The Big Announcement

ONF has open-sourced its entire portfolio of projects

SD-RAN

O-RAN Compliant RAN

AETHER

5G with Connected Edge Cloud as-a-Service

ROC

Runtime Operations & Control

and its component systems

SD-Core

4G/5G Mobile Core

SD-Fabric

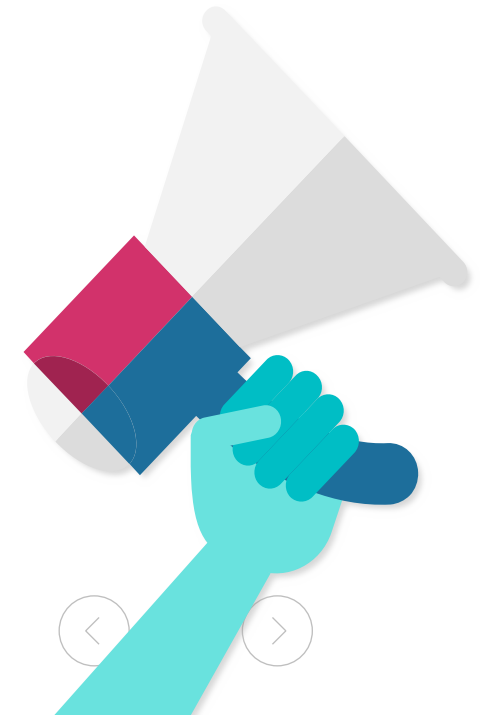Fabric with P4 Data Plane
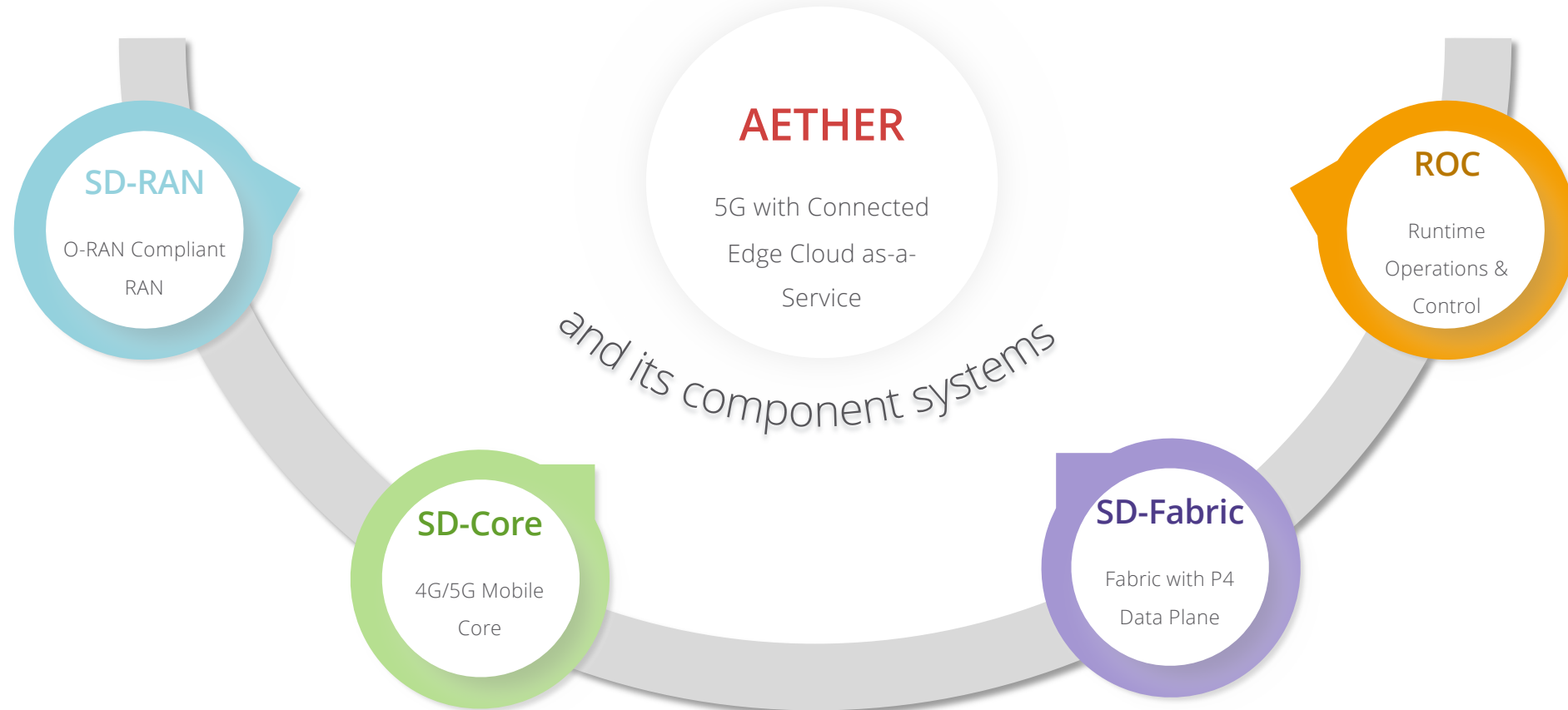
Key Attributes of ONF Platforms

Aether and its component platforms all share the following attributes

Feature Complete for MVP

Production Ready

Operationalized in a small global network

Cloud Native & Cloud Managed

Aether
Private 5G with connected edge cloud as a service: end-to-end complete solution

Leverage latest CI/CD and gitOPs tools & practices

Software defined with programmable data & control

5
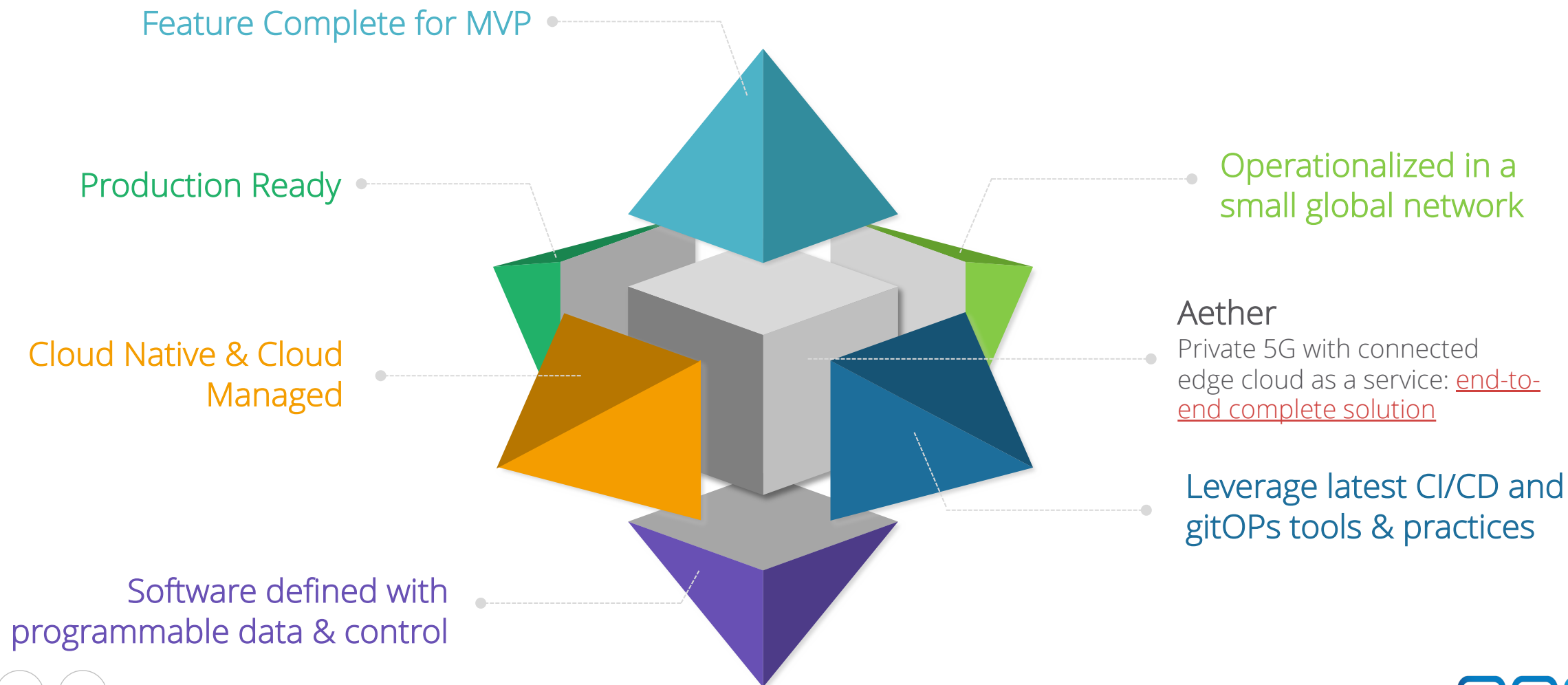
Significance of the Announcement

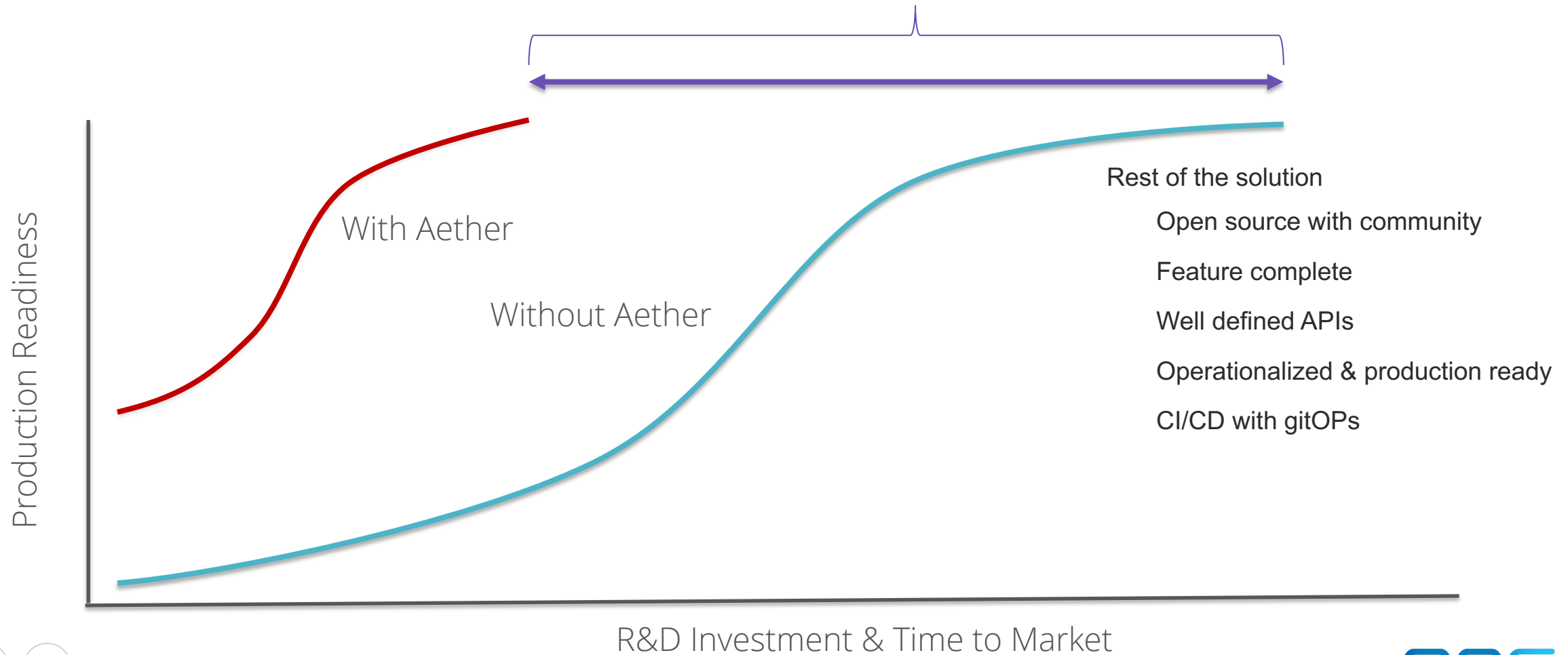# New Era for 5G/Next G and Edge: Accelerated Path to Production

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

ONF

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

Production Readiness

R&D Investment & Time to Market

With Aether

Without Aether

Rest of the solution
Open source with community
Feature complete
Well defined APIs
Operationalized & production ready
CI/CD with gitOPs
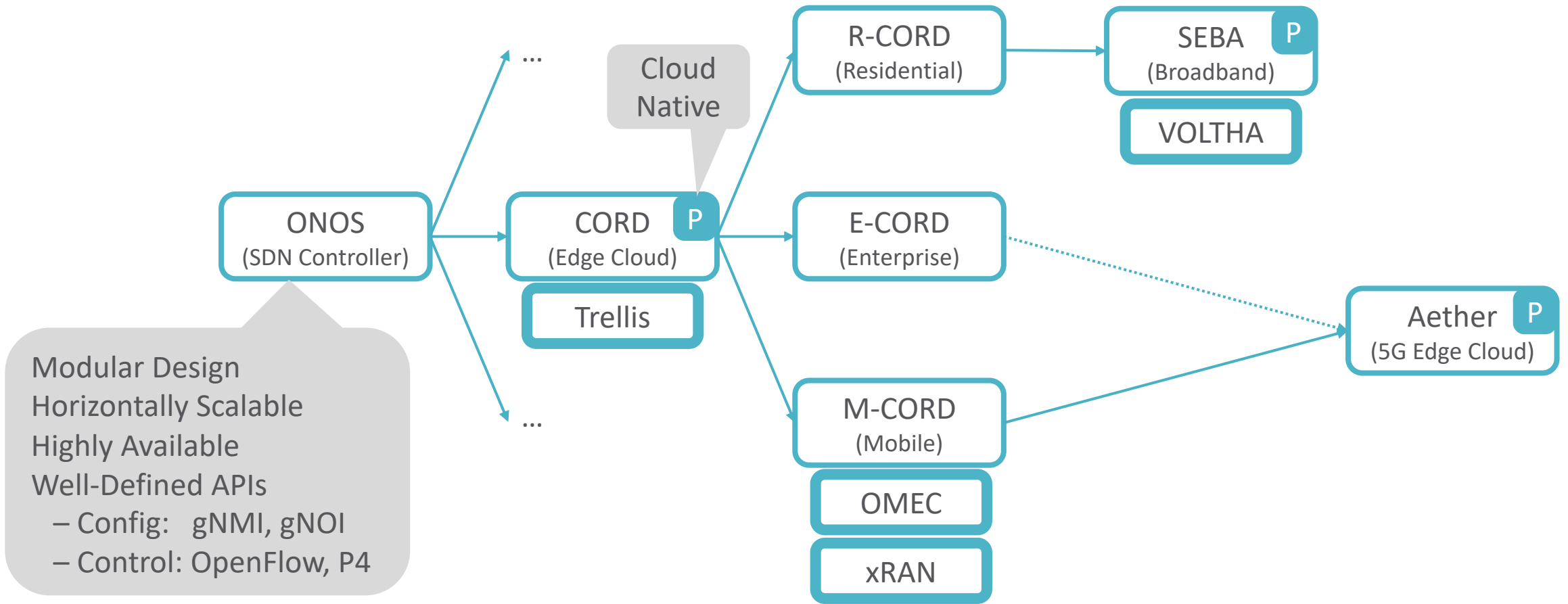
ONF Committed to Help Community

Come and Join
to Realize the Full Potential of 5G + Edge for Industry 4.0

ONF

How did we get here?

Agile Process + Architectural Coherence

Larry Peterson
CTO

Agile Process + Architectural Coherence

Cloud Native

ONOS (SDN Controller)
CORD (Edge Cloud) — P
Trellis

R-CORD (Residential)
SEBA (Broadband) — P
VOLTHA

E-CORD (Enterprise)

M-CORD (Mobile)
OMEC
xRAN

Aether (5G Edge Cloud) — P

Modular Design
Horizontally Scalable
Highly Available
Well-Defined APIs
– Config: gNMI, gNOI
– Control: OpenFlow, P4

Timeline

2012

2022

ONF

Agile Process + Architectural Coherence
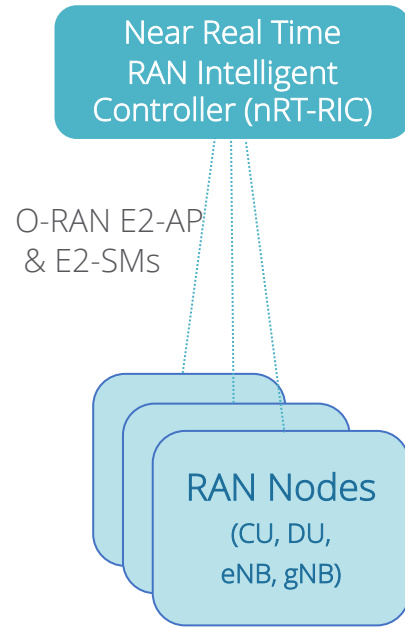

Timeline
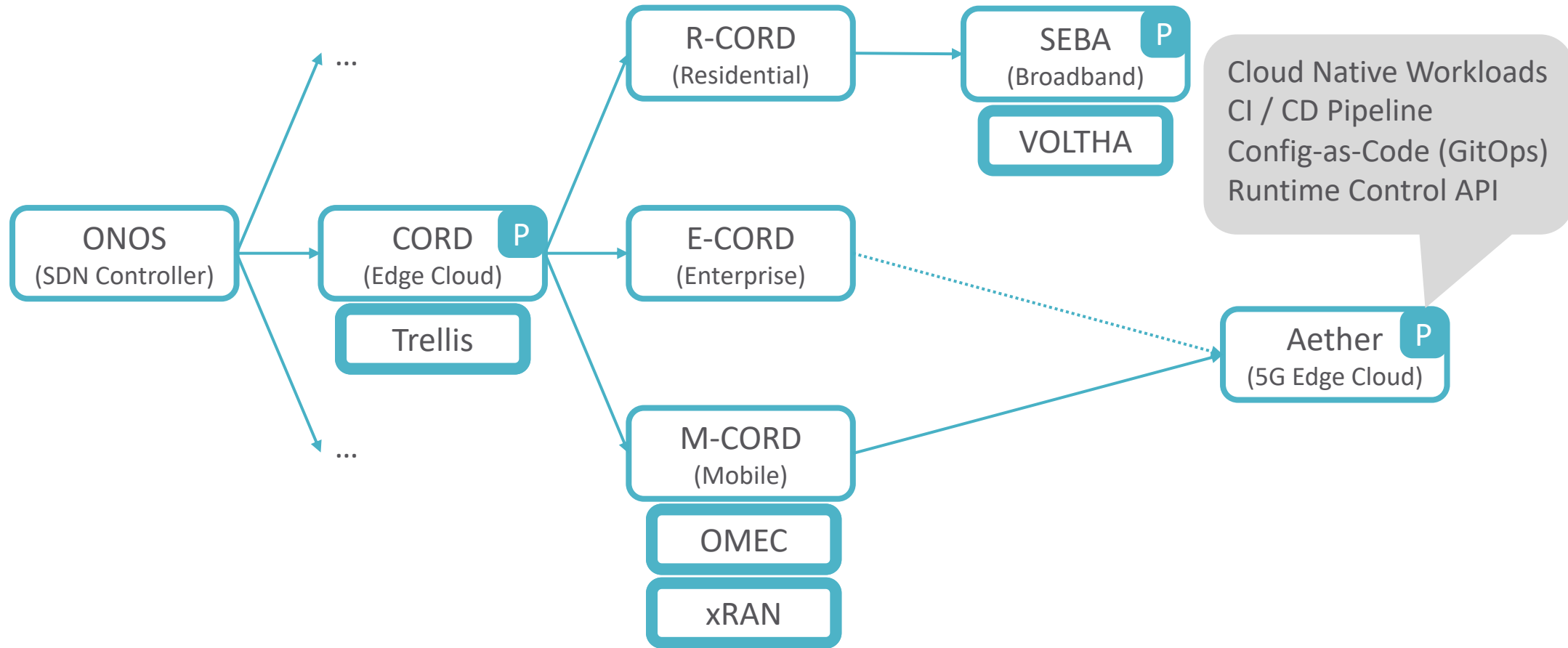
2012 ────────────────────────────────────► 2022

SD-Fabric, SD-Core, SD-RAN

Saurav Das
VP Engineering

SD - *

Near Real Time RAN Intelligent Controller (nRT-RIC)

O-RAN E2-AP & E2-SMs

RAN Nodes (CU, DU, eNB, gNB)

SD-RAN

5G-SA & LTE Mobile-core Control plane

3GPP PFCP

User Plane Functions (UPF)

SD-Core

Fabric Controller

P4RT, gNMI

Programmable Switches

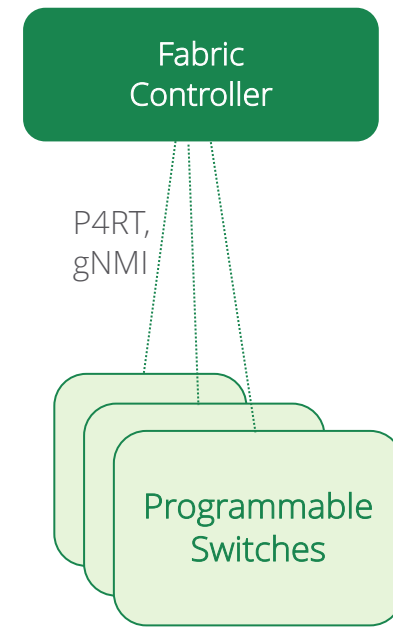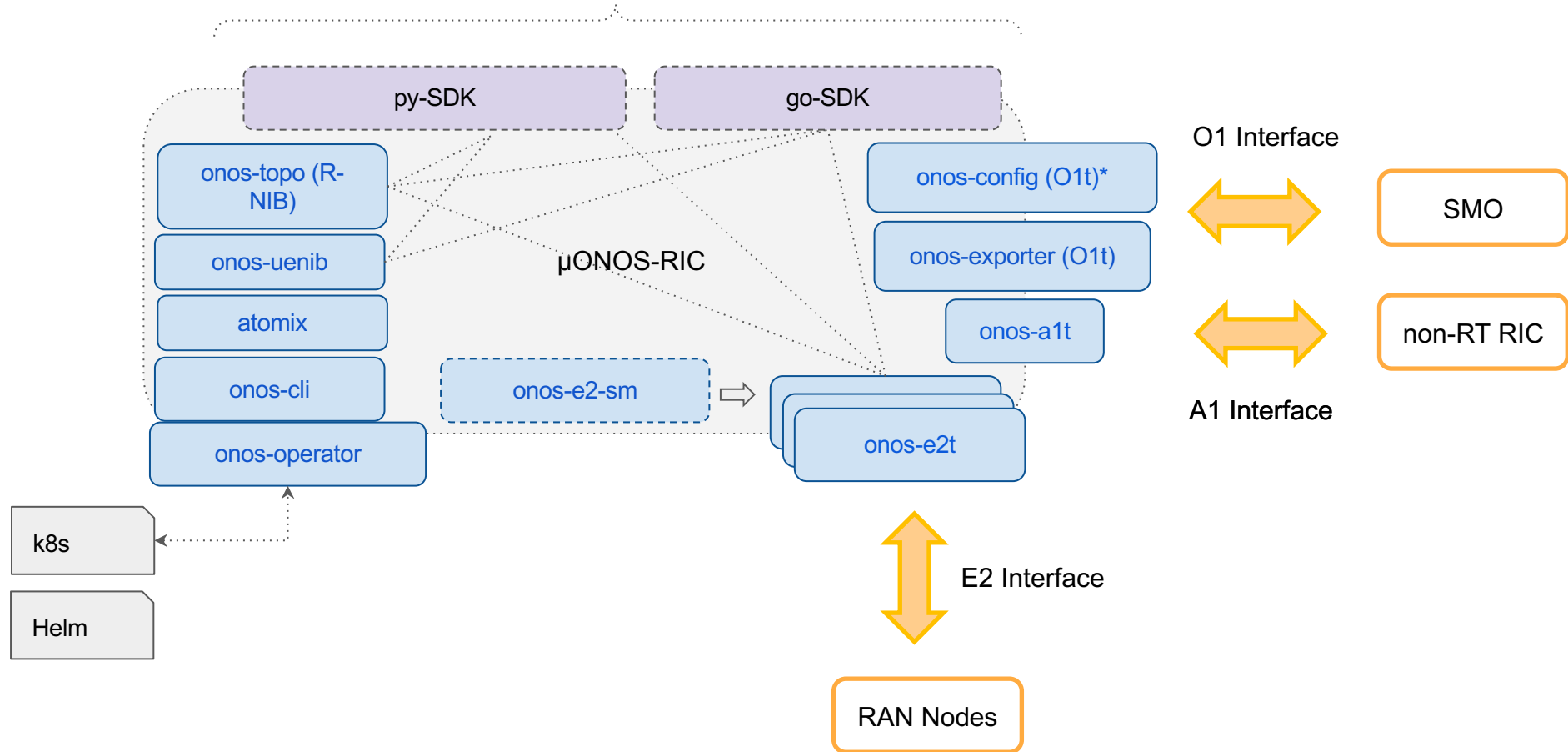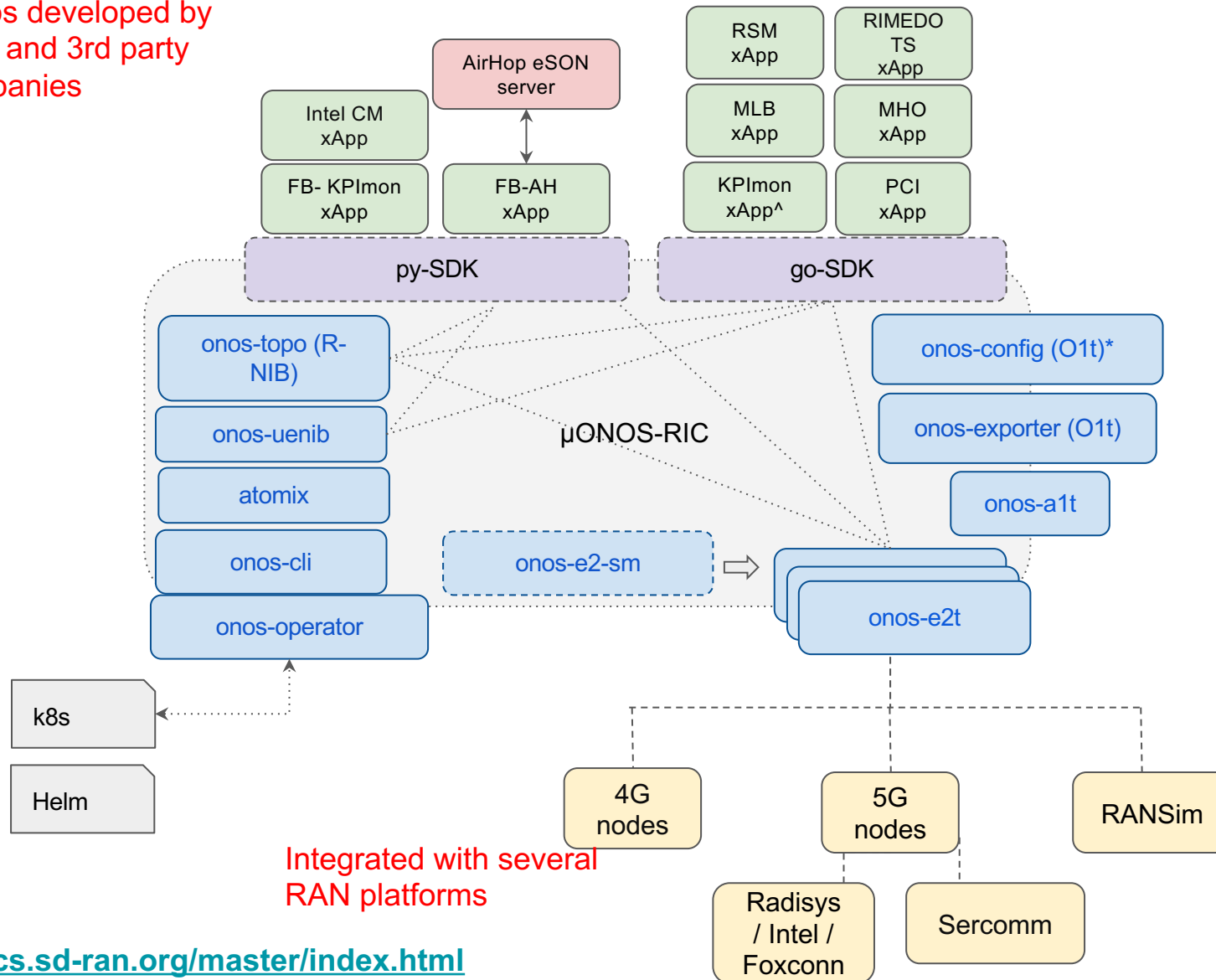**SD-Fabric**

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ONF
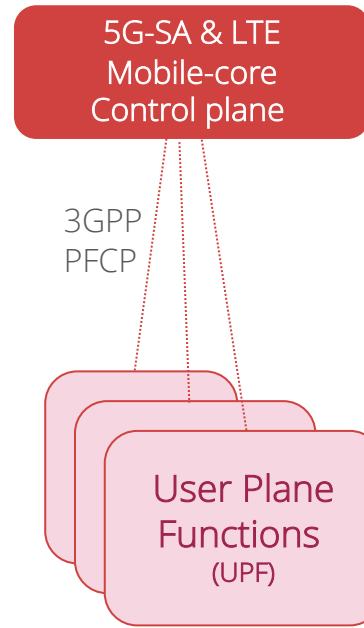
SD-RAN's µONOS-based nRT-RIC
cloud-native microservices architecture

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

SD-RAN Project

xApps developed by ONF and 3rd party companies

Intel CM xApp	AirHop eSON server	
FB- KPImon xApp	FB-AH xApp	

RSM xApp	RIMEDO TS xApp
MLB xApp	MHO xApp
KPImon xApp^	PCI xApp

py-SDK

go-SDK

μONOS-RIC

onos-topo (R-NIB)

onos-uenib

atomix

onos-cli

onos-e2-sm ⇨

onos-operator

onos-config (O1t)*

onos-exporter (O1t)

onos-a1t

onos-e2t

k8s

Helm

4G nodes

5G nodes

RANSim

Radisys / Intel / Foxconn

Sercomm

Integrated with several RAN platforms
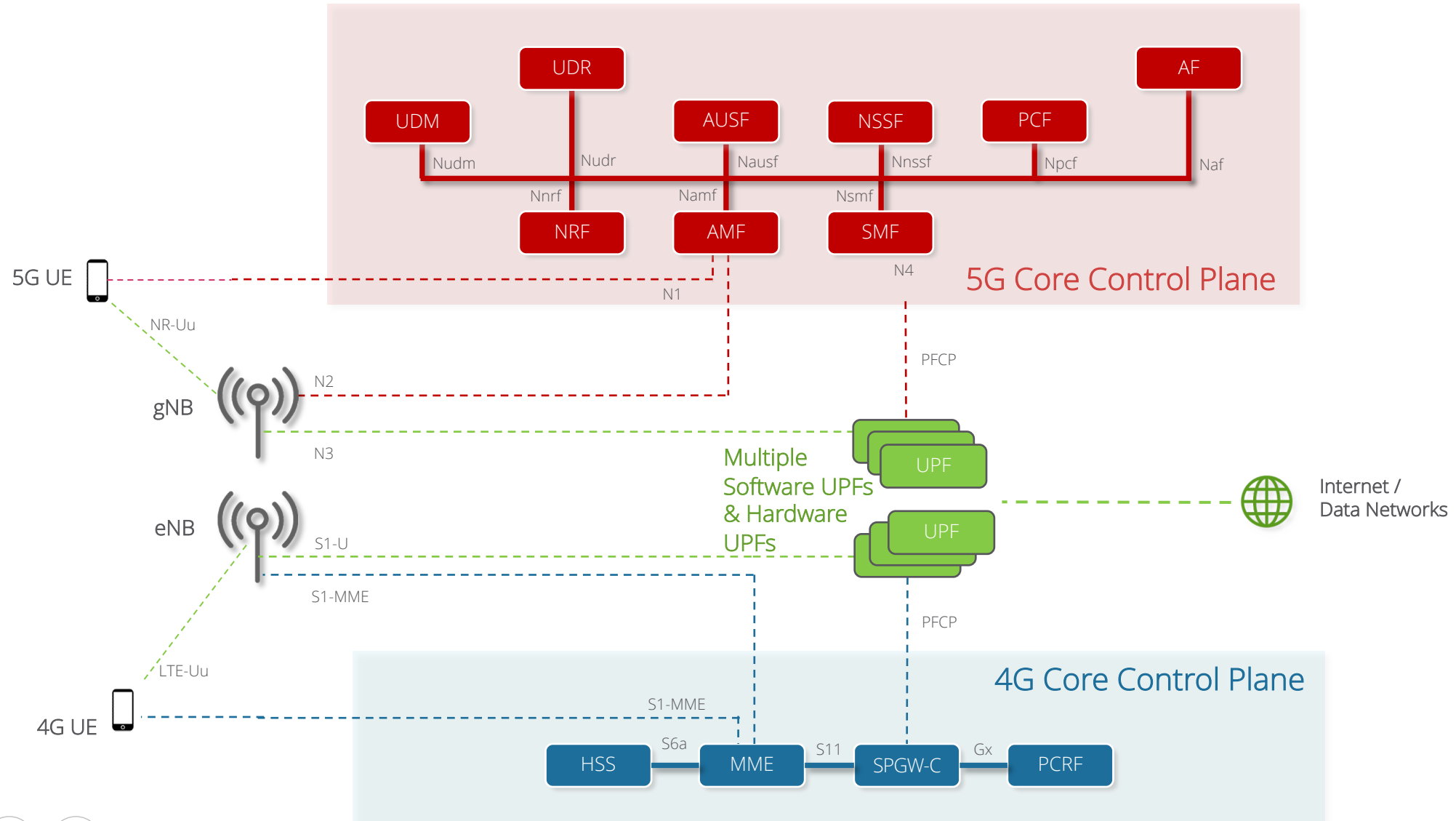
O-RAN Standardized & Pre-standard SMs

O-RAN E2AP v1.0.1, v2.0
O-RAN KPM v2.0 SM
RC-PRE v2.0 SM
MHO v1.0, v2.0 SM
RSM 1.0 SM

Learn more: https://docs.sd-ran.org/master/index.html

SD-Core Project

Original slide from SD-Core Webinar

SD-Core Deployment Flexibility

Control plane can be deployed in any central cloud

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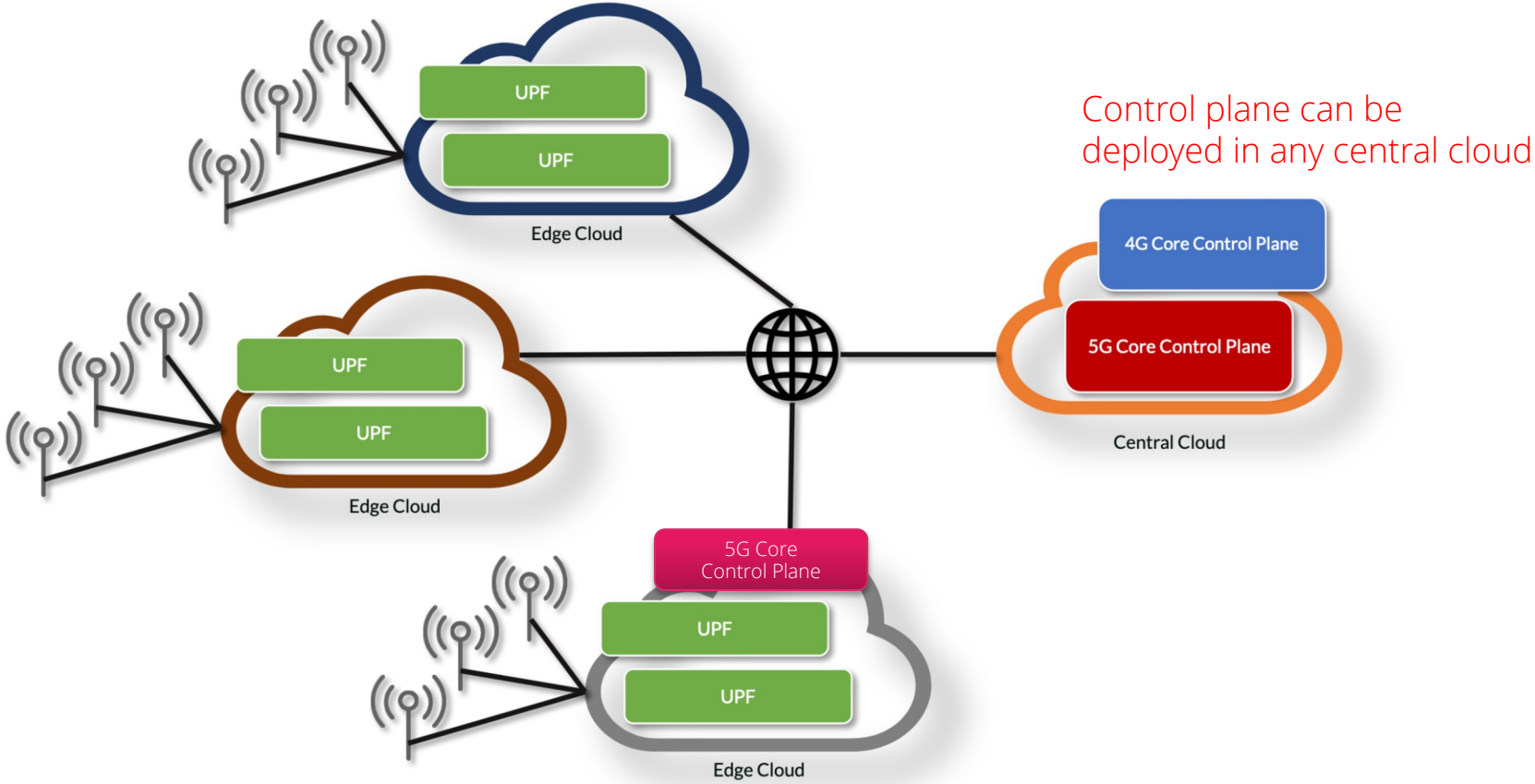
SD-Core Configuration Abstractions
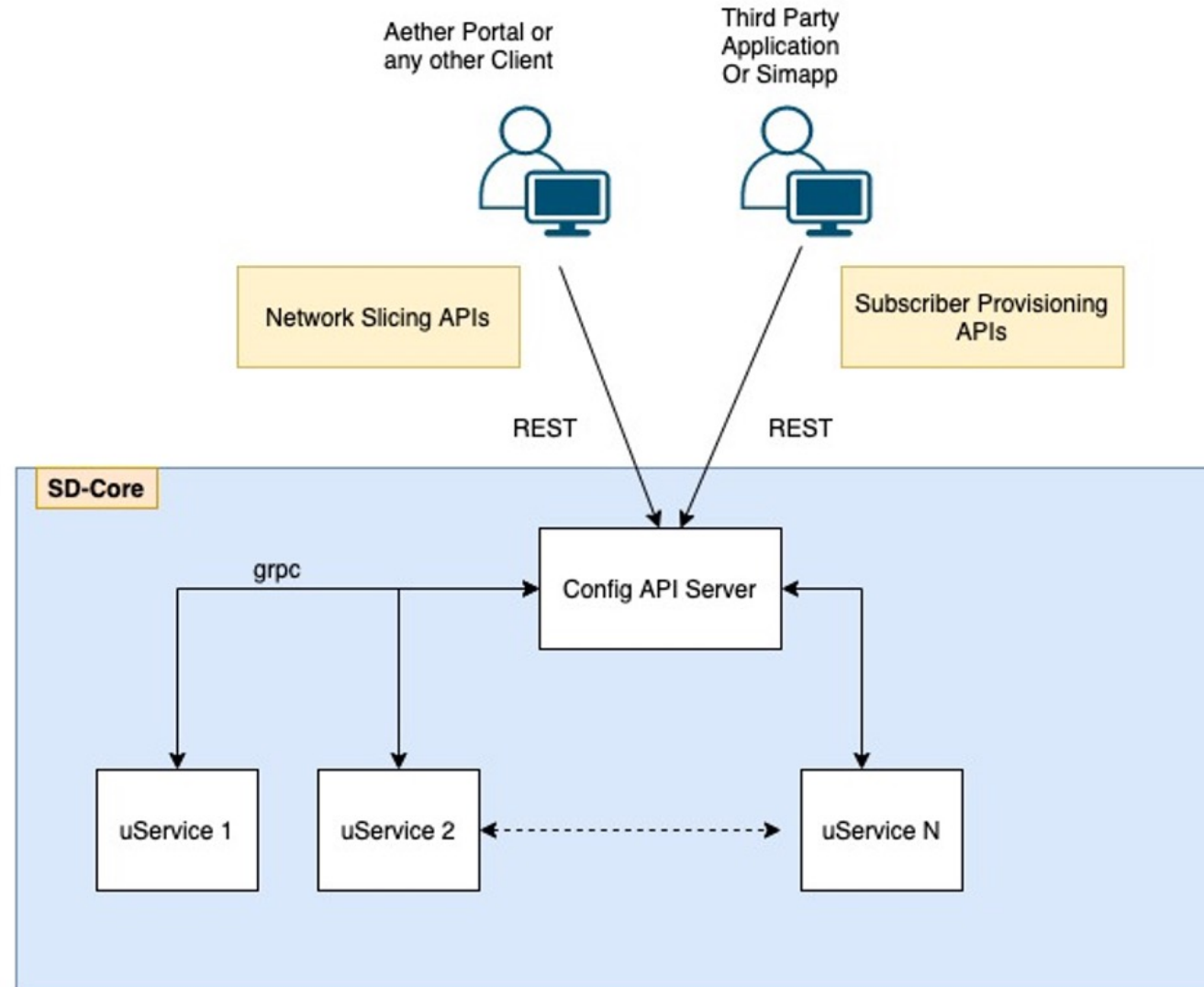
SD-Core provides an abstraction for mobile networks; that allow common configuration APIs for 4G & 5G cores

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

API driven
Fully programmable switches
Visibility throughout the network

Fabric Apps   UPF App   INT App

Fabric Controller

Closed Loop Control

P4Runtime, gNMI

INT

P4 UPF

INT

P4 UPF

5G workload

BESS UPF

CNI w/ INT

Fine-Grained Measurement

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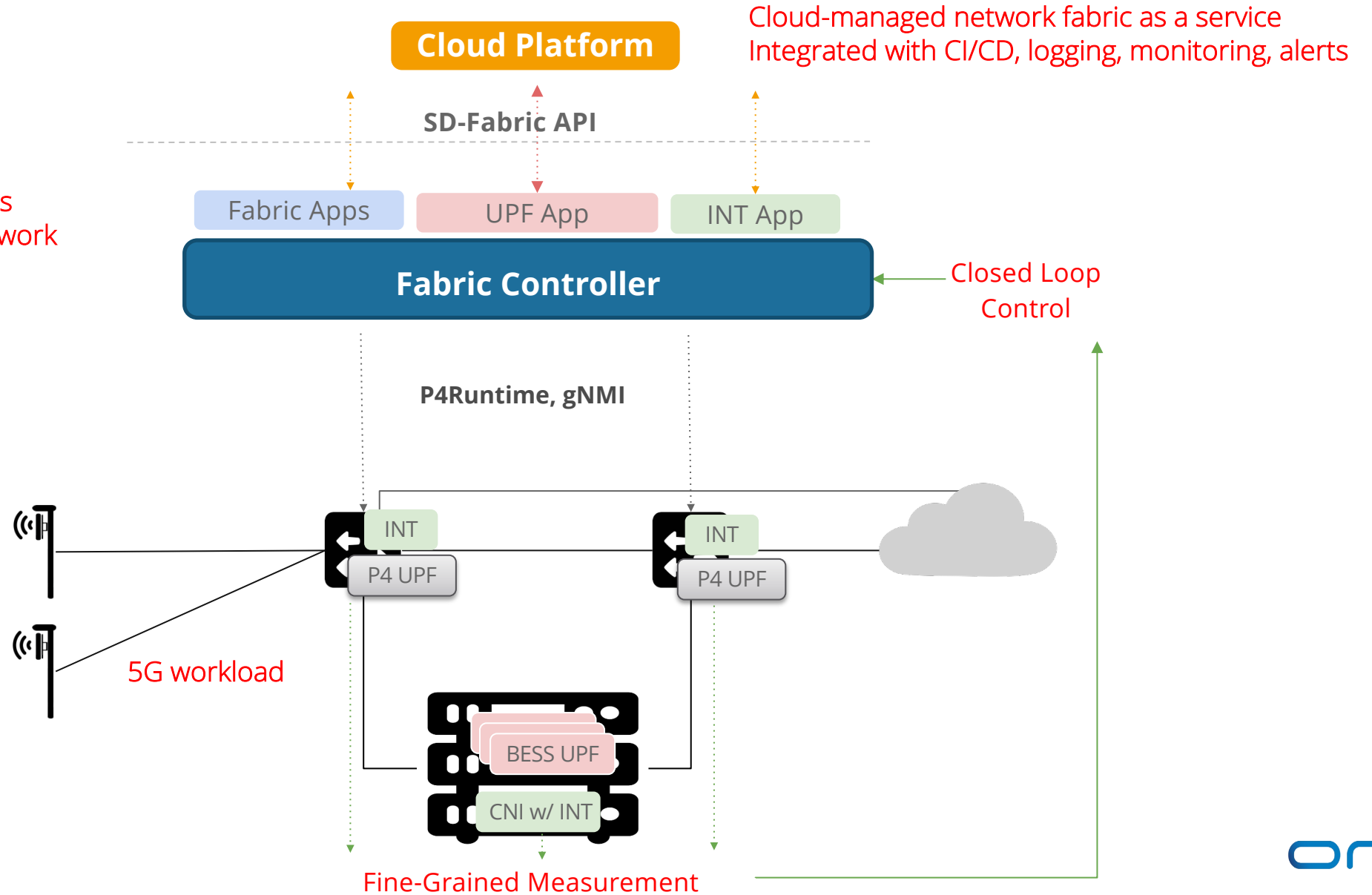
SD-Fabric Scalability and Redundancy

Single Switch
Minimal setup

Scale

Single Leaf Pair
Minimal HA setup

Scale

Scale

Leaf-Spine Fabric
With ECMP and N-way redundancy

SD-Fabric + SD-Core

P4-UPF

Edge App

Servers

Switch

BESS-UPF

Edge App

Servers

SD-Core

Mobile Core Control Plane
(4G SPGW-C or 5G SMF)

PFCP

PFCP Agent

Switch
(virtual-upf.p4)

P4Runtime

UPF App
One-Big-UPF abstraction

Fabric Control Apps
Routing, ECMP, VLANs

SD-Fabric

ONOS – SDN Controller (Highly Available)

P4Runtime & gNMI

Spine   Spine

Leaf   P4-UPF   P4-UPF   Leaf

BESS-UPF   BESS-UPF

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

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

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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
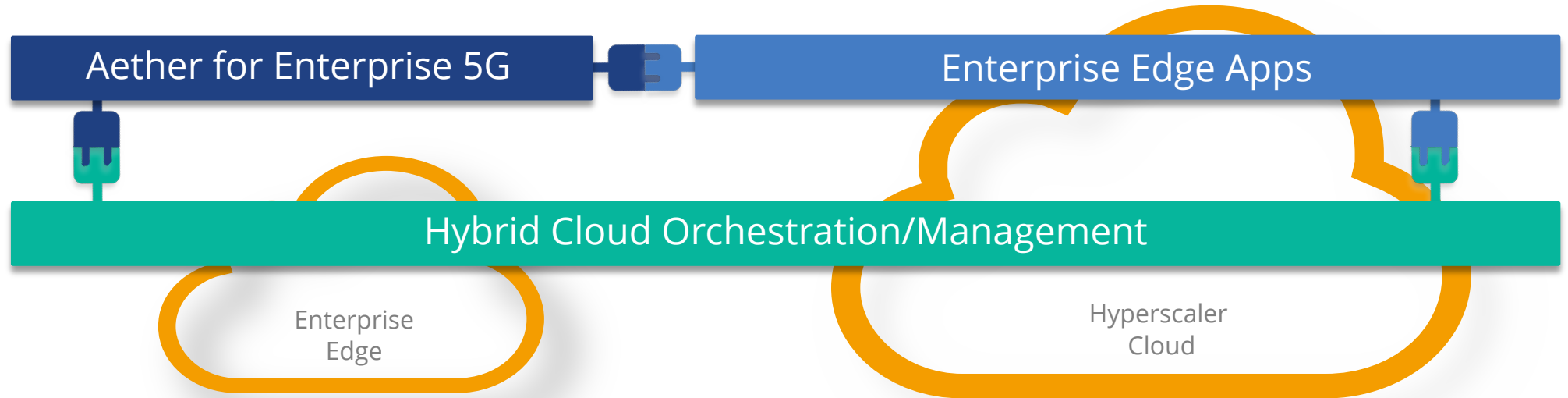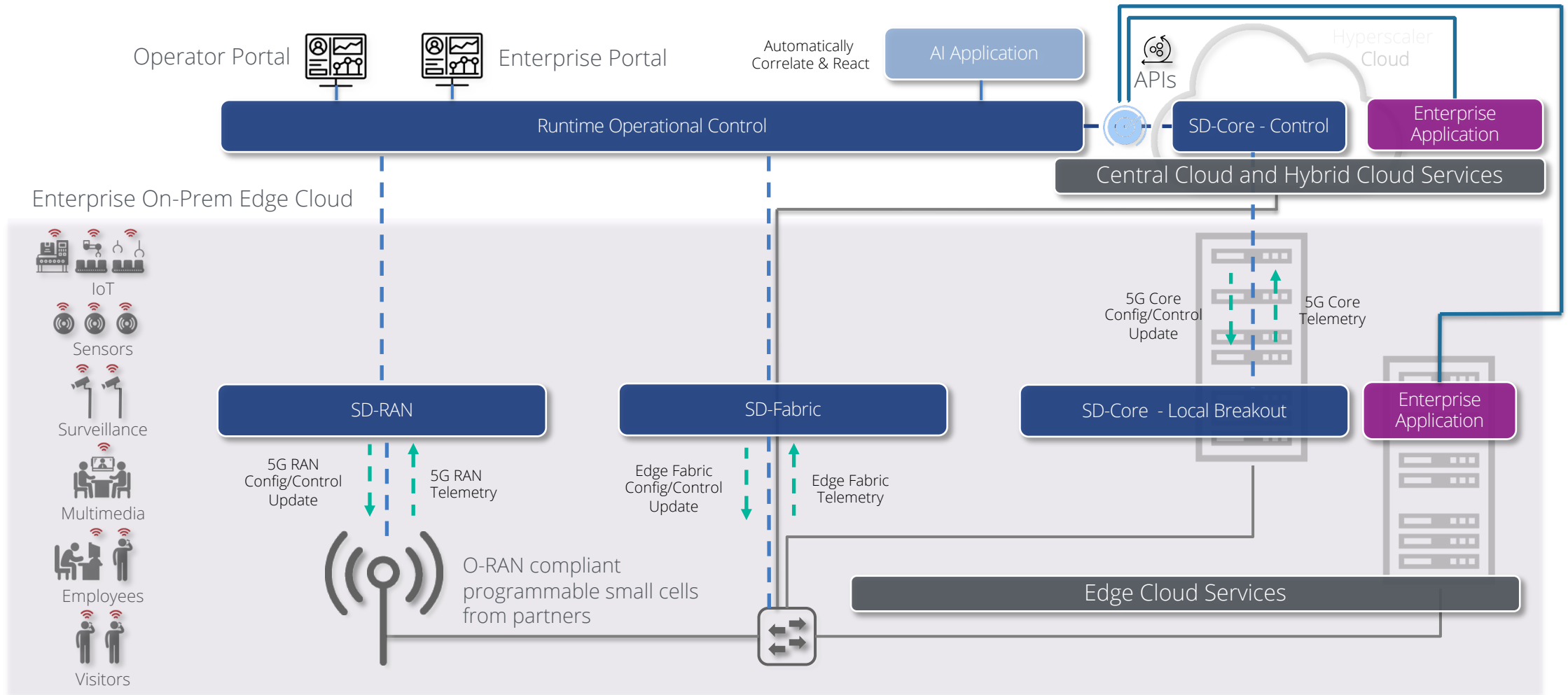
Oğuz Sunay
VP of R&D - Mobility

ONF

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

IoT

Sensors

Surveillance

Multimedia

Employees

Visitors

Aether for Enterprise 5G

Enterprise Edge Apps

Hybrid Cloud Orchestration/Management

Enterprise
Edge

Hyperscaler
Cloud

Putting the components together: Aether

Operator Portal

Enterprise Portal

Automatically Correlate & React

AI Application

APIs

Hyperscaler Cloud

Runtime Operational Control

SD-Core - Control

Enterprise Application

Central Cloud and Hybrid Cloud Services

Enterprise On-Prem Edge Cloud

IoT

Sensors

Surveillance

Multimedia

Employees

Visitors

SD-RAN

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

Enterprise Application

O-RAN compliant programmable small cells from partners

Edge Cloud Services

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Sum is greater than the components: Aether stack

Aether CI/CD & GitOps

Third Party Edge Platforms & Apps Development and Deployment Tooling

SAS

Aether Portals

Aether Operations Tools: Aether Monitoring, Aether Logging

Aether Cluster Config Management

Aether Runtime Operational Control

Aether Multi-Cluster Control

Provisioning

Edge Platforms & Apps

SD-RAN

SD-Core: 5G/4G UPF

Aether, Multi-Site VPN

Aether Kubernetes

SD-Fabric

Aether Edge Infrastructure (COTS + Programmable Fabric)

SD-Core: 5G Control

SD-Core: 4G Control

Aether Multi-Site VPN

Aether Kubernetes

Central Cloud Infrastructure

On-Prem Edge

Central Cloud

ONF

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Aether's CI/CD and GitOps

Code commit

Project Repo

trigger

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

changes requested

Merge

Reviewer

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

changes requested

Image Repo

Helm Repo

app version update

App Env Repo

Operations

app config update

infra update

Pod Env Repo

QA ENVIRONMENT

Testing

timer or other trigger

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Aether's CI/CD and GitOps

Image Repo

Helm Repo

App Env Repo

Pod Env Repo

Deploy/Update Aether Services

Pull updates

Manage Kubernetes and Apps

synch

PRE-MERGE JOBS
- Infra Plan
- Infra Validate

Merge

POST-MERGE JOBS
- Infra Apply

Deploy/Update Kubernetes

Deploy/Update Docker, VPN, vRouter, etc.

Applications

Fleet Agent

Kubernetes

Infrastructure

Aether Cluster

Operations

config changes requested

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Aether Offers APIs at multiple hierarchies

Enterprise Portal

5 Open APIs towards 3rd party product portal developers

AI Application

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

Enterprise Application

Runtime Operational Control

Adapter

Adapter

Adapter

1 O-RAN compliant Open SDK towards 3rd party RAN control and monitoring app developers

xApp

SDK

4

2 Open APIs towards 3rd party fabric control and monitoring app developers

App

4

3 Open APIs towards 3rd party mobile core app (SIM management, LDAP integration, etc) developers

App

4 Open APIs towards integration with ROC and 3rd party Operational/Business Support System Platforms

SD-RAN

SD-Fabric

SD-Core - Control

SD-Core - Local Breakout

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Aether has been operational for over 2 years

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

Deutsche Telekom
Lilyneir
CNIT
Sorbonne

NTT

Edge-Core
NCTU
FET

🔴 On-Prem Aether edge sites

🔵 Central Management and Control

🟠 On-Prem edge sites in the pipeline

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An outdoor trial with DT is now live

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

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

▶ [Trial Video](#)

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

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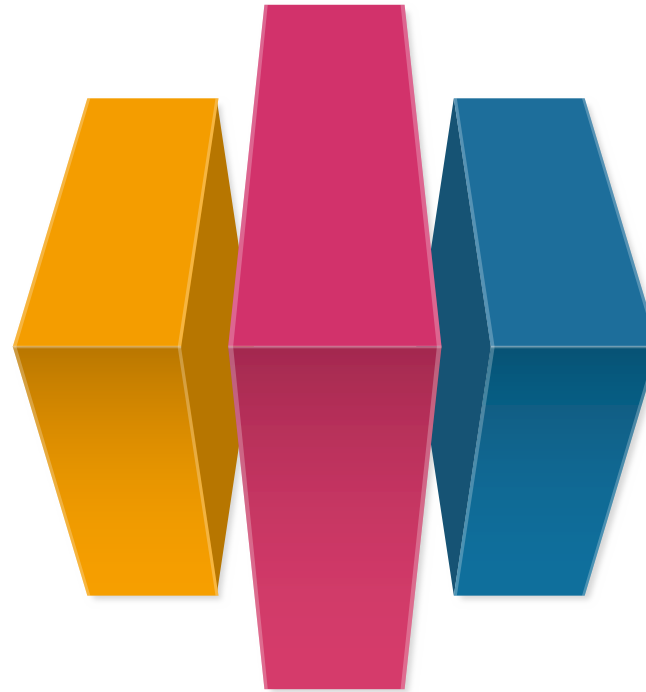
We are open-sourcing it at the perfect time – private 5G is potentially a huge emerging market and its adoption is starting to pick up.

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
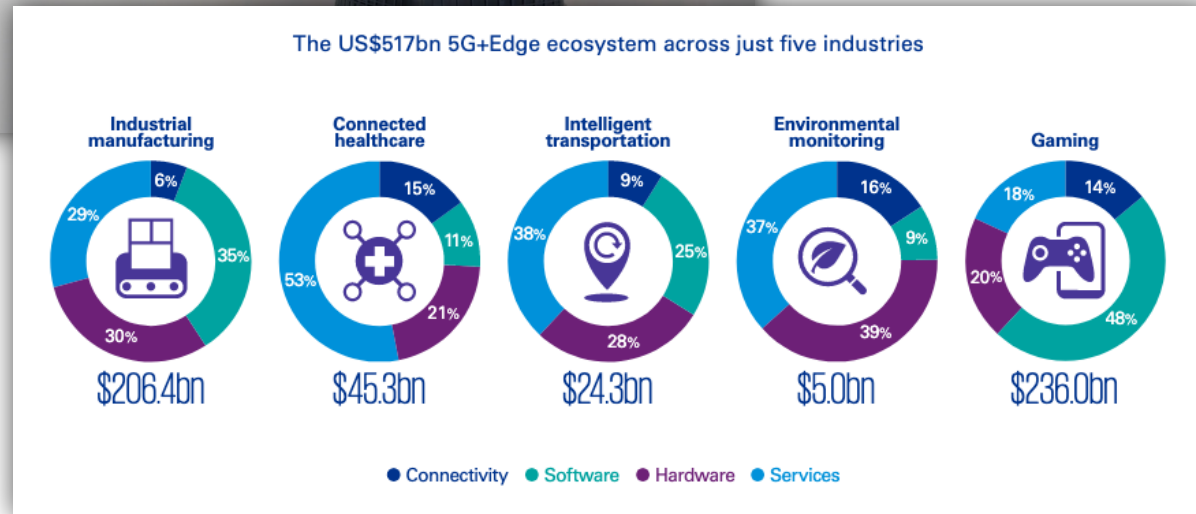
Adoption

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

2012   2014   2016   2018   2020   2022   2024

ONOS — Open Network Operating System

CORD

TRELLIS

VOLTHA — VIRTUAL OLT HARDWARE ABSTRACTION

SEBA

AETHER

XOS

ODTN

OMEC — OPEN MOBILE EVOLVED CORE

PINS

SD-RAN

SD-CORE

SD-FABRIC

ONF

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

https://home.kpmg/xx/en/home/insights/2020/06/the-5g-edge-computing-value-opportunity.html
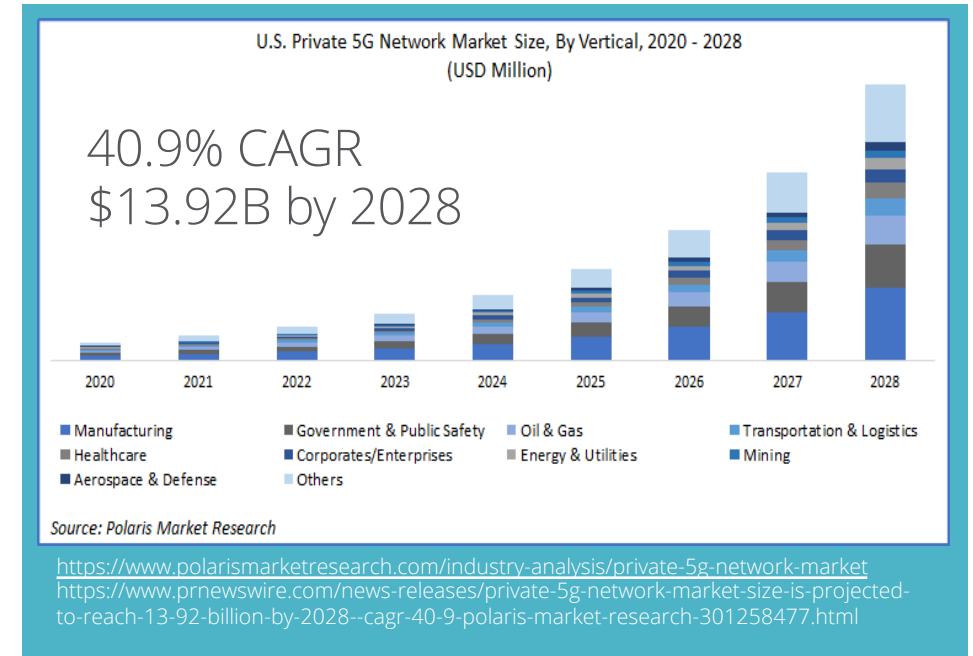
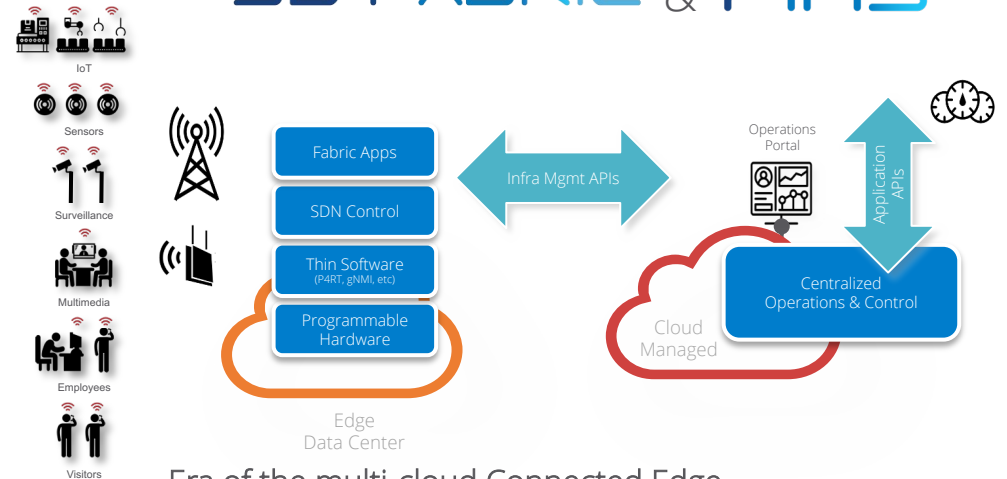# ONF Component Systems Have Broad Industry Appeal

U.S. C-RAN market size, by architecture, 2016 - 2027 (USD Billion)

Source: www.grandviewresearch.com
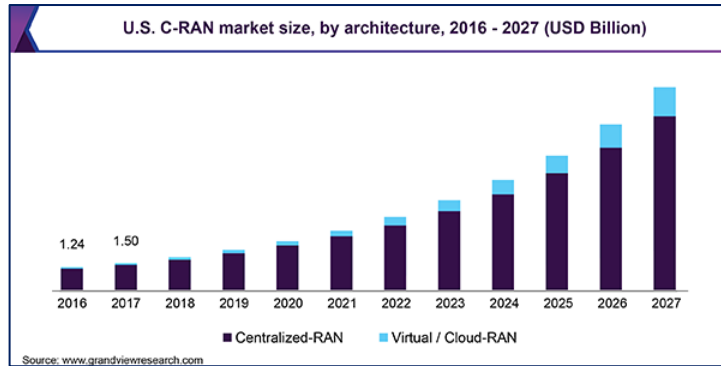
RAN Market is poised for disaggregation

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

https://www.delloro.com/news/worldwide-ran-revenues-expected-to-reach-0-2-trillion-through-2024/

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

https://www.marketsandmarkets.com/Market-Reports/data-fabric-market-237314899.html

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

Business Model Pressure on Operators

$

Data Demand / Infrastructure Cost

ARPU

Time
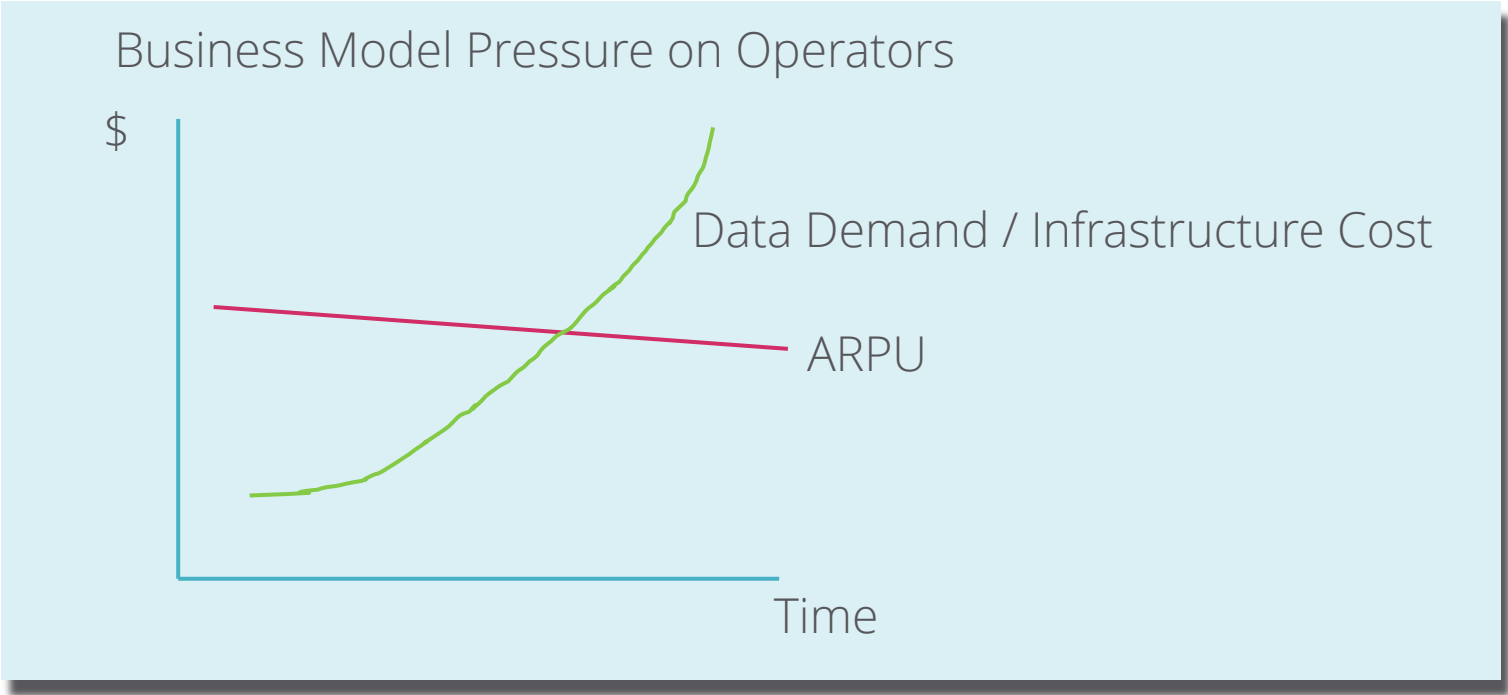
ONF became a trusted partner to operators
Non-profit
Mission oriented

ONF Needed a New Open Source Model
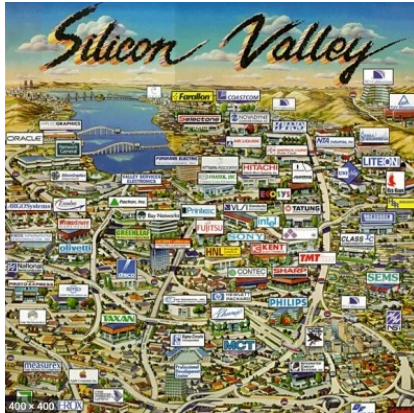

...
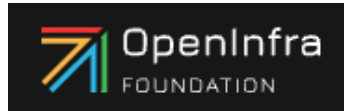
No development team
- Manage projects, community
- Adopt new technology
- Build consensus
- Incremental
- Serve community

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*"

+ startups....

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 -

45

ONF

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

ONF

Our journey is only possible because of ONF's community

Thank You !

Thank you

ONF