IPv6+创新与标准

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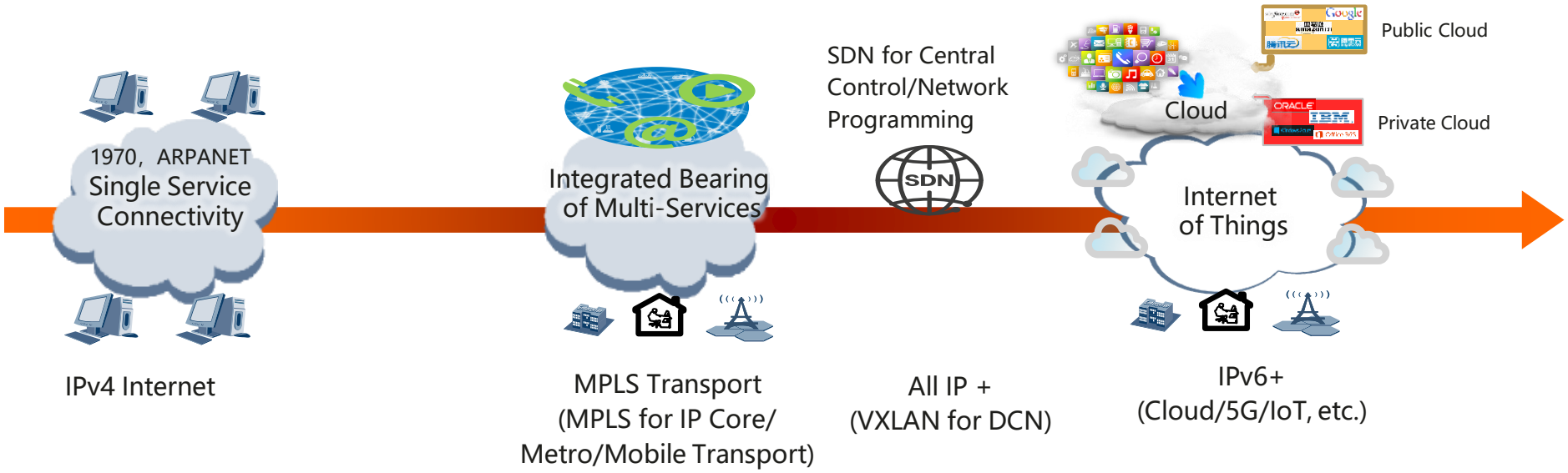
- **负责华为IP协议创新研究和标准化工作。**
- **2000年加入华为，曾负责华为IP操作系统（VRP）和MPLS子系统的架构设计和开发工作。**
- **2015 - 2017年担任SDN架构师，负责控制器的研究、架构设计与开发等工作。**
- **自2009年起积极参与IETF标准创新工作，持续推动了SDN的BGP、PCEP、Netconf/YANG等的协议创新和标准化。当前研究的重点包括SRv6、5G承载、Telemetry、网络智能等。**
- **主导和参与的IETF RFC/草案累计100余篇(www.ipv6plus.net/ZhenbinLi)，申请专利110多项，著有《SRv6网络编程：开启IP网络新时代》。**
- **2019年3月当选IETF互联网架构委员会（IAB）委员，承担2019 - 2021年的互联网架构管理工作。2021年3月获得连任，继续承担2021 - 2023年的互联网架构管理工作。**

IPv6+: 面向5G和云的IP网络新时代



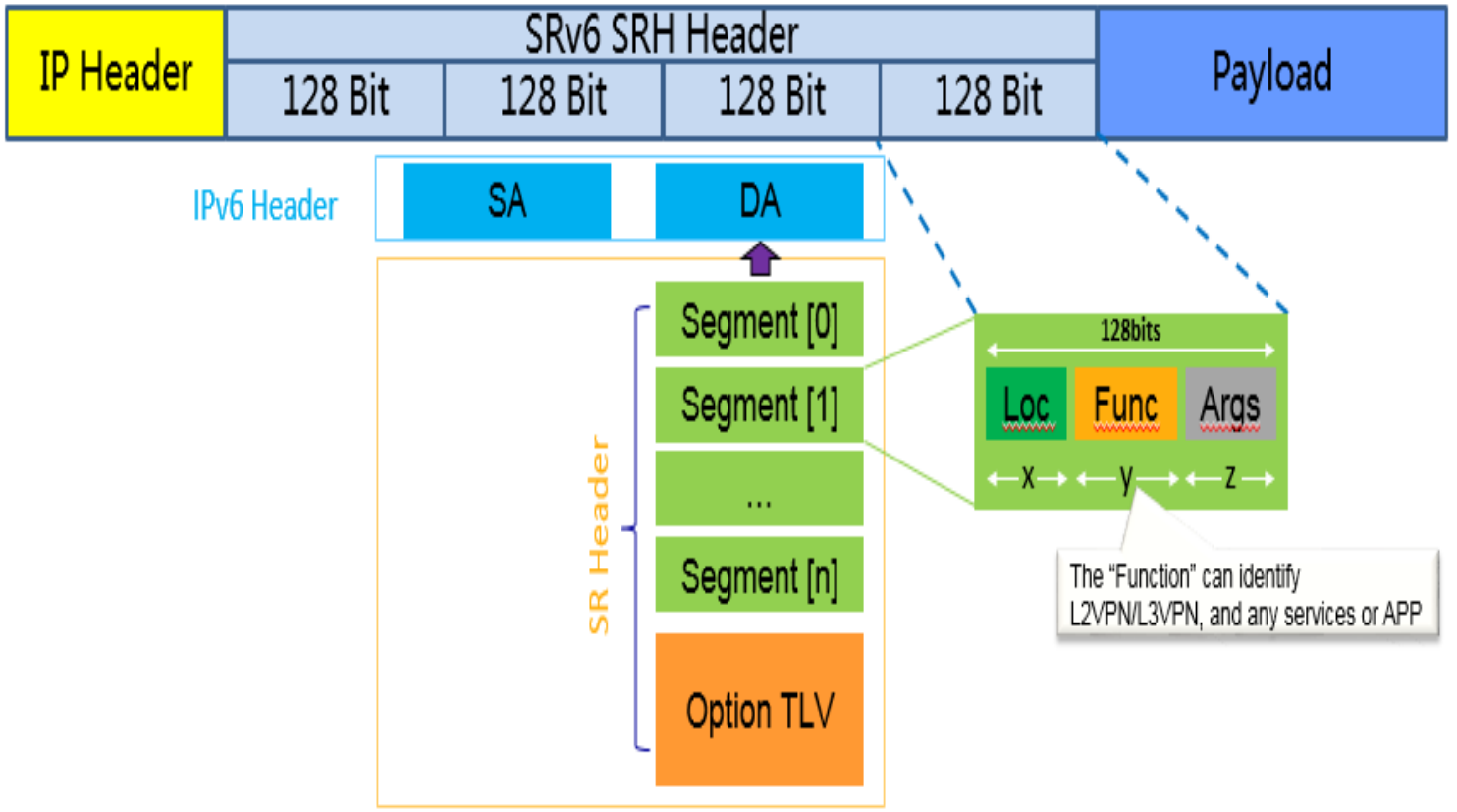
- IPv6重思考：地址空间不足未能强烈驱动IPv6部署
- 5G改变了连接的属性，云改变了连接的范围
- IPv6+的使命：
  - 基于对IP可达性的亲和性，使得不同网络域间连接更容易
  - 基于IPv6扩展头/SRH等可扩展性支持更多种类的封装，满足新业务的需求。
  - 基于对IP亲和性和网络编程能力，实现IP承载网络与应用的融合，提升网络价值。
  - 结合对更多地址空间的需求，进一步推广IPv6

IPv6扩展头/SRv6: 面向未来的网络可编程能力

IPv6 扩展头

Version	Traffic Class	Flow Label
Pload Length	Next=43	Hop Limit
Source Address		
Destination Address		
Hop-by-Hop Options Header		
Destination Options Header		
Routing Header/SRH		
……		
Destination Options Header		
Payload		

SRH: 三层网络可编程空间



IP连接的发展：无连接（IPv4/IPv6）；有连接（MPLS）；智能连接（SRv6/IPv6+）

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IPv6+研究和标准的规划建议

IPv6+ 1.0：SRv6基础能力

- SRv6 VPN
- SRv6 TE
- SRv6 FRR

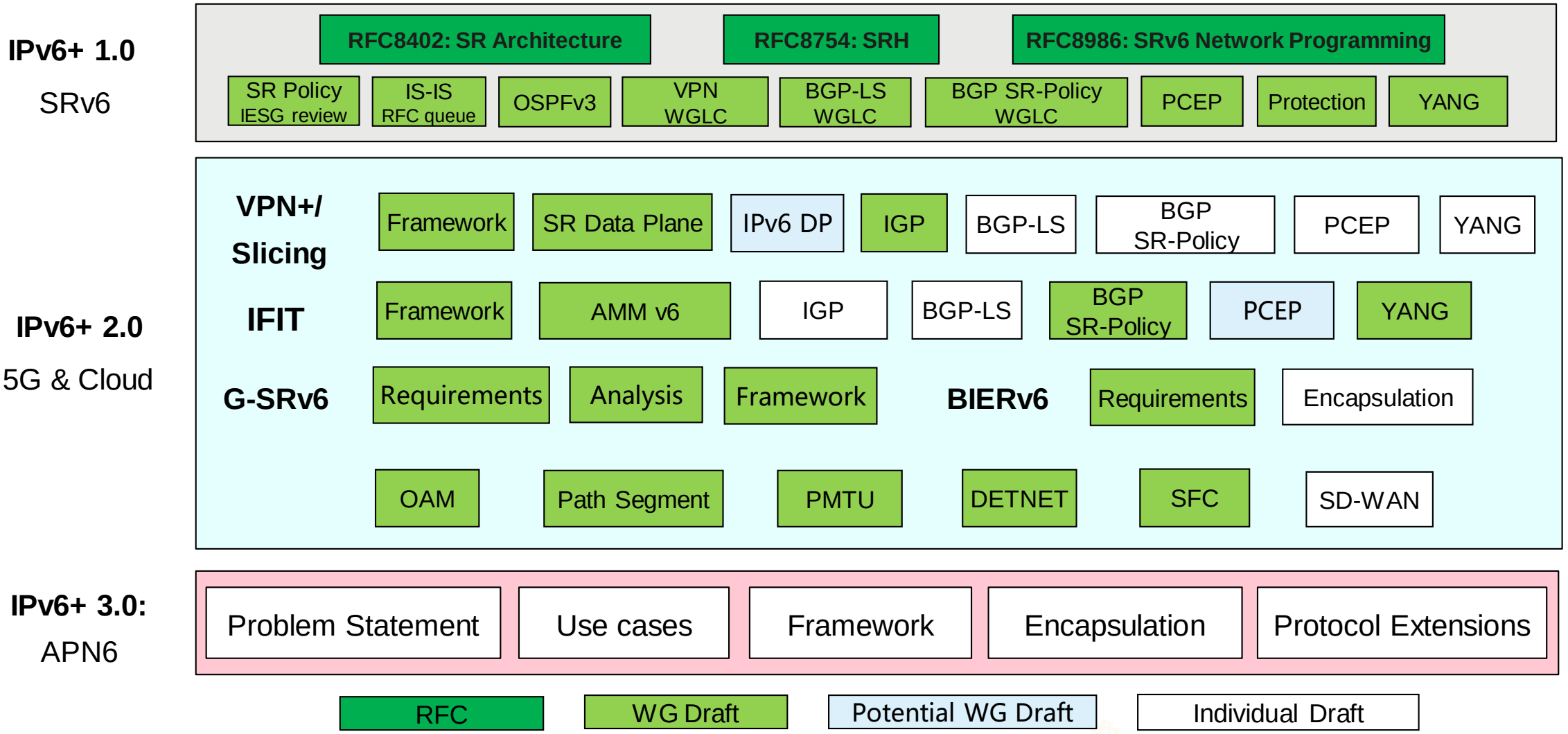
IPv6+ 2.0：面向5G/云的新应用

- Network Slicing/VPN+
- In-situ Telemetry/IFIT
- BIERv6
- OAM
- Path Segment
- Detnet
- SFC
- SD-WAN
- SRv6压缩/G-SRv6

IPv6+ 3.0：APN6 - 感知应用的新网络架构体系

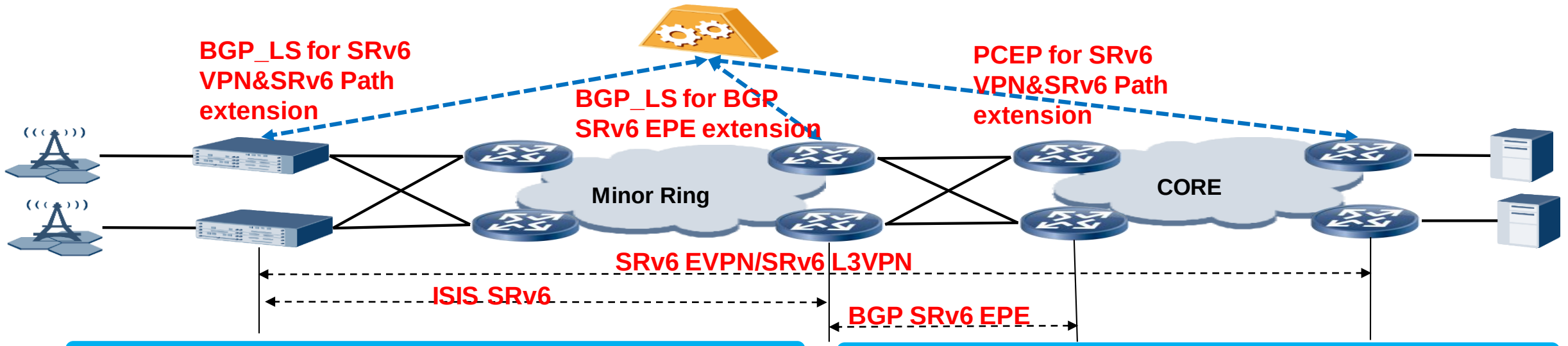
- 转发面：IPv6扩展头传递应用信息给网络
- 控制面：云/网络通过控制协议交互信息

IPv6+标准整体布局与进展



www.ipv6plus.net 提供更多标准进展信息

IPv6+ 1.0: SRv6标准推动与实现部署双管齐下，支持互联互通



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

成功完成多厂家SRv6互通测试，商业部署开启

- **Implementations**
  - Huawei: VRPV8; ATN、CX600、ME60、NE5000E、NE9000
  - Cisco: IOS XR/XE
  - Open Source: Linux, FD.io VPP; Wireshark, Tcpdump, Snort, IPtables, Nftables, etc.
- **Inter-op tests:**
  - EANTC 2019 – Test cases: SRv6 VPN, TI-LFA
- **Deployments:**
  - Softbank
  - Illiad
  - LINE
  - China Telecom
  - China Unicom
  - CERNET2
  - MTN
- **See draft-matsushima-spring-srv6-deployment-status for details**

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IPv6+ 1.0 (1) SRv6基础特性

Area	Topic	Draft	Vendors	Operators
Architecture	**SRv6 Network Programming**	**RFC8986**	Cisco/Huawei	Comcast/Bell Canada/Softbank
SRH	**IPv6 Segment Routing Header (SRH)**	**RFC8754**	Cisco/Huawei	Bell Canada/Softbank
IGP	ISIS Extensions for SRv6	draft-ietf-lsr-isis-srv6-extensions	Cisco/Huawei	Orange
	OSPFv3 Extensions for SRv6	draft-ietf-lsr-ospfv3-srv6-extensions	Huawei/Cisco	
VPN	SRv6 VPN	draft-ietf-bess-srv6-services	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
	BGP for SRv6	draft-ietf-idr-segment-routing-te-policy	Cisco/Huawei/Juniper	Microsoft/Google
	PCEP for SRv6	draft-ietf-pce-segment-routing-ipv6	Huawei/Cisco	China Telecom
	BGP Flowspec for SRv6	draft-ietf-idr-flowspec-srv6	Huawei	China Telecom

- **SRv6框架正式发布成为RFC，成为SRv6标准化的一个新的里程碑。**
- **SRv6基础特性草案基本都通过了工作组Last Call。**
- **SRv6 BGP Flowspec草案被工作组接纳。**

IPv6+ 1.0 (2) SRv6模型

Area	Topic	Draft	Vendors	Operators
Yang Models	SRv6 Base Yang	draft-ietf-spring-srv6-yang	Cisco/Huawei/Infinera/ Ciena/Ericsson	Bell Canada/ Softbank
	SRv6 TE Yang (SR Policy Yang)	draft-ietf-spring-sr-policy-yang	Cisco/Huawei/Juniper	Bell Canada/ Softbank
	SRv6 ISIS Yang	draft-ietf-isis-srv6-yang	Cisco/Huawei	
	SRv6 OSPF Yang	draft-ietf-lsr-ospf-srv6-yang	Cisco/Huawei	
	SRv6 PCEP Yang	draft-li-pce-pcep-srv6-yang	Cisco/Huawei	
	SRv6 VPN YANG	draft-ietf-bess-srv6-services-yang	Cisco/Huawei	LINKEDIN/Orange

- **SRv6 YANG模型标准化与应用部署同步展开。**
- **SRv6 IGP/VPN的YANG模型接纳成为工作组草案，SRv6基础特性草案基本都被接纳成为工作组草案。**

IPv6+ 1.0 (3) SRv6端到端保护与应用部署

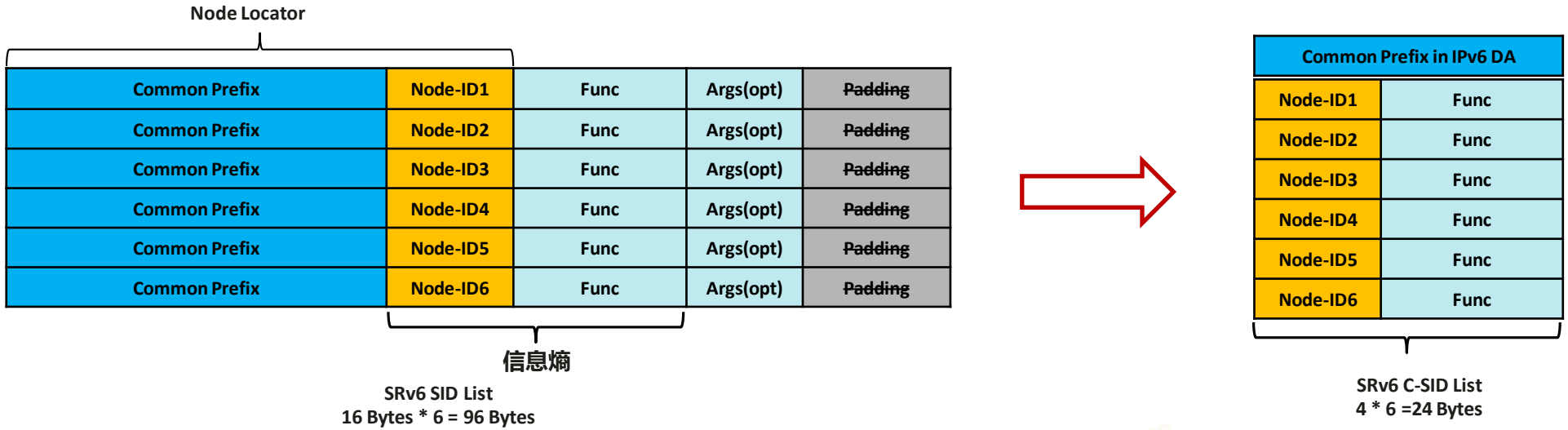
Area	Topic	Draft	Vendors	Operators
Protection	Mid-point Protection	draft-hu-spring-segment-routing-proxy-forwarding	Huawei/Juniper	China Telecom
	Mid-point Protection	draft-chen-rtgwg-srv6-midpoint-protection	Huawei	China Telecom
	Egress Protection	draft-ietf-rtgwg-srv6-egress-protection	Huawei	China Telecom
SRv6 Deployment Migration	SRv6 Deployment Status	draft-matsushima-spring-srv6-deployment-status	Cisco/Huawei	Softbank
	SRv6 Deployment Consideration	draft-tian-spring-srv6-deployment-consideration	Huawei	CAICT/China Telecom China Unicom/Unipay/MTN
SRv6 Security	SRv6 Security Framework	draft-li-spring-srv6-security-consideration	Huawei	CAICT China Telecom

- **SRv6已经形成规模化部署，网络部署经验通过草案进行共享。**

G-SRv6压缩原理（1）

基于共享前缀压缩

- 原生SRv6 SID为128bits IPv6地址，每个节点从自身的Locator地址空间中独立分配
- 而网络中节点的Locator绝大部分都是从同一个大段的地址空间中逐级分配的，该地址空间，称为Common Prefix
- 在一个SRH SR List中
  - **Common Prefix在SRH中为冗余信息，可将其放到统一的位置：IPv6 DA**
  - **Node ID + Function ID 为有效信息，SRH中封装该信息熵即可，称为Compressed SID(C-SID)**
  - Argument可选，通常为0， Padding字段通常为0，无用信息，可直接删除



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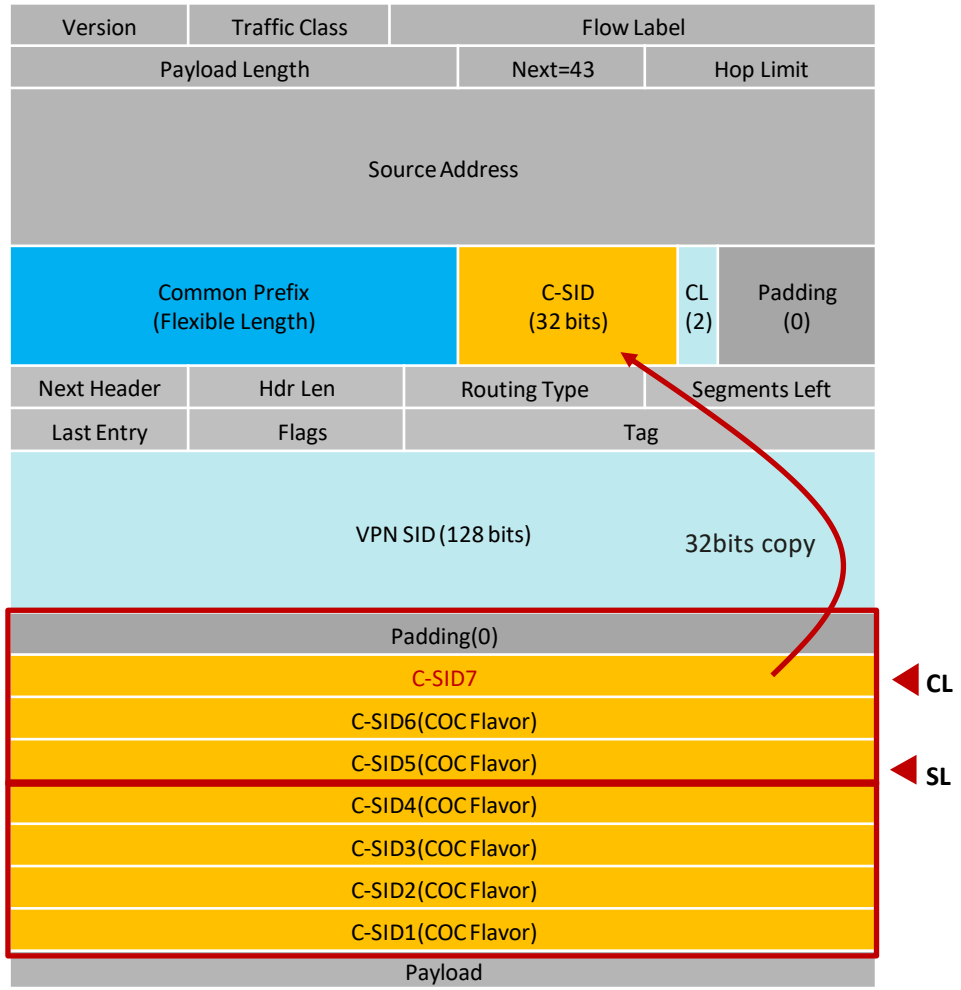
G-SRv6压缩原理（2）

二维数组定位压缩SID

- SRH中的128bits中可封装4 * 32bits C-SID，通过**CL（Compressed SID left）**标识C-SID在128bits/32bits=4 SID小循环中的位置，取值0~3
- 更新后的**C-SID = SRH[SL][CL]**，将该32bits C-SID拷贝到IPv6 DA[CP: CP+31]
- 定义**COC(Continuation of Compression)** Flavor，标识下一个SID是压缩后的C-SID，如果没有COC Flavor，标识下一个SID为128bits SRv6 SID
- COC flavor类似于PSP flavor，在IGP/BGP分配SRv6 SID时，通过控制面发布

伪代码

```
if local SID is a COC Flavor SID                    // Update 32bits C-SID to DA
    if DA.CL = 0                                    // First C-SID in next 128 bits
        SL--; CL = 3;
    else                                            // Next C-SID in current 128 bits
        CL--;
    DA[CP..CP+31] = SRH[SL][DA.CL];                 // CP: Common Prefix length
    Forward the packet based on new DA;
else
    SRv6 processing
```



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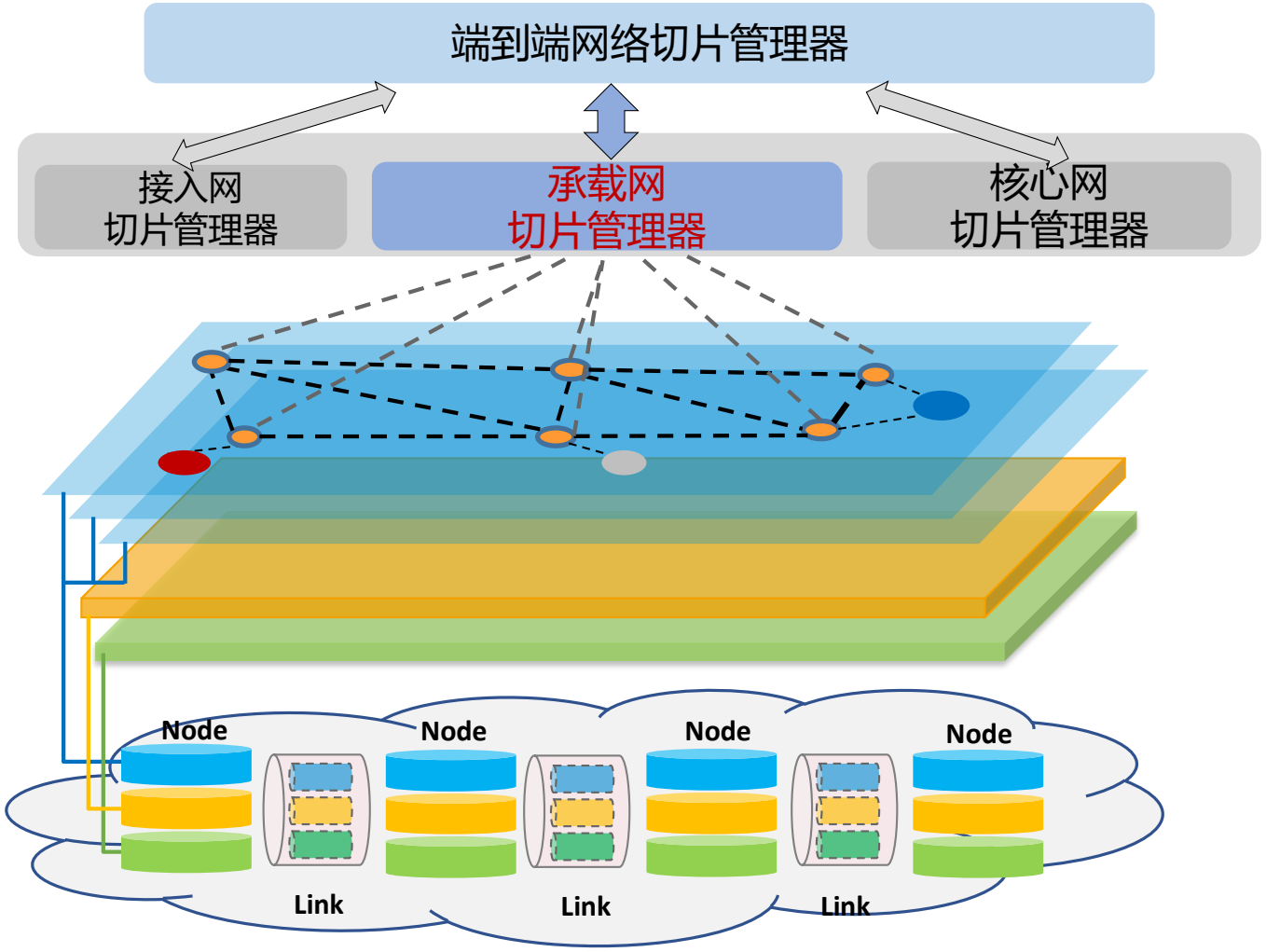
IPv6+ 2.0 (1) SRv6压缩/G-SRv6和Path MTU

Area	Topic	Drafts	Vendors	Operators
Compression	Compressed SRv6 SID List Requirements	draft-ietf-spring-compression-requirement	Huawei/Cisco/Juniper/ZTE/Nokia	China Mobile/China Telecom
	Compressed SRv6 SID List Analysis	draft-ietf-spring-compression-analysis	Huawei/Cisco/Juniper/ZTE/Nokia	China Mobile/China Telecom
	Compressed SRv6 Segment List Encoding in SRH	draft-filsfilscheng-spring-srv6-srh-comp-sl-enc	Huawei/Cisco/ZTE	China Mobile/China Telecom/FT/Bell Canada/Alibaba
PMTU	Segment Routing Path MTU in BGP	draft-ietf-idr-sr-policy-path-mtu	Huawei	STC/China Telecom
	BGP-LS Extensions for Advertising Link MTU	draft-ietf-idr-bgp-ls-link-mtu	Huawei	China Telecom
	PMTU in PCEP	draft-li-pce-pcep-pmtu	Huawei	China Mobile/MTN
	PMTU in ISIS	draft-hu-lsr-isis-path-mtu	Huawei	China Telecom

- **SRv6压缩经过Design Team一年多的运作，已经收敛。Requirement和Analysis草案已经被工作组接纳，CSID方案草案在竞争方案中获得胜出，已经被工作组接纳，遗留了两个问题：1. IPv6地址格式的问题，需要6MAN发布一个草案进行澄清；2. uSID和GSID两种方案的问题需要后续解决。**

VPN+：使能承载网切片的架构与方案



网络切片管理

- 网络切片生命周期管理
  - 创建，监控，调整，删除
- 端到端网络切片协同

网络切片实例化

- 网络切片控制面信息收集与计算
  - 切片拓扑，资源及其他属性
- 网络切片数据面标识

SRv6/IPv6 based

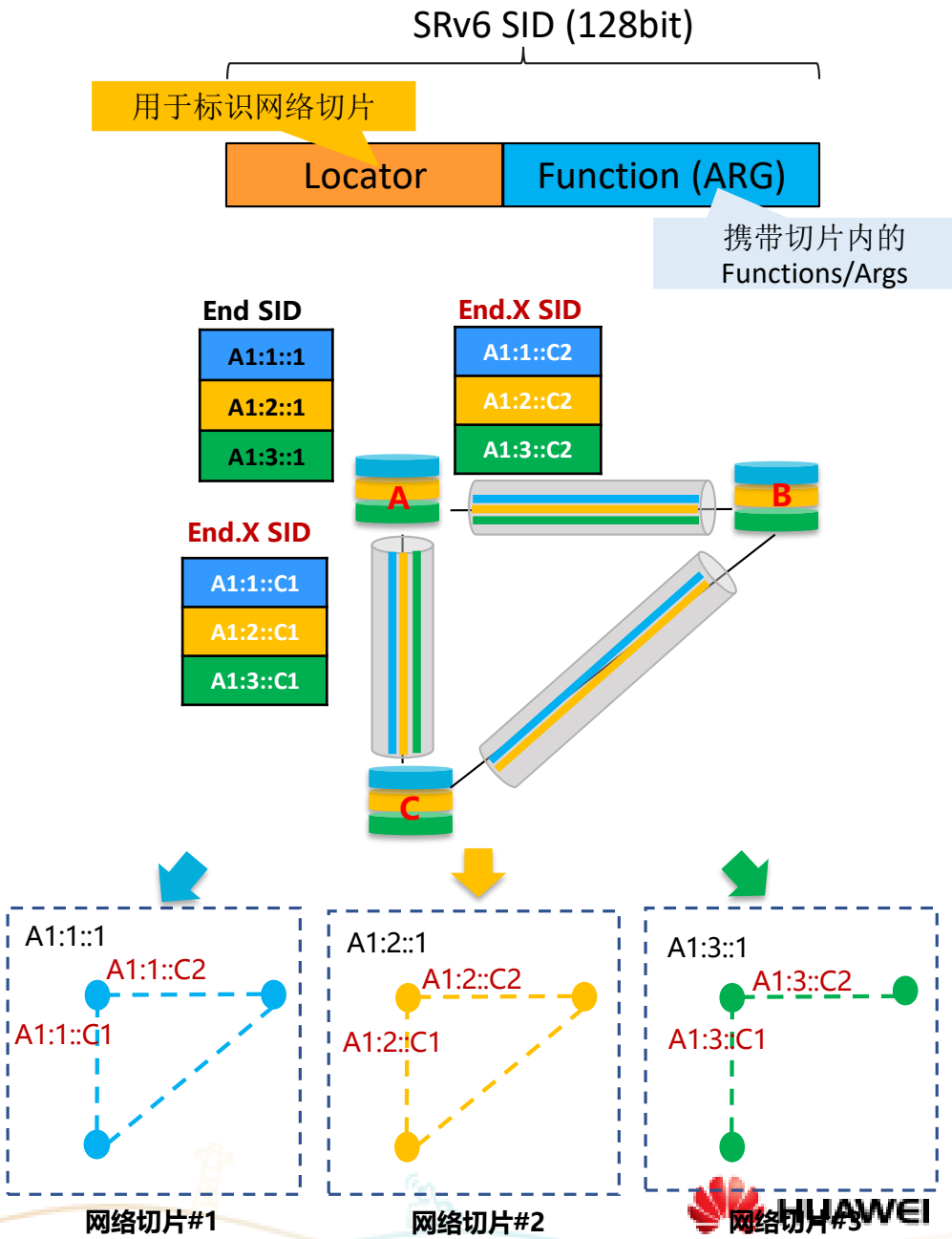
底层网络资源切分

- 物理接口
- 逻辑子接口（FlexE，信道化子接口）
- 独立转发队列
- TSN

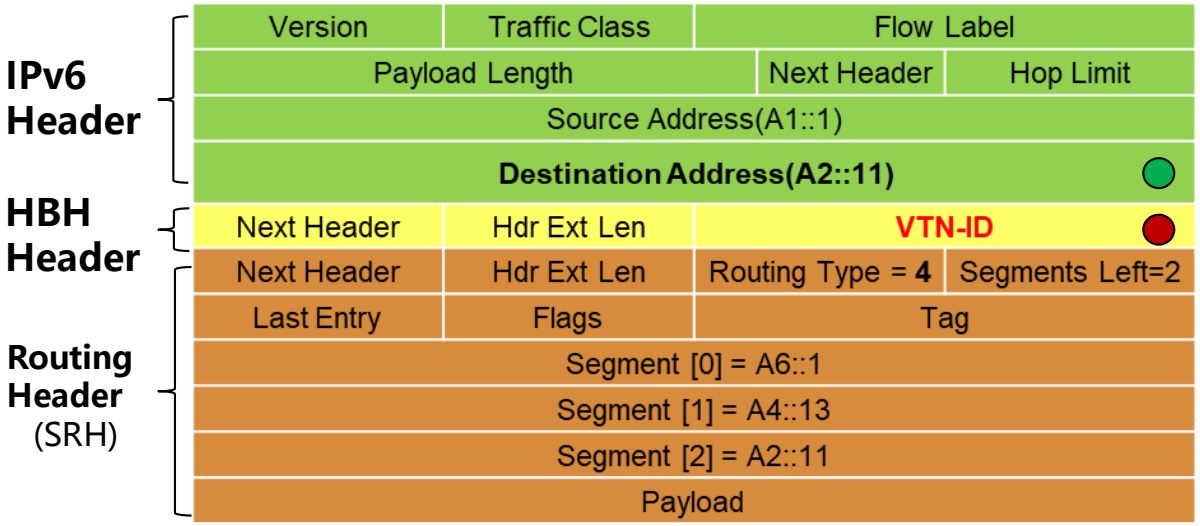
https://tools.ietf.org/html/draft-ietf-teas-enhanced-vpn

SRv6 VPN+协议扩展

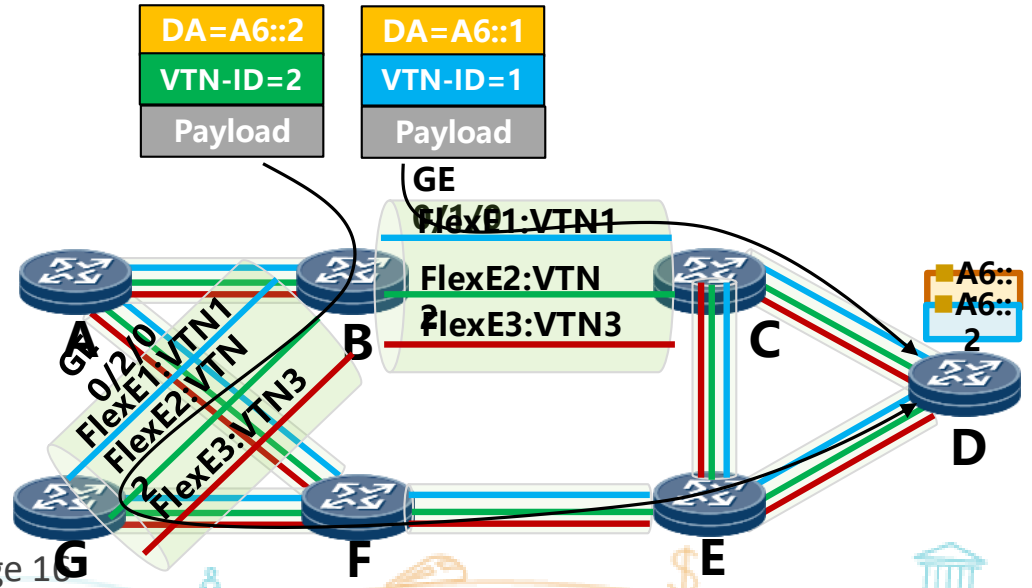
- **数据平面**
  - 每个节点为不同网络切片分配独立的SRv6 Locator
  - 每个网络切片的SRv6 SID继承该切片的Locator
  - 使用一组SRv6 SID标识特定网络切片的拓扑和资源
- **控制平面**
  - 扩展协议发布每个网络切片的Locator，SID和资源属性信息
  - 收集网络切片拓扑，计算基于切片约束的转发表项
- **IETF VPN+标准化进程**
  - VPN+ Framework
    https://tools.ietf.org/html/draft-ietf-teas-enhanced-vpn-01
  - SR/SRv6 based VPN+
    https://tools.ietf.org/html/draft-ietf-spring-sr-for-enhanced-vpn
  - IGP extensions for SR-based VPN+
    https://tools.ietf.org/html/draft-dong-lsr-sr-enhanced-vpn
- **SRv6 VPN+原型**
  - 已向多家运营商展示SRv6 VPN+网络切片原型并开展联合创新



基于IPv6数据面扩展支持网络切片标识



- **数据面使用两种转发标识的组合标识流量的二维转发需求(拓扑、资源)，指导切片报文转发**
  - **IPv6目的地址/SRv6 SID用于在指定网络拓扑内寻址，找到出接口/下一跳**
  - **VTN-ID用于选择指定出接口下为该网络切片分配的子接口/转发资源**
- **数据面扩展带来的好处：**
  - **对用于拓扑与切片资源相关处理的数据面标识进行解耦**
  - **减少需要为网络切片分配的Locator/SRv6 SID数量，降低转发表项规格要求**



节点B转发表示例

Prefix	Next-hop	OutIf
A6::1	C	GE0/1/0
A6::2	G	GE0/2/0

MainIf	VTN-ID	SubIf
GE0/1/0	1	FlexE1
GE0/1/0	2	FlexE2
GE0/1/0	3	FlexE3
GE0/2/0	1	FlexE1
GE0/2/0	2	FlexE2
GE0/2/0	3	FlexE3

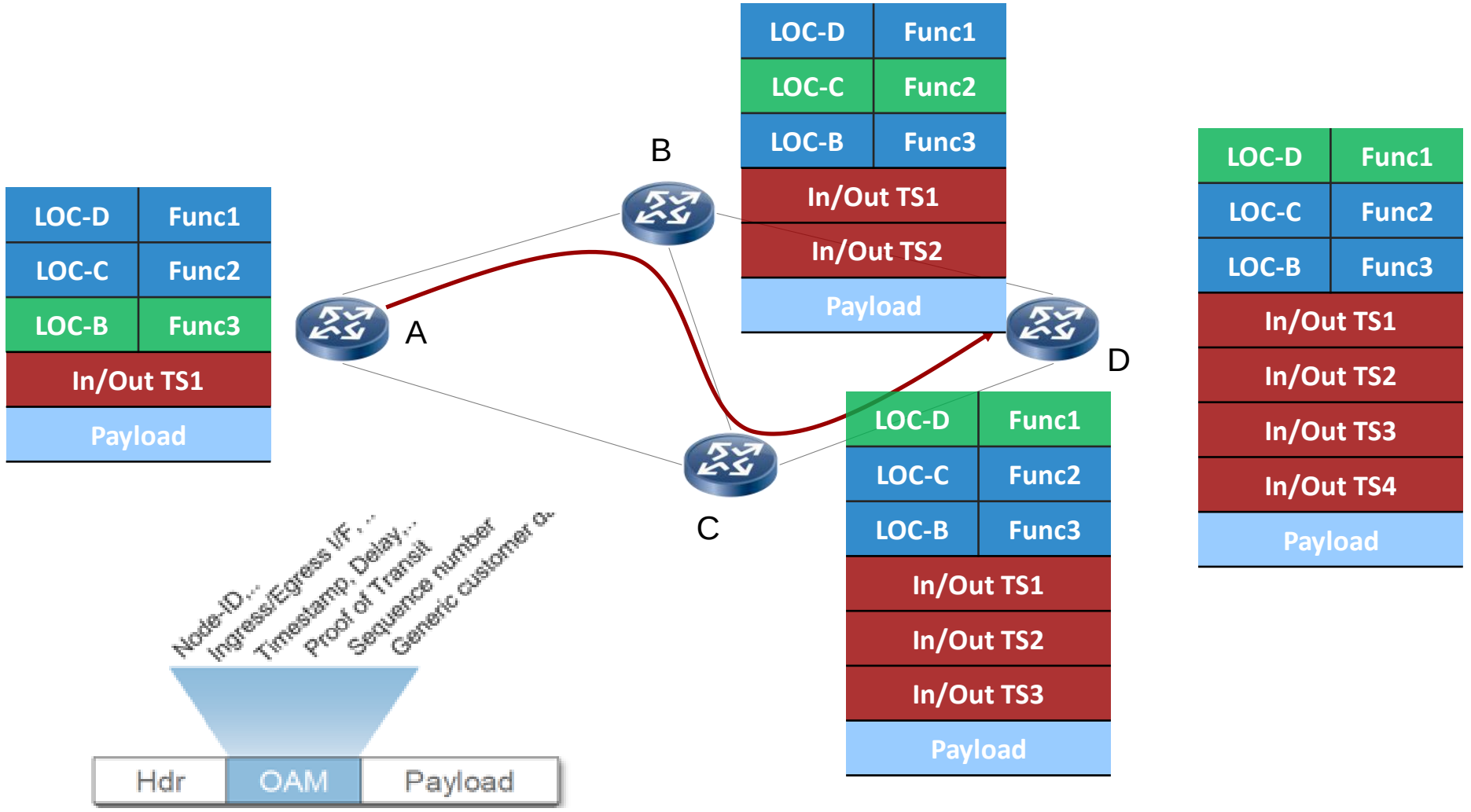
IPv6 VTN-ID扩展：*tools.ietf.org/html/draft-dong-6man-enhanced-vpn-vtn-id*

IPv6+ 2.0 (2) Network Slicing and VPN+

Area		Topic	Drafts	Vendors	Operators
Network Slicing/ VPN+	Framework	VPN+ Framework	draft-ietf-teas-enhanced-vpn	Huawei	China Mobile/KDDI
		Scalability Considerations for VPN+	draft-dong-teas-enhanced-vpn-vtn-scalability	Huawei	China Mobile
	SR切片	Resource-aware Segments	draft-ietf-spring-resource-aware-segments	Huawei/Cisco	China Mobile/China Telecom /KDDI
		SR for VPN+	draft-ietf-spring-sr-for-enhanced-vpn	Huawei/Cisco	China Mobile/China Telecom /KDDI
		IGP Flex-Algo for SR-based VTN	draft-zhu-lsr-isis-sr-vtn-flexalgo	Huawei	China Telecom
		BGP-LS Flex-Algo for SR-based VTN	draft-zhu-idr-bgpls-sr-vtn-flexalgo	Huawei	China Telecom
		IGP Multi-Topo for SR-based VTN	draft-ietf-lsr-isis-sr-vtn-mt	Huawei	China Telecom
		BGP-LS Multi-Topo for SR-based VTN	draft-xie-idr-bgpls-sr-vtn-mt	Huawei	China Telecom
	Slice ID切片	IPv6 for VPN+	draft-dong-6man-enhanced-vpn-vtn-id	Huawei	China Telecom
		IGP Extensions for Scalable VPN+	draft-dong-lsr-sr-enhanced-vpn	Huawei	China Unicom/LGU+
		BGP-LS extensions for Scalable VPN+	draft-dong-idr-bgpls-sr-enhanced-vpn	Huawei	China Unicom
		BGP SR Policy extensions for VTN	draft-dong-idr-sr-policy-vtn	Huawei	China Unicom
		PCE extensions for VTN	draft-dong-pce-pcep-vtn	Huawei	China Mobile
	跨域切片	Framework for End-to-End IETF Network Slicing	draft-li-teas-e2e-ietf-network-slicing	Huawei	China Unicom/China Telecom
		IPv6 Encap for End-to-End IETF Network Slicing	draft-li-6man-e2e-ietf-network-slicing	Huawei	China Unicom/China Telecom
		SR for End-to-End IETF Network Slicing	draft-li-spring-sr-e2e-ietf-network-slicing	Huawei	China Unicom/China Telecom
	分级切片	Hierarchical IETF Network Slices	draft-dong-teas-hierarchical-ietf-network-slice	Huawei	

- **IP网络切片Design Team持续运作，相关草案已经被工作组接纳，当前继续讨论网络切片的概念和框架，逐渐达成一致。**
- **SR切片的多篇草案被工作组接纳，Segment用于指示资源获得各方认同，方案的标准日趋成熟。**
- **Slice ID切片是当前切片标准化工作的重点，各方都有相关的草案，准备基于中立的术语体系进行合并。**
- **IP网络切片体系持续演进，跨域切片、分级切片的草案都有布局。**

IFIT（In-situ Flow Info Telemetry）：更有效的数据面监控机制

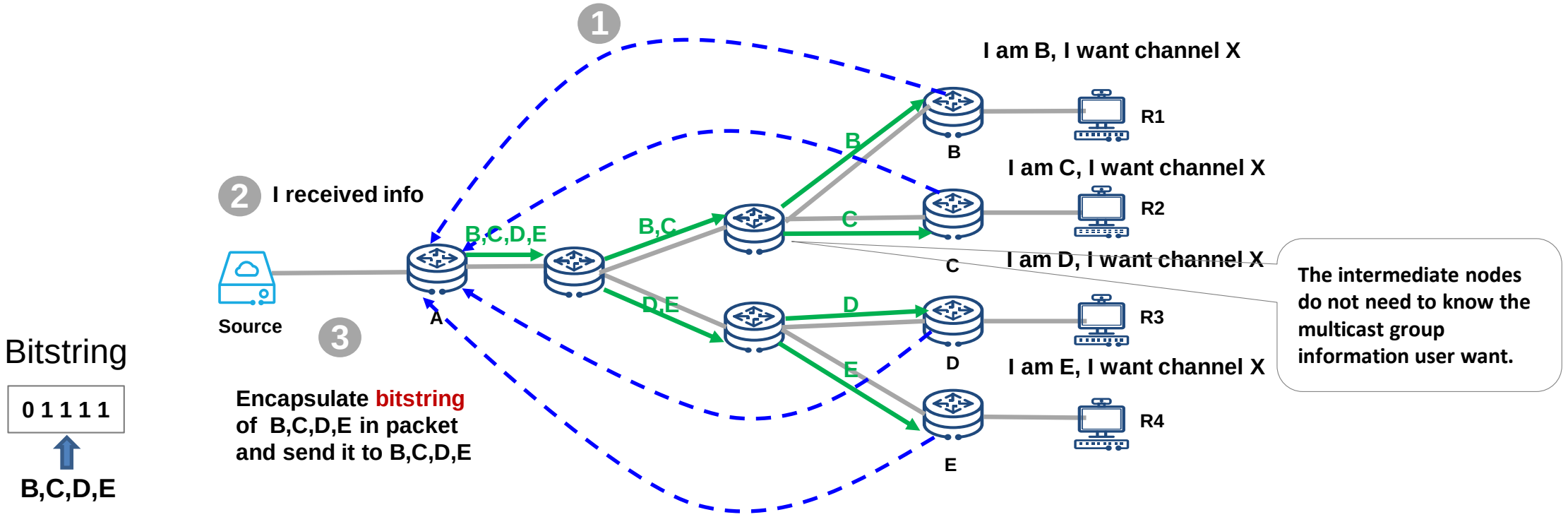


IPv6+ 2.0 (3) IFIT (In-situ Flow Information Telemetry)

Area	Topic	Drafts	Vendors	Operators
Framework	In-situ Flow Information Telemetry Framework	draft-song-ifit-framework	Huawei	China Mobile/China Telecom/SKT/LGU+
Basic Encap	Data Fields for In-situ OAM	draft-ietf-ippm-ioam-data	Cisco/Huawei	Bell Canada
	In-situ OAM Direct Exporting	draft-ietf-ippm-ioam-direct-export	Huawei/Cisco	
	Enhanced Alternate Marking Method	draft-zhou-ippm-enhanced-alternate-marking	Huawei	LGU+ Telecom Italia
Encap type	IPv6 Application of the Alternate Marking	draft-ietf-6man-ipv6-alt-mark	Huawei	Telecom Italia
	SRH for the Alternate Marking	draft-fz-spring-srv6-alt-mark	Huawei	Telecom Italia
	In-situ OAM Processing in Tunnels	draft-song-ippm-ioam-tunnel-mode	Huawei	
Control Plane	BGP SR Policy for IFIT	draft-ietf-idr-sr-policy-ifit	Huawei	China Mobile/Unipay
	PCEP SR Policy for IFIT	draft-chen-pce-sr-policy-ifit	Huawei	China Telecom/Unipay
	IGP/BGP-LS for IFIT	draft-wang-lsr-ifit-node-capability-advertisement	Huawei	China Unicom
YANG model	A YANG Data Model for In-Situ OAM	draft-ietf-ippm-ioam-yang	Huawei/Cisco	

- **数据面方案（包括IOAM Passport/Postcard、基于IPv6的染色）取得大的进展，产生了多篇工作组草案。**
- **多篇控制面草案布局，用于IFIT的自动化部署，BGP-LS协议扩展草案已经被工作组接纳。**
- **IOAM YANG模型草案被工作组接纳。**

MSR6/BIERv6：新型无状态组播



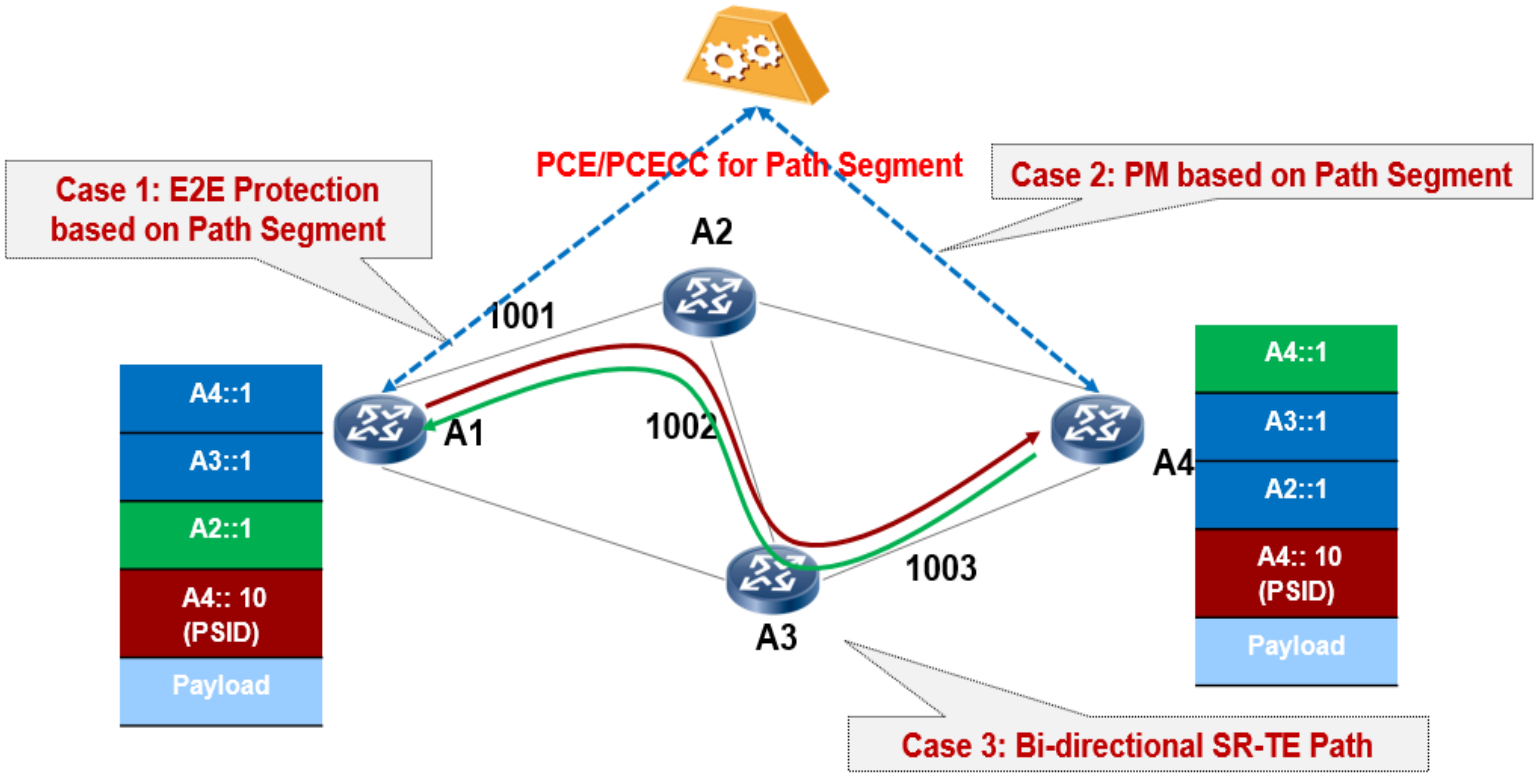
- 基于BitString复制报文到指定的接收者，其中的每个bit代表一个接收者
- 通过在BIER报文头中携带BitString信息，实现无状态组播

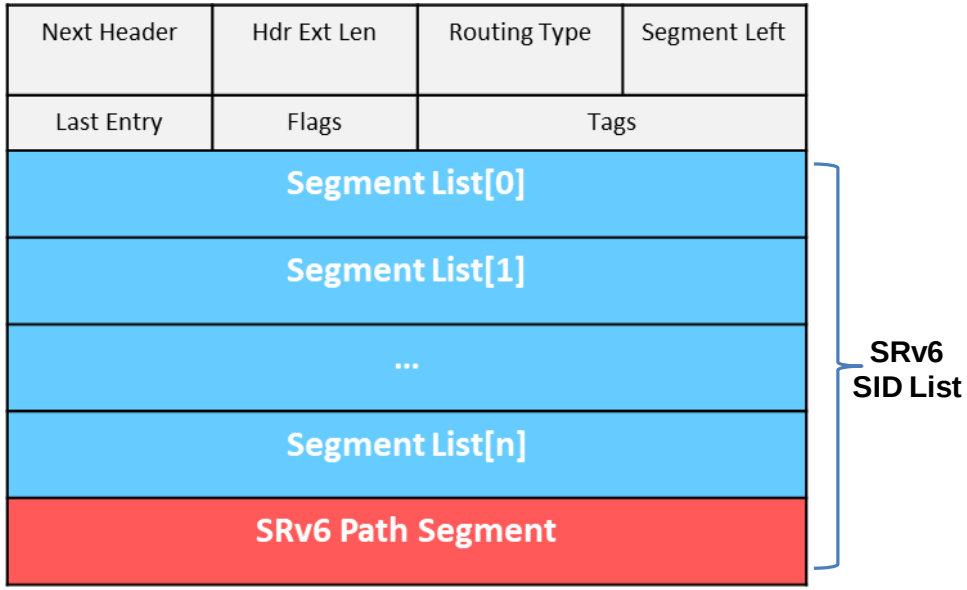
IPv6+ 2.0 (4) BIERv6/MSR6

Area		Topic	Drafts	Vendors	Operators
MSR6	Framework	Usecase/Design Consideration	draft-cheng-spring-ipv6-msr-design-consideration	Huawei/H3C	China Mobile/ Verizon/China Unicom/China Telecom
		Gap Analysis	draft-li-spring-ipv6-msr-gap-analysis	Huawei	Verizon/China Unicom
	MSR6 BE (BIERv6)	BIERv6 Requirements	draft-ietf-bier-ipv6-requirements	Huawei/Cisco/ Juniper	China Telecom/Verizon
		BIERv6 Encapsulation -> RGB Segment	draft-xie-bier-ipv6-encapsulation -> draft-lx-msr6-rgb-segment	Huawei	China Mobile
		BIERv6 MVPN -> Source Segment	draft-xie-bier-ipv6-mvpn-01 -> draft-xl-msr6-source-segment	Huawei	China Mobile
		IS-IS for BIER6	draft-xie-bier-ipv6-isis-extension	Huawei	China Telecom
		BIERv6 Inter-domain	draft-geng-bier-ipv6-inter-domain	Huawei	China Mobile
		BIERv6 YANG	draft-geng-bier-bierv6-yang	Huawei	China Unicom
	MSR6 TE	MSR6 Traffic Engineering	draft-geng-msr6-traffic-engineering	Huawei	
		Stateless SRv6 Point-to-Multipoint Path	draft-chen-pim-srv6-p2mp-path	Huawei	Verizon/China Telecom

- **BIER工作组认为BIERv6不符合BIER作为独立层的设计理念，拒绝接纳BIERv6草案。**
- **BIERv6是Native IPv6的设计理念，与BIERin6用于不同的场景，类比于SRv6 vs. SR over UDP。**
- **MSR6的工作启动，BIERv6作为BE方案成为其一部分，MSR6 TE的方案开始草案布局。**
- **MSR6的Side Meeting成功举行，获得了国内三大T、华为、华三的支持，准备推动BOF/工作组。**

SRv6 Path Segment & OAM：更高效的路径标识与性能测量机制





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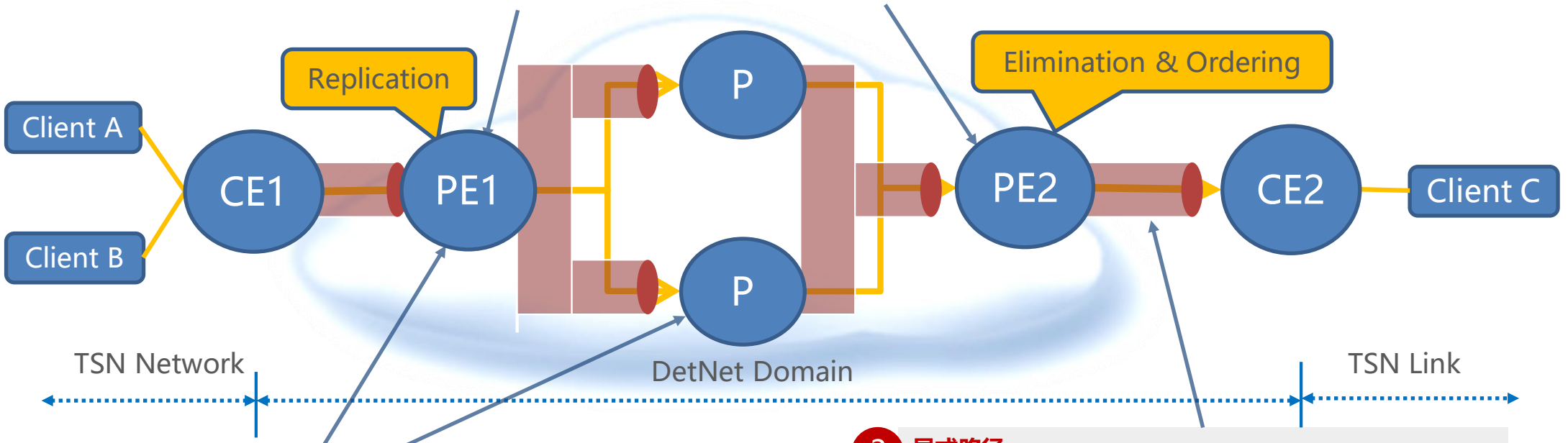
IPv6+ 2.0 (5) SRv6 OAM and Path Segment

Area	Topic	Draft	Vendors	Operators
OAM	OAM in SRv6	draft-ietf-6man-spring-srv6-oam	Cisco/Huawei	Softbank/Bell Canada
	SRv6 Light iOAM	draft-li-spring-light-weight-srv6-ioam	Huawei	China Mobile
Path Segment	Use cases and Mechanisms of MPLS Path Segment	draft-ietf-spring-mpls-path-segment	Huawei/Cisco	China Mobile
	SRv6 Path Segment	draft-ietf-spring-srv6-path-segment	Huawei/Cisco	China Mobile/China Telecom
	Path Segment and Bidir Path in BGP	draft-ietf-idr-sr-policy-path-segment	Huawei/Cisco	China Telecom/China Mobile
	Path Segment and Bidir Path in BGP-LS	draft-ietf-idr-bgp-ls-sr-policy-path-segment	Huawei/Cisco	China Telecom/China Mobile
	Path Segment in PCEP	draft-ietf-pce-sr-path-segment	Huawei/Cisco/ZTE	China Mobile
	Bidir Path in PCEP	draft-ietf-pce-sr-bidir-path	Huawei/Cisco	China Mobile
	ID Space Delegation	draft-li-pce-controlled-id-space	Huawei	China Telecom

- **SRv6 OAM被工作组接纳，已经通过工作组Last Call。**
- **SRv6 Path Segment（包含封装）草案被工作组接纳。**
- **SR Path Segment多篇草案被工作组接纳，之前主要是面向SR-MPLS，需要扩展支持SRv6。**

确定性网络核心技术

2 冗余传输
通过多路径同时传输流量来避免链路故障或其他因素造成的对包，有效 提升可靠性
- 报文复制，删除和重排



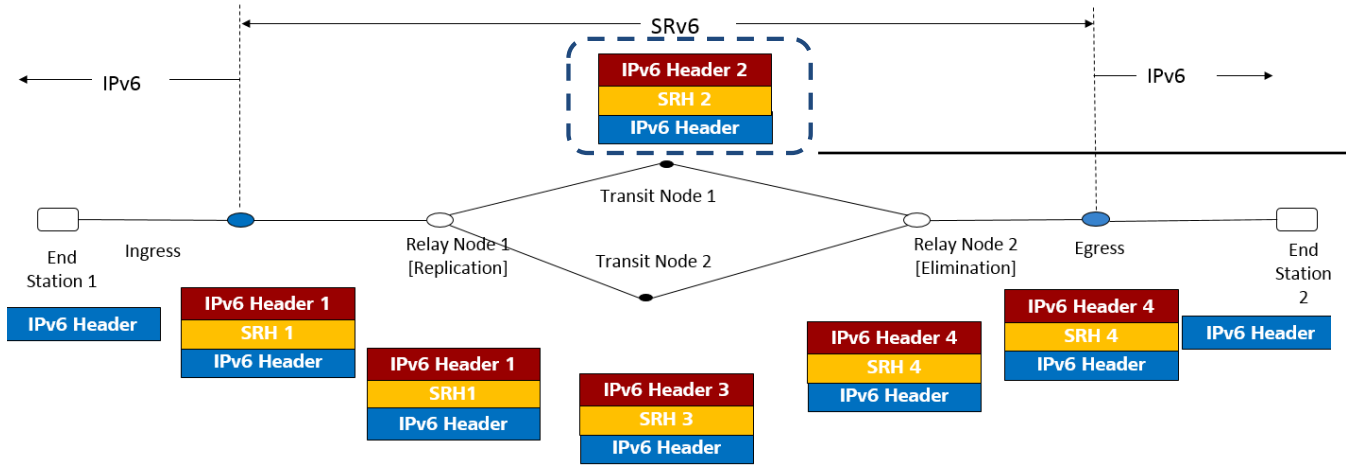
1 拥塞避免
通过规避流量之间的冲突，避免拥塞造成的丢包和时延不确定性
- 资源预留
- 队列管理（整形，调度等机制）

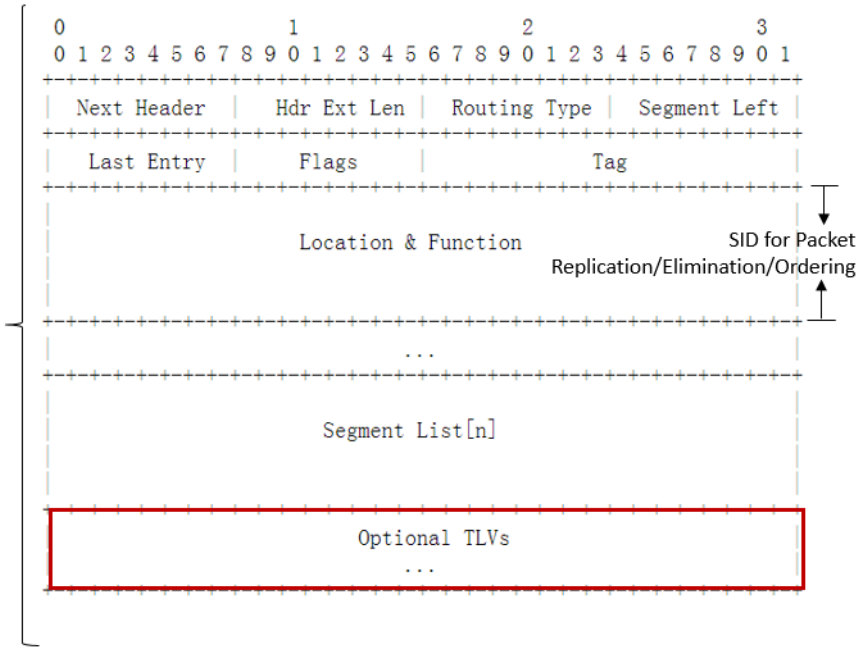
3 显式路径
指定DetNet流量的传输路径，以控制端到端时延
- Segment Routing

基于SRv6的冗余传输解决方案

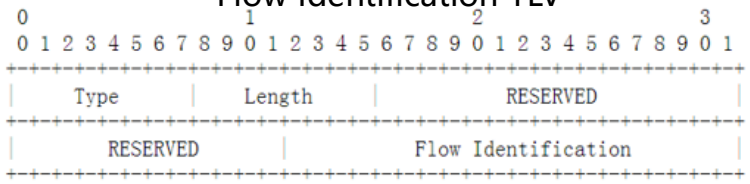
SRv6 零丢包解决方案：

- ✓ 不耦合的显示路径：用segment list指示复制报文沿着两条或以上不重合的路径进行转发；
- ✓ SRv6扩展：在SRH中optional TLV中指示流标识(Flow Identification)和报文的序列号(Sequence Number)，用于实现多路径的选收；
- ✓ 利用SRv6的灵活编程能力：定义新的SRv6 Function，指示报文在指定节点进行报文复制和汇聚；

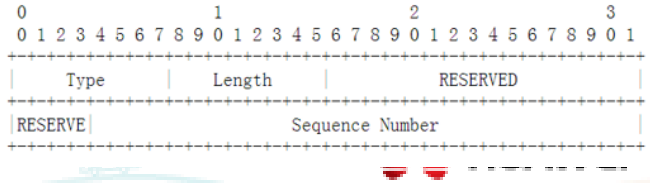




Flow Identification TLV



Sequence Number TLV

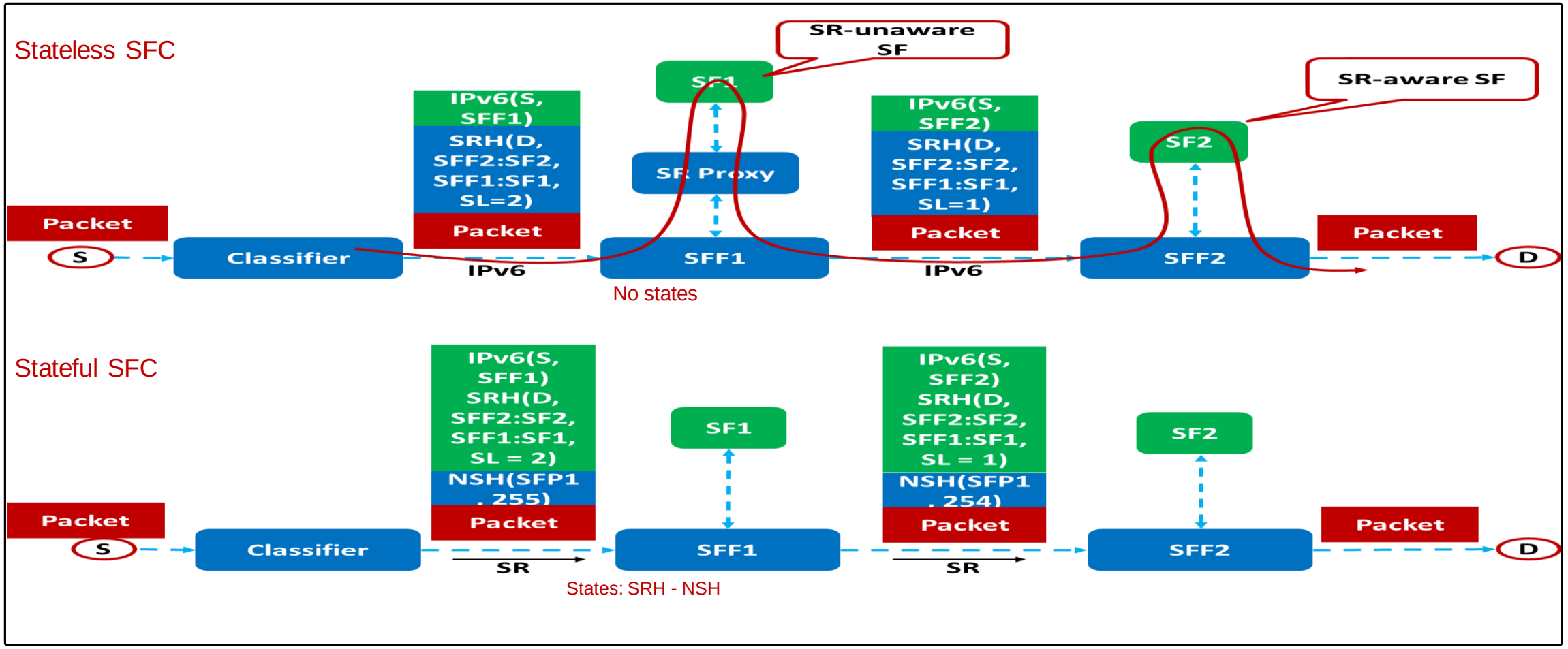


IPv6+ 2.0 (6) DetNet

Area	Topic	Drafts	Vendors	Operators
DetNet	Architecture	RFC8655	Huawei/Cisco/ Ericsson	
	Framework	RFC8938	Huawei/Ericsson	
	DetNet SRv6 Data Plane Encapsulation	draft-geng-detnet-dp-sol-srv6-01	Huawei	China Telecom
	DetNet Controller Plane Framework	Draft-ietf-detnet-controller-plane-framework-02	Huawei/Ericsso	China Mobile
	DetNet Configuration YANG Model	draft-ietf-detnet-yang-04	Huawei/Cisco	China Mobile
	SR for Redundancy Protection	draft-ietf-spring-sr-redundancy-protection	Huawei/Cisco	Verizon
	SRH Extension for Redundancy Protection	draft-geng-6man-redundancy-protection-srh	Huawei	
	Redundancy Policy for Redundant Protection	draft-geng-spring-redundancy-policy	Huawei	

- **Detnet框架、YANG和IP/MPLS等封装的草案已经被工作组接纳。**
- **基于SR的冗余备份草案被工作组接纳。**

基于SRv6的SFC：Stateless与Stateful方案



IPv6+ 2.0 (7) SFC

Area	Topic	Drafts	Vendors	Operators
SFC	SR for SFC	draft-ietf-spring-sr-service-programming	Cisco/Huawei/ Juniper/Nokia/Mellanox	Bell Canada/ Orange/AT&T/ Alibaba/Orange
	SR + NSH for Stateful SFC	draft-ietf-spring-nsh-sr	Huawei/Ericsson/ Nokia/Cisco	Orange
	Control Plane for SR SFC	draft-li-spring-sr-sfc-control-plane-framework	Huawei	STC
	BGP-LS extension for SR SFC	draft-ietf-idr-bgp-ls-sr-service-segments	Cisco/Huawei	Bell Canada/AT&T/ Orange/Alibaba
	ISIS extension for SR SFC	draft-xu-isis-service-function-adv	Huawei	Telefonica
	OSPF extension for SR SFC	draft-xu-ospf-service-function-adv	Huawei	Telefonica

- **SR SFC的数据面草案已经成熟，SR+NSH草案已经通过工作组Last Call。**
- **BGP-LS for SFC的草案被工作组接纳。**

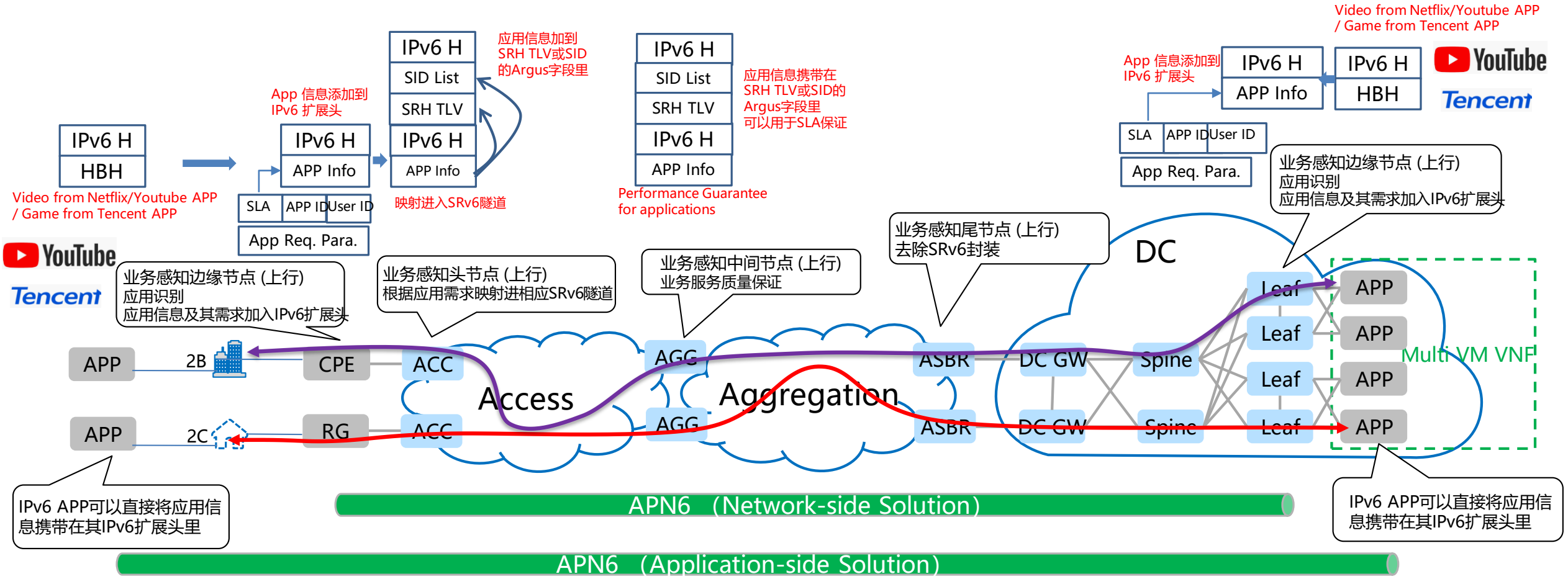
IPv6+ 2.0 (8) SD-WAN/CON

Area	Topic	Drafts	Vendors	Operators
SD-WAN	Dynamic Networks to Hybrid Cloud DCs Problem Statement	draft-ietf-rtgwg-net2cloud-problem-statement	Huawei	FT/Verizon
	SR For SDWAN	draft-dukes-spring-sr-for-sdwan	Cisco	LinkedIn/Alibaba/Bell Canada
	SR for SDWAN over Hybrid Networks	draft-dunbar-sr-sdwan-over-hybrid-networks	Huawei	Verizon
	BGP Usage for SDWAN Overlay Networks	draft-ietf-bess-bgp-sdwan-usage	Huawei/Cisco/Juniper	Bell Canada
	BGP UPDATE for SDWAN Edge Discovery	draft-ietf-idr-sdwan-edge-discovery	Huawei	Verizon
CON	IPv6 based Cloud-Oriented Networking	draft-li-rtgwg-ipv6-based-con-01	Huawei	

- **SDWAN的框架草案被工作组接纳，围绕多云场景的基于IPv6方案已经布局。**
- **BGP for SDWAN的协议扩展草案被工作组接纳。**
- **SRv6 SDWAN正在推动过程中。**

应用感知的（Application-aware）IPv6网络

- 利用IPv6扩展头将应用信息及其需求传递给网络
- 根据携带应用信息，通过业务的部署和资源调整来保证应用的SLA要求



https://tools.ietf.org/html/draft-li-6man-service-aware-ipv6-network-00 IETF104@Prague

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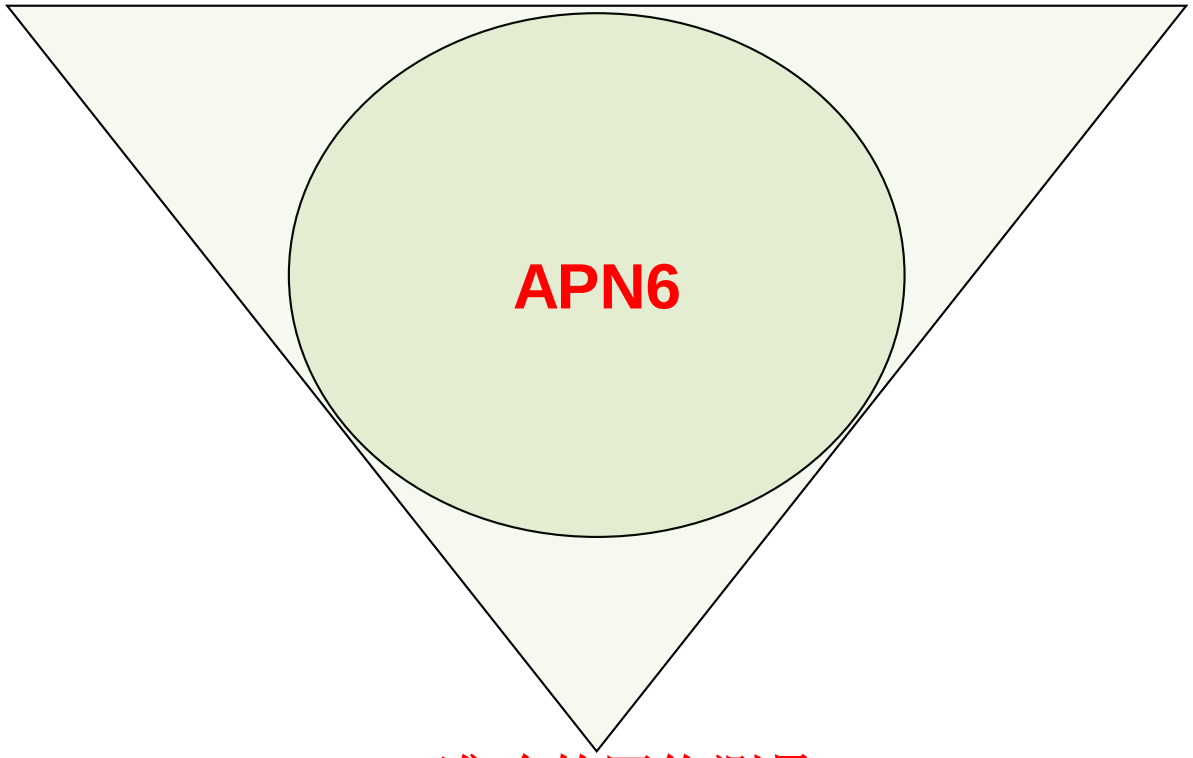
APN6的三要素

开放的应用信息携带

- APP-ID
  - SLA Level
  - 应用ID
  - 用户ID
  - 流ID
- APP参数信息
  - 带宽
  - 时延
  - 丢包率



丰富的网络服务

- DiffServ
- H-QoS
- 网络切片
- DetNet
- SFC
- BIER6

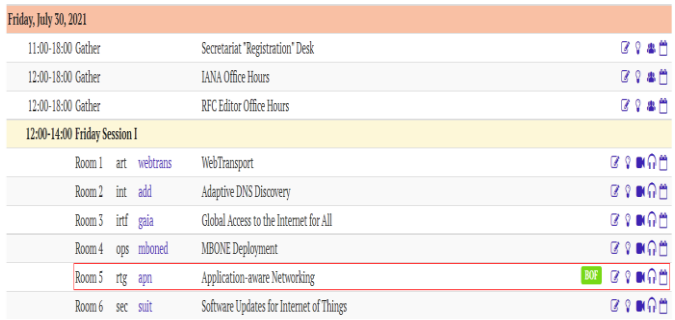
准确的网络测量

- 更细粒度（per packet vs. per flow, per node vs. E2E, individual vs. statistics, etc.)
- 综合测量 (per packet with per flow, per node with E2E, individual with statistics, in-band with out-band, passive with active, etc.)

标准进展：APN6获广泛关注，与多家运营商客户合署标准文稿，成功推动BOF

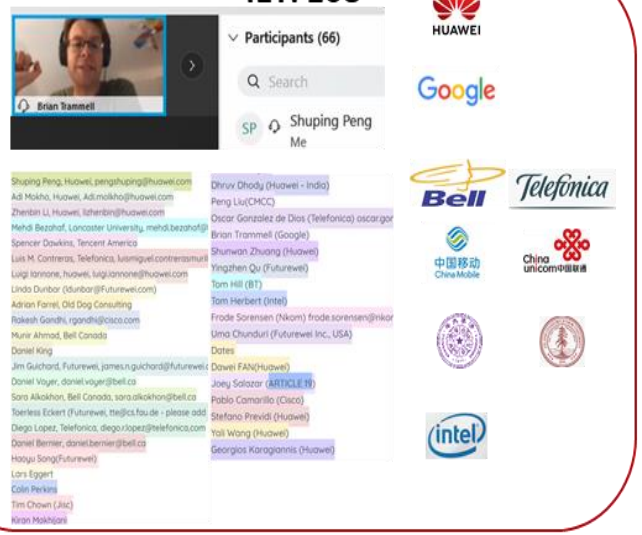
- **Side Meetings** @IETF105 & IETF108
- **Hackathons** @IETF108 & IETF109 & IETF110
- **Demos** @INFOCOM2020 & 2021
- **APN Mailing List** Discussions - apn@ietf.org
- **APN Interim Meeting** @IETF 110-111
- **APN BoF** @IETF111, Approved! 30 July 2021, 1200-1400 PDT

IETF111 APN BoF



IETF105

IETF108



IETF109

IETF110

https://www.ietf.org/blog/ietf109-bofs/
https://www.ietf.org/blog/ietf110-bofs/
https://trac.tools.ietf.org/bof/trac/wiki/WikiStart (IETF111 BoF)

https://github.com/APN-Community

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APN领域标准列表

	文稿名称	合作单位	文稿内容
问题澄清与用例	draft-li-apn-problem-statement-usecases	华为、Bell Canada、电信、移动、联通、Verizon、Toyota、Futurewei	APN问题澄清和用例
架构	draft-li-apn-framework	华为、Bell Canada、电信、移动、联通、Verizon、Toyota、Futurewei	APN架构总体介绍
Gap Analysis	draft-peng-apn-scope-gap-analysis-00	华为	APN范围与现有机制不同的澄清
用例	draft-liu-apn-edge-usecase	移动、华为	边缘计算相关用例
	draft-zhang-apn-acceleration-usecase	联通、华为	应用加速相关用例
	draft-yang-apn-sd-wan-usecase	移动、华为	SD-WAN相关用例
封装	draft-li-apn-header	华为	APN头部格式
	draft-li-apn-ipv6-encap	华为	APN IPv6数据面的封装
HBH	draft-ietf-v6ops-hbh-00	华为、电信、联通、Verizon	HBH的处理需求文稿
安全隐私	draft-peng-apn-security-privacy-consideration	华为	APN安全和隐私
FlowSpec	draft-peng-apn-bgp-flowspec-00	华为、清华	APN的FlowSpec
YANG	draft-peng-apn-yang-00	华为	APN的YANG

IPv6扩展头使用总结

特性	IPv6扩展头使用		
	HBH Header	Routing Header	DO Header
SRv6 TE/FRR/VPN		√	
VPN+	√	(√)	
IFIT	√	√	√
BIER			√
APN6	√	√	√

IPv6+产业活动：中国IPv6+技术创新工作组

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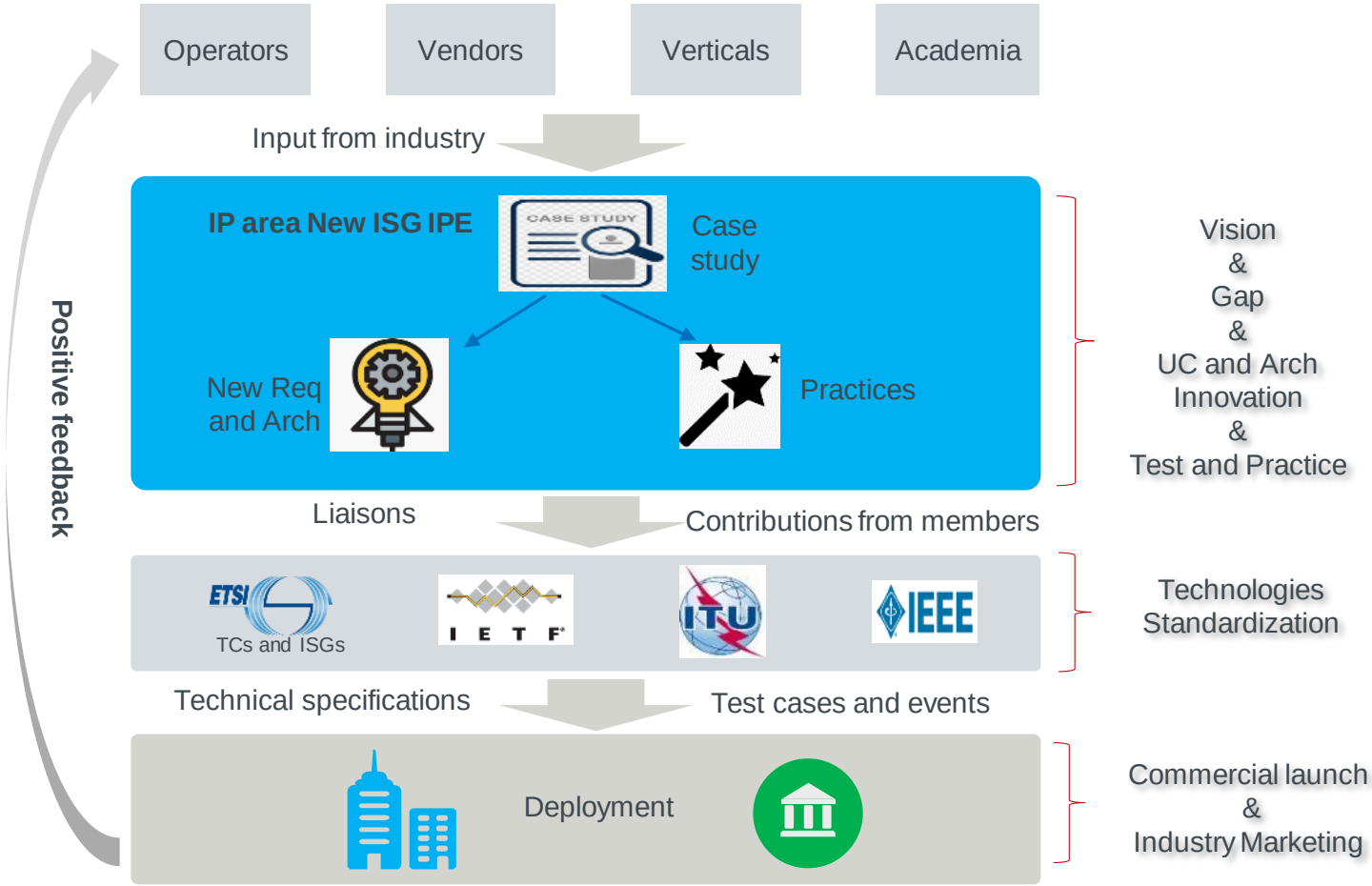
IPv6+产业活动： ETSI New ISG IPE (IPv6 Enhanced Innovation)

20 Members, 23 Participants, 1 Counsellor (Feb 2021)



Jointly make an Open Platform for IP Industry

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华为在“IPv6+”部署覆盖运营商、金融、政府和教育

欧美	中东/非洲	中国	亚太
5 运营商	13 运营商	84 运营商/行业	4 运营商

运营商

Claro, kpn, PLDT, OSP, China unicom中国联通, 中国电信 CHINA TELECOM, Asiacell, rain, Post, zain, ooredoo, XL axiata, MTN, Jazz, indosat, 中国移动 China Mobile, Globe, WIND, ...

行业

国家电网 STATE GRID, 浦发银行 SPD BANK, 中国邮政储蓄银行 POSTAL SAVINGS BANK OF CHINA, CHINA LIFE 中国人寿, UnionPay 银联 中国银联 China UnionPay, 交通银行 BANK OF COMMUNICATIONS, 中国工商银行 INDUSTRIAL AND COMMERCIAL BANK OF CHINA, CERNET, 全国一体化在线政务服务平台 广东政务服务网, 中国建设银行 China Construction Bank, 中国农业银行 AGRICULTURAL BANK OF CHINA, ..., 中国银行 BANK OF CHINA, 全国一体化在线政务服务平台 广西数字政务一体化平台, 国泰君安证券 GUOTAI JUNAN SECURITIES

全球100+“IPv6+”商用部署&创新

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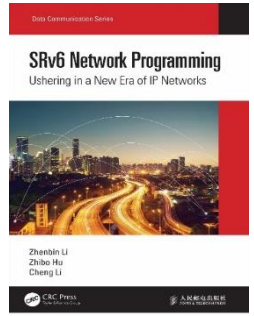
IPv6+系列书籍和视频，积极传播“IPv6+”理念

IPv6+实体书



IPv6+系列电子书

IPv6+系列视频

(多媒体) IPv6+系列 01 SRv6的技术原理和产业发展 01

(多媒体) IPv6+系列 04 随流检测iFIT技术介绍 01

(多媒体) IPv6+系列 03 网络切片 01

(多媒体) IP新技术进阶系列 - IPv6基础介绍

(多媒体) IP新技术进阶系列 - Segment Routing IPv6 (SRv6)

(多媒体) IP新技术进阶系列 - 公网IPv6 over SRv6 TE Policy深度解析

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IPv6+系列书籍和视频，积极传播“IPv6+”理念

IPv6+实体书

中文版：https://item.jd.com/12948440.html
英文版：https://www.amazon.com/SRv6-Network-Programming-Ushering-Communication/dp/1032016248

IPv6+系列电子书

中文版：https://e.huawei.com/cn/material/bookshelf/bookshelfview/202104/29153654
英文版：https://e.huawei.com/en/material/bookshelf/bookshelfview/202109/29105716

IPv6+系列视频

中文版：https://support.huawei.com/enterprise/zh/routers/netengine-8000-pid-252772223/multimedia
英文版：https://support.huawei.com/enterprise/en/routers/netengine-8000-pid-252772223/multimedia

Thank you