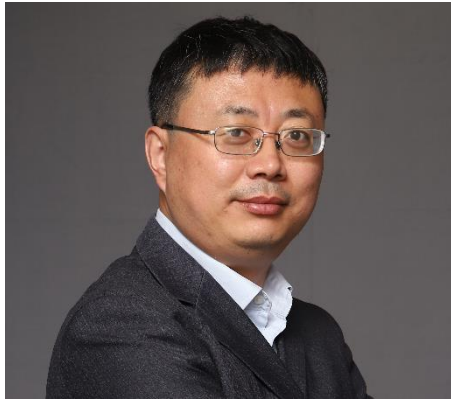


IPv6+创新与标准

李振斌

华为首席标准代表

IETF互联网架构委员会（IAB）委员



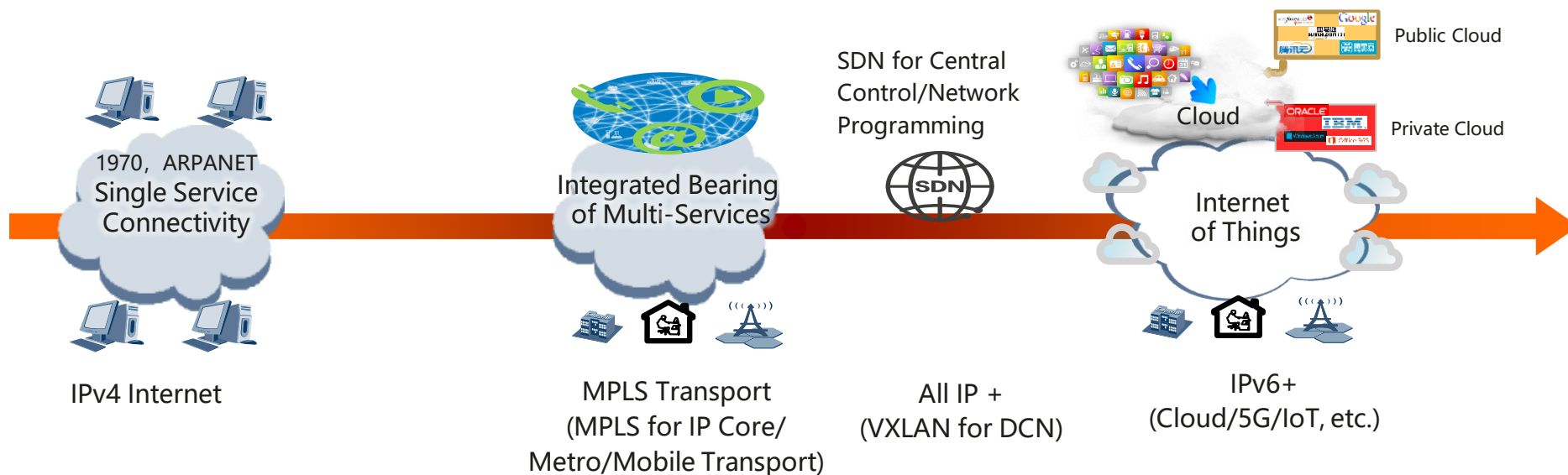
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<https://www.iab.org/about/iab-members/>

- 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。

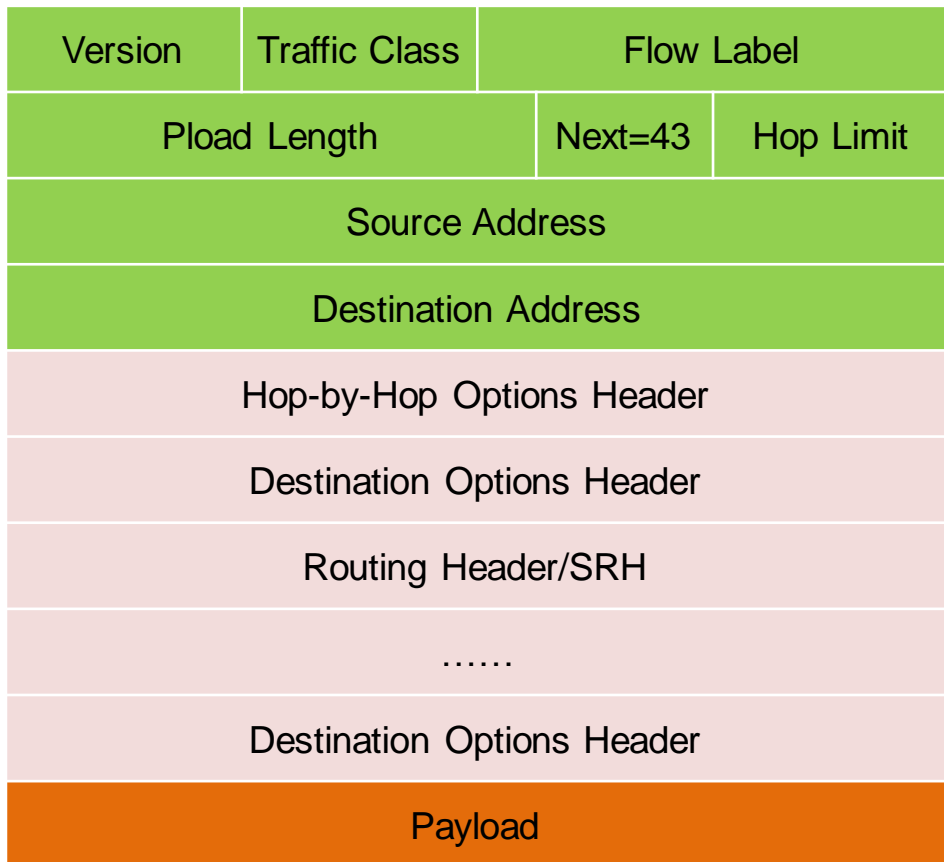
IPv6+: 面向5G和云的IP网络新时代



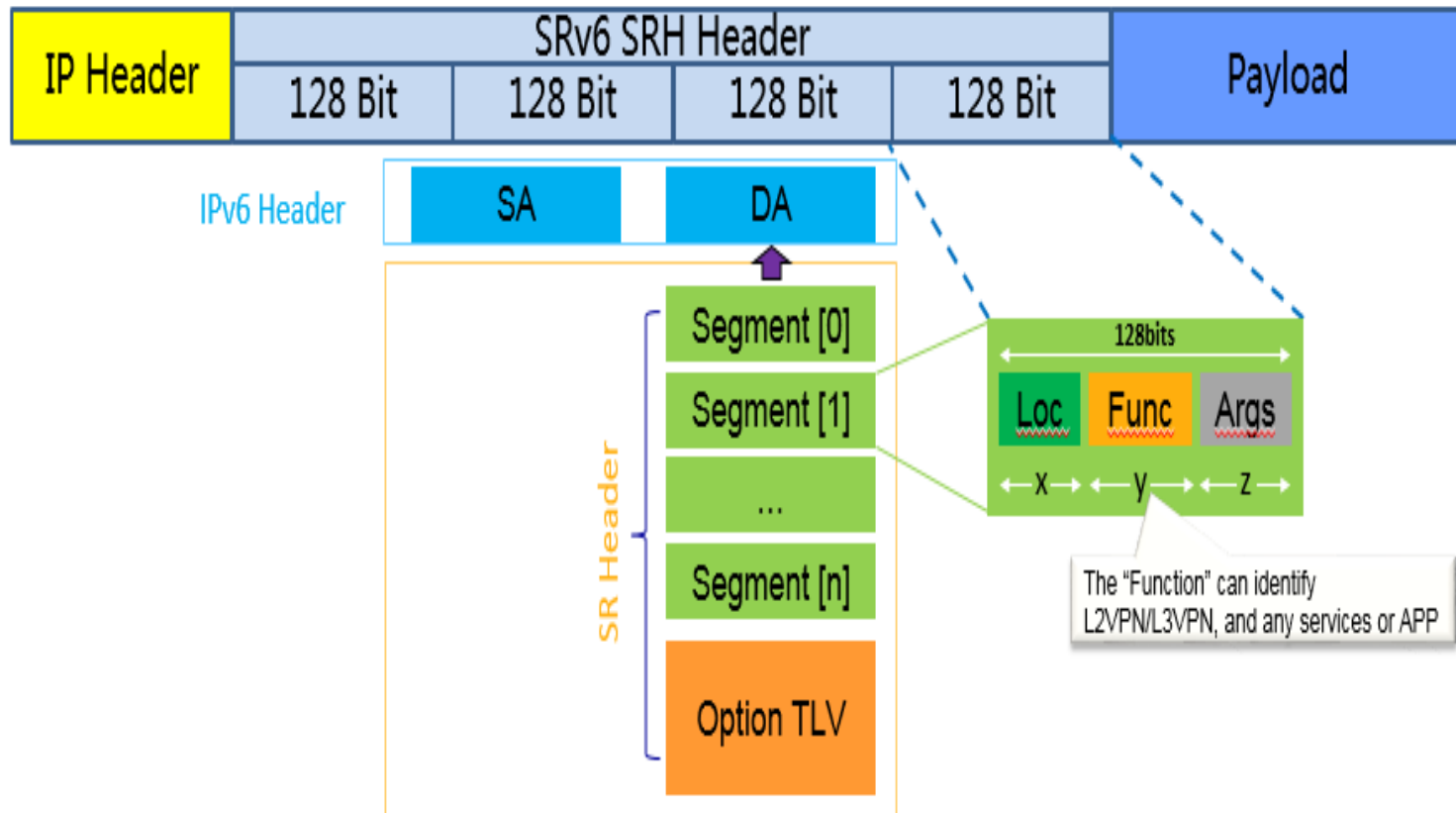
- IPv6重思考：地址空间不足未能强烈驱动IPv6部署
- 5G改变了连接的属性，云改变了连接的范围
- IPv6+的使命：
 - 基于对IP可达性的亲和性，使得不同网络域间连接更容易
 - 基于IPv6扩展头/SRH等可扩展性支持更多种类的封装，满足新业务的需求。
 - 基于对IP亲和性和网络编程能力，实现IP承载网络与应用的融合，提升网络价值。
 - 结合对更多地址空间的需求，进一步推广IPv6

IPv6扩展头/SRv6: 面向未来的网络可编程能力

IPv6 扩展头



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+）

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

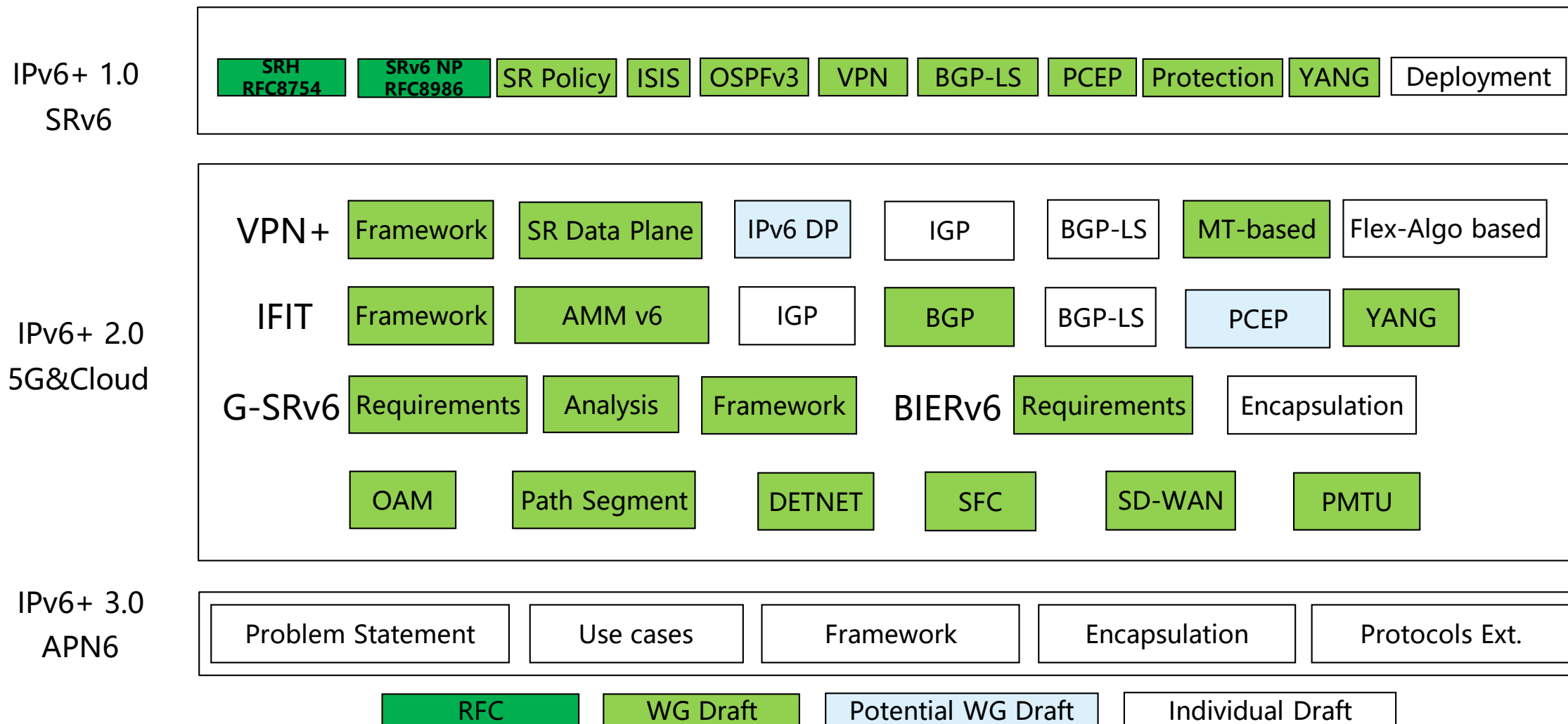
IPv6+ 2.0: 面向5G/云的新应用

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

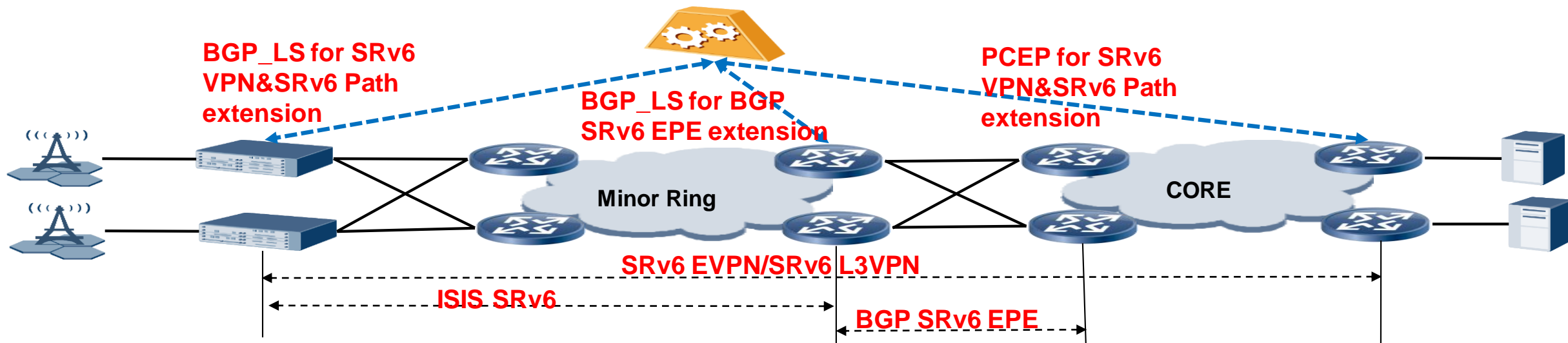
IPv6+ 3.0: APN6 - 感知应用的新网络架构体系

- 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



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

成功完成多厂家SRv6互通测试，商业部署开启

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

- **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
 - Iliad
 - LINE
 - China Telecom
 - China Unicom
 - CERNET2
 - MTN
- See [draft-matsushima-spring-srv6-deployment-status](https://www.huawei.com/press/2019/04/20190420-srv6-deployment-status) for details

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

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

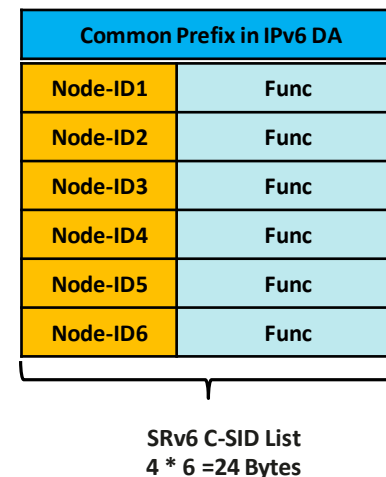
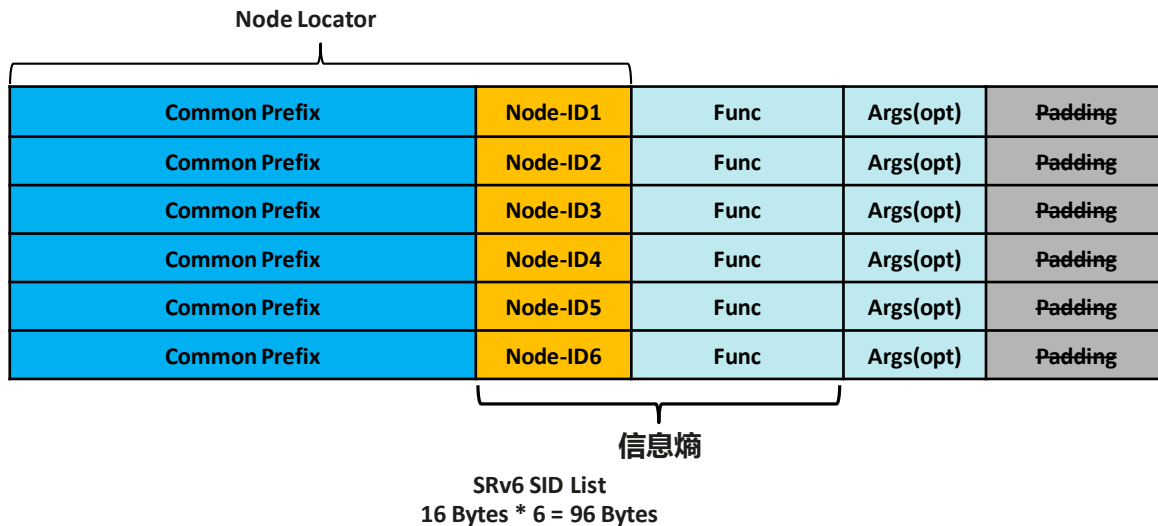
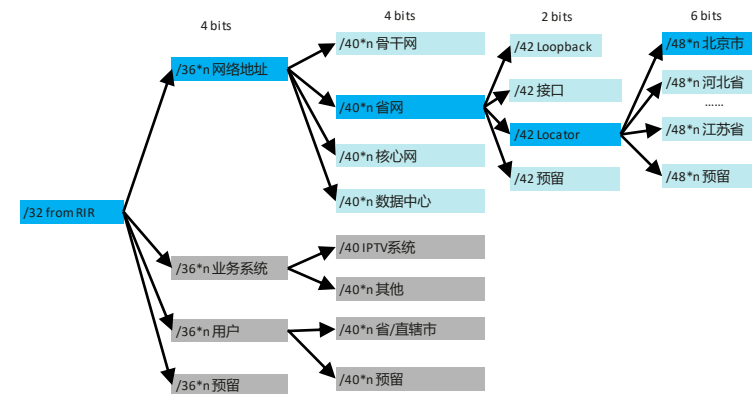
Area	Topic	Draft	Vendors	Operators
Protection	Mid-point Protection	draft-hu-spring-segment-routing-proxy-forwarding	Huawei/Juniper	China Telecom
	Mid-point Protection	draft-chen-rtgwg-srv6-midpoint-protection	Huawei	China Telecom
	Egress Protection	draft-ietf-rtgwg-srv6-egress-protection	Huawei	China 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



G-SRv6压缩原理 (2)

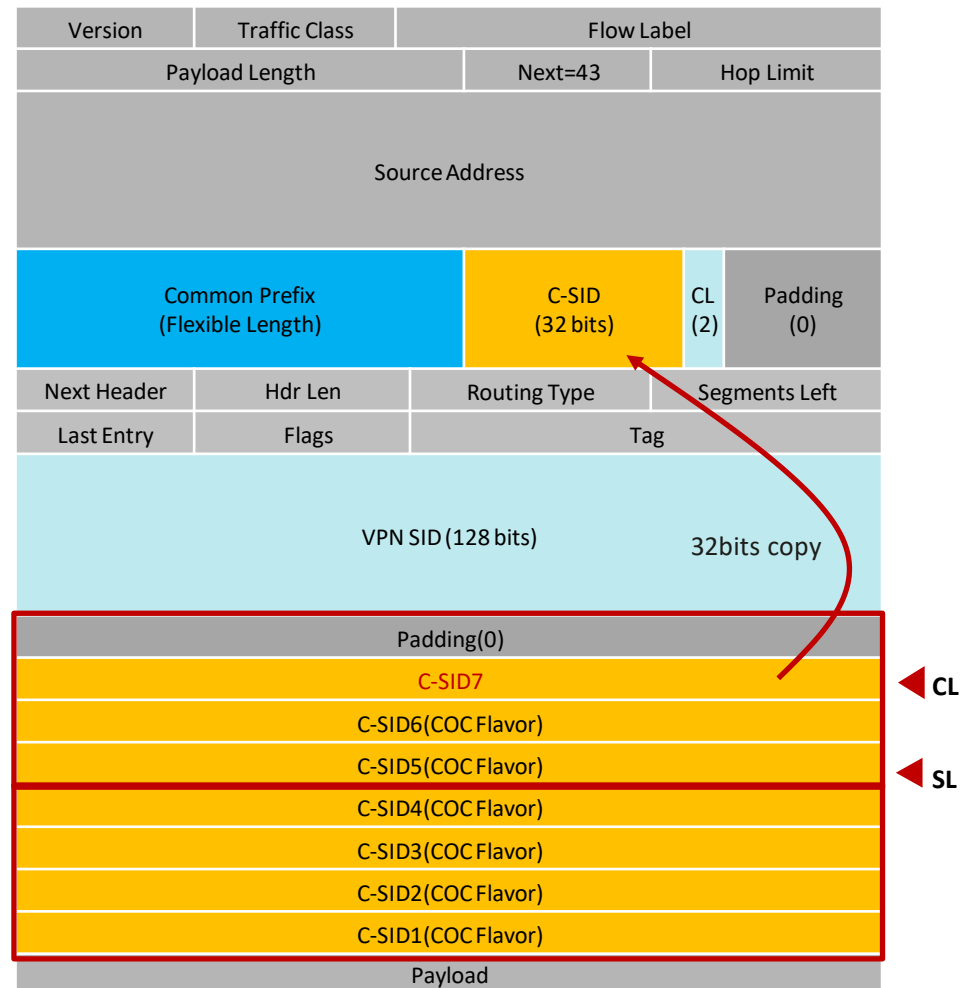
二维数组定位压缩SID

- 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
  
```

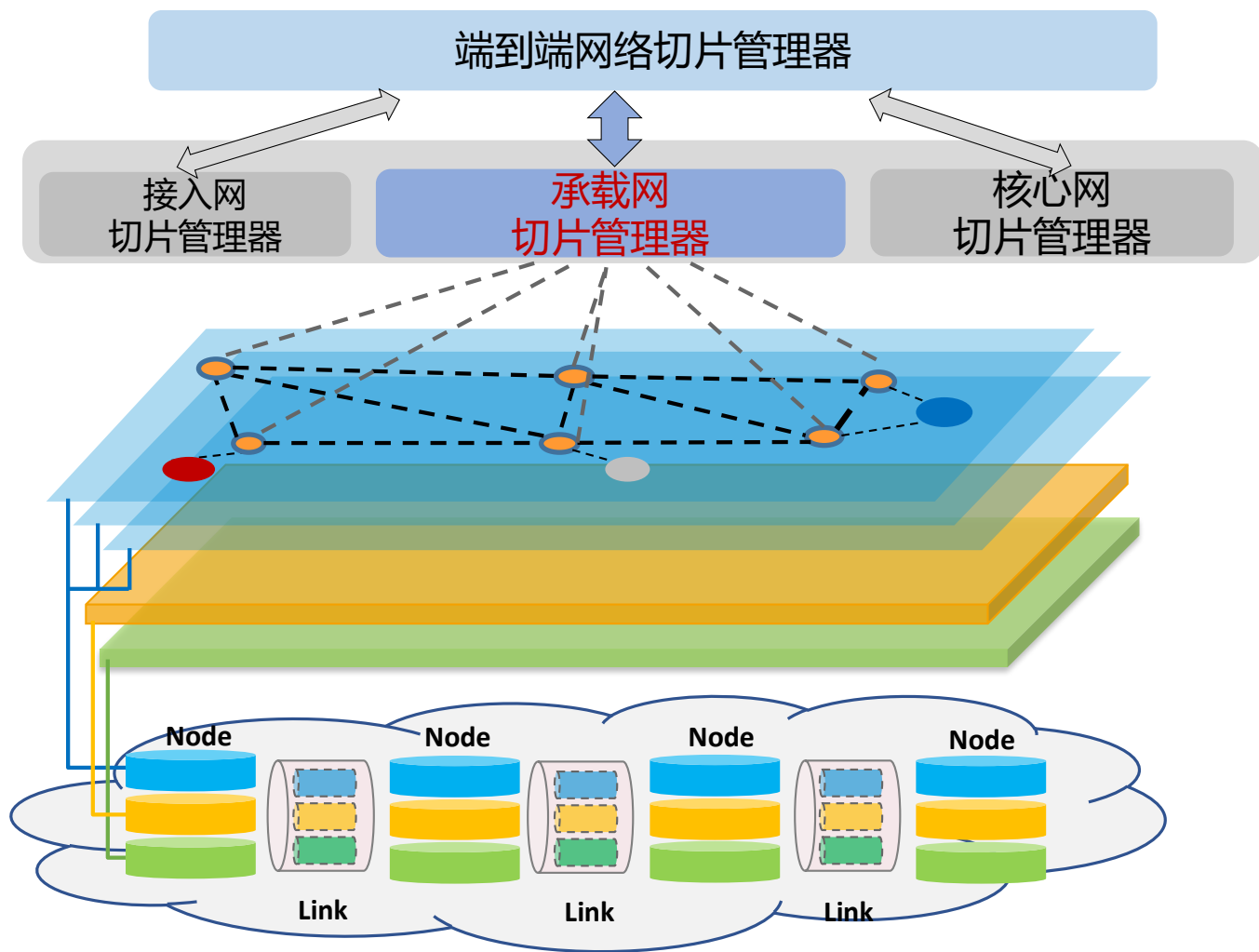


IPv6+ 2.0 (1) SRv6压缩/G-SRv6和Path MTU

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

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

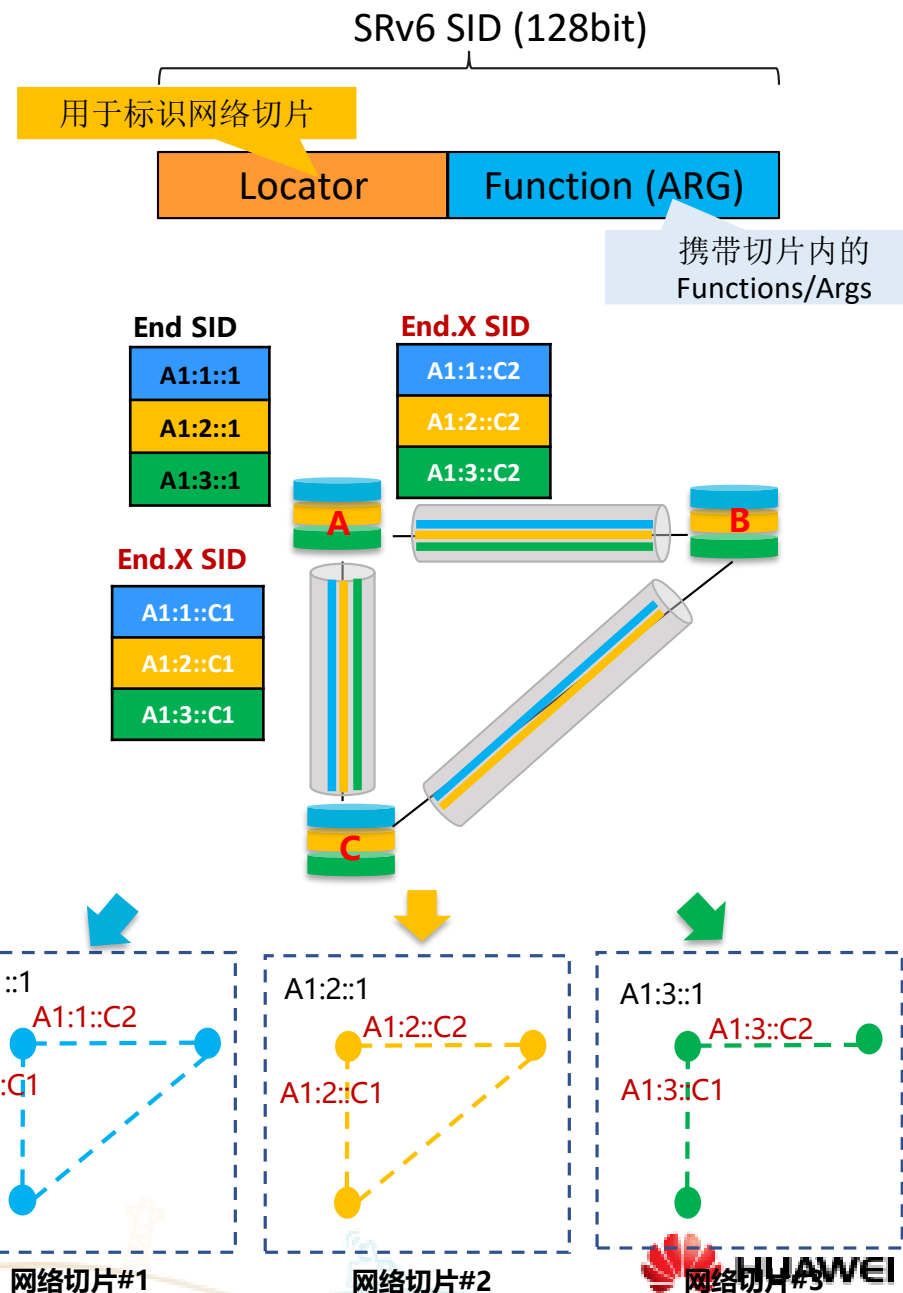
- 扩展协议发布每个网络切片的Locator, SID和资源属性信息
- 收集网络切片拓扑, 计算基于切片约束的转发表项

• IETF VPN+ 标准化进程

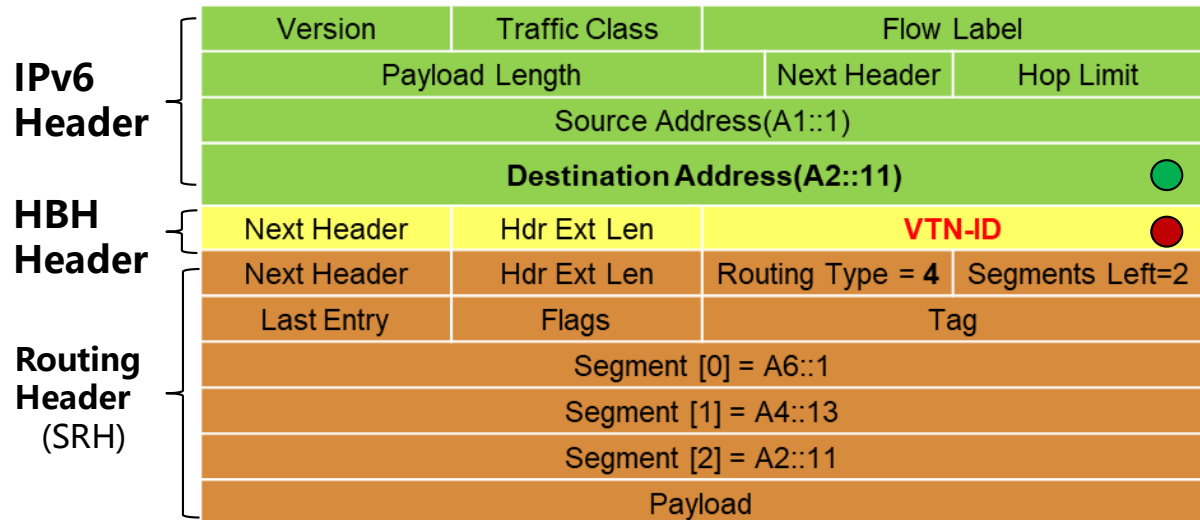
- VPN+ Framework
<https://tools.ietf.org/html/draft-ietf-teas-enhanced-vpn-01> (工作组文稿)
- SR/SRv6 based VPN+
<https://tools.ietf.org/html/draft-ietf-spring-sr-for-enhanced-vpn>
- IGP extensions for SR-based VPN+
<https://tools.ietf.org/html/draft-dong-lsr-sr-enhanced-vpn>

• 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

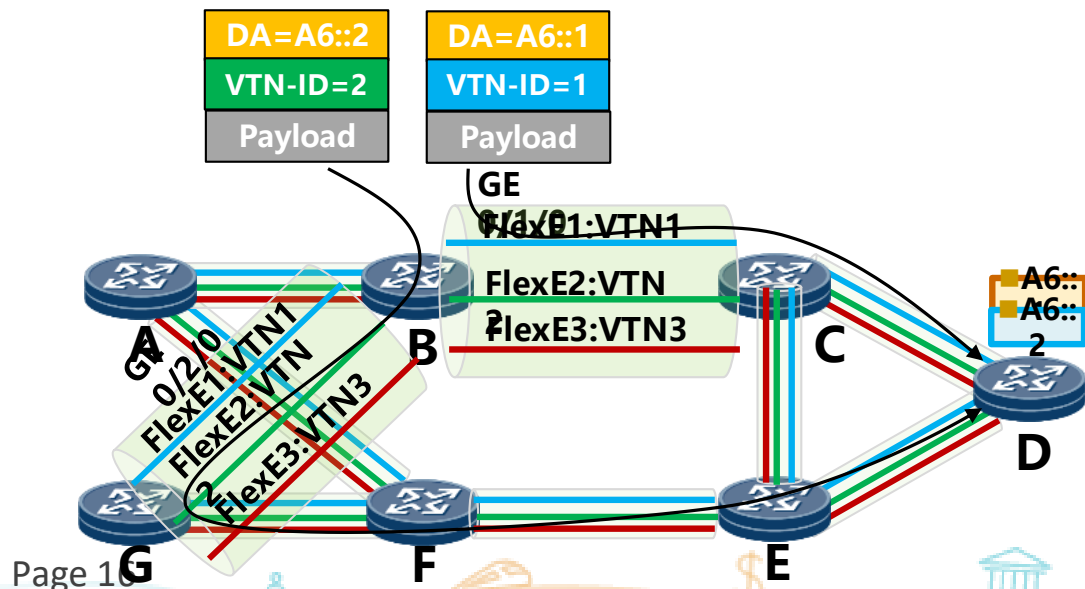


- 数据面使用两种转发标识的组合标识流量的二维转发需求(拓扑、资源)，指导切片报文转发

- 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

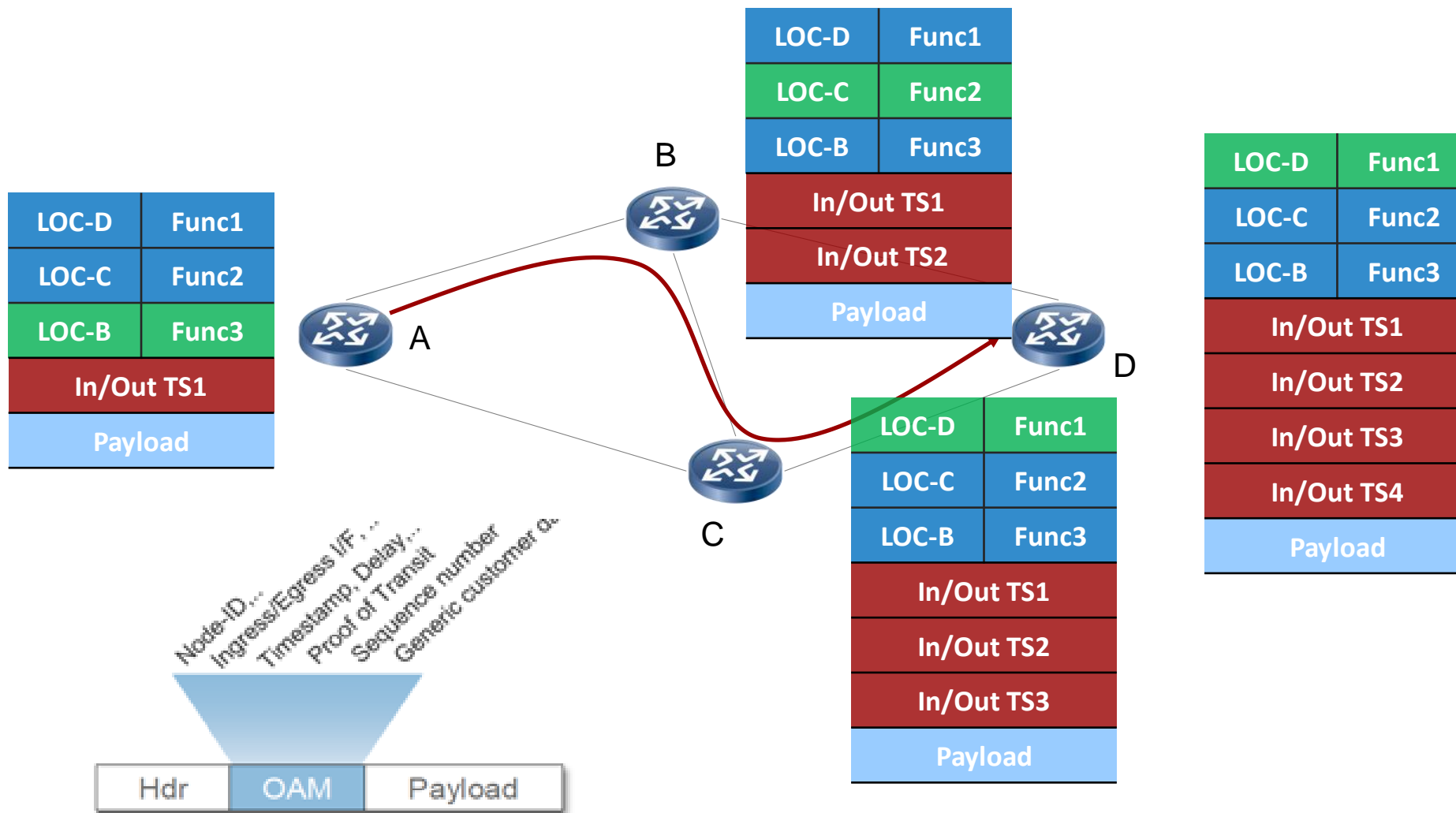
MainIf	VTN-ID	SubIf
GE0/1/0	1	FlexE1
GE0/1/0	2	FlexE2
GE0/1/0	3	FlexE3
GE0/2/0	1	FlexE1
GE0/2/0	2	FlexE2
GE0/2/0	3	FlexE3

IPv6+ 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	
	SR切片	SR for VPN+		draft-ietf-spring-resource-aware-segments 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-bgp-ls-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-bgp-ls-sr-vtn-mt	Huawei	China Telecom
	Slice ID切片	Scalability Considerations for VPN+		draft-dong-teas-enhanced-vpn-vtn-scalability	Huawei	China Mobile
		IPv6 for VPN+		draft-dong-6man-enhanced-vpn-vtn-id	Huawei	China Telecom
		IGP extensions for SR VPN+		draft-dong-lsr-sr-enhanced-vpn	Huawei	China Unicom/LGU+
		BGP-LS extensions for SR-based VPN+		draft-dong-idr-bgp-ls-sr-enhanced-vpn	Huawei	China Unicom
		PCE extensions for SR-based VPN+		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

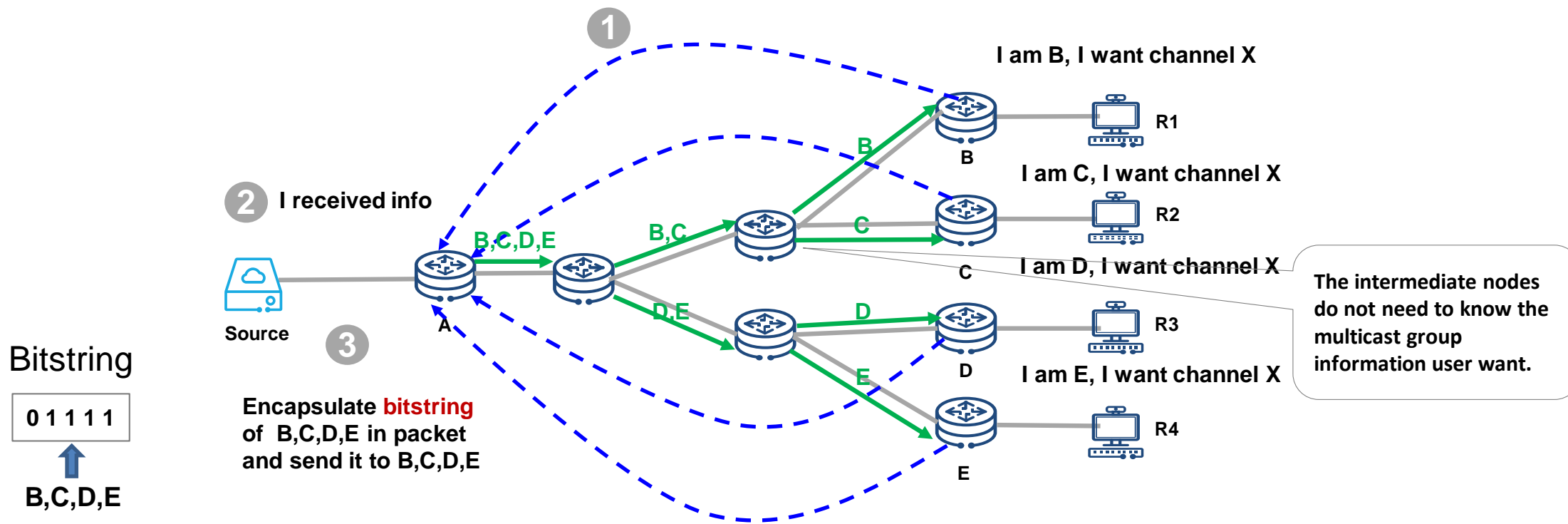


IPv6+ 2.0 (3) IFIT (In-situ Flow Information Telemetry)

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



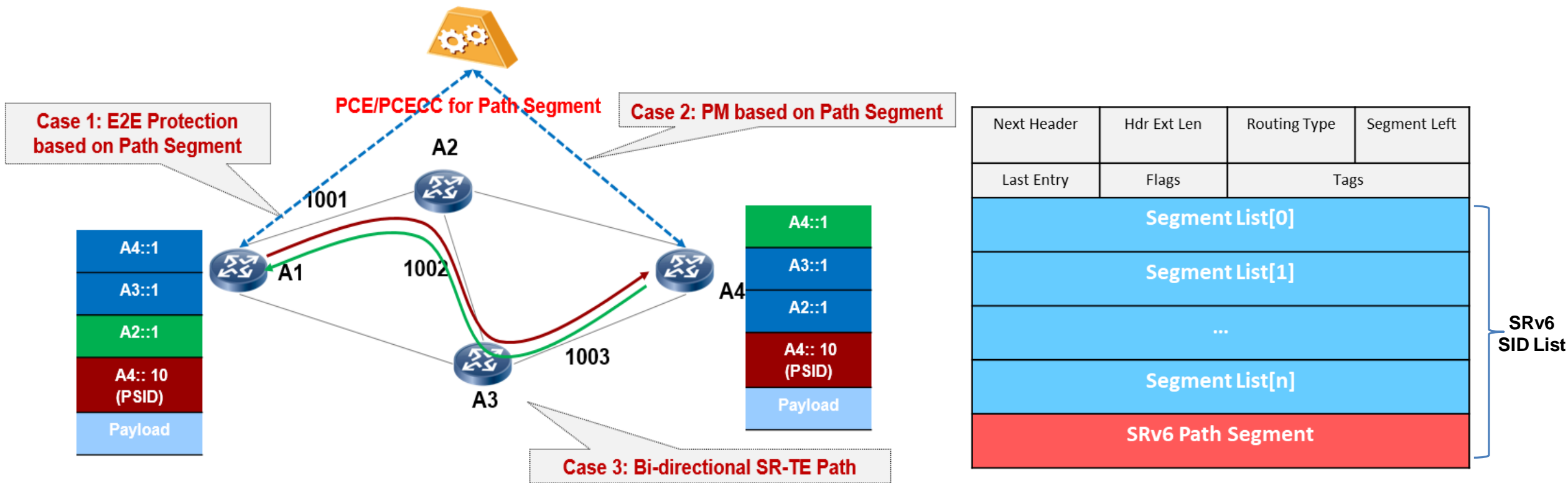
- 基于BitString复制报文到指定的接收者，其中的每个bit代表一个接收者
- 通过在BIER报文头中携带BitString信息，实现无状态组播

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



IPv6+ 2.0 (5) SRv6 OAM and Path Segment

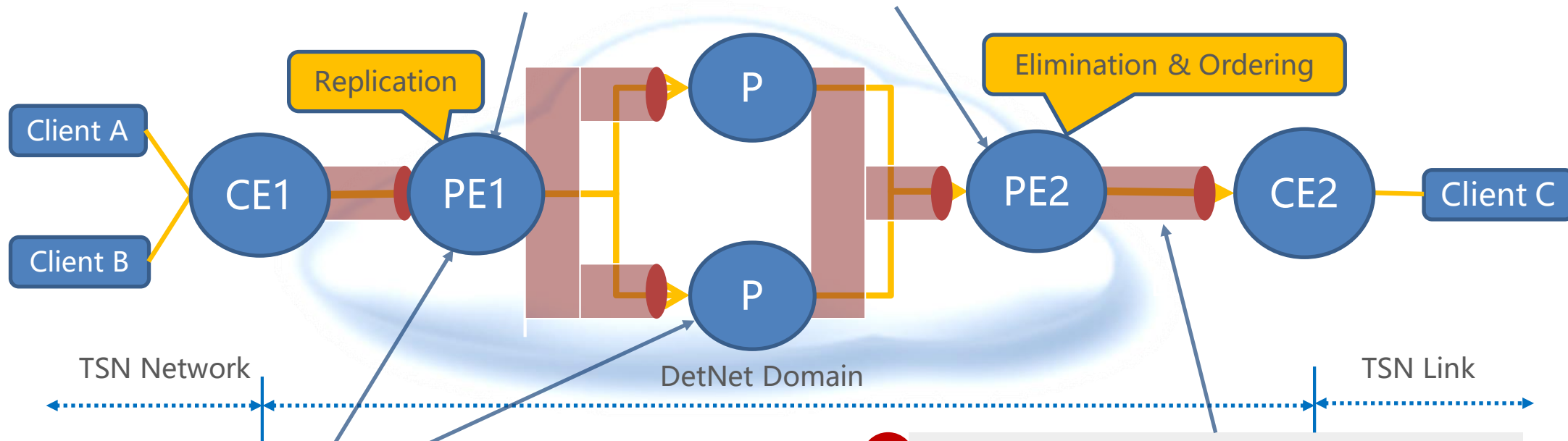
Area	Topic	Draft	Vendors	Operators
OAM	OAM in SRv6	draft-ietf-6man-spring-srv6-oam	Cisco/Huawei	Softbank/Bell Canada
	SRv6 Light iOAM	draft-li-spring-light-weight-srv6-ioam	Huawei	China Mobile
Path Segment	Use cases and Mechanisms of MPLS Path Segment	draft-ietf-spring-mpls-path-segment	Huawei/Cisco	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丢包，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）

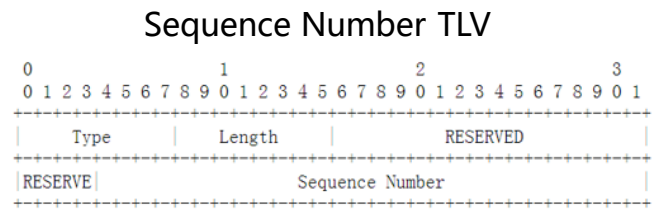
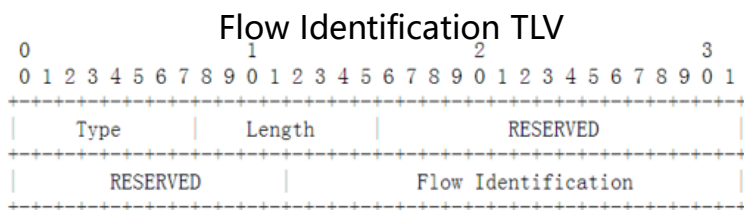
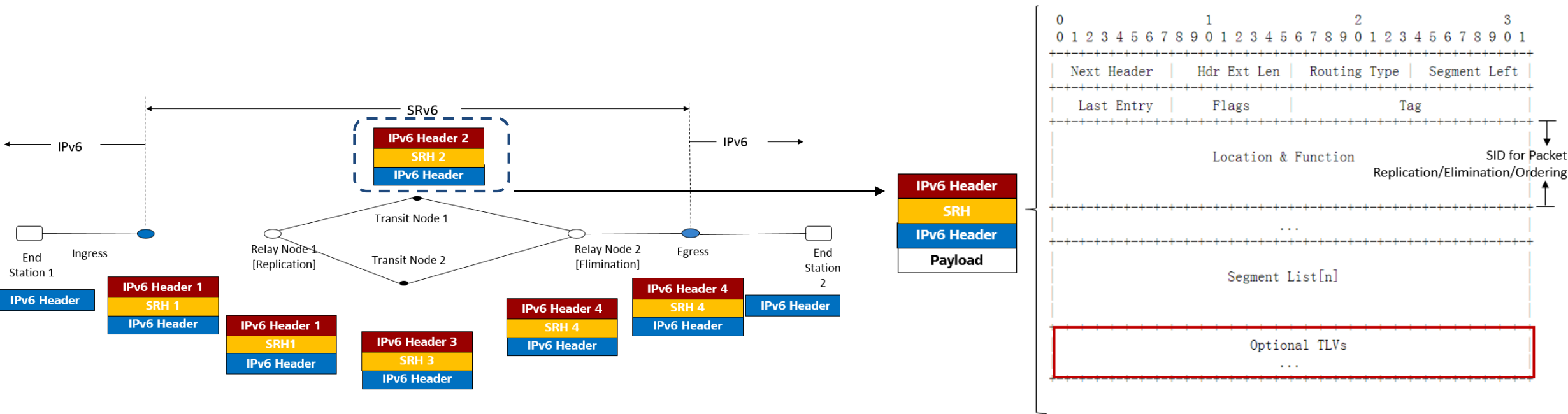
3 显式路径
指定DetNet流量的传输路径，以控制端到端时延

- 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;

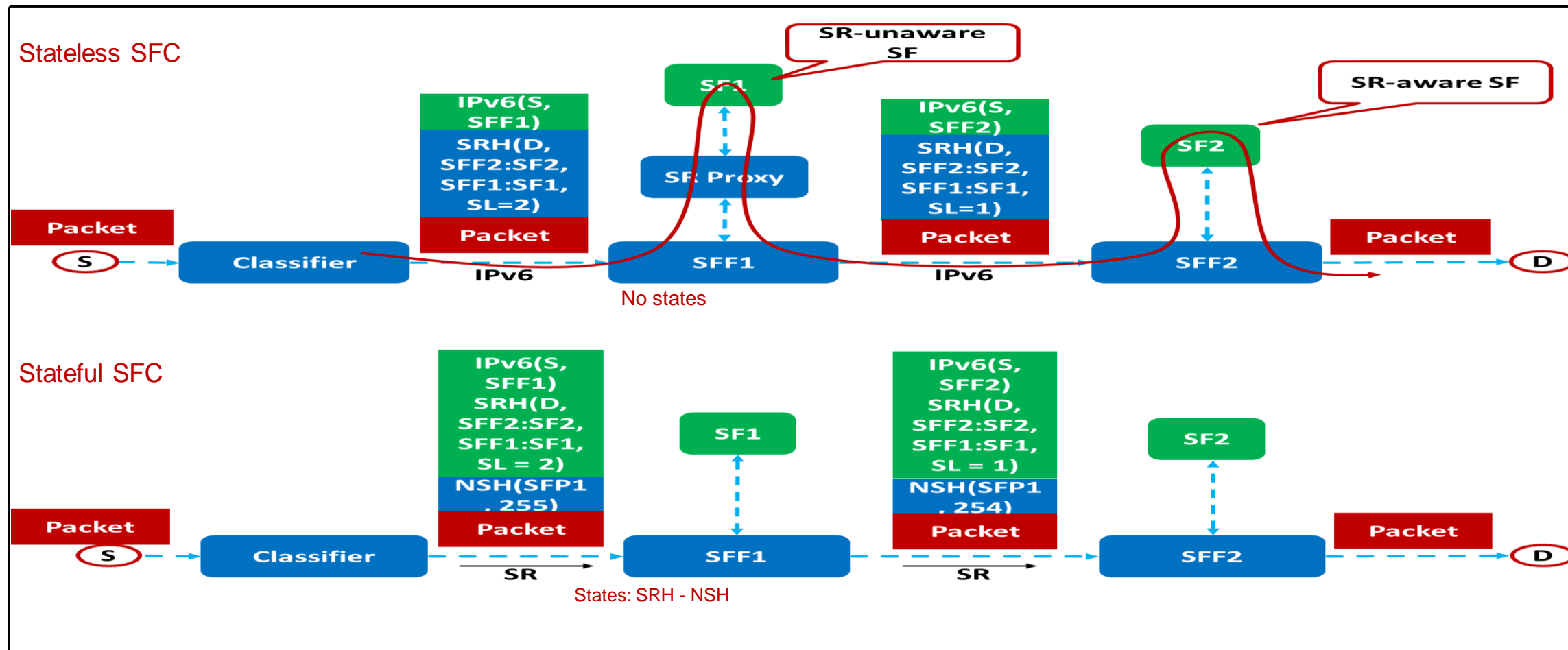


IPv6+ 2.0 (6) DetNet

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/Ericsson	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。

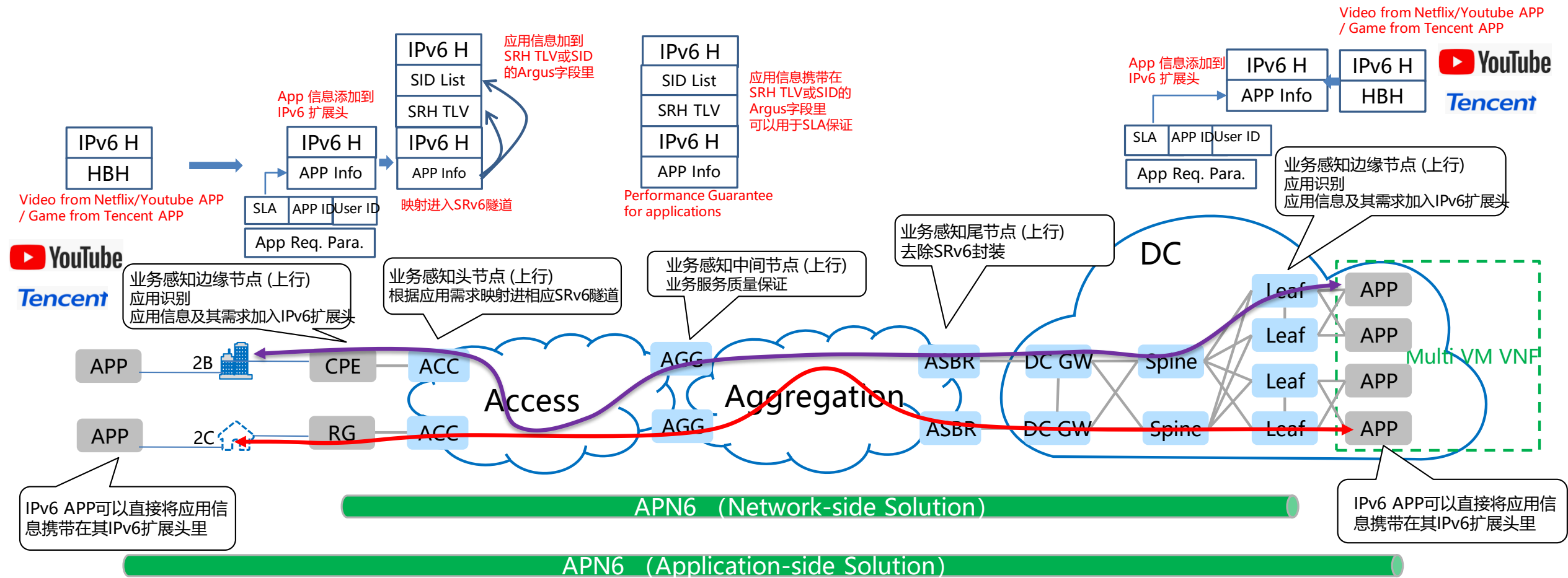
IPv6+ 2.0 (8) SD-WAN/CON

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

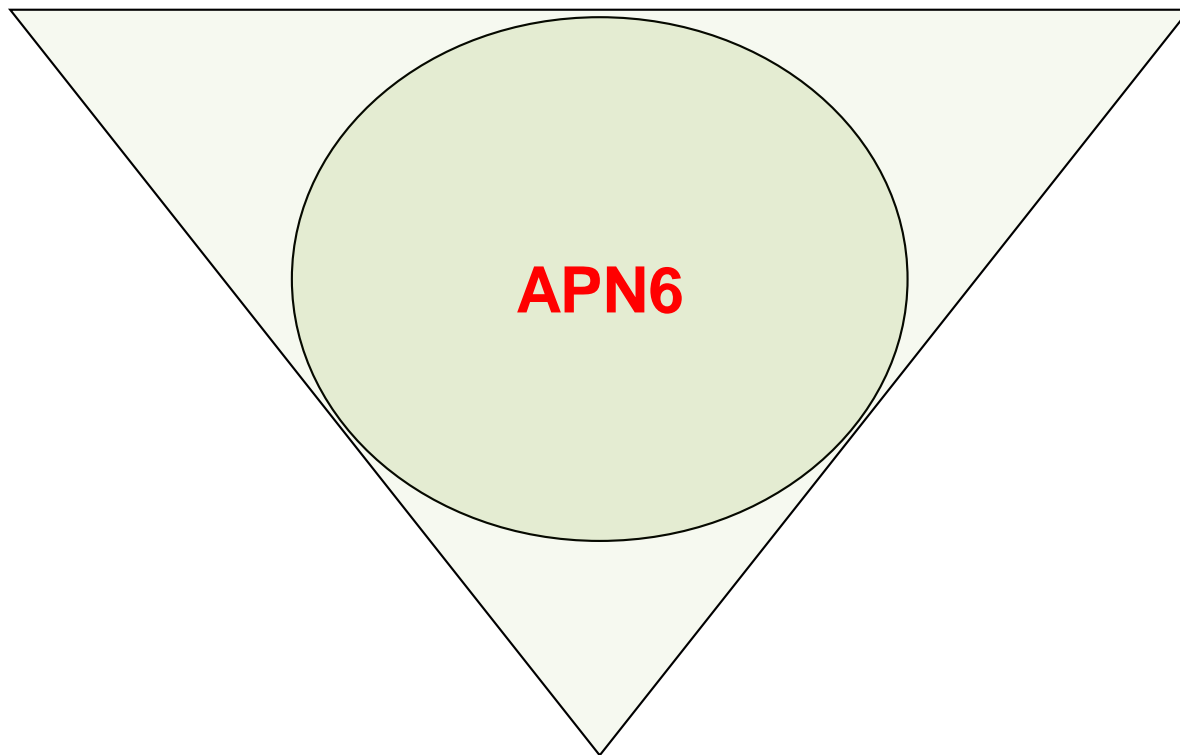
- 利用IPv6扩展头将应用信息及其需求传递给网络
- 根据携带应用信息，通过业务的部署和资源调整来保证应用的SLA要求



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

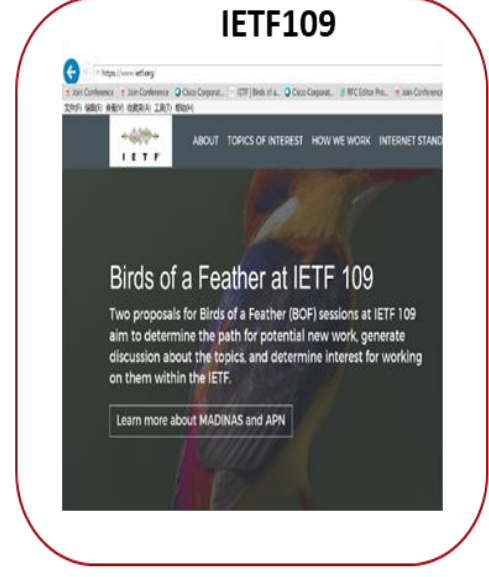
Friday, July 30, 2021		
11:00-18:00	Gather	Secretariat "Registration" Desk
12:00-18:00	Gather	IANA Office Hours
12:00-18:00	Gather	RFC Editor Office Hours
12:00-14:00 Friday Session I		
Room 1	art	webtrans WebTransport
Room 2	int	add Adaptive DNS Discovery
Room 3	irtf	gnia Global Access to the Internet for All
Room 4	ops	mboned MBOONE Deployment
Room 5	rtg	apn Application-aware Networking
Room 6	sec	suit Software Updates for Internet of Things



IETF108

Participants (66)

- Shuping Peng, Huawei
- Adi Moha, Huawei
- Zhenhai Li, Huawei
- Mehdi Beazaf, Lancaster University
- Spencer Dawkins, Tencent America
- Luis M. Contreras, Telefonica
- Luigi Lanzone, Huawei
- Linda Dunbar, Futurewei
- Adrian Farni, Old Dog Consulting
- Rakeeh Ganesh, Cisco
- Munir Ahmad, Bell Canada
- Daniel King
- Jim Guichard, Futurewei
- Daniel Vayer, Bell Canada
- Sara Alkashor, Bell Canada
- Spencer Eckert, Futurewei
- Diego Lopez, Telefonica
- Daniel Bernier, Bell Canada
- Huiyu Song, Futurewei
- Lara Eggert
- Colin Perkins
- Tim Chown, ANZ
- Kiran Mukhija
- Dhiraj Dhodaj, Huawei - India
- Peng Liu, CHCC
- Oscar Gonzalez de Dios, Telefonica
- Brian Trammell, Google
- Shuhuai Zhuang, Huawei
- Yingzhen Qu, Futurewei
- Tom Hill, BT
- Tom Herbert, Intel
- Frode Sorensen, NiKom
- Uma Chanduri, Futurewei Inc., USA
- Dates
- Dawei FAN, Huawei
- Joey Salazar, ARINC151
- Pablo Comarillo, Cisco
- Stefano Previdi, Huawei
- Tali Wang, Huawei
- Georgios Karagannis, Huawei



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

推进IPv6规模部署专家委员会

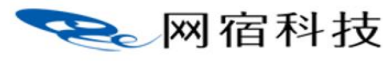
秘书处

IPv6+技术创新工作组

IPv6评测监测工作组

...

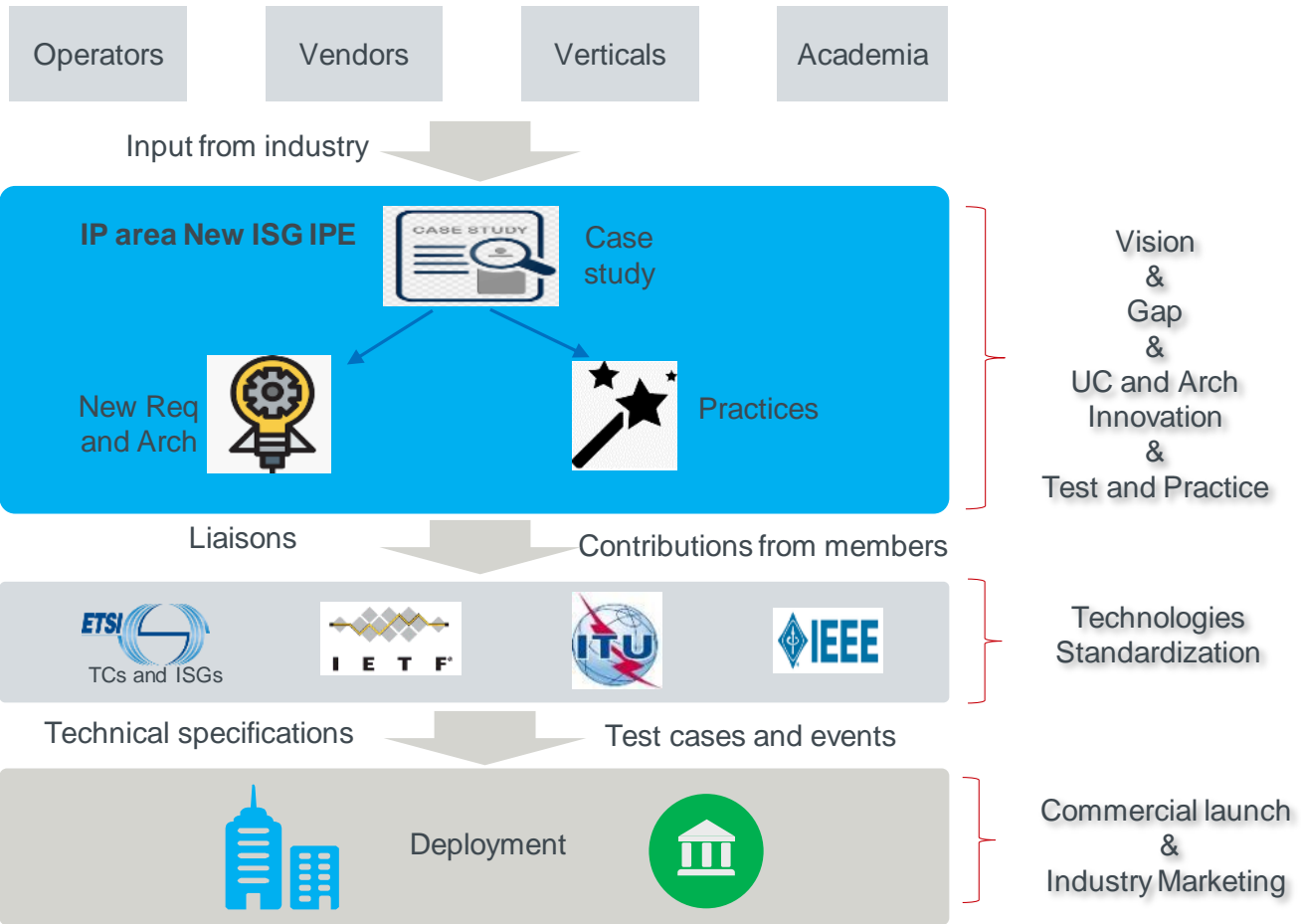
产学研用，多维融合



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



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



Positive feedback

Jointly make an Open Platform for IP Industry

华为在“IPv6+”部署覆盖运营商、金融、政府和教育



全球100+ “IPv6+” 商用部署&创新

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



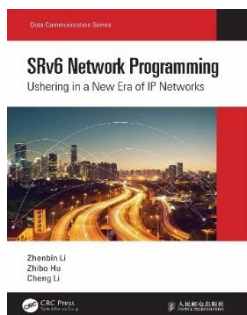
(多媒体) IPv6+系列 01 SRv6的技术原理和产业发展 01



(多媒体) IPv6+系列 04 随流检测FIT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

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