MPLS+SDN+NFV World @Paris 2018 Interoperability Showcase

Cisco Knowledge Network Webinar
June 2018
Why are we here?

• Learn highlights of Cisco’s participation at the latest public multi-vendor interoperability event organized by the European Advanced Networking Test Center (EANTC)

• Results from this event were first showcased at the MPLS + SDN + NFV World Congress conference in Paris back in April 2018
Meet the Speakers

Carsten Rossenhövel
Managing Director, EANTC

Jose Liste
Technical Marketing Engineer, Cisco
Cisco Participation to EANTC Multi-Vendor Interoperability Tests 2018

Carsten Rossenhövel
June 5, 2018
About the European Advanced Networking Test Center

- State of the art testing expertise focusing on innovative telecom technologies
- Emulating fully realistic scenarios representative for today’s production networks
- EANTC is 100% independent and vendor-neutral
- Adhering to highest quality standards and actively participating in test methods standardization

Network Design, Proof of Concept Testing and Audits for Service Providers

Acceptance Tests and Audits for Enterprises

Testing and Certification for Vendors

Tested by EANTC 2018

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EANTC regularly invites all interested vendors to join our Multi-Vendor Interoperability Test Events:

- **Since 2003:** MPLS + SDN + NFV World Congress
- **Since 2013:** SDN, NFV and Optical Tests at various events
- **Since 2015:** New IP Agency NFV Test Campaigns & Certification
- **Since 2017:** SD-WAN Events
Participating Vendors 2018

- ADVA Optical Networking
- ARISTA
- BISDN
- Calnex
- CISCO
- DELTA
- ECI
- ERICSSON
- HUAWEI
- ip infusion
- ixia
- JUNIPER NETWORKS
- MEINBERG
- metaswitch
- Microsemi
- NEC
- NOKIA
- OSCILLOQUARTZ
- UTSTARCOM
- SPIRENT
- ZTE
## Participating Devices

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2018 MPLS/SDN Technology State
As Seen in EANTC Tests

Technology Expectations

- Multicast w/ BIER
- BGP-LS w/ EPE extensions
- BGP-LU + SID
- Multicast assisted replication with EVPN
- EVPN E-Tree
- EVPN VXLAN
- EVPN-MPLS
- NETCONF
- NETCONF w/ YANG models
- OSPF w/ SR extensions
- SRv6
- TI-LFA w/ SR
- IP FRR w/ SR
- PCEP
- EVPN E-Line
- EVVPN w/ EVVPN
- IRB w/ EVVPN
- BGP-LS
- ISIS w/ SR ext.

Technology Introduction
Initial Vendor Implementations
Early Adopters
Consolidation
Massive Adoption
White Paper

- Description of tested technologies and detailed results
- 40 pages explaining working demonstrations
- Available at http://www.eantc.de/live_showcases.html
Cisco participation ...
Objectives

• A technical overview of Cisco’s participation with platforms powered by IOS XR
  - Cisco was also represented by DC / NX-OS and Network Services Orchestrator (NSO) – not covered by this presentation

• Focus on Segment Routing, PCE and Ethernet VPN test areas
Cisco Platform Participation

- Cisco ASR 9000
- Cisco NCS 5500
  - First time participation
- Cisco IOS XRv9000
  - First time participation acting as a virtual SR Path Computation Element (SR-PCE)
SR-MPLS Interoperability
SR Interop Highlights

- Cisco was one of a total of ten (10) network and test equipment vendors that validated readiness of their SR implementations.

- SR-MPLS dominated on those test cases using MPLS as a transport. This included the transport of services such as IP VPN and Ethernet VPN:
  - Use of LDP was kept to a minimum
  - RSVP-TE was not used at the event
SR Interop Highlights

• IS-IS was chosen as the main IGP throughout the event

• Baseline IS-IS SR extensions were successfully verified
  - No interoperability issues were observed among Cisco and vendors that we interconnected with

• Verified functionality included:
  - IPv4 control plane IGP extensions
  - Prefix Segment ID (Prefix-SID) for host prefixes including both Node and Anycast SIDs
  - Adjacency Segment IDs (Adj-SIDs) for IS-IS adjacencies
  - Prefix-to-SID mapping advertisements performed by the SR Mapping Server (SRMS) function
SR Interop Highlights (cont.)

- **SR Traffic Engineering (SRTE)** was another area of focus with validation of the following:
  - Path Computation Element Protocol (PCEP) - Stateful PCE model
  - PCEP extensions for Segment Routing
  - BGP Link-State (BGP-LS) and extensions for Segment Routing
SR Interop Highlights (cont.)

• In addition, the following SR-MPLS related topics were tested for the first time at EANTC:
  - Topology Independent LFA (TI-LFA)
  - SR Prefix SID extensions for BGP (BGP-SR)
  - SR Operations, Administration and Maintenance (OAM)
SR Interop Highlights (cont.)

• Note that SRv6 was validated also for the first time at an EANTC event
  - Tests with Cisco participation covered baseline functions (END and END.X) from the SRv6 Network Programming IETF draft
Participating Vendors – SR-MPLS

• Total of eight (8) vendors participated:
  • Cisco
  • Juniper
  • Nokia
  • Arista

• Huawei
  • Ericsson
  • ECI
  • IP Infusion
Interoperability Areas – SR-MPLS

- TI-LFA
- SR and LDP interworking
- BGP-SR
- SR-OAM
TI-LFA Highlights

- TI-LFA a key area of execution for Cisco since we started shipping it in 2014
  - Link, Node, SRLG protection
- First time interop test at EANTC
- Cisco successfully validated sub-50 msec protection with TI-LFA
- Cisco successfully validated TI-LFA with Link protection
TI-LFA Highlights (cont.)

- Cisco was only vendor to successfully validate TI-LFA with Local SRLG protection

![TI-LFA Diagram](https://example.com/ti-lfa-diagram.png)

Figure 9: SRMPLS TI-LFA Local SRLG Protection
Beyond the Report ... TI-LFA

• Beyond protocol interoperability, aspects NOT COVERED by the report and important to consider:

• Does the implementation provide per-destination (per-prefix) backup paths?

• Does the implementation provide prefix-independent convergence?

• Does the implementation provide protection to traffic that originally is forwarded using other paradigms such as LDP signaling or pure IP traffic (IP-routed traffic)?
SR and LDP Interworking Highlights

- Cisco’s SR implementation supports SRMS and SR/LDP data-plane interworking functions since 2014
- Cisco was successfully validated as an SRMS node in a domain with non-Cisco SR-only nodes
- Cisco was successfully validated as an SR-only node receiving IS-IS SRMS advertisements from a non-Cisco SRMS implementation
- Cisco was successfully validated as an LDP/SR interconnect “stitching” node
BGP-SR Highlights

- SR Prefix SID extensions for BGP
  - BGP attribute for announcing BGP Prefix-SID
  - Instruction to forward the packet over the ECMP-aware best-path computed by BGP to the related prefix
- First time interop test at EANTC
- Cisco was successfully validated as a Leaf node in a multi-vendor BGP-SR fabric
- Cisco was successfully validated as a Spine node in a multi-vendor BGP-SR fabric
SR OAM Highlights

- RFC 8287 defined extensions to perform LSP Ping and Traceroute operations for SR IGP-Prefix SIDs and IGP-Adjacency SIDs with an MPLS data plane
- First time interop test at EANTC
- Cisco was successfully validated as initiator of SR OAM ping / traceroute operations - using an MPLS echo request with a target FEC Stack TLV carrying FECs with IPv4 IGP-prefix SID sub-TLV
- Cisco was successfully validated as target / responder of SR OAM ping / traceroute operations
- An interop issue found with draft
  - IETF technical errata for RFC 8287
SRTE and PCEP
Interoperability
Interoperability Areas – SRTE / PCEP

- PCEP – PCC-initiated SR policy
- PCEP – PCE-initiated SR policy
- BGP Link State (BGP-LS)
- Multi-Domain SRTE
  - Multi-Domain without EPE
  - Multi-Domain with EPE
SRTE / PCEP – Cisco Highlights as SR PCC

- Cisco was one of a group of six (6) vendors that participated as PCEP PCC headend nodes

- Cisco's SR PCC was the MOST interoperable PCC at the event considering the number of successful test results across participating PCE vendors

- As PCC, successfully validated creation, update and deletion of SR policies using PCE-initiated model with participating non-Cisco SR PCEs
SRTE / PCEP – Cisco Highlights as SR PCC (cont.)

- As PCC, successfully validated creation, update and deletion of SR policies using PCC-initiated model with participating non-Cisco SR PCEs
SRTE / PCEP – Cisco Highlights as SR PCE

- Cisco was one of a group of three (3) vendors that participated as PCEP PCE nodes.
- Cisco’s SR PCE was the MOST interoperable PCE at the event considering the number of successful test results across participating PCC vendors.
- As PCE, successfully validated creation, update and deletion of SR policies using PCE-initiated model with participating non-Cisco SR PCCs.
- As PCE, successfully validated creation, update and deletion of SR policies using PCC-initiated model with participating non-Cisco SR PCCs.
SRTE / PCEP – Cisco Highlights as SR PCE (cont.)

- Cisco SR PCE successfully validated single-/multi-domain topology learning using BGP-LS feed originated at non-Cisco nodes
- Cisco SR PCE successfully validated multi-domain path computation
SRTE / PCEP – Cisco Highlights as SR PCE (cont.)

- Cisco SR PCE was the only PCE to successfully validate multi-domain (multi-AS) topology learning using Egress Peering Engineering (EPE) SIDs at domain boundaries.

- Cisco SR PCE was the only PCE to successfully validate path computation on a multi-domain (multi-AS) network.

Figure 30: Inter-AS SR-TE
Beyond the Report ... SRTE / PCEP

• Beyond protocol interoperability, aspects NOT COVERED by the report and important to consider:

• Does the vendor PCE implementation provide path computation leveraging the SR principles? (maximize ECMP and minimize SID-list)

• Does the vendor implementation allow for path computation at the headend?

• Does the vendor implementation provide maximum platform scale without a-priori full-mesh connectivity?

• Does the vendor implementation avoid complex and performance-impacting legacy traffic steering techniques?
EVPN Interoperability
EVPN Interop Highlights

• Cisco was one of a group of eight (8) vendors that participated in the EVPN test area - An all-time high!!!

• For the first time at EANTC, a common SR-MPLS network was used as the main transport for EVPN services across the core

• Cisco IOS XRv9000 acted as BGP route-reflector for EVPN and was leveraged by all participating vendors connected to the SR-MPLS core
EVPN Interop Highlights (cont.)

- EVPN VPWS over SR-MPLS
- Cisco was successfully validated as a PE in a single-home configuration
EVPN Interop Highlights (cont.)

- EVPN all-active multi-homing over SR-MPLS

- All-active multi-homing functionality is one of the main advantages of EVPN over its legacy predecessors such as VPLS

- Cisco was successfully validated as a PE in a multi-vendor multi-home Ethernet segment
EVPN Interop Highlights (cont.)

- EVPN-VXLAN and IP-VPN Interworking
- Cisco was successfully validated as a Layer 3 DCI interconnecting EVPN datacenter sites across a WAN network based on IP-VPN
Conclusion
Conclusion

- With **strong customer adoption and multi-vendor consensus with standardization at IETF**, SR has become **de-facto SDN architecture**
  - This year interop provides the latest proof-point of overwhelming multi-vendor support
  - Beyond obvious protocol interop, **operators shall evaluate a vendor’s offering based on operational simplicity, on-demand / automated functionality** that ultimately leads to scalable and performant offerings

- Also with **strong multi-vendor support and sophistication of test scenarios**, EVPN continues to establish its dominance in **Carrier Ethernet and Datacenter usecases**
Interop References

• EANTC official whitepaper

• Blog – Cisco participation at Interop

• Blog – Cisco participation at Interop (Chinese)
Stay up-to-date

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Overall SR quotes and opinions
The level of interoperability for Ethernet VPN (EVPN) services and Segment Routing (SR) implementations over MPLS (SR-MPLS) has been very reassuring. We have seen tangible progress in the number of successful multi-vendor combinations, the maturity of implementations as expressed by more complex test cases, and the efficiency of configuration and troubleshooting.

Carsten Rossenhövel, Managing Director, EANTC
There is a major evolution going on quietly: Legacy signaling protocols LDP and RSVP-TE will no longer be needed in the future, greatly improving the scalability and efficiency of core and aggregation networks.

Carsten Rossenhövel, Managing Director, EANTC
It was definitely a year of consolidation for Segment Routing as the new standard for MPLS-enabled networks. All our test scenarios involving MPLS in the Segment Routing, Ethernet VPNs and Software Defined Networking sections were carried out using Segment Routing. Therefore, it showed us how mature vendor implementations are and a clear view, whereto the industry is moving forward.

Technical team, EANTC
Segment Routing is becoming the de-facto SDN architecture. Leveraging the source routing paradigm, SR brings scalability, simplicity and end-to-end traffic engineering to MPLS and native IPv6 networks.

Technical team, EANTC
Path-Computation Element Protocol (PCEP) tests were much more promising than last year as well; router ("PCC") and controller ("PCE") implementations are increasingly aware of multi-vendor scenarios and ready to interoperate with each other in a collaborative way.

Carsten Rossenhövel, Managing Director, EANTC
Implementations of Path Computation Element Protocol (PCEP) also showed a good level of maturity. This year we could test a total of 31 combinations of different vendor/products interoping as PCE and Path Computation Clients (PCC)

Technical team, EANTC