IPv6+创新与标准

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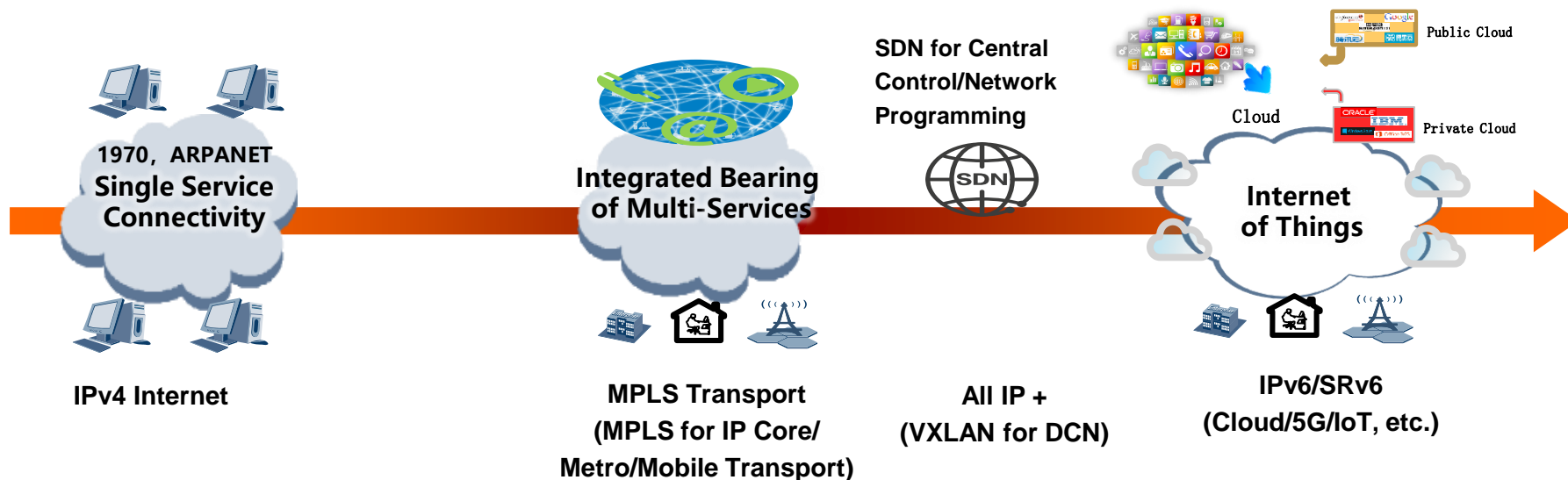
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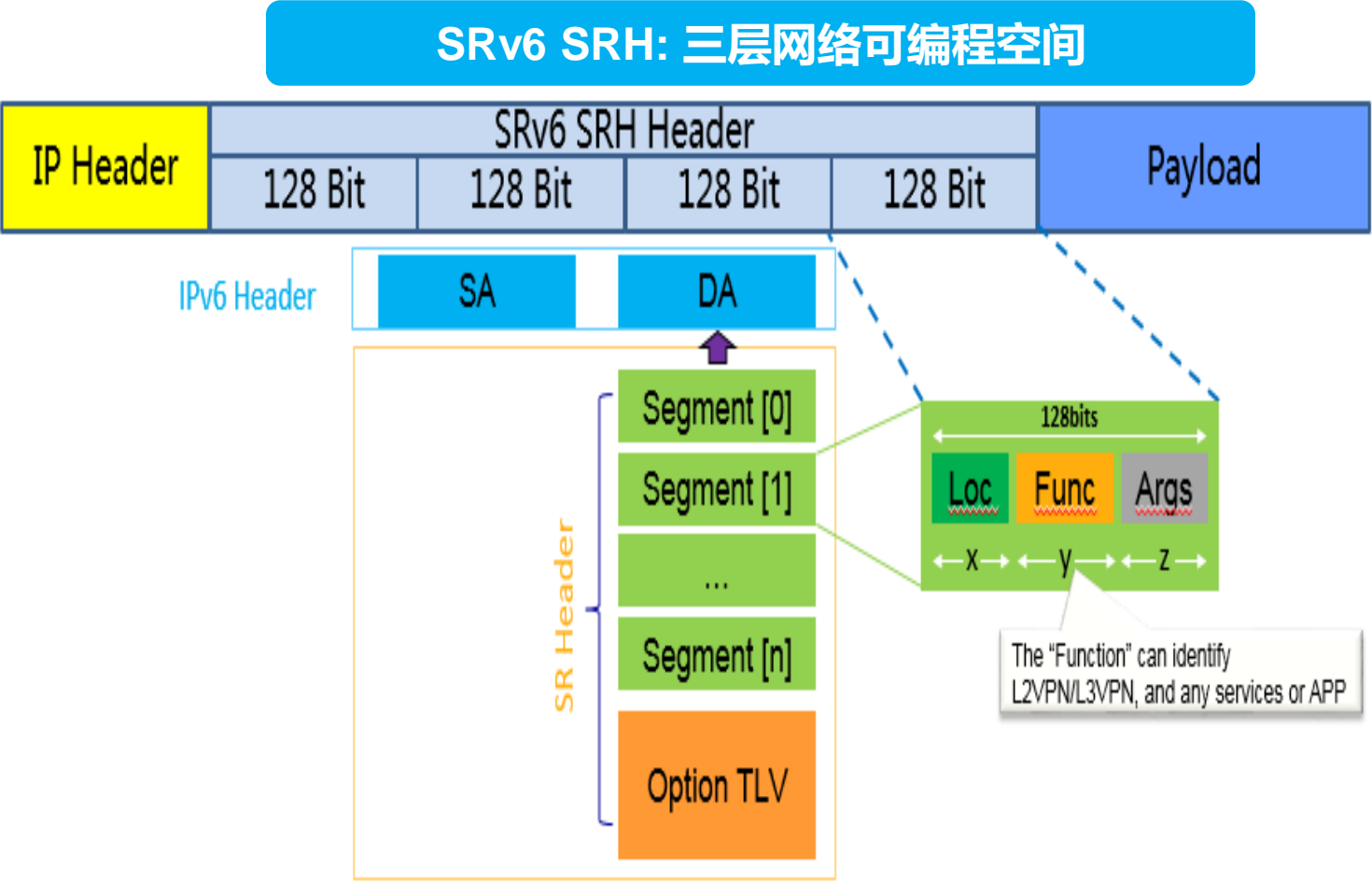https://www.iab.org/about/iab-members/

- 负责华为**IP**协议创新研究和标准化工作。
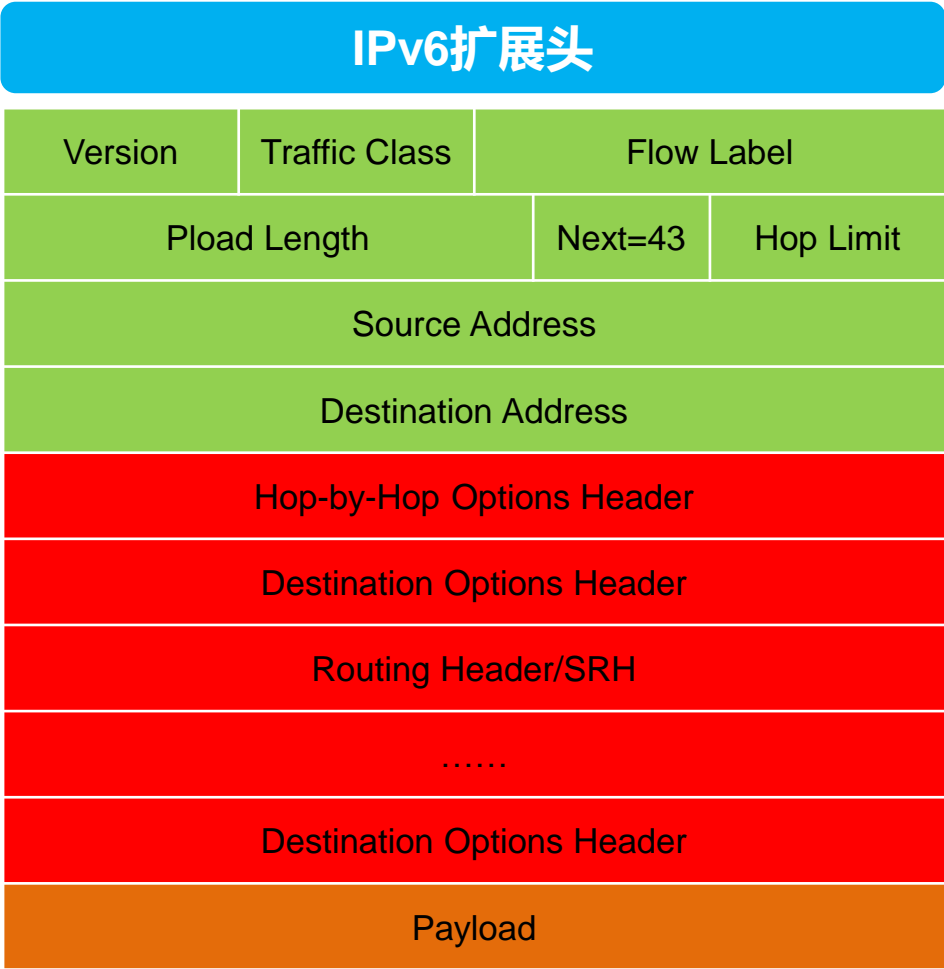- **2000**年加入华为，曾负责华为**IP**操作系统（**VRP**）和**MPLS**子系统的架构设计和开发工作。
- **2015 - 2017**年担任**SDN**架构师，负责控制器的研究、架构设计与开发等工作。
- 自**2009**年起积极参与**IETF**标准创新工作，持续推动了**SDN**的**BGP**、**PCEP**、**Netconf/YANG**等的协议创新和标准化。当前研究的重点包括**SRv6**、**5G**承载、**Telemetry**、网络智能等。
- 主导和参与的**IETF RFC/**草案累计**100**余篇(**www.ipv6plus.net/ZhenbinLi**)，申请专利**110**多项。
- **2019**年当选**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。

IPv6+: 面向5G和云的IP网络新时代

SDN for Central Control/Network Programming

1970, ARPANET
Single Service Connectivity

Integrated Bearing of Multi-Services

Cloud

Public Cloud

Private Cloud

Internet of Things

IPv4 Internet

MPLS Transport
(MPLS for IP Core/ Metro/Mobile Transport)

All IP +
(VXLAN for DCN)

IPv6/SRv6
(Cloud/5G/IoT, etc.)

- **IPv6重思考：地址空间不足未能强烈驱动IPv6部署**

- **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，进一步推动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			

SRv6 SRH: 三层网络可编程空间

IP Header	SRv6 SRH Header				Payload
	128 Bit	128 Bit	128 Bit	128 Bit	

IPv6 Header: SA | DA

SR Header:
- Segment [0]
- Segment [1]
- …
- Segment [n]
- Option TLV

128bits

Loc | Func | Args

x | y | z

The "Function" can identify L2VPN/L3VPN, and any services or APP

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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+**
- **OAM**
- **SFC**

- **In-situ Telemetry/IFIT**
- **Path Segment**
- **SD-WAN**

- **BIERv6**
- **Detnet**
- **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**

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IPv6+标准整体布局与进展

IPv6+ 1.0 SRv6

| SRH RFC8754 | SRv6 NP WGLC | SR Policy | ISIS | OSPFv3 | VPN | BGP-LS | PCEP | Protection | YANG | Deployment |

IPv6+ 2.0 5G&Cloud

VPN+

| Framework | SR Data Plane | IPv6 DP | IGP | BGP-LS | MT-based | Flex-Algo based |

IFIT

| Framework | AMM v6 | ISIS | OSPFv3 | BGP-LS | PCEP | YANG |

BIERv6

| Requirements | Encapsulation | ISIS | BGP | MVPN | OAM | YANG |

| OAM | Path Segment | DETNET | SFC | SD-WAN | PMTU | G-SRv6 |

IPv6+ 3.0 APN6

| Problem Statement | Use cases | Framework | Encapsulation | Protocols Ext. |

Legend:

| RFC | WG Draft | Potential WG Draft | Individual Draft |

www.ipv6plus.net 提供更多标准进展信息

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IPv6+ 1.0 (1) SRv6基础特性

Area	Topic	Draft	Vendors	Operators
Architecture	SRv6 Network Programming	draft-ietf-spring-srv6-network-programming (WGLC)	Cisco/Huawei	Comcast/Bell Canada/Softbank
	SRv6 NET-PGM extension: Insertion	draft-filsfils-spring-srv6-net-pgm-insertion	Cisco/Huawei	SoftBank
SRH	**IPv6 Segment Routing Header (SRH)**	**RFC8754**	Cisco/Huawei	Bell Canada/Softbank
	Deployments With Insertion of IPv6 Segment Routing Headers	draft-voyer-6man-extension-header-insertion-08	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	Cisco/Huawei	
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 ext. for SRv6	draft-ietf-idr-segment-routing-te-policy	Cisco/Huawei/Juniper	Microsoft/Google
	PCEP for SRv6	draft-ietf-pce-segment-routing-ipv6	Cisco/Huawei	China Telecom

- **SRH正式发布成为RFC。**
- **SRv6基础特性全部接纳成为工作组草案。**

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 BGP Yang	draft-raza-bess-srv6-services-yang	Cisco	Orange/Softbank
	SRv6 ISIS Yang	draft-hu-isis-srv6-yang	Cisco/Huawei	
	SRv6 OSPF Yang	draft-hu-lsr-ospf-srv6-yang	Cisco/Huawei	
	SRv6 PCEP Yang	draft-li-pce-pcep-srv6-yang	Cisco/Huawei	
	SRv6 VPN YANG	draft-raza-bess-srv6-services-yang	Cisco	Softbank/Orange

- **SRv6 YANG模型标准化与应用部署同步展开。**
- **SRv6基础YANG模型和SR Policy YANG模型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尾节点保护接纳成为工作组草案。**
- **SRv6逐渐形成规模化部署，网络部署经验通过草案进行共享。**

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IPv6+ 2.0 (1) Network Slicing and VPN+

Area	Topic	Drafts	Vendors	Operators
Network Slicing	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 for VPN+	draft-ietf-spring-resource-aware-segments	Huawei/Cisco	China Mobile/China Telecom/KDDI
	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-bgpls-sr-enhanced-vpn	Huawei	China Unicom
	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-xie-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

- 承载网络切片成为各方参与的热点，并成立了Design Team。经过各方讨论对网络切片的概念和框架基本达成一致，相关草案正在请求工作组接纳。
- SR VPN+草案被工作组接纳，Segment用于指示资源获得各方认同。
- 网络切片的可扩展性问题成为进一步技术研究的重点。

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IPv6+ 2.0 (2) 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 TelecomSKT/LGU+
Basic Encap	Data Fields for In-situ OAM	draft-ietf-ippm-ioam-data	Cisco/Huawei	Bell Canada
	Export User Flow Telemetry Data by Postcard Packets	draft-song-ippm-postcard-based-telemetry	Huawei	SKT/LGU+
	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 Encapsulation for SFC and IFIT	draft-li-6man-ipv6-sfc-ifit	Huawei	LGU+
	IPv6 Application of the Alternate Marking	draft-ietf-6man-ipv6-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-qin-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-zhou-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。

IPv6+ 2.0 (3) BIERv6

Area	Topic	Drafts	Vendors	Operators
BIERv6	BIERv6 Requirements	draft-ietf-bier-ipv6-requirements-03	Huawei	
	BIERv6 Encapsulation	draft-xie-bier-ipv6-encapsulation-03	Huawei/Cisco	China Mobile/China Unicom/China Telecom/LGU+/Verizon
	BIERv6 MVPN	draft-xie-bier-ipv6-mvpn-01	Huawei	China Mobile
	IS-IS for BIER6	draft-xie-bier-ipv6-isis-extension-00	Huawei	China Telecom
	BIERv6 Inter-domain	draft-geng-bier-ipv6-inter-domain-00	Huawei	China Mobile
	BIERv6 YANG	draft-geng-bier-bierv6-yang	Huawei	China Unicom

- **BIERv6需求已经成为工作组草案，还需要进一步讨论达成更多认同。**

- **BIERv6封装草案获得更多合署，并在邮件列表进行了广泛的讨论。**

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IPv6+ 2.0 (4) 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 for IOAM	draft-ali-spring-ioam-srv6	Cisco/Huawei	Linkedin
	SRv6 Light iOAM	draft-li-spring-light-weight-srv6-ioam	Huawei	China Mobile
Path Segment	Use cases 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-ietf-idr-bgp-ls-sr-policy-path-segment	Huawei	
	Path Segment in PCEP	draft-ietf-pce-sr-path-segment	Huawei/Cisco	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 Path Segment Encapsulation	draft-li-6man-srv6-path-segment-encap	Huawei	China Mobile

- **SRv6 OAM被工作组接纳，正在申请工作组Last Call。**
- **SR Path Segment多篇草案被工作组接纳，SRv6 Path Segment是下一步工作重点。**

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IPv6+ 2.0 (5) DetNet

Area	Topic	Drafts	Vendors	Operators
DetNet	SR for bound latency	draft-chen-detnet-sr-based-bounded-latency-00	Huawei	China Mobile
	SRv6 for bounded latency	draft-geng-detnet-srv6-based-bounded-latency-00	Huawei	
	DetNet SRv6 Data Plane Encapsulation	draft-geng-detnet-dp-sol-srv6-01	Huawei	China Telecom
	SRv6 for DetNet	draft-geng-spring-srv6-for-detnet-00	Huawei	
	DetNet Configuration YANG Model	draft-ietf-detnet-yang-04	Huawei, Cisco	China Mobile
	DetNet Topology YANG Model	draft-ietf-detnet-topology-yang-00	Huawei, Cisco	China Mobile
	DetNet Controller Plane Framework	draft-malis-detnet-controller-plane-framework-02	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和SRv6的DetNet草案正在持续推动过程中。**

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IPv6+ 2.0 (6) SFC and SD-WAN

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-dawra-idr-bgp-ls-sr-service-segments-02	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
SD-WAN	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

- **SR SFC的数据面草案已经成熟，控制面是下一步的工作重点。**
- **SRv6 SDWAN正在推动过程中。**

IPv6+ 2.0 (7) SRv6压缩/G-SRv6和Path MTU

Area	Topic	Drafts	Vendors	Operators
Compression	Shorter SRv6 SID Requirements	draft-cheng-spring-shorter-srv6-sid-requirement	Huawei/Cisco/ZTE	China Mobile/China Telecom
	Generalized SRv6 Network Programming	draft-cl-spring-generalized-srv6-np	Huawei	China Mobile/China Telecom
	Generalized Segment Routing Header	draft-lc-6man-generalized-srh	Huawei	China Mobile/China Telecom
	Generalized SRv6 Network Programming for Compression	draft-cl-spring-generalized-srv6-for-cmpr	Huawei/Cisco/ZTE	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/Bell Canada/Alibaba
	Micro SID	draft-filsfils-spring-net-pgm-extension-srv6-usid	Cisco	Bell Canada, Saudi Telecom, etc.
	Compressed Routing Header	draft-bonica-spring-srv6-plus	Juniper, Ericsson	NTT, Liquid Telecom
PMTU	Segment Routing Path MTU in BGP	draft-ietf-idr-sr-policy-path-mtu	Huawei	STC/China Telecom
	BGP-LS Extensions for Advertising Path MTU	draft-zhu-idr-bgp-ls-path-mtu-01	Huawei	China Telecom
	PMTU in PCEP	draft-li-pce-pcep-pmtu-00	Huawei	
	PMTU in ISIS	draft-hu-lsr-isis-path-mtu-00	Huawei	China Telecom

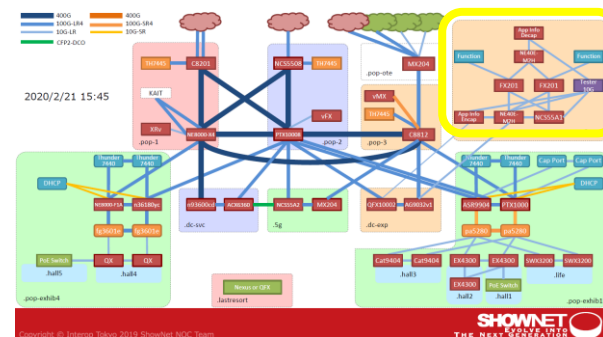- **SRv6压缩是当前SPRING工作组的热点，已经有多个方案，成立了Design Team来协调达成一致。**
- **国内多运营商/厂商就G-SRv6压缩方案逐步达成一致，正在IETF推动。**
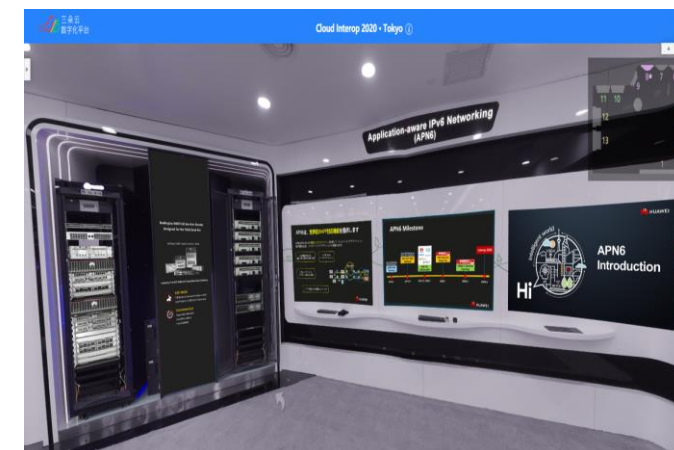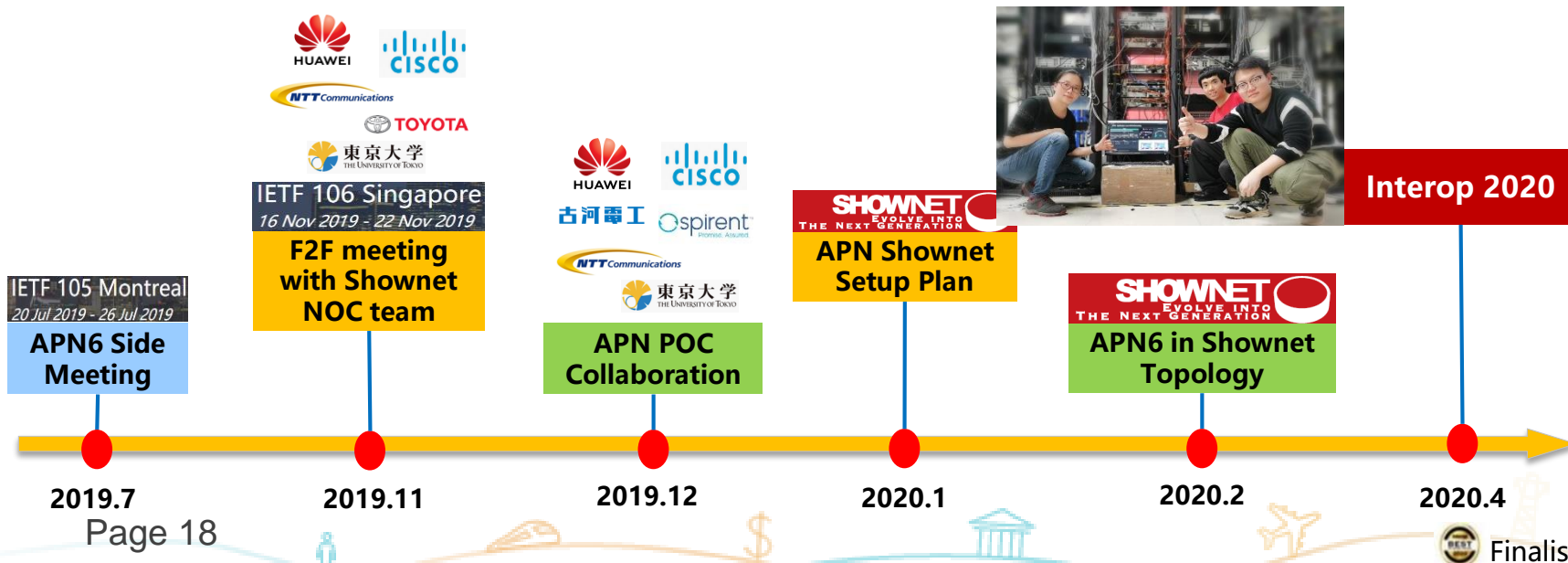
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IPv6 3.0: APN6

AreaA	Topic	Drafts	Vendors	Operators
APN6	Problem Statement and Use Cases of Application-aware IPv6 Networking (APN6)	draft-li-apn6-problem-statement-usecases	Huawei	Bell Canada/China Mobile/China Unicom/China Telecom
	Application-aware IPv6 Networking (APN6) Framework	draft-li-apn6-framework	Huawei	Bell Canada/China Mobile/China Unicom/China Telecom
	APN for Edge Computing	draft-liu-apn-edge-usecase	Huawei	China Mobile
	APN for Game Acceleration	draft-zhang-apn-acceleration-usecase	Huawei	China Unicom
	Application-aware IPv6 Networking Encapsulation	draft-li-6man-app-aware-ipv6-network	Huawei	Bell Canada/China Mobile/China Unicom/China Telecom/Tsinghua

- 发表APN INFOCOM 2020论文：**https://infocom.info/day/2#Demo-Session-4**

- **APN POC 入围Finalist @Interop Tokyo2020**：**https://github.com/APN-Community/APN6-Interop2020**

- **IETF 108成功举办第二次APN Side Meeting: https://github.com/APN-Community/IETF108-Side-Meeting-APN**

- **IETF108举办APN Hackathon，展示了APN特性：https://1drv.ms/u/s!AlsZ1mjF7rg4ywU7nCHbniBHwr2h?e=ubZa1H**

- **IETF创建APN邮件列表（apn@ietf.org）：为业界提供APN集中讨论平台，吸引更多产业力量加入支持APN发展**

- **APN的产业生态稳步扩大：更多信息可以访问https://github.com/APN-Community/**

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APN6 @Interop Tokyo2020

HUAWEI · CISCO · Spirent Promise. Assured. · NTT Communications · 古河電工 · 東京大学 THE UNIVERSITY OF TOKYO

Interop 20 Tokyo

SHOWNET EVOLVE INTO THE NEXT GENERATION

HUAWEI · CISCO
NTT Communications · TOYOTA
東京大学 THE UNIVERSITY OF TOKYO

IETF 106 Singapore
16 Nov 2019 - 22 Nov 2019

F2F meeting with Shownet NOC team

HUAWEI · CISCO
古河電工 · Spirent Promise. Assured.
NTT Communications
東京大学 THE UNIVERSITY OF TOKYO

SHOWNET EVOLVE INTO THE NEXT GENERATION

APN Shownet Setup Plan

SHOWNET EVOLVE INTO THE NEXT GENERATION

Interop 2020

IETF 105 Montreal
20 Jul 2019 - 26 Jul 2019

APN6 Side Meeting

APN POC Collaboration

APN6 in Shownet Topology

| 2019.7 | 2019.11 | 2019.12 | 2020.1 | 2020.2 | 2020.4 |

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Finalist

[Interop to Cloud – APN6 Shownet](#)

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SRv6新书发布与IPv6+产业活动

正式发布

专业团队打造
- IETF互联网架构委员会委员
- 数通首席架构师
- 数通首席IP研究专家

传播实践经验
- 网络规划与设计
- 部署、调测与优化
- 网络运维与应用分析

ETSI IPv6+ Webinar

ETSI IPv6白皮书发布，推动IPv6+创新

https://www.etsi.org/newsroom/news/1814-2020-08-etsi-ipv6-white-paper-outlines-best-practices-challenges-benefits-and-the-way-forward

IPv6+网站

https://www.ipv6plus.net/

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Thank you