



ONF Reference Designs

A Plan for Taking Open Source to Production

Reference Design Workshop

ONF & CORD Recent Activities

11:15	20min	Timon	Reference Design Intro and Overview
11:35	10min	Matteo	SEBA
11:45	10min	Uyen	Trellis & UPAN
11:55	10min	Timon	ODTN
12:05	10min	Larry	M-CORD and Edge Cloud
12:15	10min	Timon	Wrap Up & Q&A

Operator Reality

Must cope with ever growing traffic and flat ARPU

- Operators must transform how they build infrastructure and services
 - Must significantly reduce CapEx and OpEx
 - Must enable and create value added revenue generating services on their infrastructure
- ONF Operators' consensus is to build infrastructure leveraging:
 - Disaggregation, white boxes, specialized components and open source
 - Software-defined and virtualization to enable innovative services
 - Focus on Access & Edge
 - Represents 70-80% of total costs (capex & opex)
 - This is where new edge services will be deployed

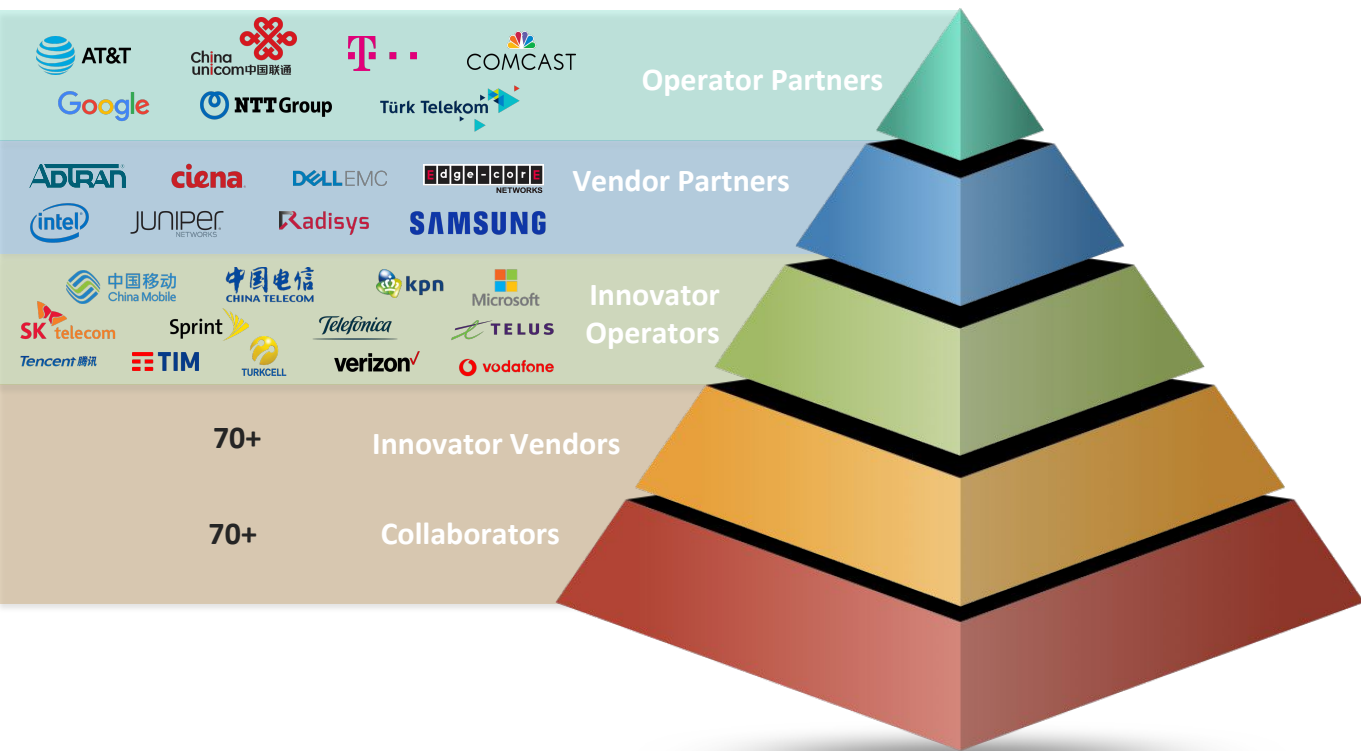
ONF - Unique Operator Led Consortium



By Operators for Operators
Collaborating to Drive Transformation

The ONF Ecosystem – 160+ Members Strong

Vibrant Operator Led Consortium Positioned for Success



ONF BOARD



Andre Feutsch – CTO
& ONF Chair



Jochen Appel - VP



Amin Vahdat - Fellow



Dai Kashiwa - Director



Rob Howald - VP



Shao Guanglu - SVP



Patric Lopez - VP



Firay Yaman Er - CSO



Nick McKeown - Prof

Guru Parulkar, Exec Dir

January 2018

Vendor Concerns Voiced to ONF Operators

- Path to production unclear
- Too many components
 - Operators all assembling different variants & solutions
- Without clear consensus, vendors can't afford to invest

In Response, Operators Expanded ONF Direction

Eight Tier-1 Operator Have Committed to:

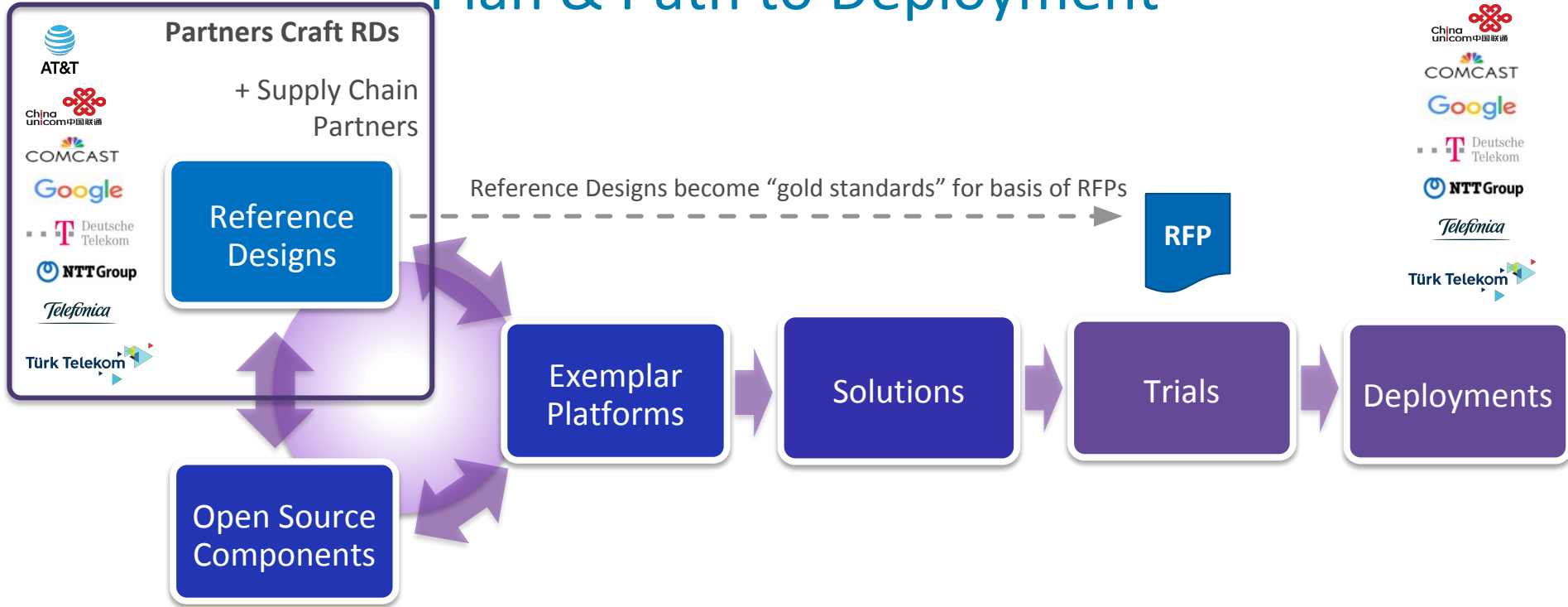


AT&T



- Create “Curated Open Source” Model
 - Operator build consensus on ‘exemplar platforms’ using selected components
- Operators to jointly create common Reference Designs for access/edge
 - “Gold Standards” for what’s to be deployed in production networks
 - Operators committing resources from Architecture, Design & Ops teams
 - Operators to craft RFPs based on these designs
- Form Keiretsu ecosystem of operators and aligned supply chain partners
 - Operators committed to reconstitute a new supply chain
 - Aligned with leveraging open source & white box for production deployments

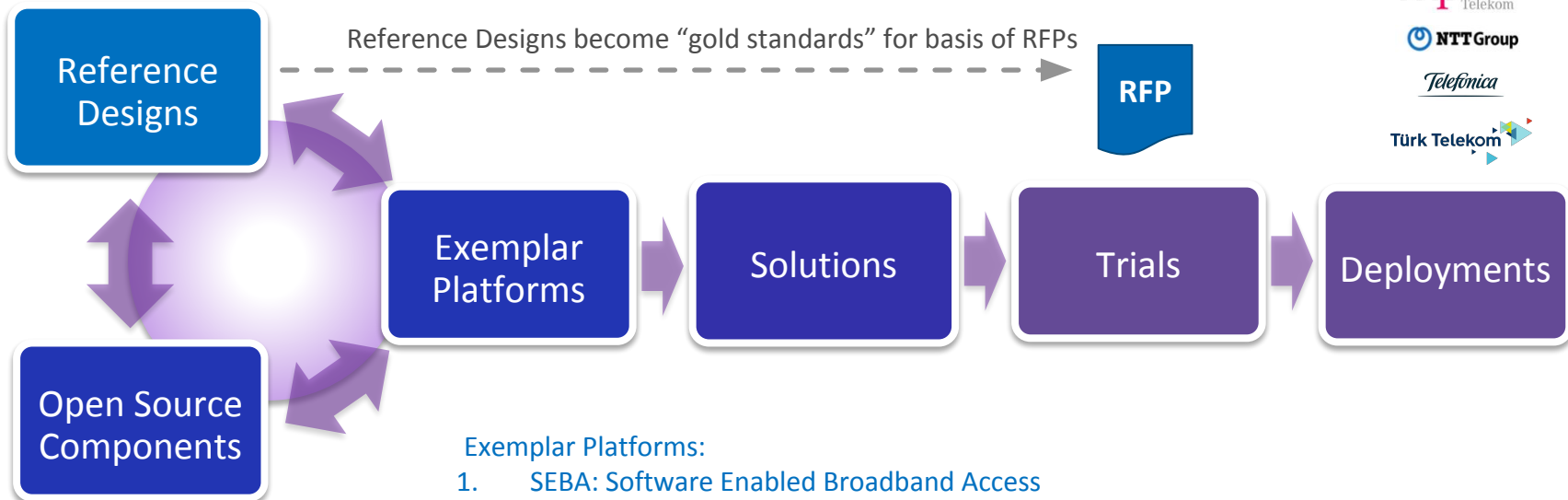
Plan & Path to Deployment



Components to Reference Designs & Exemplar Platforms

Reference Designs:

SEBA-RD
Trellis-RD
UPAN-RD
ODTN-RD



Components:

XOS
ONOS
Stratum
VOLTHA

Exemplar Platforms:

1. SEBA: Software Enabled Broadband Access
2. Trellis: A Leaf-Spine Fabric
3. UPAN: Unified Programmable Autonomous Network
4. ODTN: Open Disaggregated Transport Network



Reference Designs Drive Procurement via Phased Development

Partners Create RDs

Operators join together
by mutual commitment
to deploy a Common RD

+

Aligned supplier
partners participate
in RD creation



Reference
Design
Creation



ONF Member Participation

General ONF
Membership asked
to review and
comment on RDs

Required for RAND-Z
licensing

Draft
Reference
Design



Operator Procurement

RDs become public.

Operators refer to and procure
based on Reference Designs



Plus additional operators

Active Operators*



Reference Designs

SEBA
SDN Enabled Broadband Access

Trellis NFV Fabric
SDN Spine Leaf Fabric

UPAN
Unified Programmable Automated Network

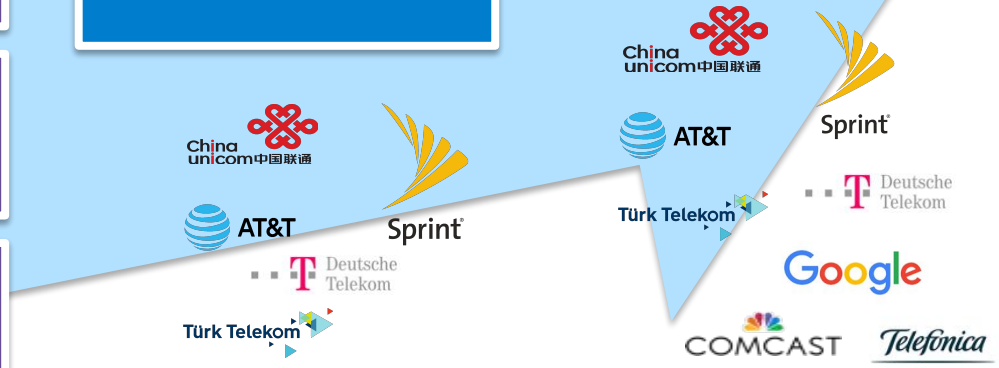
ODTN
Open Disaggregated Transport Network

Reference Designs

Trailblazing Projects & Emerging Reference Designs

M-CORD
vRAN & 5G Mobile

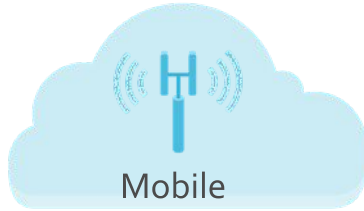
CORD
Access & Edge Cloud



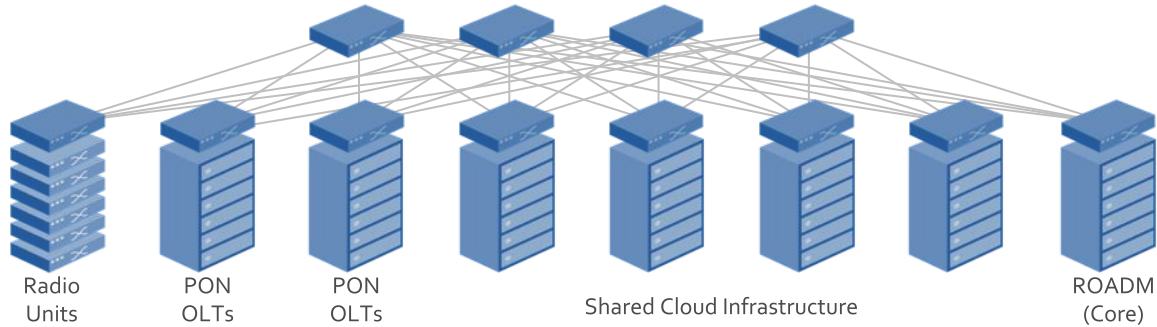
* These are the operators truly investing. Broader sets of operators are modestly investing & publicly support the work



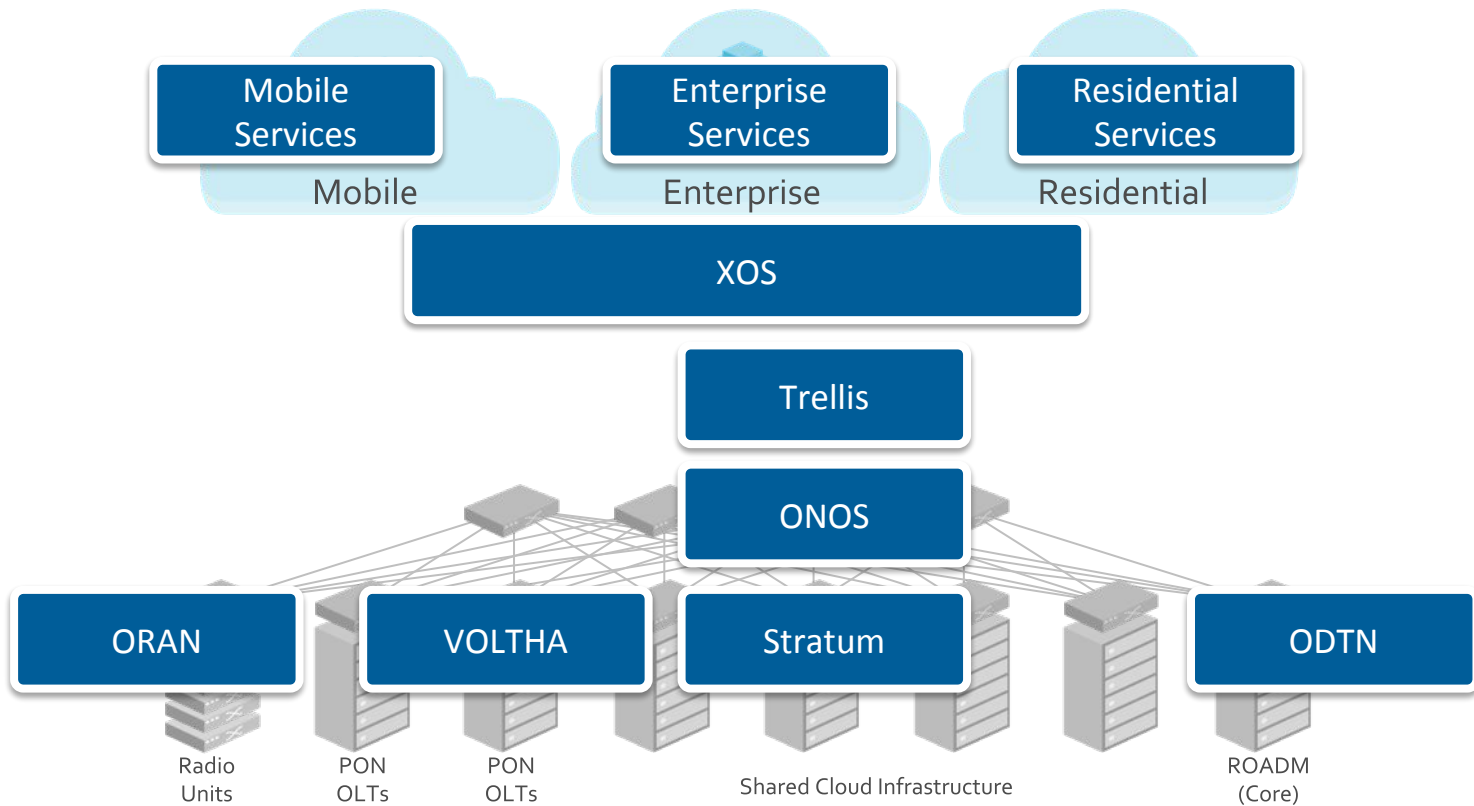
ONF Projects & Platforms



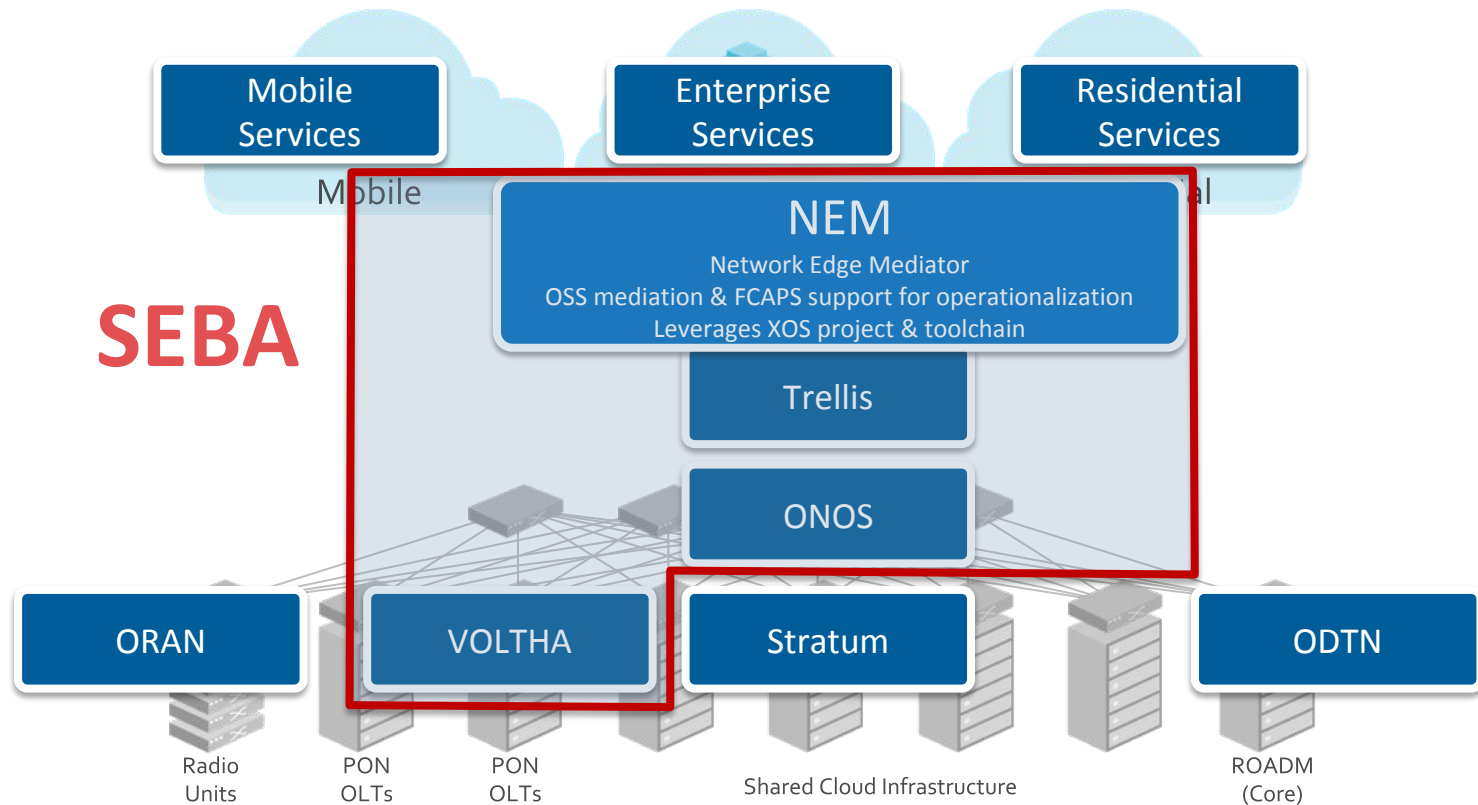
Open Source Software Stack



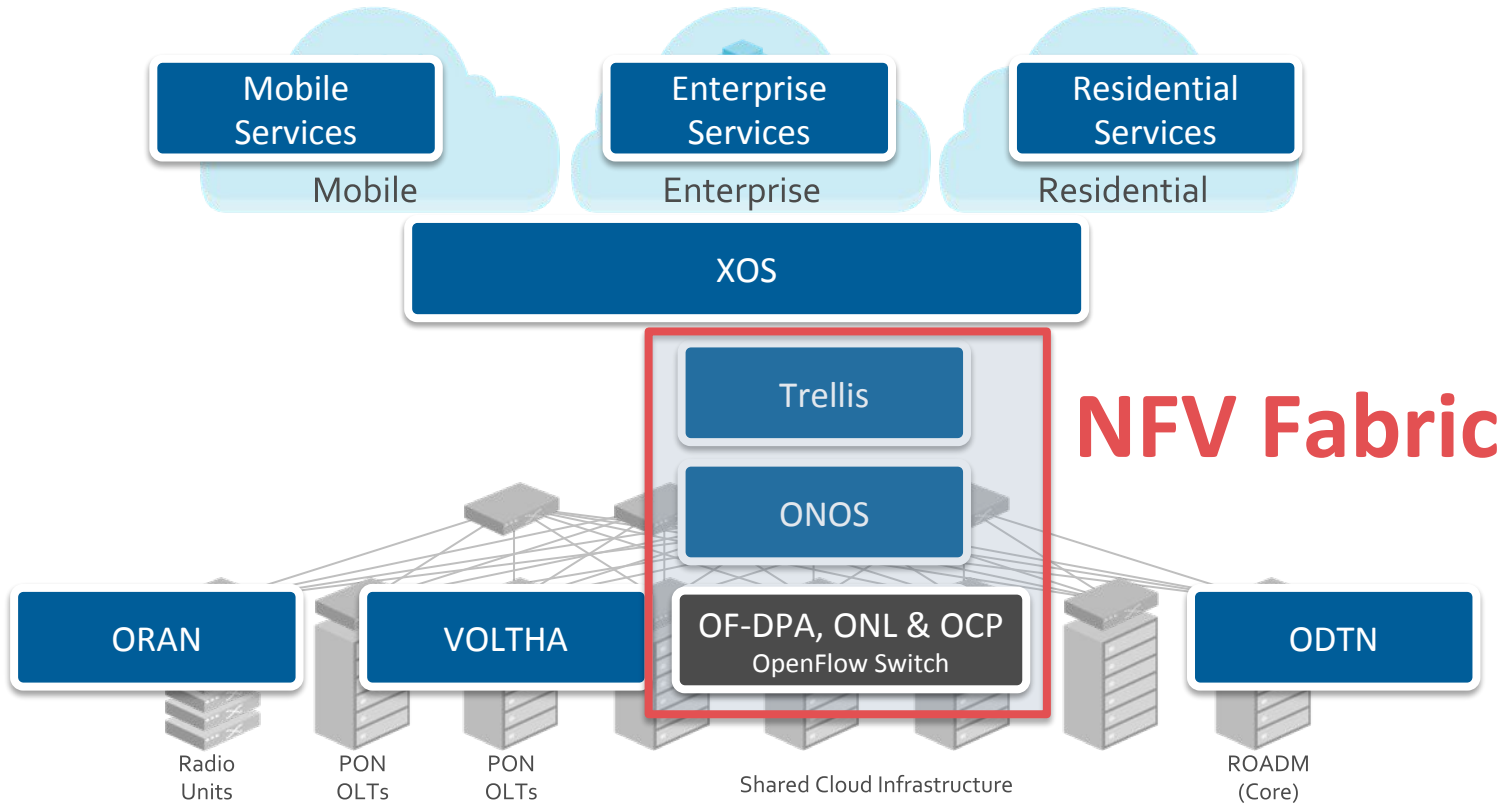
ONF Projects & Platforms



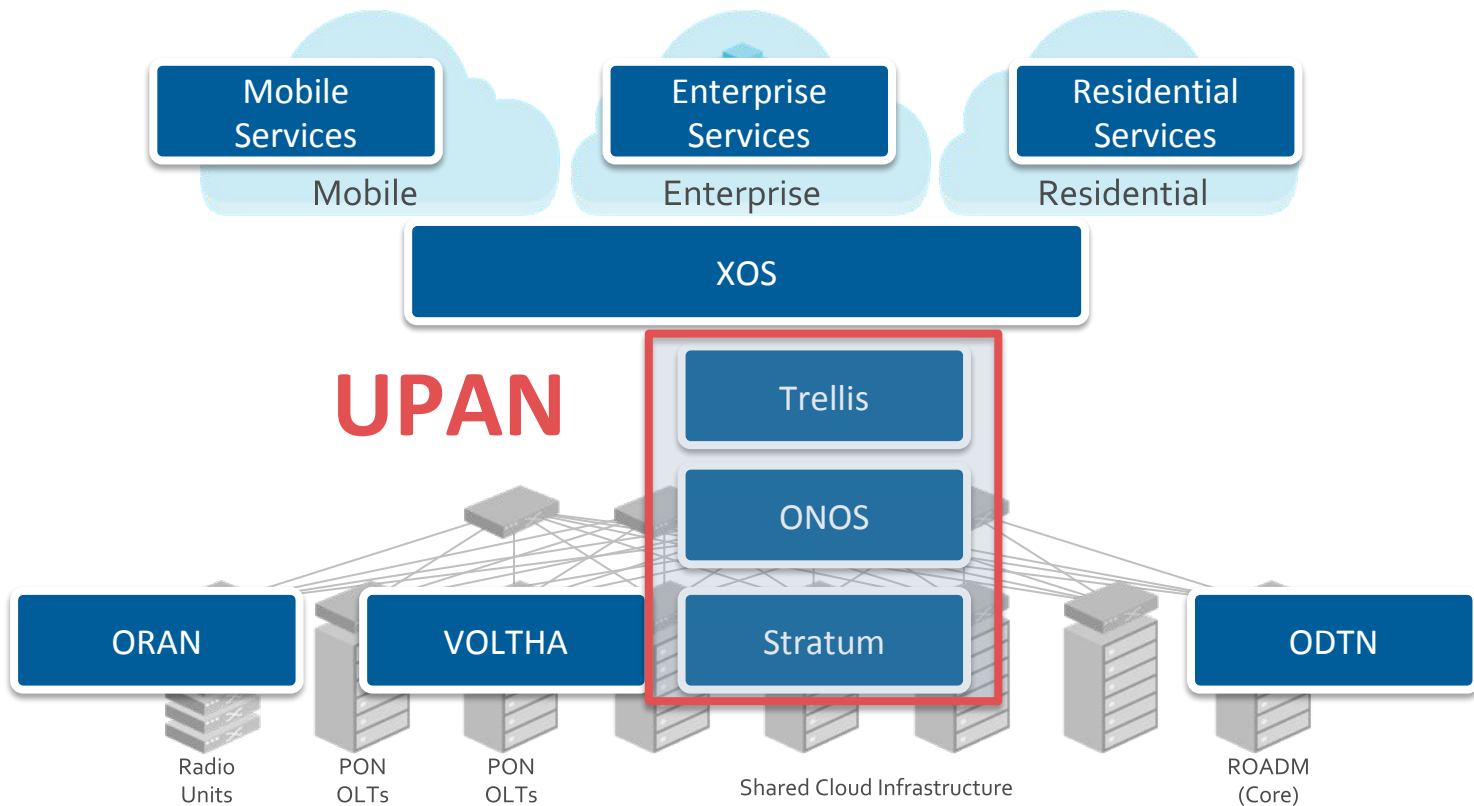
SEBA Exemplar Platform (variant of R-CORD)



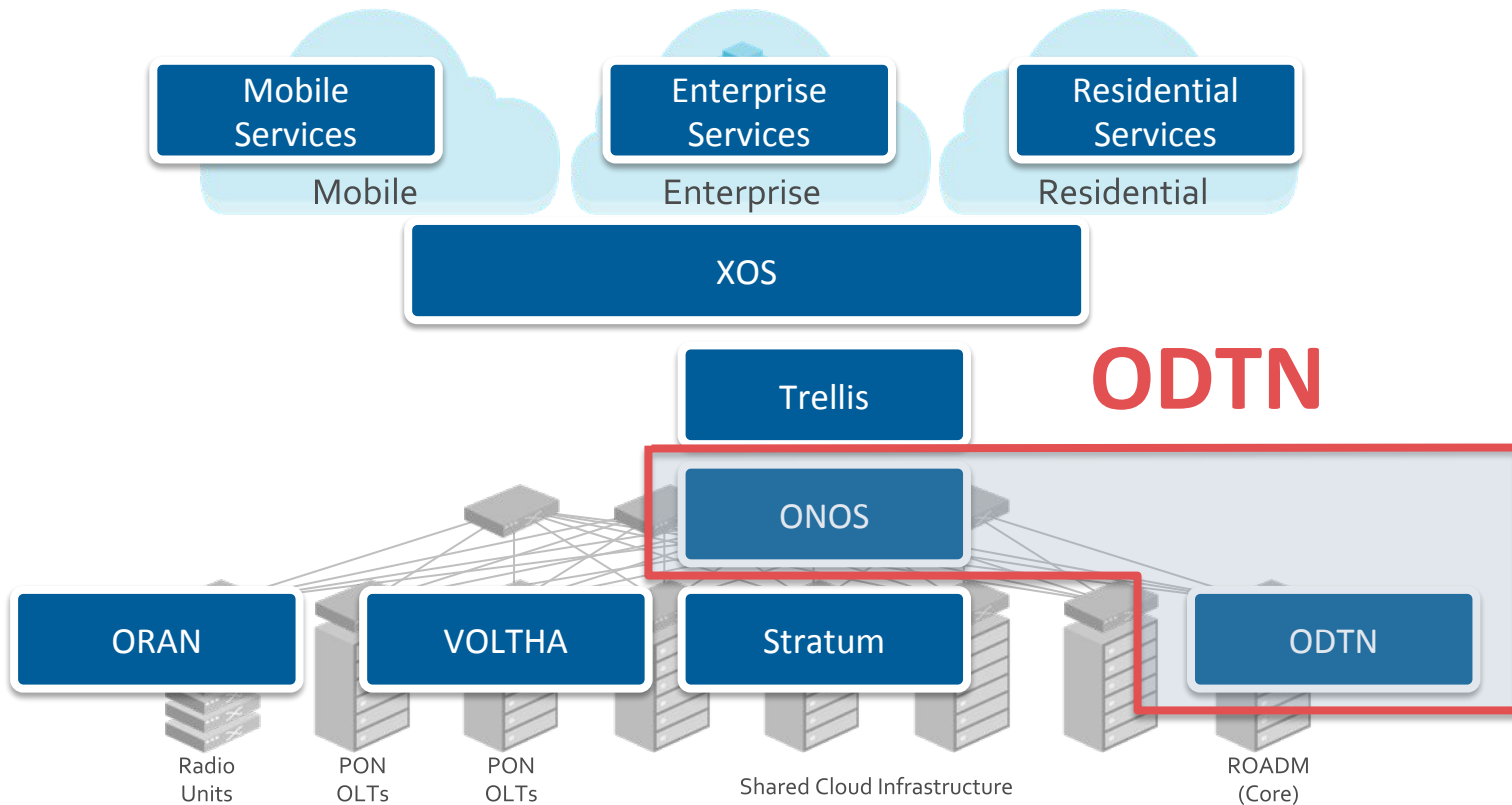
Trellis Exemplar Platform



UPAN Exemplar Platform

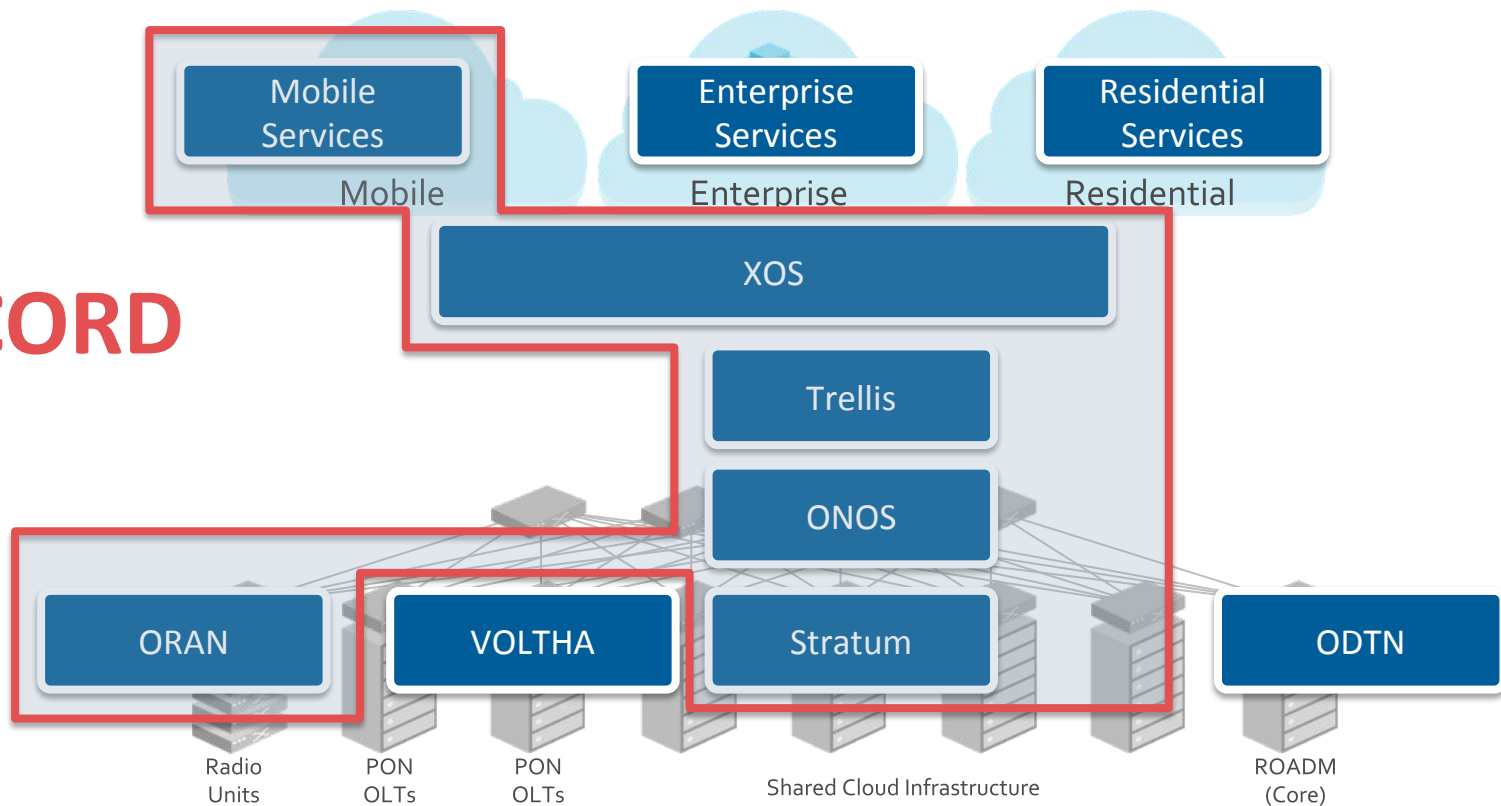


ODTN Exemplar Platform



M-CORD Platform

M-CORD



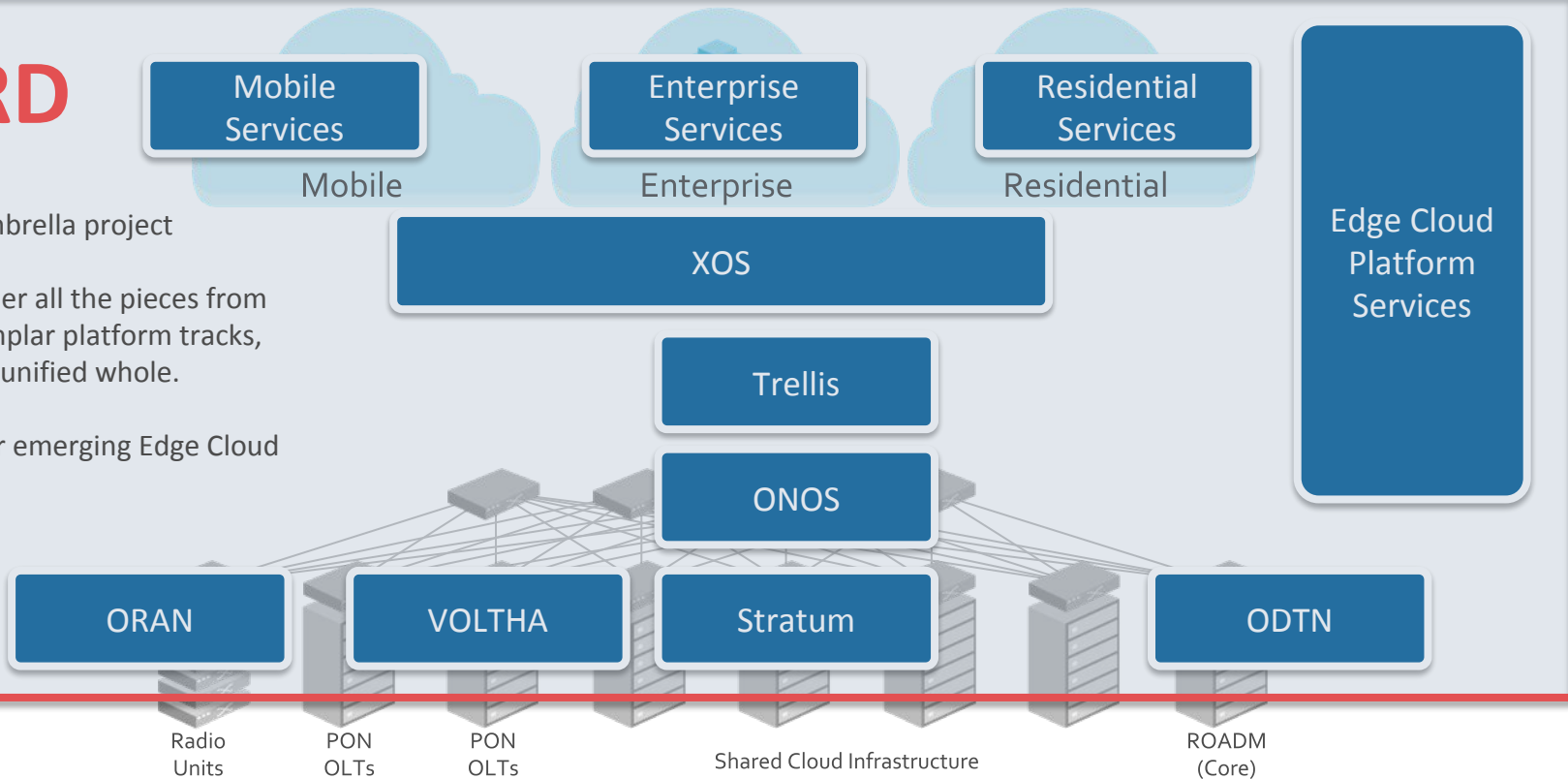
CORD® as Multi-Access Edge Cloud Platform

CORD

Unifying umbrella project

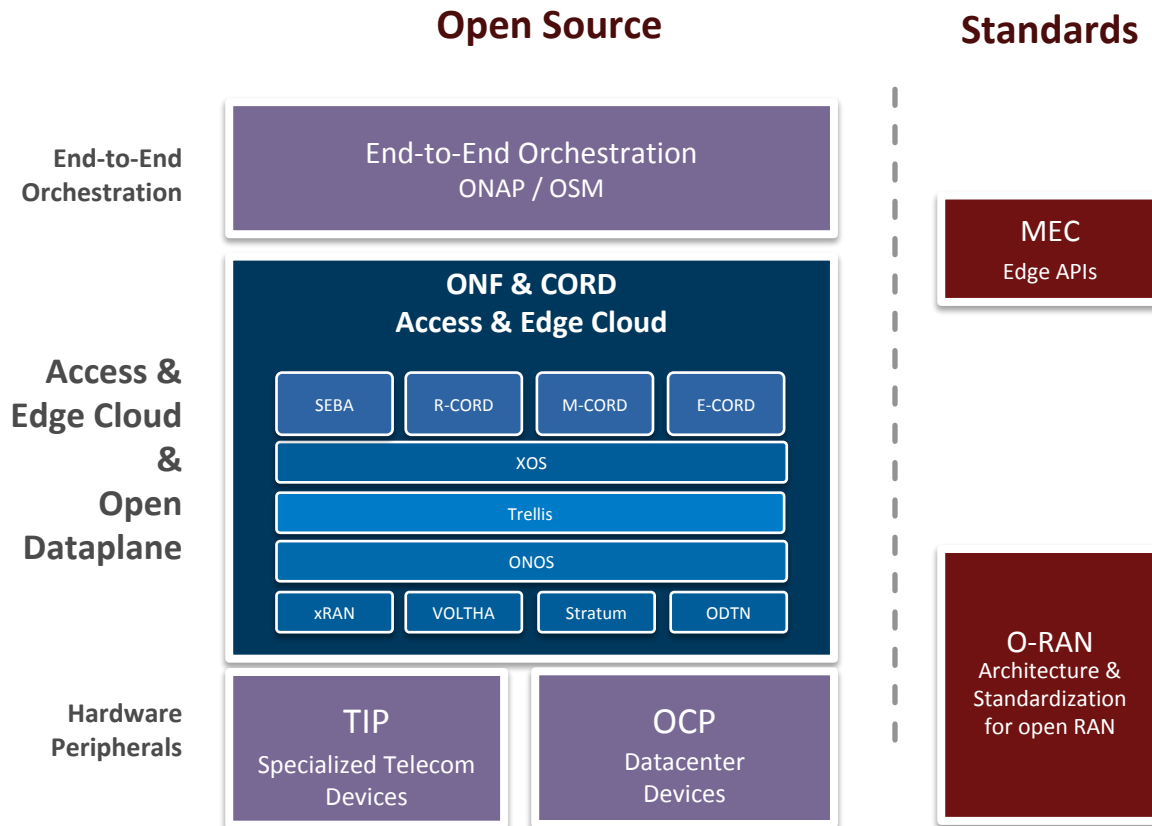
Pulls together all the pieces from all the exemplar platform tracks, providing a unified whole.

Platform for emerging Edge Cloud



ONF & CORD in Context of Open Source Ecosystem

Open Source ecosystem is creating a comprehensive stack that is poised to deliver robust solutions over time, from white box peripherals to end-to-end solutions



A New Model - Distributed DevOps

Real World Results:

7 releases in 4 months

Multiple patches & check-ins per day

Operator validating progress on multiple features in parallel

< 6 hour response time

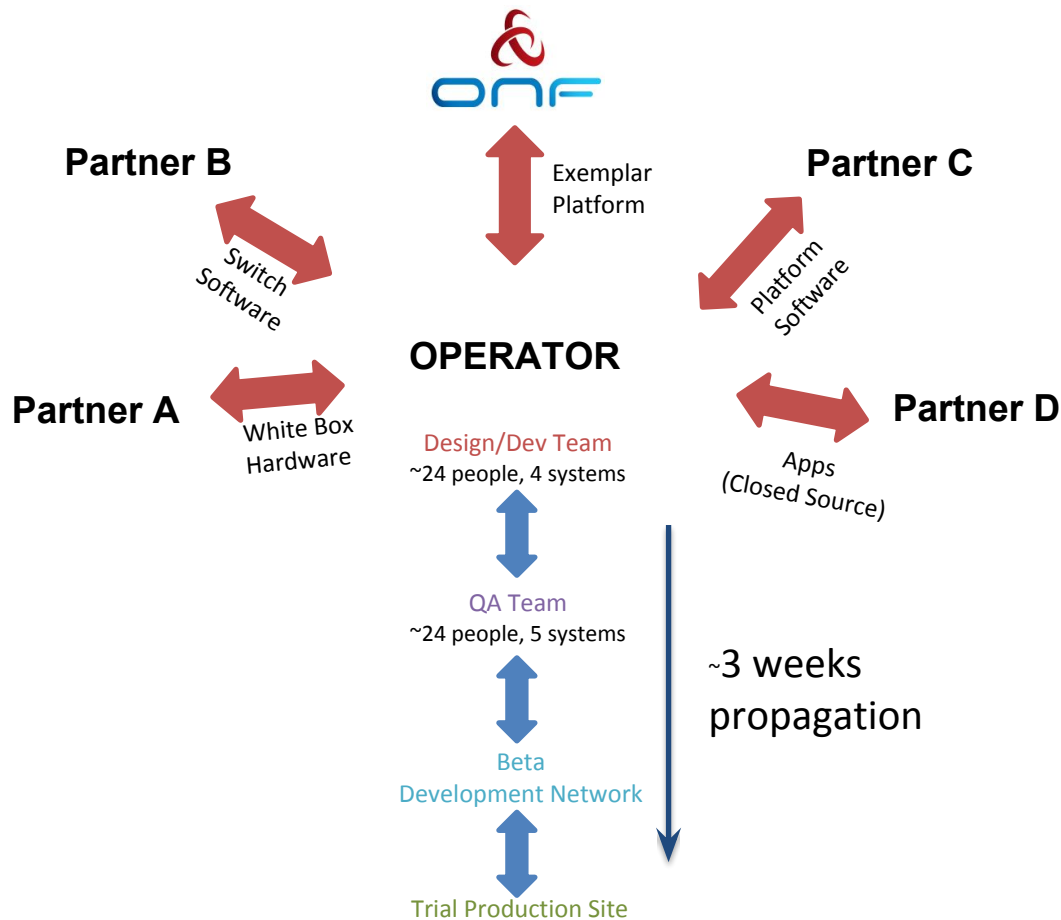
< 24 hour deep analysis

+ Nights & Weekends

Live community debugging sessions

Automated tests contributed from across community

Work going back into upstream.



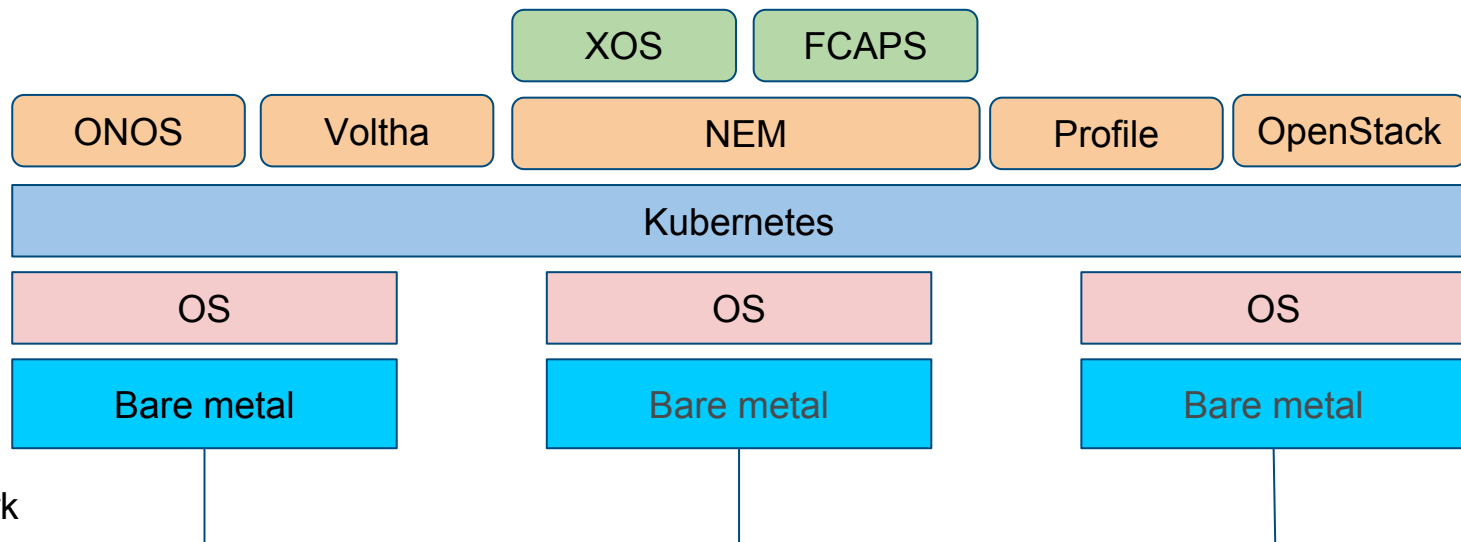
SEBA

SEBA (and its relation to R-CORD)

Lightweight platform supporting a multitude of virtualized access technologies at the edge of the carrier network, including XGS-PON and G.Fast, and eventually DOCSIS and more.

- SEBA is a variant of R-CORD
 - Addresses both residential and backhaul use cases
- Lightweight - Optimized for minimal footprint
 - Kubernetes based
 - OpenStack is optional and only needed to support VM-based VNFs
- High Speed
 - Default data path does not touch an x86
- Operationalized
 - FCAPS and OSS integration

CORD 6.0 - Platform layout



CORD 6.0 - Improvement

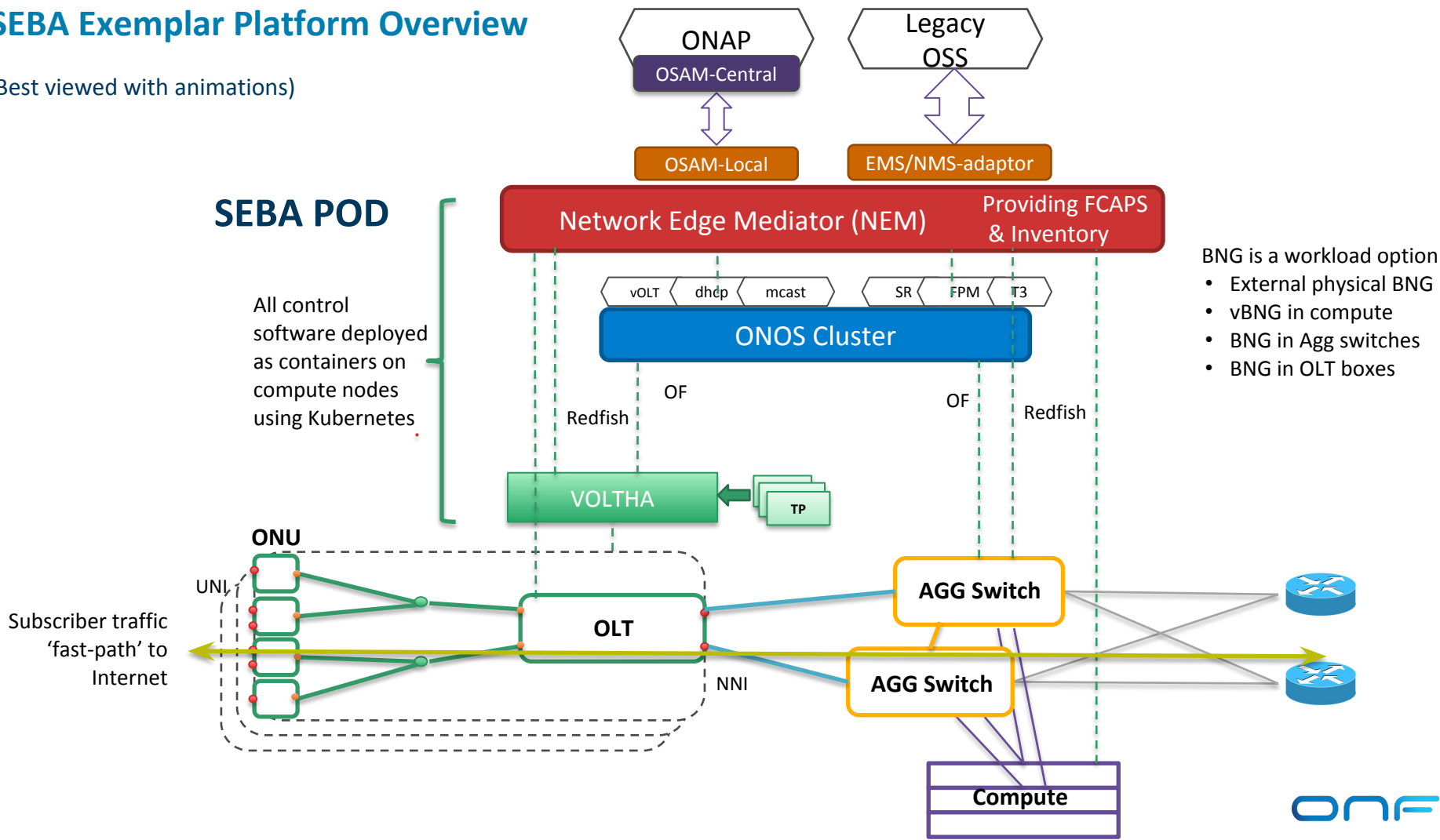
- Simplified build system
 - ~15 minutes from Kubernetes cluster to subscriber traffic
- K8s based
 - with optional Openstack support
- FCAPS support
- Increased flexibility
 - Components are independently released
 - Faster dev/release cycle
 - CI/CD oriented
 - Pipelines to support in house deployments

SEBA Exemplar Platform Overview

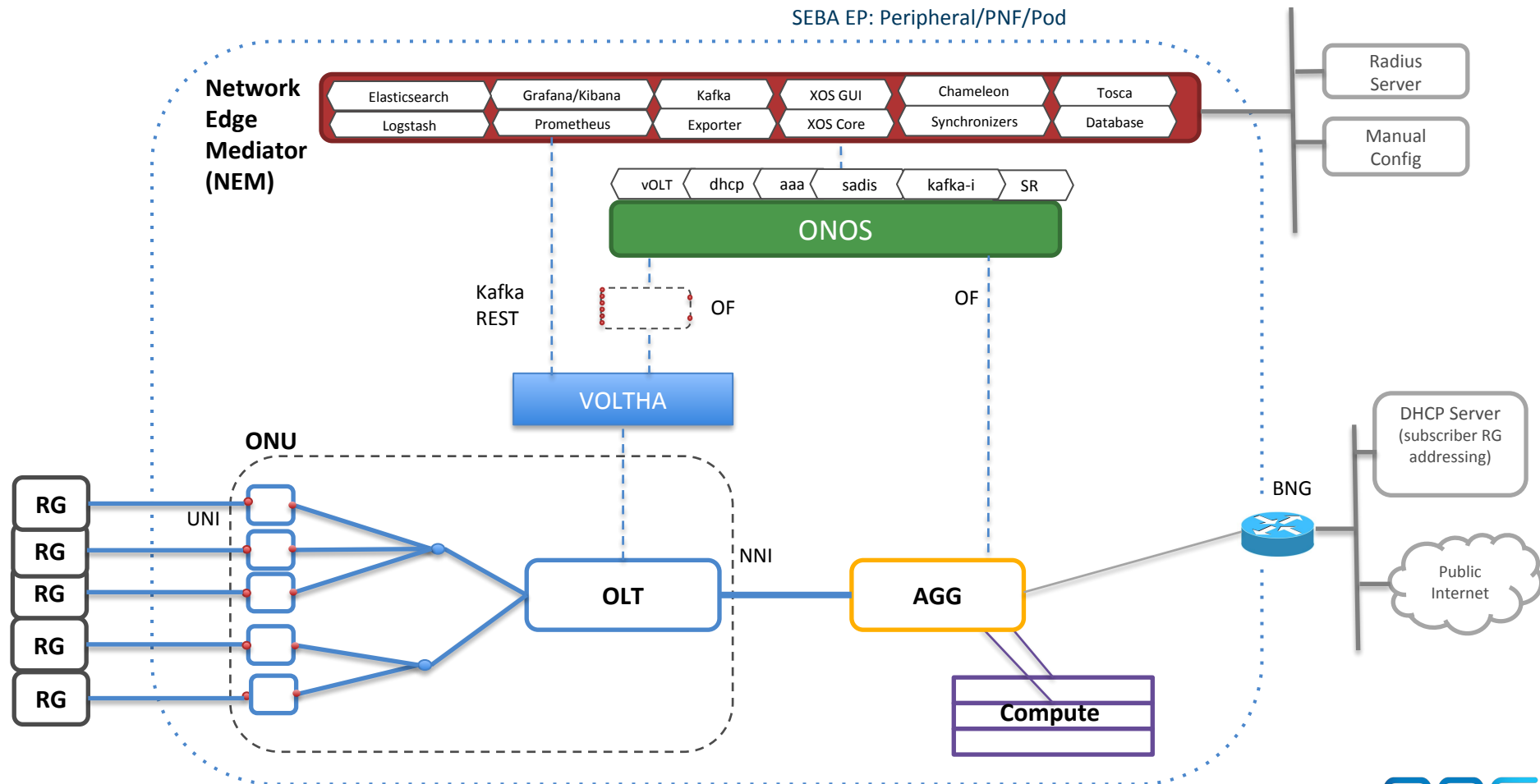
(Best viewed with animations)

SEBA POD

All control software deployed as containers on compute nodes using Kubernetes



Demo setup



Demo Features

1. ONU Registration
2. Subscriber Authentication
3. DHCP
4. Connectivity
5. Monitoring

Visit the ONF Booth Downstairs During ONS-E

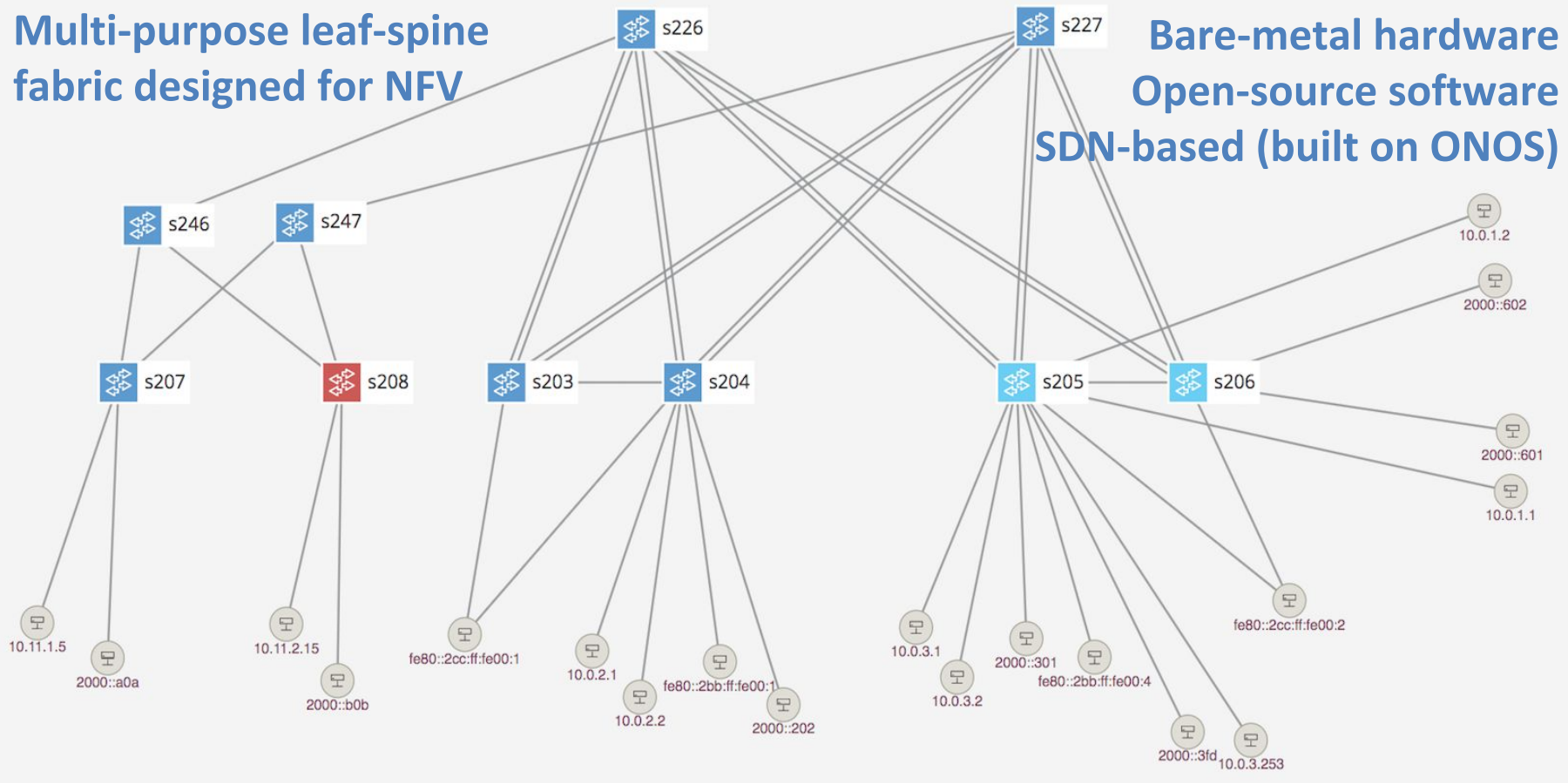


Trellis and UPAN

Trellis Overview

**Multi-purpose leaf-spine
fabric designed for NFV**

**Bare-metal hardware
Open-source software
SDN-based (built on ONOS)**

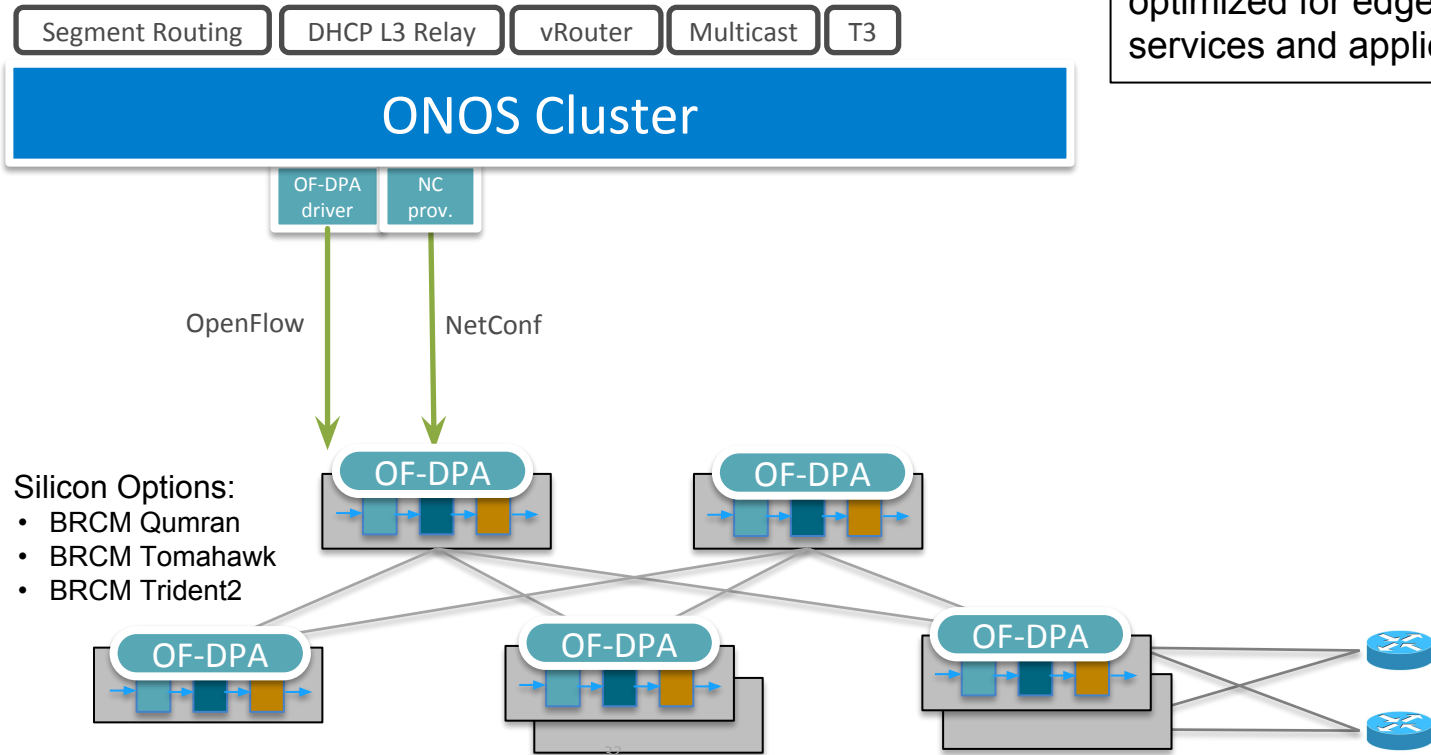


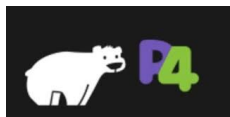
Trellis Features

- **Bridging** with Access & Trunk VLANs (within a rack)
- **Routing** (inter-rack)
 - IPv4 & IPv6 Unicast routing with MPLS Segment-Routing
 - IPv4 & IPv6 Multicast routing
- **Dual-homing** for compute-nodes and external routers
- **Multi-stage** fabrics (2 layers of spines)
- **vRouter** - entire fabric behaves as a single router
 - BGP (v4/v6) support for external (upstream) connectivity
 - Static routes, route blackholing
 - DHCP L3 relay (IPv4/v6)
- **MPLS Pseudowires**
- **QinQ termination**
- **T3** - Trellis Troubleshooting Tool
- **ASIC Support**
 - Broadcom Qumran, Tomahawk, Trident2 switches from EdgeCore & QCT
 - Preliminary support for Cavium Xpliant switches and P4-based Tofino switches

NFV Fabric Exemplar: Trellis

SDN-native spine-leaf
data center fabric
optimized for edge
services and applications





Thank you!

and
more...



UPAN RD from 10,000'

*Initial focus area
data center and
edge cloud*

Operator Systems / Backends

OSS/BSS, Global Orchestrators, Policy Engines, Inventory Databases, etc.

Unified gRPC Interfaces and Models - *WIP*

Unified Control Plane

Control, Configuration, Management, Telemetry, Inventory, Orchestration

Unified gRPC Interfaces - P4Runtime, gNMI, gNOI

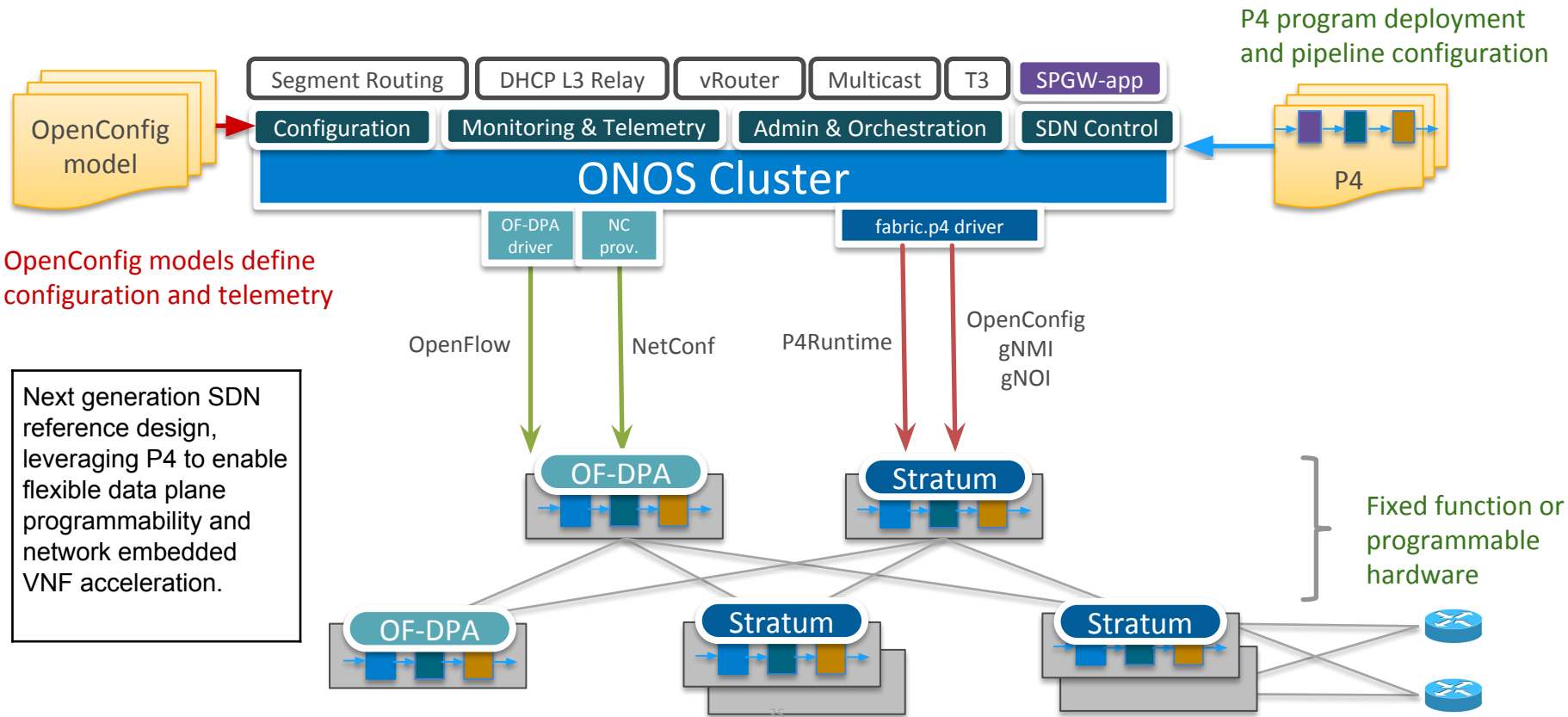
Data Plane

Switches, Routers, Network Functions

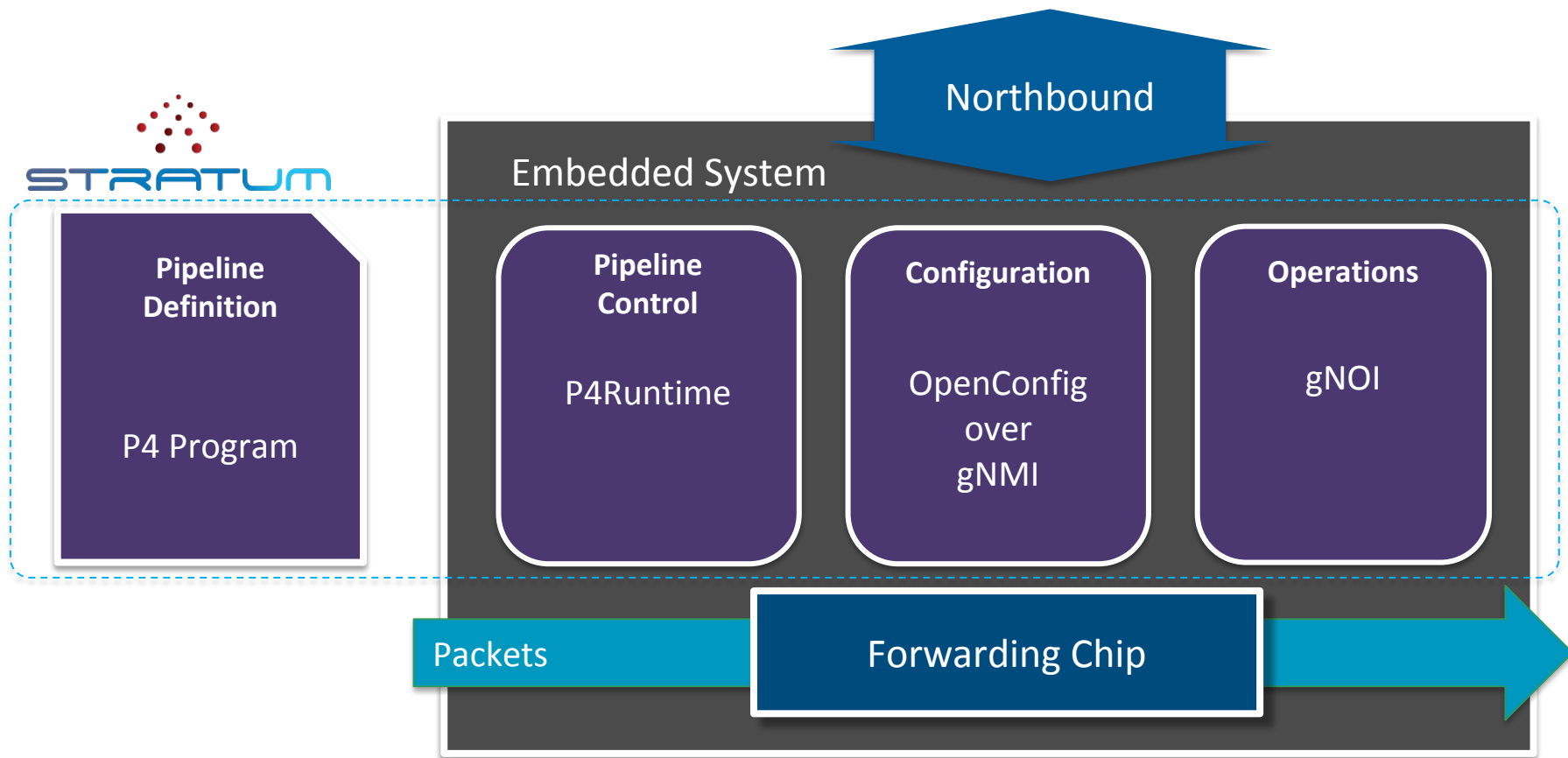
Tool Kit
*Debugging, Network Verification,
Testing*

Scope for UPAN RD

UPAN Exemplar (Trellis + Stratum + P4)



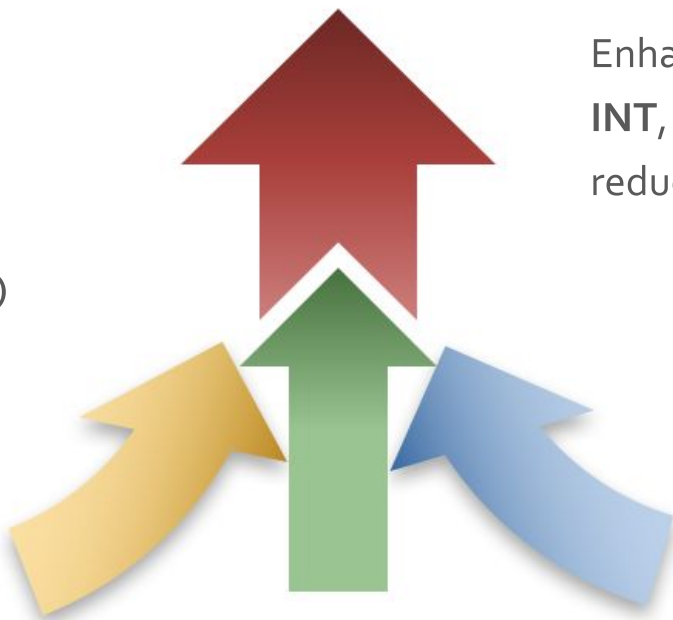
Stratum: Lightweight, Production-ready Thin Switch OS



Trellis + ONOS + Stratum

Trellis (in production now)

Multi-purpose leaf-spine fabric designed for NFV and access/edge



ONOS (in production now)

Evolved the SDN Controller to realize next generation interfaces

Next-Gen Resilient P₄ Fabric

Enhanced visibility and debugging with **INT**, increased performance and reduced OpEx using **VNF Offloading**

Stratum (on track for production)

Thin switch OS that is silicon independent, providing a unified data plane based on P₄Runtime, gNMI, and gNOI

Cloud Providers



Telecom Operators



Networking Vendors



White Box ODM Vendors



Silicon Vendors



Other Open Source Projects



ODTN

Open Disaggregated Transport Network

ONF Leadership Driving Disaggregation and SDN Control

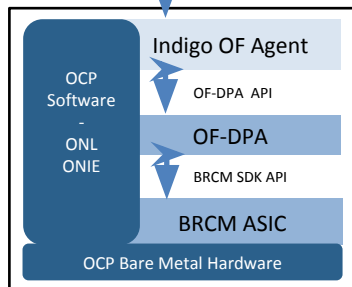
Packet Switch



Integrated control and data plane



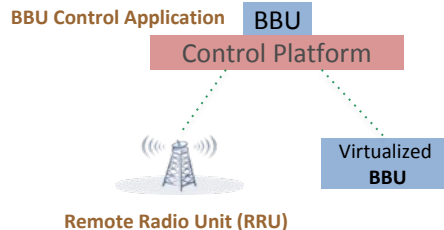
OpenFlow 1.3



eNodeB



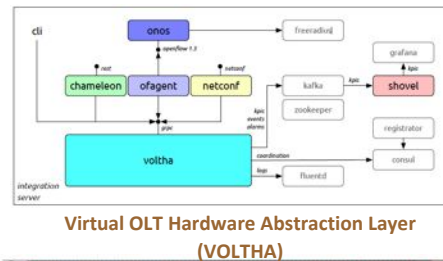
RU/DU integrated eNB



OLT



Integrated control and data plane



Virtual OLT Hardware Abstraction Layer (VOLTHA)



OCP-compliant switch using merchant silicon

Optical Transport



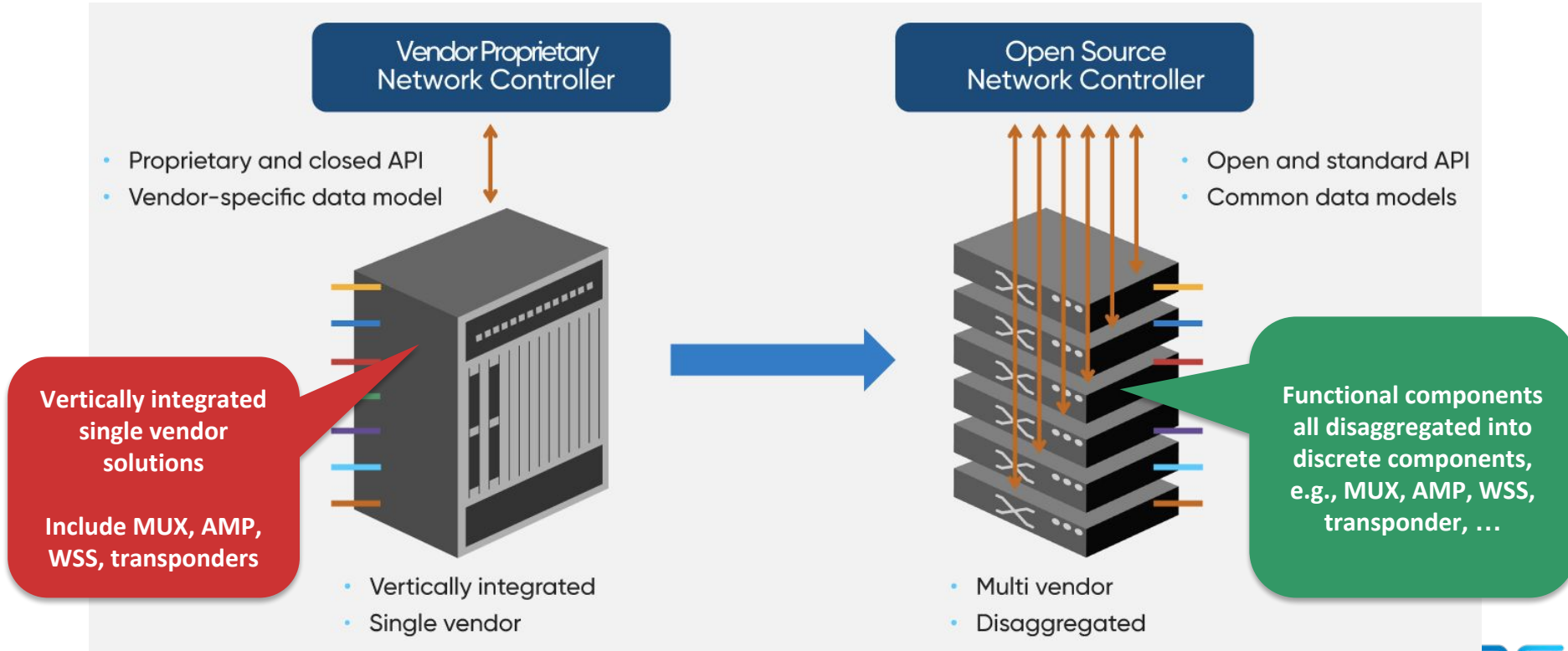
Integrated chassis, backplane and line-cards



ONF has built several proof of concepts, demonstrating

- Disaggregated optical SDN network
- Multi-vendor, multi-layer
- Advanced protection & restoration

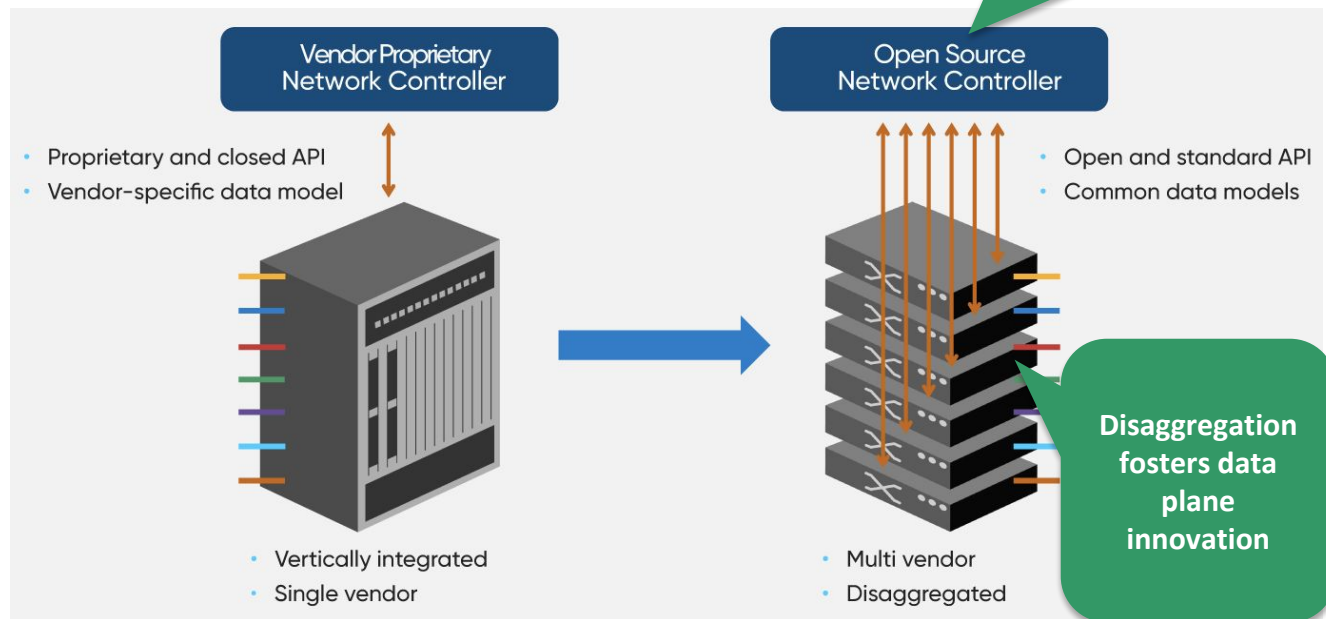
Disaggregating the Optical Network



Disaggregating the Optical Network

Business Benefits

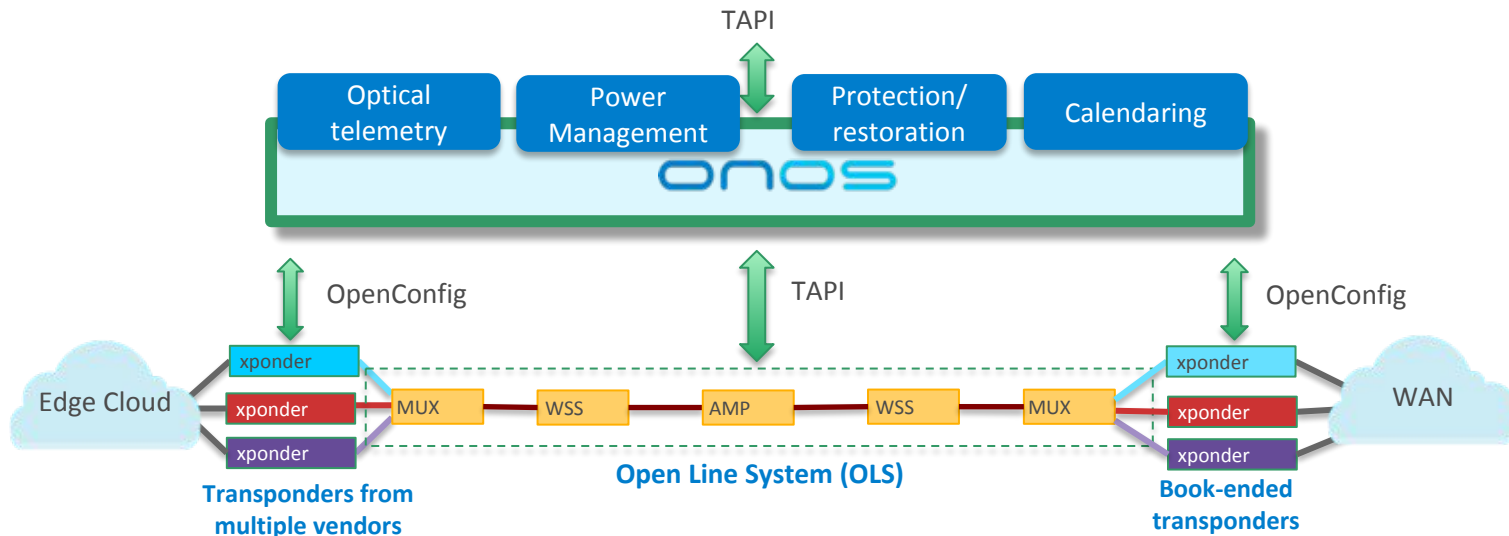
- Accelerate Innovation
- Best of Breed Choice
- Avoid Vendor Lock-In
- Give Control Back to Operators



ODTN Exemplar Platform

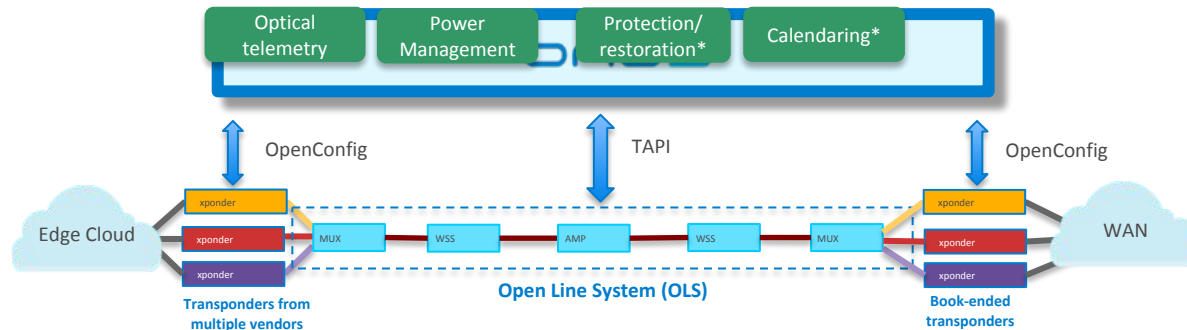
Open multi-vendor optical networks, starting with point-to-point and expanding to multi-point ROADM networks

- Disaggregate network into Transponders and OLS to support a Point-to-Point topology
- Integrate with ONOS and expose open interface TAPI northbound



Achieves Numerous Benefits without Complexity of Multi-Vendor Transponder Compatibility

- Rapid adoption of innovations in terminal equipment
 - Enable vendors to innovate: speed, reach, ...
 - Let operators reap benefits through simple bookending of pairs of a vendor's transponders
- Rapid introduction of new services in production network
 - Realize DevOps model through SDN-enabled optical network
 - Build CI/CD pipeline between operator, vendors, and open source software stack



Relationship to Other Standards & Optical Organizations

- OpenConfig
 - Develops common data models for network management
 - ODTN using OpenConfig models for transponders, MUX, WSS, AMP
- Telecom Infra Project (TIP)
 - Open Optical Packet Transport group
 - ODTN to consume TIP's network planning tools and open APIs
 - ODTN software stack can be used with TIP hardware building blocks (e.g. Voyager)
- OpenROADM MSA
 - Develops open models for optical devices, networks and services
 - Focus on transponder compatibility (eliminating need for bookending)
 - Models may be incorporated if ODTN community puts focus on data plane interoperability

**ODTN is the only
optical transport
open source project**

**First project to build open
source software stack
for control and
management of optical
networks**

ODTN – Thanks to the Community

- First open source project addressing optical transport
- 16 Founding Members
- Telefonica lab trial started May 2018
- NTT Comm lab trials started June 2018





M-CORD and Edge Cloud

Trailblazing Activities

Reference Designs

SEBA

SDN Enabled Broadband Access

Trellis NFV Fabric

SDN Spine Leaf Fabric

UPAN

Unified Programmable
Automated Network

ODTN

Open Disaggregated
Transport Network

Trailblazing Projects & Emerging Reference Designs

M-CORD

vRAN & 5G Mobile

CORD

Access & Edge Cloud

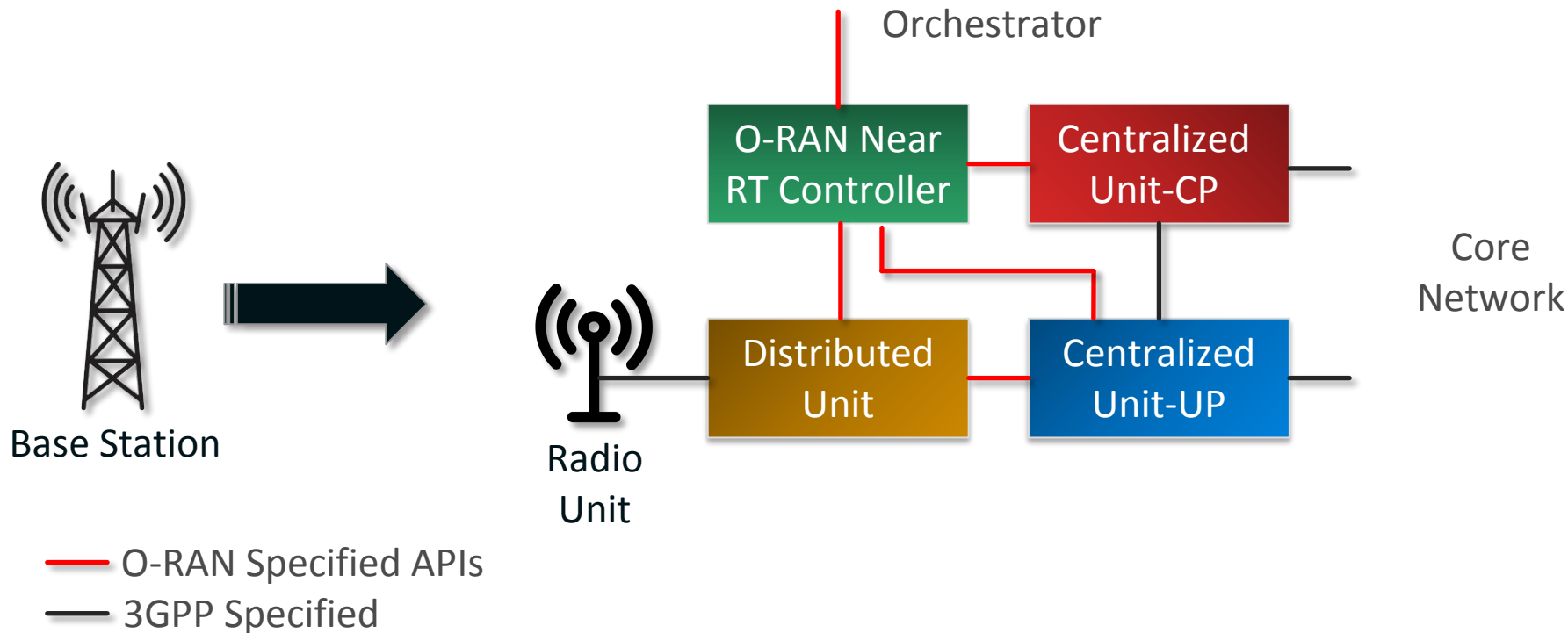


ONF Trailblazing Projects: ORAN

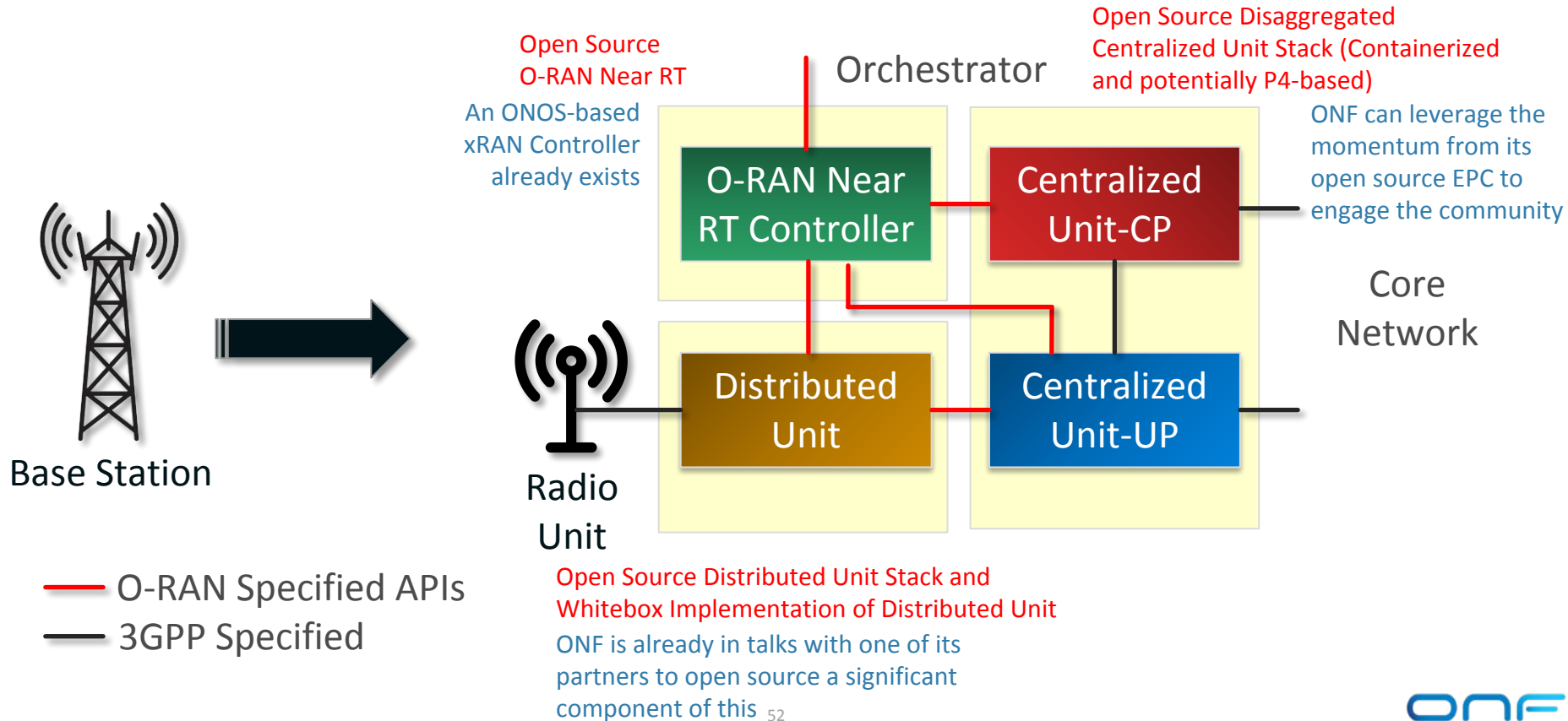
ONF and ORAN

- Open, disaggregated, virtualized RAN design and implementation critical
- A set of leading operators have created ORAN Alliance to lead this effort
- ORAN Alliance will create Reference Design: Components and APIs
- The open source ORAN community may pursue different implementations
 - Each with different trade-offs
- ONF and its ecosystem looking to focus on open source implementation of ORAN
 - Leveraging disaggregation, white boxes and specialized RF components

ORAN Architecture and Components: Simplified View



Open Source ORAN at ONF



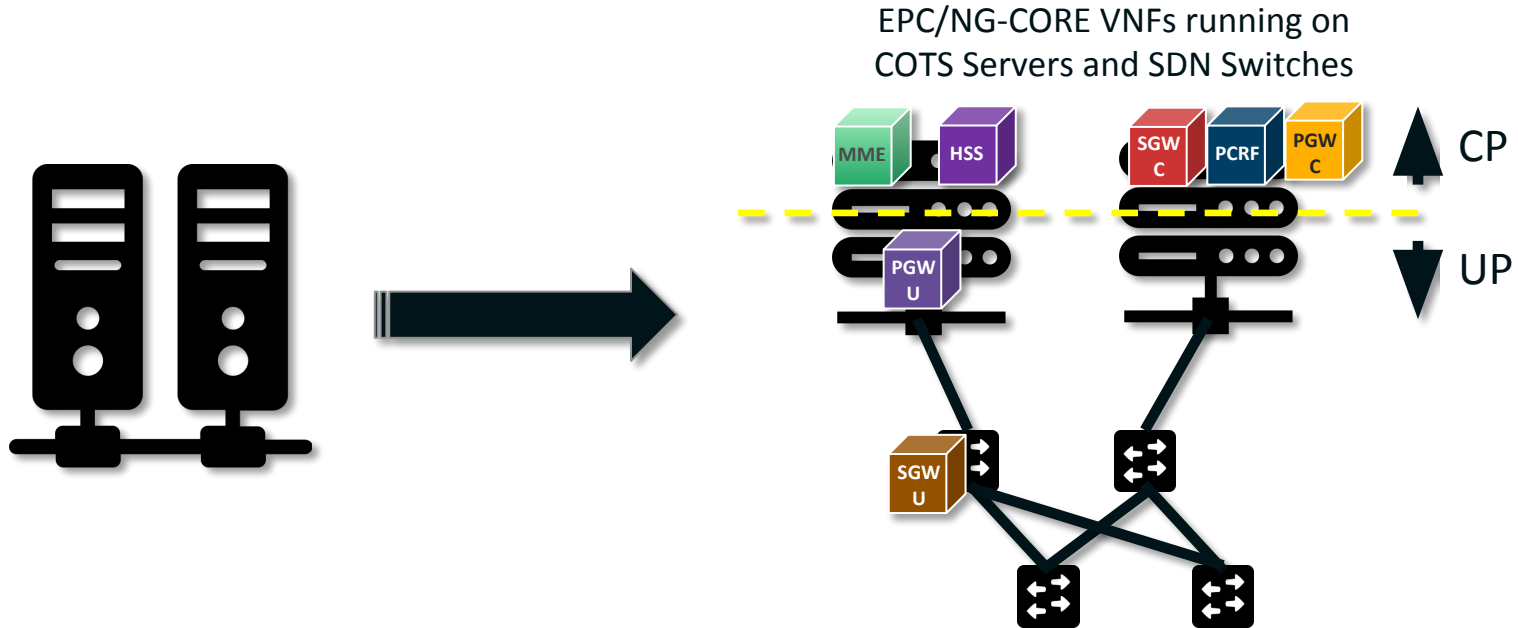


ONF Trailblazing Projects: Next Gen EPC

ONF and Next Gen EPC

- Disaggregated virtualized open source packet core is also critical
- ONF ecosystem has been building such a core – not production ready but has many key innovative capabilities
 - Disaggregated and virtualized with slicing
 - Leveraging Stratum and P4RT to map CU functions into hardware for performance and scale
 - Constructed from Micro-Services (Containers, not VMs)
- ONF leading the industry in this space

Core Network Disaggregation



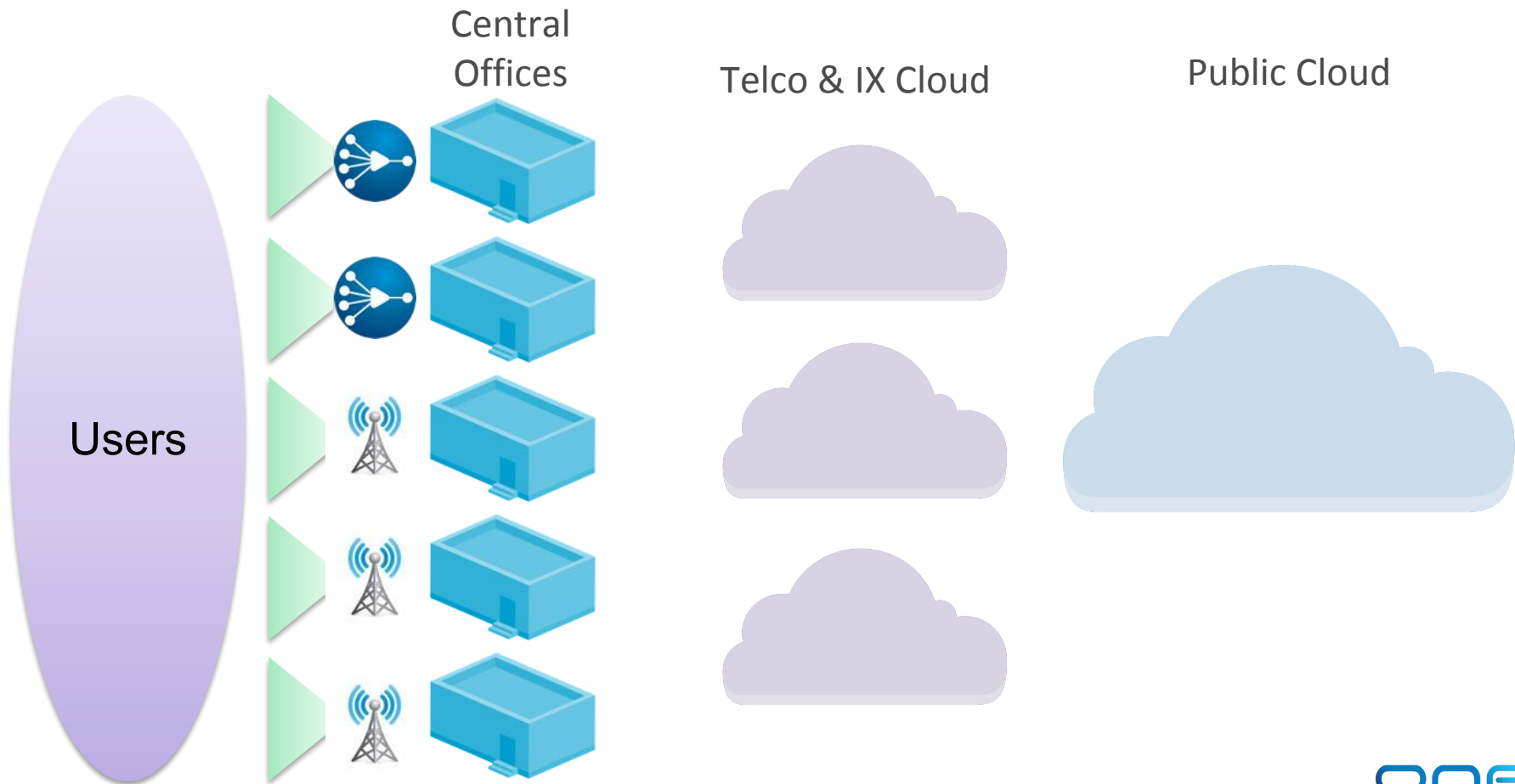
Different network slices may have different subsets of the EPC/NG-CORE VNFs instantiated at the edge.



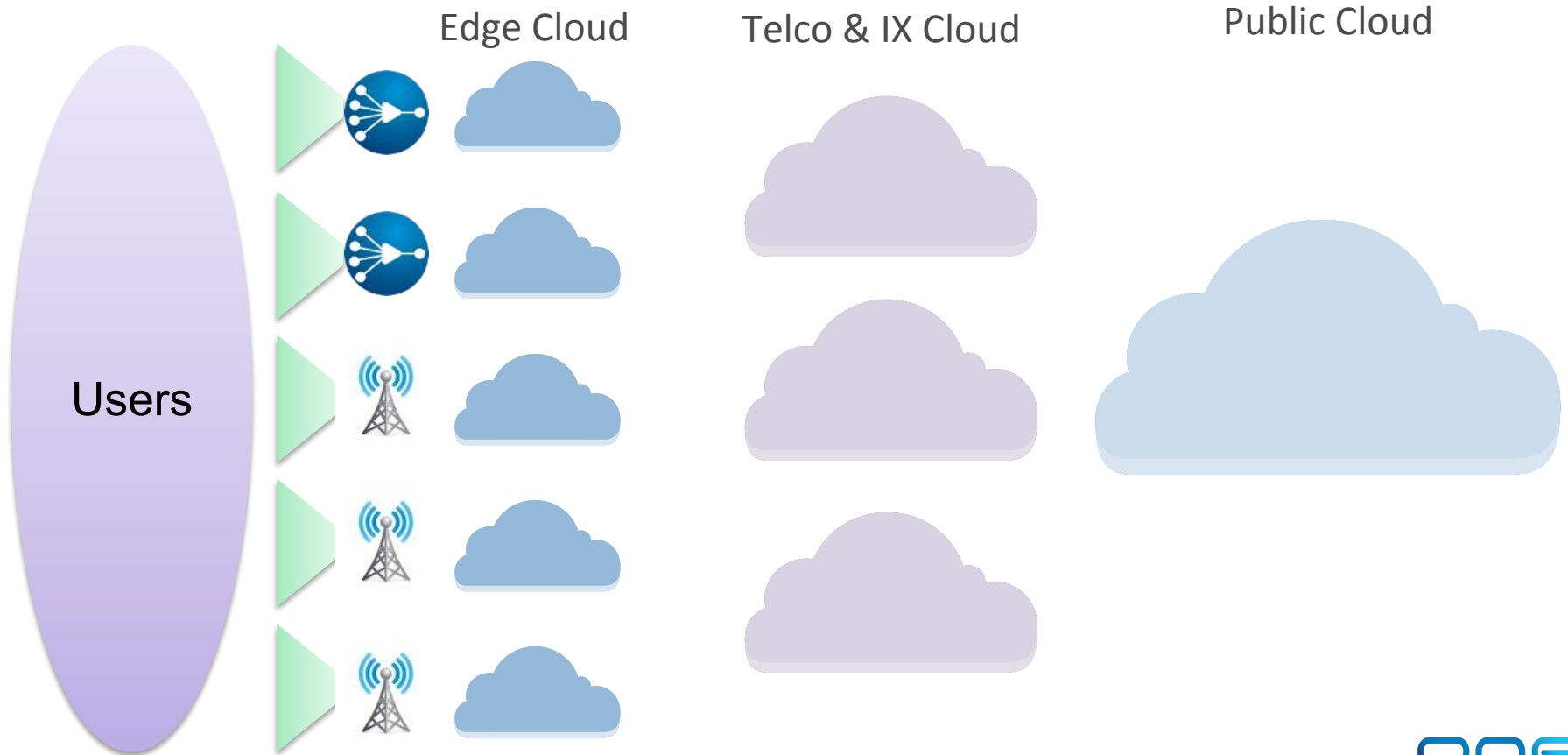
ONF Trailblazing Projects: Open Edge Cloud

(See my talk at 16:05, G104/105)

An Untapped Opportunity



An Untapped Opportunity



ONF's Focus

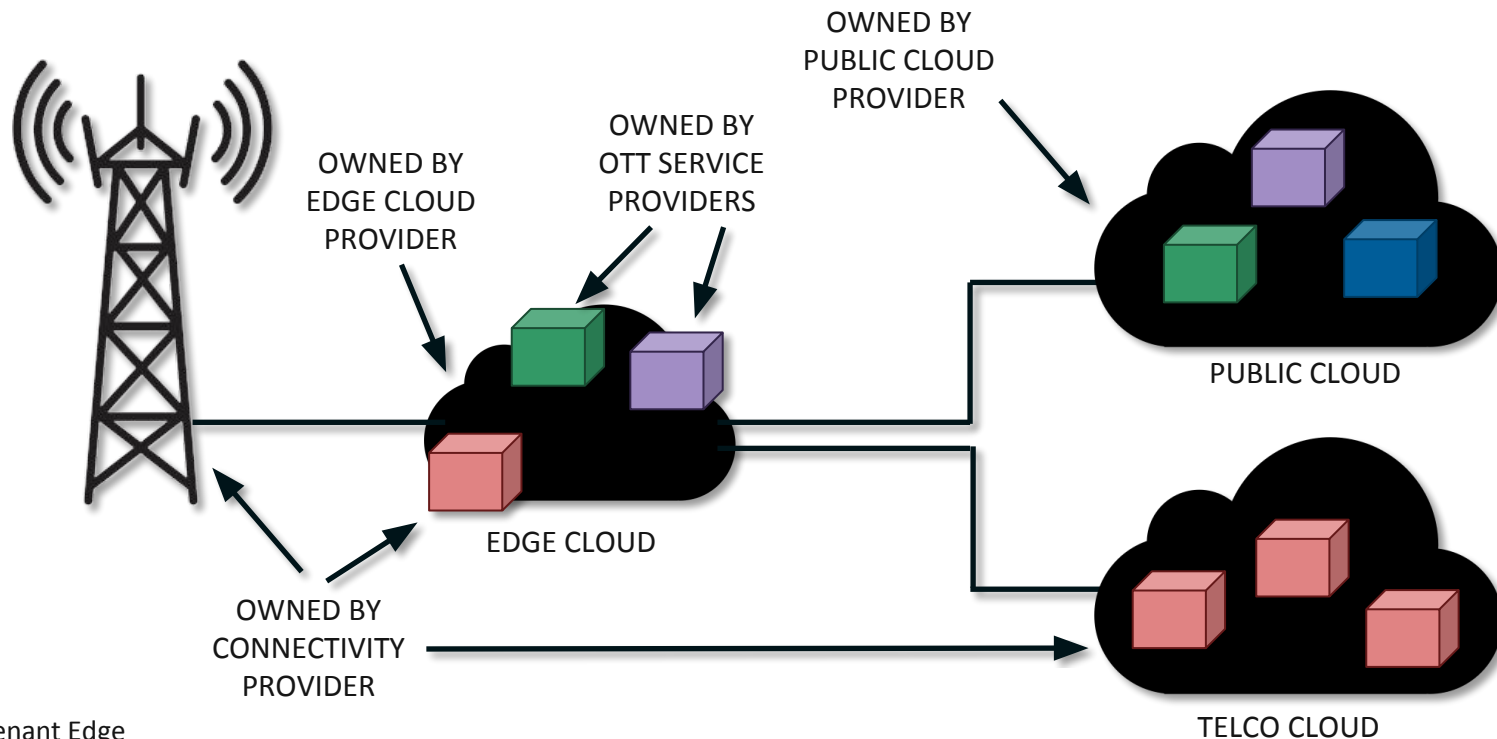
Access x Cloud → Edge Platform that hosts multiple types of services

- Access Services (RAN, PON)
- Converged Network Services (vEPC, vBNG)
- Edge Cloud Services (Immersive UI, Public Safety, Internet-of-Things)

Multi-Cloud → End-to-End Service Chains that span multiple clouds

- On-premise
- Central Offices
- Internet Exchanges
- Public Clouds

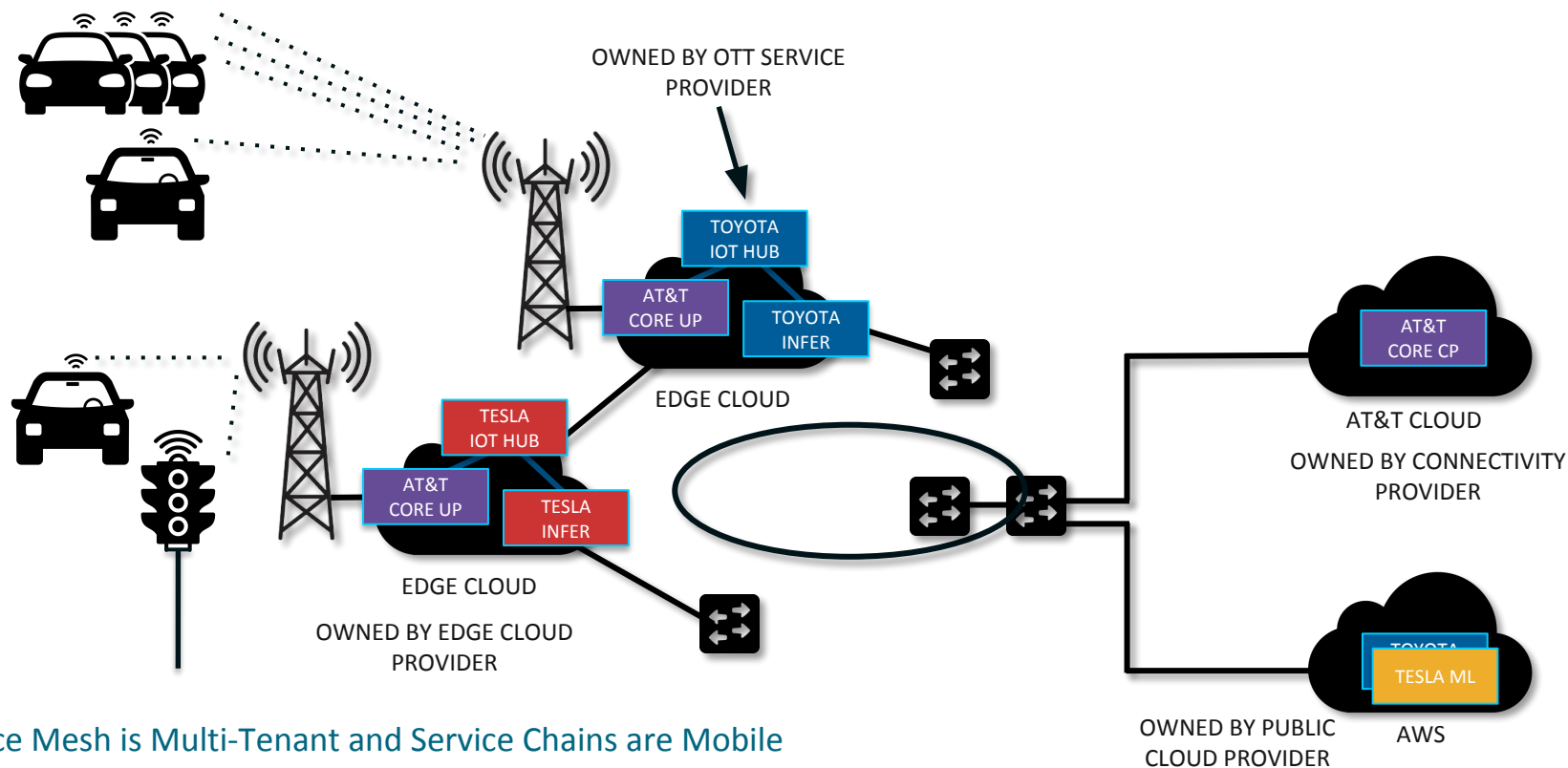
Edge Cloud Ecosystem



Multi-Tenant Edge

One Company (e.g. AT&T, AMAZON, CROWN CASTLE, GOOGLE) May Play Multiple Roles

Edge Cloud Ecosystem



Service Mesh is Multi-Tenant and Service Chains are Mobile



Wrap Up

Disaggregation and Integrated Solutions

ONF's Ying-Yang model

To enable innovation, need:
Disaggregation and
Open Source Components



To be able to deploy:
Operators Require Integrated
Platforms Leveraging Open Source
Disaggregated Components

Challenges

- Too many components
- Too many choices for each component
- Too difficult for operators to build integrated solutions leveraging these components

ONF with Its Ecosystem

- Create components that inter-work
- Create modular Reference Designs and Exemplar Platforms as integrated platforms

Disaggregation and Integrated Solutions

ONF's Ying-Yang model

To enable innovation, need:

Disaggregation and
Open Source Components



To be able to deploy:

Operators Require Integrated
Platforms Leveraging Open Source
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ONF's Components

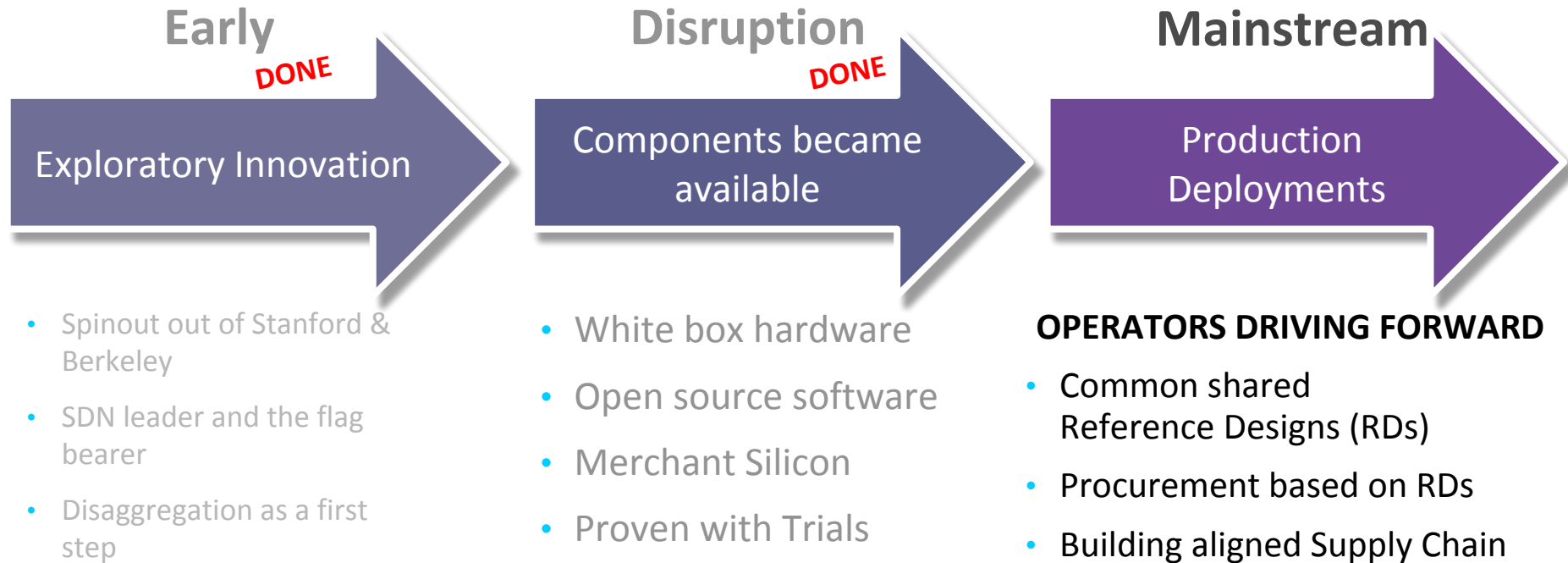
- Stratum
- VOLTHA
- ONOS
- XOS

ONF Reference Designs & Exemplar Platforms

- SEBA, Trellis, UPAN, ODTN
- vRAN and Converged Packet Core
- Access Edge Cloud

**ONF is unique in delivering Integrated Solutions leveraging open source
Disaggregated Components**

ONF Operators Have Taking Action to Achieve Mainstream Deployment



ONF Operators More Committed Than Ever

More Related Sessions Later Today

13:50 - 14:20 (G102)

Workshop Cont'd: Operator Edge Cloud Reference Design Workshop (CORD / ONF)

Next Generation PaaS

Oliviero Riganelli, University of Milano Bicocca

14:30 - 15:40 (G102)

Tutorial: P4 and P4Runtime Technical Introduction and Use Cases for Service Providers

Carmelo Cascone, ONF

16:05 - 16:35 (G104/105)

End-to-End Service Chains in a Multi-Cloud Environment

Larry Peterson, ONF



Unique Operator Hosted Event

December 4th - 6th

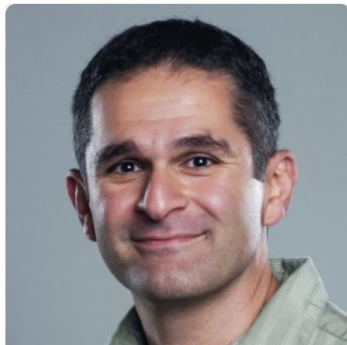
Santa Clara, CA

www.opennetworking.org/onf-connect/



Featuring Industry & Developer Tracks

Keynote Speakers



AMIN VAHDAT

Google Fellow and
Technical Lead for
networking at Google



ANDRE FUETSCH

President, AT&T Labs and
Chief Technology Officer



CHIH-LIN I

CMCC Chief Scientist of
Wireless Technologies, China
Mobile



ROB HOWALD

Vice President of Network
Architecture
Comcast



Thank You