

Network Working Group
Internet-Draft
Intended status: Standards Track
Expires: January 7, 2016

S. Randriamasy
Alcatel-Lucent Bell Labs
R. Yang
Yale University
Q. Wu
Huawei
L. Deng
China Mobile
N. Schwan
Thales Deutschland
July 6, 2015

ALTO Cost Calendar
draft-randriamasy-alto-cost-calendar-04

Abstract

The goal of Application-Layer Traffic Optimization (ALTO) is to bridge the gap between network and applications by provisioning network related information in order to allow applications to make informed decisions. The present draft extends the ALTO cost information so as to broaden the decision possibilities of applications to not only decide 'where' to connect to, but also 'when'. This is useful to applications that need to schedule their data transfers and connections and have a degree of freedom to do so. ALTO guidance to schedule application traffic can also efficiently help for load balancing and resources efficiency. Besides, the ALTO Cost Calendar also allows to schedule the ALTO requests themselves and thus save a number of ALTO transactions.

The draft proposes new capabilities and attributes on filtered cost maps and endpoint costs enabling an ALTO Server to provide "Cost Calendars". These capabilities are applicable to time-sensitive ALTO metrics. With ALTO Cost Calendars, an ALTO Server exposes ALTO Cost Values in JSON arrays where each value corresponds to a given time interval. The time intervals as well as other Calendar attributes are specified in the IRD and ALTO Server responses.

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].

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 January 7, 2016.

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 the Trust Legal Provisions and are provided without warranty as described in the Simplified BSD License.

Table of Contents

1. Introduction	3
2. Overview of ALTO Cost Calendars	5
2.1. ALTO Cost Calendar information features	5
2.2. ALTO Calendar design characteristics	6
2.2.1. ALTO Cost Calendar for all cost modes	7
2.2.2. Compatibility with legacy ALTO Clients	7
3. ALTO Calendar specification: IRD extensions	8
3.1. Calendar attributes in the IRD resources capabilities . .	8
3.2. Calendars in a delegate IRD	10
3.3. Example IRD with ALTO Cost Calendars	10
4. ALTO Calendar specification: Service Information Resources .	14
4.1. Calendar extensions for Filtered Cost Maps	14
4.1.1. Calendar extensions in Filtered cost map requests . .	15
4.1.2. Calendar extensions in Filtered Cost map responses .	15

4.1.2.1.	Calendar Start time value for "request-date"	
	calendar start mode	17
4.1.2.2.	Calendar Start time value for "periodic" calendar	
	start mode	17
4.1.3.	Example transaction for a FCM with a "request-date"	
	bandwidth Calendar	18
4.2.	Calendar extensions in the Endpoint Cost Map Service . .	21
4.2.1.	Calendar specific input in Endpoint cost map	
	requests	21
4.2.2.	Calendar attributes in the Endpoint Cost Map	
	responses	21
4.2.3.	Example transaction for the ECS with a "periodic"	
	routingcost Calendar	22
4.2.4.	Example transaction for the ECS with a calendar on	
	both routingcost and latency	25
4.3.	Recap of rules related to ALTO Cost Calendars	27
5.	Use cases for ALTO Cost Schedule	27
5.1.	Bulk Data Transfer scheduling upon bandwidth calendars .	27
5.1.1.	Applicable example transaction	28
5.2.	Applications with limited connectivity or access to	
	datacenters	29
5.2.1.	Applicable example transaction	30
5.3.	SDN Controller guided traffic scheduling with Calendars .	30
5.3.1.	Applicable example transaction	31
6.	IANA Considerations	31
6.1.	Information for IANA on proposed Cost Types	31
6.2.	Information for IANA on proposed Endpoint Properties . .	32
7.	Acknowledgements	32
8.	References	32
8.1.	Normative References	32
8.2.	Informative References	32
	Authors' Addresses	33

1. Introduction

IETF is currently standardizing the ALTO protocol which aims for providing guidance to overlay applications, that need to select one or several hosts from a set of candidates that are able to provide a desired resource. This guidance is based on parameters that affect performance and efficiency of the data transmission between the hosts, e.g., the topological distance. The goal of ALTO is to improve the Quality of Experience (QoE) in the application while simultaneously optimizing resource usage in the underlying network infrastructure.

The ALTO protocol therefore [RFC7285] specifies a Network Map, which defines groupings of endpoints in a network region (called a PID) as seen by the ALTO server. The Cost Maps Service, Endpoint Cost

Service (ECS) and Endpoint Ranking Service then provide rankings for connections between the specified endpoints and network regions and thus incentives for application clients to connect to ISP preferred endpoints, e.g. to reduce costs imposed to the network provider. Thereby ALTO intentionally avoids the provisioning of realtime information as explained in the ALTO Problem Statement [RFC5693] and ALTO Requirements [RFC5693]). Thus the current Cost Map and Endpoint Cost Service are providing, for a given Cost Type, exactly one rating per link between two PIDs or Endpoints. Applications are expected to query one of these two services in order to retrieve the currently valid cost values. They therefore need to plan their ALTO information requests according to their own estimation of frequency of cost value change.

With the base protocol, an ALTO client should interpret the returned costs as those at the query moment. However, Network costs can fluctuate, e.g. due to diurnal patterns of traffic demand or planned events such as network maintenance or holidays or highly publicized events. Providing network costs for only the current time thus may not be sufficient, in particular, for applications that can schedule their traffic in a span of time, for example, by deferring backup to night during traffic trough. Besides, other applications would like to anticipate their connections and transfers to favorable times.

In case these value changes are predicable over a certain period of time and the application does not require immediate data transfer, it can save time to get the whole set of cost values over this period in one ALTO response and using these values to schedule data transfers would allow to optimise the network resources usage and QoE. Moreover a Client can minimize its requests for calendars by scheduling them at appropriate times.

This document extends RFC7285 to allow an ALTO server to provide network costs for a given duration of time. A sequence of network costs across a time span for a given pair of network locations is referred to as an ALTO Cost Calendar. The Filtered Cost Map Service and Endpoint Cost Service are extended to provide Cost Calendars. In addition to this functional ALTO enhancement, we expect to further gain on storage and on the wire data exchange by gathering multiple Cost Values for one Cost Type into one single ALTO Server response.

In this draft an "ALTO Cost Calendar" is specified by information resources capabilities that are applicable to time-sensitive ALTO metrics. An ALTO Cost Calendar exposes ALTO Cost Values in JSON arrays where each value corresponds to a given time interval. The time intervals as well as other Calendar attributes are specified in the IRD and in the Server response and allow the ALTO Client to interpret the received ALTO values. This draft proposes a set of

Calendar attributes to be added to the resources capabilities in the IRD. Last, the proposed extensions for ALTO Calendars are applicable to any Cost Mode and they ensure backwards compatibility with legacy clients.

The rest of this document is organized as follows. Section 2 provides the design characteristics. Section 3 and 4 define the formal specification for the IRD and the information resources. Section 5 provides non-normative use cases to illustrate the usage of cost calendars. IANA considerations and security considerations will be completed in further versions.

2. Overview of ALTO Cost Calendars

An ALTO Cost calendar provided by the ALTO Server provides 2 information items:

- o an array of values for a given metric, where each value corresponds to a time interval, where the value array can sometimes be a cyclic pattern that repeats a certain number of times.
- o attributes describing the time scope of the calendar, allowing an ALTO Client to properly interpret the values, such as the size and number of the intervals and the date of the starting point of the calendar.

An ALTO Cost Calendar can be used like a "time table" to figure out the best time to schedule data transfers and also anticipate predictable events such as flash crowds, traffic intensive holidays and network maintenance. An ALTO Cost Calendar may be viewed as a synthetic abstraction of real measurements that can be historic or be a prediction for upcoming time periods.

Most likely, the ALTO Cost Calendar would be used for the Endpoint Cost Service, assuming that a limited set of feasible Endpoints for a non-real time application is already identified, that they do not need to be accessed immediately and that their access can be scheduled within a given time period. The Filtered Cost Map service is also applicable as long as the size of the Map allows it.

2.1. ALTO Cost Calendar information features

The Calendar attributes are provided in the IRD and in ALTO Server responses. The IRD announces attributes with dateless values in its information resources capabilities, where as attributes with time dependent values are provided in the "meta" of Server responses. The ALTO Cost Calendar attributes provide the following information:

- o attributes to report on Calendar value array:
 - * generic time zone,
 - * applicable time interval for each calendar value: combining numbers and time units to reflect for example: 1 hour, 2 minutes, 10 seconds, 1 week, 1 month,
 - * duration of the Calendar: e.g. the number of intervals provided in the calendar.
- o attributes on time stamps for Calendars: the ALTO Servers chooses and specifies the date at which it starts its calendars, either at the client request date or periodically:
 - * "calendar-start-date": specifying when the calendar starts, that is to which date the first value of the cost calendar is applicable.
- o possible periodicity of the calendar start date: allowing to predict when the next ALTO Calendar should be requested if needed,
 - * "repeat-indication": may be provided when the "calendar-start-date" is periodic, to indicate whether the Server will provide the number of repetitions.
 - * "repeated": is an attribute indicating for how many iterations the provided calendar will have the same values, to allow the client to schedule its next request.

2.2. ALTO Calendar design characteristics

This draft introduces new capabilities and attributes that specify an ALTO Cost Calendar. The protocol extension placeholders are: the IRD, the ALTO requests and responses for Cost calendars.

Extensions are designed to be light and ensure backwards compatibility with base protocol ALTO Clients and with other extensions. It uses section 8.3.7 "Parsing of Unknown Fields" of RFC7285 that writes: "Extensions may include additional fields within JSON objects defined in this document. ALTO implementations MUST ignore unknown fields when processing ALTO messages."

The calendar specific capabilities are integrated in the information resources of the IRD and in the "meta" member of ALTO responses to Cost Calendars requests. A calendar and its capabilities are associated to a given information resource and within this

information resource to a given cost type. This design has several advantages:

- o it does not introduce a new mode,
- o it does not introduce new media types,
- o it allows an ALTO Server to offer calendar capabilities on a cost type, with attributes values adapted to each information resource.

The Applicable Calendared information resources are:

- o the Filtered Cost Map,
- o the Endpoint Cost Map.

The ALTO Server can choose in which frequency it provides cost Calendars to ALTO Clients. It may either provide calendar updates starting at the request date, or carefully schedule its updates so as to take profit from a potential repetition/periodicity of calendar values.

2.2.1. ALTO Cost Calendar for all cost modes

Calendars are well-suited for values encoded in the 'numerical' mode. However, Calendars can also represent any metric considered as time-sensitive by an ALTO Server. For example, types of Cost values such as JSONBool can also be expressed as calendars, as states may be "true" or "false" depending on given time periods or likewise, values represented by strings, such as "medium", "high", "low", "blue", "open" .

Note also that a Calendar is applicable as well to time-sensitive metrics provided in the 'ordinal' mode, if these values are time-sensitive and their update is carefully managed by the ALTO Server.

2.2.2. Compatibility with legacy ALTO Clients

The ALTO protocol extensions for Cost Calendars have been defined so as to ensure that Calendar capable ALTO Servers can provide legacy ALTO Clients with legacy information resources as well. That is a legacy ALTO Client can request resources and receive responses as specified in RFC7285.

For compatibility with legacy ALTO Clients specified in RFC7285, calendared information resources are not applicable for Cost Maps for the following reason: a legacy ALTO client would receive a Calendared Cost Map via an HTTP 'GET' command. As specified in section 8.3.7 of

RFC7285, it will ignore the Calendar Attributes indicated in the "meta" of the responses. Therefore, lacking information on calendar attributes, it will not be able to correctly interpret and process the values of the received array of calendar cost values.

3. ALTO Calendar specification: IRD extensions

The Calendar attributes in the IRD information resources capabilities carry constant dateless values. A calendar is associated to an information resource rather than a cost type. For example, a Server can provide a "routingcost" values calendar for the Filtered Cost Map Service at a granularity of one day and a "routingcost" values calendar for the Endpoint Cost service at a finer granularity but for a limited number of endpoints.

3.1. Calendar attributes in the IRD resources capabilities

When for an applicable resource, an ALTO Server provides a Cost Calendar for a given Cost Type, it MUST indicate this in the IRD capabilities of this resource, by an object of type 'CalendarAttributes', associated to this Cost Type and specified below.

The capabilities of a Calendar aware information resource entry have a member named "calendar-attributes" which is an array of objects of type CalendarAttributes. The array has as many values as cost-type-names announced for the resource. It is necessary to use an array because of resources such as Filtered Cost Map and Endpoint Cost Map, for which the member "cost-type-names" is an array of 1 or more values. If for a given cost-type-name of this resource no Calendar attributes are defined, the ALTO Server MUST replace that value in the array by the symbol 'null'.

RULE: a member "calendar-attributes" MUST appear only once for each applicable cost type name of a resource entry. If "calendar-attributes" are specified several times for a same "cost-type-name" in the capabilities of a resource entry, the ALTO client SHOULD ignore any calendar capabilities on this "cost-type-name" for this entry.

CalendarAttributes calendar-attributes <1..*>;

```
object{
  [JSONString    cost-type-name;]
  JSONString     calendar-start-mode;
  JSONString     time-interval-size;
  JSONNumber     number-of-intervals;
  [JSONBoolean   repeat-indication;]
} CalendarAttributes;
```

o "cost-type-name":

- * an optional member indicating the cost-type-name in the IRD entry to which the capabilities apply. If this not present, it MUST be assumed to correspond to its index in the "cost-type-names" list of the IRD entry.

o "calendar-start-mode":

- * takes values in {"request date", "periodic"} . Indicates whether the ALTO Server provides this Calendar with values starting at the date of the client request or at periodical dates.

o "time-interval-size":

- * is the duration of an ALTO calendar time interval, expressed as a time unit appended to the number of these units. The time unit, ranges from "second" to "year". The number is encoded with an integer. Example values are: "5 minute" , "2 hour", meaning that each calendar value applies on a time interval that lasts respectively 5 minutes and 2 hours.

o "number-of-intervals":

- * the integer number of values of the cost calendar array, at least equal to 1.

o "repeat-indication":

- * a boolean value that indicates whether or not the ALTO Server indicates how many times the provided calendar values repeat. If this member is not present, it MUST be assumed to have a value equal to "false".

- Attribute "cost-type-name" , if used, provides a better readability to the calendar attributes specified in the IRD and avoids confusion with calendar attributes of other cost-types.

- Multiplying Attributes 'time-interval-size' and 'number-of-intervals' provides the duration of the provided calendar. For example an ALTO Server may provide a calendar for ALTO values changing every 'time-interval-size' equal to 5 minutes. If 'number-of-intervals' has the value 12, then the duration of the provided calendar is "1 hour".

- Attribute "repeat-indication": indicates whether or not the ALTO Server informs the client if the provided ALTO Calendar is a cyclic value pattern that will be repeated for a number of times.

NOTE : to cope with existing representation fomats and proposed unified ALTO naming schemes proposed in the WG, the names given in the current proposal may be revised in further versions.

3.2. Calendars in a delegate IRD

An option to clarify IRD resources is that a "root" ALTO Server implementing base protocol resources delegates "specialized" information resources such as the ones providing Cost Calendars to another ALTO Server running in a subdomain specified with its URI in the "root" ALTO Server. This option is described in Section 9.2.4 "Delegation using IRDs" of RFC7285.

This document provides an example, where a "root" ALTO Server runs in a domain called "alto.example.com". It delegates the announcement of Calendars capabilities to an ALTO Server running in a subdomain called "custom.alto.example.com". The location of the "delegate Calendar IRD" is assumed to be indicated in the "root" IRD by the resource entry: "custom-calendared-resources".

Another advantage is that some Cost Types for some resources may be more advantageous as Cost Calendars and it makes few sense to get them as a single value. For example, Cost Types with predicatble and frequently changing values, calendared in short time intervals such as a minute.

3.3. Example IRD with ALTO Cost Calendars

The cost types in this example are either specified in the base ALTO protocol or proposed in other drafts see [draft-wu-alto-te-metrics]. In this example the available cost metrics are indicated in the "meta" field by cost type names "num-routingcost", "num-Ashopcount", 'num-TEpktloss', 'num-pathbandwidth' and "string-quality-status". Metrics "routingcost" , "hopcount" , 'TEpktloss' and 'Availbandwidth' are available in the "numerical" Cost Mode. Metric "quality-status" is available in the "string" Cost Mode.

This ALTO server does not provide a calendar for cost type name num-AShopcount.

The example IRD includes 2 particular URIs providing calendars:

- o "http://custom.alto.example.com/calendar/costmap/filtered": a filtered cost map in which calendar capabilities are indicated for cost type names: "num-routingcost", "num-pathbandwidth" and "string-service-status",
- o "http://custom.alto.example.com/endpointcost/calendar/lookup": an endpoint cost map in which in which calendar capabilities are indicated for cost type names: "num-routingcost", "num-TEpktloss", "num-pathbandwidth", "string-service-status".

The design of the Calendar capabilities allows that some calendars on a cost type name are available in several information resources with different Calendar Attributes. This is the case for calendars on "num-routingcost", "num-pathbandwidth" and "string-service-status", available in both the Filtered Cost map and Endpoint Cost map service, as detailed afterwards.

```
GET /calendars-directory HTTP/1.1
Host: custom.alto.example.com
Accept: application/alto-directory+json,application/alto-error+json
-----
```

```
HTTP/1.1 200 OK
Content-Length: [TODO]
Content-Type: application/alto-directory+json
```

```
{
  "meta" : {
    "cost-types": {
      "num-routingcost": {
        "cost-mode" : "numerical",
        "cost-metric" : "routingcost"
      },
      "num-AShopcount": {
        "cost-mode" : "numerical",
        "cost-metric" : "hopcount"
      },
      "num-TEpktloss": {
        "cost-mode" : "numerical",
        "cost-metric": "TEpktloss"
      },
      "num-pathbandwidth": {
        "cost-mode" : "numerical",
```

```

        "cost-metric": "Availbandwidth",
    },
    "string-qual-status": {
        "cost-mode" : "string",
        "cost-metric": "quality-status",
    }
    ... other meta ...
},

"resources" : {
    "filtered-cost-map-calendar" : {
        "uri" : "http://custom.alto.example.com/calendar/costmap/filtered",
        "media-type" : "application/alto-costmap+json",
        "accepts" : "application/alto-costmapfilter+json",
        "capabilities" : {
            "cost-constraints" : true,
            "cost-type-names" : [ "num-routingcost", "num-pathbandwidth",
                                "string-service-status", "num-AShopcount" ]
        },

        "calendar-attributes" : [
            {
                "cost-type-names" : "num-routingcost",
                "calendar-start-mode" : "request-date",
                "time-interval-size" : "1 hour",
                "number-of-intervals" : 24
            },
            {
                "cost-type-names" : "num-pathbandwidth",
                "calendar-start-mode" : "request-date",
                "time-interval-size" : "1 hour",
                "number-of-intervals" : 24
            },
            {
                "cost-type-names" : "string-service-status",
                "calendar-start-mode" : "request-date",
                "time-interval-size" : "30 minute",
                "number-of-intervals" : 48
            },
            null
        ]
        "uses": [ "my-default-network-map" ]
    } // FCM capab
},

"endpoint-cost-calendar-map" : {
    "uri" : "http://custom.alto.example.com/calendar/endpointcost/calendar/
lookup",
    "media-types" : [ "application/alto-endpointcost+json" ],
    "accepts" : [ "application/alto-endpointcostparams+json" ],
    "capabilities" : {
        "cost-constraints" : true,
        "cost-type-names" : [ "num-AShopcount", "num-routingcost",
                            "num-TEpktloss", "num-pathbandwidth",

```

```

        "string-service-status" ],
    "calendar-attributes" : [
        null,
        {
            "cost-type-names" : "num-routingcost",
            "calendar-start-mode" : "periodic",
            "time-interval-size" : "1 hour",
            "number-of-intervals" : 24,
            "repeat-indication" : true
        },
        {
            "cost-type-names" : "latency",
            "calendar-start-mode" : "periodic",
            "time-interval-size" : "5 minute",
            "number-of-intervals" : 12,
            "repeat-indication" : true
        },
        {
            "cost-type-names" : "num-pathbandwidth",
            "calendar-start-mode" : "periodic",
            "time-interval-size" : "1 minute",
            "number-of-intervals" : 60,
            "repeat-indication" : true
        },
        {
            "cost-type-names" : "string-service-status",
            "calendar-start-mode" : "periodic",
            "time-interval-size" : "2 minute",
            "number-of-intervals" : 30,
            "repeat-indication" : true
        }
    ],
    "uses": [ "my-default-network-map" ]
} // ECM capab
} //info resource N
} // ressources

```

In this example IRD for the filtered cost map service, all calendars have a duration of 1 day and start in the "request-date" mode, that is the "date" of first value of the array belongs to the time interval "containing" the date of the request.

- o the Calendar for 'num-routingcost': is an array of 24 values each provided on a time interval lasting 1 hour.
- o the Calendar for 'num-pathbandwidth': is an array of 24 values each provided on a time interval lasting 1 hour.
- o the Calendar for "string-service-status": "is an array of 48 values each provided on a time interval lasting 30 minutes.

For the endpoint cost map service, the cost calendars have a duration of 1 day for "num-routingcost" and 1 hour for the 3 other cost type names. They start in the "periodic" mode, that is the "date" of first value of the array is chosen by the ALTO Server, that is in this case assumed to update the calendars periodically. The value of member "repeat-indication" is set to 'true', which means that the ALTO Server informs the ALTO Client if the values of the current calendar will be the same in the next periods and for how many periods.

- o the Calendar for 'num-routingcost': is an array of 24 values each provided on a time interval lasting 1 hour.
- o the Calendar for 'TEpktloss': is an array of 12 values each provided on a time interval lasting 5 minutes.
- o the Calendar for 'num-pathbandwidth': is an array of 60 values each provided on a time interval lasting 1 minute.
- o the Calendar for "string-service-status": is an array of 30 values each provided on a time interval lasting 2 minutes.

4. ALTO Calendar specification: Service Information Resources

This section documents the individual information resources defined to provide the Calendared information services defined in this document.

The reference time zone for the provided time values is GMT because the option chosen to express the time format is the HTTP header fields format:

Date: Tue, 15 Nov 1994 08:12:31 GMT

Note that if the 'calendar-start-time' date is past, the application can also use the information to compute statistics on values provided by ALTO over time to guide applications. Besides estimating some customized prediction the ALTO Client may use these values to assess their reliability w.r.t. some real measures of QoE.

4.1. Calendar extensions for Filtered Cost Maps

A legacy ALTO client requests and gets filtered cost map responses as specified in RFC7285.

4.1.1. Calendar extensions in Filtered cost map requests

The input parameters of a "legacy" request for a filtered cost map, defined by object ReqFilteredCostMap in section 11.3.2 of RFC7285, are augmented with one additional member.

A Calendar aware ALTO client requesting a Calendar on a given Cost Type for a Filtered Cost Map resource having Calendar capabilities MUST add the following field to its input parameters:

```
JSONBoolean    calendared<1..*>;
```

This field is an array of 1 to several boolean values indicating whether or not the ALTO Server should provide the values for this Cost Type as a calendar.

This field MUST NOT be specified if the calendar capability is not present or equal to false for this information resource.

A Calendar-aware ALTO client supporting single cost type values, as specified in RFC7285, MUST provide an array of 1 element:
"calendared" : [true],

A Calendar-aware ALTO client that is also Multi-Cost aware MUST provide an array of N values set to "true" or "false", depending whether it wants the applicable Cost Type values as a single or calendared value.

If this field is not present, it MUST be assumed to have only values equal to "false".

4.1.2. Calendar extensions in Filtered Cost map responses

The calendared costs are JSONArrays instead of JSONNumbers for the legacy ALTO implementation. All arrays have a number of values equal to 'number-of-intervals'.

The "meta" field of a Calendared Filtered Cost map response MUST include at least:

- o the "meta" fields specified for these information service responses, as specified in RFC 7285 if the ALTO Client supports costs for one Cost Type at a time only,
 - * "dependent-vtags ",
 - * "cost-type" field.

- o the "meta" fields specified for these information service responses, as specified in RRRR [draft-ietf-multi-cost-alto] if the ALTO Client supports Multi-Cost capabilities, that is:

- * "dependent-vtags ",
- * "multi-cost-types" field.

The "meta" field of a Calendared Filtered Cost map response MUST include in addition the member "calendar-response-attributes" for the requested information resource, together with the values provided by the ALTO Server for these attributes. This member is an array of objects of type "CalendarResponseAttributes", defined as follows:

CalendarResponseAttributes calendar-response-attributes <1..*>;

```
object{
  JSONString    calendar-start-time;
  JSONString    time-interval-size;
  JSONNumber    number-of-intervals;
  [JSONNumber   repeated;]           [OPTIONAL]
} CalendarResponseAttributes;
```

- o "calendar-start-time": indicates the date at which the first value of the calendar applies. The value provided for the "calendar-start-time" attribute MUST be no later than the request date.
- o "time-interval-size": as specified in section "Calendar attributes in the IRD resources capabilities",
- o "number-of-intervals": as specified in section "Calendar attributes in the IRD resources capabilities",
- o "repeated": is an optional field provided for Calendars available in the "periodic" 'calendar-start-mode'. It is an integer greater or equal to '0' that indicates how many times the calendar starting at the date indicated by "calendar-start-time" will have the same value array. An ALTO Server indicating a "calendar-start-mode" set to "periodic" for this Calendar SHOULD provide a value for this member. If omitted this member MUST be interpreted as having a value equal to '0'.

For example:

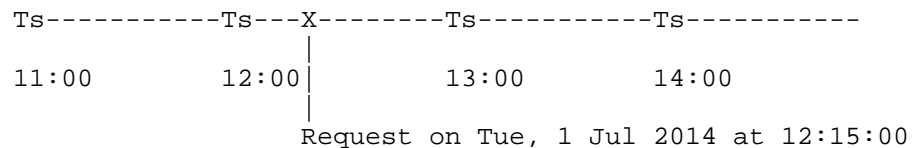
- o if a calendar has a "calendar-start-time" member with value "Mon, 30 Jun 2014 at 00:00:00 GMT" and if the calendar values are the same from Monday through Thursday included, then the value of member "repeated" will be equal to 4. The ALTO Client thus may

use the same calendar for the 4 duration periods following "calendar-start-time".

- o If the calendars for Friday, Saturday and Sunday all have different values, the value of their member "repeated" will be equal to 1.
- o If in a next week, the values are identical for Monday, Tuesday, Thursday and different for Wednesday (holiday, world wide event), the calendar update provided on Monday will have a member "repeated" with value 2.

4.1.2.1. Calendar Start time value for "request-date" calendar start mode

When the ALTO Server IRD announces a Calendar for which attribute "calendar-start-mode" is set to "request-date", the value provided in the ALTO response for attribute "calendar-start-time" MUST correspond to the start of the time interval "including" the date of the request. Figure FFFF1 uses the example IRD of section 3.3: in resource "filtered-cost-calendar-map" a calendar is offered for cost-type-name "num- pathbandwidth", as an array on 24 slots of 1 hour and is available in the calendar-start-mode "request".



The ALTO Client knows from IRD that:

- the "time-interval-size" Ts is equal to 1 hour
- the "calendar-start-time" is the beginning of the time interval to which the "request-date" belongs

So the ALTO Client can expect that the "calendar-start-time" of the requested calendar is: Tue, 1 Jul 2014 at 12:00:00

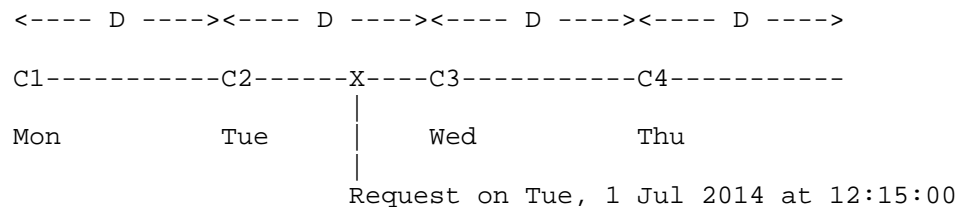
Figure FFFF1: "calendar-start-time" when the IRD indicates a "request date" set to "calendar-start-mode".

4.1.2.2. Calendar Start time value for "periodic" calendar start mode

When the ALTO Server IRD offers a Calendar for which attribute 'calendar-start-mode' is set to "periodic", it means that it chooses to update the values at periodic dates, for example every week or

hour or day. In this case, the value in the server response for attribute "calendar-start-time" MUST be the one of the last Calendar update present in the ALTO Server.

Figure FFFF2 uses the example IRD of section 3.3: in resource "endpoint-cost-calendar-map", a calendar is offered for cost- type- name "num- routingcost" as an array of array of 24 slots of 1 hour and is available in the "periodic" calendar-start-mode. The ALTO Client can expect that the value of "calendar-start-time" is aged between 0 and 23 hours plus 0 to N days. Suppose the calendar starts everyday at 00.00.00. GMT and that its values are the same from Monday through Thursday included. If the request is done at date: Tue, 1 Jul 2014 at 12:15:00 GMT, the "calendar- start-time" field takes value "Mon, 30 Jun 2014 at 00:00:00 GMT".



The ALTO Client knows from IRD that:

- the "calendar-start-time" is "periodic"
- the "time-interval-size" T_s is equal to 1 hour
- each period has a duration D of 24 T_s
- Calendars C_i may have the same values for 1 or more periods D

So the ALTO Client can expect that the "calendar-start-time" of the requested calendar is aged $n \cdot D = k \cdot T_s$, where k lies in $[0, 23]$ and $n \geq 0$

Figure FFFF2: estimation by the ALTO Client of the "calendar-start-time" when the IRD indicates a "periodic" "calendar-start-mode".

4.1.3. Example transaction for a FCM with a "request-date" bandwidth Calendar

An example of non-real time information that can be provisioned in a 'calendar' is the expected path bandwidth. While the transmission rate can be measured in real time by end systems, the operator of a data center is in the position of formulating preferences for given paths, at given time periods for example to avoid traffic peaks due to diurnal usage patterns. In this example, we assume that an ALTO Client requests a bandwidth calendar as specified in the IRD to shedule its bulk data transfers as described in the use cases.

In the example IRD, calendars for cost type name "num-pathbandwidth" are available for the information resources: "filtered-cost-calendar-map" starting at the request date and "endpoint-cost-calendar-map" starting in a periodic date. The ALTO Client requests a calendar for "num-pathbandwidth" via a POST request for a filtered cost map.

We suppose in this example that the ALTO Client sends its request on Tuesday July 1st 2014 at 13:15

POST /calendar/costmap/filtered HTTP/1.1

Host: alto.example.com

Content-Length: [TODO]

Content-Type: application/alto-costmapfilter+json

Accept: application/alto-costmap+json,application/alto-error+json

```
{
  "cost-type" : { "cost-mode" : "calendar", "cost-metric" : "Availbandwidth" },
  "calendared" : [true],

  "pids" : {
    "srcs" : [ "PID1", "PID2" ],
    "dsts" : [ "PID1", "PID2", "PID3" ]
  }
}
```

HTTP/1.1 200 OK

Content-Length: [TODO]

Content-Type: application/alto-costmap+json

```
{
  "meta" : {
    "dependent-vtags" : [...],
    "cost-type" : { "cost-mode" : "numerical", "cost-metric" : "Availbandwidth"
  },
  "calendar-response-attributes" : [
    "calendar-start-time" : Tue, 1 Jul 2014 13:00:00 GMT,
    "time-interval-size" : "2 hour",
    "numb-intervals" : 12
  ]
},

  "cost-map" : {
    "PID1" : {
      "PID1" : [v1,v2,v3,v4,v5,v6,v7,v8,v9,v10,v11,v12],
      "PID2" : [v1,v2,v3,v4,v5,v6,v7,v8,v9,v10,v11,v12],
      "PID3" : [v1,v2,v3,v4,v5,v6,v7,v8,v9,v10,v11,v12] },
    "PID2" : {
      "PID1" : [v1,v2,v3,v4,v5,v6,v7,v8,v9,v10,v11,v12],
      "PID2" : [v1,v2,v3,v4,v5,v6,v7,v8,v9,v10,v11,v12],
      "PID3" : [v1,v2,v3,v4,v5,v6,v7,v8,v9,v10,v11,v12] }
  }
}
```

4.2. Calendar extensions in the Endpoint Cost Map Service

This document extends the Endpoint Cost Service, as defined in {11.5.1} of [RFC7285], by adding new input parameters and capabilities, and by returning JSONArrays instead of JSONNumbers as the cost values. The media type {11.5.1.1} and HTTP method {11.5.1.2} are unchanged.

4.2.1. Calendar specific input in Endpoint cost map requests

The extensions to the requests for calendared Endpoint Cost Maps are the same as for the Filtered Cost Map Service, previously specified in section XXXX.

The ReqEndpointCostMap object for a Calendared ECM request will have the following format:

```
object {
  CostType          cost-type;
  [JSONBoolean      calendared<1..*>;]
  EndpointFilter endpoints;
} ReqEndpointCostMap;

object {
  [TypedEndpointAddr srcs<0..*>;]
  [TypedEndpointAddr dsts<0..*>;]
} EndpointFilter;
```

4.2.2. Calendar attributes in the Endpoint Cost Map responses

The "meta" field of a Calendared Endpoint Cost map response MUST include at least:

- o the "meta" fields specified for these Endpoint Cost service responses, as specified in RFC 7285 if the ALTO Client supports costs for one Cost Type at a time only,
 - * "cost-type" field.
- o the "meta" fields specified for these information service responses, as specified in RRRR [draft-ietf-multi-cost-alto] if the ALTO Client supports Multi-Cost capabilities, that is:
 - * "multi-cost-types" field.

The "meta" member of a Calendared Endpoint Cost Map response MUST include the same additional member "calendar-response-attributes" as

specified for the Filtered Cost Map Service. If the client request does not provide member "calendared" or if it provides it with a value equal to 'false', then the ALTO Server response is exactly as specified in {11.5.1.6} of [RFC7285]. If the client provides member "calendared" with a value equal to 'true' in the input parameters, the Server response is changed as follows:

- o the "meta" member has one additional field "CalendarResponseAttributes", as specified for the Filtered Cost Map Service,
- o the calendared costs are JSONArrays instead of JSONNumbers for the legacy ALTO implementation. All arrays have a number of values equal to 'number-of-intervals'.

4.2.3. Example transaction for the ECS with a "periodic" routingcost Calendar

Let us assume an Application Client located in an end system with limited resources and having an access to the network that is either intermittent or provides an acceptable quality in limited but possibly predictable time periods. Therefore, it needs to both schedule its resources demanding networking activities and minimize its ALTO transactions.

The Application Client has the choice to trade content or resources with a set of Endpoints of moderate 'routingcost', and needs to decide with which Endpoint it will trade at what time. For instance, one may assume that the Endpoints are spread on different time-zones, or have intermittent access. In this example, the 'routingcost' is assumed to be the time sensitive decision metric, with values provided in the ALTO Calendar Mode.

The ALTO Client embedded in the Application Client queries an ALTO Calendar on 'routingcost' and will get the Calendar covering the 24 hours time period "containing" the date and time of the ALTO client request.

For Cost Type 'calendar-routing', this example ALTO Server has defined 3 different daily patterns each represented by a Calendar, to cover the week of Monday June 30th at 00:00 to Sunday July 6th 23:59:

- C1 for Monday, Tuesday, Wednesday, Thursday, (week days)
- C2 for Saturday, Sunday, (week end)
- C3 for Friday (maintenance outage on July 4, 2014 from 02:00:00 GMT to 04:00:00 GMT, or big holiday such as New Year evening).

The presence of attributes "repeated" and "calendar-start-time" allows an ALTO client to fetch 3 Calendars instead of 7 and thus to reduce the volume of on-the-wire data exchange,

In the following example transaction, the ALTO Client sends its request on Tuesday July 1st 2014 at 13:15. It will then get the value pattern "C1" , valid from Monday at 00:00:00 until Thursday at 23:59:59, thus repeated 4 times.

POST /calendar/endpointcost/lookup HTTP/1.1

Host: alto.example.com

Content-Length: [TODO]

Content-Type: application/alto-endpointcostparams+json

Accept: application/alto-endpointcost+json,application/alto-error+json

```
{
  "cost-type" : {"cost-mode" : "numerical", "cost-metric" : "routingcost"},
  "calendared" : [true],
  "endpoints" : {
    "srcs": [ "ipv4:192.0.2.2" ],
    "dsts": [
      "ipv4:192.0.2.89",
      "ipv4:198.51.100.34",
      "ipv4:203.0.113.45"
    ]
  }
}
```

HTTP/1.1 200 OK

Content-Length: [TODO]

Content-Type: application/alto-endpointcost+json

```
{
  "meta" : {
    "cost-type" : {"cost-mode" : "numerical", "cost-metric" : "routingcost"},
    "calendar-response-attributes" : [
      { "calendar-start-time" : Mon, 30 Jun 2014 00:00:00 GMT,
        "time-interval-size" : "1 hour",
        "numb-intervals" : 24,
        "repeated": 4 }
    ],
  } // end meta

  "endpoint-cost-map" : {
    "ipv4:192.0.2.2": {
      "ipv4:192.0.2.89" : [v1, v2, ... v24],
      "ipv4:198.51.100.34" : [v1, v2, ... v24],
      "ipv4:203.0.113.45" : [v1, v2, ... v24]
    }
  }
}
```


4.2.4. Example transaction for the ECS with a calendar on both routingcost and latency

In this example, it is assumed that the ALTO Server implements multi-cost capabilities, as specified in [draft-ietf-alto-multi-cost] . That is, an ALTO client can request and receive values for several cost types in one single transaction. An illustrating use case is a path selection done on the basis of 2 metrics: routing cost and latency.

The assumptions on the routing cost calendars are the same as in the previous example.

For metric "latency", the calendar attributes in the IRD indicate that the values are updated every hour and each one applies to an interval of 5 minutes. The Server response provides value 1 for attribute 'repeated' it is assumed that the current calendar values are repeated 1 time, that is, in the next hour the calendar will have different values.

In the following example transaction, the ALTO Client sends its request on Tuesday July 1st 2014 at 13:15. It is assumed that it does this multi-cost request for the first time.

When receiving the response, the client sees that the calendar for latency will change in the next hour where as the calendar values for routing cost will be the same for the next 3 days. Therefore, in its next requests until the routing cost calendar is expected to change, the client will only need to request a calendar for 1 single metric which is latency.

Without the ALTO Calendar extensions, the ALTO client would have no clue on the dynamicity of the metric value change and would spend needless time requesting values at an inappropriate pace. In addition, without the Multi-Cost ALTO capabilities, the ALTO client would duplicate this waste of time as it would need to send one request per cost metric.

```
POST calendar/endpointcost/lookup HTTP/1.1
Host: alto.example.com
Content-Length: [TODO]
Content-Type: application/alto-endpointcostparams+json
Accept: application/alto-endpointcost+json,application/alto-error+json

{
  "multi-cost-types" : [
    { "cost-mode" : "numerical", "cost-metric" : "routingcost" },
    { "cost-mode" : "numerical", "cost-metric" : "latency" }
```

```

],
"calendared" : [true, true],
"endpoints" : {
  "srcs": [ "ipv4:192.0.2.2" ],
  "dsts": [
    "ipv4:192.0.2.89",
    "ipv4:198.51.100.34",
    "ipv4:203.0.113.45"
  ]
}
}

```

HTTP/1.1 200 OK

Content-Length: [TODO]

Content-Type: application/alto-endpointcost+json

```

{
  "meta" : {
    "multi-cost-types" : [
      { "cost-mode" : "numerical", "cost-metric" : "routingcost" },
      { "cost-mode" : "numerical", "cost-metric" : "latency" }
    ],
    "calendar-response-attributes" : [
      { "cost-type-name" : "num-routingcost"
        "calendar-start-time" : Mon, 30 Jun 2014 00:00:00 GMT,
        "time-interval-size" : "1 hour",
        "numb-intervals" : 24,
        "repeated": 4 },
      { "cost-type-name" : "num-latency"
        "calendar-start-time" : Tue, 1 Jul 2014 13:00:00 GMT,
        "time-interval-size" : "5 minute",
        "numb-intervals" : 12,
        "repeated": 1 }
    ],
  } // end meta

  "endpoint-cost-map" : {
    "ipv4:192.0.2.2": {
      "ipv4:192.0.2.89" : [[r1, r2, ... r24], [l1, l2, ... l12]],
      "ipv4:198.51.100.34" : [[r1, r2, ... r24], [l1, l2, ... l12]],
      "ipv4:203.0.113.45" : [[r1, r2, ... r24], [l1, l2, ... l12]]
    }
  }
}

```

4.3. Recap of rules related to ALTO Cost Calendars

XXXXX TO BE COMPLETED + MOVED AT THE END OF THE SPECS

A Calendar-aware ALTO Server MUST implement the base protocol specified in RFC7285.

If no Calendar attributes are defined for a given Cost Type, in a given resource entry, the ALTO Server MUST set the value in the 'calendar-attributes' array to the symbol 'null'.

When a metric is available as a calendar, it MUST be available as a single value. An ALTO Server acquiring cost values in limited time intervals only can construct a single value from the value array.

Calendared information resources MUST be requested via a POST method.

If this member "repeat-indication" is not present in the calendar attributes indicated in the IRD, it MUST be assumed to have a value equal to "false".

5. Use cases for ALTO Cost Schedule

This section presents use cases showing the benefits of ALTO Cost calendars for applications needing to decide both "where" to connect and "when".

5.1. Bulk Data Transfer scheduling upon bandwidth calendars

Large Internet Content Providers (ICPs) like Facebook or YouTube, as well as CDNs rely on data replication across multiple sites and time zones to offload the core site and increase user experience through shorter latency from a local site. Typically the usage pattern of these data centers or caches follows a location dependent diurnal demand pattern. In these examples, data replication across the various locations of an ICP, leads to bulk data transfers between datacenters on a diurnal pattern.

In the meantime, there is a degree of freedom on when the content is transmitted from the origin server to the caching node, or from the core site to a local site. However, scheduling these data transfers is a non-trivial task as they should not infer with the user peak demand to avoid degradation of user experience and to decrease billing costs for the datacenter operator by leveraging off-peak hours for the transfer.

As a result, these ICPs need to have a good knowledge on the link utilization patterns between the different datacenters before making

an efficient scheduling decision. While usage data today is already gathered and used to schedule data transfers, provisioning these data gets increasingly complex with the number of CDN nodes and datacenter operators that are involved. In particular, privacy concerns prevent that this kind of data is shared across administrative domains. The ALTO Cost Calendar avoids these problems by presenting an abstracted view of time sensitive utilization maps through a dedicated ALTO service to allow ICPs a coherent scheduling of data transfers across administrative domains and time zones.

Likewise, bandwidth Calendaring allows network operators to reserve resources in advance according to agreements with their customers, enabling them to transmit data with specified starting time and duration, for example, for a scheduled bulk data replication between data centers. Traditionally, this can be supported by a Network Management System operation such as path pre-establishment and activation on the agreed starting time. However, this does not provide efficient network usage since the established paths exclude the possibility of being used by other services even when they are not used for undertaking any service.

An ALTO Cost calendar for TE metrics on transfer paths can support the scheduled bulk data replication with better efficiency since it can alleviate the processing burden on network elements.

Cost calendars for these time-sensitive ALTO TE metrics need to consider the network topology and the dynamicity of the traffic. For example, a small topology with low density and low capacity that carries unpredictable, heavy and bursty traffic has few chances to exhibit stationary TE metric value patterns over large periods and would benefit to use the ALTO Calendar over smaller time slots. Some ALTO TE metric values, even aggregated over time may need to be updated at a frequency that would require doing ALTO requests at a pace that would be overload both the ALTO Client and the Server. Large high capacity topologies would benefit from Cost Calendars with a coarse time granularity for the filtered cost map service where as Calendars of finer time granularity for the Endpoint Cost Service would be better suited for small low density and capacity topologies.

5.1.1. Applicable example transaction

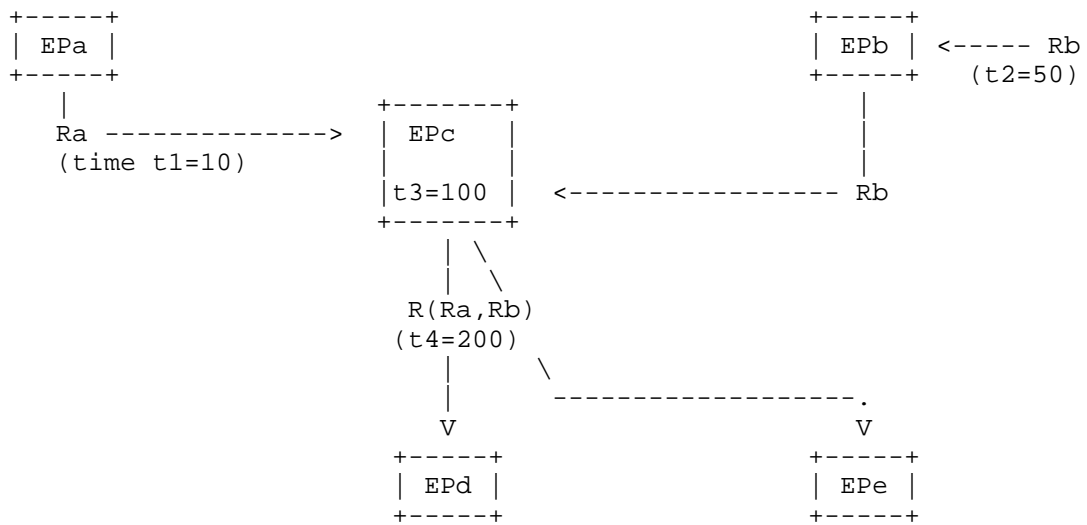
Assuming a Large high capacity topology, an applicable example transaction for this use case is provided by section 4.1.3. "Example transaction for a FCM with a "request-date" bandwidth Calendar".

5.2. Applications with limited connectivity or access to datacenters

Some applications are limited in their connectivity either in time or resources or both. For example applications running on devices in remote locations or in developing countries that need to synchronize their state with a data center periodically, in particular if sometimes there is no connection at all. Example applications are enterprise database update, remote learning, remote computation distributed on several data center endpoints.

Wireless connections have a variable quality and may even be intermittent. On the other hand, the wireless network conditions are often predictable and have a rapid impact on applications. Non real time applications and time-insensitive data transfers such as client patching, archive syncing, etc. can benefit from careful scheduling. It is thus desirable to provide ALTO clients with routing costs to connection nodes (i.e. Application Endpoints) over different time periods. This would allow end systems using ALTO aware application clients to schedule their connections to application endpoints.

Another challenge arises with applications using data and physical resources scattered around the world. For non-real time applications, the interaction with Endpoints can be scheduled at the time slots corresponding to the best possible network conditions in order to improve the QoE. For instance, resource Ra downloaded from Endpoint EPa at time t1, Resource Rb uploaded to EPb at time t2, some batch computation involving Ra and Rb done on EPc at time t3 and results R(A,B) downloaded to EPd and EPe at time t4.



5.2.1. Applicable example transaction

An applicable example transaction for this use case is provided by section 4.2.3. "Example transaction for the ECS with a "periodic" routingcost Calendar".

5.3. SDN Controller guided traffic scheduling with Calendars

An ALTO Server can assist an SDN Controller by hosting abstracted network information that can be provided to SDN aware applications via an ALTO Client.

Via the Northbound interface (NBI), applications may get QoE impacting information such as network provider preferences w.r.t. delay and bandwidth on the network paths. Such information may be provided via the ALTO Service if the latter supports the requested metrics.

One key objective of an SDN controller is the ability to balance the application traffic whenever possible. Resources availability may often be predicted and strong incentives for applications to time shift their traffic may be given by network operators appropriately setting routing cost values at different time values, according to their policy on network utilization over time.

To achieve this objective, the SDN controller can:

1. get the network state information from its controlled network elements through its southbound API and derive an estimation of these values over given time frames
2. abstract the network topology and costs on end to end paths and store this in an ALTO Server in the form of Network Maps and Cost Calendars
3. deliver these values to ALTO Clients linked to SDN applications, through the NBI.

This way:

- o On one hand, the applications get the best possible QoE, as they can pick the best time for them to access one or more Endpoints or PIDs,
- o On the other hand the SDN controller achieves load balancing and optimizes application traffic as it may guide the application traffic so as to better distribute the traffic over time, and thus optimize its resources usage.

5.3.1. Applicable example transaction

An applicable example transaction for this use case is provided by section 4.2.4. "Example transaction for the ECS with a calendar on both routingcost and latency".

6. IANA Considerations

Information for the ALTO Endpoint property registry maintained by the IANA and related to the new Endpoints supported by the acting ALTO server. These definitions will be formulated according to the syntax defined in Section on "ALTO Endpoint Property Registry" of [ID-alto-protocol],

Information for the ALTO Cost Type Registry maintained by the IANA and related to the new Cost Types supported by the acting ALTO server. These definitions will be formulated according to the syntax defined in Section on "ALTO Cost Type Registry" of [RFC7285],

6.1. Information for IANA on proposed Cost Types

When a new ALTO Cost Type is defined, accepted by the ALTO working group and requests for IANA registration MUST include the following information, detailed in Section 11.2: Identifier, Intended Semantics, Security Considerations.

6.2. Information for IANA on proposed Endpoint Properties

Likewise, an ALTO Endpoint Property Registry could serve the same purposes as the ALTO Cost Type registry. Application to IANA registration for Endpoint Properties would follow a similar process.

7. Acknowledgements

Thank you to Diego Lopez, He Peng and Haibin Song and the ALTO WG for fruitful discussions.

8. References

8.1. Normative References

- [RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, March 1997.
- [RFC5693] Seedorf, J. and E. Burger, "Application-Layer Traffic Optimization (ALTO) Problem Statement", RFC 5693, October 2009.

8.2. Informative References

- [draft-ietf-alto-multi-cost]
S. Randriamasy, W. Roome, N. Schwan, , "Multi-Cost ALTO (work in progress), draft-ietf-alto-multi-cost", May 2015.
- [draft-wu-alto-te-metrics]
Q. Wu, Y. Yang, Y. Lee, D. Dhody, S. Randriamasy, , "ALTO Traffic Engineering Cost Metrics (work in progress)", October 2014.
- [draft-yang-alto-topology]
Y. Yang, , "ALTO Topology Considerations (work in progress)", July 2013.
- [ID-alto-protocol]
R. Alimi, R. Penno, Y. Yang, Eds., "ALTO Protocol, RFC 7285", September 2014.
- [RFC7285] R. Alimi, R. Yang, R. Penno, Eds., "ALTO Protocol", September 2014.
- [sdnrg] "Software Defined Network Research Group,
<http://trac.tools.ietf.org/group/irtf/trac/wiki/sdnrg>".

[slides-88-alto-5-topology]

G. Bernstein, Y. Lee, Y. Yang, , , "ALTO Topology Service:
Use Cases, Requirements and Framework (presentation slides
IETF88 ALTO WG session),
[http://tools.ietf.org/agenda/88/slides/
slides-88-alto-5.pdf](http://tools.ietf.org/agenda/88/slides/slides-88-alto-5.pdf)", November 2013.

Authors' Addresses

Sabine Randriamasy
Alcatel-Lucent Bell Labs
Route de Villejust
NOZAY 91460
FRANCE

Email: Sabine.Randriamasy@alcatel-lucent.com

Richard Yang
Yale University
51 Prospect st
New Haven, CT 06520
USA

Email: yry@cs.yale.edu

Qin Wu
Huawei
101 Software Avenue, Yuhua District
Nanjing, Jiangsu 210012
China

Email: sunseawq@huawei.com

Lingli Deng
China Mobile
China

Email: denglingli@chinamobile.com

Nico Schwan
Thales Deutschland

Email: nico.schwan@thalesgroup.com