

SRv6 Innovation and Standards

2019.3

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Huawei Chief IP Standard Representative
IETF Internet Architecture Board (IAB) Member



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**Huawei Chief IP Standard Representative
IETF Internet Architecture Board (IAB) Member**

<https://www.iab.org/about/iab-members/>

- Head of Huawei IP research and standard work.
- Be active in standard activities since IETF79 and proposes 40+ drafts/RFCs in RTG/OPS areas.
- Promote SDN Transition (Netconf/YANG, BGP/PCEP, etc.) innovation and standard work in the past 5 years.
- Focus on the innovation standard work of SRv6, Network Intelligence, Telemetry, etc. since 2016.
- Be elected as the IETF IAB member to be responsible for Internet architecture work from 2019 to 2021.

Overview of Segment Routing

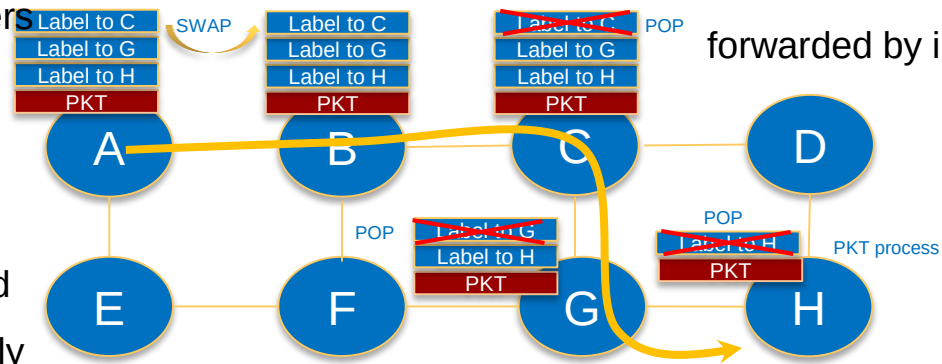
Principle of Segment Routing

The head node specifies the end-to-end forwarding path, and the subsequent nodes are forwarded by the identifier.

2. The head node push all path identifiers



1. The Path is delivered by controller or manually



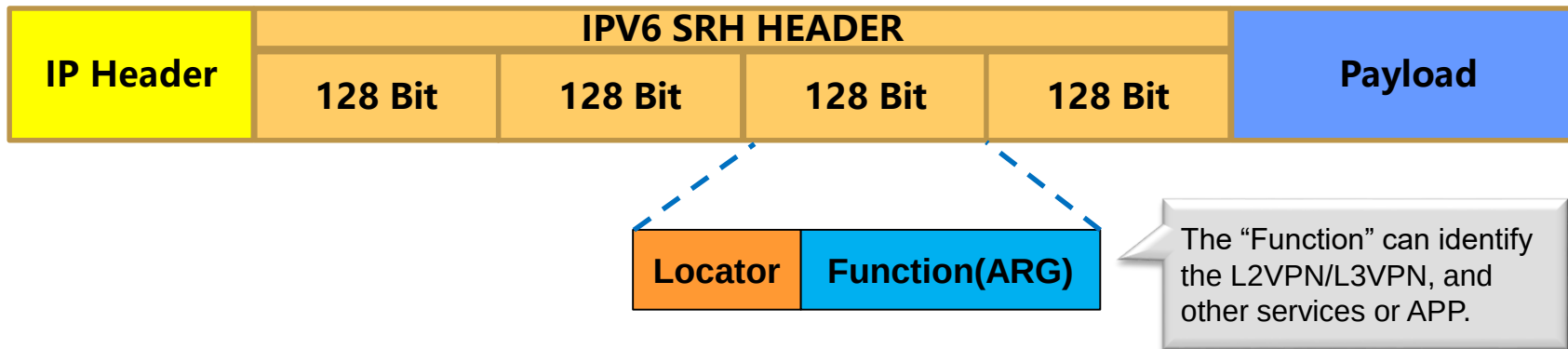
3. Subsequent nodes are forwarded by instruction

SRMPLS: mature in the VPN/FRR/TE.
SRv6: developed very quickly.

- **Advantages of Segment Routing**

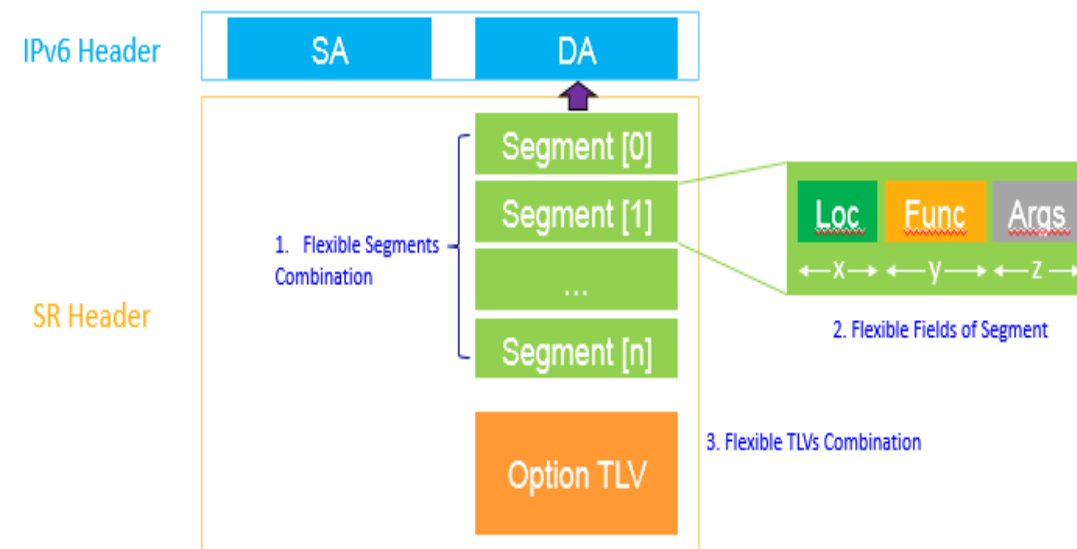
- ❑ Simplification of protocols: Replace LDP/RSVP-TE in unicast scenarios.
- ❑ High scalability: Reduce the network states and only ingress nodes install forwarding entries.
- ❑ Programmability: Flexible combination of segments for transport and service.
- ❑ More reliable protection: 100% network coverage with TI-LFA

Principle of SRv6 Network Programming

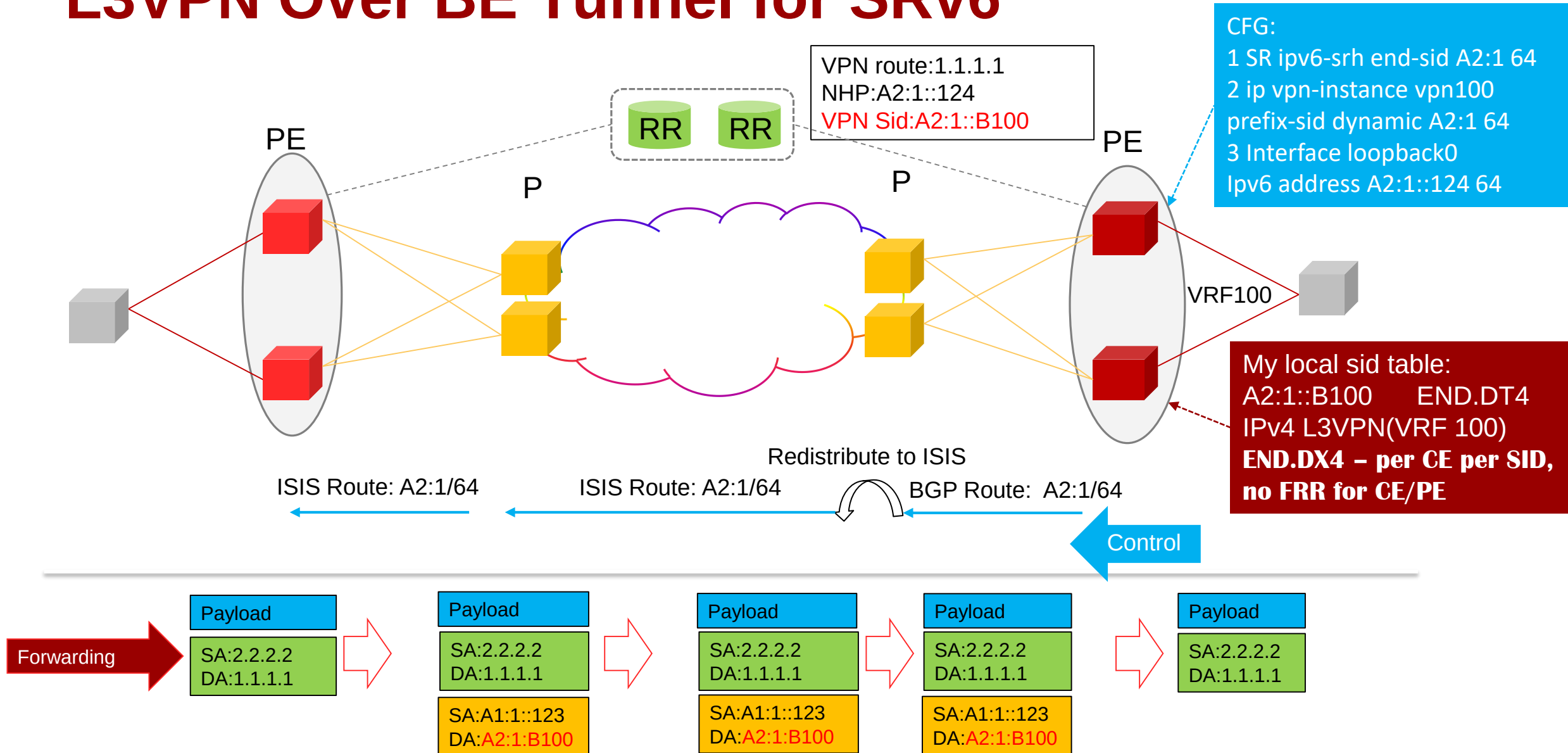


Version	Traffic Class	Flow Label	
Pload Length		Next=43	Hop Linmit
Source Address			
Destination Address			
Next Header	Hdr Ext Len	Routing Type	Segments Left
Last Entry	Flags	Tag	
Segment List[0]			
Segment List[1]			
Segment List[2]			
Payload			

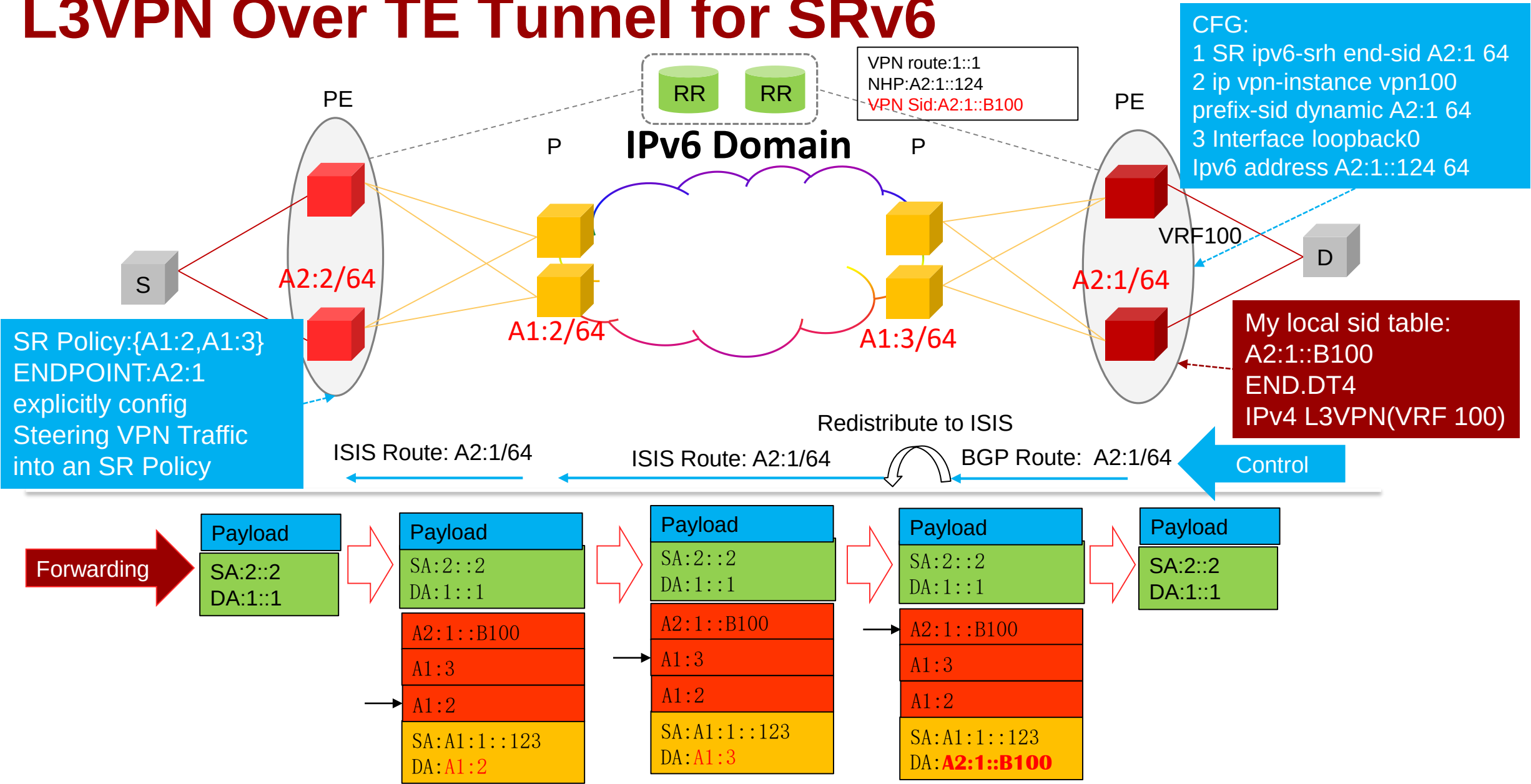
Three Layers of Programming Spaces



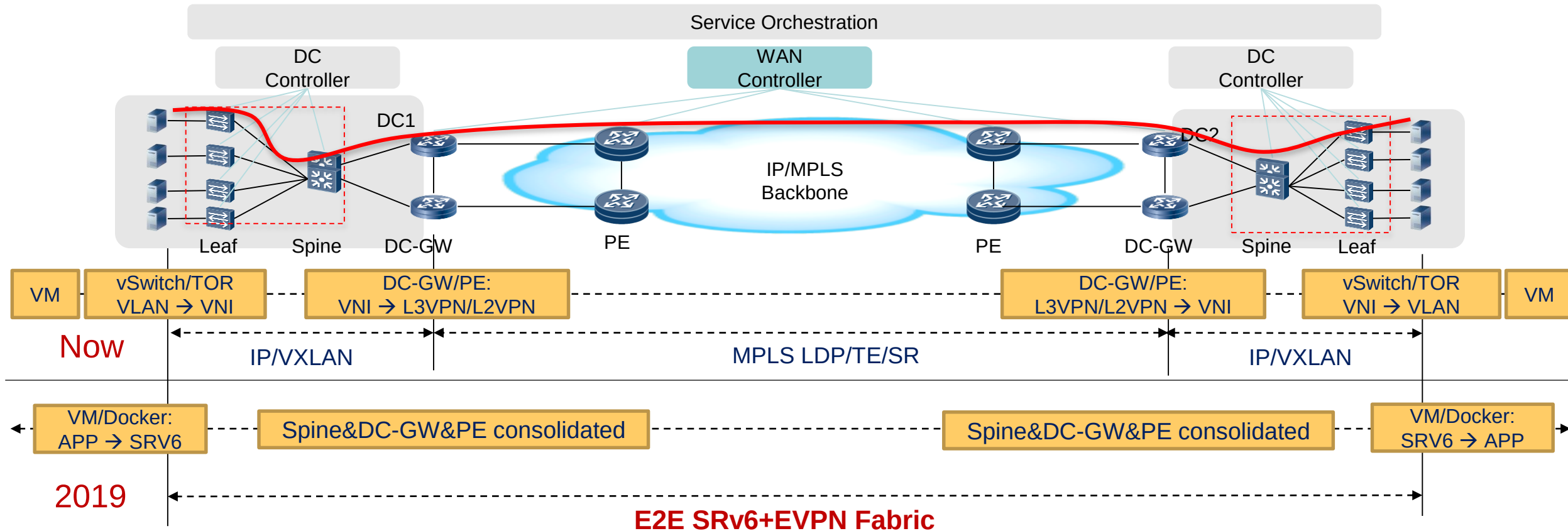
L3VPN Over BE Tunnel for SRv6



L3VPN Over TE Tunnel for SRv6

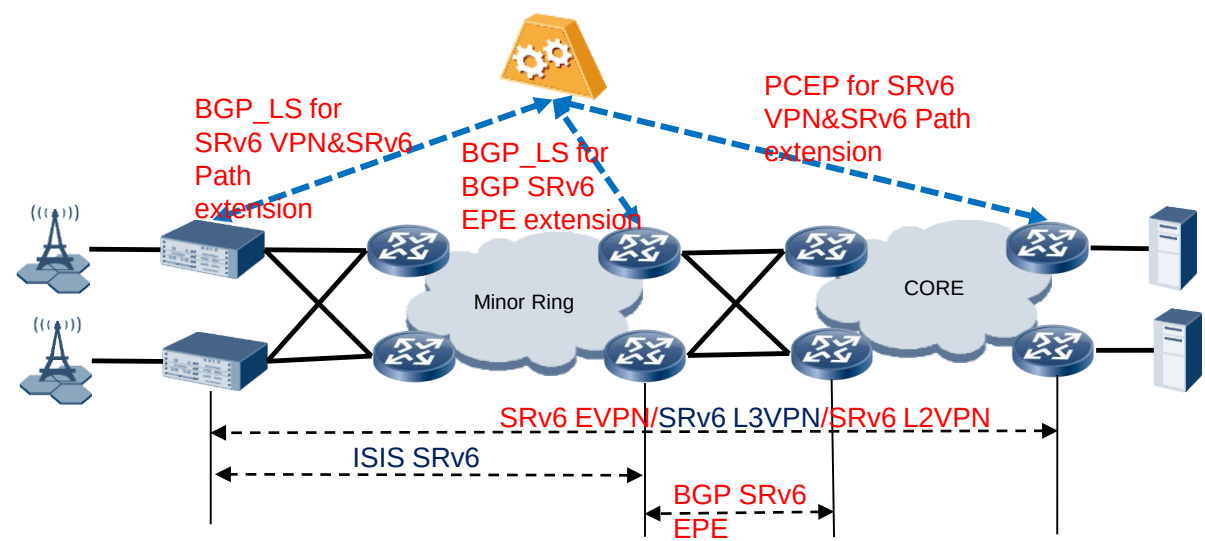


SRv6 Evolution: End-to-end Network Unified Forwarding Process

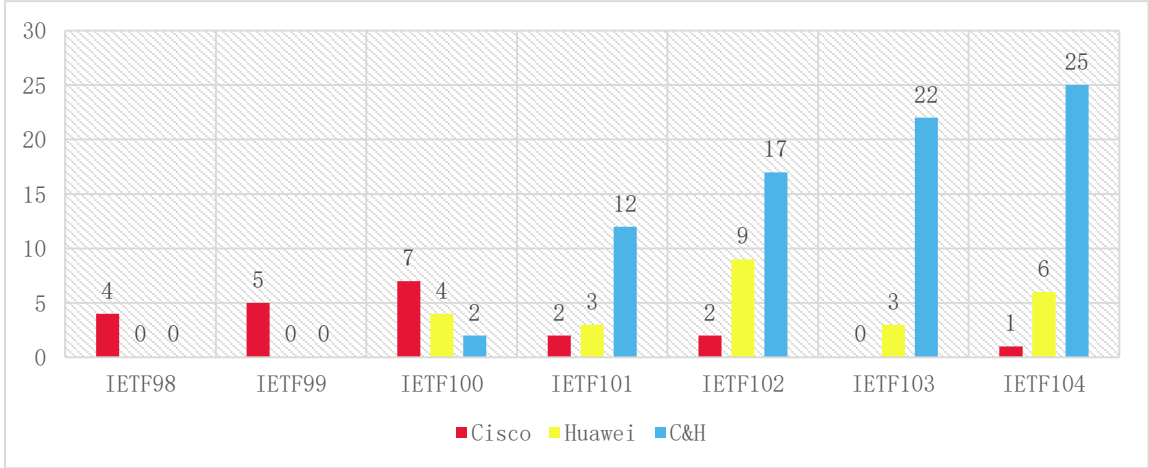


- **Simplicity:** Work based on IPv6 reachability, no extra signaling.
- **Industry Acceptance:** MPLS in DC is not well accepted. SRv6 is based on IP reachability as VXLAN.
- **E2E:** Unified process to converge different IP network domain. TE and SFC can be deployed incrementally and easily.
- **Extensibility:** Possibility to be extended from network devices to application devices which support IPv6.

Increasing Converged Standards and Implementations of SRv6 Basic Solutions



Co-work on 25 Drafts. Major Co-author: Cisco, Huawei, SoftBank.



SRv6 Standardization on Basic Solutions

Service	Description	Status	Priority
Base	SRv6 Arch	○	H
	SRH	○	H
VPN	SRv6 VPN	○	H
IGP	ISIS for SRv6	○	H
	OSPFv3 for SRv6	△	M
SDN Interface	BGP-LS for SRv6	△	M
	PCEP for SRv6	△	M

○: Draft, No Risk △: Draft, With Risk ×: Incomplete Draft

Multiple Implementations are available. Inter-op Tests are on-going.

Running Code

- Linux (Feb 2017 – Kernel)
- Cisco (April 2017)
 - 2 OSeS (IOS XR, IOS XE)
 - 3 ASICs
- FD.io VPP (April 2017)
- Bell Canada, Barefoot, P4 (May 2017)
- Huawei
 - 6 Platforms with SRH implemented
- Cisco/Huawei (March 2019)
 - IETF 104 Hackathon “SRv6 iOAM”
- Juniper (Prototypes)
- See [draft-matsushima-spring-srv6-deployment-status](#) for details

Progress of SRv6 Standards (1) Basic Solutions

Area	Topic	Draft	Vendors	Operators
Architecture/Use case	SRv6 Network Programming	draft-filsfils-spring-srv6-network-programming (WG Adoption in process)	Cisco/Huawei	Comcast/Bell Canada/Softbank
SRH	IPv6 Segment Routing Header (SRH)	draft-ietf-6man-segment-routing-header (LC Request accepted)	Cisco/Huawei	Bell Canada/ Softbank
IGP	ISIS Extensions for SRv6	draft-bashandy-isis-srv6-extensions (WG Adoption in process)	Cisco/Huawei	Orange
	OSPFv3 Extensions for SRv6	draft-li-ospf-ospfv3-srv6-extensions	Cisco/Huawei	
VPN	SRv6 VPN	draft-dawra-idr-srv6-vpn/draft-dawra-bess-srv6-services-00 (WG Adoption in process)	Cisco/Huawei	Comcast/Bell Canada/Softbank/Orange
SDN Interface	BGP-LS for SRv6	draft-dawra-idr-bgpls-srv6-ext (WG Adoption in process)	Cisco/Huawei/Ericsson	Bell Canada/ Orange/AT&T
	PCEP for SRv6	draft-ietf-pce-segment-routing-ipv6	Cisco/Huawei	

Standards of SRv6 basic solutions is in the process of WG adoption and commercial delivery/deployment is on-going.

Progress of SRv6 Standards (2) YANG Models

Area	Topic	Draft	Vendors	Operators	Plan	Status
Yang Models	SRv6 Base Yang	draft-raza-spring-srv6-yang	Cisco/Huawei/Inf inera/Ciena/Eric sson	Bell Canada/ Softbank	IETF101	Done
	SRv6 ISIS Yang	draft-hu-isis-srv6-yang	Cisco/Huawei		IETF 102	Done
	SRv6 BGP Yang	draft-dhjain-spring-bgp-sr-yang	Cisco/Huawei	Orange	IETF 102	Done
	SRv6 TE Yang (SR Policy Yang)	draft-thomas-spring-sr-policy-yang	Cisco/Huawei	Bell Canada/ Softbank	IETF 102	Done
	SRv6 OSPF Yang	draft-hu-lsr-ospf-srv6-yang	Cisco/Huawei		IETF 103	Done
	SRv6 PCEP Yang	draft-dhody-pce-pcep-srv6-yang	Cisco/Huawei		IETF 103	Done
	SRv6 EVPN YANG				IETF 104	In Plan
	SRv6 PING YANG				IETF 104	In Plan

YANG models is provided and converged along with the solutions as early as possible to facilitate interworking with 3-party.

Progress of SRv6 Standards (3) OAM/PM

Area	Topic	Draft	Vendors	Operators
OAM	SRv6 OAM/IOAM Use cases and Mechanisms	draft-ali-spring-srv6-oam/draft-ali-6man-spring-srv6-oam-01 (WG Adoption in process)	Cisco/Huawei	Comcast/Softbank/Bell Canada
	SR UDP PM	draft-gandhi-spring-udp-pm	Cisco/Huawei	Bell Canada
	SRv6 Light iOAM	draft-li-spring-light-weight-srv6-ioam	Huawei	China Mobile
Path Segment	Usecases and Mechanisms of MPLS	draft-ietf-spring-mpls-path-segment	Huawei/Cisco	China Mobile
	SRv6 Path ID	draft-li-spring-srv6-path-segment	Huawei/Cisco	
	Path Segment and Bidir Path in BGP	draft-li-idr-sr-policy-path-segment-distribution	Huawei	
	Path Segment and Bidir Path in BGP-LS	draft-li-idr-bgp-ls-sr-policy-path-segment	Huawei	
	Path Segment in PCEP	draft-li-pce-sr-path-segment (WG Adoption in process)	Huawei/Cisco	China Mobile
	Bidir Path in PCEP	draft-li-pce-sr-bidir-path (WG Adoption in process)	Huawei/Cisco	China Mobile
	ID Space Delegation	draft-li-pce-controlled-id-space	Huawei	China Telecom

Control plane is ready for WG adoption and challenges exists in the forwarding plane.

Progress of SRv6 Standards (4) 5G/Mobile Core

Area	Topic	Drafts	Vendors	Operators
Network Slicing	VPN+ Architecture	draft-ietf-teas-enhanced-vpn	Huawei	China Mobile KDDI
	SR for VPN+	draft-dong-spring-sr-for-enhanced-vpn	Huawei	China Mobile KDDI
	IGP extensions for SR-based VPN+	draft-dong-lsr-sr-enhanced-vpn	Huawei	
Detnet	SR for bound latency	draft-chen-detnet-sr-based-bounded-latency-00	Huawei	China Mobile
	SRv6 encapsulation for Detnet	draft-geng-detnet-dp-sol-srv6-00	Huawei	
User Plane	SRv6 for mobile User plane	draft-ietf-dmm-srv6-mobile-uplane	Huawei/Cisco	Softbank
	Protocol for Forwarding Policy Configuration (FPC) in DMM	draft-ietf-dmm-fpc-cpdp	Huawei/Cisco	Softbank/Bell Canada

**It is well accepted that SID is to indicate resources to guarantee BW/Latency.
It is a big step that VPN+ Arch draft is adopted by TEAS WG.
Challenges exist in 3GPP for SRv6 for Mobile core.**

Progress of SRv6 Standards (5) Cloud/Migration

Area	Topic	Drafts	Vendors	Operators
SFC	SR for SFC	draft-xuclad-spring-sr-service-programming (WG Adoption in process)	Cisco/Huawei/Juniper/Nokia	Bell Canada/Orange/AT&T
	SR + NSH for Stateful SFC	draft-guichard-spring-nsh-sr (WG Adoption in process)	Huawei/Ericsson/Nokia/Cisco	Orange
SD-WAN	SRv6 for SD-WAN	draft-dukes-spring-sr-for-sdwan	Cisco	Bell Canada
Migration	Interworking Between SRv6 and SR-MPLS	draft-agrawal-spring-srv6-mpls-interworking-00	Huawei/Cisco	Bell Canada
	SRv6 compatibility with legacy devices	draft-peng-spring-srv6-compatibility	Huawei	

SFC is almost ready for WG adoption. Migration work is in-process.

SRv6: Multiple Commercial and Open Source Delivery

Huawei

- ATN with VRPV8 – Shipping now
- CX600 with VRPV8 – Shipping now
- NE40E with VRPV8 – Shipping now
- ME60 with VRPV8 – Shipping now
- NE5000E with VRPV8 – Shipping now
- NE9000 with VRPV8 – Shipping now
- NG-OLT MA5800 with VRPV8 – Shipping now

Open Source

- Linux 4.10 Feb 2017
- Linux snext April 2017
 - <https://github.com/netgroup/SRv6-net-prog>
- FD.io VPP 17.04: April
 - https://wiki.fd.io/view/VPP/Segment_Routing_for_IPv6

Cisco

- First support April 2017
- Cisco ASR 9000 – Shipping now
- Cisco NCS 5500 – Shipping now
- Cisco NCS 540 – Shipping now
- Cisco ASR 1000 – engineering code

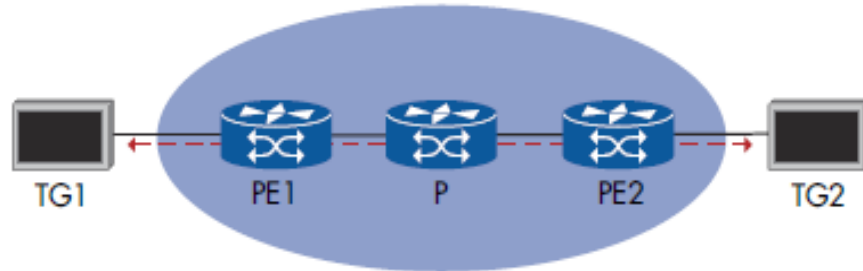
NPU & Tester

- Barefoot – Tofino NPU Shipping Now (since May 2017)
- Spirent - Hardware implementation in Spirent TestCenter.
- Ixia - Hardware implementation in Ixia IxNetwork.

<https://tools.ietf.org/html/draft-matsushima-spring-srv6-deployment-status-01>

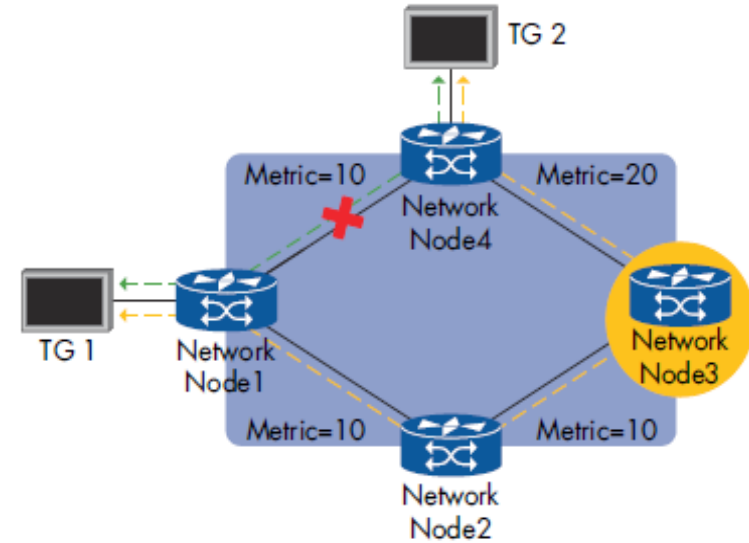
EANTC: Successful Softbank Scenario Multi-Vendor Interop Test

SRv6 VPN Test Case Huawei E2E , NCS540 act as P node



Scenario	PE1	P	PE2
IPv4 L3VPN over SRv6	HUAWEI NE9000-8	Cisco NCS 540, HUAWEI NE40E-X8A	Cisco NCS 5500
	HUAWEI NE9000-8	Cisco NCS 540, HUAWEI NE40E-X8A	Keysight (Ixia) IxNetwork
	Cisco NCS 5500	HUAWEI NE9000-8, HUAWEI NE40E-X8A	Keysight (Ixia) IxNetwork
	HUAWEI NE9000-8	Cisco NCS 540, HUAWEI NE40E-X8A	Spirent TestCenter
	Cisco NCS 5500	HUAWEI NE9000-8, HUAWEI NE40E-X8A	Spirent TestCenter
IPv6 EVPN L3VPN over SRv6	HUAWEI NE40E-F1A	HUAWEI ATN950C	Keysight (Ixia) IxNetwork
	HUAWEI NE40E-F1A	HUAWEI ATN950C	Spirent TestCenter

SRv6 TI-LFA Test case



Test Setup	PLR (PE) (Network Node 1)	P Node (Network Node 2)	PQ Node (Network Node 3)	Egress PE (Network Node 4)
1	Cisco NCS 5500	Cisco NCS 540	HUAWEI NE40E-X8A	HUAWEI NE9000-8
2	HUAWEI NE40E-X8A	HUAWEI NE9000-8	Cisco NCS 540	Cisco NCS 5500

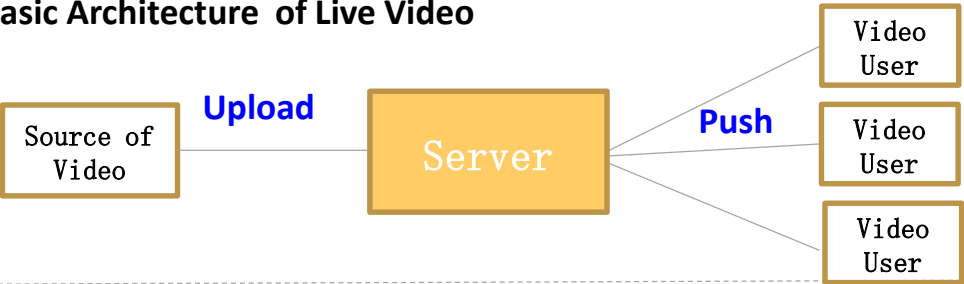
On-going SRv6 Deployment



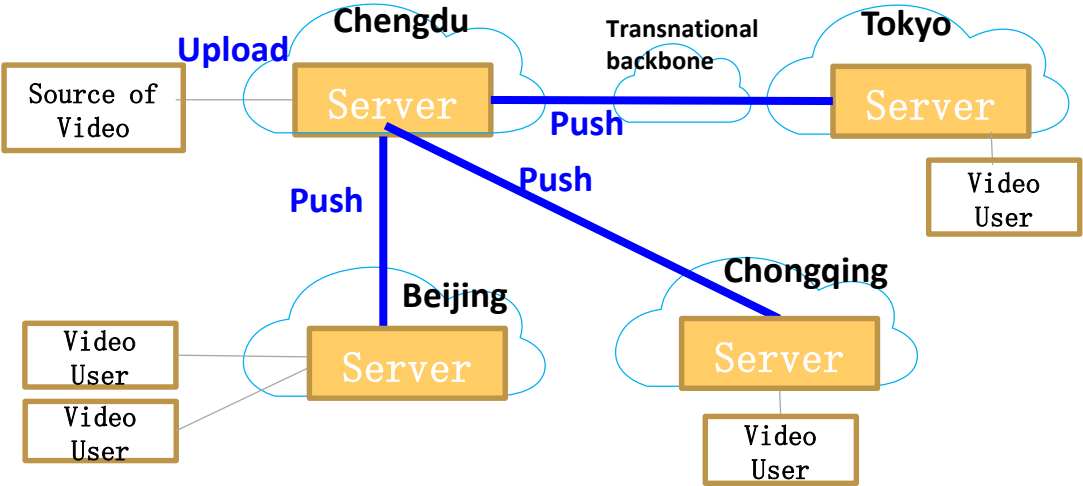
<https://www.lightreading.com/video/video-services/huawei-helps-china-telecom-sichuan-launch-commercial-srv6-network/d/d-id/749842>

Distribution Network for Video Broadcast

Basic Architecture of Live Video

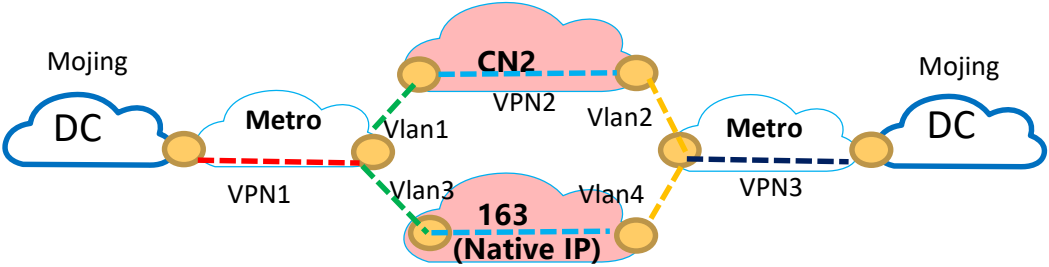


Actual Network Architecture of the Live Video



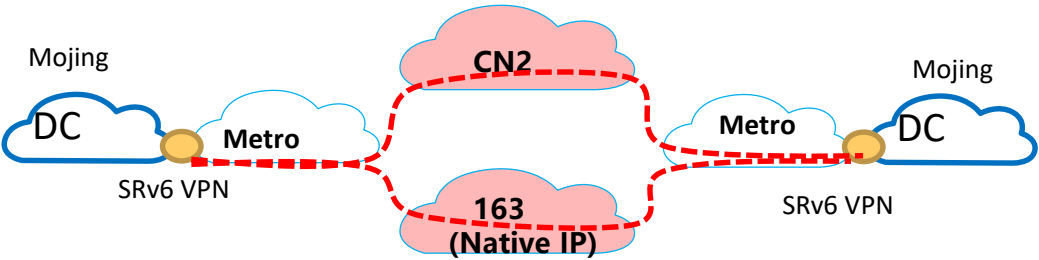
Live video enterprise and business expand rapidly, DCI deployment is complex, TTM is long, no differentiated SLA guarantee

AS IS :Traditional VPN



- 1. The intermediate network needs to support MPLS,
- 2. Inter-domain networking needs to be deployed in segments and complexly deployed.
- 3. Need intermediate network cooperation, TTM long

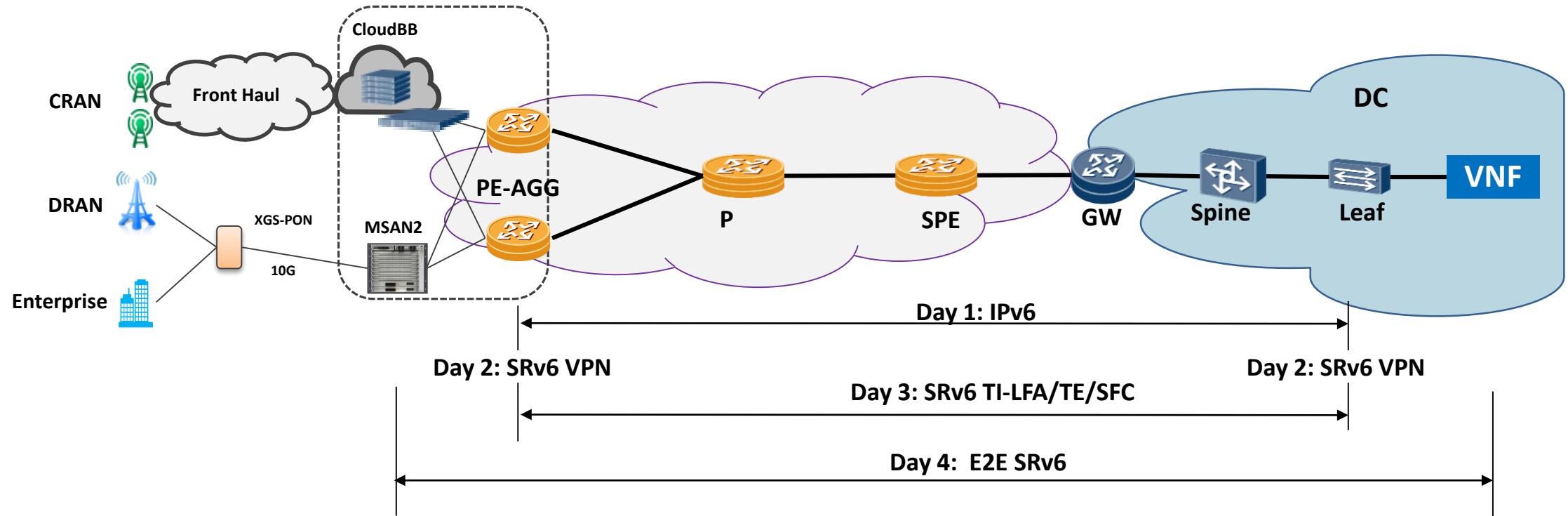
TO BE :SRv6 VPN



- 1. There is no special requirement for the intermediate network, just IP forwarding
- 2. Cross-domain, non-cross-domain solution unified;
- 3. Quickly launch the service without the cooperation of intermediate network
- 4. Bandwidth guarantee and network delay adjustment ability

Incremental Deployment is One KEY Advantage for SRv6 Migration

- Two options can be parallel:
 - Option 1: IP/MPLS -> IPv6->SRv6
 - Nature and straightforward, recommend;**
 - Option 2: IP/MPLS -> SR-MPLS -> SRv6



- Step 1: Upgrade to IPv6 (IPv6 ready is the pre-condition of SRv6);
- Step 2: Upgrade the edge devices to introduce VPN over SRv6 BE;
- Step 3: Upgrade some intermediate nodes to support traffic TI-LFA, TE, SFC, etc.
- Step 4: Upgrade the whole network to support E2E SRv6;

SRv6 Industry Roundtable in MPLS Congress 2019

**World First SRv6 Industry Roundtable
held during MPLS+NFV+SDN World Congress 2019
@Paris, 2019.4.10**



The industry experts agreed that SRv6, a successor of MPLS, will be the next-generation core protocol of IP transport networks.



Topic 1: Value of SRv6

IHS: Network Evolution and SRv6

Clarence: SRv6 NP Architecture and Usecases

Zhenbin Li: SRv6 for 5G and Cloud

Discussion:

- 1. SRv6 Value: Simplicity and extensibility for new services**
- 2. Possible Killer Applications: SRv6 VPN, Network Convergence, VPN+ for 5G, SRv6 IFIT/IOAM**

Topic 2: How to promote adoption of SRv6

EANTC: SRv6 Inter-op Test for MPLS Congress 2019

Spirent: SRv6 Test Capability and Inter-op Test

**Huawei: SRv6 Deployment in China
Telecom/Unicom**

Discussions:

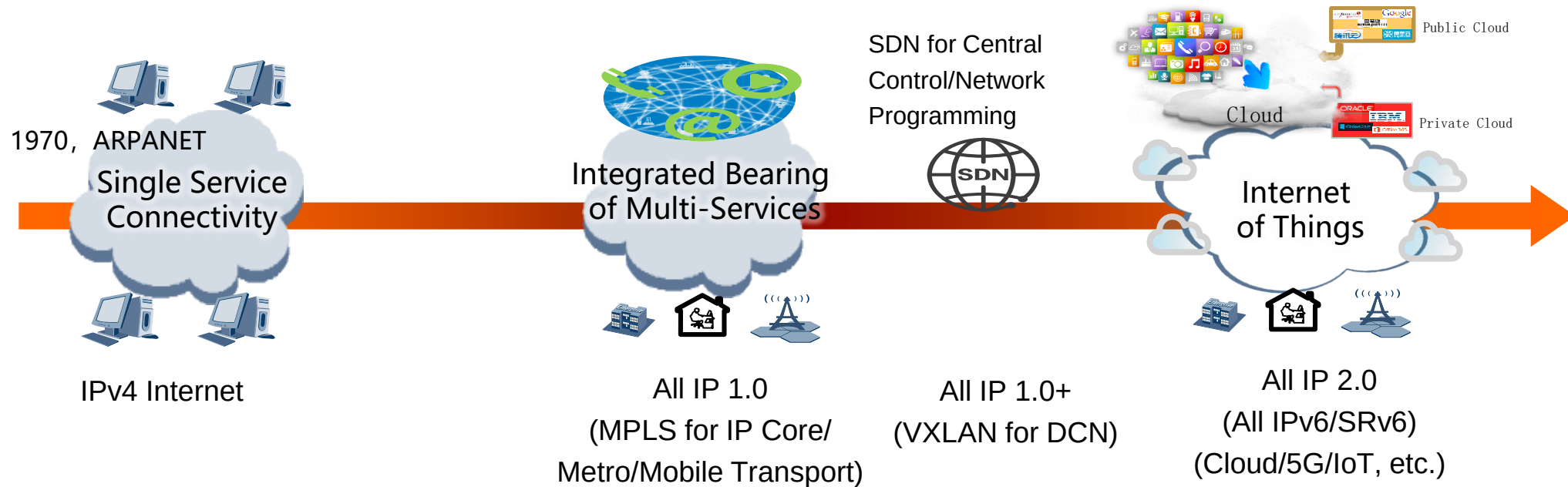
- 1. Pioneers should provide more training**
- 2. Operators should take some risk and share deployment experience.**



Rethinking on Internet

- **Lesson of IPv4: Scalability**
- **Lesson of IPv6: Compatibility**
 - SRv6 is compatible with IPv6 forwarding.
 - SRv6 is compatible with MPLS forwarding.
- **Success of All IP 1.0**
 - MPLS plays an important role.
 - SRv6 must inherit 3 advantages of MPLS firstly: VPN; FRR; TE.
- **Challenges of All IP 1.0**
 - 1. Isolation of Network Domains owing to Islands of IP Transport Network.
 - 2. Limited space of encapsulation of IPv4 and MPLS for programmability for new services.
 - IPv4: IPv4 Options are not implemented.
 - MPLS: Fixed length and fixed fields.
 - 3. Networking on its own owing to decoupling application and network transport.
 - ATM to Desktop: Failed.
 - MPLS to Cloud: Failed

SRv6 for All IP 2.0 (All IPv6)



- **Rethinking on IPv6: Address Space is not enough.**
- **Mission of SRv6**
 - Integrate different network easier based on affinity to IP reachability.
 - Cross the chasm between application and network based on affinity to IP and Network Programming conveying application information through IPv6 Extension Header/SRH into network.
 - Promote IPv6 combining with requirements on more address spaces.

Thank you