<tr>
<td>dc4</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>0.0</td>
<td>8.0</td>
<td>6.0</td>
<td>5.0</td>
<td>4.0</td>
<td>3.0</td>
</tr>
<tr>
<td>default</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>0.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>user1</td>
<td>3.0</td>
<td>4.0</td>
<td>5.0</td>
<td>6.0</td>
<td></td>
<td>0.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>user2</td>
<td>4.0</td>
<td>3.0</td>
<td>4.0</td>
<td>5.0</td>
<td></td>
<td></td>
<td>0.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>user3</td>
<td>5.0</td>
<td>4.0</td>
<td>3.0</td>
<td>4.0</td>
<td></td>
<td></td>
<td></td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>user4</td>
<td>6.0</td>
<td>5.0</td>
<td>4.0</td>
<td>3.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.0</td>
</tr>
</tbody>
</table>
```

Figure 6: "hopcount" Numerical Cost Map

2.3. Endpoint Properties

An ALTO server may provide the private endpoint property "priv:ietf-type" with the following values for endpoints in the indicated address blocks:
### 3. Server Resources and Configuration

An ALTO server MUST provide the following resources, as required by [RFC7285]:

- An Information Resource Directory (IRD) which describes all of the server’s resources.
- A Network Map resource for the default network defined above.
- A Cost Map resource for the "routingcost" metric for the default network map. The mode may be either "numerical" or "ordinal". If "numerical", the values MUST be identical to those defined above. If "ordinal", the server can use whatever values it wants, but the ordering MUST be consistent with the ordering of the "numerical" values.
- An Endpoint Property Service for the "pid" property for the default network map.

A server MAY provide whatever additional resources it desires, as long as they are consistent with the network maps, cost maps and endpoint properties defined in Section 2. In particular, a server may provide:

- An additional Network Map resource, using the PIDs and address prefixes for the alternate network map defined above.
- Cost Map resources for the "routingcost" and/or "hopcount" metrics, in either "numerical" or "ordinal" modes, using the values defined above.
- Filtered Network Map resources for either or both network maps.
- Filtered Cost Map resources for any combination of "routingcost" and "hopcount" metrics, in either "numerical" and "ordinal" modes, for either or both network maps. The resources may or may not accept constraint tests.
o Endpoint Cost Service(s) or any combination of "routingcost" and "hopcount" metrics, in either "numerical" and "ordinal" modes. The cost values MUST be consistent with those for the default network map. The resources may or may not accept constraint tests.

o Endpoint Property Service(s) for the custom endpoint properties defined above.

However, a server MUST NOT provide more than the two network maps defined in this document. This restriction simplifies testing, because it allows a client to automatically identify the alternate network map (e.g., any network map which is not the default must be the alternate network). If servers could offer three or more network maps, a client would have to be provisioned with the resource id of the alternate network map.

Note that if a server provides a Network Map resource for the alternate network map, [RFC7285] requires the server to also provide a Cost Map resource for the "routingcost" metric, in either "numerical" or "ordinal" mode, and an Endpoint Property Service for that network map’s "pid" property.

A server MAY structure the IRD however it wants. In particular, a server may

o Use secondary IRDs which the root IRD references.

o Use arbitrary resource IDs and cost type names.

o Use arbitrary URIs, in any recognized URI format.

o Provide multiple versions of POST-mode resources. For example, if a server provides the secondary network map, it must provide an Endpoint Property Service for the "pid" properties for both maps. A server may provide one EPS for both properties, or a separate EPS for each property.

4. Client Actions

When given the URI for an ALTO server’s IRD, an ALTO client should read the IRD, and for each resource that it recognizes, verify that the server returns the correct response. Note that most of the data the server returns is determined by the network maps, cost maps and property values specified in Section 2, and hence can be verified by a client. Some data cannot be determined a priori (e.g., resource id and tag of a network map), but a client can verify their consistency.
(e.g., a cost map's dependent-vtag field should match the vtag field of the associated network map).

It is expected that not every client will be able recognize and verify every possible resource. However, each client MUST be able to verify the default network map and the associated "routingcost" cost map. In particular, although clients are not required to recognize the alternate network map, if presented with an IRD with two network maps, every client MUST be able to distinguish the default network map, and its associated cost map, from the alternate network map.

Ideally clients should be scripted. That is, when given the URI for a server, an ideal client would verify the server automatically, without further operator intervention. A client should log the resources it tested, and clearly highlight any response the client considered incorrect.

The HTTP GET-mode resources (Network Map and Cost Map) do not require client input, and hence testing is straight-forward: the client sends the appropriate HTTP GET request, and verifies the response.

However, POST-mode resources, such as Filtered Cost Maps and Endpoint Property Services, require client input. The following sections present recommended input parameters for various resources, and clients SHOULD implement as many of these tests as possible. Clients MAY add additional tests, and are encouraged to do so.

4.1. Filtered Network Map Tests

- Empty "pid" array, omitted or empty "address-types" array. The server should return the entire network map.

- Empty "pid" array, "address-types" array containing just "ipv6". The server should return PIDs with ipv6 addresses, and only those PIDs.

- "pid" array with one or more non-existent PID names, such as "not-a-pid". The server should return an empty network map.

- "pid" array with a set of valid PID names (client's choice), plus one or more non-existent PID names. The server should return the valid PIDs and ignore the invalid ones.

4.2. Filtered Cost Map Tests

All tests require an appropriate "cost-type" parameter. At a minimum, clients should run these tests for the "routingcost" metric for the default network map. If possible, clients should also run
these tests for the "hopcount" metric and the alternate network map.

Clients should remember that when testing "ordinal" costs, any values are acceptable as long as they are consistent with the order of the "numerical" costs defined in Section 2. Clients are also reminded that ordinal values are only comparable to other values in the same request, and a server may recalculate ordinal values for each request. Hence the same cost point may have ordinal value "6" in a full cost map, but have value "1" in a filtered cost map.

- Empty "srcs" and "dsts" arrays. The server should return the entire cost map.
- Empty "srcs" array, "dsts" array with one or more valid PIDs. The server should return costs from all PIDs to the specified destination PIDs.
- Empty "dsts" array, "srcs" array with one or more valid PIDs. The server should return costs from the specified source PIDs to all destination PIDs.
- "srcs" and "dsts" arrays with only non-existent PID names. The server should return an empty cost map.
- "srcs" and "dsts" arrays with a set of valid PID names (client’s choice), plus one or more non-existent PID names in one or the arrays. The server should return costs for the valid PIDs and ignore the non-existent ones.
- The two-element constraint test "ge 20", "le 30" for the numerical "routingcost" for the default network map, with empty "srcs" and "dsts" arrays (assuming that resource allows constraints, of course). The server should return the all costs in the range, namely:

<table>
<thead>
<tr>
<th></th>
<th>mine</th>
<th>mine1</th>
<th>minela</th>
<th>mine2</th>
<th>mine3</th>
<th>peer1</th>
<th>peer2</th>
</tr>
</thead>
<tbody>
<tr>
<td>mine</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>30.0</td>
<td>30.0</td>
</tr>
<tr>
<td>mine1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>20.0</td>
<td>25.0</td>
</tr>
<tr>
<td>minela</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>22.0</td>
<td>24.0</td>
</tr>
<tr>
<td>mine2</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>23.0</td>
<td>25.0</td>
</tr>
<tr>
<td>mine3</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>25.0</td>
<td>28.0</td>
</tr>
<tr>
<td>peer1</td>
<td>30.0</td>
<td>20.0</td>
<td>22.0</td>
<td>23.0</td>
<td>25.0</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>peer2</td>
<td>30.0</td>
<td>25.0</td>
<td>24.0</td>
<td>25.0</td>
<td>28.0</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Figure 8: Filtered Cost Map Constraint Test
4.3. Endpoint Property Service Tests

Every client should verify that the server’s EPS resource for the default network’s "pid" property returns the correct PID name for a representative set of endpoint addresses. If possible, clients should also verify the alternate network’s "pid" property and the "priv:ietf-type" property.

The table below gives the expected values for a set of addresses. Clients are encouraged to test other addresses as well.
<table>
<thead>
<tr>
<th>Address</th>
<th>def.pid</th>
<th>alt.pid</th>
<th>priv:ietf-type</th>
</tr>
</thead>
<tbody>
<tr>
<td>ipv4:0.0.0.1</td>
<td>default</td>
<td>default</td>
<td>-</td>
</tr>
<tr>
<td>ipv4:10.1.2.3</td>
<td>private</td>
<td>private</td>
<td>-</td>
</tr>
<tr>
<td>ipv4:100.0.0.1</td>
<td>mine1</td>
<td>default</td>
<td>mine</td>
</tr>
<tr>
<td>ipv4:100.0.1.1</td>
<td>mine1a</td>
<td>default</td>
<td>mine</td>
</tr>
<tr>
<td>ipv4:100.0.192.1</td>
<td>mine1a</td>
<td>default</td>
<td>mine</td>
</tr>
<tr>
<td>ipv4:100.0.64.1</td>
<td>mine1a</td>
<td>default</td>
<td>mine</td>
</tr>
<tr>
<td>ipv4:100.130.0.1</td>
<td>mine3</td>
<td>default</td>
<td>mine</td>
</tr>
<tr>
<td>ipv4:100.200.0.1</td>
<td>mine</td>
<td>default</td>
<td>mine</td>
</tr>
<tr>
<td>ipv4:100.75.0.1</td>
<td>mine2</td>
<td>default</td>
<td>mine</td>
</tr>
<tr>
<td>ipv4:101.0.0.1</td>
<td>default</td>
<td>dc1</td>
<td>-</td>
</tr>
<tr>
<td>ipv4:101.1.0.1</td>
<td>default</td>
<td>default</td>
<td>-</td>
</tr>
<tr>
<td>ipv4:102.0.0.1</td>
<td>default</td>
<td>dc2</td>
<td>-</td>
</tr>
<tr>
<td>ipv4:103.0.0.1</td>
<td>default</td>
<td>dc3</td>
<td>-</td>
</tr>
<tr>
<td>ipv4:104.0.0.1</td>
<td>default</td>
<td>dc4</td>
<td>-</td>
</tr>
<tr>
<td>ipv4:127.0.0.1</td>
<td>loopback</td>
<td>loopback</td>
<td>-</td>
</tr>
<tr>
<td>ipv4:127.255.255.255</td>
<td>loopback</td>
<td>loopback</td>
<td>-</td>
</tr>
<tr>
<td>ipv4:128.0.0.1</td>
<td>peer1</td>
<td>default</td>
<td>peer</td>
</tr>
<tr>
<td>ipv4:129.0.0.1</td>
<td>peer2</td>
<td>default</td>
<td>peer</td>
</tr>
<tr>
<td>ipv4:130.0.0.1</td>
<td>peer1</td>
<td>default</td>
<td>peer</td>
</tr>
<tr>
<td>ipv4:131.0.0.1</td>
<td>peer2</td>
<td>default</td>
<td>peer</td>
</tr>
<tr>
<td>ipv4:132.0.0.1</td>
<td>tran1</td>
<td>default</td>
<td>transit</td>
</tr>
<tr>
<td>ipv4:135.0.0.1</td>
<td>tran2</td>
<td>default</td>
<td>transit</td>
</tr>
<tr>
<td>ipv4:169.254.1.2</td>
<td>linklocal</td>
<td>linklocal</td>
<td>-</td>
</tr>
<tr>
<td>ipv4:201.0.0.1</td>
<td>default</td>
<td>user1</td>
<td>-</td>
</tr>
<tr>
<td>ipv4:201.1.2.3</td>
<td>default</td>
<td>default</td>
<td>-</td>
</tr>
<tr>
<td>ipv4:202.0.0.1</td>
<td>default</td>
<td>user2</td>
<td>-</td>
</tr>
<tr>
<td>ipv4:203.0.0.1</td>
<td>default</td>
<td>user3</td>
<td>-</td>
</tr>
<tr>
<td>ipv4:204.0.0.1</td>
<td>default</td>
<td>user4</td>
<td>-</td>
</tr>
<tr>
<td>ipv4:99.0.0.1</td>
<td>default</td>
<td>default</td>
<td>-</td>
</tr>
<tr>
<td>ipv6:::1</td>
<td>loopback</td>
<td>loopback</td>
<td>-</td>
</tr>
<tr>
<td>ipv6:::2</td>
<td>default</td>
<td>default</td>
<td>-</td>
</tr>
<tr>
<td>ipv6:2001:db8::</td>
<td>peer1</td>
<td>default</td>
<td>peer</td>
</tr>
<tr>
<td>ipv6:2001:db8:8000::1</td>
<td>peer2</td>
<td>default</td>
<td>peer</td>
</tr>
<tr>
<td>ipv6:fc00:1::</td>
<td>private</td>
<td>private</td>
<td>-</td>
</tr>
<tr>
<td>ipv6:ff80:1:2::</td>
<td>linklocal</td>
<td>linklocal</td>
<td>-</td>
</tr>
</tbody>
</table>

Figure 9: EPS Test Addresses And Property Values

4.4. Endpoint Cost Service Tests

TBD!!!

5. Error Tests

TBD!!!
6. Security considerations

This document does not present any new security considerations above and beyond what is documented in the ALTO protocol [RFC7285].

7. IANA considerations

This document does not require any action from IANA.

8. Normative References


Appendix A. Appendix: JSON Network And Cost Maps

This section presents the network and cost maps defined in Section 2 formatted as JSON ([RFC7159]) objects.
A.1. Default Network Map

```
"network-map": {
  "default": {
    "ipv4": ["0.0.0.0/0"],
    "ipv6": [":/0"]},
  "linklocal": {
    "ipv4": ["169.254.0.0/16"],
    "ipv6": ["::/10"]},
  "loopback": {
    "ipv4": ["127.0.0.0/8"],
    "ipv6": [":/128"]},
  "mine": {
    "ipv4": ["100.0.0.0/8"]},
  "mine1": {
    "ipv4": ["100.0.0.0/10"]},
  "mine1a": {
    "ipv4": ["100.0.64.0/24", "100.0.192.0/24", "100.0.1.0/24"]},
  "mine2": {
    "ipv4": ["100.64.0.0/10"]},
  "mine3": {
    "ipv4": ["100.128.0.0/10"]},
  "peer1": {
    "ipv4": ["130.0.0.0/16", "128.0.0.0/16"],
    "ipv6": ["2001:DB8::/33"]},
  "peer2": {
    "ipv4": ["131.0.0.0/16", "129.0.0.0/16"],
    "ipv6": ["2001:DB8:8000::/33"]},
  "private": {
    "ipv4": ["10.0.0.0/8", "172.16.0.0/12", "192.168.0.0/16"],
    "ipv6": ["FC00::/7"]},
  "tran1": {
    "ipv4": ["132.0.0.0/16"]},
  "tran2": {
    "ipv4": ["135.0.0.0/16"]}
}
```

Figure 10: Default Network Map, in JSON
A.2. Default "routingcost" Cost Map

"cost-map": {
  "default": {
    "default": 1.0,  "mine": 75.0,  "mine1": 75.0,  "mine1a": 75.0,
    "mine2": 75.0,  "mine3": 75.0 },
  "mine": {
    "default": 75.0,  "mine": 1.0,  "mine1": 15.0,  "mine1a": 15.0,
    "mine2": 15.0,  "mine3": 15.0,  "peer1": 30.0,  "peer2": 30.0,
    "tran1": 50.0,  "tran2": 50.0 },
  "mine1": {
    "default": 75.0,  "mine": 15.0,  "mine1": 1.0,  "mine1a": 2.5,
    "mine2": 5.0,  "mine3": 7.0,  "peer1": 20.0,  "peer2": 25.0,
    "tran1": 40.0,  "tran2": 45.0 },
  "mine1a": {
    "default": 75.0,  "mine": 15.0,  "mine1": 2.0,  "mine1a": 1.0,
    "mine2": 7.0,  "mine3": 9.0,  "peer1": 22.0,  "peer2": 24.0,
    "tran1": 42.0,  "tran2": 48.0 },
  "mine2": {
    "default": 75.0,  "mine": 15.0,  "mine1": 5.5,  "mine1a": 7.0,
    "mine2": 1.0,  "mine3": 6.0,  "peer1": 23.0,  "peer2": 25.0,
    "tran1": 43.0,  "tran2": 46.0 },
  "mine3": {
    "default": 75.0,  "mine": 15.0,  "mine1": 7.0,  "mine1a": 9.0,
    "mine2": 6.0,  "mine3": 1.0,  "peer1": 25.0,  "peer2": 28.0,
    "tran1": 45.0,  "tran2": 49.0 },
  "peer1": {
    "mine": 30.0,  "mine1": 20.0,  "mine1a": 22.0,  "mine2": 23.0,
    "mine3": 25.0,  "peer1": 1.0 },
  "peer2": {
    "mine": 30.0,  "mine1": 25.0,  "mine1a": 24.0,  "mine2": 25.0,
    "mine3": 28.0,  "peer2": 1.0 },
  "tran1": {
    "mine": 50.0,  "mine1": 40.0,  "mine1a": 42.0,  "mine2": 43.0,
    "mine3": 45.0,  "tran1": 1.0 },
  "tran2": {
    "mine": 50.0,  "mine1": 45.0,  "mine1a": 48.0,  "mine2": 46.0,
    "mine3": 49.0,  "tran2": 1.0 }
}

Figure 11: Default "routingcost" Cost Map, in JSON
A.3. Default "hopcount" Cost Map

"cost-map": {
  "default": {
    "default": 1.0,  "mine": 10.0,  "mine1": 10.0,  "minela": 10.0,  
    "mine2": 10.0,  "mine3": 10.0,

  "mine": {
    "default": 10.0,  "mine": 1.0,  "mine1": 3.0,  "minela": 3.0,  
    "mine2": 3.0,  "mine3": 3.0,  "peer1": 5.0,  "peer2": 6.0,  
    "tran1": 8.0,  "tran2": 8.0,

  "mine1": {
    "default": 10.0,  "mine": 3.0,  "mine1": 1.0,  "minela": 2.0,  
    "mine2": 2.0,  "mine3": 2.0,  "peer1": 4.0,  "peer2": 5.0,  
    "tran1": 6.0,  "tran2": 7.0,

  "mine1a": {
    "default": 10.0,  "mine": 3.0,  "mine1": 2.0,  "minela": 1.0,  
    "mine2": 2.0,  "mine3": 3.0,  "peer1": 4.0,  "peer2": 5.0,  
    "tran1": 6.0,  "tran2": 7.0,

  "mine2": {
    "default": 10.0,  "mine": 3.0,  "mine1": 2.0,  "minela": 2.0,  
    "mine2": 1.0,  "mine3": 2.0,  "peer1": 4.0,  "peer2": 5.0,  
    "tran1": 6.0,  "tran2": 7.0,

  "mine3": {
    "default": 10.0,  "mine": 3.0,  "mine1": 2.0,  "minela": 3.0,  
    "mine2": 2.0,  "mine3": 1.0,  "peer1": 4.0,  "peer2": 5.0,  
    "tran1": 6.0,  "tran2": 7.0,

  \"peer1\": {
    \"mine\": 5.0,  \"mine1\": 4.0,  \"minela\": 5.0,  \"mine2\": 4.0,  
    \"mine3\": 4.0,  \"peer1\": 1.0,

  \"peer2\": {
    \"mine\": 6.0,  \"mine1\": 5.0,  \"minela\": 6.0,  \"mine2\": 5.0,  
    \"mine3\": 5.0,  \"peer2\": 1.0,

  \"tran1\": {
    \"mine\": 8.0,  \"mine1\": 6.0,  \"minela\": 7.0,  \"mine2\": 6.0,  
    \"mine3\": 6.0,  \"tran1\": 1.0,

  \"tran2\": {
    \"mine\": 8.0,  \"mine1\": 7.0,  \"minela\": 8.0,  \"mine2\": 7.0,  
    \"mine3\": 7.0,  \"tran2\": 1.0 } 

}

Figure 12: Default "hopcount" Cost Map, in JSON
A.4. Alternate Network Map

"network-map": {
    "dc1": {
        "ipv4": ["101.0.0.0/16"]
    },
    "dc2": {
        "ipv4": ["102.0.0.0/16"]
    },
    "dc3": {
        "ipv4": ["103.0.0.0/16"]
    },
    "dc4": {
        "ipv4": ["104.0.0.0/16"]
    },
    "default": {
        "ipv4": ["0.0.0.0/0"],
        "ipv6": ["::/0"]
    },
    "linklocal": {
        "ipv4": ["169.254.0.0/16"],
        "ipv6": ["FF80::/10"]
    },
    "loopback": {
        "ipv4": ["127.0.0.0/8"],
        "ipv6": ["::1/128"]
    },
    "private": {
        "ipv4": ["10.0.0.0/8", "172.16.0.0/12", "192.168.0.0/16"],
        "ipv6": ["FC00::/7"]
    },
    "user1": {
        "ipv4": ["201.0.0.0/16"]
    },
    "user2": {
        "ipv4": ["202.0.0.0/16"]
    },
    "user3": {
        "ipv4": ["203.0.0.0/16"]
    },
    "user4": {
        "ipv4": ["204.0.0.0/16"]
    }
}

Figure 13: Alternate Network Map, in JSON
A.5. Alternate "routingcost" Cost Map

```
"cost-map": {
  "dc1": {
    "dc1": 0.0,  "dc2": 5.0,  "dc3": 5.0,  "dc4": 5.0,
    "default": 50.0,  "user1": 10.0,  "user2": 20.0,  "user3": 30.0,
    "user4": 40.0 },
  "dc2": {
    "dc1": 5.0,  "dc2": 0.0,  "dc3": 5.0,  "dc4": 5.0,
    "default": 50.0,  "user1": 20.0,  "user2": 10.0,  "user3": 20.0,
    "user4": 30.0 },
  "dc3": {
    "dc1": 5.0,  "dc2": 5.0,  "dc3": 0.0,  "dc4": 5.0,
    "default": 50.0,  "user1": 30.0,  "user2": 20.0,  "user3": 10.0,
    "user4": 20.0 },
  "dc4": {
    "dc1": 5.0,  "dc2": 5.0,  "dc3": 5.0,  "dc4": 0.0,
    "default": 50.0,  "user1": 40.0,  "user2": 30.0,  "user3": 20.0,
    "user4": 10.0 },
  "default": {
    "dc1": 50.0,  "dc2": 50.0,  "dc3": 50.0,  "dc4": 50.0,
    "default": 0.0 },
  "user1": {
    "dc1": 10.0,  "dc2": 20.0,  "dc3": 30.0,  "dc4": 40.0,
    "user1": 0.0 },
  "user2": {
    "dc1": 20.0,  "dc2": 10.0,  "dc3": 20.0,  "dc4": 30.0,
    "user2": 0.0 },
  "user3": {
    "dc1": 30.0,  "dc2": 20.0,  "dc3": 10.0,  "dc4": 20.0,
    "user3": 0.0 },
  "user4": {
    "dc1": 40.0,  "dc2": 30.0,  "dc3": 20.0,  "dc4": 10.0,
    "user4": 0.0 }
}
```

Figure 14: Alternate "routingcost" Cost Map, in JSON
A.6. Alternate "hopcount" Cost Map

```
"cost-map": {
  "dc1": {
    "dc1": 0.0,  "dc2": 1.0,  "dc3": 1.0,  "dc4": 1.0,
    "default": 8.0,  "user1": 3.0,  "user2": 4.0,  "user3": 5.0,
    "user4": 6.0 },
  "dc2": {
    "dc1": 1.0,  "dc2": 0.0,  "dc3": 1.0,  "dc4": 1.0,
    "default": 8.0,  "user1": 4.0,  "user2": 3.0,  "user3": 4.0,
    "user4": 5.0 },
  "dc3": {
    "dc1": 1.0,  "dc2": 1.0,  "dc3": 0.0,  "dc4": 1.0,
    "default": 8.0,  "user1": 5.0,  "user2": 4.0,  "user3": 3.0,
    "user4": 4.0 },
  "dc4": {
    "dc1": 1.0,  "dc2": 1.0,  "dc3": 1.0,  "dc4": 0.0,
    "default": 8.0,  "user1": 6.0,  "user2": 5.0,  "user3": 4.0,
    "user4": 3.0 },
  "default": {
    "dc1": 8.0,  "dc2": 8.0,  "dc3": 8.0,  "dc4": 8.0,
    "default": 0.0 },
  "user1": {
    "dc1": 3.0,  "dc2": 4.0,  "dc3": 5.0,  "dc4": 6.0,
    "user1": 0.0 },
  "user2": {
    "dc1": 4.0,  "dc2": 3.0,  "dc3": 4.0,  "dc4": 5.0,
    "user2": 0.0 },
  "user3": {
    "dc1": 5.0,  "dc2": 4.0,  "dc3": 3.0,  "dc4": 4.0,
    "user3": 0.0 },
  "user4": {
    "dc1": 6.0,  "dc2": 5.0,  "dc3": 4.0,  "dc4": 3.0,
    "user4": 0.0 }
},
```

Figure 15: Alternate "hopcount" Cost Map, in JSON

Appendix B. Acknowledgements

The editors will like to thank the ALTO working group participants for reviewing test cases. Richard Alimi and Mikio Hara contributed review cycles to the contents of this document.
Author’s Address

Wendy Roome (editor)
Bell Laboratories, Alcatel-Lucent

Email: w.roome@alcatel-lucent.com