“Milestone Moment” Webinar

March 30, 2022

Guru Parulkar, Larry Peterson, Saurav Das, Oğuz Sunay, Aseem Parikh, William Snow, Timon Sloane
The Big Announcement
ONF has open-sourced its entire portfolio of projects

AETHER
5G with Connected Edge Cloud as-a-Service

SD-RAN
O-RAN Compliant RAN

SD-Core
4G/5G Mobile Core

SD-Fabric
Fabric with P4 Data Plane

ROC
Runtime Operations & Control

and its component systems
Key Attributes of ONF Platforms

Aether and its component platforms all share the following attributes:

- **Feature Complete for MVP**
- **Production Ready**
- **Cloud Native & Cloud Managed**
- **Software defined with programmable data & control**
- **Operationalized in a small global network**
- **Aether**
  - Private 5G with connected edge cloud as a service: end-to-end complete solution
- **Leverage latest CI/CD and gitOPs tools & practices**
Significance of the Announcement
Enable application developers to realize the full potential of 5G and Edge for enterprise digital and industry 4.0 transformation.

Take innovations and applications of 5G/Next G to production with:

(i) significantly reduced R&D investment and
(ii) Faster time to market

For a huge emerging market
Aether provides an accelerated path to building your own network (or your own 5G/Next G & Edge product)

With Aether:
- Open source with community
- Feature complete
- Well defined APIs
- Operationalized & production ready
- CI/CD with gitOPs

Without Aether:
ONF Committed to Help Community

Come and Join
to Realize the Full Potential of 5G + Edge for Industry 4.0
How did we get here?

Agile Process + Architectural Coherence

Larry Peterson
CTO
Agile Process + Architectural Coherence

**ONOS (SDN Controller)**

- **Trellis**

**CORD (Edge Cloud)**

- **R-CORD (Residential)**
  - **SEBA (Broadband)**
    - **VOLTHA**

- **E-CORD (Enterprise)**

- **M-CORD (Mobile)**
  - **OMEC**
  - **xRAN**

- **Aether (5G Edge Cloud)**

- **P**

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**Modular Design**

**Horizontally Scalable**

**Highly Available**

**Well-Defined APIs**

- **Config:** gNMI, gNOI
- **Control:** OpenFlow, P4

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**Timeline**

2012

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2022
SD-Fabric, SD-Core, SD-RAN

Saurav Das
VP Engineering
SD - *

- **SD-RAN**
  - O-RAN E2-AP & E2-SMs
  - RAN Nodes (CU, DU, eNB, gNB)

- **SD-Core**
  - 3GPP PFCP
  - User Plane Functions (UPF)

- **SD-Fabric**
  - Programmable Switches
  - P4RT, gNMI

Near Real Time RAN Intelligent Controller (nRT-RIC)

5G-SA & LTE Mobile-core Control plane
SD-RAN’s µONOS-based nRT-RIC

cloud-native microservices architecture

app-SDKs are a collection of APIs and tools in different languages that allow xApps to interact with RIC platform services

Original slide from keynote at the SD-RAN DT-Trial Event
SD-RAN Project

xApps developed by ONF and 3rd party companies

Integrated with several RAN platforms

Learn more: https://docs.sd-ran.org/master/index.html
SD-Core Deployment Flexibility

Control plane can be deployed in any central cloud

Or it can be deployed at each edge
SD-Core provides an abstraction for mobile networks; that allow common configuration APIs for 4G & 5G cores

Config-server distributes configuration to individual microservices (network functions) that make up the 4G and 5G cores

Learn more: https://docs.sd-core.opennetworking.org/master/index.html
SD-Fabric

Cloud Platform

Cloud-managed network fabric as a service
Integrated with CI/CD, logging, monitoring, alerts

SD-Fabric API

Fabric Apps

UPF App

INT App

Fabric Controller

P4Runtime, gNMI

Closed Loop Control

API driven
Fully programmable switches
Visibility throughout the network

5G workload

Fine-Grained Measurement

BESS UPF

CNI w/ INT

P4 UPF

P4 UPF

INT

INT
SD-Fabric Scalability and Redundancy

Single Switch
Minimal setup

Single Leaf Pair
Minimal HA setup

Leaf-Spine Fabric
With ECMP and N-way redundancy
SD-Fabric + SD-Core

Software (BESS) & Hardware (P4) UPFs can be used simultaneously

Learn more: https://docs.sd-fabric.org/master/index.htm
Get Involved

**SD-RAN**

Resources
- Website
- Wiki
- Whitepaper
- Docs
- SD-RAN YouTube channel
- Presentations

Preferred means of communication
- #sdran-dev channel in ONF Community Slack
- sdran-dev mailing list

**SD-CORE**

Resources
- Website
- Whitepaper
- Wiki
- Docs
- SD-Core 2021 Review

Preferred means of communication
- #sdcore-dev channel in ONF Community Slack
- SD-Core mailing list

**SD-FABRIC**

Resources
- Website
- Whitepaper
- Docs
- Wiki

Preferred means of communication
- #sdfabric-dev channel in ONF Community Slack
- SD-Fabric developer mailing list
Aether

Oğuz Sunay
VP of R&D - Mobility
Aether for Enterprise 5G
5G Made Simple

Plug-and-play - simple to deploy, integrate and operate, aiming to accelerate 5G adoption at scale at enterprises.
Putting the components together: Aether

- **Operator Portal**
- **Enterprise Portal**
- **Runtime Operational Control**
- **SD-Core - Control**
- **AI Application**
- **Central Cloud and Hybrid Cloud Services**
- **Enterprise Application**

**Enterprise On-Prem Edge Cloud**

**SD-RAN**
- O-RAN compliant programmable small cells from partners
- 5G RAN Config/Control Update
- 5G RAN Telemetry

**SD-Fabric**
- Edge Fabric Config/Control Update
- Edge Fabric Telemetry

**SD-Core - Local Breakout**
- 5G Core Config/Control Update
- 5G Core Telemetry

**Edge Cloud Services**

**APIs**

**3GPP**

**5G RAN**
- Telemetry
- Config/Control Update

**5G Core**
- Telemetry
- Config/Control Update

**Automatically Correlate & React**
Sum is greater than the components: Aether stack
Aether’s CI/CD and GitOps

PRE-MERGE JOBS
- CLA
- License
- Testing
- Other Checks

POST-MERGE JOBS
- Publish Artifacts
- Update Env. Repos

QA ENVIRONMENT
Testing

Operations

Image Repo

Helm Repo

App Env Repo

Pod Env Repo

Project Repo

Timer or other trigger

changes requested

changes requested

app version update

app config update

infra update

Code commit

trigger

Reviewer

merge
Aether’s CI/CD and GitOps

1. Image Repo
2. Helm Repo
3. App Env Repo
4. Pod Env Repo

Manage Kubernetes and Apps

- Pre-merge jobs:
  - Infra Plan
  - Infra Validate

- Post-merge jobs:
  - Infra Apply

Operations

Deploy/Update Aether Services

- Pull updates
- synch
- Deploy/Update Kubernetes
- Deploy/Update Aether Services

Applications

Fleet Agent

Kubernetes

Infrastructure

Aether Cluster

Operations

config changes requested
Aether Offers APIs at multiple hierarchies

1. Open APIs towards 3rd party product portal developers
2. Open APIs towards 3rd party fabric control and monitoring app developers
3. Open APIs towards 3rd party mobile core app (OSSM integration, etc) developers
4. Open APIs towards integration with ROC and 3rd party Operational/Business Support System Platforms
5. Open APIs towards 3rd party Industry 4.0 app developers
6. Open APIs towards 3rd party end-to-end 5G connectivity control and management app developers
7. Open APIs towards 3rd party Industry 4.0 app developers

SD-RAN
SD-Fabric
SD-Core - Control
SD-Core - Local Breakout

Enterprise Portal
Runtime Operational Control
AI Application
Adapter
App
xApp
SDK
Enterprise Application

O-RAN compliant Open SDK towards 3rd party RAN control and monitoring app developers
Aether has been operational for over 2 years

Central Management and Control

On-Prem Aether edge sites

ONF
Intel
ONF
Stanford
AT&T
Purdue
Ciena
Yale
Cornell
Princeton

On-Prem edge sites in the pipeline

ONF
Deutsche Telekom
Lilyneir
Sorbonne
CNIT
Purdue
Sorbonne
Yale
Cornell
Princeton

In the pipeline

Edge-Core
FET
NCTU
NTT
An outdoor trial with DT is now live

Providing connectivity in the DT Building Courtyard using Aether’s fully disaggregated, software-defined, deeply programmable, cloud-enabled and operated private 5G and 4G networks.

3 5G and 1 4G Radio Units are mounted on the poles in the courtyard with fiber connections to Aether Edge Cloud inside the building.

Broadband connectivity over 5G and 4G is now live. The networks will remain operational for the foreseeable future with new features being continuously added.

The Berlin Aether Edge is deployed inside the Deutsche Telekom data center in the building and is composed of COTS and P4-switches. This edge cloud is connected to the central cloud running from Google Cloud.

Trial Video
Takeaways

Aether is an amazing open-source platform for private 5G and connected edge cloud that is innovative, highly programmable, multi-cloud supporting, feature rich, and for all practical purposes, near production grade.

We are open-sourcing it at the perfect time – private 5G is potentially a huge emerging market and its adoption is starting to pick up.

With Aether’s rich set of APIs, the ecosystem can easily take it, add their own innovations on it, and run with it.
Business Opportunities

Aseem Parikh
VP Solutions & Partnerships
Commercial Adoption directly Correlates to Maturity & Consume-ability of ONF Open-Source Artifacts

SDN Architectures, Components & Use-Cases

Component Systems

Platforms & Solutions


Adoption

SK Telecom
NTT Labs
Telefonica
Samsung
Ciena
Huawei
Argela, ...

Comcast
DT (A4)
Turk Telekom
Edgecore
Google
Radisys
Infosys

DT/T-Mobile
FarEastTone
Radisys
Reliance Jio
Dell
Intel
Canopus

Stanford Hospital
Colt
Accenture
ManTech
Capgemini
GE

SDN Architectures, Components & Use-Cases

Component Systems

Platforms & Solutions
Aether 5G+Edge Platform
Key to Unlock $50+B Enterprise Infrastructure Market

The US$517bn 5G+Edge ecosystem across just five industries

- Industrial manufacturing: $206.4bn
- Connected healthcare: $45.3bn
- Intelligent transportation: $24.3bn
- Environmental monitoring: $5.0bn
- Gaming: $236.0bn

40.9% CAGR
$13.92B by 2028


https://www.polarismarketresearch.com/industry-analysis/private-5g-network-market
ONF Component Systems Have Broad Industry Appeal

RAN Market is poised for disaggregation

Operators like AT&T, DT, Rakuten, China Mobile are pushing Open RAN based solutions for innovation and competition

Tech Partners like Intel and Facebook are developing AI/ML driven RAN xApps to advance spectrum efficiency and open RAN ecosystem

Size: Dell’Oro Predictions for 2024:
- RAN revenue to reach $200B
- 5G NR RAN investments to surpass $100 Billion
- 5G NR small cells will be 10-20% of overall 5G NR market


Era of the multi-cloud Connected Edge

Needs of the new datacenter fabric
- Lines between servers and networking are blurring
- Deeply Programmable, Developer Optimized with APIs
- Cloud Orchestrated and Managed
- Resilient and Self-Healing

Markets and Markets predicts the Global Data Center Fabric TAM to be $4.2B by 2026

How did ONF achieve this great result?

Bill Snow
Chief Development Officer
Original Mission (2011)

*Accelerate innovation and bring CAPEX and OPEX efficiencies to Network Operators*
*Leverage SDN, Disaggregation and Open Source*

ONF became a trusted partner to operators

Non-profit
Mission oriented
ONF Needed a New Open Source Model

No development team
- Manage projects, community
- Adopt new technology
- Build consensus
- Incremental
- Serve community

Developer team key to organization
- Drive agenda for innovation
- Break technical “barriers”
- Transformational
- Working systems
- Serve end customer
Could ONF Staff Such An Organization?

Concerns

- Hiring is tough
- Little SDN talent
- Non-Profit
- Learn SDN, then move on

Realities

- Top leaders in SDN – Nick, Guru, Larry
- Early A-team of developers
- Strong partnerships – Intel, Google...
- Compelling mission
How We Hired
“Smart, Gets Things Done*”

SDN, mission passion
PhDs wanting to build systems
Relations, intern program
Distributed Systems

SDN, mission passion
Best development practices
Quality in operations – CI/CD
Distributed Systems

*Joel Spolsky's Book Title
Build a Great Culture

- Compelling mission, bigger than one’s self
- Flexible, flat organization
  - Low friction to get work done, ability to “flow” between projects
- Commitment - aggressive goals and meaningful challenges
- Latest technologies and methods
- Transparency
- Mutual respect
Come and build on it

Timon Sloane
VP Marketing & Ecosystem
Entering a New Phase in ONF’s Journey

Now that we’ve seeded the industry through partner funded development, we’ve released everything to open source to enable broad adoption to expand the impact of our work.

Phase 1
- Evangelizing for SDN
- Standardizing OpenFlow

2011 - 2015

Phase 2
- Partners (operators) jointly fund development of platforms
- Operators begin to deploy platforms into production

2016 - 2021

New - Phase 3
- Expand consumption & adoption
- Broaden our developer community
- Activate the open source multiplier effect for our projects

2022 -
What you can do next

• Come consume and use the platforms
  – Deploy private 5G
  – Deploy P4 programmable fabrics

• Where you can extend the work
  – Support new silicon targets: port SD-Fabric and PINS on switches, extend work to IPUs/DPUs and hosts
  – Bring new RAN components (RU/DU/CU) into SD-RAN
  – Build xApps on top of SD-RAN
  – Build Industry 4.0 applications on top of Aether
  – Next-G Research: leverage Aether as a whole, or components: SD-RAN, SD-Core and SD-Fabric
    • Single best platform for bringing up your own 5G network
    • Most programmable platform, easy to customize and extend
Our journey is only possible because of ONF’s community

Thank You!
Thank you