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ALTO Cost Schedule
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Abstract

The goal of Application-Layer Traffic Optimization (ALTO) is to bridge the gap between network and applications by provisioning network related information. This allows applications to make informed decisions, for example when selecting a target host from a set of candidates. The ALTO problem statement [RFC5693] considers typical applications as file sharing, real-time communication and live streaming peer-to-peer networks. Recently other use cases focused on Content Distribution Networks and Data Centers have emerged [draft-jenkins-alto-cdn-use-cases-01].

The present draft proposes to extend the cost information provided by the ALTO protocol. The purpose is to broaden the decision possibilities of applications to not only decide 'where' to connect to, but also 'when' to connect. This is useful to applications that have a degree of freedom on when to schedule data transfers, such as non-instantaneous data replication between data centers. The draft therefore specifies a new cost mode, called the "schedule" mode. In this mode the ALTO server offers cost maps that contain link ratings that are valid for a given timeframe (e.g. hourly) for a period of time (e.g. a day). Besides the functional time-shift enhancement providing multi-timeframe cost values the extansion also allows the saving of a number of ALTO transactions and thus resources on the ALTO server and clients.

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

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 [ID-alto-protocol] specifies a Network Map, which defines groupings of endpoints in a network region (called a PID) as seen by the ALTO server. The Endpoint Cost Service and the Endpoint (EP) Ranking Service then provide rankings for connections between the specified 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 (cmp. ALTO Problem Statement [RFC5693] and ALTO Requirements [RFC5693]), as "Such information is better suited to be transferred through an in-band technique at the transport layer instead". 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 to en Endpoint. 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 the estimated frequency of cost value change. In case these value changes are predicable over a certain period of time and the application does not require immediate data transfer, it would save time to get the whole set of cost values over the period in one ALTO response and using these values to schedule data transfers would allow to optimise the network resources usage and QoE.

In this draft we introduce use cases that describe applications that have a degree of freedom on scheduling data transfers over a period of time, thus they do not need to start a transfer instantaneously on a retrieved request. For this kind of applications we propose to extend the Cost Map and Endpoint Cost Services by adding a schedule on the cost values, allowing applications to time-shift data transfers.

In addition to this functional ALTO enhancement, we expect to further gain by gathering multiple Cost Values for one cost type as one Cost Map reporting on N Cost Values is less bulky than N Cost Maps containing one Cost value each, in addition to reducing N ALTO transactions to a single one. This is valuable for both the storage

of these maps and their transfer. Similar gains can be obtained for the ALTO Endpoint Cost Service.

The remainder of this draft first provides use cases that motivate the need for a 'schedule' cost mode. It then specifies the needed extensions to the ALTO protocol and details some example messages.

2. Use cases for ALTO Cost Schedule

2.1. Bulk Data Transfer scheduling

Some CDNs are prepopulating caches with content before it actually gets available for the user and thus there is a degree of freedom on when the content is transmitted from the origin server to the chaching node. Other applications like Facebook or YouTube rely on data replication across multiple sites for several reasons, such as offloading the core network or increasing user experience through short latency. Typically the usage pattern of these data centers or caches follows a location dependent diurnal pattern.

In the examples above data needs to be replicated across the various locations of a CDN provider, leading to bulk data transfers between datacenters. Scheduling these data transfers is a non-trivial task as the transfer 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. This peak demand typically follows a diurnal pattern according to the geographic region of the datacenter. One precondition to schedule transfers however is to have a good knowledge about the demand and link utilization patterns between the different datacenters and networks.

While this usage data today already is gathered and also used for the scheduling of data transfer, provisioning this data gets increasingly complex with the number of CDN nodes and in particular the number of datacenter operators that are involved. For example, privacy concerns prevent that this kind of data is shared across administrative domains. Therefore the Cost schedule specified later in this document avoids this problem by presenting an abstracted view of time sensitive utilization maps through a dedicated ALTO service to allow CDN operators a mutual scheduling of such data transfers across administrative domains.

2.2. Endsystems with limited access to datacenters using schedule mode

Another use case that benefits from the availability of multi-timeframe cost information is based on applications that are limited

by 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 is enterprise database update, remote learning, remote computation.

Another challenge arises with endsystems using resources located in datacenters and trading content and 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 QoE. For instance, resource Ra downloaded from Endpoint (EP) 1 at time Ta, Resource Rb uploaded to EP2 at time Tb, some batch computation results RC downloaded from EP3 at Tc. Example applications are similar to the ones cited in the previous paragraph.

These examples describe situations where a client has the choice of trading content or resources with several Endpoints and needs to decide with which Endpoint it will trade and at what time. For instance, one may assume that the Endpoints are spread over different time-zones, or have intermittent access. The ALTO schedule mode specified below allows these clients to retrieve Endpoint cost maps valid for a certain timeframe (e.g. 24 hours), and get a set of values, each applicable on a (e.g. hourly) slot. Thus the application can optimize the needed data transfer according to this information.

Let us assume an Application Client is located in an end sytem with limited resources and/or has an access to the network that is either intermittent or provides an acceptable QoE in limited but predictable time periods. Therefore, it needs to both schedule its resources demanding networking activities. Instead of carefully schedule multiple ALTO requests for Cost values and having to figure out when the cost values may change it could benefit from relying on Cost attributes indicating the time granularity, the validity and time scope of the cost information, together with the values themselves.

Suppose that for some Cost Types, the ALTO cost values are available in the "schedule" mode. If the values of Cost type 'routingcost' and/or another time-sensitive Cost Type named for example 'pathoccupationcost' are available in the "schedule" mode for the 24 following the last update, the ALTO Client embedded in the Application Client may query ALTO information on 'routingcost' or 'pathoccupationcost' for these 24 hours, and get a set of values, each applicable to an hour slot. If appropriate Cost Attributes are provided together with the cost values, the Application client also knows the date of their last update. An example ALTO transaction is provided later in this draft.

3. ALTO Cost Schedule

One example of non-realtime information that can be provisioned in a 'schedule' 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 on given time scales, for example to avoid hotspots due to diurnal usage patterns. The entity managing the ALTO Server values can decide to integrate path bandwidth in the ALTO 'routingcost' metric. However to better highlight the purpose of the cost schedule we will use the Cost Type name 'pathoccupationcost' in the remainder of this document.

The usage of a time related cost is more proactive in that it can be used like a "time table" to figure out the best time to schedule data transfer and also anticipate predictable events including predictable flash crowds. The time-related information is not necessarily historical and statistic. This is why the proposed time-sensitive Costs should be viewed as synthetic or as abstraction of real measurements rather than as statistics.

3.1. Cost Schedule Attributes

For further extensions, specifications on the cost "schedule" are proposed and will be completed in further versions of this draft.

3.1.1. ALTO Cost-Mode: Schedule

The "schedule" mode applies to Costs that are eligible for a single-valued Cost Mode and can also be expressed as such. In that sense, when the "numerical" mode is available for a Cost-Type, the cost expressed in the "schedule" mode is an extension of its expression in the "numerical" mode to an array of several values varying over time.

Types of Cost values such as JSONBool can also be expressed in the "schedule" mode, as states may be "true" or "false" depending on given time periods. It may be expressed as a single value which is either "true" or "false" following a decision rule outside the ALTO protocol.

3.2. ALTO Capability: Cost-Scope

To ensure that the application client uses the NP provided information in the cost schedule in an unambiguous way we define the Cost Scope capability, which defines the validity of the "scheduled" cost values.

For Cost Types whose values are provided in a mode different than

'schedule', the Cost Scope capability is specified by the string "permanent". The Cost Scope attributes provided for the 'schedule' mode are listed below. The reference time zone for the provided values is UTC.

- Unit: expresses the time interval applicable to each value. A 2 element array where the first element is the time unit, ranging from "second" to "year", and the second one the number of units of this duration. For example: '["minute", 5]' means that each value is provided on a time interval lasting 5 minutes.

- Size: the number of values of the cost schedule array,

- Begin: the index of the first unit in the array,

- Reference time zone: set to "UTC",

- Next update: the date at which the sample will be re-computed,

- Last update: the last re-computation date.

The reference time zone is UTC.

Attributes 'Last update 'and 'Next update' report on the update frequency and age of the information.

3.2.1. Example of time scope for a cost schedule

For example: a metric called 'pathoccupationcost' (POC for short) is computed for 24 hours, on time intervals lasting 2 hours, with the first interval starting at 0h00. The ALTO Server thus provides an array 12 values. This information is then used to enable applications to see which time intervals in a day are the most favorable to operate, and which "busy " time intervals should be avoided. If the "Begin" date is past, the application can also use the information to compute statistics or infer a some customized prediction.

3.3. Example of scheduled information resources in the IRD

The example IRD given in this Section includes 2 particular URIs:

- "http://alto.example.com/endpointcost/lookup", in which the ALTO Server offers several Endpoint Cost Types, including a Cost called "pathoccupationcost" for which the "schedule" Cost Mode is available. The Endpoint Costs available are the "hopcount", "routingcost" and "pathoccupationcost" Cost Types, with the two first ones in the "numerical" Cost Mode and "pathoccupationcost"

in the "schedule" Cost Mode.

- "http://custom.alto.example.com/endpointcost/lookup", in which the ALTO Server provides the 'routingcost' in both "numerical" and "schedule" modes. This resource is accessible via a separate subdomain called "custom.alto.example.com". The ALTO Client may either get the last update of the 'routingcost' value or request for a previsonal sample of 24 values established each for 1 hour. An ALTO Client can discover the services available at "custom.alto.example.com" by successfully performing an OPTIONS request to "http://custom.alto.example.com/endpointcost".

```
GET /directory HTTP/1.1
   Host: 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

   {

      ... usual ALTO resources ...

    "resources" : [
      {
         "uri" : "http://alto.example.com/endpointcost/lookup",
         "media-types" : [ "application/alto-endpointcost+json" ],
         "accepts" : [ "application/alto-endpointcostparams+json" ],
         "capabilities" : {
           "cost-constraints" : true,
           "cost-modes" : [ "numerical", "numerical", "schedule" ],
           "cost-types" : [ "routingcost", "hopcount", "pathoccupationcost" ],
           "cost-scope":  [ "permanent", "permanent",
                            {"unit": ["hour", 1], "size": 24, "begin": 0,
                             "time zone": "UTC",
                             "lastupdate": mm/hh/dd/mm/yyyy,
                             "nextupdate": mm/hh/dd/mm/yyyy}
           ]
         },
      {
         "uri" : "http://custom.alto.example.com/endpointcost/lookup",
         "media-types" : [ "application/alto-endpointcost+json" ],
         "accepts" : [ "application/alto-endpointcostparams+json" ],
         "capabilities" : {
           "cost-constraints" : true,
           "cost-modes" : [ "numerical", "schedule" ],
           "cost-types" : [ "routingcost", "routingcost" ],
           "cost-scope":  [ "permanent",
                            {"unit": ["hour", 1], "size": 24, "begin": 0,
                             "time zone": "UTC",
                             "lastupdate": mm/hh/dd/mm/yyyy,
                             "nextupdate": mm/hh/dd/mm/yyyy}
           ]
         }
       }
     ]
   }
```

3.3.1. Example scenario and response with a cost schedule

The Application Client is located in an end sytem with limited resources and has 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 constant for the scheduling period and the time sentitive decision metric is the path bandwidth reflected by a Cost type called 'pathoccupationcost'.

The ALTO Client embedded in the Application Client queries ALTO information on 'pathoccupationcost' for the 24 hours following (implicitely) the date of "lastupdate", as this resource is listed in the IRD.

```
POST /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" : ["pathoccupationcost"],
    "cost-mode" : ["schedule"],
    "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" : {},
    "data" : {
      "cost-type" : ["pathoccupationcost"],
      "cost-mode" : ["schedule"],
      "map" : {
        "ipv4:192.0.2.2": {
          "ipv4:192.0.2.89"    : [7, ... 24 values],
          "ipv4:198.51.100.34" : [4, ... 24 values],
          "ipv4:203.0.113.45"  : [2, ... 24 values]
        }
      }
    }
  }
```

4. 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 [ID-alto-protocol],

4.1. 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.

4.2. Information for IANA on proposed Endpoint Propeeries

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.

5. Acknowledgements

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6. References

6.1. Normative References

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[RFC5693] Seedorf, J. and E. Burger, "Application-Layer Traffic Optimization (ALTO) Problem Statement", RFC 5693, October 2009.

6.2. Informative References

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