SRv6
Technology and Deployment Update

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Systems Architect – Global SP Team

Thank you

- Lead operators

- EcoSystem Partners

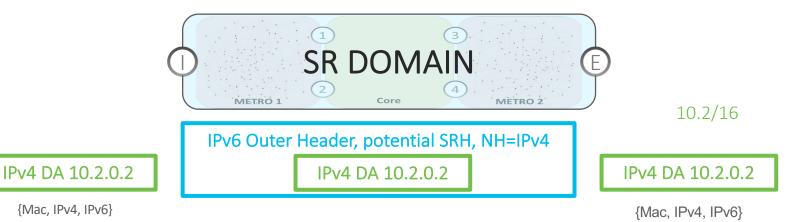- Academic and Open-Source Partners

- IETF Partners

- Cisco SR Team

segment-routing.net

- SRv6 uSID: [CKN](), [MPLS WC](), [DKNOG](), [Training]()

- SRv6 Ultra-Scale SR Policy: 26 uSID push at linerate: [demo]()

- BGP PIC Edge with SRv6 Summarization: ISIS UPA: [demo]()

- Path Tracing: [NANOG](), [Tutorial]()

Introduction

Transparent Services

SR DOMAIN

METRO 1   Core   METRO 2

10.2/16

IPv6 Outer Header, potential SRH, NH=IPv4

IPv4 DA 10.2.0.2   IPv4 DA 10.2.0.2   IPv4 DA 10.2.0.2

{Mac, IPv4, IPv6}   {Mac, IPv4, IPv6}

- Customer packet is encapsulated from ingress to egress of the SR Domain

- SRv6 is applied to the OUTER header

- The inner packet is untouched

- Unified control-plane data-plane E2E

- Native inter-domain routing with optimal ECMP
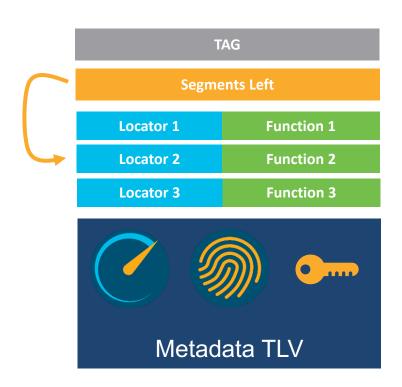
- Native core and DC integration

SRv6 Network Programming - RFC8986

- The End-to-End Policy is encoded as a Network Program
  - The first instruction is in the outer DA
  - The remaining instructions are in the SRH

- An instruction (a SID) may be bound to any behavior
  - TILFA FRR and uLoop Avoidance
  - Traffic Engineering: internal to the domain and across peering links
  - L2/L3 VPN's
  - NFV
  - Any HW custom behavior: P4 on Silicon1
  - Any SW custom behavior: Container orchestrated by Kubernetes

- Powerful Service Creation
  - Any service can be encoded as an ordered list of instructions (Low-latency Slice, VPN, NFV)

- Stateless-Fabric
  - The state (Network program) is in the header

SR Extension Header

- SRv6 is a native extension of IPv6
  - RFC 8754
  - As foreseen 25 years ago by RFC2460

- SRH contains an ordered list of SID's

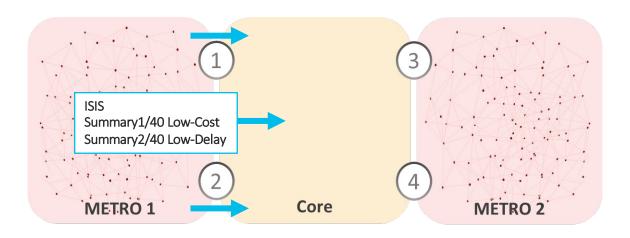| TAG	
Segments Left	
Locator 1	Function 1
Locator 2	Function 2
Locator 3	Function 3

Metadata TLV

Unified Data Plane And Seamless Deployment

- A unified data plane spanning from Application socket to Internet peering though Datacenter, Access, Metro, Core, Peering

- A single data plane natively supported by all nodes – just IP!

- Seamless forwarding through IPv6 transit nodes

- Most use-cases do not need an SRH
  - DA SID contains up to 6 micro-instructions (uSID's)

Host

User Equipment Container

Peering Cell Site

Access Metro

Datacenter

SRv6 Solves Many Challenges

ISIS
Summary1/40 Low-Cost
Summary2/40 Low-Delay

METRO 1

Core

METRO 2

- 1000 times less IGP routes than with MPLS

- No BGP inter-AS Option A/B/C

- End-to-End Flex Algo Continuity

```
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|Version| Traffic Class |         Flow Label                  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|         Payload Length        |  Next Header  |  Hop Limit   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                              |
+                                                              +
|                                                              |
+                    Source Address                            +
|                                                              |
+                                                              +
|                                                              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                              |
+                                                              +
|                                                              |
+                  Destination Address                         +
|                                                              |
+                                                              +
|                                                              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

More on SRv6

- Cisco Knowledge Network "SRv6 Standardization Deployed at Scale"
  - https://www.segment-routing.net/tutorials/2021-11-18-CKN-SRv6/

Deployment Status

Record-Speed Deployment

- 3 years of commercial deployment (2019-2022)

- ~100M SRv6 subscribers

- ~100 deployments, with ~14 public reports

- Across markets (Web, SP, Enterprise) and geographies (Asia, EU, US)

SoftBank	Rakuten	Indosat	MTN Uganda	Noia
Iliad	Alibaba	China Telecom	China Bank	Cernet2
Free	Bell Canada	China Unicom	Line	

NEW

Commitment to SR Lead-Operators

✅ Standard-Based Technology

✅ Vendor eco-system

✅ Open-Source eco-system

Cisco Public

Mature Standardization

- Proposed Standard
  - RFC 8402   SR Architecture
  - RFC 8754   SRv6 DataPlane
  - RFC 8986   SRv6 Network Programming
  - RFC 9252   SRv6 BGP Extension
  - RFC 9256   SR Policy
  - RFC 9259   SRv6 OAM

Rich SRv6 Ecosystem

Network Equipment Manufacturers

Merchant Silicon

Open-Source Applications

Open-Source Networking Stacks

Smart NIC

Partners

Many Successful Interops

- 2020/04: EANTC: SRv6 interop between Cisco, Huawei, Juniper, Arrcus, Ixia (link)
  - Classic IPv6 nodes as SRv6 transit nodes
  - SRv6-L3VPN for IPv4 and IPv6 services
  - SRv6 TI-LFA FRR link protection with SRH insert
  - SRv6 EVPN for E-Line and EVPN L3VPN services
  - SRv6 TE SR Policy

- 2021/02: NetOne Systems (link)
  - Cisco XR, Cisco NX, Juniper

- 2021/09: EANTC: SRv6 interop between Cisco, Huawei, Juniper, Nokia, Spirent   (link)
  - SRv6-Based Global IPv4 and IPv6 services
  - SRv6-L3VPN for IPv4 and IPv6 services
  - SRv6 TI-LFA FRR local SRLG protection with SRH insert
  - SRv6 EVPN for E-Line and EVPN L3VPN services
  - IGP Flex-Algo using TWAMP-measured link delays

SRv6 uSIDs

SRv6 uSID Terminology

- Industry:
  - SRv6 Micro Segment
  - SRv6 uSID
  - Briefly: uSID

- IETF: NEXT-C-SID
  - Briefly: Next
  - IETF document: draft-ietf-spring-srv6-srh-compression-01
  - Training: link

Container of 6 uSID's

- SRv6 Network Programming (RFC8986)
  - The source encodes any end-to-end program as an ordered list of instructions
  - The first instruction is in the outer DA
  - The remaining instructions are in the SRH

- An instruction is called a SID

- A Container SID may contain up to 6 micro-instructions called uSID's
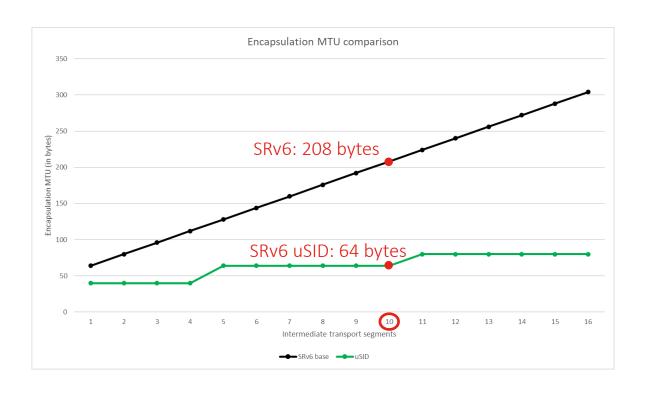
FC00:0000:1111:2222:3333:4444:5555:6666

uSID Block   uSID1   uSID2   uSID3   uSID4   uSID5   uSID6

Perfect SRv6 Integration

- uSID reuses SRH (RFC8754) without any change

- uSID strictly applies the SRv6 Network Programming (RFC8986)

- uSID can be bound to any Network Programming Instruction

SRv6 uSID offers the best SRv6 Compression

Encapsulation MTU comparison

SRv6: 208 bytes

SRv6 uSID: 64 bytes

SRv6 uSID in Deployments

Rakuten – SRv6 uSID in Deployment

Rakuten

- 5G End-to-End Network Slicing based on SRv6 uSID Flex-Algo
  - SRv6 uSIDs are allocated from the ULA address range
  - SRv6 uSID ISIS Flex-Algo: Low-Cost vs Low-Delay
  - SRv6 uSID BGP services
  - SRv6 uSID TILFA
  - Cisco NCS5500 and NCS-540 series

- Innovation in partnership with Cisco
  - BGP PIC Core and Edge with SRv6 Summarization: ISIS UPA   (demo)
  - SR BW counters for deterministic and scalable capacity planning and BW guarantee

https://www.segment-routing.net/conferences/MPLS-WC-2022-Amit-Dhamija/

Bell Canada - SRv6 uSID Deployment

Bell

- Bell promptly switched from SR-MPLS to SRv6 uSID
- Continued Simplification (remove MPLS dataplane)
- Better Routing Scale: Summarization
- Better HW Scale: linerate 26 uSID push for end-to-end SR Policy
- Seamless Deployment (6 uSID's in DA without SRH)
- End-to-End IP Unified Dataplane from socket to Internet Peering
  - SRv6-TE Policy: topological and service uSID's
- Service Programming
- Reduce network service costs by up to 90%
          footprint by 75%
          power consumption by as much as 66%

https://www.segment-routing.net/conferences/MPLS-WC-2022-Daniel-Voyer/

https://www.segment-routing.net/conferences/MPLS-WC-2022-Daniel-Bernier-Jesper-Eriksson/

SRv6 uSID - Rich Eco-System

- Cisco, NoviFlow, Arrcus, Nokia, Ciena

- Merchant: Silicon One, Broadcom, Marvell, Barefoot

- Open Source: Linux, FD.io, P4, eBPF, Cillium, SAI, SONIC, FRR

More on uSID

- SRv6 Technology Status and Deployment Update
  - https://www.segment-routing.net/conferences/MPLS-WC-2022-Clarence-Filsfils/

Cisco Public

Path Tracing

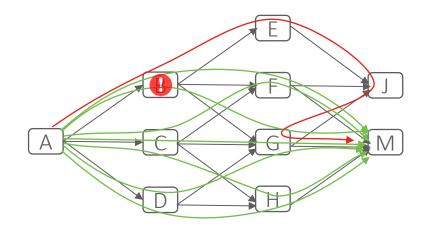# The exact path from A to M is not known

- 7 possible "valid" ECMP path
  - ABFM, ABGM, ACFM, ACGM, ACHM, ADGM, ADHM …

The exact path from A to M is not known
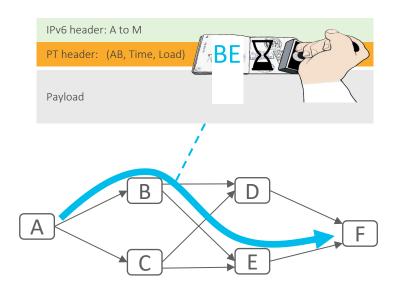
- 7 possible "valid" ECMP path
  - ABFM, ABGM, ACFM, ACGM, ACHM, ADGM, ADHM …

- What exact path was taken by one specific packet?
  - 40-year-old unsolved IP problem
  - Packet may have also taken an invalid path (Routing or FIB corruptions)
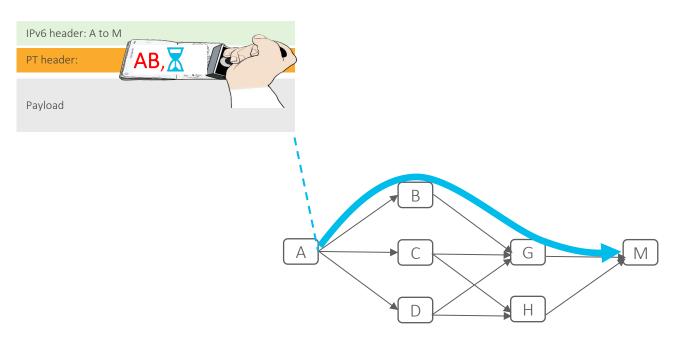
- Timestamp at each hop
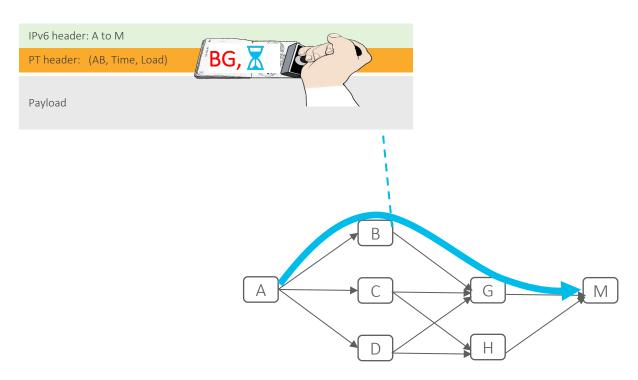
- Interface Load at each hop

The Path Tracing Idea

- Stamping in the packet header

- Implemented at linerate in the most basic HW pipeline
  - Reports true packet experience
  - No punting to CPU, no offload to co-processors

- Ultra-MTU-efficient
  - Highly compressed for low MTU overhead
  - Only 3 bytes per hop (12bit interface, 8bit TS, 4bit load)

- Each transit router records:
  - Outgoing interface ID
  - Timestamp
  - Outgoing interface Load

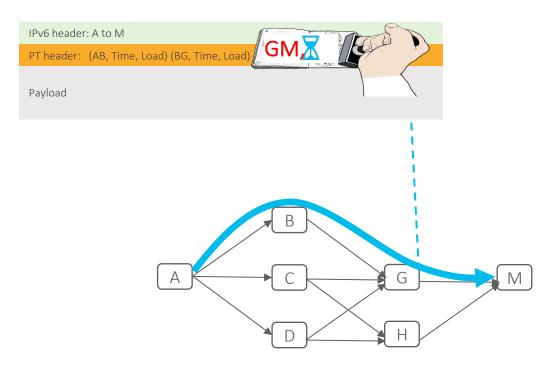- Native interworking with legacy nodes
  - Seamless deployment

Stamping Trajectory in PT Header

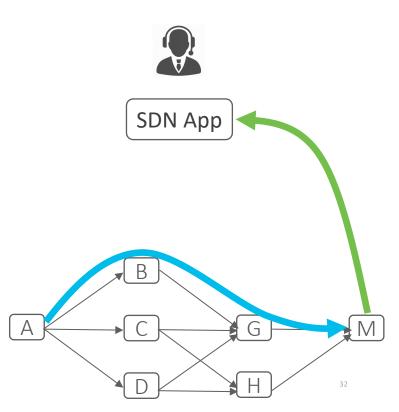| IPv6 header: A to M |
|---|
| PT header: AB,⌛ |
| Payload |

Stamping Trajectory in PT Header

IPv6 header: A to M

PT header: (AB, Time, Load)   BG,

Payload

Stamping Trajectory in PT Header

IPv6 header: A to M

PT header: (AB, Time, Load) (BG, Time, Load)

GM,

Payload

Minimize HW complexity by leveraging SDN analytics

- Exact path validation (interface by interface)
  - detect blackholes
  - detect unexpected paths
  - detect missing paths

- Propagation latency & Optical stability

- Per node jitter measurement

Ecosystem

- Cisco Shipping in CY22
  - C8000 (Q200), NCS5700 (J2), ASR9000 (LS)

- Rich Eco-System
  - Cisco, Broadcom, Marvell, +others

- Rich Open-Source
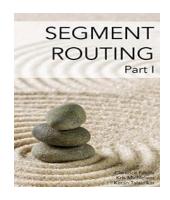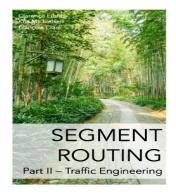 - Linux, FD.io VPP, P4, Wireshark, TCPDUMP

- Path Tracing is being standardized at IETF
  - Path Tracing in SRv6 networks (ietf.org)

Stay up-to-date

SEGMENT ROUTING Part I

amzn.com/B01I58LSUO

SEGMENT ROUTING Part II – Traffic Engineering

amazon.com/dp/B07N13RDM9

SRv6 Part III
CY2023

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linkedin.com/groups/8266623

ask-segment-routing@cisco.com

CISCO

The bridge to possible