The IETF ALTO protocol and its extensions

Helping end hosts and applications to have a topology-aware insight into end to end paths

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IETF100 PANRG meeting – Nov 16 2017

Open questions in PANRG & challenges

- See https://tools.ietf.org/html/draft-trammell-panrg-questions-01 11/07
- How are path properties defined and represented?
- How do endpoints get access to trustworthy path properties?
- How can endpoints select paths to use for traffic in a way that can be trusted by the network?
- How can interfaces to the transport and application layers support the use of path awareness?
- How can a path aware network in a path aware internetwork be effectively operated, given control inputs from the network administrator as well as from the endpoints?
- Some challenges gathered from list discussions
  - Different priorities for hosts and networks
  - Privacy concerns on both sides
    - "pseudo" instead of "real" path information more appropriate for end points and more realistic from networks' controller
  - What is the appropriate level of exposure?

The IETF ALTO protocol

- Exposes abstracted operator-centric network view to applications and end hosts
- Goal: guide applications for a topology-aware selection among several endpoints
  - Trading operator cost efficiency with equal or better application performance
- To this end, ALTO offers RESTful APIs to convey provider-defined
  - **ALTO network map**: set of network location groupings with Provider-Defined Identifier (PIDs) and enumerated endpoints in each group.
  - **PID**: indirect and network agnostic manner to aggregate network endpoints that share some characteristic: subnet, POP, autonomous system, central office, …
  - **ALTO cost map**: pairwise e2e path costs amongst sets of source and destination PIDs or endpoints.
- ALTO thus hides complexity and confidentiality
  - Network can protect confidential network state information, by abstracting real metric values into non-real numerical scores or ordinal ranking
- ALTO information assumed not available to 3rd parties by other means
- Requires mutual trust between operator and applications

ALTO – base protocol – RFC 7285

- « single node » topology abstraction
- 1 path per destination
- Specifies and conveys 1 single « routingcost » metric between src and dest
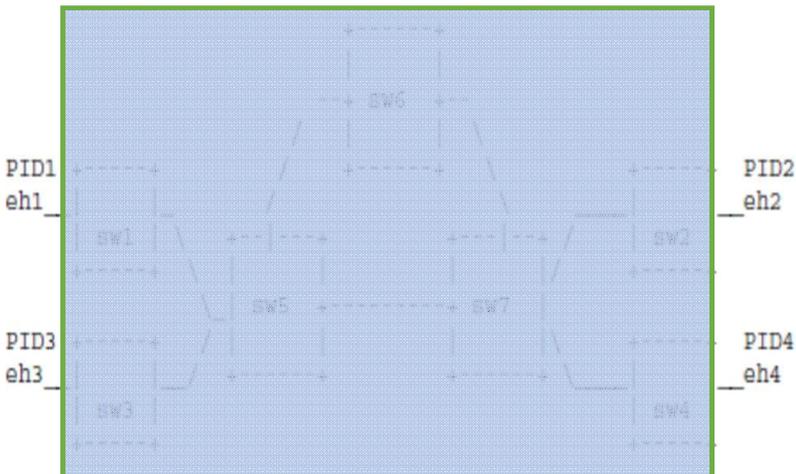

```
GET /costmap/num/routingcost HTTP/1.1
...

HTTP/1.1 200 OK
...
{
"meta" : {
    ...
    "cost-type" :
        {"cost-mode": "numerical",
         "cost-metric": "routingcost"},
    }
"cost-map" : {
    "PID1": {"PID1": 1, "PID2": 5, "PID3": 8 "PID4": 6},
    "PID2": {"PID1": 5, "PID2": 1, "PID3": 1,"PID4": 8},
    "PID3": {"PID1": 5, "PID3": 8, "PID3": 1},
    "PID4": {"PID1": 6, "PID2": 10,"PID3": 1},
}
}
```

PID = City, Region, any name, …

IETF ALTO WG extensions relating to PANRG

- Base protocol: [RFC 7285] = **WHERE to connect**
- The ALTO WG specifies protocol extensions for deeper insight in paths
- Relation to PANRG: **HOW to connect** given N >= 1 paths / destination
  - ALTO Path Vector Cost Mode = multi-switch path [id-pvect]
    - Exposes abstraction of some intermediate steps of available paths
  - ALTO Contextual Cost Values: several costs per metric for one dest [pd-acont]
    - Exposes costs given qualitative parameters such as « access type » or others
  - Multi-Cost ALTO [RFC 8189]
    - Exposes costs IF path is feasible : w.r.t. constraints on cost values – path filtering
- ALTO Network Performance Cost Metrics [id-aperf]
  - Abstraction of network delay, jitter, packet loss, hop count, and bandwidth
- WHEN to connect = ALTO Cost Calendars [id-acal]
  - 1 or N destinations, one path for each

HOW to connect - ALTO path vector- in progress

Provides abstracted details on paths

- **Abstracted Network Elements (ANE)**
  - **Set of $N \geq 1$ switches, links, networks, …**
  - **ANE properties may be exposed in a separate « ANE property map »**

All link capacities = 100
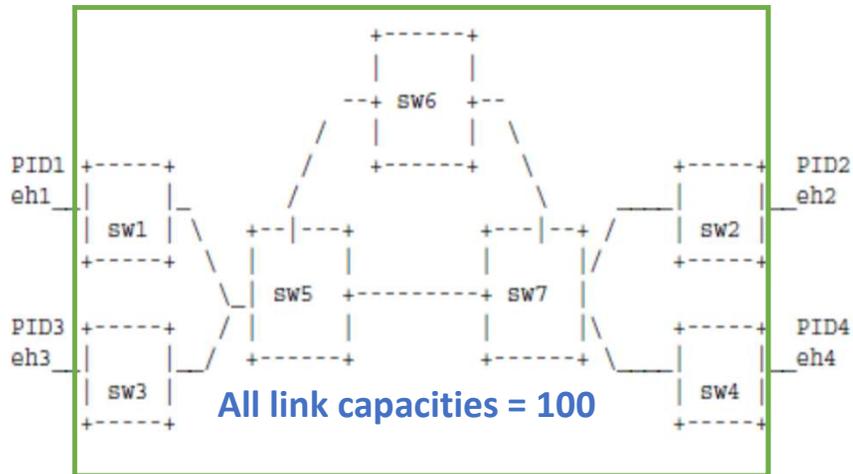
```
HTTP/1.1 200 OK
…
{
"meta": {
  "dependent-vtags": […],
  "multi-cost-types": [
    {"cost-mode": "array", "cost-metric": "ane-path"},
    {"cost-mode": "numerical", "cost-metric": "BWcapa"}]
  "vtag": { //information to get ANE properties}
},
"cost-map": {
  "PID1": {
    "PID2": [["ane:L15", "ane:L56", "ane:L67", "ane:L72"], 100]},
  "PID3":
    "PID4": [["ane:L35", "ane:L57", "ane:L74"], 100]      }}}
```
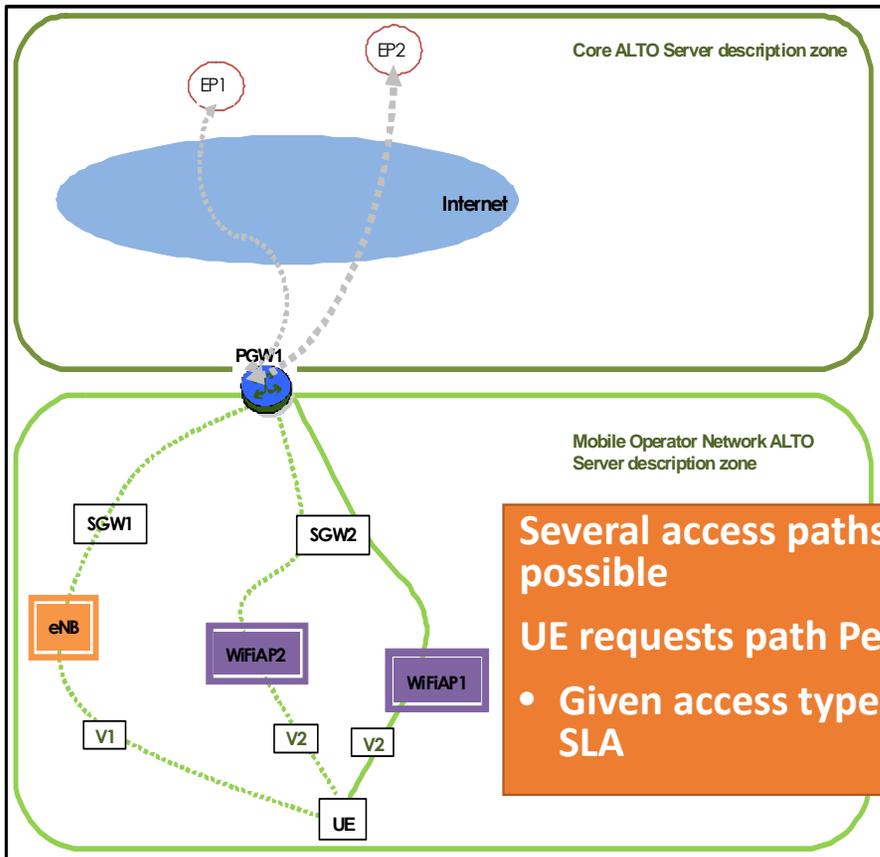
The application thus knows whether flows share bottleneck and how much total capacity they get

HOW to connect - ALTO Cost Context – in progress

Several access paths possible

UE requests path Perf

- **Given access type and SLA**

```
HTTP/1.1 200 OK
Content-Length: [TODO]
Content-Type: application/alto-endpointcost+json
{
  "meta" : {
  "cost-type" : {"cost-mode" : "numerical",
                 "cost-metric" : "BWscore"},
  "context-params" : [["cell", "wifi"], ["SLA-3"]]
   }
  "endpoint-cost-map" : {
    "ipv4:192.0.2.2": {
      "ipv4:192.0.2.89" : [10, 5],
      "ipv6:2000::1:2345:6789:abcd" : [4, 6]
    }
  }
}
```

Array of 2 context-based values:
[cell AND sla3, wifi AND sla3]

HOW to connect – Multi-Cost ALTO with constraints
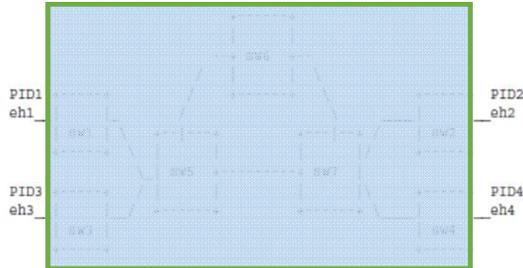
Client can request « routingcost » + « BW capacity »
On paths with EITHER lower cost and bandwidth
OR   higher cost and bandwidth

ALTO response provided ONLY on paths meeting the constraints

```
POST /costmap/filtered HTTP/1.1
...
{
  "multi-cost-types" : [
    "cost-mode": "numerical", "cost-metric": "routingcost",
    "cost-mode": "numerical", "cost-metric": "BWcapa"
  ],
  "or-constraints" :  [["[0] le 30", "[1] le 70"]
                       ["[0] le 50", "[1] gt 80"]],
  "pids" : {"srcs" : [ "PID1" ],
            "dsts" : [ "PID2", "PID3" ]}
}
```

```
HTTP/1.1 200 OK
Content-Type: application/alto-costmap+json
{
  "meta" : {
    "dependent-vtags" : [...],
    "multi-cost-types" : [ ... ]
  }
  "cost-map" : {
    "PID1": {
      "PID2": [40, 90]
    }
  }
}
```

WHEN to connect – ALTO Cost Calendars – in progress

```
HTTP/1.1 200 OK
Content-Type: application/alto-costmap+json
Content-Length: ###
{
"meta" : {...
  "cost-type" : {"cost-mode": "numerical", "cost-metric": « BWcapa"},

  "calendar-response-attributes" : {
      "calendar-start-time" : Wed,  18 Oct 2017 00:00:00 GMT,
      "time-interval-size" : "4 hour",
      "numb-intervals" : 6 }
   } // end meta

"cost-map" : {
    "PID1": {
      "PID2": [90, 70, 80, 90],
      "PID4": [90, 80, 60, 80]
  }  }}
```

- Array of time-dependent cost values
- Attributes specifying how to understand them

References

- ALTO Status Pages
  - https://tools.ietf.org/wg/alto/
- [RFC 7285] - Application-Layer Traffic Optimization (ALTO) Protocol
  - https://tools.ietf.org/html/rfc7285
- [id-pvect] « ALTO Extension: Path Vector Cost Mode »
  - https://tools.ietf.org/html/draft-ietf-alto-path-vector-00
- [pd-acont] « ALTO Contextual Cost Values »
  - https://tools.ietf.org/id/draft-randriamasy-alto-cost-context-02.txt
- [RFC 8189] « Multi-Cost ALTO »
  - https://tools.ietf.org/html/rfc8189
- [id-aperf] « ALTO Performance Cost Metrics »
  - https://tools.ietf.org/html/draft-ietf-alto-performance-metrics-02
- [id-acal] « ALTO Cost Calendar »
  - https://tools.ietf.org/html/draft-ietf-alto-cost-calendar-02