ALTO Code Bases and Deployment

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IETF Plenary 114

ALTO WG Session

07/19/2022

Content

- OpenALTO Code Base Architecture
- OpenALTO Project Management and Approach
- ALTO New Deployment Initiatives:
  - Optimizing Global Science Data Transfers
  - ALTO Integration with Telefonica CDN
  - MPTCP and MPQUIC Path Selection with SDN
  - Application Performance Optimization for the Pacific Research Platform 5G Edge Cloud
- IETF Hackathon 114: ALTO Project

OpenALTO Code Base Architecture

IETF ALTO Working Group

- IETF ALTO Charter:
  - Standardizing a network API that applications can query to get the state of the network and to use this information to optimize their performance.
- IETF ALTO history of applications / use cases:
  - Peer-to-peer applications CDNs {Cloud, Edge-computing, 5G, V2X, XR}
- Participation from a variety of carriers, vendors and universities:
  - Nokia, Ericsson, Verizon, Comcast, Telefonica, Deutsche Telekom, Huawei, China Telecom, Google, Cisco, Samsung, Qualcomm, Yale University, Tsinghua University, etc.

IETF OpenALTO Code Base Architecture

https://www.rfc-editor.org/rfc/rfc7285.txt

```
+-------------------------------------------------------------------+
|                          Network Region                           |
|                                                                   |
|                    +-----------+                                  |
|                    | Routing   |                                  |
|  +--------------+  | Protocols |                                  |
|  | Provisioning |  +-----------+                                  |
|  | Policy       |        |                                        |
|  +--------------+\       |                                        |
|                   \      |                                        |
|                    \     |                                        |
|  +-----------+      \+---------+                      +--------+  |
|  |Dynamic    |       | ALTO    | ALTO Protocol        | ALTO   |  |
|  |Network    |.......| Server  | ==================== | Client |  |
|  |Information|       +---------+                      +--------+  |
|  +-----------+      /                                /            |
|                    /         ALTO SD Query/Response /             |
|                   /                                /              |
|          +----------+                  +----------------+        |
|          | External |                  | ALTO Service   |        |
|          | Interface|                  | Discovery (SD) |        |
|          +----------+                  +----------------+        |
|               |                                                  |
+-------------------------------------------------------------------+
                |
      +------------------+
      | Third Parties    |
      |                  |
      | Content Providers|
      +------------------+

                 Figure 1: Basic ALTO Architecture
```

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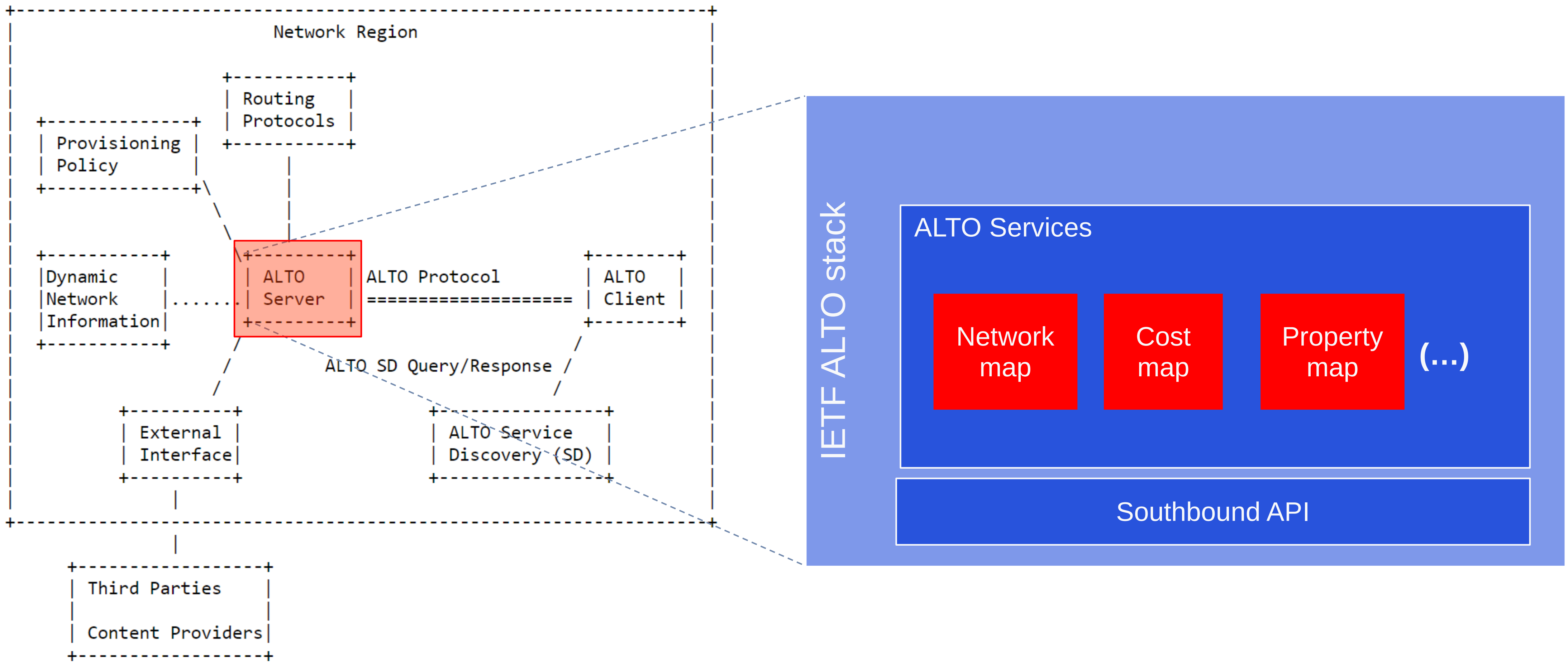

Figure 1: Basic ALTO Architecture

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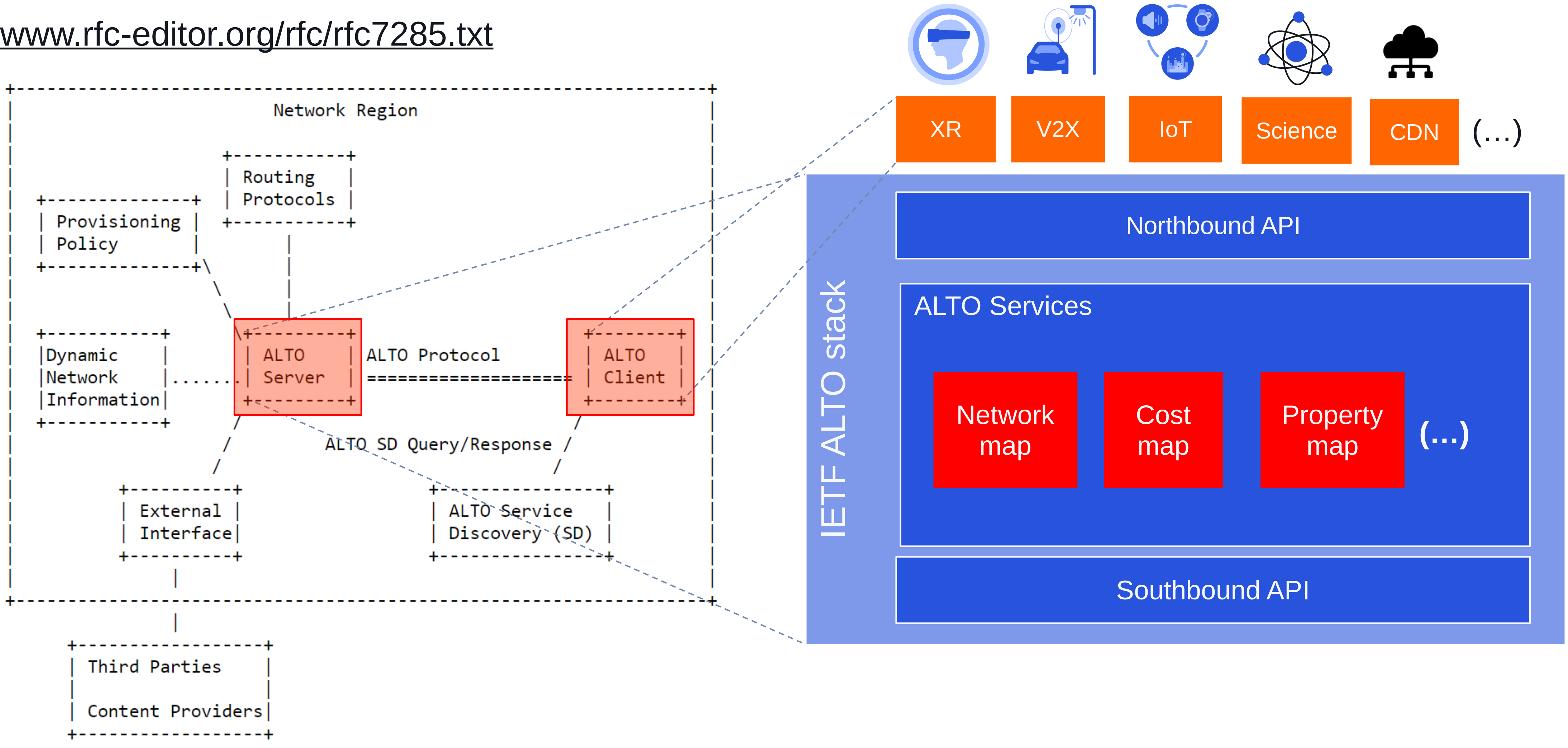

Figure 1: Basic ALTO Architecture

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|                         Network Region                            |
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|   | Provisioning | +-----------+                                  |
|   | Policy       |       |                                        |
|   +--------------+\      |                                        |
|                    \    |                                        |
|                     \   |                                        |
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|               |                                                   |
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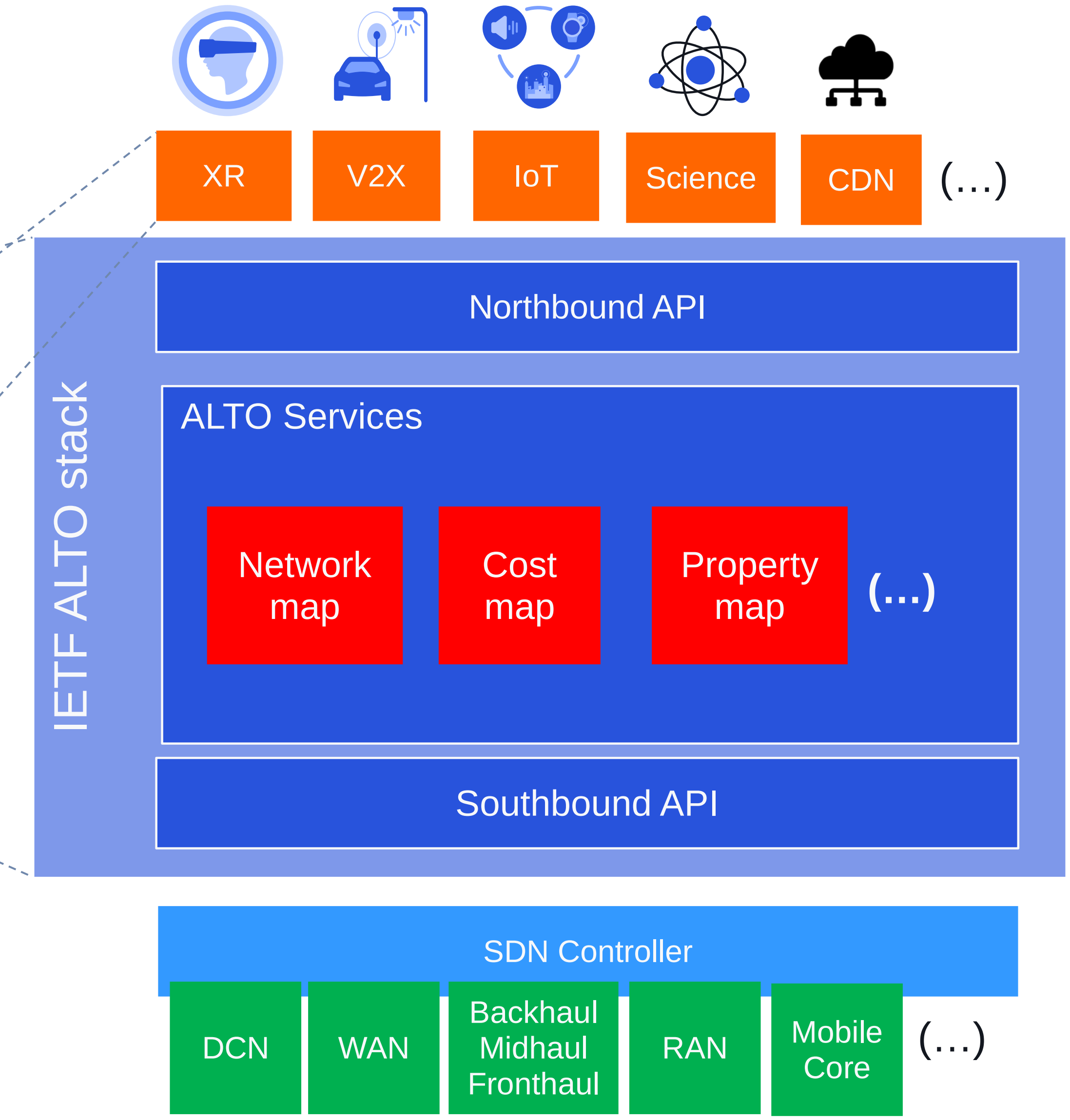
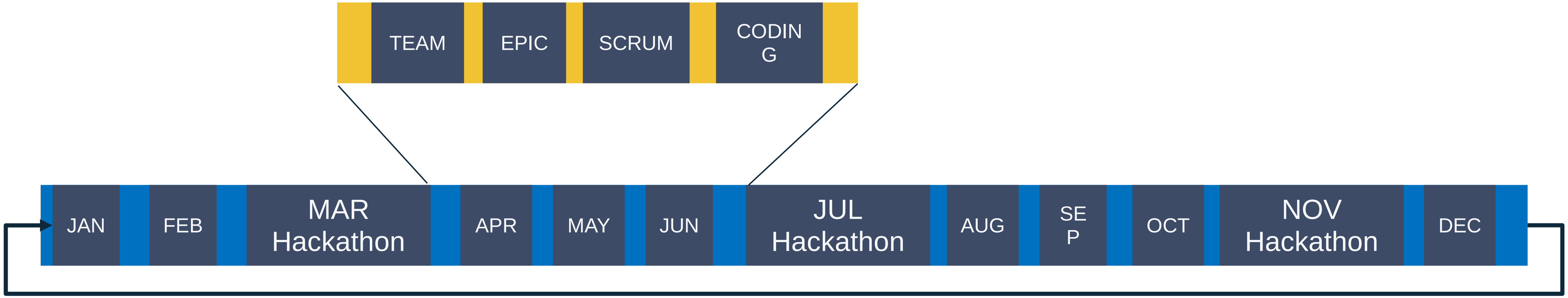
Figure 1: Basic ALTO Architecture



OpenALTO Project Management and Approach

Project Management and Approach

- The ALTO Code Base Project provides a parallel track to the WG's standardization effort towards implementing the features introduced in the latest RFCs.
- IETF Hackathons will be used as 3-checkpoints a year to test interoperability, demo latest standard capabilities and identify issues and improvements for standardization.
- Identify and build production, open-source environments for use cases and deployment ("lean startup") to help steer ALTO standardization.

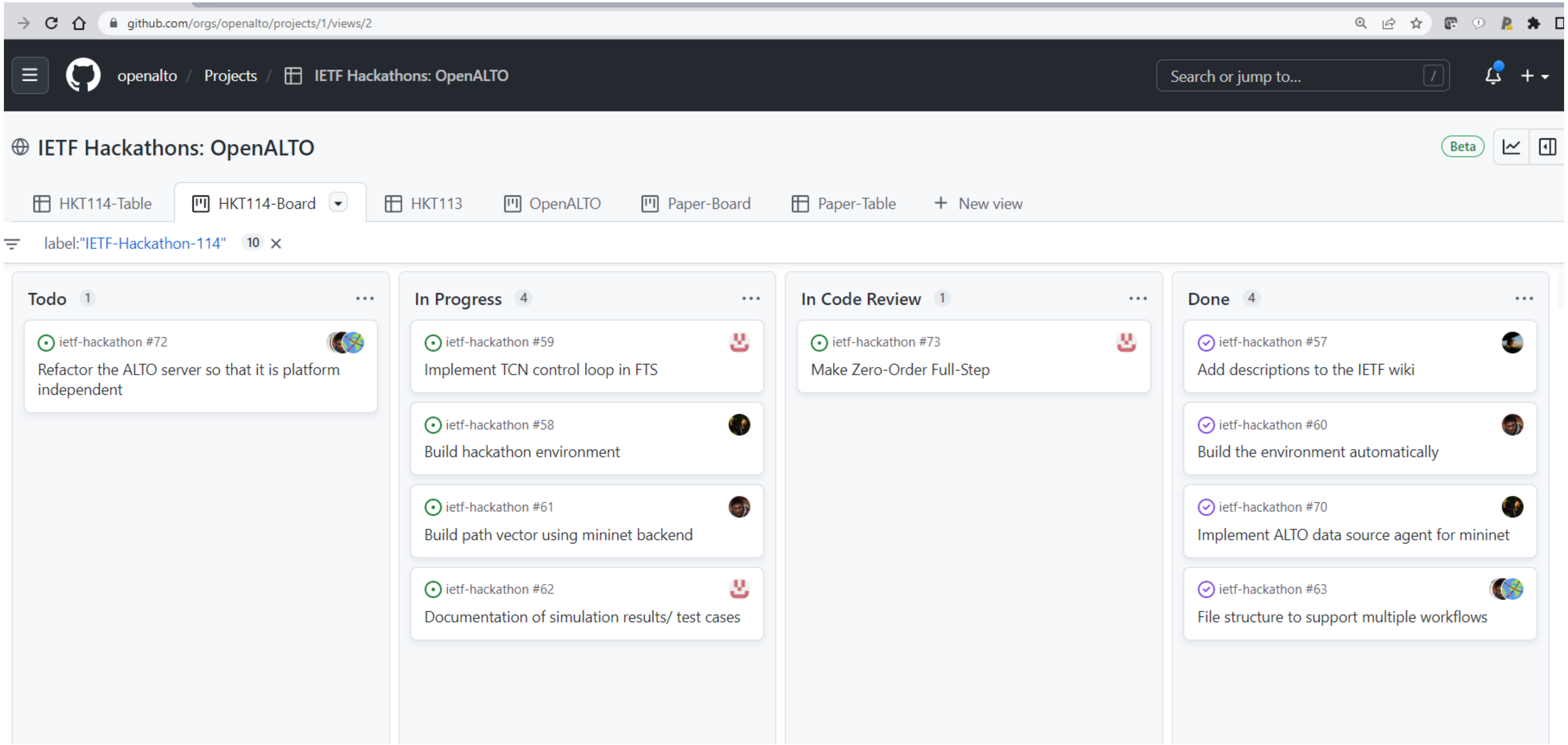


Project Management and Approach

- Adopting industry standard Agile / Scrum methodologies to ensure:
  - Productivity
  - Quality
  - Participation
  - Lean startup, rough consensus running code
- Invoke community participation to develop the ALTO Code Base:
  - Two roles: developers and mentors.
  - Mentors are usually experienced members of the IETF ALTO WG
  - Developers usually come from universities and the industry in general
- Project management resources:
  - Repo: https://github.com/openalto/
  - Project Scrum Dashboard (IETF Hackathon 114): https://github.com/orgs/openalto/projects/1

Project Management and Approach

Scrum dashboard:



ALTO Deployments

ALTO Deployments

- Current implementations/deployments:
  - Wiki list of implementations: https://trac.ietf.org/trac/alto/wiki/Impl
  - Examples:
    - Comcast P4P: RFC 5632: https://datatracker.ietf.org/doc/html/rfc5632
    - Benocs: https://people.csail.mit.edu/gsmaragd/publications/CoNEXT2019/CoNEXT2019.pdf
    - Telefonica: https://dl.ifip.org/db/conf/im/im2021mini/212012.pdf
- Forthcoming new deployments (work in progress):
  - Pacific Research Platform
  - CERN FTS / Rucio
  - UCSD 5G
  - MPQUIC, MPTCP
  - Edge Cloud
  - Science Networks

ALTO to Optimize Global Science Data Transfers

Using ALTO to Optimization Large-Scale Data Transfers for Science Networks (CERN)

- Designing a new control loop called Transport Control Networking to optimize large scale global data transfers for science.
- Co-exists and designed to help improve the performance of the existing Rucio / FTS data transfer stack.
- In collaboration with CERN and UCSD / San Diego Supercomputer Center (SDSC).
- Architecture published and to be presented at ACM SIGCOMM NAI (August 2022):
  - Paper title: "Transport Control Networking: Optimizing Efficiency andControl of Data Transport for Data-Intensive Networks“
- Targeted features:
  1. FTS to specify resource control goal and use ALTO to map FTS control state to network state;
  2. Full zero-order algorithm to achieve fully efficient, zero-order gradient control as FTS Optimizer;
  3. Composition framework to enable end-to-end resource performance function, including both zero-order and first-order gradient, covering the bottleneck structure.

Using ALTO to Optimization Large-Scale Data Transfers for Science Networks (CERN)

(Preview of architecture and results to be presented in full at ACM SIGCOMM NAI 2022)

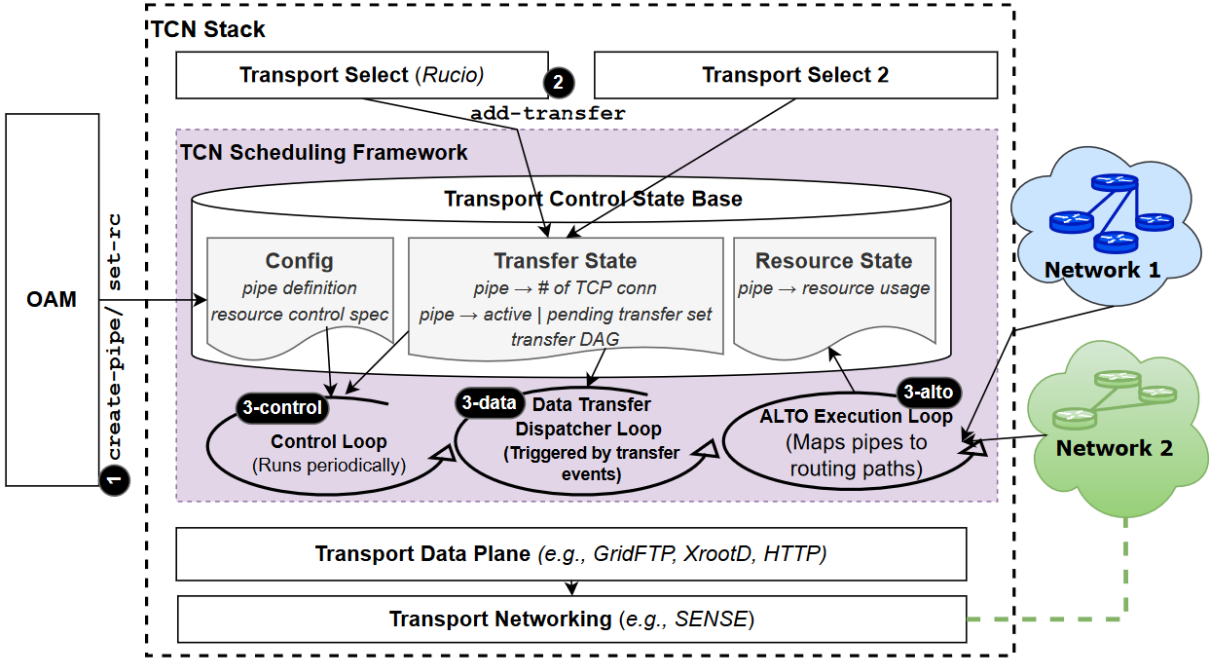
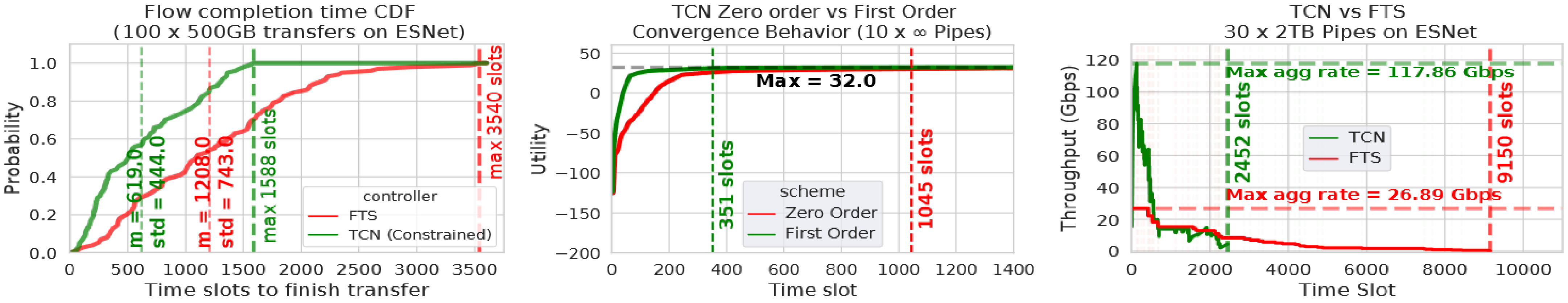


Figure 1: Architecture and workflow of TCN.

Using ALTO to Optimization Large-Scale Data Transfers for Science Networks (CERN)

(Preview of architecture and results to be presented in full at ACM SIGCOMM NAI 2022)



(a) TCN vs FTS FCT (100×500GB Pipes). (b) TCN 0-order vs 1st-order (10×∞ Pipes). (c) TCN vs FTS (30×2TB Pipes).

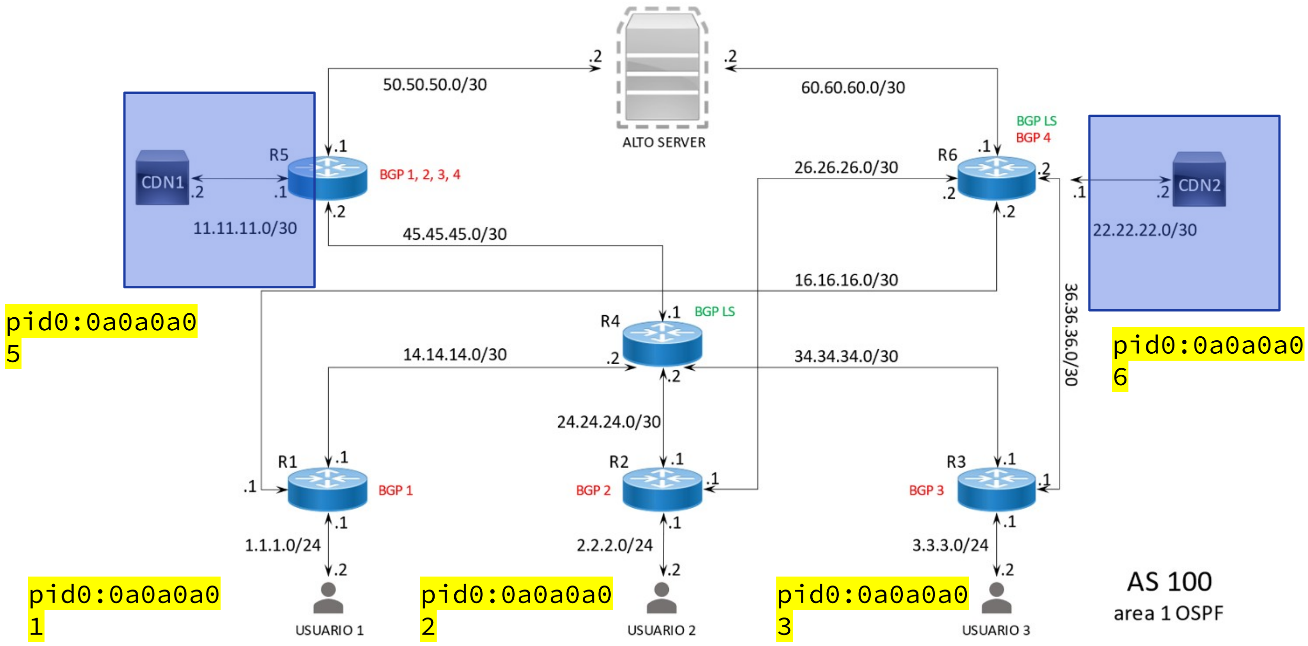
Figure 4: TCN Evaluations

ALTO Telefonica Deployment

How TCDN leverages on ALTO information?

- *Pid_file* and *cost_map* generated with BGP and BGP-LS updates show information from the network
  - PIDs associated to customer's IP prefixes represent consumers of video streming
  - PIDs associated to the connection of CDN streamers represent the potential sources of TCDN traffic.
- By checking network and cost map info from Both kind of PIDs it´s easy to map CDN streamers with customers.

- In oder to select the more convenient stremar in each case, the RRL can be complemented with the view of the lowest cost between PIDs of CDN streamers and PIDs of customers.
  - For example, for a given PID of customers, e.g. pid0:0a0a0a01, the more convenient streamer can be determined from the lowest cost of pid0:0a0a0a05 and pid0:0a0a0a06 (assuming the rest of considerations in RRL is similar).



TCDN Request Routing Logic (RRL) inputs: streamer health status and load level, cache hit ratio maximization, content popularity, ..., and network topology (PIDs and cost matrix)

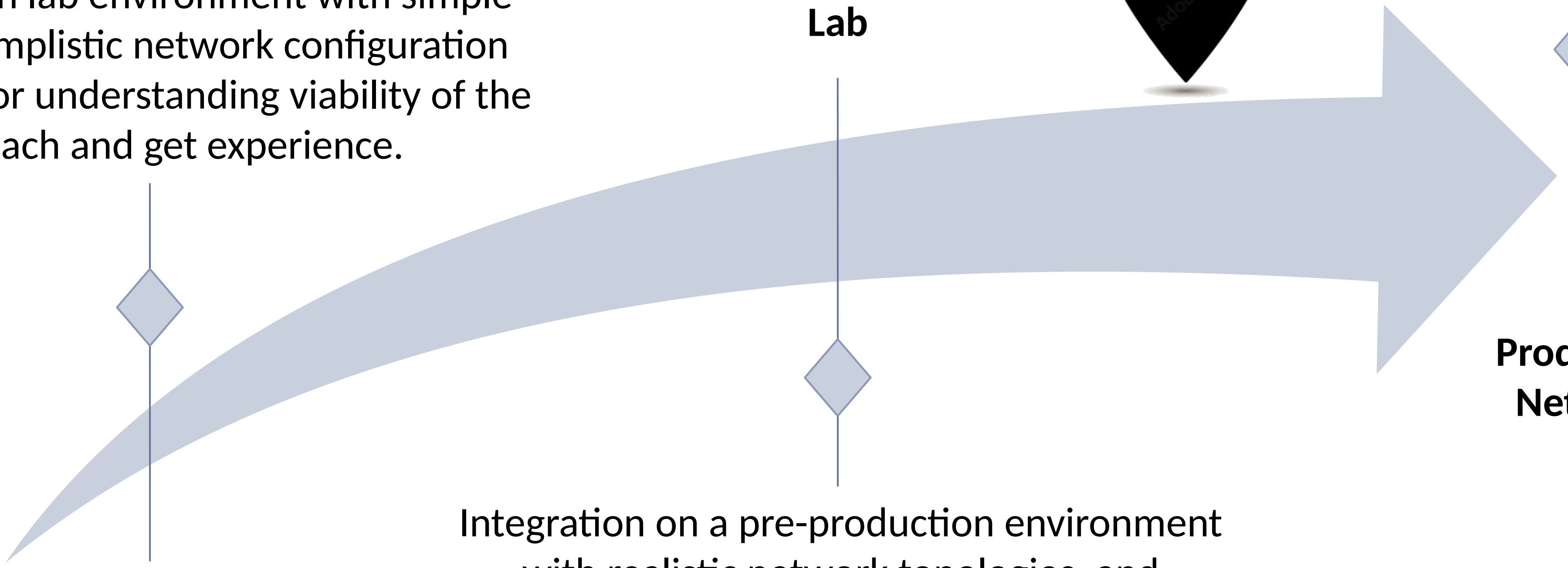
Process followed

Initial tests in lab environment with simple topology. Simplistic network configuration (e.g., OSPF) for understanding viability of the approach and get experience.

Technology Lab

Pre-production Lab

Integration on a pre-production environment with realistic network topologies, and network configuration as in the production network, with the purpose of assess the solution and solve problems found.



Deployment of ALTO as an element of the production network and full integration with TCDN

Production Network

“Engineering” path followed

Technology lab tests

- Initial tests with ALTO module of ODL
- Integration with ODL BGP (originally LLDP)
- Monovendor router scenario
- Virtualized routers
- Virtualized ALTO
- Simple IP network based on OSPF as IGP
- Single AS
- Simple metrics (= hopcount)
- Some of the routers acting as RR

Pre-production network tests

- Migration to exaBGP
- Fixing of issues in exaBGP (3 ticketsraised and solved) mainly related to BGP-LS[*]
- Multivendor router scenario
- Physical routers
- Dedicated ALTO server
- Complex MPLS network combining OSPF and IS-IS
- Multiple private ASs
- More sophisticated metrics in IGP
- Dedicated RR, separated for BGP and BGP-LS

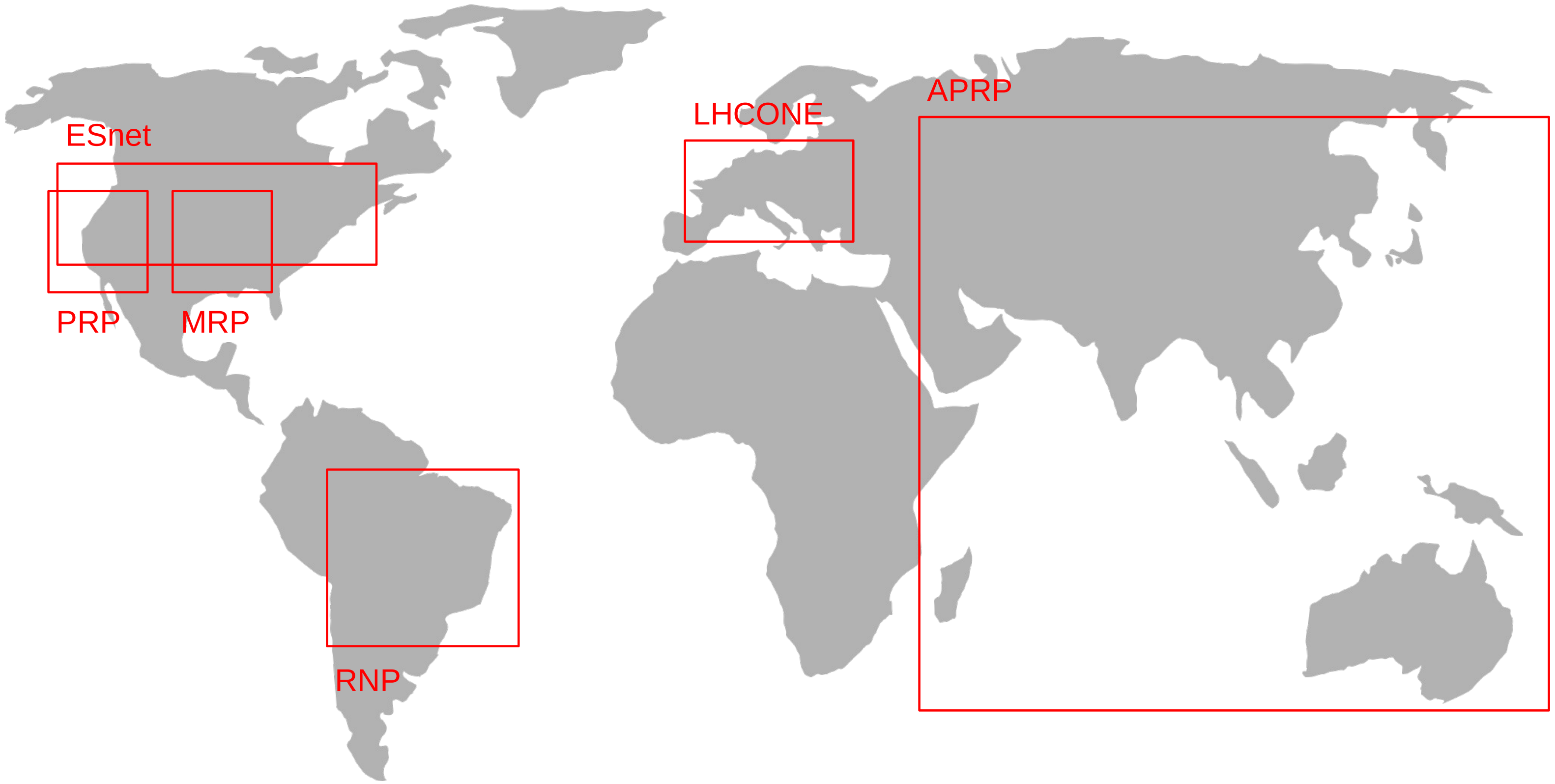
Integration in production network

- Adaptation to production processes and rules
- Hardening of all the environment to prevent security issues (HW, SW, …)
- Limited activation of BGP-LS by now
- Coexistence with many other services in the network
- Complete deployment expected for Q3’22

[*]
https://github.com/Exa-Networks/exabgp/issues/1071
https://github.com/Exa-Networks/exabgp/pull/1075
https://github.com/Exa-Networks/exabgp/issues/1077

ALTO to Optimize 5G Edge Computing at the Pacific Research Platform (UCSD)

Global Interconnect for Science Networks



(These are only a few examples of interconnected science networks, it is not a comprehensive map)

Pacific Research Platform (PRP) 5G Edge Cloud

- The Pacific Research Platform (PRP) is an NSF-supported network that connects more than 50 research institutions in the US and the Asia Pacific Region: https://pacificresearchplatform.org/
- In the process of extending its containerized backbone network with a 5G edge computing network.
- Targeting high-throughput, low latency applications that include holodeck, augmented reality, vehicle networks and the metaverse.
- The project brings an ecosystem of collaborators and partners working on the various end-to-end components necessary to build, manage and optimize the network.

Architecture Building Blocks of the PRP 5G / Edge Cloud Network

```
+----------------+      +----------------+     +------------------+          +---------+
|                |      |                |     |                  |          |    O    |
|  Visibility    +-------> Intelligence  +-----> Controllability  |          |    r    |
|                |      |                |     |                  |          |    c    |
+---------^------+      +----------------+     +--------+---------+          |    h    |
          |                                             |           <---->   |    e    |
+---------+-------------------------------------------v---------+          |    s    |
|                     Network  (5G, Edge Cloud)                    |          |    t.   |
+------------------------------------------------------------------+          +---------+
```

Visibility:
- IETF ALTO / OpenALTO
- BGP-LS
- sFlow, NetFlow
- Perfsonar , Traceroute
- Kubernetes statistics
- LibreNMS - P4
- Inband telemetry

Intelligence:
- GradientGraph
- NetPredict
- TCN
- Hecate

Controllability:
- SENSE / OpenNSA
- SRv6
- BGP / PCEP
- Polka - P4

Orchestration:
- Composable architecture
- Kubernetes
- Interoperation
- Integration
- GitOps

ALTO to Optimize MPTCP and MPQUIC Path Selection with SDN

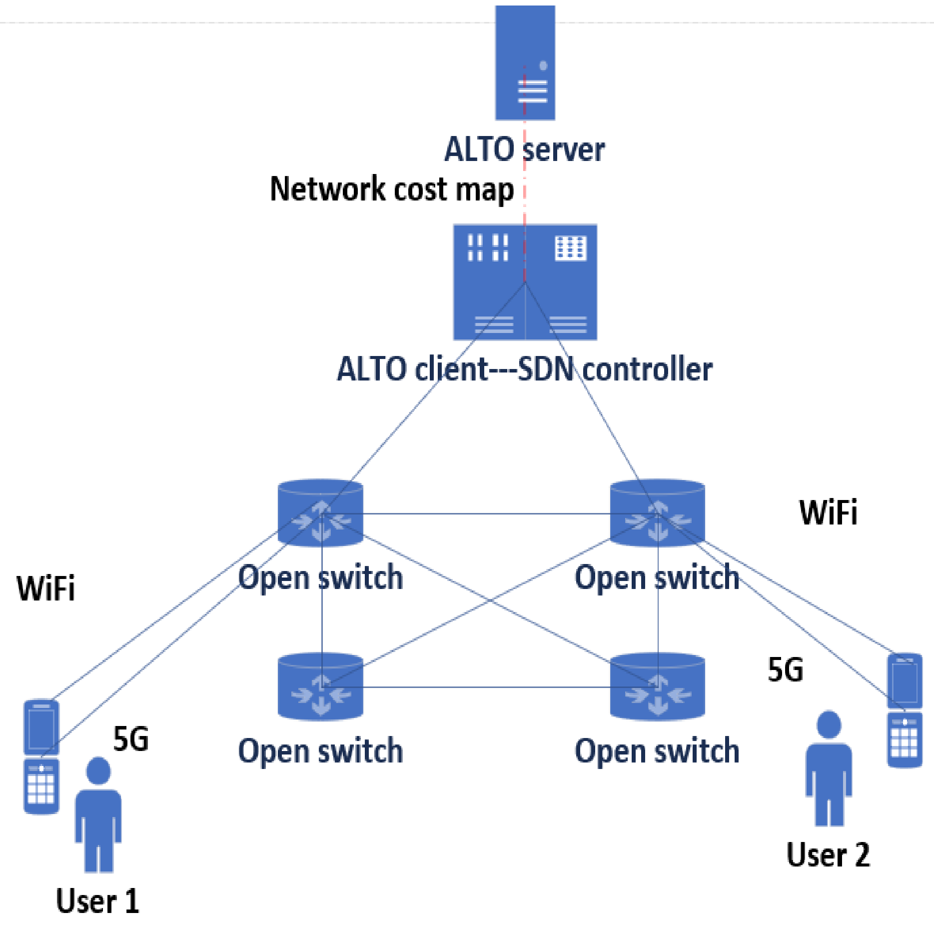
Deployment of ALTO in Multipath transmission

Architecture

- ALTO Server: collect network status information
- ALTO Client: controller in SDN
- Collect network performance data from the network every 2 hours
- Controller allocates MPTCP or MPQUIC packets to suitable transmission paths according to the network cost indicators by ALTO

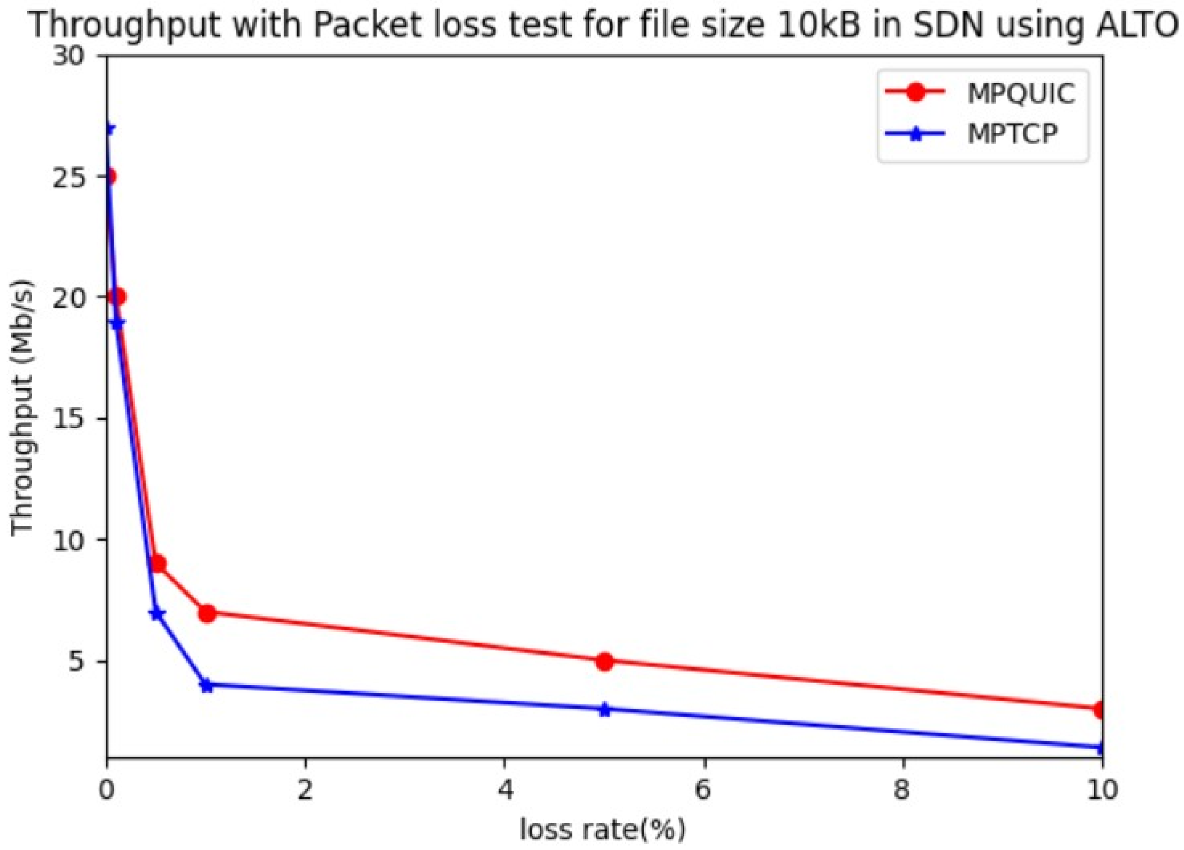
Test environment

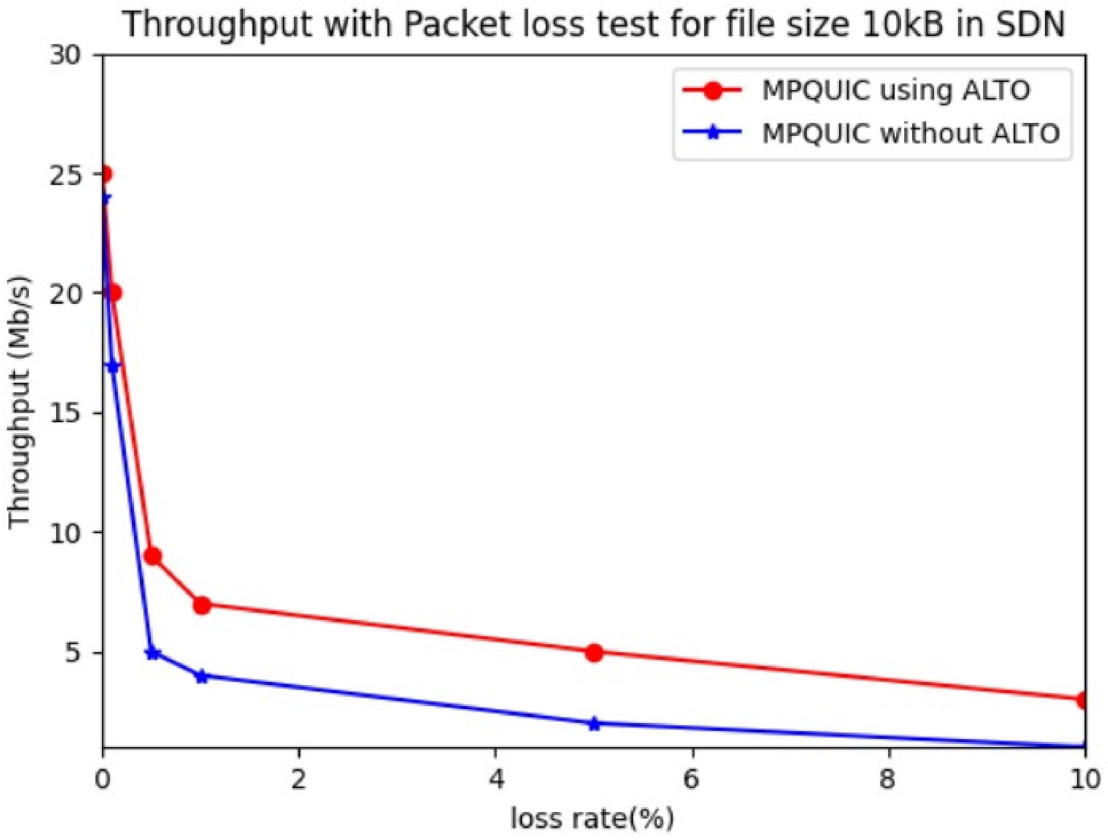
- 1.SDN controller: OpenDaylight
- 2.Network topo: Mininet
- 3.SDN server and client: MPQUIC-go \ MPTCP
- 4. Traffic measurement: mahimahi \ Wireshark



Test result

- **The throughout of MPQUIC/MPTCP using ALTO is higher than without ALTO in SDN especially in poor network**



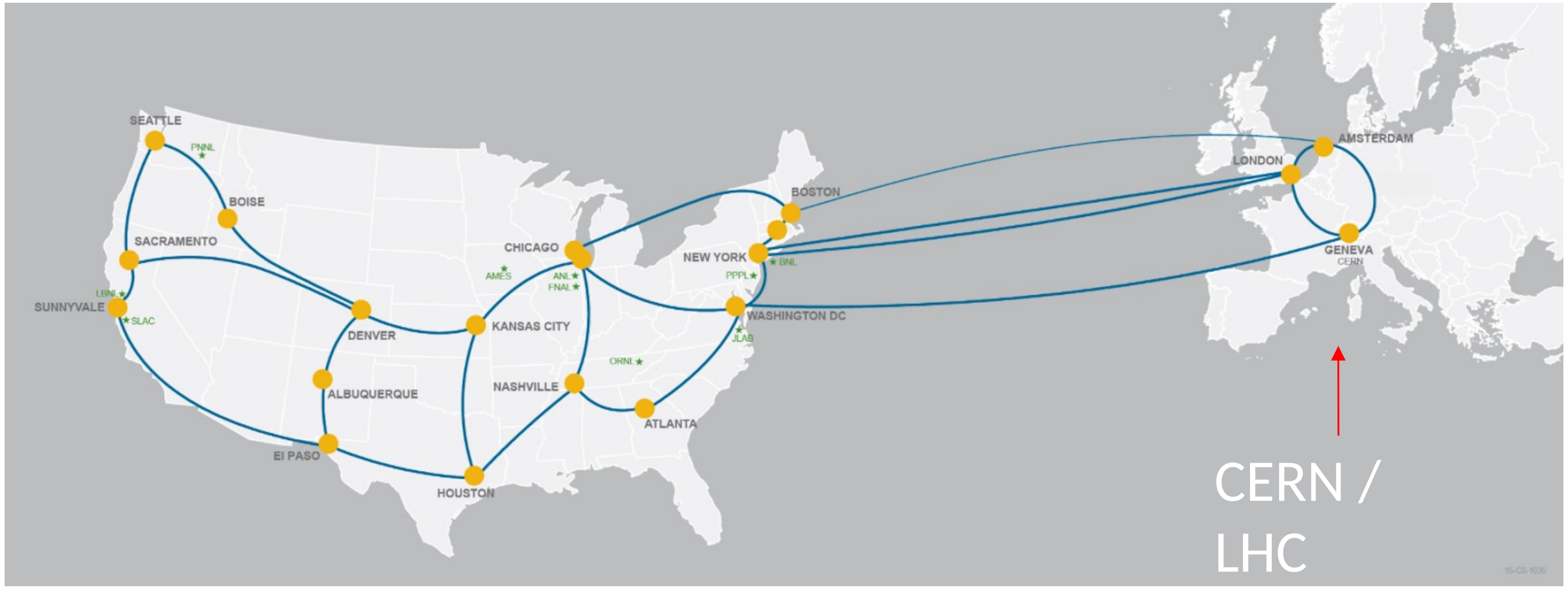


IETF Hackathon 114: ALTO Project

See also https://youtu.be/eQqwbQ0zqwI?t=1620

Goal of the Hackathon Project

- Use ALTO path vector to help achieve resource control in FTS, the file transfer service used in scientific projects such as ATLAS, CMS, and LHC
- Continuation of IETF Hackathon 113
  - In IETF 113, ALTO support was added to Rucio, the data management system of CERN



* ESnet / LHCONE source: https://www.es.net/about/

RFCs Involved in the Hackathon

- RFC-to-be: An ALTO Extension: Path Vector
  - https://datatracker.ietf.org/doc/draft-ietf-alto-path-vector/
- RFC 9240: An Extension for Application-Layer Traffic Optimization (ALTO): Entity Property Maps
  - https://datatracker.ietf.org/doc/rfc9240/
- I-Draft ALTO Extension: Flow-based Cost Query
  - https://datatracker.ietf.org/doc/draft-gao-alto-fcs/

What Got Done

- Application side:
  - [TBD] ALTO-enabled optimizer integrated in FTS
    - [TBD] Pull request to FTS
  - [TBD] Demo: ALTO-enabled FTS optimizer achieves resource control and improves aggregated throughput
- Server side:
  - Path vector service is added to the OpenALTO project, providing bandwidth and latency information
  - Mininet/OpenDaylight plugin
  - [TBD] Pull request to OpenALTO
- Infrastructure:
  - *Customizable* containerized environment for Rucio/FTS

Discussion Q&A

Thank you

References

[1] SDN controller OpenDaylight https://github.com/opendaylight/controller
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[4] traffic measurement http://mahimahi.mit.edu/
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