Peeling off the layers, one protocol at a time with SR and EVPN

Werner Viljoen
Systems Engineer
wv@arista.com
Agenda

• Cloud Principles and Cloud-Grade Routing
• Cloud-Grade Routing Innovations
  – Scale-Out Architectures with Merchant Silicon Platforms
  – Simplify Operations with Modern Open Protocols
  – Software-Driven Control for Automation and Visibility
• Key Takeaways
Cloud Principles Applied to Network Transformations

Legacy Networking

- Rigid Architecture
- Inefficient Operations
- Inflexible Service Delivery
- Proprietary Protocols
- Custom Silicon

Cloud Networking

- Scale-Out
- Simplify
- Software-Driven Control
- Standards-Based Protocols
- Merchant Silicon

Cloud Principles have driven Compute, Switching, Storage… and now Routing!
## Merchant Silicon Influence in Mega Cloud Providers

### Stellar Growth of Merchant Silicon

<table>
<thead>
<tr>
<th>Features</th>
<th>2008</th>
<th>2014</th>
<th>2016</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optical Transport</td>
<td>Transport</td>
<td>Transport</td>
<td>Transport</td>
<td>Transport</td>
</tr>
<tr>
<td>Routing</td>
<td>Core</td>
<td>Core</td>
<td>Core</td>
<td>Core</td>
</tr>
<tr>
<td></td>
<td>Edge</td>
<td>Edge</td>
<td>Edge</td>
<td>Edge</td>
</tr>
<tr>
<td>Switching</td>
<td>Core</td>
<td>Core</td>
<td>Core</td>
<td>Core</td>
</tr>
<tr>
<td></td>
<td>Spine</td>
<td>Spine</td>
<td>Spine</td>
<td>Spine</td>
</tr>
<tr>
<td></td>
<td>Leaf</td>
<td>Leaf</td>
<td>Leaf</td>
<td>Leaf</td>
</tr>
</tbody>
</table>

**Vendor ASIC vs. Merchant Silicon**

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**Broadcom ‘Jericho’ Silicon**

- **Routing Feature Complexity vs. Time**
- **Merchant Silicon capabilities**
Dave Temkin  
@dtemkin

Super proud of my team - today they removed the last "big expensive router" from our network; […]

Inexpensive commodity switches run the entire Netflix Open Connect CDN!

5:24 AM - 10 Nov 2017

270 Retweets  602 Likes
## Building Cloud-Grade OS

<table>
<thead>
<tr>
<th>Modern OS</th>
<th>Spine/Leaf Optimized</th>
<th>Automation</th>
<th>Monitoring @ Scale</th>
<th>Agile Certification</th>
</tr>
</thead>
</table>
| • Lean OS  
  • Programmable @ all layers | • Enhanced Load Balancing  
  • Optimal convergence | • NETCONF/YANG  
  • CloudVision Turnkey Automation | • Large-scale ECMP, Monitoring with BMP  
  • OpenConfig → State Streaming | • cEOS/vEOS to simulate large-scale networks |

### Fundamental Requirements of a Cloud OS
Traditional Service Provider Architecture Building Blocks

- End User (UE)
- Access & Agg
- Metro
- Service Edge
- Core
- Peering / DC & MTSO
- Internet
Connecting Transport to Places In The Cloud (PIC)

Any-Cloud Platform (Cloud / Service Domain)

Transport Domain
Scale Up vs Scale Out

**Scale Up (Legacy)**
- **Forklift** (Chassis or Linecards)
- **Legacy (1+1)**
  - **Single Vendor Solution**
  - Difficult to Upgrade Software
  - Additional Capacity Via System or Linecard Replacement
  - Forklift Lowers Investment Protection
  - 100% ‘Peak Capacity’ Loss During Outage/Maintenance

**Scale Out**
- **128-way ECMP**
- **576 x 100G leaf using 7516R**
- **UCN Design Pattern (Open Architecture)**
- **More Spines For Higher Capacity**
- **More Leaves For Higher Port Count**
- **Multi Vendor Solution**
  - Hitless Upgrades
  - Effortless Scale (Spine for Capacity, Leaf for Ports)
  - Higher Investment Protection Without Forklifts
  - 1/N% ‘Peak Capacity’ Loss During Outage/Maintenance (25% n=4, 6.25% n=16, 0.8% n=128)
Internet Exchange Providers

Legacy L2 Interconnect

Best-in-class convergence with Leaf-Spine architecture

Scale-Out

Modern IX Fabric

Open IP Fabrics with EVPN Services

Simplify

Automation and northbound orchestration integration

Software-Driven Control
Use Of Merchant Silicon Allows For Cost Effective Consolidation of L2 and L3 Elements At Each Location
Core Transport Summary

Traditional Transport
Multi-label MPLS Transport

Segment Routing
SDK programmability or third-party PCE integration

Network Services
EVPN for Layer 2/3 VPNs for Cloud, NFV and PE

High Density 10G/100G merchant silicon for MPLS transport

Scalable and Simplified, Traffic Engineering

Single scalable BGP control plane for Layer 2 and 3 VPNs
What is Segment Routing (SR)?

Basic Philosophy
- Reuse IGP and BGP to distribute the labels
- Simplify
  - Protocols required - eliminate need for additional signaling protocols
  - Removes per tunnel state (control and data-plane) though out the network
- Provide ECMP
- Encode source routing using MPLS label stack in the data-plane

Concepts
- Segment Routing envisions the network as a collection of ‘topological sub-paths’ – also called ‘segments’.
- Global labels
- Local labels
- Packet is transmitted from source with a list of Segment IDs (or SIDs)

Applicability
- Non-TE Replacement -> Remove redundant signaling protocols (LDP), and follow SPF
- TE Alternative -> External Controller for fine-grained or Macro TE

Segment Routing – Operation Overview

- SR divides the network into “segments” identified by a Segment ID (SID)
  - Global SIDs identify nodes (loopback ip), prefix or Anycast SID (shared loopback IP)
    - All nodes in the SR domain use same SID to identify the prefixes, node or Anycast an SID – reducing data plane state
  - Local significant SIDs identify, the Adjacency links in the network
    - Only the originating Node understands the advertised Adjacency SID
  - Both local and global SIDs are advertised as TLV extensions to the IGP (IS-IS/OSPF)
  - The SID is encoded as an MPLS Label in the forwarding plane
Segment Routing Analogy

Constraints

Computed Paths
Segment Routing Analogy

from Mineta San José International Airport
to Arista Networks Inc, 5453 Great America Parkway...

21 min (6.5 miles)
via N 1st St and Lafayette St
The usual traffic

Use the left 2 lanes to turn left onto Montague Expwy
0.7 mi

Turn right onto Agnew Rd
0.8 mi

Turn right onto Lafayette St
1.7 mi

Turn left onto Great America Way
0.4 mi

Turn left onto Great America Pkwy
0.2 mi

Make a U-turn at Old Mountain View-Alviso Rd
0.1 mi

Arista Networks Inc
5453 Great America Parkway, Santa Clara, CA 95054
# Segment Routing – Evolution of Core Routing

<table>
<thead>
<tr>
<th></th>
<th>LDP</th>
<th>RSVP-TE</th>
<th>SR</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Overview</strong></td>
<td>MP2P</td>
<td>P2P</td>
<td>MP2P</td>
</tr>
<tr>
<td><strong>Operation</strong></td>
<td>Simple</td>
<td>Difficult</td>
<td>Simple</td>
</tr>
<tr>
<td><strong>Separate Label Distribution Protocol</strong></td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td><strong>Dependencies</strong></td>
<td>Relies on IGP</td>
<td>Relies on IGP extensions</td>
<td>Relies on IGP</td>
</tr>
<tr>
<td><strong>Label Allocation</strong></td>
<td>Locally significant</td>
<td>Locally significant</td>
<td>Global (local ADJ SID)</td>
</tr>
<tr>
<td><strong>MPLS ECMP</strong></td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Traffic Engineering (TE)</strong></td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>TE Scale</strong></td>
<td>N/A</td>
<td>Medium/Low N(N-1)</td>
<td>High</td>
</tr>
<tr>
<td><strong>Fast Reroute</strong></td>
<td>Partial LFA (&lt;100%)</td>
<td>Yes Node/Link Protection</td>
<td>Yes TI-LFA</td>
</tr>
<tr>
<td><strong>Multicast</strong></td>
<td>Yes mLDP</td>
<td>Yes P2MP LSP</td>
<td>No Deployed With Parallel MC Control Plane</td>
</tr>
<tr>
<td><strong>IPv6</strong></td>
<td>Limited Extensions Required</td>
<td>Limited Extensions Required</td>
<td>Native</td>
</tr>
</tbody>
</table>

A Transformation in Routing Protocols is Required

SR Use Cases for SPs

- MPLS in the DC/POP
- SR based L-S DC design
- EVPN MPLS for L2 or L3 EVPN

- Solving the “Ring” topology problem
- Allows moving to L3 design
- May inter-work with RSVP-TE in core (binding SID) or tunnel over LDP (SR Mapping Server)
- Mainly looking at SR for TI-LFA
Egress Peer Engineering - Traditional approach

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- Policy on ASBR4 set high local-preference for prefix A from AS3
  - Preferred path for Prefix A via NNI 3.1
- Packet with destination IP address matching prefix “A”
  - All sent out of NNI 3.1, regardless of the ingress ASBR
- If ASBR 4 and 5 visible to each of the ingress ASBRs
  - Policy on ingress ASBR’s may choose and egress ASBR (ASBR 4 or 5)
  - Can chose ASBR for exit but still not the actual NNI.

Approach limited to
- Egress link selection per destination prefix, on egress ASBR
- Egress ASBR selection per Prefix on ingress ASBR, but without visibility to egress link
- No Global Policy!!!
Egress Peer Engineering - SR approach

- Path advertised by Peer AS
- ASBR advertise all path and link state info to the controller via BGP-LS
- From LS information and constraints controller computes best path for prefix A.
  - Path decision can be per ingress ASBR
  - Including the NNI interface in the path along with the intra-AS path within AS1
- ASBR3 encapsulates traffic with Segment path to reach ASBR4 and exit NNI3.1.

- Internal path provisioning from ingress ASBR to egress ASBR, GRE, LDP, SPRING Node-SID, RSVP-TE
- Label for NNI selection on egress ASBR- BGP-LU and SPRING peering-SID
SR – Class based traffic Engineering

- Forwarding path computed based on the Traffic Class of the traffic
  - Differential Forwarding paths calculated for the aggress service classes
  - Best path determined from business rules, technical constraints (loss, latency), or a combination of both.
  - With EOS SDK controller has limitless constraints and a programmatic interface to LER
EVPN – Extending Cloud Into Routing Services

- Standards Based - Open Standards for Inter-operation
- Flexible Service Types – E-Line/E-LAN & IP VPN Services
- Universal BGP Control Plane – Simplify, Standardize
- Scalable – BGP Based Scalable VPN Services
- Secure – MAC Mobility, ARP Suppression, Policy Control
- Efficient – Multi-Homing Support, A/A Forwarding, Scaled ECMP
- Supports Different Encapsulation Types – IP (VXLAN) & MPLS

EVPN

WAN

DC L3SL

DCI

IX

Cloud/NFV

Edge VPN Services

Metro Ethernet

Participated in Public Multi-Vendor Routing Interop Test – April 2018
MPLS + SDN + NFV World Congress 2018
MPLS EVPN – Layer 3 VPNs

• Provide Layer 3 VPNs across a MPLS transport
  – Alternative solution to IP-VPNs (RFC 2746/RFC 4364)
  – BGP control-plane with EVPN NLRI (RFC 7432)
  – Type 5 route to advertise IP prefixes to emulate an IP VPN like service
  – Prefix advertised with Route-Target (RT), Route-Distinguisher (RD) and MPLS label
Route Types – Type 5 (EVPN MPLS)

- **EVPN MPLS Type-5 Route**

```bash
PE-2(config)#show bgp evpn route-type ip-prefix ipv4 rd 1.1.1.1:65001 detail
BGP routing table information for VRF default
Router identifier 1.1.1.2, local AS number 65001
BGP routing table entry for ip-prefix 10.10.10.0/24, Route Distinguisher: 1.1.1.1:65001
Paths: 1 available
Local
    2.2.2.1 from 1.1.1.1 (1.1.1.1)  
    Origin IGP, metric -, localpref 100, weight 0, valid, internal, best
    Extended Community: Route-Target-AS:1001:1001 TunnelEncap:tunnelTypeMpls
    MPLS label: 116384

BGP routing table entry for ip-prefix 10.10.12.0/24, Route Distinguisher: 1.1.1.1:65001
Paths: 1 available
Local
    2.2.2.1 from 1.1.1.1 (1.1.1.1)  
    Origin IGP, metric -, localpref 100, weight 0, valid, internal, best
    Extended Community: Route-Target-AS:1001:1001 TunnelEncap:tunnelTypeMpls
    MPLS label: 116384
PE-2(config)#
```

**Notes:**
- IP-prefix and RD being advertised
- Next hop (2.2.2.1) for the prefix and advertising Router (1.1.1.1)
- Route-target (1001:1001), encapsulation (MPLS) and label for the VPN route (116384)
Use Case: MPLS L3 EVPN DCI
Traffic Steering: Automation, Telemetry & State Streaming

- Access to all state in the system via standardized (OpenConfig) YANG or internal EOS models
- Full device configuration management via OpenConfig models + CLI
- Supported across all devices
- Standard gRPC transport
  - A transport layer with efficient data encoding!

CloudVision®
Summary

**TODAY**

- Inconsistent operational models
- Expensive Fixed Routers
- Slow convergence
- Disparate Protocols

**TARGET ARCHITECTURE**

- Programmability, Automation, Telemetry, Visibility
- Flexible Config Monitoring
- Merchant Silicon
  - Economics, Scale, Services
  - BGP, Route Scale
- Scale-Out & Simplify
  - Rapid Route Convergence
- Consistent Open Protocols
  - SPRING/SR, EVPN, (SIMPLIFY)
Thank You

www.arista.com, eos.arista.com
www.youtube.com/user/AristaNetworks
http://github.com/arista-eosplus