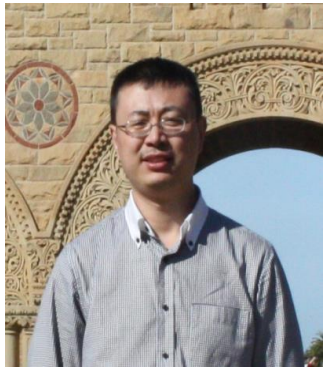
SRv6创新与标准进展

2019.3

李振斌 (Robin)
华为首席IP标准代表
IETF互联网架构委员会（IAB）委员



Zhenbin (Robin) Li

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 IETF75 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 (No.1 IAB member from Asian Enterprise in the Internet History) to be responsible for Internet architecture work from 2019 to 2021.

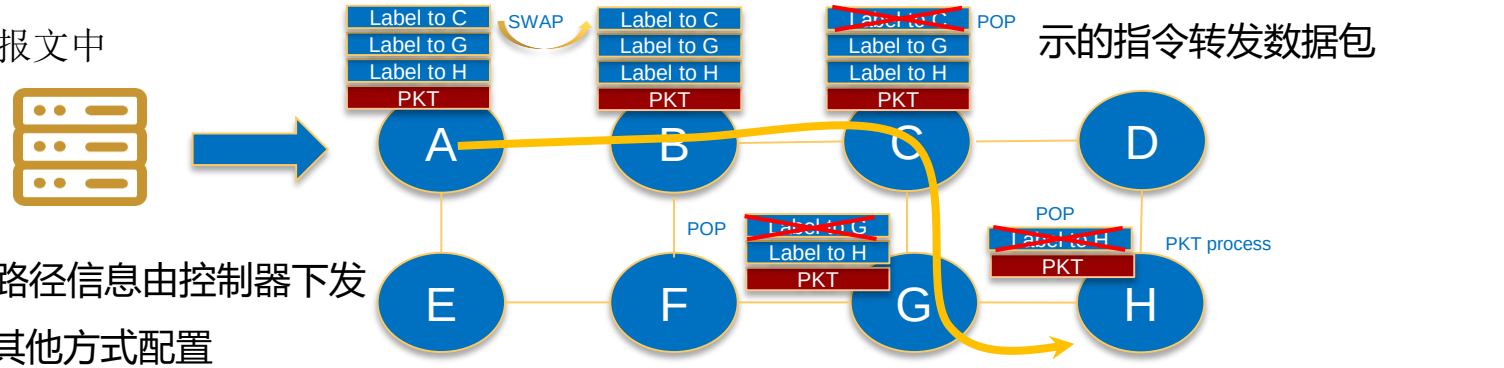
Segment Routing简介

首节点指定数据包的端到端转发路径。转发指令被携带在报文头中，用于指导转发节点转发数据包。

2. 头节点将描述转发路径的Segment List插入到报文中

1. 路径信息由控制器下发或其他方式配置

Segment Routing原理

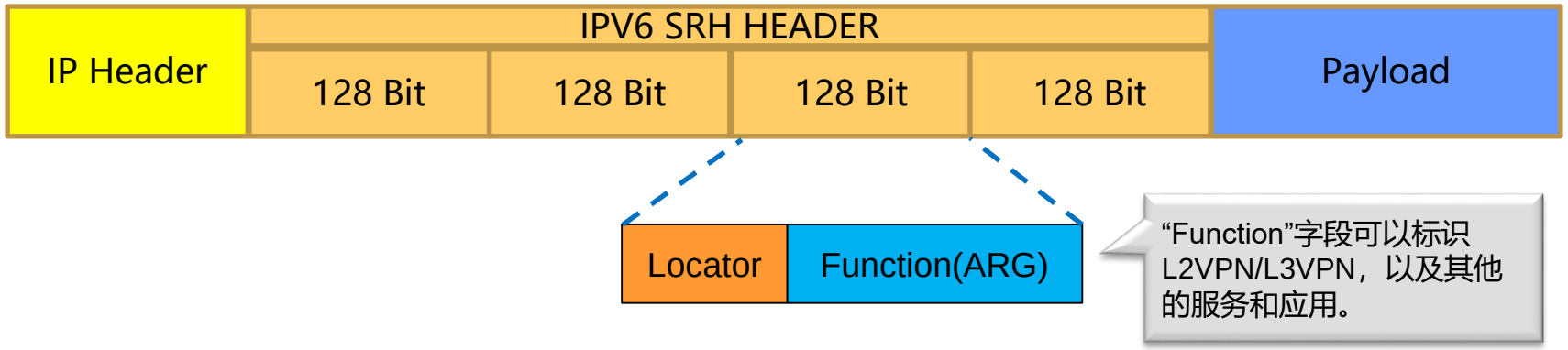


3. 后续节点根据Segment指示的指令转发数据包

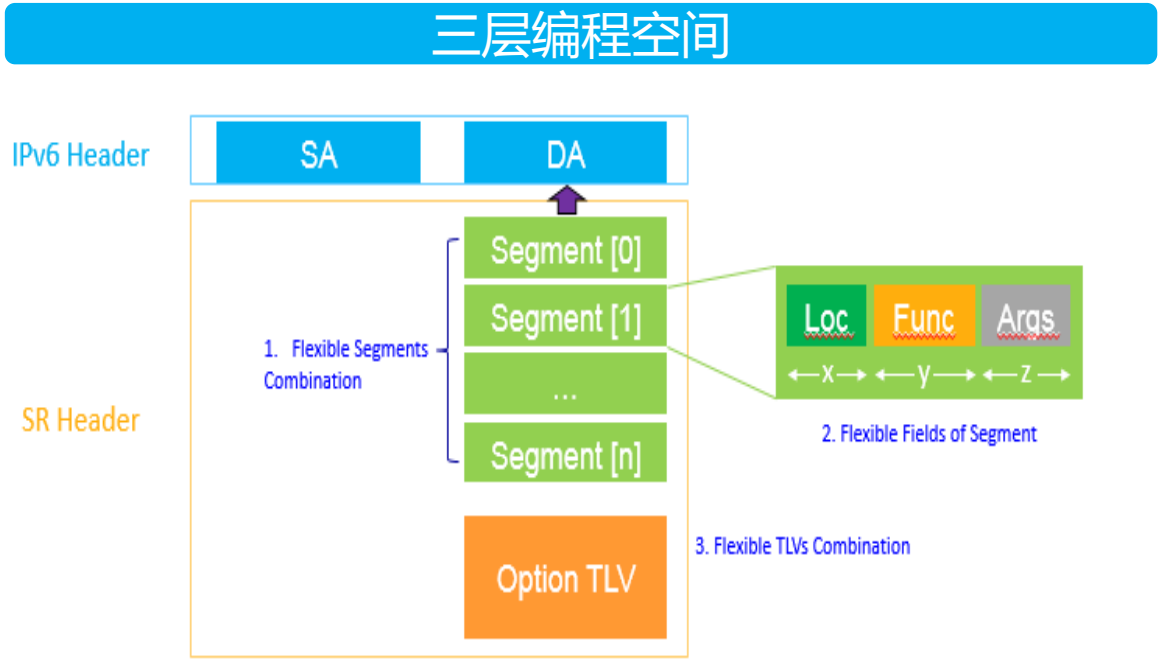
- **Segment Routing的优点**
  - 简化控制协议：无需RSVP-TE/LDP
  - 高扩展性：减少网络状态，只在源节点维护逐流的状态
  - 可编程：Segment灵活组合满足不同路径服务需求
  - 更可靠的保护：基于TI-LFA支持100%网络覆盖的FRR

SR-MPLS: TE/FRR/VPN等基础特性已成熟，落地部署中
SRv6: 快速发展中

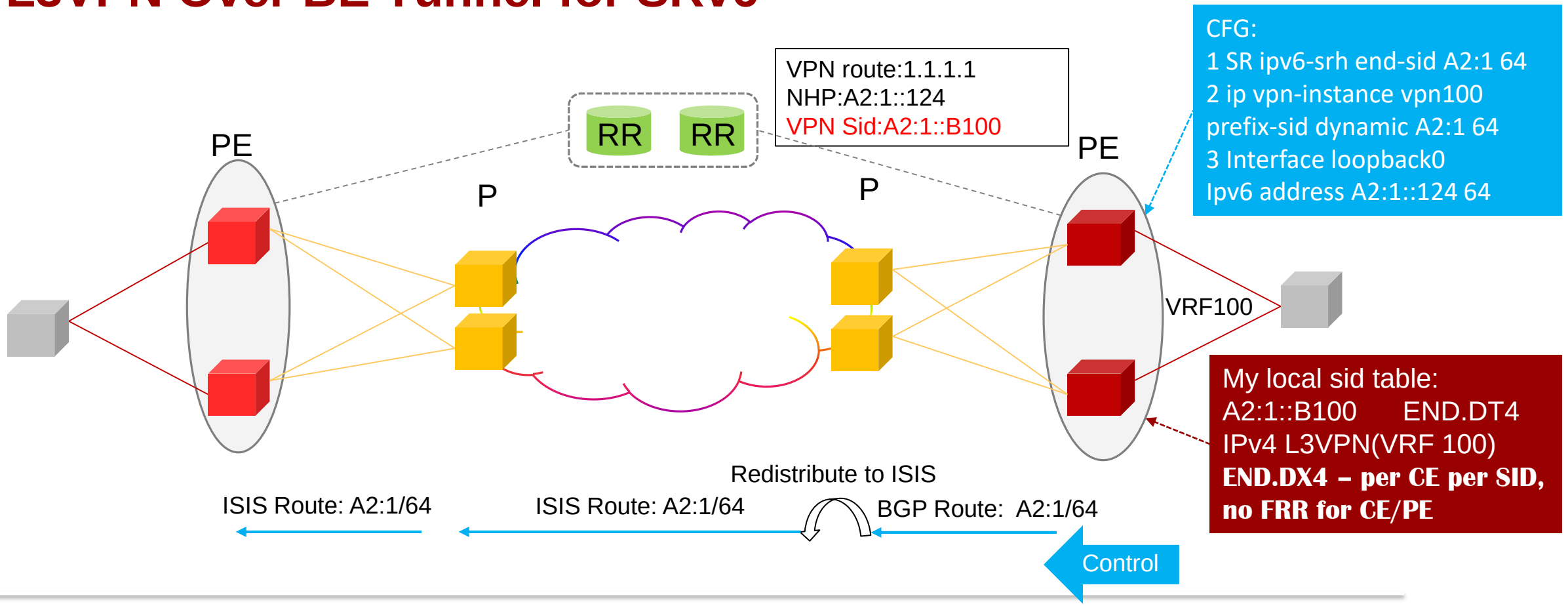
SRv6 网络编程原理



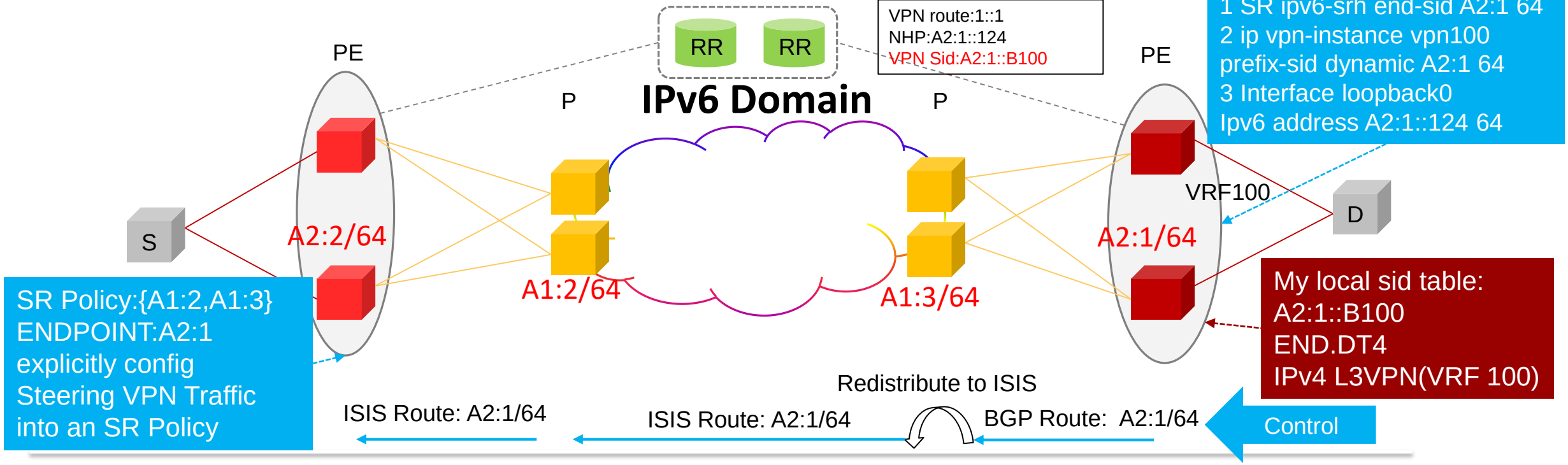
Version	Traffic Class	Flow Label	
Pload Length		Next=43	Hop Linmit
Source Address			
Destination Address			
Next Header	Hdr Ext Len	Routing Type	Segments Left
Last Entry	Flags	Tag	
Segment List[0]			
Segment List[1]			
Segment List[2]			
Paylod			

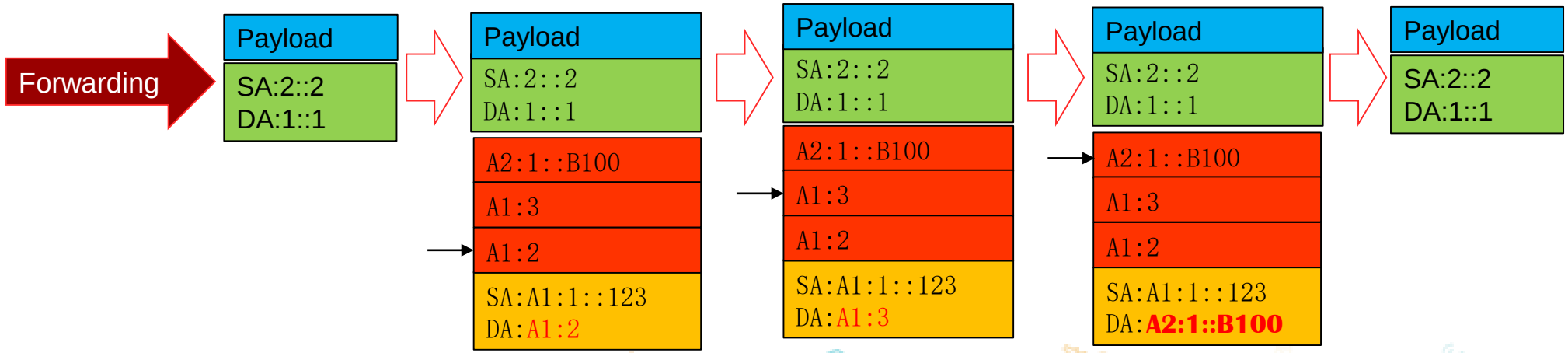


L3VPN Over BE Tunnel for SRv6



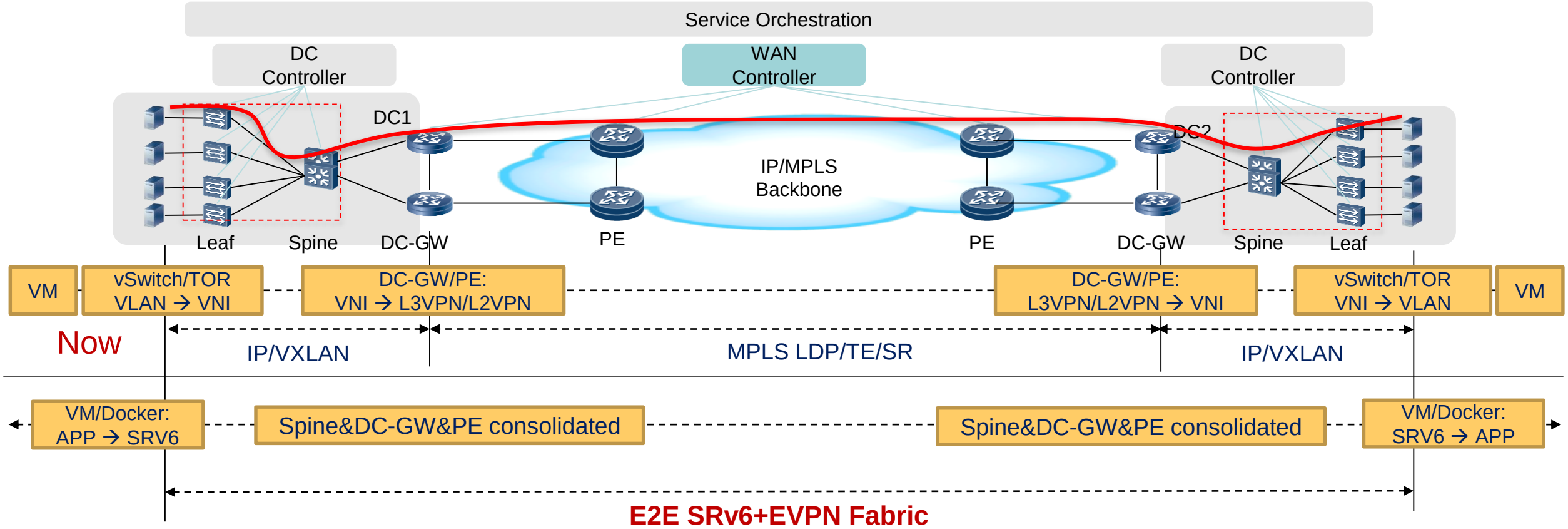
L3VPN Over TE Tunnel for SRv6





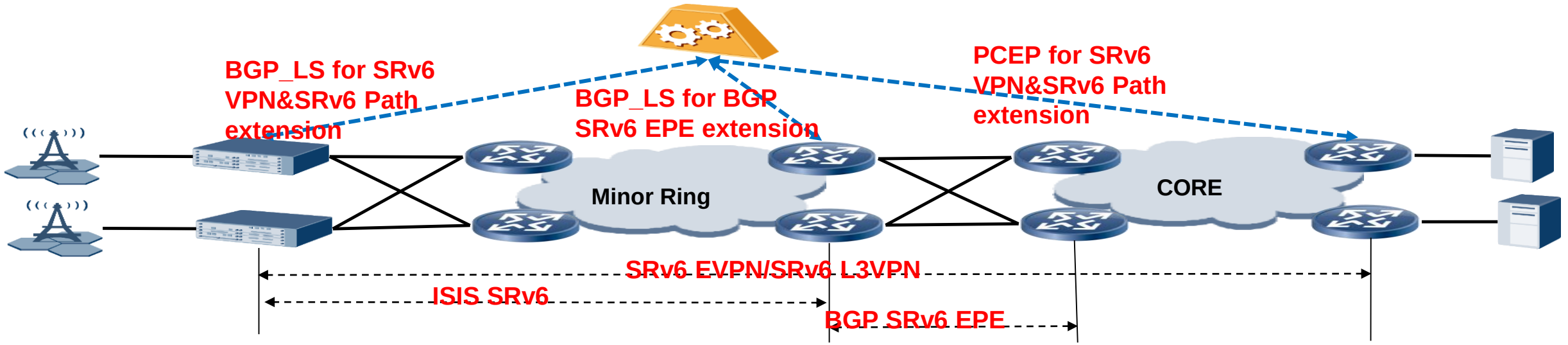
HUAWEI

SRv6愿景: 端到端网络统一转发

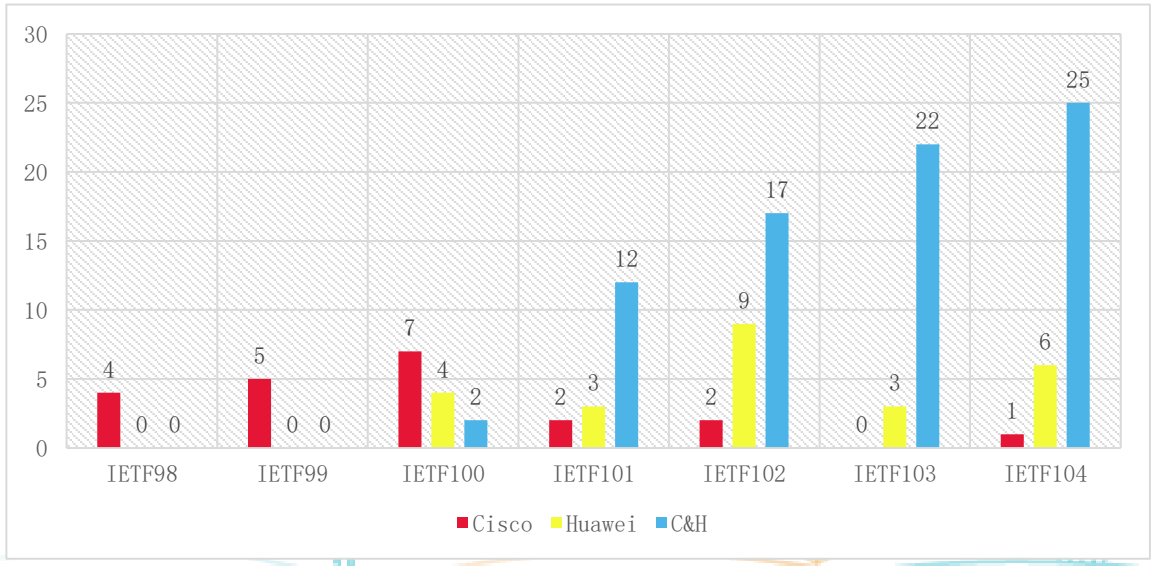


- **简化:** 基于IPv6可达性即可工作，无需MPLS额外信令 。
- **行业接受度:** MPLS无法进DC，基于IPv6可达的SRv6称为SR进数据中心的选择。
- **端到端统一:** 端到端统一的路由/转发技术；E2E业务和SFC可以轻易增量部署。
- **可延伸性**: 按需PNF & VNF连接, 无缝实现云网融合联动，从网络扩展到业务/APP。

SRv6标准推动与实现部署双管齐下，支持互联互通



华为与Cisco等合作的草案达到25篇



SRv6 基础特性趋于成熟

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

SRv6标准进展（1）基础特性

Area	Topic	Draft	Vendors	Operators
Architecture/Usecase	SRv6 Network Programming	draft-ietf-spring-srv6-network-programming	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-ietf-isis-srv6-extensions	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-ietf-idr-bgpls-srv6-ext	Cisco/Huawei/Ericsson	Bell Canada/ Orange/AT&T
	PCEP for SRv6	draft-ietf-pce-segment-routing-ipv6	Cisco/Huawei	

SRv6基础特性标准大都已经成为工作组草案，商用实现和商用部署正在进行。

SRv6标准进展（2）YANG模型

Area	Topic	Draft	Vendors	Operators	Plan	Status
Yang Models	SRv6 Base Yang	draft-raza-spring-srv6-yang	Cisco/Huawei/Infinera/Ciena/Ericsson	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 Process
	SRv6 PING YANG				IETF 104	In Process

SRv6 YANG模型草案与解决方案同步推出，方便第三方对接

SRv6标准进展（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 Telcom

SRv6 OAM/PM控制面草案已经准备进行工作组接纳，转发面还存在一定的挑战。

SRv6标准进展（4）5G/云核心网

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

通过SID来指示保证带宽/时延的资源的理念已经被广泛接受。
VPN+框架草案被TEAS工作组接纳是5G网络切片在IETF标准化的一个重要里程碑。
SRv6用于云核心网替代GTP在3GPP受到挑战。

SRv6标准进展（5）云/演进

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	

SRv6 SFC相关草案准备发起工作组接纳。
SRv6网络演进方案标准化工作正在进行中。

SRv6已经有多家商用和开源实现

华为产品支持SRv6

- 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

Cisco产品支持SRv6

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

开源支持SRv6

- Linux 4.10 Feb 2017
- Linux srext 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

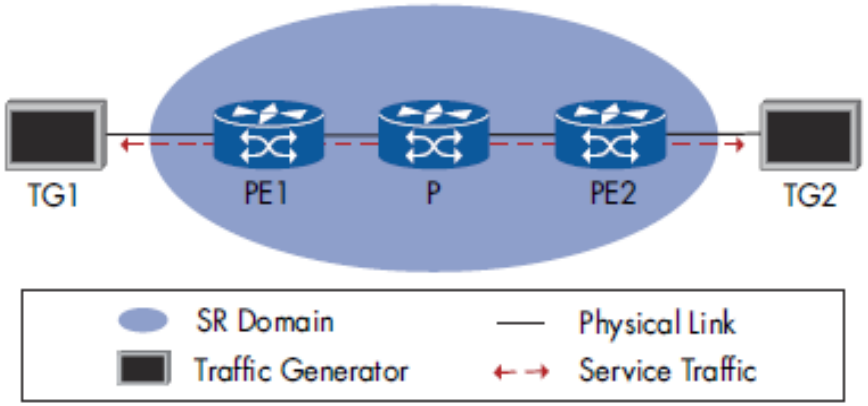
NPU和测试仪厂商支持SRv6

- 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

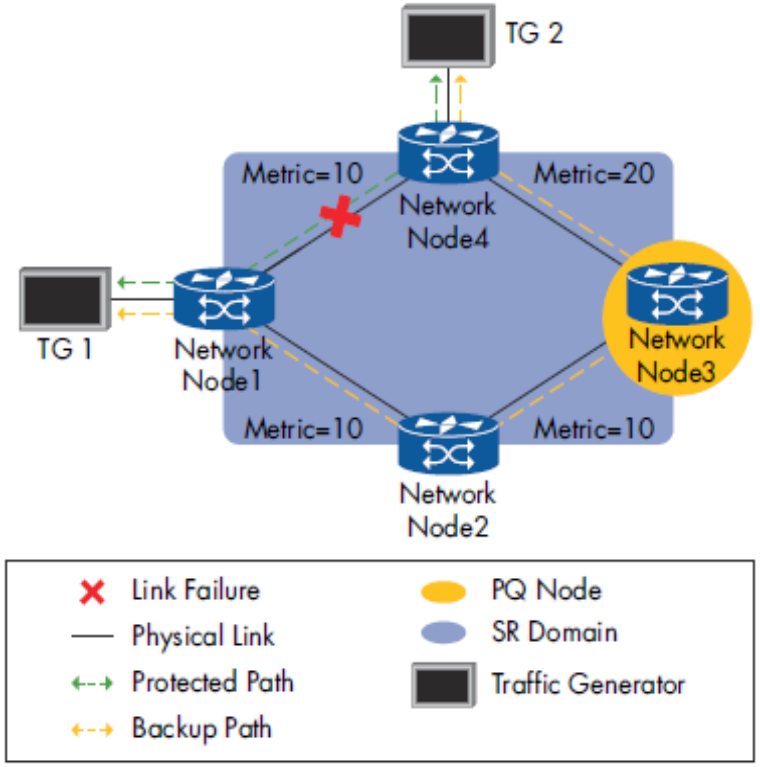
EANTC 2019: 成功完成多厂家SRv6互通测试

SRv6 VPN测试例



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 FRR（TI-LFA）测试例

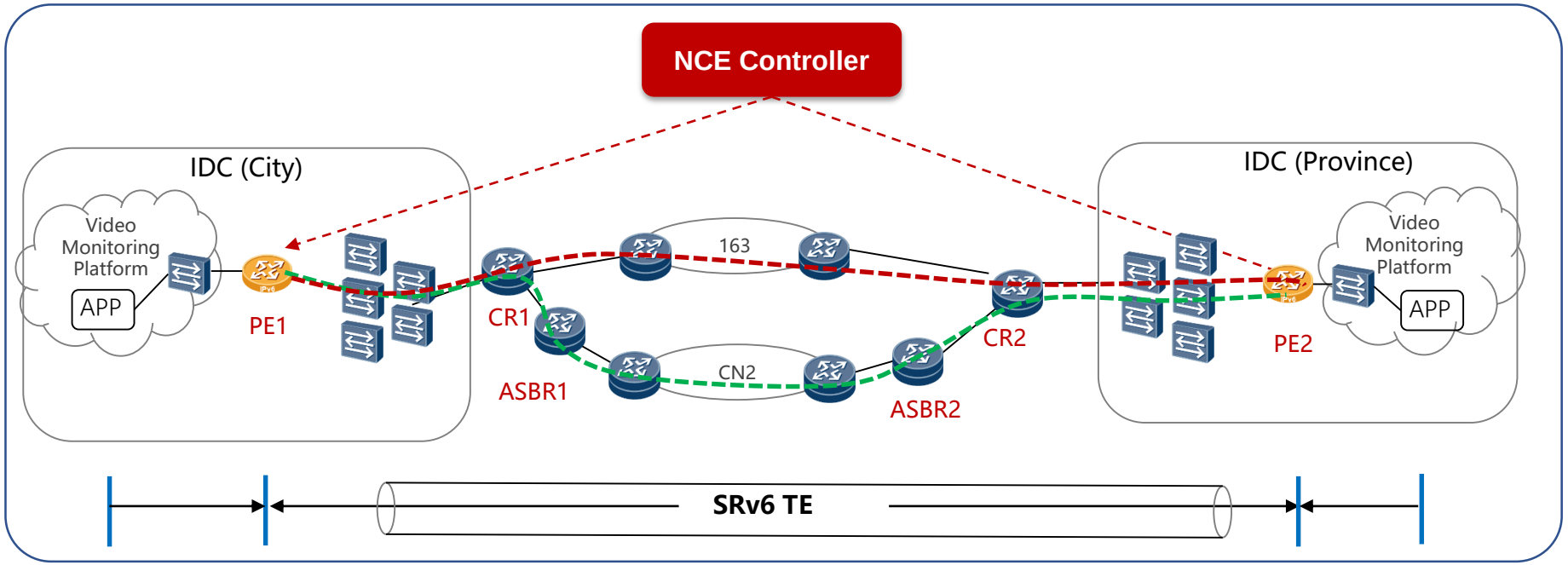


Test Setup	PLR (PE) (Network Node 1)	P Node (Network Node 2)	PQ Node (Network Node 3)	Egress PE (Network Node 4)
1	Cisco NCS 5500	Cisco NCS 540	HUAWEI NE40E-X8A	HUAWEI NE9000-8
2	HUAWEI NE40E-X8A	HUAWEI NE9000-8	Cisco NCS 540	Cisco NCS 5500

HUAWEI

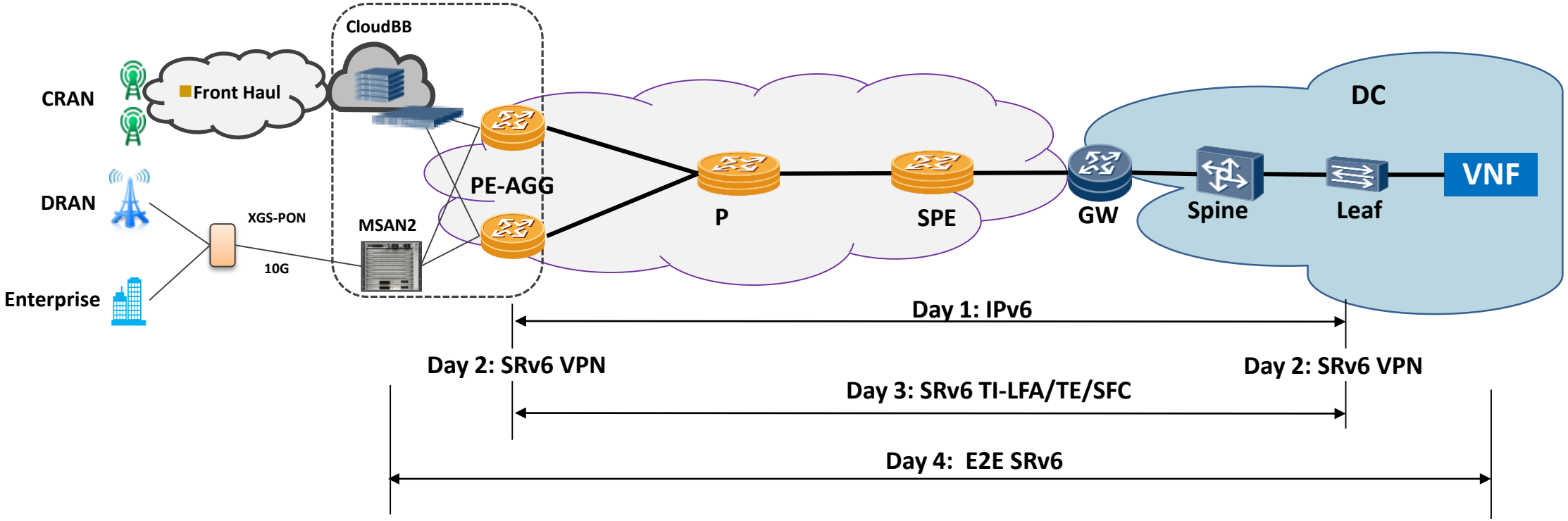
四川电信SRv6现网试验: 魔镜业务

- 四川电信和华为联合部署SRv6，用于支持魔镜业务。
- 第一阶段跨域163骨干网部署SRv6 VPN开通业务，第二阶段考虑引入SRv6 TE用于路径调优。
- https://tools.ietf.org/html/draft-matsushima-spring-srv6-deployment-status-00



易于增量部署是SRv6网络演进的重要优势

- 两种网络演进思路:
  - Option 1: IP/MPLS -> IPv6->SRv6 （优先推荐）
  - Option 2: IP/MPLS -> SR-MPLS -> IPv6 -> SRv6



- 步骤1：网络升级支持IPv6可达性 （IPv6部署是SRv6的基础）
- 步骤2：网络边缘节点升级支持部署SRv6 VPN，通过BE隧道承载业务。
- 步骤3：升级部分或全部网络内节点支持快速重路由（TI-LFA），TE，SFC等。
- 步骤4：升级业务网络设备支持端到端SRv6。

SRv6产业圆桌会议（MPLS + SDN + NFV Congress 2019）

国际首次SRv6产业圆桌会议

MPLS+NFV+SDN World Congress 2019
@Paris, 2019.4.10

业界专家认为SRv6是继MPLS之后下一代IP承载网络的核心协议

HUAWEI

CISCO

IHS Markit

Spirent

EANTC

redhat

Topic 1: SRv6价值

IHS: Network Evolution and SRV6

Clarence: SRV6 NP Architecture and Usecases

Zhenbin Li: SRV6 for 5G and Cloud

讨论:

1. SRv6价值：简单性以及支持新业务的可扩展性
2. 可能的杀手级应用：SRV6 VPN, 网络融合, VPN+切片, SRV6 IFIT/IOAM

Topic 2: 如何促进SRv6发展

EANTC: SRV6 Inter-op Test for MPLS Congress 2019

Spirent: SRV6 Test Capability and Inter-op Test

Huawei: SRV6 Deployment in China

讨论:

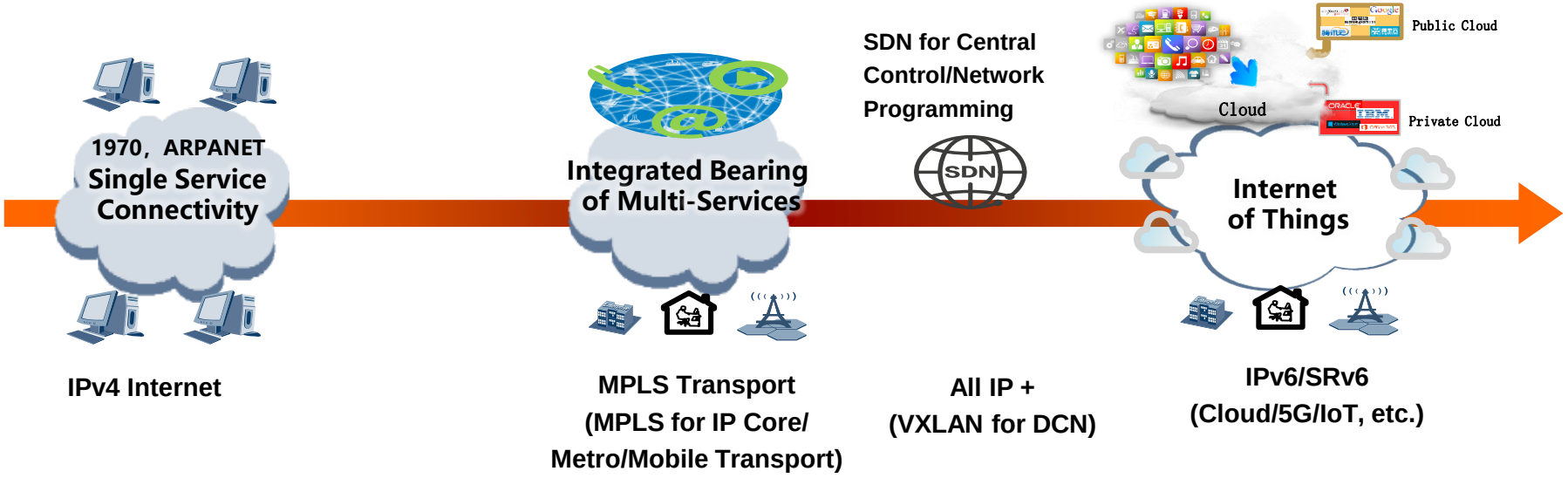
1. 先行者应当提供更多相关培训和指导
2. 运营商应当承担一定的风险，快速试错，分享经验。

HUAWEI

Internet发展历史反思

- IPv4的教训: 可扩展性（Scalability）
- IPv6的教训: 兼容性（Compatibility）
  - SRv6兼容IPv6转发
  - SRv6 兼容MPLS转发
- All IP 1.0的成功
  - MPLS承担了重要角色
  - SRv6必须首先继承MPLS三个成功之处：VPN/FRR/TE
- All IP1.0的挑战
  - 1. IP承载网络孤岛问题突出，基于MPLS的网络融合复杂度高
  - 2. IPv4和MPLS封装的可编程空间有限，无法支持新业务
    - IPv4: IPv4报头选项几乎没有实现
    - MPLS: 固定长度/固定封装域字段
  - 3. 应用与网络承载解耦导致网络自身优化难以提升价值
    - ATM到桌面: 失败
    - MPLS到云：失败

SRv6开启IP新时代



- IPv6重思考：地址空间不足未能强烈驱动IPv6部署
- SRv6的使命：
  - 基于对IP可达性的亲和性，使得不同网络域间连接更容易
  - 基于IPv6扩展头/SRH等可扩展性支持更多种类的封装，满足新业务的需求。
  - 基于对IP亲和性和网络编程能力，实现IP承载网络与应用的融合，提升网络价值。
  - 结合对更多地址空间的需求，进一步推广IPv6

THANK YOU

www.huawei.com