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Using ALTO for exposing Time-Variant Routing information
draft-contreras-tvr-alto-exposure-03

Abstract

Network operations can require time-based, scheduled changes in nodes, links, adjacencies, etc. All those changes can alter the connectivity in the network in a predictable manner, which is known as Time-Variant Routing (TVR). Existing IETF solutions like ALTO can assist, as an off-path mechanism, on the exposure of such predicted changes to both internal and external applications then anticipating the occurrence of routing changes. This document describes how ALTO helps in that purpose.

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1. Introduction

There can be operational situations where changes in the network, such as modifications in either nodes, links or adjacencies, can introduce variations on the routing of that network. Use cases representative of such operational situations are documented in [I-D.ietf-tvr-use-cases]. Those predictable changes can be scheduled either from a higher-level system (e.g., OSS) or from a Network Controller.

Since the expected changes can be predicted beforehand, then it is possible to anticipate the impacts of that changes in the routing of the network, for instance by means of algorithms embedded in the Network Controller allowing to recalculate the resulting routing metrics, or through experimental observations e.g. in network digital twins [I-D.irtf-nmrg-network-digital-twin-arch].

Being feasible then to automatize the changes and to pre-calculate the impacts that those changes can introduce into the routing of the network, it is possible to expose in advance such changes in a way that applications (both internal and external) can become aware of those routing variations along time.

Current IETF solutions like ALTO [RFC7285] have been conceived for exposing topological information with associated metrics. In consequence, ALTO can be perceived as a suitable piece allowing to expose the impacts due to changes in the routing of a network. Figure 1 sketches a potential architecture facilitating the exposure of changes introduced by TVR operation. There can be multiple variants of such architecture.

```
        Network             (programming       (impact
        Operator ---------+ of scheduled      estimation
                          | TVR changes)     of scheduled
                          V                  TVR changes)
                   +-------------+       +--------------+
                   |   Network   |       |   Network    |
                   |  Controller |<----->| Digital Twin |
                   +-------------+       +--------------+
                       A     |
   (feeding impacts    |     |        (activation
   of scheduled +------+     +------+ of scheduled
   TVR changes) |                   | TVR changes)
                |                   |
                V                   V
           +--------+            ,------._
           |  ALTO  |         ,-'         `-.
           | Server |        /               \
           +--------+       (     Network     )
                A            \               /
                |             `-.         ,-'
     (exposure  |                `+------'
   of scheduled |                     ^
   TVR changes) |                     :
                |  (awareness         :
                | of scheduled        v
                | TVR changes) +-------------+
                +------------->| Application |
                               +-------------+
```

Figure 1. Potential architecture using ALTO for TVR

ALTO can act as an off-path mechanism for exposing scheduled topological changes. It permits different strategies at the time of working with time-based topological variations due to changes affecting nodes, links, adjacencies, or metrics.

One strategy is to relay on centralized network control elements populating scheduled changes to the ALTO server sufficiently in advance as to calculate and expose the intended topological changes before those changes are effectively activated in the network by the

controllers. That is, the introduction of changes is governed by the network controller configuring dynamically the network elements (i.e., nodes, links) following a planned set of actions. Such planned actions are the ones fed to ALTO so that ALTO can create and expose updated topological views for the scheduled modifications.

A second strategy is to disseminate the scheduled changes by means of the routing protocols in the network, so that the routing protocols distribute the planned topological changes at link or node level. It is worthy to note that a change distributed in this manner just by a single node can motivate a cascade of some other scheduled changes in different other nodes, thus representing potential stability issues that should be addressed with care. Anyway, in certain environments it can be suitable for signaling scheduled changes so that can serve as basis for deriving from it the topological views to be exposed by ALTO.

2. Capabilities of ALTO for exposing information

2.1. ALTO exposed information

ALTO [RFC7285] provides topological-related information in the form of both network and cost maps. The network map basically summarizes the IP address ranges aggregated in each Provider-defined Identifier (PID). Such IP addresses define either customers or service functions attached to each network node. The cost map details the topological relationship among PIDs in terms of a certain metric. The basic metric provided is the routing cost among PIDs, but other metrics can be also provided such as performance-related metrics [RFC9439].

Because of the possibility of incorporating additional metrics and a variety of topological information, ALTO can be considered as a generic IETF network exposure function [I-D.contreras-alto-ietf-nef].

2.2. Mechanism for anticipating routing changes in ALTO

For the purpose of exposing future changes on the reachability between PIDs in the network, ALTO defines in [RFC8896] a calendared cost map (named ALTO cost calendar) which allows to signal future changes on the cost metric. Thus, for a metric related to routing, the cost calendar can expose scheduled modifications in the connectivity between PIDs in a natural manner.

The ALTO cost calendar presents the information (i.e., metrics between PIDs) in the form of JSON arrays, where each listed value corresponds to a certain time interval. The ALTO cost calendar also includes attributes to describe the time scope of the calendar. The calendar provided by ALTO has the following attributes defined in [RFC8896]:

* "Calendar-start-time", which indicates the date at which the first value of the calendar applies.

* "Time-interval-size", that defines the duration of an ALTO Calendar time interval in a unit of seconds.

* "Number-of-intervals", that indicates the number of values of the cost calendar array.

* "Repeated", which is an optional attribute that indicates how many iterations of the calendar value array have the same values.

3. Ways of retrieving scheduled topological changes

According to the two strategies commented in the Introduction, it can be considered two different ways in which ALTO retrieves the information about scheduled topological changes. In one case, the changes can be notified directly by a network controller, while in the second case the changes are collected from advertisements in augmented routing protocols.

In both cases, the data model to be defined for representing the scheduled changes can be the same, so representing the changing topological events in a similar way. An example of a potential data model representing scheduled changes is proposed in [I-D.united-tvr-schedule-yang]. A model like that could serve the same purpose in any of the options describe next.

3.1. Interaction with a network controller

The architecture in Figure 1 assumes the intervention of a Network Controller in order to schedule and activate the changes in the network in a predictable manner. The network controller can pass the information about the planned changes to the ALTO server, so that the ALTO server can calculate the future topological map (in terms of network and cost maps provided by ALTO). Alternatively, if the network controller has the means of doing so, the network controller could even pass the future topology to ALTO. In any case, with the different topological representations, ALTO can expose the current and future views in a time-based manner leveraging on the cost calendar feature.

3.2. Interaction with routing protocols augmented to support TVR advertisements

As an alternative solution, it could be the case that existing routing protocols become augmented in order to natively support the advertisement of network changes along the time, as suggested in [I-D.taylor-tvr-prb-stmt]. If that is the case, ALTO can participate of the network routing information by listening to IGPs and/or peering with BGP speakers, as described in [RFC7971].

4. Assessment of ALTO as off-path solution against TVR requirements

The Time Variant Routing requirements are being documented in [I-D.ietf-tvr-requirements]. Despite that is yet a work in progress, it is convenient to start an assessment of the off-path solution provided by ALTO against the requirements expected to be supported by any TVR-capable solution.

The following Table summarizes the assessment exercise. The requirements are listed including the section (in brackets) of [I-D.ietf-tvr-requirements] where they are defined.

Requirement	Compliance
(3.1) Resource scheduling	Feasible to reflect scheduled changes in a topology by means of a sequence of network and cost maps along the time
(3.2.1) Scope of Time-Variability	Combines both time-invariant and time-variant entities. Allows representation of global and individual changes
(3.2.2) Time Horizon	Specified by means of "time-interval-size" attribute expressed in seconds
(3.2.3) Time Precision	Determined in units of seconds
(3.2.4) Validity in a Schedule	Permits to accommodate multiple subsequent schedules
(3.2.5) Periodicity in a Schedule	Repetitive states specified by means of the attribute "repeated"

(3.2.6) Continuity in a Schedule	Governed by the "time-interval-size" attribute expressed in seconds
(3.2.7) Time-Overlap and Priority	Not supported. It would require extension of RFC8896
(3.2.8) Property Value Interpolation	Zero-order hold mode. Other modes could be potentially supported
(3.2.9) Changes to Model State	Support of fine-grained changes
(3.3) Topologies	Schedules applicable to nodes and links. Support of potential future node or link connectivity
(3.4) Routing	Allows computation of TVR-enabled paths

5. Security and operational considerations

Same security and operational considerations as described in [RFC8896] apply also in this document.

6. Informative References

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