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W. Roome  
Nokia Bell Labs  
Y. Yang  
Tongji/Yale University  
S. Chen  
Tongji University  
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**ALTO Incremental Updates Using Server-Sent Events (SSE)**  
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Abstract

The Application-Layer Traffic Optimization (ALTO) [[RFC7285](#)] protocol provides network related information, called network information resources, to client applications so that clients can make informed decisions in utilizing network resources. For example, an ALTO server can provide network and cost maps so that an ALTO client can use the maps to determine the costs between network endpoints when choosing communicating endpoints.

However, the ALTO protocol does not define a mechanism to allow an ALTO client to obtain updates to the information resources, other than by periodically re-fetching them. Because some information resources (e.g., the aforementioned maps) may be large (potentially tens of megabytes), and because only parts of the information resources may change frequently (e.g., only some entries in a cost map), complete re-fetching can be extremely inefficient.

This document presents a mechanism to allow an ALTO server to push updates to ALTO clients, to achieve two benefits: (1) updates can be immediate, in that the ALTO server can send updates as soon as they are available; and (2) updates can be incremental, in that if only a small section of an information resource changes, the ALTO server can send just the changes.

Requirements Language

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 [RFC 2119](#) [[RFC2119](#)].

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## 1. Introduction

The Application-Layer Traffic Optimization (ALTO) [[RFC7285](#)] protocol provides network related information called network information resources to client applications so that clients may make informed decisions in utilizing network resources. For example, an ALTO server provides network and cost maps, where a network map partitions the set of endpoints into a manageable number of sets each defined by



a Provider-Defined Identifier (PID), and a cost map provides directed costs between PIDs. Given network and cost maps, an ALTO client can obtain costs between endpoints by first using the network map to get the PID for each endpoint, and then using the cost map to get the costs between those PIDs. Such costs can be used by the client to choose communicating endpoints with low network costs.

The ALTO protocol defines only an ALTO client pull model, without defining a mechanism to allow an ALTO client to obtain updates to network information resources, other than by periodically re-fetching them. In settings where an information resource may be large but only parts of it may change frequently (e.g., some entries of a cost map), complete re-fetching can be inefficient.

This document presents a mechanism to allow an ALTO server to push incremental updates to ALTO clients. Integrating server-push and incremental updates provides two benefits: (1) updates can be immediate, in that the ALTO server can send updates as soon as they are available; and (2) updates can be small, in that if only a small section of an information resource changes, the ALTO server can send just the changes.

While primarily intended to provide updates to GET-mode network and cost maps, the mechanism defined in this document can also provide updates to POST-mode ALTO services, such as the endpoint property and endpoint cost services. We intend that the mechanism can also support new ALTO services to be defined by future extensions, but a future service needs to satisfy requirements specified in [Section 13](#).

The rest of this document is organized as follows. [Section 4](#) gives background on the basic techniques used in this design: (1) Server-Sent Events to allow server push; (2) JSON merge patch and JSON patch to allow incremental update. With the background, [Section 5](#) gives a non-normative overview of the design. [Section 6](#) defines individual messages in an update stream, and [Section 7](#) defines the overall update stream service; [Section 8](#) defines the stream control service; [Section 9](#) gives several examples; [Section 10](#) describes operation and processing considerations by both ALTO servers and clients; [Section 11](#) discusses two design features that are not supported; [Section 12](#) discusses security issues; The last two sections review the requirements for future ALTO services to use SSE and IANA considerations, respectively.

## **2. Major Changes Since Version -01**

To RFC editor: This will be removed in the final version. We keep this section to make clear major changes in the technical content.



- o Incremental encoding: Added JSON patch as an alternative incremental delta encoding.
- o Client-assigned client-id to allow concurrent updates of the same server resource: The client now assigns a unique client-id to each resource in an update stream. The server puts the client-id in each update event for that resource (before, the server used the server's resource-id). This allows a client to use one update stream to receive updates to multiple requests for the same server resource, for example, for a POST-mode resource; before, that required separate update streams.
- o Flexible control: Defined a new "stream control" resource ([Section 8](#)) to allow a client to add or remove resources from a previously created update stream. The ALTO server creates a new stream control resource for each update stream instance, assigns a unique URI to it, and sends the URI to the client as the first event in the stream.

### 3. Terms

This document uses the following terms: Update Stream, Update Stream Server, Update Message, Data Update Message, Full Replacement, Incremental Change, Control Update Message, Stream Control Service, Stream Control.

**Update Stream:** An update stream is an HTTP connection between an ALTO client and an ALTO server so that the server can push a sequence of update messages using SSE to the client.

**Update Stream Server:** We refer to an ALTO server providing an update stream as an ALTO update stream server, or update stream server for short. Note that the ALTO server mentioned in this document refers to a general server that provides various kinds of services; it can be an update stream server or stream control server (see below); it can also be a server providing ALTO IRD information.

**Update Message:** An update message is either a data update message or a control update message.

**Data Update Message:** A data update message is for a single ALTO information resource and sent from the update stream server to the ALTO client when the resource changes. A data update message can be either a full-replacement message or an incremental-change message. Full replacement is a shorthand for a full-replacement message, and incremental change is a shorthand for an incremental-change message.





**Full Replacement:** A full replacement for a resource encodes the content of the resource in its original ALTO encoding.

**Incremental Change:** An incremental change specifies only the difference between the new content and the previous version. An incremental change can be encoded using either JSON merge patch or JSON patch in this document.

**Stream Control Service:** An stream control service provides an HTTP URI so that the ALTO client of an update stream can use it to send stream control requests on the addition or removal of resources receiving update messages from the update stream.

**Stream Control:** A shorthand for stream control service.

**Stream Control Server:** An stream control server providing the stream control service.

**Control Update Message:** A control update message is a message in an update stream for the update stream server to notify the ALTO client of related control information of the update stream. The first message of an update stream is a control update message and provides the URI using which the ALTO client can send stream control requests to the stream control server. Additional control update messages in an update stream allow the update stream server to notify the ALTO client of status changes (e.g., the server will no longer send updates for an information resource).

## **4. Background**

The design requires two basic techniques: server push and encoding of incremental changes. Using existing techniques whenever possible, this design uses Server-Sent Events (SSEs) for server push; JSON merge patch and JSON patch to encode incremental changes. Below we give a non-normative summary of these two techniques.

### **4.1. Server-Sent Events (SSEs)**

The following is a non-normative summary of SSE; see [[SSE](#)] for its normative definition.

Server-Sent Events enable a server to send new data to a client by "server-push". The client establishes an HTTP ([[RFC7230](#)], [[RFC7231](#)]) connection to the server and keeps the connection open. The server continually sends messages. Each message has one or more lines, where a line is terminated by a carriage-return immediately followed by a new-line, a carriage-return not immediately followed by a new-line, or a new-line not immediately preceded by a carriage-return. A



message is terminated by a blank line (two line terminators in a row).

Each line in a message is of the form "field-name: string value". Lines with a blank field-name (that is, lines which start with a colon) are ignored, as are lines which do not have a colon. The protocol defines three field names: event, id, and data. If a message has more than one "data" line, the value of the data field is the concatenation of the values on those lines. There can be only one "event" and "id" line per message. The "data" field is required; the others are optional.

Figure 1 is a sample SSE stream, starting with the client request. The server sends three events and then closes the stream.

```
(Client request)
GET /stream HTTP/1.1
Host: example.com
Accept: text/event-stream

(Server response)
HTTP/1.1 200 OK
Connection: keep-alive
Content-Type: text/event-stream

event: start
id: 1
data: hello there

event: middle
id: 2
data: let's chat some more ...
data: and more and more and ...

event: end
id: 3
data: goodbye
```

Figure 1: A Sample SSE stream.

## [4.2.](#) JSON Merge Patch

### [4.2.1.](#) JSON Merge Patch Encoding

To avoid always sending complete data, a server needs mechanisms to encode incremental changes. This design uses JSON merge patch as one mechanism. Below is a non-normative summary of JSON merge patch; see [\[RFC7396\]](#) for the normative definition.



JSON merge patch is intended to allow applications to update server resources via the HTTP patch method [[RFC5789](#)]. This document adopts the JSON merge patch message format to encode incremental changes, but uses a different transport mechanism.

Informally, a JSON merge patch object is a JSON data structure that defines how to transform one JSON value into another. Specifically, JSON merge patch treats the two JSON values as trees of nested JSON objects (dictionaries of name-value pairs), where the leaves are values (e.g., JSON arrays, strings, numbers) other than JSON objects and the path for each leaf is the sequence of keys leading to that leaf. When the second tree has a different value for a leaf at a path, or adds a new leaf, the JSON merge patch tree has a leaf, at that path, with the new value. When a leaf in the first tree does not exist in the second tree, the JSON merge patch tree has a leaf with a JSON "null" value. The JSON merge patch tree does not have an entry for any leaf that has the same value in both versions.

As a result, if all leaf values are simple scalars, JSON merge patch is a quite efficient representation of incremental changes. It is less efficient when leaf values are arrays, because JSON merge patch replaces arrays in their entirety, even if only one entry changes.

Formally, the process of applying a JSON merge patch is defined by the following recursive algorithm, as specified in [[RFC7396](#)]:

```
define MergePatch(Target, Patch) {
  if Patch is an Object {
    if Target is not an Object {
      Target = {} # Ignore the contents and
                  # set it to an empty Object
    }
    for each Name/Value pair in Patch {
      if Value is null {
        if Name exists in Target {
          remove the Name/Value pair from Target
        }
      } else {
        Target[Name] = MergePatch(Target[Name], Value)
      }
    }
    return Target
  } else {
    return Patch
  }
}
```



Note that null as the value of a name/value pair will delete the element with "name" in the original JSON value.

#### **4.2.2. JSON Merge Patch ALTO Messages**

To provide both examples of JSON merge patch and a demonstration of the feasibility of applying JSON merge patch to ALTO, we look at the application of JSON merge patch to two key ALTO messages.

##### **4.2.2.1. JSON Merge Patch Network Map Messages**

[Section 11.2.1.6 of \[RFC7285\]](#) defines the format of an ALTO network map message. Assume a simple example ALTO message sending an initial network map:

```
{
  "meta" : {
    "vtag": {
      "resource-id" : "my-network-map",
      "tag" : "da65eca2eb7a10ce8b059740b0b2e3f8eb1d4785"
    }
  },
  "network-map" : {
    "PID1" : {
      "ipv4" : [ "192.0.2.0/24", "198.51.100.0/25" ]
    },
    "PID2" : {
      "ipv4" : [ "198.51.100.128/25" ]
    },
    "PID3" : {
      "ipv4" : [ "0.0.0.0/0" ],
      "ipv6" : [ "::/0" ]
    }
  }
}
```

Consider the following JSON merge patch update message, which (1) adds an ipv4 prefix "193.51.100.0/25" and an ipv6 prefix "2001:db8:8000::/33" to "PID1", (2) deletes "PID2", and (3) assigns a new "tag" to the network map:





```
{
  "meta" : {
    "vtag" : {
      "tag" : "a10ce8b059740b0b2e3f8eb1d4785acd42231bfe"
    }
  },
  "network-map": {
    "PID1" : {
      "ipv4" : [ "192.0.2.0/24", "198.51.100.0/25",
                 "193.51.100.0/25" ],
      "ipv6" : [ "2001:db8:8000::/33" ]
    },
    "PID2" : null
  }
}
```

Applying the JSON merge patch update to the initial network map is equivalent to the following ALTO network map:

```
{
  "meta" : {
    "vtag": {
      "resource-id" : "my-network-map",
      "tag" : "a10ce8b059740b0b2e3f8eb1d4785acd42231bfe"
    }
  },
  "network-map" : {
    "PID1" : {
      "ipv4" : [ "192.0.2.0/24", "198.51.100.0/25",
                 "193.51.100.0/25" ],
      "ipv6" : [ "2001:db8:8000::/33" ]
    },
    "PID3" : {
      "ipv4" : [ "0.0.0.0/0" ],
      "ipv6" : [ "::/0" ]
    }
  }
}
```

#### **4.2.2.2. JSON Merge Patch Cost Map Messages**

[Section 11.2.3.6 of \[RFC7285\]](#) defines the format of an ALTO cost map message. Assume a simple example ALTO message for an initial cost map:



```

{
  "meta" : {
    "dependent-vtags" : [
      { "resource-id": "my-network-map",
        "tag": "a10ce8b059740b0b2e3f8eb1d4785acd42231bfe"
      }
    ],
    "cost-type" : {
      "cost-mode" : "numerical",
      "cost-metric": "routingcost"
    },
    "vtag": {
      "resource-id" : "my-cost-map",
      "tag" : "3ee2cb7e8d63d9fab71b9b34cbf764436315542e"
    }
  },
  "cost-map" : {
    "PID1": { "PID1": 1, "PID2": 5, "PID3": 10 },
    "PID2": { "PID1": 5, "PID2": 1, "PID3": 15 },
    "PID3": { "PID1": 20, "PID2": 15 }
  }
}

```

The following JSON merge patch message updates the example cost map so that (1) the "tag" field of the cost map is updated, (2) the cost of PID1->PID2 is 9 instead of 5, (3) the cost of PID3->PID1 is no longer available, and (4) the cost of PID3->PID3 is defined as 1.

```

{
  "meta" : {
    "vtag": {
      "tag": "c0ce023b8678a7b9ec00324673b98e54656d1f6d"
    }
  },
  "cost-map" : {
    "PID1" : { "PID2" : 9 },
    "PID3" : { "PID1" : null, "PID3" : 1 }
  }
}

```

Hence applying the JSON merge patch to the initial cost map is equivalent to the following ALTO cost map:



```
{
  "meta" : {
    "dependent-vtags" : [
      { "resource-id": "my-network-map",
        "tag": "a10ce8b059740b0b2e3f8eb1d4785acd42231bfe"
      }
    ],
    "cost-type" : {
      "cost-mode" : "numerical",
      "cost-metric": "routingcost"
    },
    "vtag": {
      "resource-id": "my-cost-map",
      "tag": "c0ce023b8678a7b9ec00324673b98e54656d1f6d"
    }
  },
  "cost-map" : {
    "PID1": { "PID1": 1, "PID2": 9, "PID3": 10 },
    "PID2": { "PID1": 5, "PID2": 1, "PID3": 15 },
    "PID3": { "PID2": 15, "PID3": 1 }
  }
}
```

### [4.3.](#) JSON Patch

#### [4.3.1.](#) JSON Patch Encoding

One issue of JSON merge patch is that it does not handle array changes well. In particular, JSON merge patch considers an array as a single object and hence can only replace an array in its entirety. When the change is to make a small change to an array such as the deletion of an element from a large array, whole-array replacement is inefficient. Consider the example in [Section 4.2.2.1](#). To add a new entry to the ipv4 array for PID1, the server needs to send a whole new array. Another issue is that JSON merge patch cannot change a value to be null, as the JSON merge patch processing algorithm (MergePatch in [Section 4.2.1](#)) interprets a null as a removal instruction. On the other hand, some ALTO resources can have null values, and it is possible that the update will want to change the new value to be null.

JSON patch [[RFC6902](#)] can address the preceding issues. It defines a set of operators to modify a JSON object. Below is a non-normative description of JSON patch; see [[RFC6902](#)] for the normative definition.



#### **4.3.2. JSON Patch ALTO Messages**

To provide both examples of JSON patch and a demonstration of the difference between JSON patch and JSON merge patch, we take a look at the application of JSON patch to the same updates shown in [Section 4.2.2](#).

##### **4.3.2.1. JSON Patch Network Map Messages**

First consider the same update as in [Section 4.2.2.1](#) for the network map. Below is the encoding using JSON patch:

```
[
  {
    "op": "replace",
    "path": "/meta/vtag/tag",
    "value": "a10ce8b059740b0b2e3f8eb1d4785acd42231bfe"
  },
  {
    "op": "add",
    "path": "/network-map/PID1/ipv4/2",
    "value": "193.51.100.0/25"
  }
  {
    "op": "add",
    "path": "/network-map/PID1/ipv6",
    "value": ["2001:db8:8000::/33"]
  },
  {
    "op": "remove",
    "path": "/network-map/PID2"
  }
]
```

##### **4.3.2.2. JSON Patch Cost Map Messages**

Compared with JSON merge patch, JSON patch does not encode cost map updates efficiently. Consider the cost map update shown in [Section 4.2.2.2](#), the encoding using JSON patch is:





```
[
  {
    "op": "replace",
    "path": "/meta/vtag/tag",
    "value": "c0ce023b8678a7b9ec00324673b98e54656d1f6d"
  },
  {
    "op": "replace",
    "path": "/cost-map/PID1/PID2",
    "value": 9
  },
  {
    "op": "remove",
    "path": "/cost-map/PID3/PID1"
  },
  {
    "op": "replace",
    "path": "/cost-map/PID3/PID3",
    "value": 1
  }
]
```

## 5. Overview of Approach

With the preceding background, we now give a non-normative overview of the update mechanism to be defined in later sections of this document.

The building block of the update mechanism defined in this document is the update stream service (defined in [Section 7](#)), where each update stream service is a POST-mode service that provides update streams. When an ALTO client requests an update stream service, the ALTO client establishes a persistent connection to the update stream server, creating an update stream. The update stream server uses the update stream to continuously send a sequence of update messages (defined in [Section 6](#)) to the ALTO client. An update stream can provide updates to both GET-mode resources, such as ALTO network and cost maps, and POST-mode resources, such as ALTO endpoint property service.

An ALTO server may provide any number of update stream services, where each update stream may provide updates for a given subset of the ALTO server's resources. An ALTO server's Information Resource Directory (IRD) defines the update stream services and declares the set of resources for which each update stream service provides updates. The ALTO server selects the resource set for each update stream service. It is recommended that if a resource depends on one or more other resource(s) (indicated with the "uses" attribute



defined in [[RFC7285](#)]), these other resource(s) should also be part of that update stream. Thus the update stream for a cost map should also provide updates for the network map on which that cost map depends.

An ALTO client may request any number of update streams simultaneously. Because each update stream consumes resources on the update stream server, an update stream server may require client authorization and/or authentication, limit the number of open update streams, close inactive streams, or redirect an ALTO client to another update stream server.

The key objective of an update stream is to update the ALTO client on data value changes to ALTO resources. We refer to messages sending such updates as data update messages. Although an update stream may update one or more ALTO resources, each data update message updates only one resource and is sent as a Server-Sent Event (SSE), as defined by [[SSE](#)]. A data update message is encoded either as a full replacement or as an incremental change. A full replacement uses the JSON message format defined by the ALTO protocol. There can be multiple encodings for incremental changes. The current design supports incremental changes using JSON merge patch ([[RFC7396](#)]) or JSON patch ([[RFC6902](#)]) to describe the changes of the resource. Future documents may define additional mechanisms for incremental changes. The update stream server decides when to send data update messages, and whether to send full replacements or incremental changes. These decisions can vary from resource to resource and from update to update.

An update stream can run for a long time, and hence there can be status changes at the update stream server side during the lifetime of an update stream; for example, the update stream server may encounter an error or need to shut down for maintenance. To support robust, flexible protocol design, this design allows the update stream server to send server control updates (vs data updates) to the ALTO client as well, showing as control update messages from the update stream server to the ALTO client.



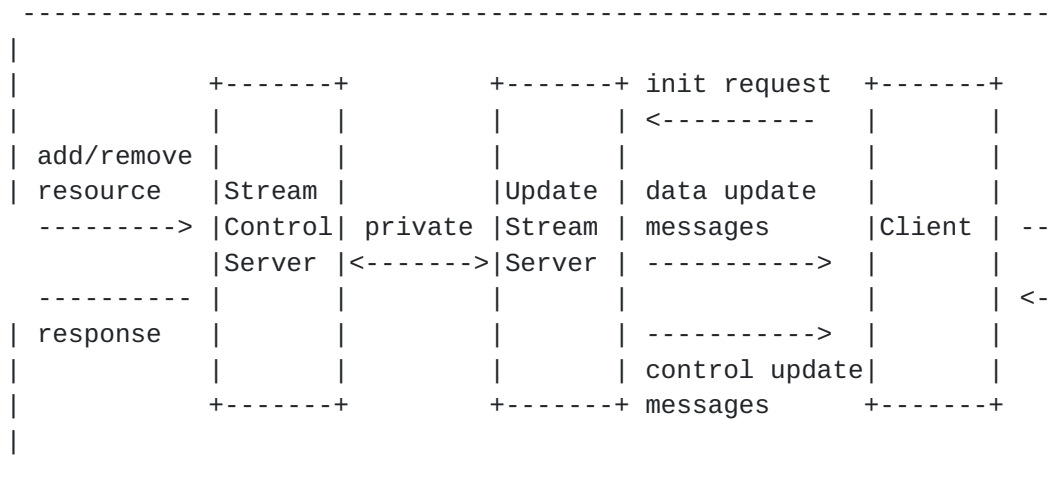


Figure 2: ALTO SSE Architecture.

In addition to control changes triggered from the update stream server side, in a flexible design, an ALTO client may initiate control changes as well, in particular, by adding or removing ALTO resources receiving updates. An ALTO client initiates such changes using the stream control service. Although one may use a design that the client uses the same HTTP connection to send the control requests, it requires stronger server support such as HTTP pipeline. For more flexibility, this document introduces stream control service. In particular, the update stream server of an update stream uses the first message to provide the URI of the stream control service. The ALTO client can then use the URI to ask the update stream server to (1) send data update messages for additional resources, (2) stop sending data update messages for previously requested resources, or (3) gracefully stop and close the update stream altogether. Figure 2 shows the complete ALTO SSE architecture.

## 6. Update Messages: Data Update and Control Update Messages

We now define the details of ALTO SSE. Specifically, an update stream consists of a stream of data update messages ([Section 6.2](#)) and control update messages ([Section 6.3](#)).

### 6.1. ALTO Update Message Format

Data update and control update messages have the same basic structure. The data field is a JSON object, and the event field contains the media type of the data field and an optional client-id. Data update messages use the client-id to identify the ALTO resource to which the update message applies. Client-ids MUST follow the



rules for ALTO ResourceIds ([Section 10.2 of \[RFC7285\]](#)). Client-ids MUST be unique within an update stream, but need not be globally unique. For example, if an ALTO client requests updates for both a cost map and its dependent network map, the ALTO client might assign client-id "1" to the network map and client-id "2" to the cost map. Alternatively, the ALTO client could use the client-ids for those two maps.

JSON specifications use the type ClientId for a client-id, and the type ClientId conforms to the specification of ResourceId as defined in [Section 10.2 of \[RFC7285\]](#).

The two sub-fields (media-type and client-id) of the event field are encoded as comma-separated strings:

```
media-type [ ',' client-id ]
```

The media-type name used by ALTO SSE MUST NOT contain a comma (character code 0x2c). [TODO: conform to [Section 4.2 of \[RFC6838\]](#); confirm with IANA.]

Note that an update message does not use the SSE "id" field. [TODO: Discuss to move client-id to SSE id?]

## **[6.2.](#) ALTO Data Update Message**

A data update message is sent when a monitored resource changes. The data is either a complete specification of the resource, or else a patch (either JSON merge patch or JSON patch) describing the changes from the last version. We will refer to these as full replacement and incremental change, respectively. The encoding of full replacement is defined by [\[RFC7285\]](#); examples are network and cost map messages. They have the media types defined in that document. The encoding of JSON merge patch is defined by [\[RFC7396\]](#), with media type "application/merge-patch+json"; the encoding of JSON patch is defined by [\[RFC6902\]](#), with media type "application/json-patch+json".

Figure 3 shows some examples of ALTO data update messages:





```
event: application/alto-networkmap+json,1
data: { ... full network map message ... }

event: application/alto-costmap+json,2
data: { ... full cost map message ... }

event: application/merge-patch+json,2
data: { ... JSON merge patch update for the cost map ... }
```

Figure 3: Examples of ALTO data update messages.

### 6.3. ALTO Control Update Message

Control update messages have the media type "application/alto-updatestreamcontrol+json", and the data is of type `UpdateStreamControlEvent`:

```
object {
  [String      control-uri;]
  [ClientId    started<1..*>;]
  [ClientId    stopped<1..*>;]
  [String      description;]
} UpdateStreamControlEvent;
```

`control-uri`: the URI providing stream control for this update stream (see [Section 8](#)). The server MUST send a control update message with an URI as the first event in an update stream. If the URI is NULL, the update stream server does not support stream control for this update stream; otherwise, the update stream server provides stream control through the given URI.

`started`: a list of client-ids of resources. It notifies the ALTO client that the update stream server will start sending data update messages for each resource listed.

`stopped`: a list of client-ids of resources. It notifies the ALTO client that the update stream server will no longer send data update messages for the listed resources. There can be multiple reasons for an update stream server to stop sending data update messages for a resource, including a request from the ALTO client using stream control ([Section 7.7.1](#)) or an internal server event.

`description`: a non-normative text providing an explanation for the control event. When an update stream server stops sending data update messages for a resource, it is RECOMMENDED that the update stream server use the description field to provide details.



## **7. Update Stream Service**

An update stream service returns a stream of update messages, as defined in [Section 6](#). An ALTO server's IRD (Information Resource Directory) MAY define one or more update stream services, which ALTO clients use to request new update stream instances.

### **7.1. Media Type**

The media type of an ALTO update stream service is "text/event-stream", as defined by [\[SSE\]](#).

### **7.2. HTTP Method**

An ALTO update stream service is requested using the HTTP POST method.

### **7.3. Accept Input Parameters**

An ALTO client specifies the parameters for the new update stream by sending an HTTP POST body with the media type "application/alto-updatestreamparams+json". That body contains a JSON Object of type UpdateStreamReq, where:

```
object {
  [AddUpdatesReq  add;]
  [ClientId       remove<0..*>;]
} UpdateStreamReq;

object-map {
  ClientId -> AddUpdateReq;
} AddUpdatesReq;

object {
  String      resource-id;
  [String     tag;]
  [Boolean    incremental-changes;]
  [Object     input;]
} AddUpdateReq;
```

add: specifies the resources for which the ALTO client wants updates, and has one entry for each resource. An ALTO client creates a unique client-id ([Section 6.1](#)) for each such resource, and uses those client-ids as the keys in the "add" field.

resource-id: the resource-id of an ALTO resource, and MUST be in the update stream's "uses" list (Section 8.5.2 of [Section 7.5](#)). If the resource-id is a GET-mode resource with a version tag (or



"vtag"), as defined in [Section 6.3](#) and [Section 10.3 of \[RFC7285\]](#), and the ALTO client has previously retrieved a version of that resource from the update stream server, the ALTO client MAY set the "tag" field to the tag part of the client's version of that resource. If that version is not current, the update stream server MUST send a full replacement before sending any incremental changes, as described in [Section 7.7.1](#). If that version is still current, the update stream server MAY omit the initial full replacement.

incremental-changes: the ALTO client specifies whether it is willing to receive incremental changes from the update stream server for a specific resource-id. If the "incremental-changes" field for a resource-id is "true", the update stream server MAY send incremental changes for that resource (assuming the update stream server supports incremental changes for) that resource; see [Section 7.4](#)). If the "incremental-changes" field is "false", the update stream server MUST NOT send incremental changes for that resource. The default value for "incremental-changes" is "true", so to suppress incremental changes, the ALTO client MUST explicitly set "incremental-changes" to "false". Note that the ALTO client cannot suppress full replacement. When the ALTO client sets "incremental-changes" to "false", the update stream server MUST send a full replacement instead of an incremental change to the ALTO client. The update stream server MAY wait until more changes are available, and send a single full replacement with those changes. Thus an ALTO client which declines to accept incremental changes may not get updates as quickly as an ALTO client which does.

input: If the resource is a POST-mode service which requires input, the ALTO client MUST set the "input" field to a JSON Object with the parameters that resource expects.

remove: it is used in update stream control requests ([Section 8](#)), and is not allowed in the update stream request. The update stream server SHOULD ignore this field if it is included in the request.

If a request has any errors, the update stream server MUST NOT create an update stream. Also, the update stream server will send an error response to the ALTO client as specified in [Section 7.6](#).

#### **[7.4](#). Capabilities**

The capabilities are defined as an object of type UpdateStreamCapabilities:



```
object {
  IncrementalUpdateMediaTypes incremental-change-media-types;
  Boolean                      support-stream-control;
} UpdateStreamCapabilities;

object-map {
  ResourceID -> String;
} IncrementalUpdateMediaTypes;
```

If this update stream can provide data update messages with incremental changes for a resource, the "incremental-change-media-types" field has an entry for that resource-id, and the value is the media-type of the incremental change. Normally this will be "application/merge-patch+json", "application/json-patch+json", or "application/merge-patch+json,application/json-patch+json", because, as described in [Section 6](#), they are the only incremental change types defined by this document. However future extensions may define other types of incremental changes.

When choosing the media-type to encode incremental changes for a resource, the update stream server **SHOULD** consider the limitations of the encoding. For example, when a JSON merge patch specifies that the value of a field is null, its semantics is that the field is removed from the target, and hence the field is no longer defined (i.e., undefined); see the MergePatch algorithm in [Section 4.2.1](#) on how null value is processed. This, however, may not be the intended result for the resource, when null and undefined have different semantics for the resource. In such a case, the update stream server **SHOULD** choose JSON patch over JSON merge patch.

The "support-stream-control" field specifies whether the given update stream supports stream control. If "support-stream-control" field is "true", the update stream server will use the stream control specified in this document; else, the update stream server may use other mechanisms to provide the same functionality as stream control.

## 7.5. Uses

The "uses" attribute **MUST** be an array with the resource-ids of every resource for which this update stream can provide updates. Each resource specified in the "uses" **MUST** support full replacement: the update stream server can always send full replacement, and the ALTO client **MUST** accept full replacement.

This set may be any subset of the ALTO server's resources, and may include resources defined in linked IRDs. However, it is **RECOMMENDED** that the ALTO server selects a set that is closed under the resource dependency relationship. That is, if an update stream's "uses" set





includes resource R1, and resource R1 depends on ("uses") resource R0, then the update stream's "uses" set SHOULD include R0 as well as R1. For example, an update stream for a cost map SHOULD also provide updates for the network map upon which that cost map depends.

### 7.6. Response

If the update stream request has any errors, the update stream server MUST return an HTTP "400 Bad Request" to the ALTO client. The body part of the HTTP response is the JSON object defined in [Section 8.5.2 in \[RFC7285\]](#). Hence, an ALTO error response has the format:

```
HTTP/1.1 400 Bad Request
Content-Length: [TBD]
Content-Type: application/alto-error+json
Connection: Closed
```

```
{
  "meta":{
    "code":  "****",
    "field": "****",
    "value": "****"
  }
}
```

Note that "field" and "value" are optional fields. If the "value" field exists, the "field" field MUST exist.

- o If an update stream request does not have an "add" field specifying one or more resources, the error code of the error message MUST be E\_MISSING\_FIELD and the "field" field SHOULD be "add". The update stream server MUST close the stream without sending any events.
- o If the "resource-id" field is invalid, or is not associated with the update stream, the error code of the error message MUST be E\_INVALID\_FIELD\_VALUE; the "field" field SHOULD be "resource-id" and the "value" field SHOULD be the invalid resource-id. If there are more than one invalid resource-ids, the update stream server SHOULD pick one and return it. The update stream server MUST close the stream without sending any events.
- o If the resource is a POST-mode service which requires input, the client MUST set the "input" field to a JSON Object with the parameters that that resource expects. If the "input" field is missing or invalid, the update stream server MUST return the same error response that that resource would return for missing or



invalid input (see [[RFC7285](#)]). In this case, the update stream server MUST close the update stream without sending any events. If the input for several POST-mode resources are missing or invalid, the update stream server MUST pick one and return it.

The response to a valid request is a stream of update messages. [Section 6](#) defines the update messages, and [[SSE](#)] defines how they are encoded into a stream.

An update stream server SHOULD send updates only when the underlying values change. However, it may be difficult for an update stream server to guarantee that in all circumstances. Therefore a client MUST NOT assume that an update message represents an actual change.

## **[7.7.](#) Additional Requirements on Update Messages**

### **[7.7.1.](#) Event Sequence Requirements**

- o The first event MUST be a control update message with the URI of the update stream control service [Section 8](#) for this update stream.
- o As soon as possible after the ALTO client initiates the connection, the update stream server MUST send a full replacement for each resource-id requested with a version tag. In this case the update stream server MAY omit the initial full replacement for that resource, if the "tag" field the ALTO client provided for that resource-id matches the tag of the update stream's current version.
- o If this update stream provides update for resource-ids and R0 and R1, and if R1 depends on R0, then the update stream server MUST send the update for R0 before sending the related updates for R1. For example, suppose an update stream provides updates to a network map and its dependent cost maps. When the network map changes, the update stream server MUST send the network map update before sending the cost map updates.
- o When the ALTO client uses the stream control service to stop updates for one or more resources [Section 8](#), the ALTO client MUST send a stream control request. The update stream server MUST send a control update message whose "stopped" field has the client-ids of all active resources.



### **7.7.2. Cross-Stream Consistency Requirements**

If several ALTO clients create multiple update streams for updates to the same resource, the update stream server **MUST** send the same updates to all of them. However, the update stream server **MAY** pack data items into different patch events, as long as the net result of applying those updates is the same.

For example, suppose two different ALTO clients create update streams for the same cost map, and suppose the update stream server processes three separate cost point updates with a brief pause between each update. The server **MUST** send all three new cost points to both clients. But the update stream server **MAY** send a single patch event (with all three cost points) to one ALTO client, while sending three separate patch events (with one cost point per event) to the other ALTO client.

A update stream server **MAY** offer several different update stream resources that provide updates to the same underlying resource (that is, a resource-id may appear in the "uses" field of more than one update stream resource). In this case, those update stream resources **MUST** return the same update data.

### **7.8. Keep-Alive Messages**

In an SSE stream, any line which starts with a colon (U+003A) character is a comment, and an ALTO client **MUST** ignore that line ([SSE]). As recommended in [SSE], an update stream server **SHOULD** send a comment line (or an event) every 15 seconds to prevent ALTO clients and proxy servers from dropping the HTTP connection.

## **8. Stream Control Service**

An stream control service allows an ALTO client to remove resources from the set of resources that are monitored by an update stream, or add additional resources to that set. The service also allows an ALTO client to gracefully shut down an update stream.

When an update stream server creates a new update stream, and if the update stream server supports stream control for the update stream, the update stream server creates a stream control service for that update stream. An ALTO client uses the stream control service to remove resources from the update stream instance, or to request updates for additional resources. An ALTO client cannot obtain the stream control service through the IRD. Instead, the first event that the update stream server sends to the ALTO client has the URI for the associated stream control service (see [Section 6.3](#)).



Each stream control request is an individual HTTP request. If the ALTO client and the stream control server the ALTO client MAY send multiple stream control requests to the stream control server using the same HTTP connection.

### **8.1. URI**

The URI for an stream control service, by itself, MUST uniquely specify the update stream instance which it controls. The stream control server MUST NOT use other properties of an HTTP request, such as cookies or the client's IP address, to determine the update stream. Furthermore, an update stream server MUST NOT reuse a control service URI once the associated update stream has been closed.

The ALTO client MUST evaluate a non-absolute control URI (for example, a URI without a host, or with a relative path) in the context of the URI used to create the update stream. The stream control service's host MAY be different from the update stream's host.

It is expected that the update stream server will assign a unique stream id to each update stream instance and will embed that id in the associated stream control URI. However, the exact mechanism is left to the update stream server. ALTO clients MUST NOT attempt to deduce a stream id from the control URI.

To prevent an attacker from forging a stream control URI and sending bogus requests to disrupt other update streams, stream control URIs SHOULD contain sufficient random redundancy to make it difficult to guess valid URIs.

### **8.2. Media Type**

An ALTO stream control response does not have a specific media type.

### **8.3. HTTP Method**

An ALTO update stream control resource is requested using the HTTP POST method.

### **8.4. Accept Input Parameters**

An stream control service accepts the same input media type and input parameters as the update stream service ([Section 7.3](#)). The only difference is that a stream control service also accepts the "remove" field.





If specified, the "remove" field is an array of client-ids the ALTO client previously added to this update stream. An empty "remove" array is equivalent to a list of all currently active resources; the update stream server responds by removing all resources and closing the stream.

An ALTO client MAY use the "add" field to add additional resources. However, the ALTO client MUST assign a unique client-id to each resource. Client-ids MUST be unique over the lifetime of this update stream: an ALTO client MUST NOT reuse a previously removed client-id.

If a request has any errors, the update stream server MUST NOT add or remove any resources from the associated update stream. Also, the stream control server will return an error response to the client as specified in [Section 8.6](#).

### **8.5. Capabilities & Uses**

None (Stream control services do not appear in the IRD).

### **8.6. Response**

The stream control server MUST process the "add" field before the "remove" field. If the request removes all active resources without adding any additional resources, the update stream server MUST close the update stream. Thus an update stream cannot have zero resources.

If the request has any errors, the stream control server MUST return an HTTP "400 Bad Request" to the ALTO client. The body part of the HTTP response is the JSON object defined in [Section 8.5.2 in \[RFC7285\]](#). An error response has the same format as specified in [Section 7.6](#). Detailed error code and error information are specified as below.

- o If the "add" request does not satisfy the requirements in [Section 7.3](#), the stream control server MUST return the ALTO error message defined in [Section 7.6](#).
- o If any client-id in the "remove" field was not added in a prior request, the error code of the error message MUST be `E_INVALID_FIELD_VALUE`; the "field" field SHOULD be "remove" and the "value" field SHOULD be the array of the invalid client-ids. Thus it is illegal to "add" and "remove" the same client-id in the same request. However, it is legal to remove a client-id twice.
- o If any client-id in the "add" field has been used before in this stream, the error code of the error message MUST be



E\_INVALID\_FIELD\_VALUE, the "field" field SHOULD be "add" and the "value" field SHOULD be the array of invalid client-ids.

- o If the request has a non-empty "add" field and a "remove" field with an empty list of client-ids (to replace all active resources with a new set, the client MUST explicitly enumerate the client-ids to be removed), the error code of the error message MUST be E\_INVALID\_FIELD\_VALUE; the "field" field SHOULD be "remove" and the "value" field SHOULD be an empty array.

If the request is valid but the associated update stream has been closed. The stream control server MUST return an HTTP "404 Not Found".

If the request is valid and the stream control server successfully processes the request without error, the stream control server should return either an HTTP "202 Accepted" response or an HTTP "204 No Content" response. The difference is that for the latter case, the stream control server is sure that the update stream server has also processed the request. Regardless of 202 or 204 HTTP response, the final updates of related resources will be notified by the update stream server using its control update message(s), due to our modular design.

## **9. Examples**

### **9.1. Example: IRD Announcing Update Stream Services**

Below is an example IRD announcing two update stream services. The first, which is named "update-my-costs", provides updates for the network map, the "routingcost" and "hopcount" cost maps, and a filtered cost map resource. The second, which is named "update-my-prop", provides updates to the endpoint properties service.

Note that in the "update-my-costs" update stream shown in the example IRD, the update stream server uses JSON patch for network map, and it uses JSON merge patch to update the other resources. Also, the update stream will only provide full replacements for "my-simple-filtered-cost-map".

Also, note that this IRD defines two filtered cost map resources. They use the same cost types, but "my-filtered-cost-map" accepts cost constraint tests, while "my-simple-filtered-cost-map" does not. To avoid the issues discussed in [Section 10.4](#), the update stream provides updates for the second, but not the first.

```
"my-network-map": {  
  "uri": "http://alto.example.com/networkmap",
```



```
    "media-type": "application/alto-networkmap+json",
  },
  "my-routingcost-map": {
    "uri": "http://alto.example.com/costmap/routingcost",
    "media-type": "application/alto-costmap+json",
    "uses": ["my-networkmap"],
    "capabilities": {
      "cost-type-names": ["num-routingcost"]
    }
  },
  "my-hopcount-map": {
    "uri": "http://alto.example.com/costmap/hopcount",
    "media-type": "application/alto-costmap+json",
    "uses": ["my-networkmap"],
    "capabilities": {
      "cost-type-names": ["num-hopcount"]
    }
  },
  "my-filtered-cost-map": {
    "uri": "http://alto.example.com/costmap/filtered/constraints",
    "media-type": "application/alto-costmap+json",
    "accepts": "application/alto-costmapfilter+json",
    "uses": ["my-networkmap"],
    "capabilities": {
      "cost-type-names": ["num-routingcost", "num-hopcount"],
      "cost-constraints": true
    }
  },
  "my-simple-filtered-cost-map": {
    "uri": "http://alto.example.com/costmap/filtered/simple",
    "media-type": "application/alto-costmap+json",
    "accepts": "application/alto-costmapfilter+json",
    "uses": ["my-networkmap"],
    "capabilities": {
      "cost-type-names": ["num-routingcost", "num-hopcount"],
      "cost-constraints": false
    }
  },
  "my-props": {
    "uri": "http://alto.example.com/properties",
    "media-type": "application/alto-endpointprops+json",
    "accepts": "application/alto-endpointpropparams+json",
    "capabilities": {
      "prop-types": ["priv:ietf-bandwidth"]
    }
  },
  "update-my-costs": {
    "uri": "http://alto.example.com/updates/costs",
```



```
"media-type": "text/event-stream",
"accepts": "application/alto-updatestreamparams+json",
"uses": [
  "my-network-map",
  "my-routingcost-map",
  "my-hopcount-map",
  "my-simple-filtered-cost-map"
],
"capabilities": {
  "incremental-change-media-types": {
    "my-network-map": "application/json-patch+json",
    "my-routingcost-map": "application/merge-patch+json",
    "my-hopcount-map": "application/merge-patch+json"
  },
  "support-stream-control": true
}
},
"update-my-props": {
  "uri": "http://alto.example.com/updates/properties",
  "media-type": "text/event-stream",
  "uses": [ "my-props" ],
  "accepts": "application/alto-updatestreamparams+json",
  "capabilities": {
    "incremental-change-media-types": {
      "my-props": "application/merge-patch+json"
    },
    "support-stream-control": true
  }
}
}
```

### **9.2. Example: Simple Network and Cost Map Updates**

Given the update streams announced in the preceding example IRD, below we show an example of an ALTO client's request and the update stream server's immediate response, using the update stream resource "update-my-costs". In the example, the ALTO client requests updates for the network map and "routingcost" cost map, but not for the "hopcount" cost map. The ALTO client uses the ALTO server's resource-ids as the client-ids. Because the client does not provide a "tag" for the network map, the update stream server must send a full replacement for the network map as well as for the cost map. The ALTO client does not set "incremental-changes" to "false", so it defaults to "true". Thus, the update stream server will send patch updates for the cost map and the network map.





```
POST /updates/costs HTTP/1.1
Host: alto.example.com
Accept: text/event-stream,application/alto-error+json
Content-Type: application/alto-updatestreamparams+json
Content-Length: ###
```

```
{ "add": {
  "my-network-map": {
    "resource-id": "my-network-map"
  },
  "my-routingcost-map": {
    "resource-id": "my-routingcost-map"
  }
}
```

```
HTTP/1.1 200 OK
Connection: keep-alive
Content-Type: text/event-stream
```

```
event: application/alto-updatestreamcontrol+json
data: {"control-uri":
data: "http://alto.example.com/updates/streams/3141592653589"}
```

```
event: application/alto-networkmap+json,my-network-map
data: {
data:   "meta" : {
data:     "vtag": {
data:       "resource-id" : "my-network-map",
data:       "tag" : "da65eca2eb7a10ce8b059740b0b2e3f8eb1d4785"
data:     }
data:   },
data:   "network-map" : {
data:     "PID1" : {
data:       "ipv4" : [ "192.0.2.0/24", "198.51.100.0/25" ]
data:     },
data:     "PID2" : {
data:       "ipv4" : [ "198.51.100.128/25" ]
data:     },
data:     "PID3" : {
data:       "ipv4" : [ "0.0.0.0/0" ],
data:       "ipv6" : [ "::/0" ]
data:     }
data:   }
data: }
data: }
```

```
event: application/alto-costmap+json,my-routingcost-map
```



```

data: {
data:   "meta" : {
data:     "dependent-vtags" : [{
data:       "resource-id": "my-network-map",
data:       "tag": "da65eca2eb7a10ce8b059740b0b2e3f8eb1d4785"
data:     }],
data:     "cost-type" : {
data:       "cost-mode" : "numerical",
data:       "cost-metric": "routingcost"
data:     },
data:     "vtag": {
data:       "resource-id" : "my-routingcost-map",
data:       "tag" : "3ee2cb7e8d63d9fab71b9b34cbf764436315542e"
data:     }
data:   },
data:   "cost-map" : {
data:     "PID1": { "PID1": 1, "PID2": 5, "PID3": 10 },
data:     "PID2": { "PID1": 5, "PID2": 1, "PID3": 15 },
data:     "PID3": { "PID1": 20, "PID2": 15 }
data:   }
data: }

```

After sending those events immediately, the update stream server will send additional events as the maps change. For example, the following represents a small change to the cost map. PID1->PID2 is changed to 9 from 5, PID3->PID1 is no longer available and PID3->PID3 is now defined as 1:

```

event: application/merge-patch+json,my-routingcost-map
data: {
data:   "meta" : {
data:     "vtag": {
data:       "tag": "c0ce023b8678a7b9ec00324673b98e54656d1f6d"
data:     }
data:   },
data:   "cost-map": {
data:     "PID1" : { "PID2" : 9 },
data:     "PID3" : { "PID1" : null, "PID3" : 1 }
data:   }
data: }

```

As another example, the following represents a change to the network map: an ipv4 prefix "193.51.100.0/25" is added to PID1. It triggers changes to the cost map. The update stream server chooses to send an incremental change for the network map and send a full replacement instead of an incremental change for the cost map:



```
event: application/json-patch+json,my-network-map
data: {
  data: {
    data: {
      data: "op": "replace",
      data: "path": "/meta/vtag/tag",
      data: "value" : "a10ce8b059740b0b2e3f8eb1d4785acd42231bfe"
    data: },
    data: {
      data: "op": "add",
      data: "path": "/network-map/PID1/ipv4/2",
      data: "value": "193.51.100.0/25"
    data: }
  data: }

event: application/alto-costmap+json,my-routingcost-map
data: {
  data: "meta" : {
    data: "vtag": {
      data: "tag": "c0ce023b8678a7b9ec00324673b98e54656d1f6d"
    data: }
  data: },
  data: "cost-map" : {
    data: "PID1": { "PID1": 1, "PID2": 3, "PID3": 7 },
    data: "PID2": { "PID1": 12, "PID2": 1, "PID3": 9 },
    data: "PID3": { "PID1": 14, "PID2": 8 }
  data: }
data: }
```

### [9.3.](#) Example: Advanced Network and Cost Map Updates

This example is similar to the previous one, except that the ALTO client requests updates for the "hopcount" cost map as well as the "routingcost" cost map and provides the current version tag of the network map, so the update stream server is not required to send the full network map data update message at the beginning of the stream. In this example, the client uses the client-ids "net", "routing" and "hops" for those resources. The update stream server sends the stream control URI and the full cost maps, followed by updates for the network map and cost maps as they become available:



```
POST /updates/costs HTTP/1.1
Host: alto.example.com
Accept: text/event-stream,application/alto-error+json
Content-Type: application/alto-updatestreamparams+json
Content-Length: ###
```

```
{ "add": {
  "net": {
    "resource-id": "my-network-map".
    "tag": "a10ce8b059740b0b2e3f8eb1d4785acd42231bfe"
  },
  "routing": {
    "resource-id": "my-routingcost-map"
  },
  "hops": {
    "resource-id": "my-hopcount-map"
  }
}
```

```
HTTP/1.1 200 OK
Connection: keep-alive
Content-Type: text/event-stream
```

```
event: application/alto-updatestreamcontrol+json
data: {"control-uri":
data: "http://alto.example.com/updates/streams/2718281828459"}
```

```
event: application/alto-costmap+json,routing
data: { ... full routingcost cost map message ... }
```

```
event: application/alto-costmap+json,hops
data: { ... full hopcount cost map message ... }
```

(pause)

```
event: application/merge-patch+json,routing
data: {"cost-map": {"PID2" : {"PID3" : 31}}}
```

```
event: application/merge-patch+json,hops
data: {"cost-map": {"PID2" : {"PID3" : 4}}}
```

If the ALTO client wishes to stop receiving updates for the "hopcount" cost map, the ALTO client can send a "remove" request on the stream control URI:





```
POST /updates/streams/2718281828459" HTTP/1.1
Host: alto.example.com
Accept: text/plain,application/alto-error+json
Content-Type: application/alto-updatestreamparams+json
Content-Length: ###
```

```
{
  "remove": [ "hops" ]
}
```

```
HTTP/1.1 204 No Content
Content-Length: 0
```

(stream closed without sending data content)

The update stream server sends a "stopped" control update message on the original request stream to inform the ALTO client that updates are stopped for that resource:

```
event: application/alto-updatestreamcontrol+json
data: {
data:   "stopped": ["hops"]
data: }
```

Below is an example of an invalid stream control request. The "remove" field of the request includes an undefined client-id and the stream control server will return an error response to the ALTO client.



```
POST /updates/streams/2718281828459 HTTP/1.1
Host: alto.example.com
Accept: text/plain,application/alto-error+json
Content-Type: application/alto-updatestreamparams+json
Content-Length: ###
{
  "remove": [ "properties" ]
}

HTTP/1.1 400 Bad Request
Content-Length: [TBD]
Content-Type: application/alto-error+json

{
  "meta":{
    "code": "E_INVALID_FIELD_VALUE",
    "field": "remove",
    "value": "properties"
  }
}
```

If the ALTO client no longer needs any updates, and wishes to shut the update stream down gracefully, the client can send a "remove" request with an empty array:

```
POST /updates/streams/2718281828459 HTTP/1.1
Host: alto.example.com
Accept: text/plain,application/alto-error+json
Content-Type: application/alto-updatestreamparams+json
Content-Length: ###

{
  "remove": [ ]
}

HTTP/1.1 204 No Content
Content-Length: 0
```

(stream closed without sending data content)

The update stream server sends a final control update message on the original request stream to inform the ALTO client that all updates are stopped and then closes the stream:



```
event: application/alto-updatestreamcontrol+json
data: {
  data:  "stopped": ["net", "routing"]
  data: }
```

(server closes stream)

#### **9.4. Example: Endpoint Property Updates**

As another example, here is how an ALTO client can request updates for the property "priv:ietf-bandwidth" for one set of endpoints and "priv:ietf-load" for another. The update stream server immediately sends full replacements with the property values for all endpoints. After that, the update stream server sends data update messages for the individual endpoints as their property values change.

```
POST /updates/properties HTTP/1.1
Host: alto.example.com
Accept: text/event-stream
Content-Type: application/alto-updatestreamparams+json
Content-Length: ###
```

```
{ "add": {
  "props-1": {
    "resource-id": "my-props",
    "input": {
      "properties" : [ "priv:ietf-bandwidth" ],
      "endpoints" : [
        "ipv4:198.51.100.1",
        "ipv4:198.51.100.2",
        "ipv4:198.51.100.3"
      ]
    }
  },
  "props-2": {
    "resource-id": "my-props",
    "input": {
      "properties" : [ "priv:ietf-load" ],
      "endpoints" : [
        "ipv6:2001:db8:100::1",
        "ipv6:2001:db8:100::2",
        "ipv6:2001:db8:100::3",
      ]
    }
  },
}
```



HTTP/1.1 200 OK

Connection: keep-alive

Content-Type: text/event-stream

event: application/alto-updatestreamcontrol+json

data: {"control-uri":

data: "http://alto.example.com/updates/streams/1414213562373"}

event: application/alto-endpointprops+json,props-1

data: { "endpoint-properties": {

data:     "ipv4:198.51.100.1" : { "priv:ietf-bandwidth": "13" },

data:     "ipv4:198.51.100.2" : { "priv:ietf-bandwidth": "42" },

data:     "ipv4:198.51.100.3" : { "priv:ietf-bandwidth": "27" } }

data: } }

event: application/alto-endpointprops+json,props-2

data: { "endpoints": {

data:     "ipv6:2001:db8:100::1" : { "priv:ietf-load": "8" },

data:     "ipv6:2001:db8:100::2" : { "priv:ietf-load": "2" },

data:     "ipv6:2001:db8:100::3" : { "priv:ietf-load": "9" } }

data: } }

(pause)

event: application/merge-patch+json,props-1

data: { "endpoint-properties":

data:     {"ipv4:198.51.100.1" : {"priv:ietf-bandwidth": "3"}}}

data: }

(pause)

event: application/merge-patch+json,props-2

data: { "endpoints":

data:     {"ipv6:2001:db8:100::3" : {"priv:ietf-load": "7"}}}

data: }

If the ALTO client needs the "bandwidth" property for additional endpoints, the ALTO client can send an "add" request on the stream control URI:





```
POST /updates/streams/1414213562373" HTTP/1.1
Host: alto.example.com
Accept: text/plain,application/alto-error+json
Content-Type: application/alto-updatestreamparams+json
Content-Length: ###
```

```
{ "add": {
  "props-3": {
    "resource-id": "my-props",
    "input": {
      "properties" : [ "priv:ietf-bandwidth" ],
      "endpoints" : [
        "ipv4:198.51.100.4",
        "ipv4:198.51.100.5",
      ]
    }
  },
  "props-4": {
    "resource-id": "my-props",
    "input": {
      "properties" : [ "priv:ietf-load" ],
      "endpoints" : [
        "ipv6:2001:db8:100::4",
        "ipv6:2001:db8:100::5",
      ]
    }
  },
}
}
```

```
HTTP/1.1 204 No Content
Content-Length: 0
```

(stream closed without sending data content)

The update stream server sends full replacements for the two new resources, followed by incremental changes for all four requests as they arrive:



```
event: application/alto-endpointprops+json,props-3
data: { "endpoint-properties": {
data:   "ipv4:198.51.100.4" : { "priv:ietf-bandwidth": "25" },
data:   "ipv4:198.51.100.5" : { "priv:ietf-bandwidth": "31" },
data: } }
```

```
event: application/alto-endpointprops+json,props-4
data: { "endpoint-properties": {
data:   "ipv6:2001:db8:100::4" : { "priv:ietf-load": "6" },
data:   "ipv6:2001:db8:100::5" : { "priv:ietf-load": "4" },
data: } }
```

(pause)

```
event: application/merge-patch+json,props-3
data: { "endpoint-properties":
data:   {"ipv4:198.51.100.5" : {"priv:ietf-bandwidth": "15"}}
data: }
```

(pause)

```
event: application/merge-patch+json,props-2
data: { "endpoint-properties":
data:   {"ipv6:2001:db8:100::2" : {"priv:ietf-load": "9"}}
data: }
```

(pause)

```
event: application/merge-patch+json,props-4
data: { "endpoint-properties":
data:   {"ipv6:2001:db8:100::4" : {"priv:ietf-load": "3"}}
data: }
```

## **10. Operation and Processing Considerations**

### **10.1. Considerations for Choosing SSE Line Lengths**

SSE was designed for events that consist of relatively small amounts of line-oriented text data, and SSE clients frequently read input one line-at-a-time. However, an update stream sends full cost maps as single events, and a cost map may involve megabytes, if not tens of megabytes, of text. This has implications for both the update stream server and the ALTO Client.

First, SSE clients might not be able to handle a multi-megabyte data "line". Hence it is RECOMMENDED that an update stream server limit data lines to at most 2,000 characters.



Second, some SSE client packages read all the data for an event into memory, and then present it to the client as a single character array. However, a client computer may not have enough memory to hold the entire JSON text for a large cost map. Hence an ALTO client SHOULD consider using an SSE library which presents the event data in manageable chunks, so the ALTO client can parse the cost map incrementally and store the underlying data in a more compact format.

## **10.2. Considerations for Choosing Data Update Messages**

The choice on data update messages depends on both how frequently the resources will change, and how extensive those changes will be. For stable resources with minor changes, the update stream server may choose to send incremental changes; for resources that frequently change, the update stream server may choose to send a full replacement after a while. Whether to send full replacement or incremental change depends on the update stream server.

For incremental updates, we allow both JSON patch and JSON merge patch for incremental changes. JSON merge patch is clearly superior to JSON patch for describing incremental changes to Cost Maps, Endpoint Costs, and Endpoint Properties. For these data structures, JSON merge patch is more space-efficient, as well as simpler to apply; we see no advantage to allowing a server to use JSON patch for those resources.

The case is not as clear for incremental changes to network maps.

First, consider small changes such as moving a prefix from one PID to another. JSON patch could encode that as a simple insertion and deletion, while JSON merge patch would have to replace the entire array of prefixes for both PIDs. On the other hand, to process a JSON patch update, the ALTO client would have to retain the indexes of the prefixes for each PID. Logically, the prefixes in a PID are an unordered set, not an array; aside from handling updates, a client has no need to retain the array indexes of the prefixes. Hence to take advantage of JSON patch for network maps, ALTO clients would have to retain additional, otherwise unnecessary, data.

Second, consider more involved changes such as removing half of the prefixes from a PID. JSON merge patch would send a new array for that PID, while JSON patch would have to send a list of remove operations and delete the prefix one by one.

Therefore, each update stream server may decide on its own whether to use JSON merge patch or JSON patch according to the changes in network maps.



Other JSON-based incremental change formats may be introduced in the future.

### **10.3. Considerations for Client Processing Data Update Messages**

In general, when an ALTO client receives a full replacement for a resource, the ALTO client should replace the current version with the new version. When an ALTO client receives an incremental change for a resource, the ALTO client should apply those patches to the current version of the resource.

However, because resources can depend on other resources (e.g., cost maps depend on network maps), an ALTO client **MUST NOT** use a dependent resource if the resource on which it depends has changed. There are at least two ways an ALTO client can do that. We will illustrate these techniques by referring to network and cost map messages, although these techniques apply to any dependent resources.

Note that when a network map changes, the update stream server **MUST** send the network map update message before sending the updates for the dependent cost maps (see [Section 7.7.1](#)).

One approach is for the ALTO client to save the network map update message in a buffer and continue to use the previous network map, and the associated cost maps, until the ALTO client receives the update messages for all dependent cost maps. The ALTO client then applies all network and cost map updates atomically.

Alternatively, the ALTO client **MAY** update the network map immediately. In this case, the ALTO client **MUST** mark each dependent cost map as temporarily invalid and **MUST NOT** use that map until the ALTO client receives a cost map update message with the new network map version tag. Note that the ALTO client **MUST NOT** delete the cost maps, because the update stream server may send incremental changes.

The update stream server **SHOULD** send updates for dependent resources in a timely fashion. However, if the ALTO client does not receive the expected updates, the ALTO client **MUST** close the update stream connection, discard the dependent resources, and reestablish the update stream. The ALTO client **MAY** retain the version tag of the last version of any tagged resources and give those version tags when requesting the new update stream. In this case, if a version is still current, the update stream server will not re-send that resource.

Although not as efficient as possible, this recovery method is simple and reliable.





#### **10.4. Considerations for Updates to Filtered Cost Maps**

If an update stream provides updates to a Filtered cost map which allows constraint tests, then an ALTO client MAY request updates to a Filtered cost map request with a constraint test. In this case, when a cost changes, the update stream server MUST send an update if the new value satisfies the test. If the new value does not, whether the update stream server sends an update depends on whether the previous value satisfied the test. If it did not, the update stream server SHOULD NOT send an update to the ALTO client. But if the previous value did, then the update stream server MUST send an update with a "null" value, to inform the ALTO client that this cost no longer satisfies the criteria.

An update stream server can avoid such issues by offering update streams only for filtered cost maps which do not allow constraint tests.

#### **10.5. Considerations for Updates to Ordinal Mode Costs**

For an ordinal mode cost map, a change to a single cost point may require updating many other costs. As an extreme example, suppose the lowest cost changes to the highest cost. For a numerical mode cost map, only that one cost changes. But for an ordinal mode cost map, every cost might change. While this document allows an update stream server to offer incremental updates for ordinal mode cost maps, update stream server implementors should be aware that incremental updates for ordinal costs are more complicated than for numerical costs, and ALTO clients should be aware that small changes may result in large updates.

An update stream server can avoid this complication by only offering full replacements for ordinal cost maps.

### **11. Alternative Designs Not Supported**

#### **11.1. Why Not HTTP/2 Server-Push**

HTTP/2 ([RFC7540]) provides a Server Push facility. Although the name implies that it might be useful for sending asynchronous updates from the update stream server to the client, in reality Server Push is not well suited for that task. To see why it is not, here is a quick summary of HTTP/2.

HTTP/2 allows an client and a server to multiplex many HTTP requests and responses over a single TCP connection. The requests and responses can be interleaved on a block by block basis, avoiding the head-of-line blocking problem encountered with the Keep-Alive



mechanism in HTTP/1.1. Server Push allows a server to send a resource (an image, a CSS file, a javascript file, etc.) to the client before the client explicitly requests it. A server can only push cacheable GET-mode resources. By pushing a resource, the server implicitly tells the client, "Add this resource to your cache, because a resource you have requested needs it."

One approach for using Server Push for updates is for the update stream server to send each data update message as a separate Server Push item and let the client apply those updates as they arrive. Unfortunately, there are several problems with that approach.

First, HTTP/2 does not guarantee that pushed resources are delivered to the client in the order they were sent by the client, so each data update message would need a sequence number, and the client would have to re-sequence them.

Second, an HTTP/2-aware client library will not necessarily inform a client application when the server pushes a resource. Instead, the library might cache the pushed resource, and only deliver it to the client when the client explicitly requests that URI.

But the third problem is the most significant: Server Push is optional and can be disabled by any proxy between the client and the server. This is not a problem for the intended use of Server Push: eventually the client will request those resources, so disabling Server Push just adds a delay. But this means that Server Push is not suitable for resources which the client does not know to request.

Thus we do not believe HTTP/2 Server Push is suitable for delivering asynchronous updates. Hence we have chosen to base ALTO updates on HTTP/1.1 and SSE.

### **11.2. Why Not Allowing Stream Restart**

If an update stream is closed accidentally, when the ALTO client reconnects, the update stream server must resend the full maps. This is clearly inefficient. To avoid that inefficiency, the SSE specification allows an update stream server to assign an id to each event. When an ALTO client reconnects, the ALTO client can present the id of the last successfully received event, and the update stream server restarts with the next event.

However, that mechanism adds additional complexity. The update stream server must save SSE messages in a buffer, in case ALTO clients reconnect. But that mechanism will never be perfect: if the ALTO client waits too long to reconnect, or if the ALTO client sends



an invalid id, then the update stream server will have to resend the complete maps anyway.

Furthermore, this is unlikely to be a problem in practice. ALTO clients who want continuous updates for large resources, such as full Network and cost maps, are likely to be things like P2P trackers. These ALTO clients will be well connected to the network; they will rarely drop connections.

Mobile devices certainly can and do drop connections and will have to reconnect. But mobile devices will not need continuous updates for multi-megabyte cost maps. If mobile devices need continuous updates at all, they will need them for small queries, such as the costs from a small set of media servers from which the device can stream the currently playing movie. If the mobile device drops the connection and reestablishes the update stream, the update stream server will have to retransmit only a small amount of redundant data.

In short, using event ids to avoid resending the full map adds a considerable amount of complexity to avoid a situation which we expect is very rare. We believe that complexity is not worth the benefit.

The Update Stream service does allow the ALTO client to specify the tag of the last received version of any tagged resource, and if that is still current, the update stream server need not retransmit the full resource. Hence ALTO clients can use this to avoid retransmitting full network maps. cost maps are not tagged, so this will not work for them. Of course, the ALTO protocol could be extended by adding version tags to cost maps, which would solve the retransmission-on-reconnect problem. However, adding tags to cost maps might add a new set of complications.

## **12. Security Considerations**

As an extension of the base ALTO protocol [[RFC7285](#)], this document fits into the architecture of the base protocol, and hence the Security Considerations ([Section 15](#)) of the base protocol fully apply when this extension is provided by an ALTO server. For example, the same authenticity and integrity considerations ([Section 15.1 of \[RFC7285\]](#)) still fully apply; the same considerations for the privacy of ALTO users ([Section 15.4 of \[RFC7285\]](#)) also still fully apply.

The addition of update streams and stream control can introduce additional risks which we discuss below.



### **12.1. Update Stream Server: Denial-of-Service Attacks**

Allowing persistent update stream connections enables a new class of Denial-of-Service attacks.

For the update stream server, an ALTO client might create an unreasonable number of update stream connections, or add an unreasonable number of client-ids to one update stream.

To avoid these attacks on the update stream server, the server MAY choose to limit the number of active streams and reject new requests when that threshold is reached. An update stream server MAY also choose to limit the number of active client-ids on any given stream, or limit the total number of client-ids used over the lifetime of a stream, and reject any stream control request which would exceed those limits. In these cases, the update stream server SHOULD return the HTTP status "503 Service Unavailable".

While the preceding techniques prevent update stream DoS attacks from disrupting an update stream server's other services, it does make it easier for a DoS attack to disrupt the update stream service.

Therefore an update stream server may prefer to restrict update stream services to authorized clients, as discussed in [Section 15 of \[RFC7285\]](#).

Alternatively, an update stream server MAY return the HTTP status "307 Temporary Redirect" to redirect the client to another ALTO server which can better handle a large number of update streams.

### **12.2. ALTO Client: Update Overloading or Instability**

The availability of continuous updates can also cause overload for an ALTO client, in particular an ALTO client with limited processing capabilities. The current design does not include any flow control mechanisms for the client to reduce the update rates from the server. Under overloading, the client may choose to remove the information resources with high update rates.

Also, under overloading, the client may no longer be able to detect whether an information is still fresh or has become stale. In such a case, the client should be careful in how it uses the information to avoid stability or efficiency issues.

### **12.3. Stream Control: Spoofed Control Requests**

An outside party which can read the update stream response, or which can observe stream control requests, can obtain the control URI and use that to send a fraudulent "remove" requests, thus disabling





updates for the valid ALTO client. This can be avoided by encrypting the update stream and stream control requests (see [Section 15 of \[RFC7285\]](#)). Also, the update stream server echoes the "remove" requests on the update stream, so the valid ALTO client can detect unauthorized requests.

### **13. Requirements on Future ALTO Services to Use this Design**

Although this design is quite flexible, it has underlying requirements.

At the high level, the key requirements are that (1) each data update message is for a single resource; (2) incremental changes can be applied only to a resource that is a single JSON object, as both JSON merge patch and JSON patch can apply only to a single JSON object. Hence, if a future ALTO resource can contain multiple objects, then either each individual object also has a resource-id or an extension to this design is made.

Since the low level encoding level, new line in SSE has its own semantics. Hence, the requirement is that the encoding does not include new line that can confuse with SSE encoding. In particular, the data update message MUST NOT include "event: " or "data: " at a new line as part of data message.

If an update stream provides updates to a filtered cost map that allows constraint tests, the requirements for such services are stated in [Section 10.4](#).

### **14. IANA Considerations**

This document defines two new media-types, "application/alto-updatestreamparams+json", as described in [Section 7.3](#), and "application/alto-updatestreamcontrol+json", as described in [Section 6.3](#). All other media-types used in this document have already been registered, either for ALTO, JSON merge patch, or JSON patch.

Type name: application

Subtype name: alto-updatestreamparams+json

Required parameters: n/a

Optional parameters: n/a



Encoding considerations: Encoding considerations are identical to those specified for the "application/json" media type. See [\[RFC7159\]](#).

Security considerations: Security considerations relating to the generation and consumption of ALTO Protocol messages are discussed in [Section 12](#) of this document and [Section 15 of \[RFC7285\]](#).

Interoperability considerations: This document specifies format of conforming messages and the interpretation thereof.

Published specification: [Section 7.3](#) of this document.

Applications that use this media type: ALTO servers and ALTO clients either stand alone or are embedded within other applications.

Additional information:

Magic number(s): n/a

File extension(s): This document uses the mime type to refer to protocol messages and thus does not require a file extension.

Macintosh file type code(s): n/a

Person & email address to contact for further information: See Authors' Addresses section.

Intended usage: COMMON

Restrictions on usage: n/a

Author: See Authors' Addresses section.

Change controller: Internet Engineering Task Force (<mailto:iesg@ietf.org>).

Type name: application

Subtype name: alto-updatestreamcontrol+json

Required parameters: n/a

Optional parameters: n/a

Encoding considerations: Encoding considerations are identical to those specified for the "application/json" media type. See [\[RFC7159\]](#).



Security considerations: Security considerations relating to the generation and consumption of ALTO Protocol messages are discussed in [Section 12](#) of this document and [Section 15 of \[RFC7285\]](#).

Interoperability considerations: This document specifies format of conforming messages and the interpretation thereof.

Published specification: [Section 6.3](#) of this document.

Applications that use this media type: ALTO servers and ALTO clients either stand alone or are embedded within other applications.

Additional information:

Magic number(s): n/a

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Macintosh file type code(s): n/a

Person & email address to contact for further information: See Authors' Addresses section.

Intended usage: COMMON

Restrictions on usage: n/a

Author: See Authors' Addresses section.

Change controller: Internet Engineering Task Force  
(mailto:iesg@ietf.org).

## **[15.](#) Acknowledgments**

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#### Authors' Addresses

Wendy Roome  
Nokia Bell Labs (Retired)  
124 Burlington Rd  
Murray Hill, NJ 07974  
USA

Phone: +1-908-464-6975  
Email: [wendy@wdroome.com](mailto:wendy@wdroome.com)





Y. Richard Yang  
Tongji/Yale University  
51 Prospect St  
New Haven CT  
USA

Email: yang.r.yang@gmail.com

Shiwei Dawn Chen  
Tongji University  
4800 Caoan Road  
Shanghai 201804  
China

Email: dawn\_chen\_f@hotmail.com

