Production-ready Multi-purpose leaf-spine fabric

Trellis apps
ONOS Cluster (SDN Controller)

Legend:
- Trellis Software Component
- Trellis Compliant Bare-metal Hardware

Tenets
SDN-based White-boxes Open-source

Upstream Routers

Access Nodes

Leaf (ToR)

Spine

Compute Nodes
Completely open-source (Apache licensed)

Open source

Trellis apps
ONOS Cluster

Indigo OF Agent
BRCM OF-DPA
SDK
ONL
ONIE
BRCM ASIC
OCP Bare Metal Switch

Labs/Trials: Community Edition
Binary available from ONF

Production: Commercial Edition
Binary available from Broadcom
Trellis Redundancy

ECMP groups

Paired Leaves (Dual-ToRs)

Pair-link

Linux bonding active-active

Trellis apps
ONOS 1

Trellis apps
ONOS 2

Trellis apps
ONOS 3

LEAF 1
LEAF 2
LEAF 3
LEAF 4

SPINE 1
SPINE 2

Dual-homed servers

SERVER

Server

External Routers
Specifications

FEAURES | DESCRIPTION
--- | ---
**SDN Features**
- ONOS cluster of all-active N instances affording N-way redundancy and scale, where N = 3 or N = 5
- Unified operations interface (GUI/REST/CLI)
- Centralized configuration – all configuration is done on controller instead of each individual switch
- Centralized role-based access control (RBAC)
- Automatic host (end-point) discovery – attached hosts, access-devices, appliances (PNPs), routers, etc. based on ARP, DHCP, NDP, etc.
- Automatic switch, link and topology discovery and maintenance (keep-alives, failure recovery)

**L2 Features**
- Various L2 connectivity and tunneling support
- VLAN-based bridging
  - Access, Trunk and Native VLAN support
  - VLAN cross connect
  - Forward traffic based on outer VLAN id
  - Forward traffic based on outer and inner VLAN id (QinQ)
  - Pseudowire
  - L2 tunneling across the L3 fabric
  - Support tunneling based on double tagged and single tagged traffic
  - Support VLAN translation of outer tag

**L3 Features**
- IP connectivity
  - IPv4 and IPv6 unicast routing (internal use of MPLS Segment Routing)
  - Subnet configuration on all non-spine facing leaf ports; no configuration required on any spine port
  - IPv6 router advertisement
  - ARP, NDP, IGMP handling
- Number of flows in spines greatly simplified by MPLS Segment Routing
- Further reduction of peer-yay flows with route optimization logic

**DHCP Relay**
- DHCP L3 relay
- DHCPv4 and DHCPv6
- DHCP server either directly attached to fabric leaves, or indirectly connected via upstream router
- DHCP client directly either attached to fabric leaves, or indirectly connected via LORA
- Multiple DHCP servers for HA

**vRouter**
- vRouter presents the entire Trellis fabric as a single router (or dual-routers for HA), with disaggregated control/data plane
- Uses open-source protocol implementations like Quagga (or FRR)
- BGPv4 and BGPv6
- Static routes
- Route blackholing
- ACLs based on port, L2, L3 and L4 headers

**Multicast**
- Centralized multicast tree computation, programming and management
- Support both IPv4 and IPv6 multicast
- Dual-homed multicast sinks for HA
- Multiple multicast sources for HA

**Troubleshooting & Diagnostics**
- Troubleshooting tool – T3: Trellis Troubleshooting Tool
- Diagnostics one-click collection tool - ‘ons-diags’

**Topology**
- Single leaf (ToR) or dual-ToR (dual-homing)
- Supports typical leaf-spine topology, 2 to 4 spines, up to 10 leaves
- Multi-stage leaf-spine fabric (leaf-spine-leaf)
- Can start at the smallest scale (single leaf) and grow horizontally

Specifications (continued)

FEAURES | DESCRIPTION
--- | ---
**Resiliency**
- Provides HA in following scenarios
  - Controller instance failure (requires 3 or 5 node ONOS cluster)
  - Link failures
  - Spine failure
  - Further HA support in following failure scenarios with dual-homing enabled
  - Leaf failure
  - Upstream router failure
  - Host NIC failure

**Scalability**
- [In production] Up to 50k routes, 110k flows, 8 Leaf, 2 Spines, with route optimization enabled
- [In pre-production] Up to 120k routes, 250k flows, 8 Leaf, 2 Spines, with route optimization enabled

**Security**
- TLS-secured connection between controllers and switches (premium feature)
- AAA 802.1x authentication
- MACSec (L2 encapsulation)

**P4-ready**
- Support for Stratum, P4Runtime and gP4 and P4 programs
- Innovative services enabled by programmable pipeline
  - BNG – PFFE, anti-spoofing, accounting and more
  - GTP encaps/decap

**Overlay Support**
- Can be used integrated with 3rd party overlay networks (e.g. OpenStack Neutron, Kubernetes CNI)

**Orchestrator Support**
- Can be integrated with external orchestrator, logging, telemetry and alarm service via REST apis and Kafka events

**Controller Support**
- Recommended (per ONOS instance)

**Server Specs**
- CPU: 32 Cores
- RAM: 128 GB RAM, 65 GB dedicated to ONOS JVM heap (based on 50K routes)

**Whitebox Switch Hardware**
- Multi-vendor: Edgecore, QCT, Delta, Inventec
- Multi-chipset
- Broadcom Tomahawk, Trident2, Quorum
- Barefoot Tofino
- 1/100, 25G, 40G to 100G
- Refer to docs.trellisfabric.org/supported-hardware.html for the most up-to-date hardware list

**Whitebox Switch Software**
- Open source ONL, ONE and Indigo OF client
- In production OF-DPA software commercial version – contact Broadcom
- In labs/trials OF-DPA software community version available from ONF (for switch models based on Trident and Tomahawk, not Quorum)
- In labs/trials Stratum available from ONF

**Documentation**
- docs.trellisfabric.org

ONF is an operator-led consortium transforming networks into agile platforms for service delivery. For more technical information and tutorials: opennetworking.org/trellis
To learn of the Trellis commercial ecosystem: info@opennetworking.org
Why Trellis?

- Trellis is designed for service provider access/edge
Trellis apps
IPv4/v6 unicast/multicast, vlans, MPLS SR, vRouter ...

ONOS Cluster

Central Office

Leaf
Leaf
Leaf
Leaf
Leaf
Leaf
Spine
Spine

Optimized for Service Provider Access/Edge

Base station
R-PHY
R-OLT

2

Types of Switches

Types of Traffic
Trellis apps
IPv4/v6 unicast/multicast, vlans, MPLS SR, vRouter ...

ONOS Cluster

Field Office

Central Office

Optimized for Service Provider Access/Edge
Why Trellis?

• Trellis is designed for *service provider access/edge*
  - Traffic types/encapsulations, topologies, ASICs

• SDN *simplifies and optimizes* features
Trellis apps
IPv4/v6 unicast/multicast, vlans, MPLS SR, vRouter ...

ONOS Cluster

Field Office
Leaf
Spine
Leaf
Spine

Central Office
Leaf
Spine
Leaf
Spine
Leaf

Metro/Core Routers
Internet

Base station
R-PHY
R-OLT
Why Trellis?

• Trellis is designed for service provider edge
  - Traffic types/encapsulations, topologies, ASICs

• SDN simplifies and optimizes existing features
  - Learn more at Trellis booth

• SDN & P4 switches enable new features
Trellis enhanced with embedded & disaggregated BNG using P4, supporting ONF’s SDN Enabled Broadband Access (SEBA) platform
Why Trellis?

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- SDN & P4 switches enable new features
  - Learn more at SEBA BNG booth

- Open-source -> ownership & customizability
Trellis apps
IPv4/v6 unicast/multicast, vlans, MPLS SR, vRouter...

ONOS Cluster

Field Office

Central Office

~ 10k routes

120k+ routes

Base station

R-PHY

R-OLT

Leaf

Spine

Leaf

Spine

Leaf

Spine

Leaf

Spine
Why Trellis?

- **Trellis is designed for service provider edge**
  - Traffic types/encapsulations, topologies, ASICs

- **SDN simplifies and optimizes existing features**
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- **SDN & P4 switches enable new features**
  - Learn more at SEBA BNG booth

- **Open-source -> ownership & customizability**
  - Learn more at Comcast booth
Use Cases

Distributed Fabric for Access/Edge Networking
- IPv4/IPv6 unicast/multicast, VLAN, MPLS SR, vRouter...
- ONOS Cluster
- Leaf
- Spine

SEBA with Embedded BNG using P4
- Network Edge Mediator (NEM)
- ONOS
- SDN Controller - ONOS
- P4Runtime, gNMI, gNOI

Enterprise DC Fabric
- OpenStack
- Kubernetes
- VMWare
- ONOS Cluster (SDN Controller)
- Trellis Apps

Chassis Router
- Leaf
- Leaf
- Leaf
- Leaf
- Leaf
- Spine
- Spine
- Linecards
- Backplane
- Route Processor Cards
- Server
- Server
- Server
Trellis Continues to Scale

# routes

150000
100000
50000
0


120k
Bringing Trellis into Production Deployments

George Tchaparian
Edgecore Networks
Accton Technology and Edgecore Networks

**Accton Technology**
- Leading Network ODM: Systems, networking, and OEM customers (Tier 1 OEMS)
- Founded 1988, IPO Taiwan 1995
- 4,000 + employees worldwide, > 700 network engineers, R&D Centers
- Volume manufacturing in China and Taiwan (TAA Compliant)
- One Stop Shop!

**Edgecore Networks**
- Brand Business; wholly owned subsidiary of Accton
- Go-to-market business to network operators – Data Center, Telecom, and Enterprise
- Manages customer, partner and open community relationships
- Leading contributor of network designs to [OCP](https://www.opencord.org), [TIP](https://www.opendaylight.org), and [LF](https://www.linuxfoundation.org) Active participant
- **ONF** – Charter Partner and leading ONF Strategic Initiative – Building Reference Designs (HW and SW).

> 10M Ports Shipped 2018
Edgecore Contributions in ONF Exemplar Designs and Solutions

Trellis

NG-SDN

SEBA

ODTN

Mobile Services

Enterprise Services

Residential Services

Mobile

Enterprise

Residential

XOS

ORAN

VOLTHA

Stratum

ONOS

Network Edge Mediator

Pre-integrated SDN

Open Source Infrastructure

Vendor-Proprietary Network Controller

Open Source Network Controller

Proprietary and closed API

Vendor-Specific data model

Vertically-integrated

Single vendor

Disaggregated

Multi vendor

Common data models
ONF Trellis building block

- Trellis is common in most ONF reference exemplar designs
- Trellis contains generic Leaf/Spine fabric, Compute nodes, Controller, and networking functions
Most Network Design Contributions to Open Source

Industry Firsts: 10G to 400G Data Center, Telco /MSO Switches

**OCP-Accepted™ Designs & Products**
- 1G Rack Mgmt Switch  Helix4
- 10G TOR Switch  Trident II
- 40G Spine Switch  Trident II
- 100G TOR & Spine Switch  Tomahawk
- 100G TOR & Spine Switches  Trident3
- 64 x 100G Spine Switch  Tomahawk II
- 32 x 400G  Tomahawk III
- 10G/100G Edge Switch  Qumran
- Open Rack Switch Adapter

**Design Contributions in OCP Review**
- 100G OMP800 Chassis  Tomahawk
- 100G OMP1600 Chassis  Tomahawk
- 25G TOR Switch  Tomahawk
- MiniPack AS8000  Tomahawk III

**Partner Designs, Edgecore OCP-Inspired™ Product**
- Wedge40-16X  Facebook
- Wedge100-32X  Facebook
- Wedge100BF-32X  Barefoot
- Wedge100BF-65X  Barefoot

**OCP Telco Working Group**
- ASXvOLT16 10G OLT  BCM Qumran & Maple
- AS7316-26XB Cell Site Gateway  QumranAX
- AS7926-40XK and -80XK Aggregation Routers  Jericho2 in OCP Review

**OCP-Accepted™ Access Products**
- 1G PoE Switch  Helix4
- 802.11ac Wave1 Wi-Fi APs  BCM
- 802.11ac Wave2 Wi-Fi APs  QCA

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Software Paths in Open Networking

Open Network Hardware: whitebox, bare metal, disaggregated

Open Source Software

Commercial Software

Platforms
ONF Trellis
ONF Stratum
ONF VOLTHA/SEBA
Etc...

Software Components
ONL
OFDPA
Open BMC
P4
ONF Other
Etc...

Packaged NOS

Software Components

Aggregating the Disaggregated

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Proven Benefits of Open Networking

Freedom  Automation  Innovation

- Open “Whitebox” Hardware
- SDN Software Control
- Open Technology

- Capex/Opex Reduction
- Disaggregation - Modularity
- Feature and velocity of deployment
GTM: Edgecore Open Networking

- Open Hardware Leadership
- Open Software Value / Enablement Leadership (Ecosystem Partnership)
- Integration (Ecosystem Partnership)
Partnerships / Ecosystem Bringing **Trellis** to Market

- Leading SDN design – ONF Trellis
- Leading Open Networking Infra Supplier - Edgecore
- Leading System Integration partner- Infosys
Thank You

www.edge-core.com
Trellis
ONF Production Ready Solution

Nitesh Bansal
SVP and Global Head, Engineering Services
Who are we?

- A next-generation technology services company
- $11.8B Revenues
- 228,000+ People Globally
- 1,000+ Clients
- 45 Countries
- 8 out of top 10 Telecom companies have chosen Infosys as Strategic Partner

We help our clients:

- **DESIGN** next-generation Networks
- **TRANSFORM** OSS, BSS, Digital and Telecom Networks
- **BUILD** new-age solutions for Telecom Networks
- **OPERATE** across the value-chain by enabling the ‘digital thread’
Infosys is invested & committed to Open Networking Software

Infosys was the first SI to become the supply chain partner of ONF

Contributing R&D efforts to Open-source projects in ONF

- Trellis
- SEBA
- STRATUM
- CoMAC

Infosys brought ONF to Asia in July 2019

Accelerating Open Networking Software Deployment Leading to Digitization and Transformation of Networks

- 20+ Industry Visionaries
- 70+ Companies
- 400+ Attendees
- 30+ Showcases
- 80+ Thought Leadership

200+ Engineers enabled on ONF Platforms
Infosys Contributions to Trellis

- System Up Time: 10x
- Scale: ~120k Routes, 250k flows
- Test Automation: 200+ Automated Test-cases
- Service outages: 80% Reduction

New feature commits: 25
Code Commits: 70
Bug Fix commits: 45
Complex Features: 10

Infosys has partnered with ONF to address some of the key performance and reliability issues.
Bringing Trellis to the Market

Infosys is partnering with ONF and Edgecore to bring Trellis to the market

Hardened and carrier-grade release

Fully SLA driven commercial support model

Single neck to choke

Back to back agreements with all ecosystem players in the stack
The future roadmap

**MVP – Dec 2019**
- SDN Management Plane
- Unified Dashboard

**Release 1 – Jun 2020**
- Performance and Scale Optimization
- Fully Integrated Support Model
- Metro-Ethernet Capabilities

**Release 2 – Dec 2020**
- Hitless Upgrades
- P4, Stratum Integration
- Automated Regression suite

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**Infosys Network Controller**
- SDN-M
- Apps
- ONOS Core
- Adaptors / Plugins
THANK YOU