IPv6+ Innovation and Standards

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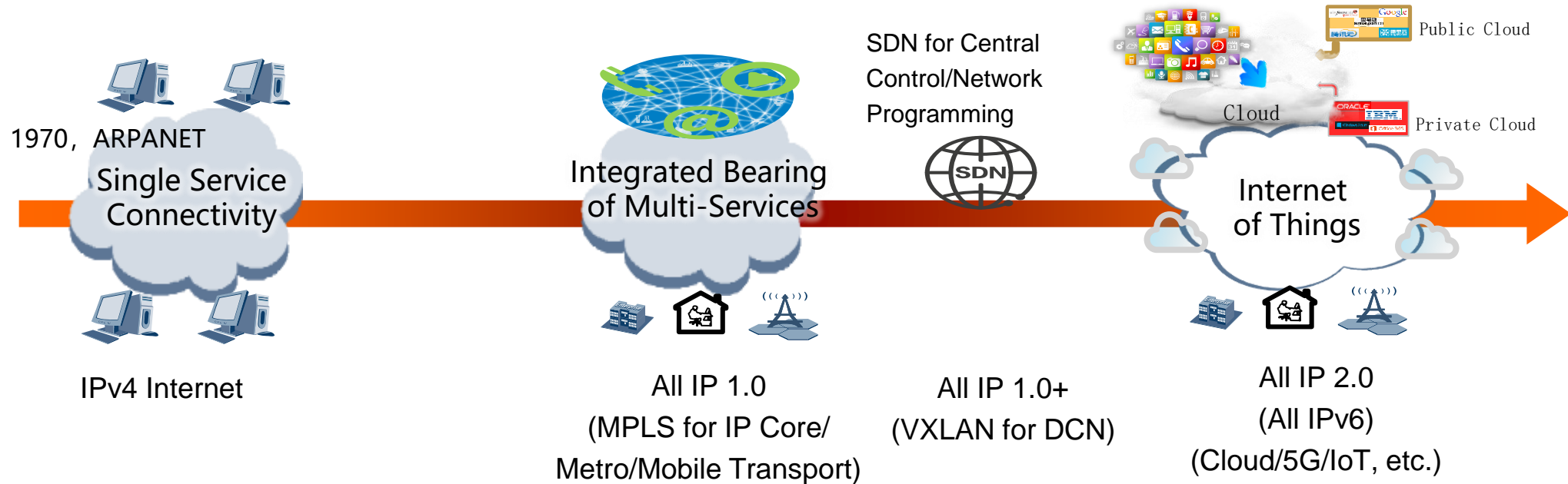
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https://www.iab.org/about/iab-members/

- Head of Huawei IP research and standard work.
- 15+ years research and development work in Huawei IP Operating System (VRP) and SDN Controller as the system architect.
- Be active in standard activities since IETF75 and propose 100+ drafts/RFCs in RTG/OPS areas (www.ipv6plus.net/ZhenbinLi).
- Promote SDN Transition (Netconf/YANG, BGP/PCEP, etc.) innovation and standard work in the past 6 years.
- Focus on the innovation standard work of SRv6, 5G Transport, Telemetry, Network Intelligence, etc. since 2016.
- Be elected as the IETF IAB member to be responsible for Internet architecture work from 2019 to 2021.
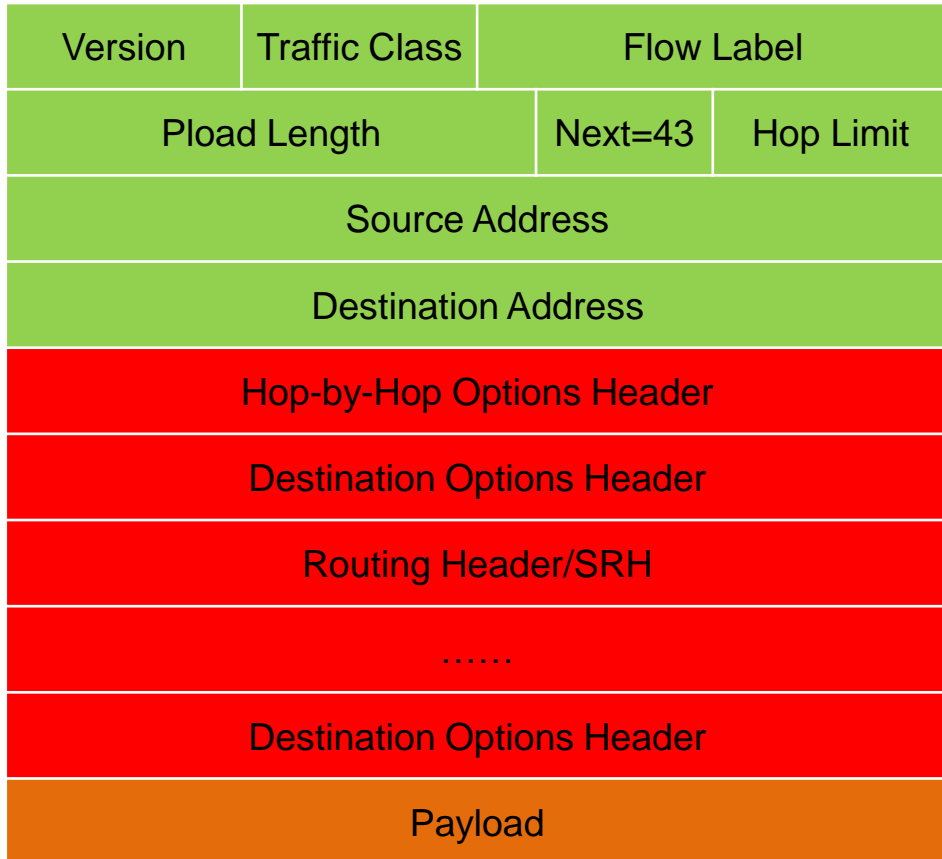
IPv6+: A New Era of IP Networks for 5G and Could

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

All IP 1.0
(MPLS for IP Core/
Metro/Mobile Transport)

All IP 1.0+
(VXLAN for DCN)

All IP 2.0
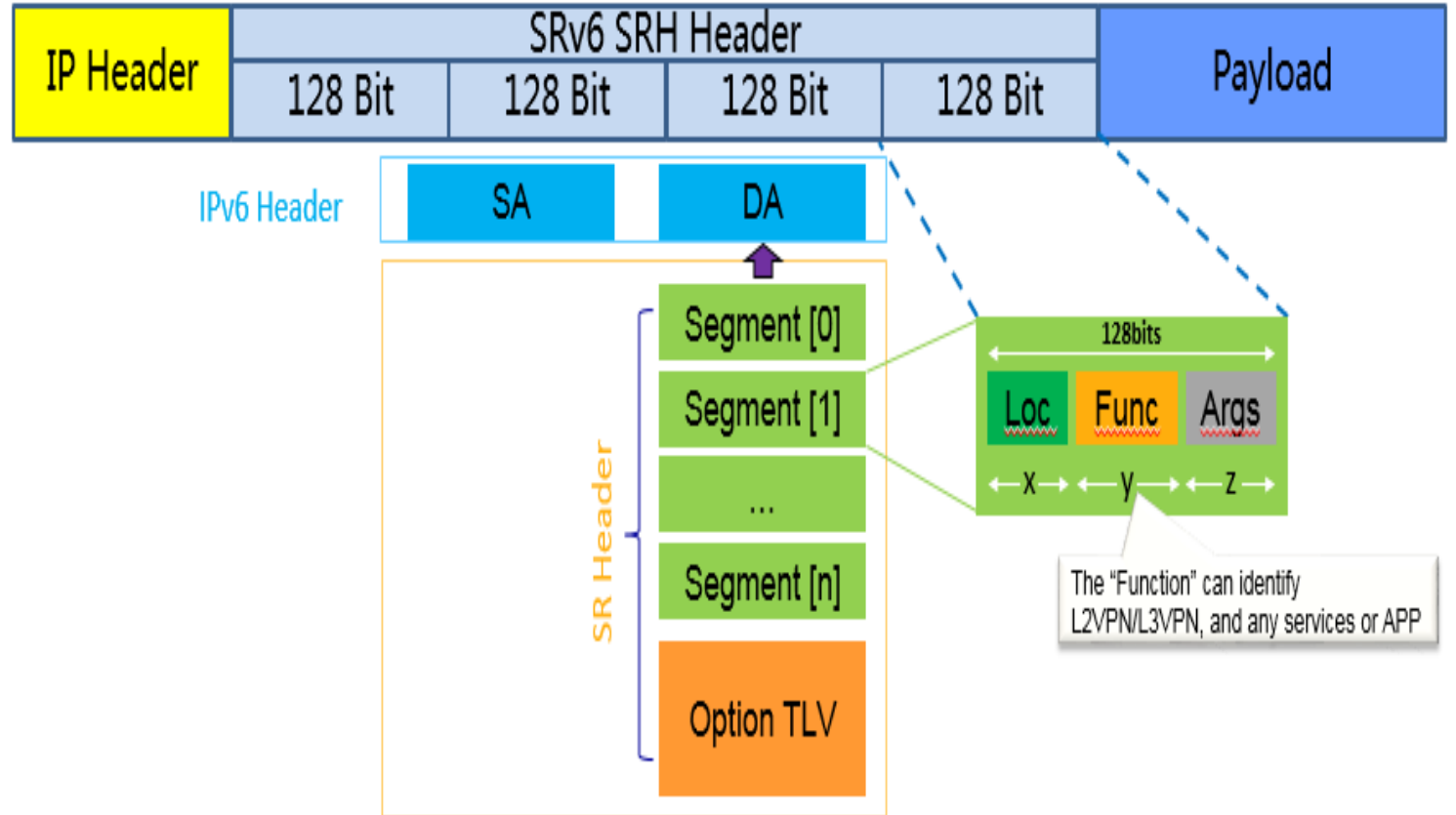(All IPv6)
(Cloud/5G/IoT, etc.)

- Rethinking on IPv6: Address Space is not enough.

- Mission of IPv6+:

  □ Integrate different network easier based on affinity to IP reachability.

  □ Provide more encapsulations for new network services such as Network Slicing, DetNet, etc.

  □ Cross the chasm between application and network based on affinity to IP and Network Programming conveying application information through IPv6 Extension Header into network.

  □ Promote IPv6 combining with requirements on more address spaces.

IPv6 Extension Headers and SRv6: Release Network Programming Capabilities

IPv6 Extension Headers

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: Three Layers of Programming Spaces

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

IPv6+ Research and Standard Planning

IPv6+ 1.0： SRv6 Basic Capabilities

- SRv6 VPN
- SRv6 TE
- SRv6 FRR

IPv6+ 2.0 ： New Network Services for 5G/Cloud
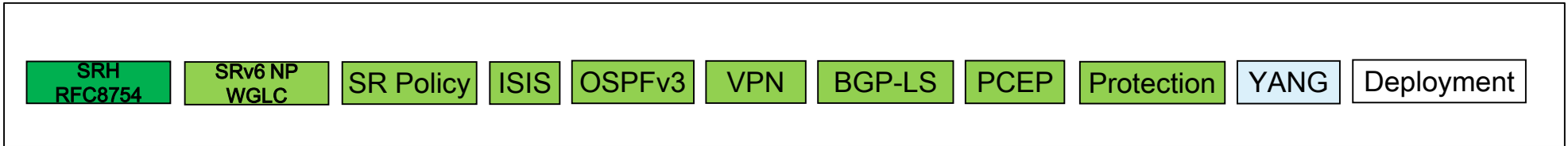
- Network Slicing/VPN+
- In-situ Telemetry/IFIT
- BIERv6

- OAM
- Path Segment
- Detnet

- SFC
- SD-WAN
- SRv6 Compression/G-SRv6

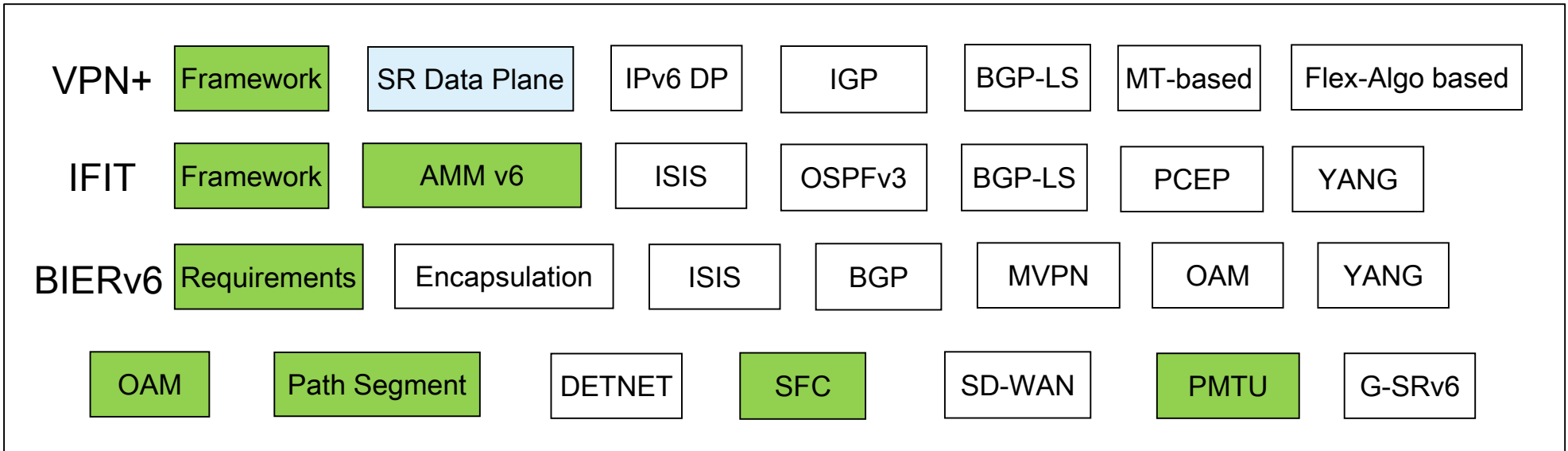**IPv6+ 3.0： APN6 – App-aware network architecture**

- Forwarding Plane： Conveying Application information via IPv6 extension header
- Control Plane： Exchange Application information through control protocols
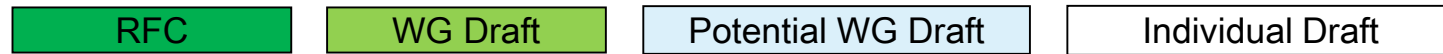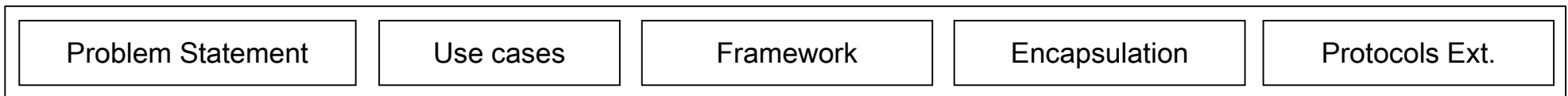
IPv6+ Standardization Work Layout

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. |

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

Please visit www.ipv6plus.net for the latest progress

IPv6+ 1.0 (1) SRv6 Basic Capabilities

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 has been published as RFC.**
- **SRv6 basic features are accepted as WG draft.**
- **SRv6 deployment fundamentals have become mature to some extent.**

IPv6+ 1.0 (2) SRv6 Yang Models

Area	Topic	Draft	Vendors	Operators
Yang Models	SRv6 Base Yang	draft-raza-spring-srv6-yang	Cisco/Huawei/Infinera/ Ciena/Ericsson	Bell Canada/ Softbank
	SRv6 TE Yang (SR Policy Yang)	draft-raza-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 EVPN YANG	Incorporated by draft-raza-bess-srv6-services-yang		

- **SRv6 YANG standardization moves on in parallel with the deployments.**
- **SRv6 BASE YANG and TE YANG is in the mid of application towards WG draft**

IPv6+ 1.0 (3) SRv6 E2E Protection and Deployments

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
	SRv6 Compatibility	draft-peng-spring-srv6-compatibility	Huawei	China Telecom
SRv6 Security	SRv6 Security Framework	draft-li-spring-srv6-security-consideration	Huawei	CAICT China Telecom

- **SRv6 deployment consideration and migration recommendation.**
- **SRv6 protection is accepted by the WG.**

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-dong-spring-sr-for-enhanced-vpn	Huawei	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

- **VPN+ Framework draft is in WG stage. Scalability will be the important factor for the development of VPN+ solutions.**
- **SR VPN+ is expected to become WG draft. IPv6 VPN+ was proposed taking into account the scalability.**
- **VPN+ control plane extension is on going.**

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 Telecom SKT/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-ietf-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	

- **Much progress has been made in the data plane and multiple drafts has been adopted by WG.**
- **Control plane drafts has been proposed for the auto provision of IFIT.**

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 Usecases/Requirements become WG draft. It is close to be stable.**

- **BIERv6 encapsulation draft is in active discussion. BIERv6 standardization will speed up.**

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 is accepted by WG, Will launch WG Last call and speed up RFC progress**
- **SRv6 Path Segment will be applied for WG draft**

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	

- **Four DetNet data plane draft finished WG last call before IETF106**
- **DetNet SRv6 data plane and YANG model presentation draw WG attention. Need to continuously promote it.**

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
	draft-li-spring-sr-sfc-control-plane-framework	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

- **2019 Interop Exhibition Japan, Shownet successfully demo multi-vendors inter-Op test**
- **SFC data plane – two proposals were accepted by WG. SFC control plane is in planning.**

IPv6+ 2.0 (7) SRv6 Compression/G-SRv6 and 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-li-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

- **Multiple solutions are proposed for SRv6 compression and being converged gradually.**

IPv6 3.0: APN6

Area	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
	Application-aware IPv6 Networking Encapsulation	draft-li-6man-app-aware-ipv6-network	Huawei	Bell Canada/China Mobile/China Unicom/China Telecom

- **APN has been proposed as an important change of the network architecture.**
- **IETF 105: APN6 side meeting has been held and drawn much attention.**
  https://github.com/APN-Community/IETF105-Side-Meeting-APN6

Thank you