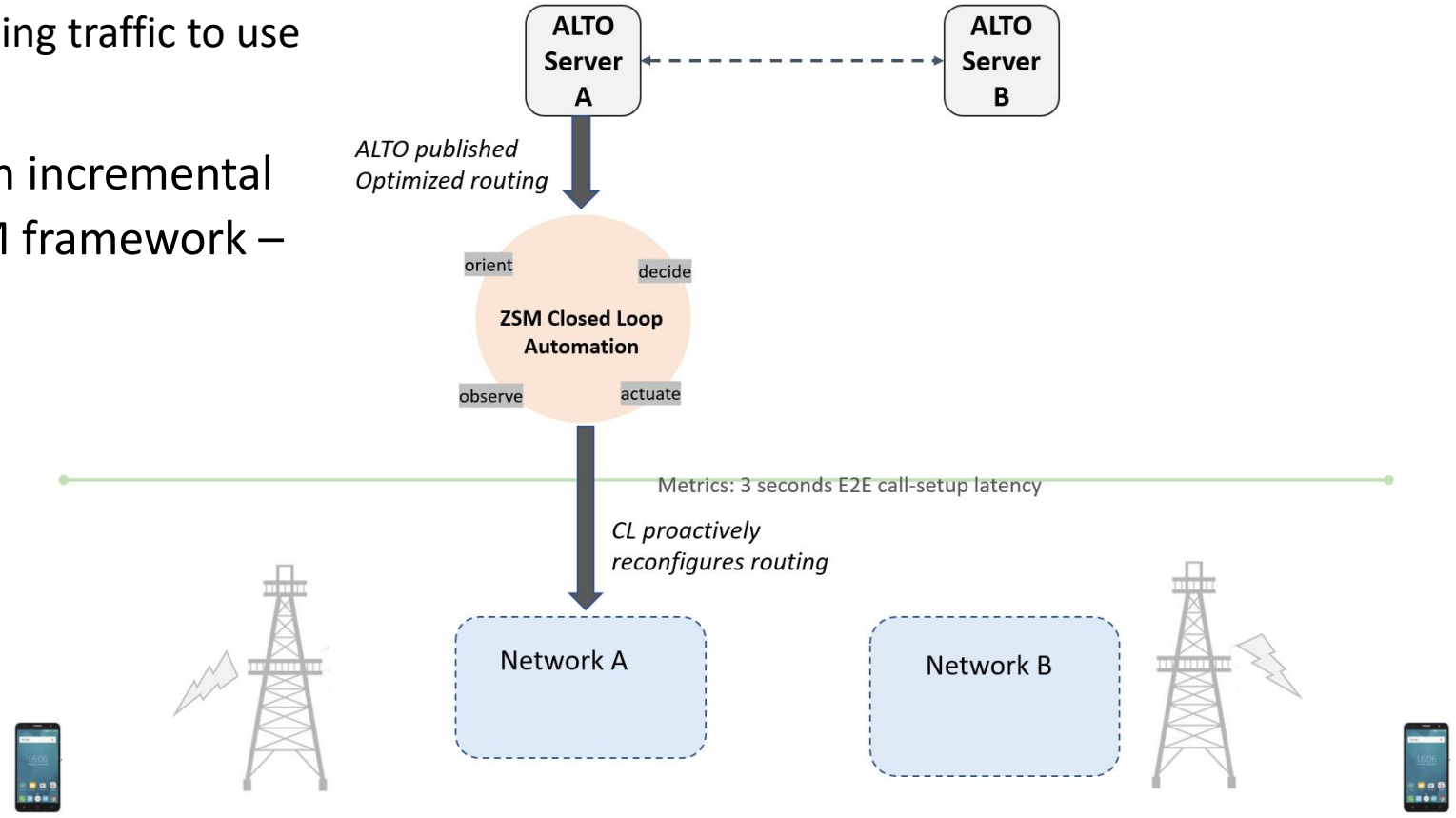
MoWIE information exposure, benefit and proposals

- **Problem description and benefits**
  - Cellular networks are better, but network variations are larger. In addition, applications are more adaptive, e.g. adaptive bitrates
  - Live network trials have been conducted to demonstrate it is beneficial to expose refined granularity of cellular information, especially for cloud interactive services, for throughput improvement and latency reduction
  - Such cellular information can be conveyed via in-band or out-band for application usage
  - Currently the solution is proprietary and not standardized. e.g., such information is not supported by current ALTO Information Services
- **Potential exposed cellular network Information**
  - UE level information, e.g. Radio channel status, User plane measurements
  - Cell/slice level information, e..g Cell/slice load status
  - The period of validity should be specified
- **Use case1: ABR for Cloud gaming**
  - Exposing radio channel status, e.g. MCS, to derive predicted bandwidth for adaptive bitrates of cloud gaming
  - Lagging ratio (MTP>200ms) is significantly reduced from 63% (a constant bit rate of 7.5 Mbps) to 19% (average bit rate of 6.7 Mbps)
- **Use case2: Video QoE Prediction**
  - The UE radio channel status (e.g., RSRP, CQI, MCS), User plane measurements (e.g. PDCP buffer status, DL PDCP data rate, MAC data rate) and cell load are used to predict video QoE(stalling probability) for seconds
  - A feedforward neural network with LSTM Model, 100K samples, overall QoE prediction accuracy up to 85%. The predicted accuracy of video stall ratio is over 90%.
- **Use case3: TCP Performance optimization**
  - Available UE radio bandwidth and Available UE buffer size for TCP sending window adjustment every 100 ms
  - Under the good and medium coverage, the throughput is significantly improved by more than 50%
- **Proposal**
  - Extend ALTO to provide a single framework to support cellular information exposure

ETSI ZSM Use Case

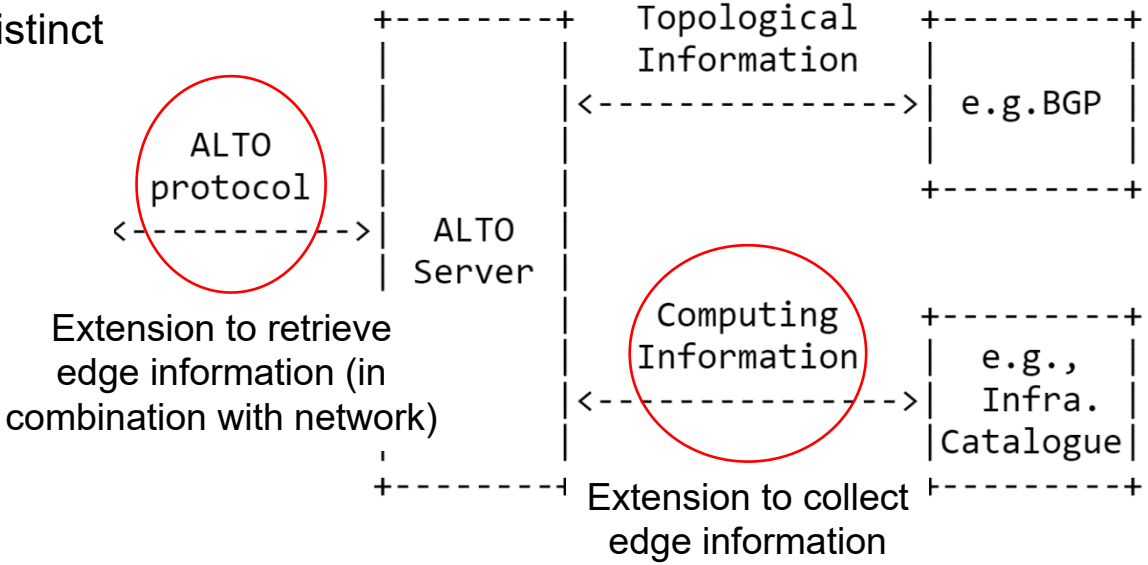
- Today: ZSM Closed Loop automation would react to network anomaly (e.g. E2E call setup latency for 5G VoNR)
  - Example resolution is to reroute the signaling traffic to use a less congested path (reactive)
- ALTO to proactively and reactively (through incremental updates) provide optimized routing to ZSM framework – avoid congested path
- ALTO extensions to realize ZSM support
  - Support cellular entities
  - Support cellular performance metrics
- Collaboration with ETSI ZSM (LS)
  - ZSM004 Landscape specification
  - ZSM009-2 CL automation-Solution



Using ALTO to Determine Service Edge

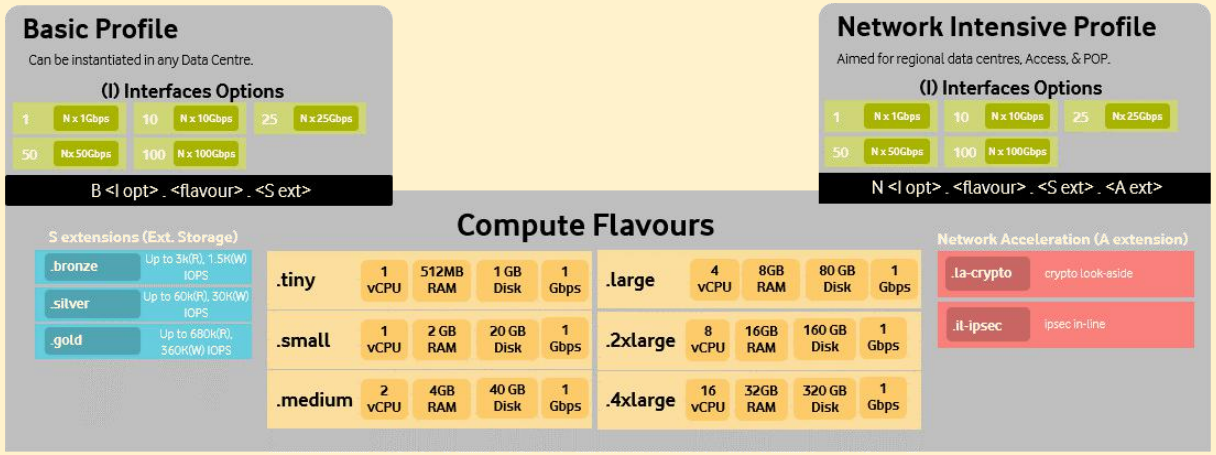
draft-contreras-alto-service-edge

- Problem:
  - Multiple data centers of different sizes across the network of distinct sizes (CPUs, memory, storage, bandwidth, etc)
  - Identify the proper DC for a given application considering both compute and transport substrates
- Solution:
  - Leverage on ALTO to assist on the selection of the more “convenient” edge combining transport network information
- Recharter:
  - Allowing clients to request edge information
  - Handling and combine service edge plus network information



Example

Common Network Function Virtualisation Infrastructure Telecom Taskforce (CNTT)



https://cntt-n.github.io/CNTT/doc/ref_model/chapters/chapter04.html

Flavor Name	Type of instance (T)	Interface Option (I)	Compute flavor (F) {CPU, RAM, disk and bandwidth}	S.	A.
Small-1	Basic	{1, 2, 3, 4, 5, 6, 7, 8, 9 Gbps}	{1,512 MB,1 GB,1 Gbps}	...	...
Small-2	Network Intensive	{1, 2, 3, 4, 5, 6, 7, 8, 9 Gbps}	{1,512 MB,1 GB,1 Gbps}	...	...
Medium-1	Network Intensive	{25, 50, 75, 100, 125, 150 Gbps}	{2,4 GB,40 GB,1 Gbps}	...	...
Large-1	Compute Intensive	{50, 100, 150, 200, 250, 300 Gbps}	{4,8 GB,80 GB,1 Gbps}	...	...
Large-2	Compute Intensive	{100, 200, 300, 400, 500, 600 Gbps}	{8,16 GB,160 GB,1 Gbps}	...	...
...	...	...	...	...	...

Delivering Functions over Edge Computing by Using ALTO protocol

- Problem description and benefits
  - Function as a Service are popular for modern applications
  - Delivering functions in distributed networks, e.g., edge computing, is difficult due to the lack of global view
  - ALTO protocol provides global network information and capabilities for distributed architectures, which can be adopted for function delivery
- Proposal
  - Use ALTO protocol to provide a global view to deliver functions to the appropriate edge servers
  - Extend cdni to provide footprints to generic functions/capablities

- Function Delivering Process
  - ALTO client requests the information from ALTO server, e.g., network map and cost map, FCI of distributed edge clusters
  - Cluster Client gets information from ALTO client and connects and delivers function to the corresponding edge computing cluster, which will process and return the computation results to users
- Where will it be deployed?
  - qzcloud, one of a large function delivery network, providing 100x functions, in trial.

ALTO Extensions for Huge Data (Harvey Newman on behalf of team)

Problem

- SENSE [1] is a DoE project building smart network services to accelerate scientific discovery in the era of 'big data'.
- The SENSE architecture is 'intent' based, to support complex workflows of science applications managing the network as first-class schedulable resources spread across a vast footprint
- IETF standard based solutions have many benefits, ALTO resource information models (cost metric, calendar and path vector) are good match, but existing ALTO **services** need extensions

1. Build on existing ALTO models, to define **flexible resource information services** that instantiate SENSE services including Time-Block-Maximum Bandwidth (TBMB), Bandwidth-Sliding-Window (BSW), and Time-Bandwidth-Product (TBP)
2. Define **interaction models (standard or informational)** between the resource information services and resource life-cycle management services

Initial Result on Resource Information Service Design

- Network resource status as a time series
- Network resource aggregation/filter operators to define flexible, general resource information services
- Well understood in related context such as network measurements information [2] to be ready to be adopted in ALTO for resource information

TBMB	`"argmax(bw_gbps[10h:])"`
BSW	`"min(bw_gbps[10h:]) >= 40"`
TBP	`"sum(bw_gbps[8h:5m]) * 300 / 8 >= 36000"`

Discussions

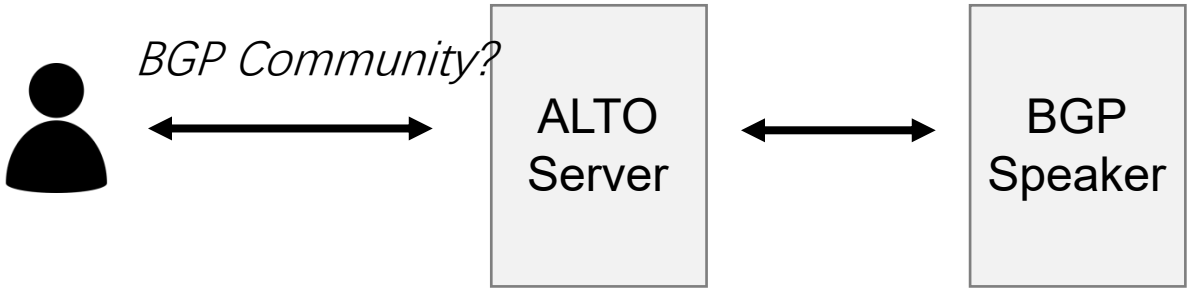
- Need to limit the scope of the resource information model to make concrete progress (e.g., a generic functional model can be more general but too complex)
- Propose strong collaboration between ALTO, SENSE/AutoGOLE and GNA-G PNWG; discussions minutes at [3]

[1] http://sense.es.net
[2] http://https://prometheus.io/docs/introduction/overview/
[3] https://docs.google.com/document/d/1h1AHt1JsyXT3U1z0vdSaGV0VUjyvd5jRoPfYKL6q_Zk/edit

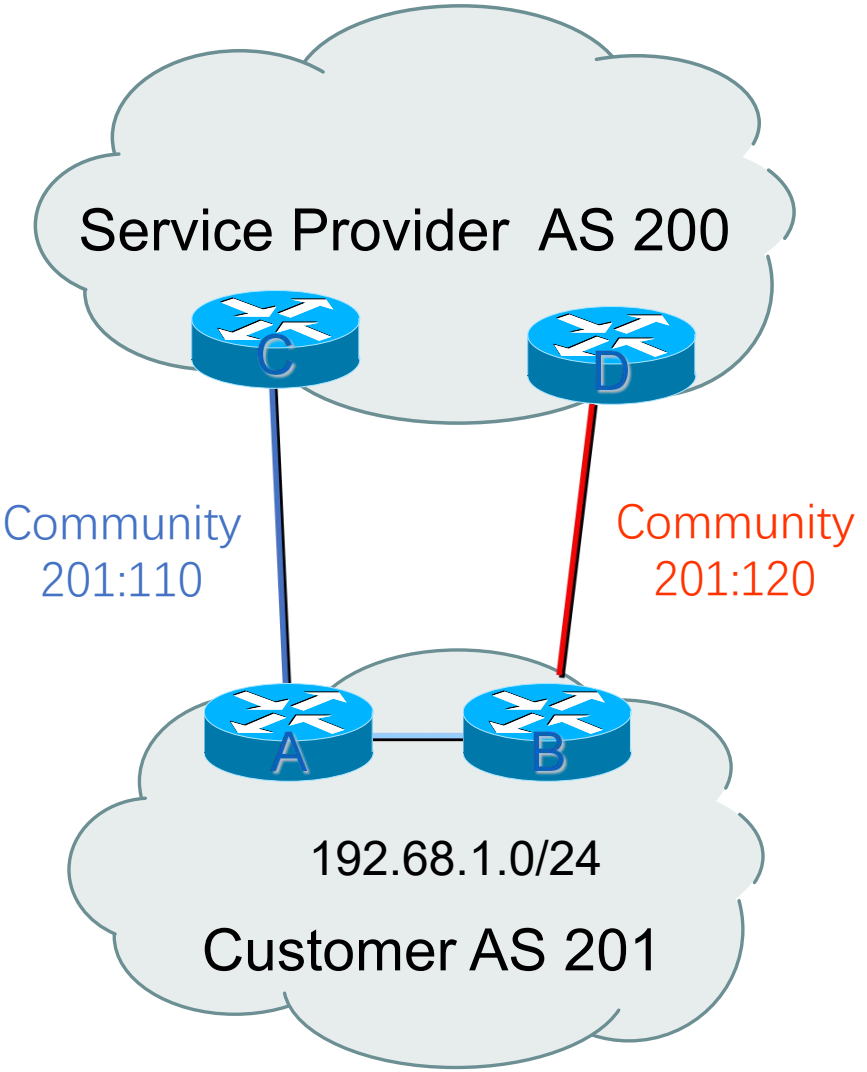
ALTO extension to support BGP Communities

draft-contreras-alto-bgp-communities-00

- Problem:
  - Network operators use extensively BGP Communities for applying policies to a group of destinations (i.e., IP prefixes)
  - ALTO works with PIDs which also are essentially destination groupings, but decoupled from the concept of BGP Community
  - BGP Communities are advertised through BGP, then being consumable by ALTO
- Solution:
  - To extend ALTO for supporting BGP communities for both map formation and retrieval
- Recharter:
  - ALTO to process Community information from BGP (as used to get topology information)
  - ALTO to provide Network / Cost maps based on Communities

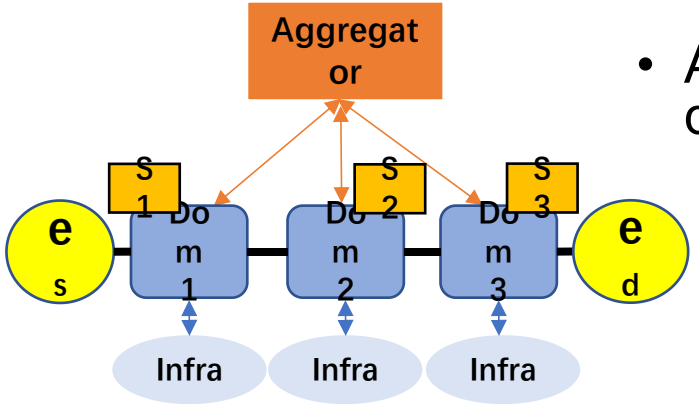


Community	Local Preference
201:110	110
201:120	120



Multi-domain ALTO services

- **Motivation:**
  - A common setting for many novel use cases is that the traffic from **a source to a destination traverses multiple domains**. E.g., data intensive science applications, multi-domain SFC, flexible inter-domain routing control.
- **Problem statement & solution:**
  - From single network representation to **multiple network representation.**
  - Look up every single ALTO service (network/cost map, path vector) and make it multi domain.



- A single aggregator A is queried:
  - The aggregator A represents the networks of D domains (D1, D2, D3).
  - Each domain Di has its internal ALTO server Si.

- Network Map
  - Provides a partition of D1 U D2 U D3
- Cost Map (e_s -> e_d, where e_i in D)
  - Aggregator A discovers the domain paths from (e_s,e_d) = [D1->D2->D3]
  - Aggregator A discovers the ALTO server Si for each domain ([D1,S1],[D2,S2],…)
  - Aggregator A discovers E2E cost (e_s -> e_d) = Sum i domains (cost[Di])**

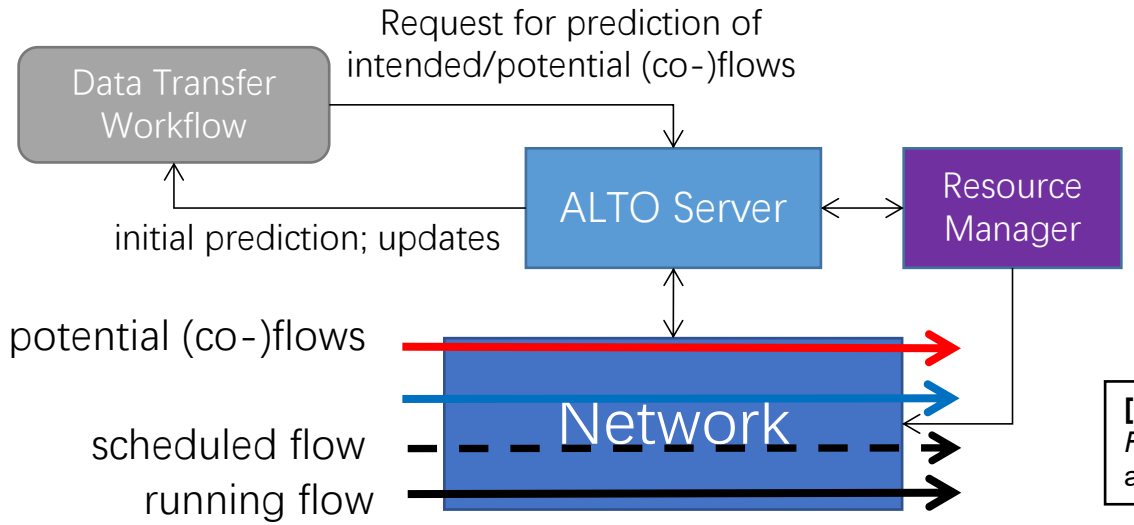
- **Standards direction:**
  - Motivating use cases & design requirements [MD-ALTO1][MD-ALTO2] (**Informational draft(s)**).
  - Multi-domain discovery
    - Sequence of domains/candidate paths [RFC4271] [RFC7752] [RFC5441][RFC6805]
    - ALTO server discovery for each domain [RFC8686] [RFC4674] [PROTO-BGP]
  - Multi-domain aggregation
    - Unified representation
      - **Universal units (bw, latency, etc)
      - Mathematical programming constraints ([UNI-REPRE][UNICORN][MERCATOR])
    - Vector representation
      - Not universal units (Numerical cost but ordinal).
- **Open discussion:**
  - What parts are already ripe for standardization?
    - or we need further discussions?
  - Are industrial players willing to implement/deploy?
    - Benocs?, which parts require standardization?

Predictive Throughput for TCP Reactive Flows

Problem

- Network flows in many use cases are reactive flows (e.g., data transfer using GridFTP, FDT over TCP)
- Resource to be obtained by such flows will need to be predicted
- Prediction needs network information (e.g., network multiplexing level, calendar) and is a good match for ALTO, but missing in current ALTO services

Architecture



Foundational Result

- *Network Utility Maximization (NUM) Model-based Throughput Prediction for Reactive Flows in DC Networks* [Prophet-ToN]

Recharter Proposals

New resource information request model, supporting

- New cost metric enabling predictive cost;
- Related parameters such as flow-level information (e.g., number of simultaneous TCP streams)

Discussions

- The service can be highly valuable, but at the same time, the service design needs careful, **thorough discussion and specification** on the operational issues on **overhead** (e.g., limit incremental updates), **stability**.

[Prophet-ToN] *"Prophet: Toward Fast, Error-Tolerant Model-based Throughput Prediction for Reactive Flows in DC Networks"* (TNET-2018-00567.R2). Appeared in INFOCOM 2018; Extended version to appear In ACM/IEEE Transactions in Networking 2020.

Flow-base Network Information Query

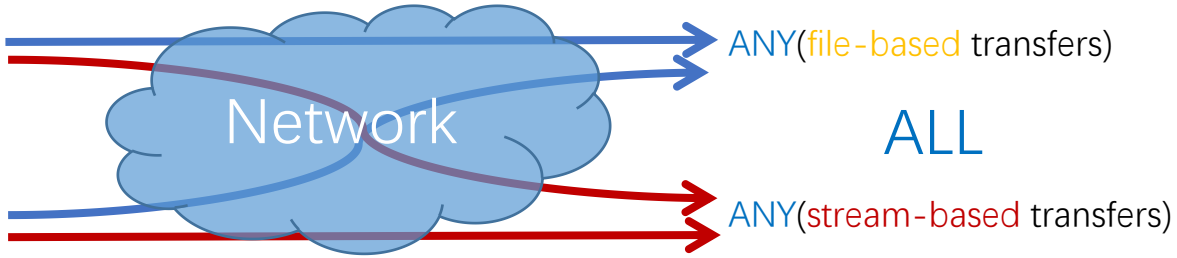
draft-gao-alto-fcs

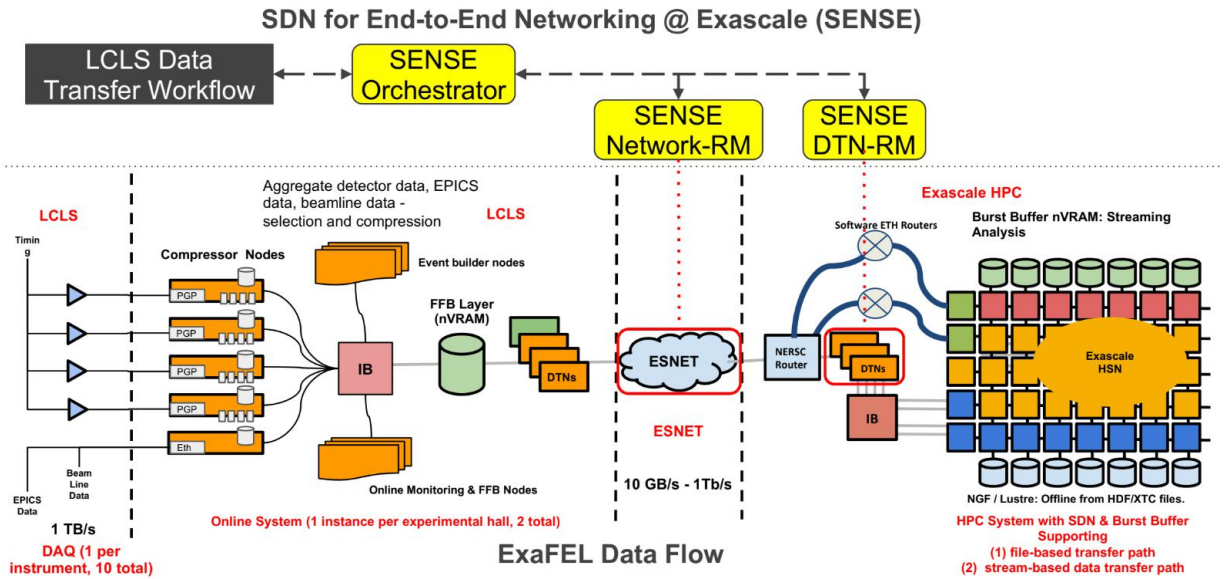
Problem

- Basic ALTO connection is coarse-grained, but there are use cases (e.g., SDN for end-to-end data transfers) with fine-grained (e.g., TCP 5 tuples) resource allocation
- Basic ALTO considers simple co-flow model, but there are use cases with more complex patterns beyond full-mesh individual flows
  - ANY: only one flow will go
  - ALL: all the flows go simultaneously

Initial results and re-charter proposal

- Extend query schema to support generic attributes of **Flow**
- Extend query schema to express semantics of **CoFlow**





https://drive.google.com/file/d/1081YTFQVYC1yMR2AJRUYtf2nz-Ncm_Gp/edit

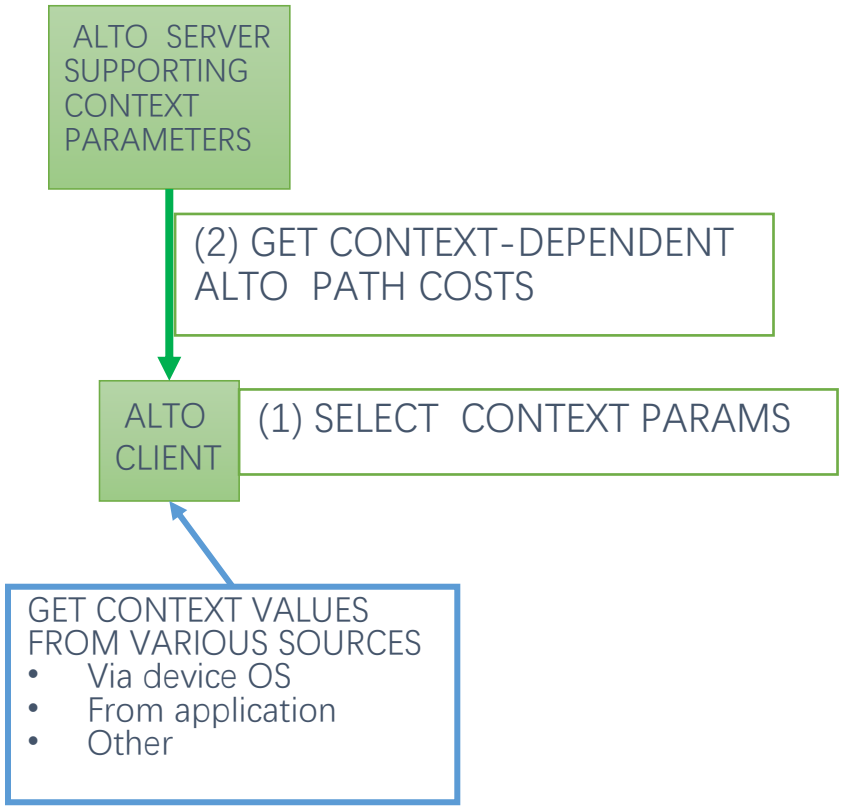
Open Discussions

- Generic design for Internet
- Security considerations

Path cost for (src, dst) pair may take several values depending on Context
- Several network conditions, Several paths, Several policies, Other Context parameters
- may have different dynamics, or come from diverse channels,

Current ALTO provides

One single cost value per (src, dst) pair




```
HTTP/1.1 200 OK
Content-Type: application/alto-costmap+json
Content-Length: ###
{
"meta" : {
  "dependent-vtags" : [
  {"resource-id": "my-default-network-map",
   "tag": "3ee2cb7e8d63d9fab71b9b34cbf764436315542e"}
  ],
   "cost-type" : {"cost-mode": "numerical", "cost-metric": "RFcost"},
   "context-params" : [["uda", "uplink"],
                       ["uda", "downlink"],
                       ["udna", "uplink"],
                       ["udna", "downlink"]]
  }
  "cost-map" : {
    "Cell1": { "Cell1" :  [70, 20, 90, 20], "Cell2":  [20, 70, 20, 90]}
  }
}
```

Discussion: How to make the design modular and scalable
- To support both fixed and variable Context values
- To logically combine context parameters

Generic Query Language Extension for ALTO

Problem

- The network information query mechanisms in the base ALTO protocol have limitations in allowing applications to discover additional resource information (e.g., on-demand routing) that can satisfy their needs (e.g., waypoint routing).

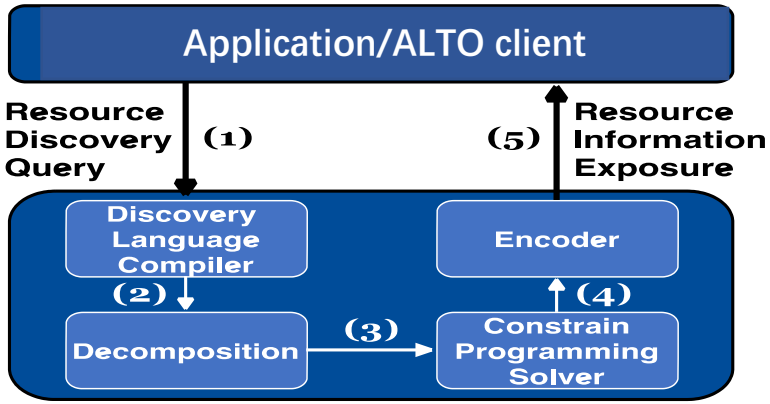
Preliminary architecture

- Use generic, mathematical-programming constraints as a unified, compact representation of resource information [draft-xiang-alto-unified-representation]
- Design a SQL-style generic resource query language for application / ALTO client to express their intents on discovering resources in the network [PED-NAI20]

Deliverables

A new Internet draft that

- specifies a new cost type that uses generic, mathematical-programming constraints as a unified information representation
- extends the ALTO query mechanisms to a generic, language-based resource information query mechanism

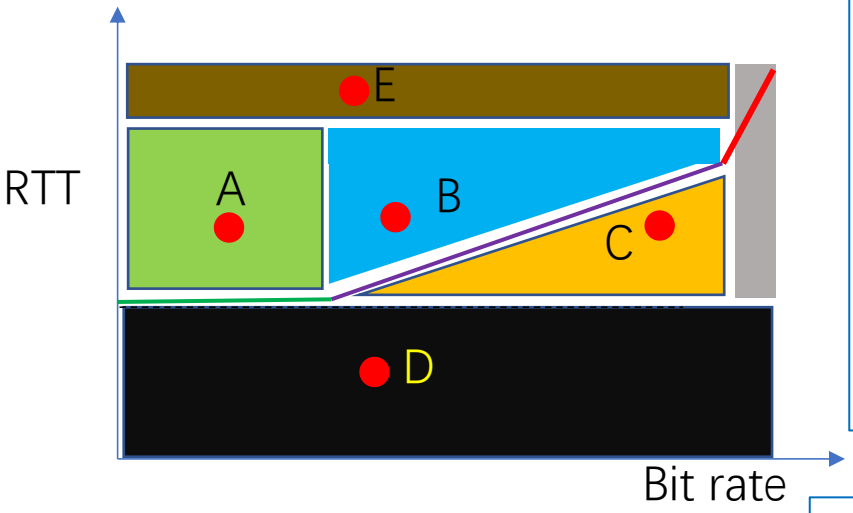


Where may it deploy

- Data center
- SD-WAN
- Data-analytics platforms (e.g., SENSE) and systems (e.g., HTCondor and Spark)

In band + Out of Band Network Information Exposure

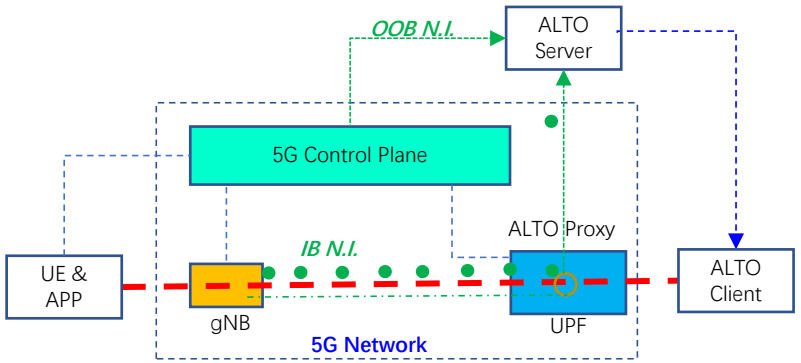
1. Problem Description



Cloud Gaming APP is sensitive to the latency and bandwidth. The Cloud Gaming APP needs to detect the network capability , determines the its status (as the left figure) and changes its APP functions or codec scheme.

- A area are safe.
- **B area is not stable enough**
- **C area can stay for a very short time**
- D area is forbidden.
- E area is not supported.

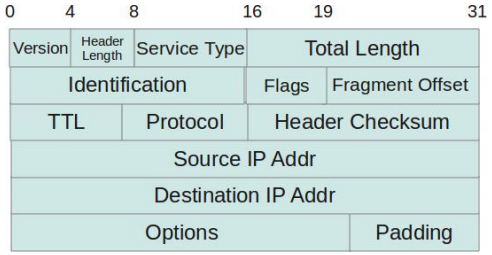
2. IB+ OOB Description



The Radio Link capability is changed frequently in the wireless communication network.

- OOB network information exposure architecture has been defined in TS23.222 for 4G and TS 23.501 for 5G. OOB can be used firstly by the ALTO. but only static or low changed information can be provided in OOB.
- IB network information can provide quick changed information.
- Related Standard work has started in 3GPP R17 EC SID, and some solutions are proposed in TR 23.748.
- In IETF, there are also some draft papers:
  - MoWIE for Network Aware Application
  - Mobile Throughput Guidance Inband Signaling Protocol

3. Standards Direction



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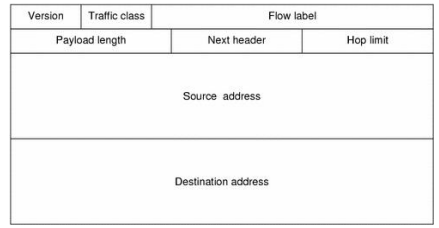


1280-40=1240Bytes

1. Uniformed ALTO Architecture to support IB,OOB, IB+OOB network information.
2. ALTO Server initiates and collects the IB, OOB, IB+OOB network information collection from heterogeneous networks.
3. IB network information piggybacked in **IP/TCP** or **GTP-U** header.

4. Who wants to use

- Tencent Cloud Gaming, Tencent Cloud Meeting, Tencent Video
- Tests have been performed in CMCC real mobile network.

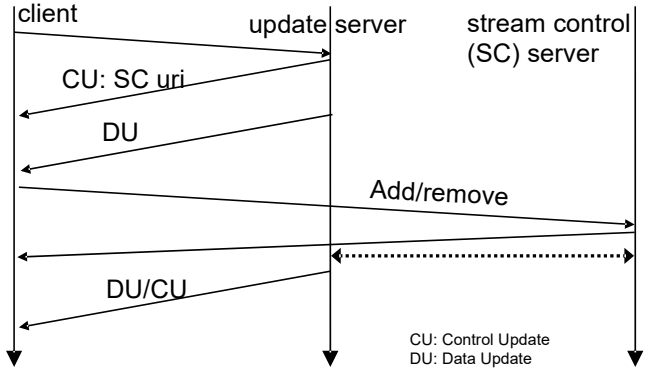
5. Open Discussion

1. Combine the IB and OOB network information.
2. Whether to use an IB path-associated protocol, like the ICMP+
3. Security and Access Control

ALTO Transport Extensions: HTTP/2/3 as Transport (Y. Richard Yang on behalf of team)

Problem

- Both standard ALTO information services (e.g., 7285) and ALTO incremental updates (e.g., ALTO SSE) are based on HTTP/1.x and hence they need to add mechanisms to address HTTP/1.x issues (handling one resource request at a time)



- Extension of ALTO SSE from HTTP/1.x to HTTP/2 was discussed and promised during IESG review of ALTO SSE, but it is not done yet
- Extend ALTO transport from HTTP/1.x to HTTP/2 can have multiple benefits
  - Bi-directional control of resource information
  - Multiplexing without head of line blocking
  - High encoding efficiency

Initial Design of ALTO Incremental Updates with a simple design using a single HTTP/2 connection

- Request: client picks HTTP/2 stream-ID (only number, no longer generic string), and sends the update request to the server
- Updates: server uses SSE encoding to push full-replace/incr of the resource through the HTTP/2 stream
- Close: Server closes stream by indicate END_STREAM flag of last DATA; Client closes stream by sending RST_STREAM; Client closes stream by sending RST_STREAM

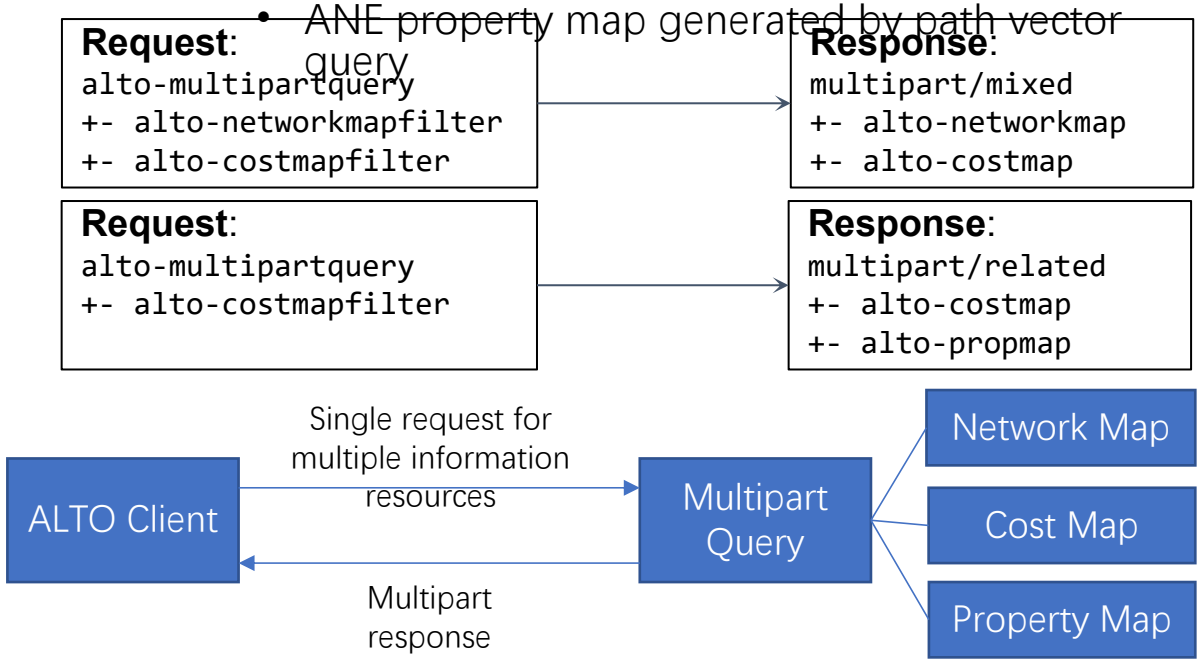
Discussions

- An introduction of a new ALTO transport is a wonderful opportunity but need careful coordination for usability and relevance:
  - coordinate with the MOWIE use cases
  - consider the possibility of IB + OB

ALTO Transport over Multipart Messages

Problem

- An application requests multiple ALTO information resources simultaneously
  - Path Vector: cost map + property map
  - CDNi: network map + CDNi advertisement
- Requesting dependent information resources separately increases latency and may lead to inconsistency
- Information resources may be anonymous
  - ANE property map generated by path vector query



Results and Initial Design

- **[draft-ietf-alto-path-vector]** has succeeded by adopting multipart messages and proven its feasibility
- **[draft-ietf-alto-incr-update-sse]** has supported incremental updates of multipart messages
- **[draft-zhang-alto-multipart-04]** proposed a new ALTO service to support multipart messages in general cases
  - IRD capability: declare an ALTO information resource supporting multipart messages
  - Request: provide a unified request schema for multipart messages
  - Dependency: announce dependencies among related information resources
  - Error Handling: handle error of each part

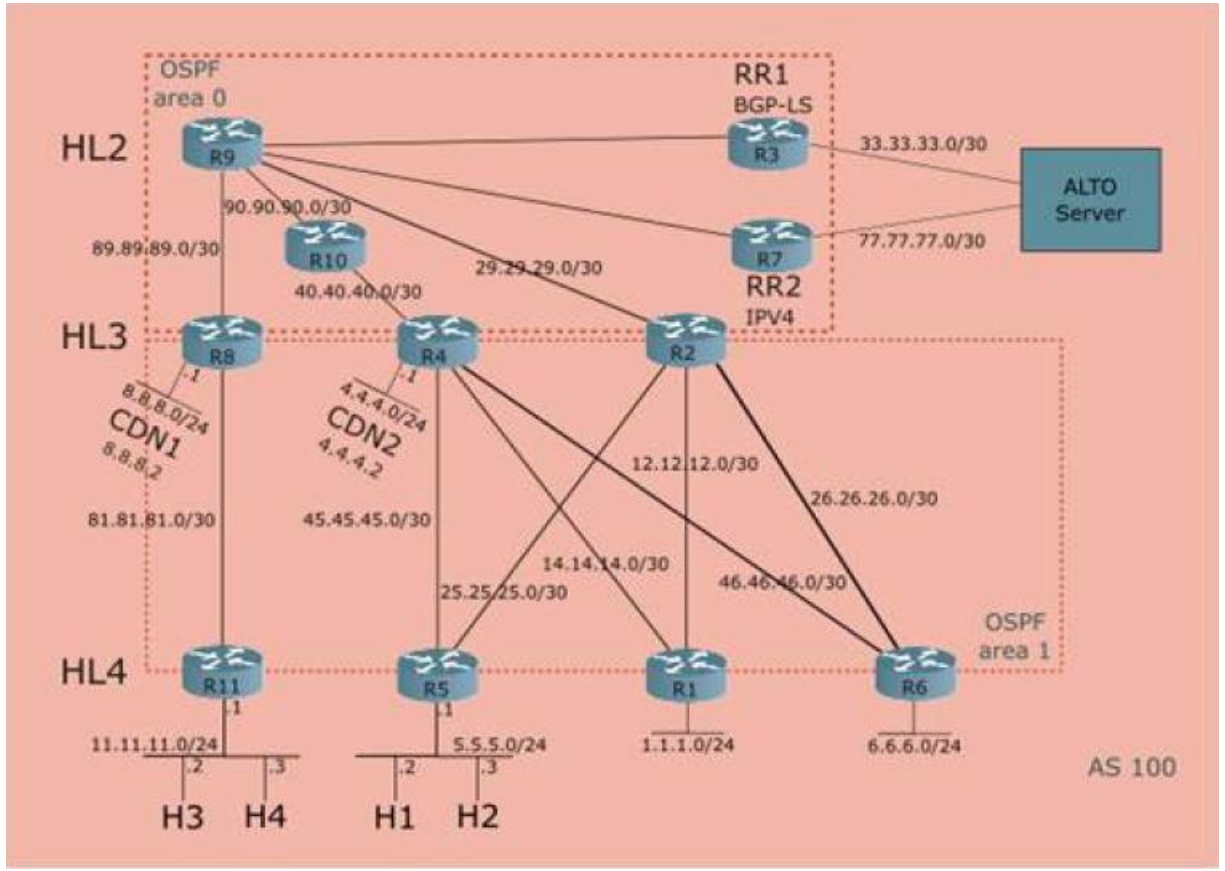
Discussions

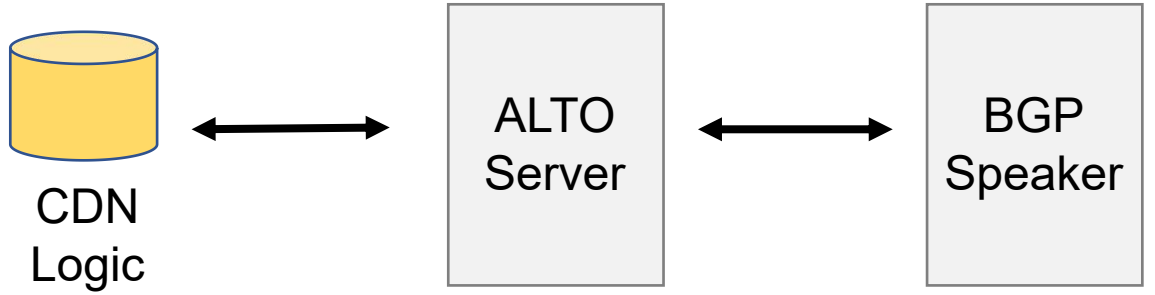
- Carefully design the framework extension to adapt potential ALTO extensions (e.g., MEC, Contextual Cost, Predictive Cost, FCS)
- Coordinate with ALTO HTTP/2 extension

Automatic Derivation of ALTO Information from the network

draft-zhang-alto-bgp-ls-01

- Problem:
  - Network conditions are dynamic, changing over time
  - Applications and services require up-to-date information for and efficient service delivery
  - Automatic derivation of ALTO information from the Network is essential for optimal decisions
- Solution:
  - Integration of ALTO with Network protocols helping to obtain a timely and precise view of the network status
- Recharter:
  - Augment ALTO with the support of protocols and information populated by Network protocols to assist on building up-to-date view of status and capabilities of the network
  - Extend ALTO protocol for supporting request leveraging on such information

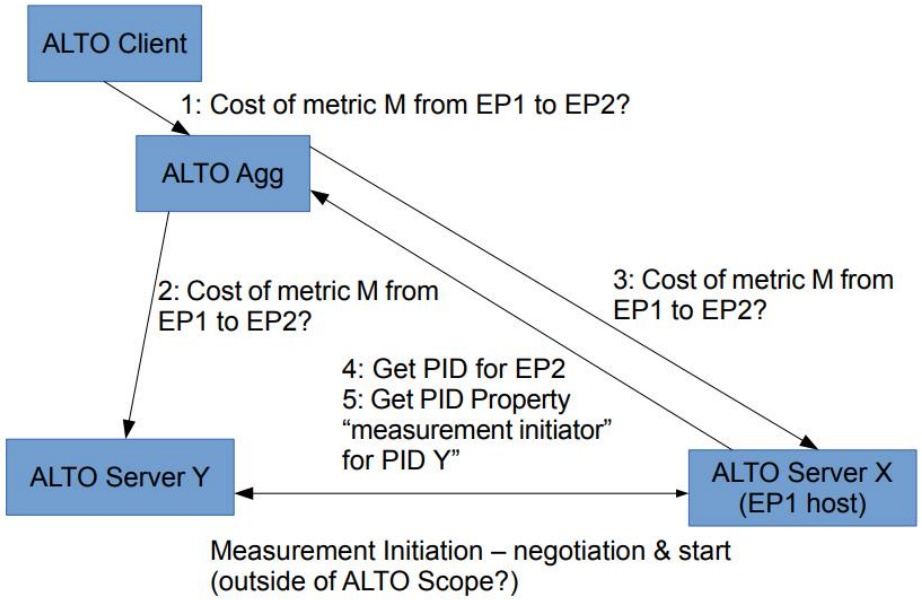




Aggregation & Associated Use Cases

Longer Presentation / discussions - https://datatracker.ietf.org/meeting/96/materials/slides-96-alto-0
Related - https://tools.ietf.org/html/draft-bertz-alto-aggrimpl-00
Related - draft-bertz-alto-sdnnfvalto-02
Aggregation (with filtering) of data concept is required in ALTO

- Client side integration is complex and defeats the ease of service ALTO provides
- There will be multiple domains and with filters people are likely to share data
- Big issue for ALTO is an incorrect assumption of number of sources, esp. SDN Controllers. If this is a service, Client should only need to connect to one server and not all of them.



As systems go up / down data will not be present in the system. We have also identified 3 Use Cases that can help take advantage of aggregation:
UC 1 : Data is present in underlying Server BUT not visible in ALTO Server (implies a Filter) => ALTO MUST support Server side filtering (On Demand Measurements is proposed)
UC 2: Data is not present server at all => ALTO MUST support some form of Measurement Initiation
UC 3: Metric not currently supported by ALTO Sever => Dynamic loading of measurement data